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Patterns of Thought and Numbers: A History of Mathematical Logic in Late Republican and Early Socialist China (1930-1960)

Vzory mišlenek a čísel: dějiny matematické logiky v pozdně republikánské a raně socialstické Číně (1930-1960)

Disertační práce

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Prohlašuji, že jsem disertační práci napsal samostatně s využitím pouze uvedených a řádně citovaných pramenů a literatury a že práce nebyla využita v rámci jiného vysokoškolského studia či k získání jiného nebo stejného titulu.

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Abstract

This PhD dissertation surveys the development of the concept and the academic discipline of mathematical logic in the transitional period between late Republican and early socialist China. Providing a contrastive analysis of the main developmental aspects of its conceptual variegations, its institutional life and research-related development, this dissertation focusses on the main continuities and discontinuities between these two important periods of its existence in the period of China's modernisation. The main analytical apparatus of this treatise is divided into two main parts. The first part outlines the main developmental milestones in research and teaching of mathematical logic in Chinese academic community in the late Republican period (1930-1949). Its main focus lies on the establishment of mathematical logic as a philosophical discipline in framework of the "Qinghua School of Logic" at National Qinghua University, on the one side, and the beginnings of Chinese mathematicians' research in mathematical logic in the early 1930s, on the other.

The second part, on the other hand, closely examines the main three aspects of change which the idea and discipline of mathematical logic underwent in the first decade after the founding of the People's Republic (PRC): from its unique role in Chinese Marxist discourse on philosophy of mathematics, to the institutional reform related to its reestablishment in Chinese academia, down to its newly acquired content-related identity as an applicative branch of mathematics in the late 1950s.

By evaluating both its role in Chinese general intellectual discourse and its development as a branch of Chinese academic philosophy and mathematics, this survey offers a comprehensive insight into the mechanism, motives and the intellectual foundations which underlay the development of mathematical logic in the pivotal period of Chinese modernisation. Most importantly, in its main analysis, the survey presents an extensive overview of the life and work of leading Chinese mathematical logicians, who provided vital contributions to its propagation and advancement in modern China.

Key words: mathematical logic, history and philosophy of science, modern Chinese philosophy, Late Republican China, Socialist China

Tato disertační práce zkoumá vývoj pojmu a akademického oboru matematické logiky v Číně, v přechodném období mezi pozdní republikou a raným socialismem. Práce se zaměřuje na hlavní kontinuity a diskontinuity mezi těmito dvěma důležitými obdobími vývoje oboru v době modernizace Číny, a to zejména prostřednictvím srovnávací analýzy hlavních vývojových aspektů jeho konceptuálních proměn, institucionálního života a vývoje bádání samotného.

Hlavní analytická stať této práce se dělí na dvě části. První část představuje hlavní milníky vývoje v bádání a výuce matematické logiky v čínské akademické obci v pozdně republikánském období (1930-1949). Zaměřuje se na jedné straně na ustavení matematické logiky jako filosofické disciplíny v rámci „logické školy Qinghua" na Národní univerzitě v Qinghua, a na straně druhé na počátky výzkumu čínských matematiků v oboru matematické logiky v raných třicátých letech.

Druhá část je věnována podrobnému rozboru tří hlavních aspektů proměny, jíž prošla myšlenka i obor matematické logiky v období první dekády po založení Čínské lidové republiky: od unikátní role, jíž sehrála filosofie matematiky v čínském marxistickém diskurzu, přes institucionální reformu související s jejím novým místem v rámci čínské akademické obce, až po získání nové identity jakožto odvětví aplikované matematiky v pozdních padesátých letech 20. století.

Práce tedy zkoumá jak roli matematické logiky v čínském intelektuálním diskurzu, tak i její vývoj jakožto odvětví čínské akademické filosofie a matematiky, čímž nabízí komplexní vhled do toho, jaké mechanismy, motivy a intelektuální východiska určovala vývoj matematické logiky v klíčovém období modernizace Číny. Nad to ve své hlavní analytické části poskytuje zevrubný přehled života a díla předních čínských matematických logiků, kteří svou prací zcela zásadním způsobem přispěli k jejímu šíření a rozvoji v moderní Číně.

Klíčová slova: matematická logika, dějiny a filosofie vědy, moderní čínská filosofie, pozdně republikánská Čína, socialistická Čína

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1. Introduction

This dissertation surveys the development of mathematical logic as the idea and an academic discipline in China in the transitional period between late Republican period and the first decade of the People's Republic (PRC). It surveys the development of this discipline in the pivotal period between its first establishment in Chinese academia, as a discipline studied in the scope of academic philosophy – the Qinghua school of logic, to its reestablishment within the context of socialist construction of science and technology in the 1950s. In parallel, one of the main focal points of this study will be the transition from a philosophical notion of mathematical logic, which was related to the intellectual context of its first establishment in China, to its subsequent redefinition within the domain of mathematics and technological sciences in the context of the socialist reform of Chinese science in the early PRC period. In so doing, this treatise will set out by outlining the main features of the main results in teaching and research of mathematical logic in the late Republican era, so as to contrast the characteristics it acquired in its initial intellectual environment against its new identity, developed in the first decade of the socialist era. While the former will serve as the background, the latter shall serve as the central topic of the present dissertation.

The history of mathematical logic in China reaches back to the early 1920s, when a certain notion of it was introduced to the Chinese intellectuals in the framework of the visit of Bertrand Russell, one of the key founders of the modern mathematical logic in the West. So far, the history of mathematical logic in China has been studied or discussed only in most general and thus inevitably superficial manner. Earliest Chinese studies on its early history stem back to the 1980s, when they appeared in the context of numerous historiographic projects prompted by the early reforms of the Deng Xiaoping era. Thus, the earliest considerable attempt to provide a concise overview of its history in Republican and early-PRC periods was produced by Zhou Yunzhi 周云之 and Zhou Wenying 周文英 in the fifth volume of the extensive *History of Chinese Logic* (*Zhongguo luojishi* 中國邏輯史, 1989). A slightly altered rendition of the chapter on mathematical logic was later reproduced in Zhou Yunzhi's *History of Chinese Logic* from 2004. Regarding journal articles, the earliest attempt at giving a comprehensive overview of the main milestones of its history in China was provided by Lin Xiashui 林夏水 and Zhang Shangshui 張尚水 (1983). The common feature of this early retrospectives of its developmental past in China consists in their exclusive focus on the academic work of a few representative figures such as Jin Yuelin 金岳林, Shen Youding 沈有鼎, Wang Xianjun 王憲鈞 and others, while completely ignoring the broader intellectual, institutional, and ideological circumstances that surrounded and even conditioned its development in China. Consequently, these early surveys tend to disregard such important propagators and exponents of the notion of mathematical logic as Zhang Shenfu 張申府, and at the same time fail to acknowledge the complex networks of influence and developmental trajectories that underlay the advancement of mathematical logic as a notion and an academic discipline. In 1998, a moderate attempt at casting some light on these neglected aspects was made by Shi Mingde 時明德 and Zeng Zhaoshi 曾昭式. In the Western scholarship, considerable advances in studies of mathematical logic in China were made by the late scholar Xu Yibao, who in his dissertation "Concepts of Infinity in Chinese Mathematics" from 2005 explored previously understudied aspects of its early history in China, most notably the early role of Bertrand Russell in its introduction to Chinese academic world (see Xu 2003). Most recently, new research on the topic has been conducted by a group of researchers at Inner Mongolia University of Science and Technology.[1]

Setting out from the current state-of-art in the field, the main aim of this dissertation will be to fill in the gaps in our historical understanding of the multi-layered development of mathematical logic in the Republican and early-PRC China. Its main focus will be on the transitory period between the late-Republic and the early years of ideological restructuring of Chinese academic world in the 1950s. By closely observing two seemingly contrastive chapters in the institutional and conceptual life of mathematical logic in China, I will try to gain a more precise understanding of the intellectual, philosophical, political, and scientific factors and circumstances underpinning its existence and identity in the crucial period of its establishment in China. Hence, while in the parts devoted to the Republican period special consideration will be given, on the one hand, to its initial establishment as a philosophical discipline at the Qinghua University and the early emergence of its "mathematical counterpart" in Chinese mathematical circles, the subsequent and main part will be devoted mainly to the key role of

[1] See, for example, Su and Dai 2019. In the time of writing this dissertation, their results were not yet published. For a critical evaluation of their contributions see my forthcoming article "The Liberating Power of Harmony and Order: On the Notions of Liberty and Mathematical Logic in Zhang Shenfu's Philosophical Thought" (2022).

mathematical logic in the formation of Chinese socialist philosophy of science (philosophy of mathematics, dialectics of nature) and its eventual reestablishment as a semi-technical mathematical discipline in the context of new socialist science. In that way, the following study will not only significantly complement previous scholarship, but, more importantly, investigate the ideological fundaments and intellectual-historical mechanisms which, due to political reasons, remain largely unexplored in contemporary Chinese historiography of mathematical logic and philosophy (ideology) of science in modern China. The broader historical conclusions and inferences which were inevitably drawn in the following dissertation were all grounded upon a series of my previous studies relating both to the early and contemporary history of logic in China (see Vrhovski 2020a-c, 2021a-f).

One of the main theses of this dissertation will be that, contrary to the established historical narrative (history of mathematical logic), the early period of its establishment at Chinese universities in the late Republican period was still defined by profound variegations in its scientific and philosophical identity, while its understanding as a notion was in consonance with the current intellectual trends in the country. In the 1930s, the latter were still largely dominated by a strong propensity towards scientism, analytical philosophy, and materialist dialectics on the one side and a modern Chinese conception of "vitalist" philosophy on the other. Consequently, in the Republican period, both the popular notion as well as academic character were inextricably connected to the philosophical views, academic background, or personal preferences of its pioneer-propagators in the country, which resulted in a diversity of different approaches to studying mathematical logic as established at the philosophical department of Qinghua University on one side and the mathematical department of Wuhan University on the other. In parallel to the content-related diversity in its existence in Chinese academia, from its first introduction in the May Fourth period (1917-1921), mathematical logic enjoyed a special status in general Chinese intellectual world as a concept associated closely with the modern scientific worldview and as the key pillar of the objectivity[2] which surged in new Chinese academia. Its very status in context of the modern science-centred worldview was also the main driving force behind its subsequent establishment in Chinese academia, revealing the essential intertwinement between the identity of a notion in the general intellectual or popular discourse and the degree and manner of its initial establishment in the academic environment. An assumption subordinate to the above-stated thesis would also be

[2] Our use of the term "objectivity" will be explained in the concluding part of this introduction.

that, at least in the early period, mathematical logic as a notion is to be distinguished from mathematical logic as a scientific discipline.

The second major thesis follows the same rationale as the first one. It namely conjectures that, in the subsequent period, when the notion and discipline of mathematical logic underwent a seemingly complete transformation, this change was still rooted in very same form of objectivism or worldview which underlay the past and current Chinese intellectual discourse. Although, at the surface, the content of this discourse was replaced by a new ideology – dialectical materialism as the general philosophical worldview and dialectics of nature as its consistent philosophy of science, I assume that the socialist intellectual reconstruction was in direct continuity with the prior intellectual development, in the sense that it took place in coherence or within the same objectivist worldview. The second thesis assumes that the development of mathematical logic in the PRC period was conceptually still deeply rooted in the main trajectory of Chinese intellectual development. As a consequence, it can be conjectured that its past development in Chinese intellectual discourse and academia resulted in a relatively unique advancement of the concept within the new socialist order. In this sense, the fate of mathematical logic in early-PRC China would be expected to be formally in cohesion with that of the same discipline in the Soviet Union, while at the same time its development would have to be completely dissimilar at ideological level and in manner of its institutional re-establishment. The ideological alignment with the Soviet science would be expected at the earliest stage of adoption or emulation of the Soviet model, while, hypothetically, the developmental uniqueness of mathematical logic will be recognised in the later period, when the aforementioned specifically-Chinese intellectual current would gain expression through intellectuals and scientists who were able to reassert their identity through mastery of the language of the new ideology and erudition in its philosophical tenets.

Another central thesis of this research assumes that, in the process of undergoing the transition from a philosophical discipline to a branch of mathematics, the Chinese academic discipline (i.e. teaching and research of mathematical logic at Chinese Universities and research institutes) of mathematical logic was gradually aligning itself with the current advances or developmental trends in the field on the one hand and the needs stipulated by global trends in technological development on the other. Furthermore, by drawing closer to the realm of the applied sciences, the gap between the ideological or philosophical nature of mathematical logic and its scientific value and identity would also gradually disappear.

Accordingly, the main research goals of this dissertation will be: (1) to describe the general circumstances in research and teaching mathematical logic in the late Republican period; (2) to highlight the differences between propagation of mathematical logic in late Republican philosophical circles on the one hand and mathematical circles on the other; (3) to provide a comprehensive overview of the developments relating to research and teaching of mathematical logic in the transitory period of socialist (re)construction of Chinese science and academia in the 1950s; (4) to separately discuss different aspects of change in teaching and research of mathematical logic in the 1950s, i.e. the changes mathematical logic as a notion and discipline underwent at ideological, institutional, and content-related levels; and (5) to compare these changes against the general conditions in the field in the late-Republic on one side and the current trends in the Soviet Union on the other.

To evaluate the above-listed theses and reach its main research goals, the present dissertation will provide an overview of the main developmental aspects of the notion and the scientific discipline of mathematical logic in the period between 1930 and 1960. These aspects include developments related to: firstly, its institutionalisation and its advancement at Chinese universities; secondly, the development of the notion or conception of mathematical logic in popular discourse and the general discourse on philosophy of science; and, thirdly, developments pertaining to its, so to say, "internal" advancement as a field of studies. Methodologically, the main research goals will be pursued by means of primary and secondary published sources and documents from the period under examination, ranging from various published reports to original articles, monographs, and other sources of historical value. The historical framework for the main discussion will be set up by means of contemporary historiographical studies dealing with the general circumstances in the Chinese, socio-political sphere, the common intellectual spheres of influence, and the general scientific or intellectual communities in the period under examination.

One of the key methodological terms which will be used in this dissertation is the concept of *objectivity*. Although our use of this term is derived mainly from the ground-breaking work *Objectivity* by Peter Galison and Loraine Daston, because this concept will be used in an entirely different cultural and intellectual context, it requires further explanation. In this study the concept of objectivity will be used primarily to denote a conceptual entity close to that the worldview (*Weltanschauung*), with one major difference: apart from being a collection of cosmological, epistemological, and ontological principles extracted from the context of scientific or humanistic ideational domain, objectivity also strongly implies a dichotomic nature not only of cognition but also evolution2ary and other aspects of the universe. In the context of mathematical logic in China it is useful to generalise objectivity and subjectivity to include further dichotomies: intuition versus positive knowledge, of ontology-based moral right and wrong, evolutionary growth versus decline, and so on. Under the requirement of this generalized objectivity, questions and concepts from contemporary science entered the popularized social discourse of the May Fourth period China. Sometimes these popularized forms were quite distant from their sources in the scientific context, and gradually grew into independent ideologies. This is directly relevant to the case of mathematical logic, which produced a separate (what we call) notion of mathematical logic as part of a general ideology of scientific objectivity. The fact that the development of mathematical logic in China took place under special circumstances – appropriation/adoption and integration of foreign ideas – opens up two additional aspects, central to our understanding of the notion of *objectivity*: inter-cultural exchange and historicity. the developing requirement of objectivity created part of the context under which foreign ideas were integrated when coming to China. The transfer of ideas model of Chun-chieh Huang, who discusses transfer of ideas in terms of de-contextualisation and contextualisation of external ideas in into the native conceptual framework (see Huang 2007, 2015, 2017), should thus be expanded to take note of the fact that foreign frameworks adapted in the course of transmission shape all the subsequent reception. Even opposition to these later ideas from cultural conservatives was often formulated in the already established framework of generalized objectivity.

The phrase "patterns of numbers and thought" in the title of this dissertation, refers to the dual character of mathematical logic, as a philosophical (thought) and mathematical (numbers) discipline, which makes up the heart of our investigation. The word "patterns" alludes to the word *li* 理 (pattern, principle) in *shuli luoji* 數理邏輯, the established Chinese term for mathematical logic, indicating the profoundly traditional perspective which underpinned the earliest introductions of both the term and the notion by Zhang Shenfu 張申府 in the early 1920s.

2. Mathematical Logic in the Late-Republican Period: From a Philosophical Discipline to Mathematical Research

The first part of the dissertation surveys the main developmental trends in research and teaching of mathematical logic in the late Republican period (1930s-1949). The focal point of this part will be the so-called "Qinghua School of Logic", which developed at the department of philosophy at Qinghua University in Peking. As the first group of Chinese scholars who devoted their work and lectures to mathematical logic, the Qinghua logicians vitally contributed to the establishment of the discipline in Chinese academia. On the other hand, their efforts at propagating the field in Chinese academia were all conducted from the perspective and in the framework of the then emerging (in China) field of philosophy (see Lin 2012). In the early 1930s, this, so to say, "philosophical" notion of mathematical logic became rivalled by the research and introductory endeavours – focused mainly on set theory and Hilbertian formalism – conducted by a certain group of Chinese mathematicians, centred around the recently reformed National Wuhan University. Hence, the second aim of this part will be to introduce to the reader the gradual rise of mathematical logic as a subject studied by mathematicians, or in other words a "mathematical" notion of mathematical logic. Apart from this conceptual and research-related duality, this part will also offer a short introduction to the gradual inclusion of mathematical logic into the new standardised curricula of logic and the developments relating to logical terminology in the late Republican period. By providing a general overview of these developments, the just-mentioned chapter will cast some new light on the role and development of the idea of mathematical logic in the general intellectual discourse of Republican China.

2.1. "Qinghua School of Logic": Mathematical Logic at Qinghua University in Peking

The concept of mathematical logic was introduced to China approximately in the late 1910s, through various philosophical writings and classifications of logic given in Chinese translations of modern Western or Japanese textbooks on logic. The expression could thus be already found in the vocabulary of some more or less significant intellectual figureheads, who spilled their ink and contributed their voice to the May Fourth movement in 1919, which issued, amongst many other thigs, a resounding call for modernisation of Chinese society. Thus, for example, in a series of revolutionary articles, China's first propagator of philosophical ideas of Bertrand Russell, Zhang Shenfu (張申府, original name Songnian 崧年, 1893-1986) located the New Culture Movement's ideal of 'Mr. Science' (*sai xiansheng* 赛先生) in his idealised notion of mathematical logic.

As a scientific discipline, mathematical logic was first introduced to Chinese intellectuals during the visit of the renowned philosopher and mathematical logician Bertrand Russell, between 1920 and 1921. During his stay at the National Peking University, Russell also delivered an introductory lecture on mathematical logic. Although Russell's visit had left a significant imprint on contemporary Chinese intellectual world, it took almost a decade before mathematical logic finally became established as a discipline at Chinese universities. Despite some minor attempts by some members of the host institution of Russell's visit in China, the Peking University, before the late 1920s, neither mathematical logic nor Russell's New Realism had not been adequately integrated into the standard curriculum of its philosophical department.[3] Such a development at Peking University was hindered by the general tendency at the department, which prioritised textual exegesis of traditional Chinese philosophy and reinvigoration of Chinese tradition through ideas from American pragmatism, over contemporary science-based analytic philosophy (Cf. Lin 2012).

The semi-traditionalist tendency at Peking University obtained its counterpart in the newly established National Qinghua University in 1928. Qinghua University owed its incomparably more Western-oriented and modern outlook to its predecessor, Qinghua College (*Qinghua xuetang* 清華學堂, later also referred to as *Qinghua xuexiao* 清華學校), which was established in 1911 as a preparatory school for students who wanted to study at American

[3] On general developments at Peking University see, for instance, Lin 2005.

universities. Consequently, its department of philosophy, which had been established already back in 1926, became the centre of studies in analytical philosophy (initially predominantly Russell's New Realism) and mathematical logic in China.[4] By the early 1930s, its senior professors of logic, Jin Yuelin (金岳霖, sobriquet Longsun 龍蓀, 1895-1984), Zhang Shenfu and later also Shen Youding and others, became collectively known as "Qinghua School of Logic" (*Qinghua luoji (xue)pai* 清華邏輯(學)派).[5]

The aim of this chapter shall be to outline the developments at Qinghua department of philosophy in the period of two decades from its establishment in 1926 to the year 1945, when Qinghua university started gradually losing its former prestige and influence.[6] The survey will focus on two main aspects: mathematical logic in the department's curriculum and mathematical logic as a subject of research. It will start with an overview of curricular developments, which highlight the course of establishment of modern logic at the department, while in the subsequent parts, the discussion will concentrate on the aspects, topics and sources of mathematical logic researched by the members of the department. Special emphasis shall be made on the early advances in studies of Russell's and Whitehead's keystone work *Principia*

[4] On Qinghua school of philosophy and New Realism see Hu Weixi 2002.

[5] Already in the 1930s, the group of philosophers at Qinghua were known to as "[the Qinghua] school of logic" (*luoji pai* 邏輯派; see Feng Youlan 1936, 13; Zhang Shenfu 1934, 21-22). Due to its strong proclivity towards analytic philosophy, New Realism and mathematical logic, Zhang Shenfu (1934, 22) also called the group of philosophers at Qinghua the "Oriental Cambridge school" (*Dongfang de Jianqiao pai* 東方的劍橋派) of philosophy. Otherwise, the term "Qinghua school" (*Qinghua xuepai* 清華學派) or "Qinghua school of logic" (*Qinghua luoji xuepai* 清華邏輯學派) became more widely used in the 1980s, following the emergence of a new wave in Chinese historiography of the intellectual history of the Republican period (Zhang Dainian 1994, 11-12; Wang Xun 2017, 160). The main reason for the early disappearance and late re-emergence of the notion of "Qinghua school" as a school of logic and analytic philosophy resided in the fact that, at the start of the Second Sino-Japanese war in 1937, Qinghua University, as it were, "lost" its independent standing and became first a part of The National Changsha Provisional University (*Guoli Changsha linshi daxue* 國立長沙臨時大學) and later (1938-1945) also a part of the National Southwestern Associated University (*Guoli Xinan lianhe daxue* 國立西南聯合大學) in Kunming. The department of philosophy became an independent unit again in 1945, when the university was restored in Beijing, and continued its former existence only for a short period of time, before its final resolution in the frameworks of reforms of 1951-1952, when Qinghua University was remodelled into a Soviet-style polytechnic, and a fraction of the former department was moved to Peking University.

[6] The first decade, that is the period between 1928 and 1937, is also often referred to as the "golden age" (*huangjin shidai* 黃金時代) of Qinghua University (see, for example, Wu Hongcheng 2003, 91-114).

Mathematica and the later introduction of the so-called 'Harvard logicians'' critiques of the *Principia.*[7] In its final parts, the chapter will focus on the initial introductions of theories of Kurt Gödel by the later generations of Qinghua logicians. By connecting the curricular developments on one side and developments related to research of concrete topics in mathematical logic, the following analysis will try to piece together a more complete picture of the so-called 'Qinghua School of Logic' in the late Republican China. It will try to show, that the school represented a confluence of several different, yet equally important, discursive tendencies, which were manifested both in the structure of the curriculum as well as in the research work conducted by its main representatives.

2.1.1. Curricular Developments at Qinghua Department of Philosophy

Not unlike other Chinese universities, in early 1920s, the then called Qinghua College offered an introductory course in logic as a part of the basic curriculum. Between 1923 and 1926 logic at Qinghua was taught successively by the renowned logician and linguist Zhao Yuanren (趙元任, 1892-1982),[8] a scholar called Wu Zai (吳在) and the philosopher Zhang Pengchun (張彭春, P. C. Chang, 1892-1957).[9] Under Zhang, who held a doctorate in educational sciences from Columbia University, the course on logic was modelled in line with the pragmatist notion of experimentalist nature of logic.[10] This kind of pragmatist approach was usually in consonance with a psychologistic notion of logic, which manifested itself in the early logical courses taught by psychologists.[11]

In 1925, a largescale reform scheme was launched at the college, which also set into motion the establishment of first university-level programmes, accompanying the establishment of first departments. The fundamental reorganisation of Qinghua did also affect the structure of the basic curriculum. Thus, in the school year 1925/6 an elective course on

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[7] In part and from different perspectives this topic has already been touched upon in Xu 2003, 2005; Zhou & Zhou 1989; Zhou 2004; Lin & Zhang 1983; Shi & Zeng 1998 and so on. On the history of Western logic in Imperial China (up to 1911) see Kurtz 2011.

[8] In 1918, Zhao was awarded a PhD degree in philosophy from Harvard University. In his doctoral dissertation "Continuity: A Study in Methodology", written under supervision of Harvard logician Henry Sheffer, he also touched upon mathematical logic (*Principia Mathematica*), cf. Zhao 1977, 40-3.

[9] See *Qinghua nianbao* 清華年報 1924/5 (*Tsinghuapper*), 29; *1923/4*, 30.

[10] After Dewey's *Experimental Logic* (1916).

[11] E.g. Peking University in 1910s.

science of logic (*lunlixue* 論理學) was offered in the framework of preparatory department of philosophy (Qinghua xuexiao 1926, 28-31). Following the resignation of Zhang Pengchun in late 1926, Jin Yuelin was hired by the college to take over the task of setting up a department of philosophy for a future Qinghua University. At the time Jin was the only member of the department, which hosted only two undergraduate students, one of whom was the future Chinese logician Shen Youding (Yu-ting Shen, 沈有鼎, 1909-1989; Liu Peiyu 1995, 385). Under Jin, teaching of logic at Qinghua started to gain a new outlook. Although Jin originally earned his doctoral degree in the field of political science and philosophy, in 1922, when he was studying at the London School of Economic, he became strongly interested in Russell's *Principia Mathematica* and philosophy of British empiricist David Hume (Liu Peiyu 1994, 383). His first encounter with Russell made him abandon his former studies in political science for logic and New Realism, to which he decided to devote a year of studies at Cambridge University. By the year of his appointment as a professor at Qinghua, Jin was already deeply immersed into modern logic and philosophy. As a direct consequence of his interests in modern logic, through Jin significant fragments from contemporary mathematical logic – predominantly Russell's *Principia Mathematica* – were introduced into both the elementary and advanced course on logic at Qinghua.

In 1928, the college was officially renamed into National Qinghua University as Luo Jialun (羅家倫, 1897-1969) was named the new president of the university. Luo was a strong advocate of Western science and maintained a profound interest in modern logic.[12] With the college's reorganisation, the department of philosophy also grew. By the year 1929, when president Luo initiated the establishment of graduate schools (*yanjiusuo* 研究所, 'research institute'), the department already employed three new professors, including Feng Youlan (馮友蘭, 1895-1990), who in the coming years contributed significantly to furtherance of analytic philosophy and mathematical logic in Chinese philosophical circles. By virtue of the national education system reforms of 1928, logic became a mandatory subject in the first year of study

[12] In 1923 Luo wrote a book *Science and Metaphysics* (*Kexue yu xuanxue* 科學與玄學). At the time Luo was studying at the Columbia University in New York. According to Luo, his writing had been assisted by Dewey and Spaulding as well as his friends Zhao Yuanren and Yu Dawei (Berlin 1922-1924), who had a sound knowledge of contemporary mathematical logic. The above-mentioned book also briefly summarised some of the most important aspects of mathematical logic (Luo Jialun 1930, 2-3; Chen Mingzhu 2006, 109-111). On Luo's years at Qinghua see, for example, Chen Mingzhu 2006, 131-200.

at university.[13] In 1929, the Qinghua department offered a course in logic, which consisted of two different parts: deductive logic was taught in the first semester and induction in the second (see Guoli Qinghua daxue 1929, s.d.).

In the academic year 1929/30, Zhang Shenfu was hired as a lecturer at the department. I assume that Zhang was employed either through intervention of president Luo Jialun, who was an old acquaintance of Zhang's (see Schwarcz 1992, 47-48), or the current head of the department Feng Youlan, Zhang's former colleague from department of philosophy at Peking University[14]. Whatever the cause behind his employment had been, the fact was that in the 1920s Zhang enjoyed the reputation of China's foremost expert on Russell and Wittgenstein. Most importantly, from 1919 on, he was also an ardent propagator and populariser of mathematical logic. He completed his basic training in mathematics and philosophy from Peking University in 1918 (he specialised in Cantorian transfinite set theory and modern logic),[15] and since then taught mathematics, logic, and contemporary Western philosophy at various Chinese universities. Zhang was also a passionate advocate of dialectical materialism

[13] For a general overview of reforms in the system of education in Republican China see Pepper 1996. About the changes related to the role of logic in the new standard curricula see Zhai Jincheng 2016, 59-63; He Qingqin 1989, 75-106.

[14] Although in his reminiscences *Suoyi* (1993, 107) Zhang only mentioned that he was hired by the university, it is highly probable that this was the result of either Luo's or Feng's intervention on his behalf. Jin Yuelin, on other hand, strongly disliked Zhang. However, it must also be noted that no concrete evidence for either of the two options has been found. On the other hand, it is highly unlikely, as claimed by Xiaoqing Diana Lin (2016, 57), that "the appointment […] of Jin Yuelin, […], led to the appointment of Feng Youlan, Zhang Shenfu […]" At least not in the most direct sense.

[15] Shortly upon his graduation in 1917, as a graduate student Zhang joined the graduate school (Research Institute 研究所) for both philosophy and mathematics. In the framework of his graduate studies of philosophy, Zhang attended Zhang Shizhao's lectures on the history of logic, Hu Shi's introduction to Chinese logic (*mingxue* 名學, see Guoli Beijing daxue 1917), and maintained a deep interest in Buddhist and contemporary Western philosophy (Guoli Beijing daxue 1918, 376). In 1917, he became a member of the recently established mathematical research institute (*Shuxuemen yanjiusuo* 數學門研究所), which was supervised by two senior members of the Department of Mathematics, Feng Zuxun (馮祖荀, 1880-1940) and Qin Fen (秦汾, 1882-1973). As a graduate student at the institute, Zhang specialized in Cantorian transfinite set theory and also composed two articles introducing the main concepts of set theory (Zhang Shenfu 1918a, 1918b). His work was supervised by Feng Zuxun (Guoli Beijing daxue 1917).

and devised a syncretic philosophy, where logical analysis (incl. mathematical logic) was blended with dialectical materialism.

From 1929 on, the elementary mandatory course in logic was taught jointly by Jin and Zhang. The subject at the department of philosophy was renamed into *luoji* 邏輯, which conveyed a more modern and Western notion of logic (*Guoli Qinghua daxue 1930*, 6-7). Both Zhang and Jin concurrently also lectured at Peking University, where, for the first time in Chinese history, a specialised elective course on Russell's philosophy was organised by the former (Guoli Beijing daxue 1929).[16] After Zhang was promoted to the rank of professor in 1931, Zhang also organised the first specialised course on mathematical logic (*shuli luoji* 數理邏輯) at Qinghua. The course was intended for students in the third and fourth year of their studies. The description of the course in stated that the primary objective of the subject was to introduce the elementary concepts from mathematical logic, such as propositional calculus (*mingti suanfa* 命題算法), propositional function, the notion of incomplete symbol, logical structure, class, relation, system, sequence, inference and implication, logical paradox, logisation of mathematics, axiomatic method and so on (Guoli Qinghua daxue 1932, 59). The students were also informed about its developmental history and its main applications in philosophy and sciences. According to Zhang's own description, the main source for the lectures was the Principia Mathematica. In addition to that, another 35 books were listed as recommended literature for the course, including the most representative works in the field between late-19th century up to the year 1931.

Logic and mathematical logic were not the only logic-related courses taught by Zhang Shenfu. From 1932 on, Zhang also taught a course in history of logic (*lunlixue shi* 論理學史, later renamed to *luoji shi* 邏輯史), covering the history of Western logic, from Aristoteles

[16] Although conventional histories, such as *Zhou Yunzhi 2004*, 400-403; *Zhou Yunzhi & Zhou Wenying 1989*, 6 etc., claim that the first specialised course on mathematical logic was organised by Jin Yuelin at Qinghua University, the sources reveal that the first such course, which also bore the title "Mathematical Logic" was organised and given by Zhang Shenfu. The philosopher Mou Zongsan 牟宗三 even claimed that Zhang gave specialised lessons on mathematical logic at Peking University as early as in 1929 (*Mou Zongsan 1993*, 41-43; *Guo Yiqu 2001*, 80), but it is more probable that these were given in the framework of the general course on logic – no official documents from the time confirm that a separate selective course on mathematical logic was organised at Peking University as claimed by Mou.

through Leibniz, Russell down to the most recent developments in Western logic. The course also prescribed a lengthy list of literature used in the lectures, including Scholz's *Geschichte der Logik* [*History of Logic*], published only one year earlier (1931). The 1932 guide to courses and study programs at Qinghua University further reveals that Zhang also taught a specialised course on philosophy of Bertrand Russell (ibid., 59-62).

In 1934, the configuration of the curriculum at the department of philosophy changed further in favour of logic, when the first graduate of the department, Shen Youding returned from his studies in the West and was hired as a lecturer at the department. Between the years 1928 and 1934 Shen studied mathematical logic at Harvard University in the US, and Freiburg and Heidelberg universities in Germany. From the year of his employment at his *alma mater* on, Shen taught several specialised courses on modern logic. Already in the initial year, he carried out an elective course entitled 'Studies in Logic' (*luoji yanjiu* 邏輯研究; Guoli Qinghua daxue 1934, 4). Shen's studies represented a major step forward in tracing of current developments in the field. The course aimed at revealing the inadequacies of mathematical logic as found in the *Principia Mathematica*, most probably those indicated in the recent years at Harvard (later, most notably W. V. O. Quine),[17] Gödel's incompleteness theorem (1931) or other contemporary philosophical views on mathematical logic (from formalism to intuitionism and logistics of Vienna School). By the year 1934, Carnap's 'logistics' was also integrated into Zhang Shenfu's course on mathematical logic, who now also used the term *shuli luoji* 數理邏輯 for 'logistics'.[18] In the previous years, Zhang and his younger brother Zhang Dainian started introducing the philosophy of Vienna School to Chinese philosophical circles.[19]

The presence of logic in the undergraduate curriculum at the department reached its pinnacle in the academic year 1935-1936. From 1935 on, Shen Youding taught an elective course on "Systems of Logic" (*luoji tixi* 邏輯體系), and Jin Yuelin's notes for the general course in logic were published in the form of a textbook. The book simply entitled Logic (*Luoji*

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[17] On Quine and the *Principia Mathematica* see Grattan-Guinness 2000, 529-31 etc.

[18] In the 1930s, the greatest contribution to dissemination of Carnap's logistic and the philosophy of Vienna School in China was made by Hong Qian (洪謙 or 洪潛, Tscha Hong, 1909-1992), a former student of Moritz Schlick and an actual member of Vienna School, who joined the department of philosophy in 1937 (see, for example, Fan Dainian 1992).

[19] Zhang Shenfu believed that mathematical logic of Russell and Whitehead had been superseded by logistics of Carnap and Gödel (Masson 1985, 43).

邏輯) represented the most extensive and exhaustive introduction to *Principia Mathematica* in Republican period China (Xu Yibao 2003, 189-90). After its second publication with the Commercial Press, Jin's Logic became one of the most popular Chinese textbooks in logic. The content of the book reveals that in the early 1930s the general course on logic at the department revolved mainly around Jin's theory of induction, on the one side, and Principia Mathematica and related deductive systems of logic, on the other.

In March 1936, as a result of his participation in the student protests in Peking Zhang Shenfu lost his position at the university. His post was filled by Shen, who became a full professor of logic at the department. After the outbreak of the Second Sino-Japanese war in 1937, Qinghua University moved to Kunming, where it was merged with Peking and Nankai universities into the provisional National Southwestern Associated University (*Guoli Xinan lianhe daxue* 國立西南聯合大學). Apart from the fact that the former student Wang Xianjun (王憲鈞, Wang Sian-jun, 1910-1993) joined the collective as a professor of logic in 1938 (Liu Peiyu 1994, 394), not much is known about the curricular changes at the wartime joint department.

2.1.3. Introductions of *Principia Mathematica*: From Zhang Shenfu to Jin Yuelin's *Logic*, 1929-1935

From its establishment in the late 1920s onwards, the distinguishing feature of Qinghua department of philosophy had been its advancement of Western scientific or analytic philosophy, most notably Russell's philosophy of New Realism. In consequence, from the very beginning on, much emphasis had been laid on Russell's mathematical logic as its pivotal important methodological foundation. Because of this relatively unique trend which took hold at its department of philosophy, Qinghua University became the very centre of Chinese studies in mathematical logic, which between late 1920s and early 1930s revolved almost entirely around Russell's and Whitehead's *Principia Mathematica*.

Probably the earliest advocacies of mathematical logic and Russell's philosophy, which also mentioned the *Principia,* were Zhang Shenfu's articles from 1919. The idea of mathematical logic became more widely known and established between 1920 and 1921, during Russell's visit in China (see Xu Yibao 2003). In China Russell also delivered a lecture on mathematical logic, which was recorded and published in a magazine and as an independent publication by the Peking University.[20] In the following years Russell's *Introduction to Mathematical Philosophy* was translated into Chinese by two young students of mathematics, who attended the lectures in 1921. Fu Zhongsun's (傅種孫, 1898-1962) and Zhang Bangming's (張邦銘, ?) *Russell's Mathematical Philosophy* (*Luosu suanli zhexue* 羅素算理哲學) was first published in 1922 by the Commercial Press. The second publication of the book two years later prompted a minor debate in various Chinese journals in 1925, which also saw the participation of the translator (later topologist and expert in fundaments of mathematics) Fu Zhongsun, Zhang Shenfu and the, as it were, philosopher and historian of mathematical logic, Wang Dianji (汪奠基, 1900-1979). In the debate, which ultimately developed into a discussion about infinitesimal, Zhang Shenfu used the opportunity to expound on foundations of Cantorian set theory and mathematical logic, in the context of which he also mentioned Russell's *Principia* (see Zhang Shenfu 1925a, 1925b). Zhang's passionate advocacy of his notion of Russell's mathematical logic makes us assume that, as a lecturer of logic at various Chinese universities, at the time Zhang was most probably also advancing knowledge about the *Principia*. Finally, first considerable introduction to the *Principia* was made by Wang Dianji in his book *A Treatise on Logic and Mathematical Logic* (*Luoji yu shuli luoji lun* 邏輯與數理邏輯論) published in 1927.21 The book offered a superficial overview of three basic calculi from the *Principia* – propositional calculus, calculus of classes and relational calculus. Wang's focus was mainly on notation and elementary concepts of aforementioned calculi.

All these early attempts at introducing Russell's mathematical logic were superseded by far by the developments at Qinghua University in late 1920s. As mentioned above, the first specialised course on mathematical logic, which also involved the essentials of *Principia* was Zhang Shenfu's homonymous elective course, delivered concurrently at Qinghua and Peking University. Notwithstanding the fact that Zhang had greatly contributed to popularisation of mathematical logic in China, the testimonies of students who attended the lectures indicate an

[20] The latter were Wu Fanhuan's (吳範寰) notes, published under the title *Shuli luoji* 數理邏輯 in 1921. The short booklet was issued as a part of the *Russell's Five Great Lectures* (*Luosu wu da jiangyan* 羅素五大講演) series.

[21] It was the Chinese translation of Wang's doctoral thesis, which was allegedly submitted at the University of Paris in 1924 – no proof was found, however, that Wang actually submitted such doctoral thesis.

overall elementary or propaedeutic level of the content.[22] Similarly, though immensely popular amongst students from all departments at the university, Zhang's general lectures on logic followed a rather practical approach towards explaining the tenets of modern logic. On one hand the reminiscences reveal that Zhang often dwelt at length on Russell's views, while at the same time also highlight a strong philosophical undertone, which also included his own philosophical views on the possibility of creating a fusion between mathematical logic and dialectical materialism (see Schwarcz 1991/2, 127-8; Meng 2014, 20; Zhang 1993, 178-183).

Hence, it seems that in the early years of the department the task of teaching the technically more demanding aspects of the *Principia* was entirely in the hands of Jin Yuelin. Already in the late 1920s, Jin wrote a number of articles introducing various topics from contemporary logic, covering also different aspects of Russell's relational calculus (1928), down to the latter's treatment of logical paradox and Theory of Types (1927, 1932). Quite early on, his logical explorations had led Jin to discover the so-called Harvard school of logic, growing increasingly fond of the work of C. I. Lewis and Henry M. Sheffer. In his article on logical paradoxes from 1927 Jin already explored Lewis' critique of Russell's treatment of logical paradox. Concurrently, Jin also developed a profound interest for the theory of induction. This was also the reason why, subsequently, Jin decided to spend his sabbatical, between Winter term 1931 and summer term 1932, at Harvard University. There he conducted research in logic under Sheffer and was also able to become more closely familiar with ideas of Whitehead, who at the time was also staying and lecturing at Harvard (Liu Peiyu 1994, 338). Apart from that, Jin's main objective had been to receive an answer to the question whether the principle of induction was based on experience or entirely *a priori* (Wang Xianjun 1995, 116). As a result of the year spent at Harvard, Jin was able to integrate the ongoing debates on shortcomings of the system of *Principia* into his later lectures as well as his textbook on logic.

In the timeframe of four years following his return to Qinghua, Jin devoted more energy to teaching and researching logic. In 1933 he thus decided to teach a specialised course on symbolic logic, for which he also composed a lengthy manuscript, which was to become Jin's quintessential work *Logic*. As a probable consequence of his participation in the ongoing

[22] E. g. Mou Zongsan 1993, 41-3 (only in his earliest years at Qinghua); Sun Dunheng 1988; Guo Zhanbo 1935, 183-90, 216, 221; Meng 2014, 20-23 (Meng mentions the experiences of the physicist Yu Guangyuan 于光遠 who graduated from Qinghua University in 1936 as well as Zhang's alleged relationship with Mao). See also Schwarcz 1991/2, 127-128; Guo Yiqu 2001 etc.

debates about the *Principia* and alternative systems of logic at Harvard in early 1930s, Jin also became interested in the theory of systems of logic, which also became an integral part of his later lectures on logic. Moreover, in 1934 he also wrote a short note on Lewis' "Alternative Systems of Logic", an article published two years prior in *The Monist* (Lewis 1932). In his "A Note on Alternative Systems of Logic" Jin enunciated that the conceptually pragmatical choice of a system of logic would necessarily entail a nonexistence of alternative systems, because the condition of logicality of a system would inevitably lose its meaning after the choice had been made. In his view, this was intricately linked to the fact that any system of logic is always 'a system of tautology', where 'tautologicality' is a relational property rather than a quality of the complete system (Jin Yuelin 1934a, 146). Upon which, Jin concluded that "No system of tautology is as a system ever tautological; that is to say, no system is ever exhaustive of system-possibilities. In other words, there are alternative systems of logic. But this does not mean that there are alternative logics" (ibid.).[23]

Jin's efforts at understanding the contemporary systems of deductive logic, especially that of the Principia, were epitomised in his textbook Logic. Like Jin's lessons, for which it had been originally composed for, the book included a special chapter (III) which introduced the system of *Principia*, as well as another chapter on principal characteristics and foundation stones of 'various systems of logic' (IV). Altogether Jin presented and explained around 60 propositions, taken mainly from the initial chapters on the system of deductive inference of mathematical logic in the first volume of the Principia. All given propositions were equipped with their concrete proofs as well as corresponding translations into a natural language, namely Chinese. In his introductory subchapter on Principia, Jin thus covered the propositions from *1.1 to *2.67. In the subchapter devoted to atomic propositions and calculi of classes and relations, Jin provided a summary of great parts of the sections *10 to *14 of the Principia, completely leaving out the section *12, which was devoted to the widely criticised axiom of reducibility and predicative functions. Finally, Jin also recapitulated the parts of the Principia devoted to the theory and calculi of classes and relations, that is the propositions marked with numbers *20 through *23. As already pointed out by Xu Yibao (2003, 191-2), Jin's omission of the axiom of reducibility shows that Jin was well-aware about the discussions which went

[23] In the same year, Jin further elaborated on his view on alternative systems of logic in an article entitled "Alternative Systems of Logic" (*Bu xiangrong de luoji xitong* 不相融的邏輯系統), which was published in the *Qinghua xuebao* 清華學報 (*Qinghua Journal*).

on at Harvard in recent years and, hence, also with Quine's (also more recent) criticism of the said axiom.

When Jin later reviewed his ground-breaking contribution to studies of mathematical logic in China, he discovered many flaws and misinterpretations, the majority of which pertained to the ultimate chapter on alternative logic systems and their fundamental building blocks (Liu Peiyu 1994, 393). As Jin's later scholarly opus reveals, following the year 1936, Jin became gradually more immersed into more philosophical endeavours, most notably a project of constructing a new system of Chinese philosophy on basis of Western analytic philosophy.[24] Jin's work in logic, however, was carried on by members of new Qinghua-trained generation of Chinese logicians, such as Shen Youding and Wang Xianjun.

2.1.4. Topics in Contemporary Mathematical Logic: From Shen Youding to Wang Xianjun and the Logic of Kurt Gödel

Shen Youding was not only the first graduate of the department of philosophy, but later also the first lecturer at the department who obtained a formal training in logic. Upon his graduation in 1929, Shen spent two more years studying mathematical logic and philosophy under H. Sheffer at Harvard, whereupon he continued his research in mathematical logic at universities of Freiburg and Heidelberg in Germany. He returned to China in 1934 and became first a lecturer and in 1936 a professor at his *alma mater*, Qinghua University. During his tenure at Qinghua, he lectured mainly on modern logic and contemporary analytic philosophy. In the period before the establishment of the People's Republic (PRC) in 1949, Shen wrote predominantly on philosophy of logic and positivist philosophy of language, with a minor exception of an article entitled "On Finite Systems" from 1935 (Shen 1935), which aimed at providing a supplement to Sheffer's work *The General Theory of Notational Relativity* (1921) by expanding the latter's 'new method in mathematical logic' with a theory of finite system, founded partly on Russell's Theory of Types and consisting of three primitive logical concepts, three extensional postulates, and geometrical examples of tropicities, developed from the basic postulations of the system. Akin to Jin Yuelin, a defining feature of Shen's early approach to mathematical logic was his adherence to the developments in American symbolic logic. However, on the other hand, Shen also openly followed the developments in Europe. It is also

[24] For Jin's later writings on ontology and the principle of induction see Schulz Zinda 2012. On Jin's theory of induction see Chen Bo 2012.

highly probable that from 1935 on Shen also lectured on Gödel and the theory of many-valued calculi by the members of the Polish school of logic.[25] Immediately after the end of the WWII, Shen spent three years working as a research fellow at Oxford. He garnered his later critical acclaim for a pair of articles on logical paradoxes published in the prestigious *Journal of Symbolic Logic* between the years 1953 and 1955.[26]

Another member of a new generation of Qinghua logicians, who was also responsible for more extensive introduction of Gödel into the curriculum in logic at Qinghua, was Wang Xianjun. Wang concluded his graduate studies in logic at the department of philosophy in 1936. In the same year, he travelled to Europe, studying logic at universities of Berlin and Vienna. In 1937 and 1938, as a research student at University of Vienna, Wang studied logic under the world-renowned logician Kurt Gödel (Xu Yibao 2005, 194). At the time, Gödel had already moved on from researching axiomatics of arithmetic to axiomatic set theory, so that in his lectures from 1937 Gödel focused exclusively on his findings related to set theory from 1935, including the concept of constructible sets. According to his student, the renowned logician Wang Hao (王浩, Hao Wang, 1921-1995), in 1937, Wang Xianjun was the only student who officially registered for Gödel's class (*Wang Hao 1990*, 98; *1997*, 74). Wang joined the department as a lecturer of philosophy at the Southwestern Associated University in 1938 and was soon afterwards appointed a professor. Although prior to 1945, Wang only published two articles which were in any way related to mathematical logic – one of them, entitled "Semantic Necessity" (*Yuyi de biran* 語意的必然, *1944*) touched superficially on the notion of logical necessity in *Principia* and Quine's *Mathematical Logic* (*1940*) – the reminiscences of the famous Harvard logician Wang Hao reveal his invaluable role in introducing most recent advances in contemporary mathematical or symbolic logic, such as Gödel's inconsistency theorems, into the basic curriculum at Qinghua department of philosophy (see Wang Hao 1997, 132). Maybe the most important outcome of Wang's pedagogical work at the wartime Qinghua

[25] Shen's lectures "Systems of Logic" and "Studies in Logic included "most recent theories about logical systems" and "most recent [results] in mathematical logic" (Guoli Qinghua daxue 1935, 274-275), including multi-valued logical calculi and Gödel, which at the time became an occurrent topic of Chinese books and articles on modern logic.

[26] The articles were entitled "Paradox of the Class of All Grounded Classes" (Shen 1953) and "Two Semantical Paradoxes" (Shen 1955). On Shen and his work further see Qian Gengsen 2001; Liu Peiyu 2009; Zhang Jialong 2008; Liu Xinwen 2019 etc.

University resided in his success of having influenced Wang Hao to take up a profound interest in the work of Kurt Gödel, to whom he devoted a considerable part of his career.[27]

Wang Hao's training in logic at wartime Qinghua University was probably one of the last and possibly most important legacies of its seminal advancement of the study of mathematical logic in China.[28] Nevertheless, after having completed his graduate studies in philosophy in 1945,[29] Wang continued his studies of mathematical logic at Harvard University and, after he was awarded a PhD degree in philosophy, continued working there as an assistant professor. In 1961, Wang was appointed a professor of mathematical logic and mathematics at the same university. In his extremely fruitful career, Wang became particularly known for mechanically proving all mathematical logic theorems of *Principia Mathematica* by means of a program written on the IBM 704 computer. Another one of his famous contributions was the invention of the eponymous Wang tiles or dominoes.[30] Apart from his contributions to mathematical logic, Wang also garnered immense international renown for his works on the philosophy of Kurt Gödel and Ludwig Wittgenstein.

2.1.5. Conclusion

The above analysis has highlighted the main milestones and features of establishment of mathematical logic at Qinghua University in the late Republican period (up to 1945). Firstly, the view at the curricular developments at the department of philosophy has shown that the formation of the so-called 'Qinghua School of Logic' was in fact a result of confluence of various influences as well as different notions of mathematical logic, advanced by a small number of key agents. Akin to the manner of its earlier introduction to China, through the

[27] In his book *A Logical Journey: From Gödel to Philosophy* recounts on his first contact with Gödel in the following way: 'In 1939, as a college freshman in China, I audited Professor Wang Sian-jun's course on symbolic logic and met Gödel's name for the first time, in connection with his completeness proof for predicate logic. In 1941, I came across a popular article in English in which Gödel's work was praised, and translated it into Chinese' (Wang Hao 1997, 132).

[28] In the 1930s, another important centre of research of mathematical logic and set theory became the National Wuhan University (*Guoli Wuhan daxue* 國立武漢大學). There, mathematical logic was studied both at the department of philosophy as well as the department of mathematics.

[29] At the undergraduate level Wang majored in mathematics. In 1943, he commenced his graduate studies at the research institute of Qinghua department of philosophy, which he completed two years later with a thesis on epistemology, entitled *Essays on the Foundation of Empirical Knowledge* (Wang Hao 2016, xiv).

[30] On Wang's contribution to computer science and mathematical logic see, for example, Dick 2014.

lectures and thought of Bertrand Russell, the beginnings of formation of mathematical logic as an academic discipline at Qinghua University were inextricably bound to the broader context of the establishment of Qinghua school of philosophy in contemporary Chinese academia. In this way, mathematical logic represented an integral, methodological component of the analytic school of philosophy, which took hold at Qinghua department of philosophy as its discerning feature. While the initial status apportioned to mathematical logic at the department, was a direct consequence of Jin Yuelin's interest in the philosophy of Bertrand Russell, the subsequent formation of a school of logicians was a result of later joint efforts at the department. At the earliest stage, the pivotal role in creation of an overall image of studies in mathematical logic at the department was played by Zhang Shenfu. Zhang's propagation of the notion of mathematical logic and his crucial contribution to curricular change at the department represented the key link between the general philosophical discourse and the parallel occurrence of a more technical line of studies in mathematical logic at the department. Moreover, Zhang's tireless popularisation of the notion facilitated the formation of a wider reputation of the department as the contemporary centre for studies of mathematical logic in China, which in turn only amplified the idea of relevance needed for integration of mathematical logic into the general system of education. It was thus Jin's and Zhang's joint effort which kickstarted the process that led to the concentration of various interests and efforts into an, so to say, sub-current of studies in modern mathematical logic at the department.

Secondly, at the beginning, the studies of mathematical logic at the department revolved exclusively around Russell's *Principia Mathematica*. This was not only the natural outcome of the fact that the discipline had been originally introduced to China by Russell himself, but was more so in line with the general trends in the field at the time. In a purely technical sense, at the earliest stage the main goal of teaching and research in mathematical logic at the department was to explain and introduce to Chinese philosophers and logicians the main concepts and theories from the *Principia*. This was partly accomplished by Jin Yuelin, who managed to integrate a considerable part of the first volume of *Principia* into his own lectures on logic. Jin's endeavours to pinpoint the main ideas of the deductive system of logic proposed by the *Principia* were later summarised in his ground-breaking textbook *Logic* (1935), thorough which his explanations of concrete contents of the *Principia* were launched into the domain of broader intellectual Chinese intellectual discourse.

Thirdly, the later outlook of studies in mathematical logic at the department was vitally influenced by its contact with Harvard University and thereby contemporary advances in symbolic logic in the US. Jin Yuelin's and Shen Youding's stay at Harvard accelerated the inclusion of contemporary critiques of *Principia* and novel theories about systems of logic into both lectures and studies of mathematical logic at the department. In fact, the debate at Harvard in early 1930s (Grattan-Guinness 2000, 529-535), and the views of Lewis and Quine, were amongst the few current developments in Western discourse on modern logic to have been introduced into the discourse at Qinghua department of philosophy. Furthermore, the Qinghua logicians' personal affinities for or affiliations with Harvard school of logic had also manifested in their own work, which aligned with the tendencies in American logical circles rather than with the ongoing developments in continental Europe.

Finally, the contributions to mathematical logic and foundations of mathematics by the contemporary European logicians was more extensively introduced to Qinghua by the members of later generations of logicians, most notably Wang Xianjun. The limited material at hand suggests that the first considerable introduction of the theories of Kurt Gödel was made by Wang, who studied under Gödel at the university of Vienna. At the same time, there are strong indications that, aside of approaches to foundations of mathematics such as theories of Kurt Gödel, logicism and later also intuitionism, Hilbert's formalism obtained almost no concrete attention in the studies and lectures of Qinghua logicians. As a matter of fact, the task of introducing Hilbert's work in logic and foundations of mathematics to China was assumed by Chinese mathematicians rather than philosophers.[31]

[31] Hilbert's and Ackermann's *Grundzüge der theoretischen Logik* (*1928*) was first introduced by the mathematician Zhu Yanjun (朱言鈞, originally called Zhu Gongjin 朱公謹, 1902-1961), who studied under Hilbert in Göttingen – in 1927 Zhu was awarded a PhD degree in mathematics at University of Göttingen. The introductory sections of the first edition of *Grundzüge der theoretischen Logik* were recapitulated in Zhu's articles "Essentials of Mathematical Logic" (*Shuli luoji gangyao* 數理邏輯綱要) and 'An Introduction to Mathematical Logic' (*Shuli luoji daolun* 數理邏輯導論), published in 1933 and 1936, respectively (see also Zhu 1929a, 1929b, 1932, 1937). Considerable advances in studies of formalist axiomatics were also conducted by the circle of mathematicians at National Wuhan University, who initiated the studies of mathematical logic and set theory in Chinese mathematical circles. This trend at the National Wuhan University was started by Tang Zaozhen (湯璪真, 1898-1951), another Chinese mathematician who had studied at University of Göttingen in the mid-1920s.

Until the resolution of the philosophical department in the early 1950s, the 'Qinghua School of Logic' had a pivotal role in the process of establishment and formation of mathematical logic as academic discipline (field) in Republican China. Set within the context of a more general philosophical discourse, the original founders of studies of mathematical logic at the department elevated Chinese studies in mathematical logic unto an entirely new plain. They set into motion the process of gradual Chinese acquisition of knowledge about the pillars of mathematical logic, most importantly Russell's and Whitehead's *Principia Mathematica*, fostering Chinese philosophers' interest in modern logic and philosophy of logic, and through their joint effort gave rise to the first platform for training of first generations of modern logicians in China.

However, the ideological winds of change, which swept the Chinese intellectual world from 1949 on (the founding of the PRC), also brought about the nation-wide decline of studies in mathematical logic conducted in the framework of philosophical departments such as the above-discussed "Qinghua School of Logic". The reason for that was that the new objectivism imposed upon the Chinese intellectual world, allowed only one kind of philosophy, namely dialectical materialism or, in the case of natural sciences, dialectics of nature. Emulating from the past ideological developments in the Soviet Union, mathematical logic was purged of all of its former connections to philosophical theories, which were now branded as idealisms (e.g. logicism, formalism, intuitionism; see Hu Huakai 2006, Vol. 1, 171; Hu Huakai & Gou Wenzeng 2005, 87-88). Concurrently with the ideological divorce of mathematical logic from philosophy and its gradual 'reassociation' with mathematics and technology, its former cradle at Qinghua University was also gradually dissolved.[32] With the 1952 "reordering of colleges and departments" (*yuanxi tiaozheng* 院系調整) – in the framework of which Qinghua University was remodelled into a Soviet-style polytechnic – a part of the former department of philosophy was moved to a new associated department of philosophy at Peking University (see also Hayhoe 1996, 73-87). Two years later, the majority of former Qinghua logicians, who were able to retain either their teaching or research positions in the field of philosophy, such as Jin Yuelin, Shen Youding and Wang Xianjun, were relocated to the preparatory Institute of Philosophy at the Chinese Academy of Sciences (IPCAS, officially established in 1955),[33]

[32] On the period of ideological change and reorganisation of the Qinghua University see Joel 2009, 42-45 etc.

[33] At its preparatory level, the IPCAS consisted of four main research groups: dialectical materialism, historical materialism, history of Chinese philosophy and logic (see "Chinese Academy of Sciences Prepares for

where their chief task was to engage in studies of dialectical materialism and criticise the "idealist" foundations of their past research, or compose new histories of logic and philosophy in China (e.g. Wang Dianji). At the same time, a new kind of discipline of mathematical logic was emerging between the walls of the Institute of Mathematics of the Chinese Academy of Sciences (IMCAS, established in 1952).

Establishment of the Institute of Philosophy," *Renmin ribao*, December 22 (1954), s.d.). Following its inauguration in September 1955, Jin Yuelin was appointed the deputy-director of the institute and the head of the research group for logic, whose main task was to organise the campaign criticising Russell (September 1956), study the relationship between dialectical and formal logic, and establish a new official historiography of logic in China (see *Liu Peiyu 1994*, 402-404).

2.2. From Philosophy to Mathematics: Beginnings of the Field of Mathematical Logic as a Branch of Mathematics in the 1930s China

In early 1930s, the concept of mathematical logic started gradually disassociating itself from the hermetic domain of philosophy and started to be gradually redefined as a part of mathematics. On the one hand, this process coincided with the recent developments of mathematical logic, through which mathematical logic had become increasingly "mathematized". But, on the other hand, this phenomenon was also closely related to the work of a new generation of Chinese mathematicians, whose interest in the subject had been first sparked by Russell's mathematical logic, and who spent their subsequent studies of the subject at prestigious European or American universities. To a certain extent, the rise of interest in mathematical logic at mathematical departments was concomitant with their return to Chinese universities. This new interest, however, cannot be regarded in a context entirely separated from the mathematical logic's general rise of importance and relevance in Chinese academia. It is quite probable that the impetus for the mathematisation of mathematical logic originated from its advancement in the field of philosophy. Moreover, it can be assumed with some certainty that the advances made in the sphere of philosophical studies were crucial for the development of the mathematical notion of the discipline, at least in respect to institutional or governmental support.

This process of "mathematization" of mathematical logic in early 1930s had its centre at the newly established National Wuhan University. Because it was an entirely new institution with a relatively modern outlook, Wuhan university proved to be a suitable environment for developing new scientific theories and disciplines. Another key factor was also the structure of its pedagogical cadre, who subscribed to more progressive rather than conservative theoretical currents.

Concurrently with the above-described developments at mathematical departments at universities like Wuhan University, the 1930s were also a time of an extensive rise in popularisation of mathematics, as well as historiographical excursions into the realms of Chinese traditional mathematics. Consequently, mathematical logic also emerged as an important element of the popularisation efforts conducted by Chinese mathematicians and scientists who specialised in other branches of natural sciences.

I shall first examine the development of mathematical logic at the National Wuhan University and take a closer look at the circle of Wuhan mathematicians who at the time engaged in studying certain aspects of mathematical logic.

2.2.1. National Wuhan University

National Wuhan University was officially established in 1928, following an official decree by the Nanjing-based nationalist government, by which the university was reorganised from a former association of smaller institutions of higher education from Hubei, previously called National Wuchang University (Guoli Wuchang daxue 國立武昌大學, established in 1926).

2.2.1.1. Elementary and Advanced Logic at the Department of Philosophy

First course in logic were already organised at the Institute of Humanities of the National Wuchang University. In the early 1930, a general course on logic, both as a part of the general first-year curriculum and as a specialised elective course in the framework of the study of philosophy, was also organised at Wuhan University. From 1930 on, the course on logic (*Lunlixue* 論理學) was taught by Tu Xiaoshi (屠孝實, courtesy name Zhengshu 正叔, 1898-1932) a graduate of Waseda University in Tokyo and a former professor of philosophy at Peking University (Guoli Wuhan daxue 1931, 73, 82). Tu was also the author of the highly influential textbook *Logic Primer* from 1926, which also encompassed a short introduction to formal logic (mainly Boole and De Morgan) based on Jevons' *Elementary Lessons on Logic*.

In 1932, Tu was replaced by Wan Zhuoheng (萬卓恆, 1902-1948), a graduate of philosophy from Qinghua and Harvard Universities. Prior to his tenure at Wuhan University, Wan taught philosophy at Dongbei University. During his professorship at Wuhan, between 1931 and 1948, Wan was generally known as a lecturer of logic, who specialised on mathematical logic.[34] Wan's reputation as a professor of philosophy who understood mathematical logic and lectured about *Principia Mathematica* extended beyond the circle of professors and students at the university. Even though Wan did not produce any writings related to mathematical logic or even logic, he is mentioned in many contemporary Chinese histories

[34] Beside He Lin's mention of Wan as one of the leading contemporary Chinese philosophers who specialised in mathematical logic, there are also accounts and reminiscences of his former students, most notably the philosopher Xiao Shafu. See Li Mianyuan 2016; Li Weiwu 2009; Xiangren 2017.

of modern logic in China as one of those republican philosophers, who were engaged in teaching and spread of mathematical logic.[35]

Beside Logic (*lunlixue*), Wan also taught other courses related to contemporary Western philosophy and epistemology. The official overview of courses and programs at the National Wuhan University from 1932 reveals that already the first course on logic organised by Wan had already assumed a modern outlook. The content of Wan's lectures from 1932 covered the following topics: various problems in formal logic, forms of deduction and contemporary logic (Guoli Wuhan daxue 1932, 23). In the following years, apart from an elementary course Wan also organised an advanced course on logic (called "Logic 2", *Lunlixue er* 論理學二), which was offered as an elective course for students of philosophy. In 1934, the elementary course was devoted exclusively to an overview of Aristotelian logic and aimed at presenting a general outline of the principles of human thought and the idea of correct thinking. The advanced course, on the other hand, consisted of three main parts: Aristotelian logic, symbolic logic (mathematical logic) and theory of induction (Guoli Wuhan daxue 1934, 26-7, 33). According to reminiscences of Wan's former student Xiao Shafu 萧箑父, the part of lectures related to symbolic logic revolved exclusively around the *Principia Mathematica*, covering the parts about the basic principles and logical calculi (Xiangren 2017, 26). The content of the elementary course changed again in 1936, when the course was reorganised to include (I) formal logic and (II) scientific method, while the content of the advanced course remained unchanged (Guoli Wuhan daxue 1936, 33, 40). In this year, two elementary textbooks were prescribed: beside the by then already standardised textbook *Essentials of Logic* by Wolf, there was also the textbook *Logic* (*Lunlixue* 論理學), written by Fan Shoukang, another professor of philosophy at Wuhan.[36]

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[35] E.g. Shi & Zeng 1998, 29-33.

[36] The textbook was published as a part of *Kaiming Pedagogical Textbooks* (*Kaiming shifan jiaoben* 開明師範教本). The textbook was designed in accordance with a psychological approach to logic (logical psychologism), which favoured the so-called pragmatist logic. As a matter of fact, even though, in his historical introduction, Fan did mention mathematical logic or symbolic logic of Boole as one of the mainstream currents in contemporary logic, it was only a brief mention, ignoring all its main contributors who succeeded Boole. Moreover, he treated mathematical logic as a less important branch of the formalist school in philosophical logic, and rather devoted more attention to idealist conceptions of logic. Fan also regarded the pragmatist logic of Dewey as one of the most important logical schools of the time, which contended against logic formalism, as manifested in mathematical or

2.2.1.2. Mathematical Logic and the Wuhan Circle of Mathematicians

As I have already indicated, before the 1930s, mathematical logic was still a discipline dominated by philosophers-logicians, which meant that its general notion was still defined in predominantly philosophical terms. This started to change in the early 1930s, when a few young mathematicians who returned from their studies in Europe decided to engage in research of foundations of mathematics and mathematical logic. One of these young scholars, who contributed to this process was the mathematician Tang Zaozhen (湯璪真, Tang Tsao-Chen, 1898-1951). Before Tang assumed the role of a professor in Wuhan, Tang studied mathematical logic at Universities of Berlin and Göttingen. After he joined the Wuhan circle of mathematicians, he became the main driving force behind the mathematical research of mathematical logic.

The importance of Tang Zaozhen and the circle younger mathematicians at Wuhan University has already been noticed by Xu Yibao (2005), who briefly mentioned Tang in his doctoral dissertation *Concepts of Infinity in Chinese Mathematics.37* As pointed out by Xu,

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symbolic logic. (Ibid.: pp. 1-26) One of the immediate consequences of his view on logic lead Fan to exclude the most important contemporary contributions to theory of deduction from the textbook. Instead, Fan's outline of the science of reasoning derived its broadness from inclusion of a great number of metaphysical and phenomenological meditations on logic. Thus, for example, beside deductive and inductive reasoning, he also discussed the notion of analogical reasoning (*leibi tuilun* 類比推論) etc. The textbook also maintained a notion of Chinese logic, as reflected in traditional Chinese philosophy.

[37] Xu wrote: "After graduating from Department of Mathematics of Beijing Teachers College in 1919, TANG taught mathematics at Beijing Teachers College for Girls. In late of 1923, he went to Germany to pursuit his further study in mathematics. During the next two and a half years, Tang studied primarily differential geometry and mathematical logic at University of Berlin and University of Göttingen. When he returned in 1926, he was appointed as Professor of mathematics at National Wuchang University (the predecessor of Wuhan University). At the University, he used Wilhelm J. E. Blaschke's textbook for teaching his course on differential geometry. Mathematical logic was not on the curriculum of the University, but TANG did not lose his interest in it. Although his focus was on Clarence Irving Lewis's calculus of strict implication, and was not directly related to aspects of the infinite, it does show how quickly Chinese mathematicians began to respond to this new area for their own research. TANG published three articles on the subject in the *Bulletin of the American Mathematical Society.* In the first of these, "The Theorem $p - 3q = pq = p$ and Huntington's Relation Between Lewis's Strict Implication and Boolean Algebra," he shows that the theorem "$p - 3q = pq = p$" holds true in Lewis's system, and that it strengthens a previous result of Edward Huntington. Based on this result, TANG went on to show that where any implication "$p - 3q$" is asserted, then "$p - 3q = i$," from which it follows that any two asserted implications are

Tang's main contribution to mathematical logic consisted in his treatment of Huntington's discussion of Lewis's theory of strict implication and the theorem "$p \prec q .=. pq = p$".[38] Although Xu's account of Tang's main contributions to mathematical logic is close to complete, some additional points related to Tang's career must still be added.

Firstly, we need to point out that Wilhelm Blaschke's differential geometry was one of the subjects of Tang's research in Germany. Apart from mathematical logic, in the early 1930s, Tang also focused on other branches of mathematics, as for example, Levi-Civita's absolute differential calculus, which he also translated into Chinese (Cheng Minde 1994 I, 60-71). Tang's translations also included Hans Hahn's "Set-Theoretical Geometry", which was first published in 1930 in the *Quarterly Journal of Science of the National Wuhan University* (Guoli Wuhan daxue like jikan 國立武漢大學理科季刊). Secondly, according to his biography composed by his son Tang Xiangsen (湯湘森), Tang researched mathematical logic throughout the entire wartime period. If this is true, similar could also apply to the research activities of the group of mathematicians working closely with Tang (ibid., 68). Unfortunately, no textual evidence is preserved to confirm these claims and assumptions. Finally, Tang was also one of the founding members of Chinese Mathematical Society. From its first official inauguration in 1935, Tang assumed a series of important positions in the society – e.g. he was one of its 21 council members elected in 1935 and a member of the society's executive council in 1936 (Ren & Zhang 1994, 30, 52). At the second annual meeting of the society, which took place at Qinghua Science Museum in 1936, Tang also read his two articles on strict implication, published in the same year in the *Bulletin of American Mathematical Society*. Thus, together with Zhu Gongjin – about whom we shall say more in the next section – Tang was one of two important members of the society, who maintained an interest in contemporary mathematical logic and contributed to its advancement in Chinese mathematical circles. Interestingly, both Zhu and Tang had studied mathematics at Göttingen University in Germany, while only the latter contributed scientifically to the field. Furthermore, in the 1930s, both participated in

strictly equivalent, and, in particular, that any two of Lewis's first eight postulates can be deduced from each other. TANG also studied algebraic postulates for Boolean rings." (Xu 2005, 189-9)

[38] Tang's articles were published in 1936. Apparently, only two articles were published in the *Bulletin of American Mathematical Society (BAMS)*: "The Theorem '$p \prec q.=.pq=p$' and Huntington's Relation Between Lewis's Strict Implication and Boolean Algebra". In: *BAMS*, Vol. 42, No. 10 (1936): pp. 743-746; "A Paradox of Lewis's Strict Implication". Ibid.: pp. 707-709. The so-called "fishhook" symbol, $\prec$ was used by Lewis to denote the relation of strict implication.

activities related to science education. Tang was also invited to partake in the 1933 consultative symposium on astronomy, mathematics and physics organised by the Ministry of Education.

Another Wuhan mathematician, who (probably under the influence of Tang Zaozhen) engaged in research of topics related to mathematical logic, was Xiao Wencan (蕭文燦, 1898-1963), an assistant professor of mathematics at Wuhan.[39] Xiao started his path in higher education at the Guizhou Province Normal College in Guiyang (graduated in 1916). In 1921, he enrolled into Wuchang Higher Normal College (predecessor of Wuhan University), majoring in mathematics. Upon graduation in 1925 he joined the university as a lecturer in mathematics. Concurrently, he also worked as a lecturer of mathematics at the China University. Later, in 1937, he went on a scholarly exchange to Germany, where he studied consecutively at universities of Berlin and Leipzig. Xiao returned to China in 1940, after he was awarded a doctoral degree in mathematics from university of Leipzig. Working under Tang Zaozhen, back in the early 1930s, Xiao Wencan also devoted a part of his work to problems related to mathematical logic, more precisely to Cantor's transfinite set theory.[40] Between 1933 and 1934, Xiao published a series of articles entitled "Set Theory" (Jihelun 集合論) in the university's *Quarterly Journal of Science*, in which he delivered a systematic introduction to Cantorian set theory. The collection of Xiao's four articles on set theory was reprinted in the form of a monograph (*Jihelun chubu* 集合論初步 [*Elementary Set Theory*]) in 1939. In the same journal Xiao also published a Chinese translation of Hardy's work "Orders of Infinity" (Wuqiongda zhi jie 無窮大之階).[41]

In his dissertation, Xu Yibao commented on Xiao Wencan's and Zhu Gongjin's contributions to propagation and spread of mathematical logic in the following way:

> Xiao's and Zhu's articles, together with Chinese translations of Russell's work, kindled further interests in mathematical logic in China. As a result, in the 1930s a number of Chinese students of mathematical logic were able to carry out their own research. By

[39] For a condensed biographical account on Xiao Wencan, see Li & Xiao 2005.

[40] Xu Yibao and his doctoral supervisor Joseph Dauben claim that Xiao was the first Chinese mathematician to have provided a systematic overview of Cantor's set theory. (Xu Yibao 2005: 200; Dauben 2002, 267)

[41] Xu (2005: 200) mistakenly believed that Xiao's two articles were authored by Xiao himself. In truth, they were a translation of above-named work of the British mathematician Hardy. In addition to that, Xu also noted that the notion of infinity was of great interest to Chinese mathematicians of the time. (See Hardy 1932 & 1933)

> the time TANG Zaoshen's third article was published in America, another Chinese student had written his dissertation on mathematical philosophy and the theory of sets at the University of Paris. This was ZENG Dinghe 曾鼎鉌, also known as TSENG Ting-Ho.[42] The major parts of ZENG's thesis dealt with set theory and transfinite numbers. In retrospect, one may regard ZENG's thesis as superficial and sketchy.[43] It nevertheless represents the beginning of serious and important work that Chinese logicians would soon make to mathematical logic. (Xu Yibao 2005, 200-1)

Despite that in the light of the following discussion Xu's assertions appear some partial, he might have made a good point regarding mathematical logic as a subject studied by Chinese mathematicians. Furthermore, the contributions by Xiao and Zhu, which must be regarded as introductory works or attempts at popularisation of mathematical logic and set theory as one of its constitutive branches, could indeed have been pivotal for kindling the Chinese mathematician's interest for the above-named fields of studies, especially because they both purported to convey their mathematical content rather than philosophy-related categories.

2.2.2. Zhu Gongjin – A Populariser of Foundations of Mathematics in 1930s China

Another important Chinese mathematician, who to some extent contributed to introduction and propagation of mathematical logic as a branch of mathematics in China, was the well-known educator and populariser of mathematics, Zhu Gongjin (朱公謹, also known as Zhu Yanjun 朱

[42] His name was also written 曾鼎龢 (Zeng Dinghe). In 1938 Zeng was awarded a PhD degree for a doctoral dissertation entitled *La philosophie mathématique et la théorie des ensembles* (*Mathematical Philosophy and Set Theory*).

[43] This were the exact words of Frederic B. Fitch, who reviewed Zeng's doctorate in 1943 (*The Journal of Symbolic Logic*, 8(2) (June 1943), 56-57). Fitch said: "This is a philosophical and historical survey of various topics in modern mathematics, such as set theory, probability, transfinite numbers, and mathematical logic. The treatment is somewhat sketchy and often superficial. In discussing mathematical logic no mention is made of Gödel, although literature as later as 1936 is referred to." (Fitch 1943, 56) Zeng's doctorate was listed in bibliography of Bernays's and Fraenkel's (the latter wrote only the introductory parts and provided some bibliographical data) 1958 book *Axiomatic Set Theory*. Consequently, in his letter to Bernays from March 14th 1958, Gödel inquired about the content of Zeng's work: "Ich habe bemerkt, dass Sie in Ihrem neuen Buch über Mengenlehre einen gewissen Tseng[g] Ting-Ho zitieren. Ist diese Arbeit interessant?" [I noticed that in your new book on set theory you cite a certain Tsen[g] Ting-Ho. Is that paper interesting?] (Gödel 2014, 152).

言鈞, 1902-1961). Akin to many other Chinese scholars who decided to study at the most prestigious Western institutes of higher learning, Zhu started his path at Qinghua College, where he completed the basic preparatory course. Subsequently, in 1921, he was awarded a scholarship for studying at the renowned Göttingen University in Germany. In his studies at Göttingen, Zhu eventually specialised in applied mathematics and was in 1927 awarded a doctoral degree in mathematics for his thesis in theory of differential equations, entitled "On Existence Proofs of Certain Types of Single-Variable Functional Equations". After he returned to China in 1927, he worked as a professor of mathematics at Guanghua University, Central University, Shanghai Medical School, Normal Faculty of Zhejiang University, Datong University and Shanghai Jiaotong University. With the establishment of Chinese Mathematical Society in 1935, Zhu became one of its permanent council members and one of the most productive contributors to its periodical publications the *Shuxue tongbao* 數學通報 (*Bulletin of Mathematics* or *Bulletin des Sciences Mathematics*) and the *Shuxue zazhi* 數學雜志 (*Mathematical Review*). (Zhang Youyu 1991, 2)

Image 20: Zhu Gongjin as a professor of mathematics, head of the Department of Mathematics and vice-dean of Guanghua University in 1936.

Although Zhu spent almost seven years at the University of Göttingen in Germany, which at the time was one of the centres for studies mathematics and physics and obtained a PhD in mathematics studying under two of the most famous and well-established mathematicians of the time, David Hilbert and Richard Courant, upon his return to China he ended up working at relatively marginal universities, such as Guanghua University and Jiaotong in Shanghai, as well as more prominent universities such the Central University in Nanjing. Although his direct influence on the theoretical development of mathematics in China seems to be (at least in terms of documentation) somewhat obscured by the marginality of the institutes of his employment, in the late 1920s and 1930s, in Chinese intellectual sphere his voice was loud and clear. Zhu was probably the most prolific populariser of general and specific aspects of mathematics in the early 1930s China. His numerous articles introducing different aspects and problems of advanced mathematics (especially analysis), philosophy of mathematics and finally also his translations of writings by important mathematicians like Dedekind or Hilbert were not only published in university-affiliated publications or scientific journals like the

Shuxue zazhi 數學雜志, but also in popular periodicals, which established his role as a populariser of applied mathematics in China.

Among Zhu's articles introducing various topics, theories or branches of mathematics, there were also some articles, which explicitly or implicitly involved the principles of contemporary mathematical logic. One of the most influential such articles were "An Introduction to Mathematical Logic" (*Shuli luoji daolun* 數理邏輯導論) from 1936 and "Essentials of Mathematical Logic" (*Shuli luoji gangyao* 數理邏輯綱要) published in two parts in 1933 and 1934. Although the articles only expounded on a rather elementary notion of mathematical logic, their significance lay in another respect: because Zhu was introduced to mathematical logic as a mathematician, he regarded its content to be primarily a part of mathematics. Because Zhu treated mathematical logic in this manner, it naturally followed that the research of mathematical logic ought to be reserved exclusively for mathematicians. As such, introductions to mathematical logic or set theory done by mathematicians were of different value to those done by philosophers, for they each derived from different theoretical or practical contexts and ultimately also influenced separate academic spheres of discourse.

2.2.2.1. Zhu's Representative Writings, 1928-1937

Zhu's earliest publications on philosophy of mathematics were a series of articles written in response to contemporary misinterpretations of the nature of mathematics, proposed by Chinese adherents of pragmatism who propagated Dewey's experimentalist theory of logic and science. In 1928, in an article entitled "A Refutation of Experimentalism" (*Bo shiyan zhuyi* 駁實驗主義) Zhu emphasized that mathematical knowledge is *a priori* and as such a formal expression of the unchanging principles of the universe. What Zhu argued against was the experimentalist position that the universe is subjected to constant change and that the main task of science is to constantly realign itself with the current state of the universe. In order to corroborate his position, Zhu used the example of ontologically positive concept of logical laws, which are manifested in axiomatic systems of mathematics. As examples thereof he listed three axiomatic (*jiben yuanli* 基本原理) systems of geometry as developed by Euclid, Riemann, and Lobachevski. Having expounded on the concepts of consistency and non-contradiction as concrete examples of application of logical laws in mathematics, he explained the difference between different kinds of judgments as defined by Kant, shedding some light on the epistemic value and sufficient conditions of the truth of mathematical axioms. In short, Zhu's principal aim was to portray the objectiveness of logic, as the main condition of mathematical truth, through a system of laws reflecting the *a priori* structure of reality. This namely implies that mathematical judgements and inferences are beyond experimental inquiry and that mathematical judgments were *a priori* synthetic judgments. In a sequel to the article, Zhu directed his criticism against the philosophical viewpoints of Hu Shi and Dewey.[44]

In the same period, Zhu also started introducing Hilbert's work in foundations of mathematics. For example, in an article published in 1929 Zhu discussed the differences between Brouwer's intuitionist "theory of sets" (*tuanlun* 團論) and Hilbert's formalist idea of contradiction (*ziweiyu* 自違語) in the same theory. Interestingly, Zhu discussed both schools as offshoots of two currents in mathematics, analogous to those in modern cosmologies which derive from advances in modern physics (see Zhu Yanjun 1929b). In another article from 1932, Zhu gave a lengthier exposition on Hilbert's life and his theory of axiomatics (*yuanlishuo* 原理說), axiomatisation of arithmetic, as well as other aspects of Hilbert's views on questions related to fundaments of mathematics, some of which were also intrinsically linked to mathematical logic (see Zhu Yanjun 1932, 2-8). Finally, in 1935 Zhu published an updated version of his evaluation of intuitionism and formalism. In sequel to his first such mediation from 1929, Zhu focused both on set theory and theories of inference in mathematics, covering three main topics: Poincare's view on mathematical inference and set theoretical questions, the rise of intuitionism and Russell's mathematical logic. The main topic of Zhu's second survey were still Hilbert's views on axiomatisation of mathematics. The content of Zhu's writings on foundations of mathematics from this period still reveals that his views on the subject remained within the constraints of Hilbertian theory, which he came into contact with during his studies in Germany. He did not discuss, for instance, the developments in the Polish school of logic or, most importantly, Gödel's results related to the above-mentioned problems and topics. Even in his "Critiques of Mathematical Axiomatics" (*Shuxue yuanlixue zhi piping* 數學原理學之批評) from 1937, the primary purport of which was to outline criticisms raised against Hilbert's

[44] Similar was intended also in Zhu's other writings from the late 1920s, such as, for example, "New Geometry and Philosophy" (Xin jihexue yu zhexue 新幾何學與哲學), "From Theory of Knowledge to Critical Theory" (Cong renshilun dao pipinglun 從認識論到批評論), "On the Relationship Between Metaphysics and Natural Science" (Xuanxue yi ziran kexue de guanxi 玄學與自然科學的關係) and "Socrates and Leonard Nelson" (Sugeladi yu Na'ersong 蘇格臘底與納爾松) which were all published in 1929.

project of axiomatisation of mathematics, Zhu made no mention of these important contemporary contributions.

In the early 1930s, Zhu edited a series of short discussions on practical or purely theoretical curiosities of mathematics, which was regularly published in the *Guanghua daxue banyuekan* 光華大學半月刊 (*Guanghua University Fortnightly*). These discussions were subsumed under a common title "Shuli congtan 數理叢談" (Mathematical Discussions) and by the year 1934 the total count of individual discussions already reached twenty.[45] Furthermore, in 1936, Zhu published yet another series of writings introducing the advances in foundations of mathematics and mathematical logic in the above-mentioned periodical. The series bore the tile "Casual Conversations on Set Theory" (*Jilun xiaotan* 集論小談) and was written in form of a dialogue between Zhu and a colleague of his, who was also a professor of mathematics. Through dialogues Zhu touched upon various questions related to the recent advances in fundaments of mathematics. Probably, the most important feature of these conversations was that it was written from the mathematical perspective – it treated set-theoretical problems and mathematical logic as an integral part of mathematics, which, as also pointed out by Zhu himself, had been often entirely neglected (ibid.). Even though the title of the conversations implies a sense of casualness and elementariness, the dialogues also touched upon more advanced topics in set theory, mathematical logic and even number theory, all of which were bound together in meta-mathematics of Hilbert. The conversations were published in ten parts between 1936 and 1937.

In 1936, Zhu also published a series of other propaedeutic articles on topics related to foundations of mathematics and mathematical logic. Such were, for example, the series of articles entitled "Methods of Inference in Mathematics" (*Shuxue zhong zhi tuili fangfa* 數學中之推理方法). Other relevant articles from the same period were "The Origins of Mathematical Knowledge" (*Shuxue renshi zhi benyuan* 數學認識之本源), "Topological Geometry and Our Views on Space" (*Dingxing jihexue yu wuren zhi kongjian guan* 定性幾何學與吾人之空間觀) and so on. The common thread interconnecting the majority of his writings from 1930s was again Hilbert's theory of foundations of mathematics (axiomatics, geometry, arithmetic, set theory). Whenever Zhu required assistance of more philosophical views on mathematical principles, he resorted to philosophy of Leonard Nelson, one of his former professors at

[45] Eight of these chapters were also published in form of a book in 1947.

university in Göttingen and a close friend of Hilbert's. In 1928, one year after he had returned to China, Zhu even published a short booklet commemorating Nelson's life and work.[46]

In 1930s, Zhu also translated a few short writings by important Western mathematicians, like Felix Klein and Dedekind. Such were: "Speaking About Elementary Mathematics from the Pont of View of Advanced Mathematics" (*Cong gaodeng shuxue de guandian tantan chudeng shuxue* 從高等數學的觀點談談初等數學) from Felix Klein's *Elementarmathematik vom höheren Standpunkte aus* (1908), "Absolute and Relative Invariants" (*Juedui liang yu xiangdui liang* 絕對量與相對量) (1936), Klein's "Essence of Algebra" (*Daishu jingyun* 代數精蘊), published in the *Shuxue zazhi* in 1937, and Dedekind's *Was sind und was sollen die Zahlen?* [What are Numbers, and What is Their Meaning?] (1888)[47] and *Stetigkeit und irrationale Zahlen* [Continuity and Irrational Numbers] (1872).[48] In 1949, Zhu's translation of his mentor Richard Courant's work *Vorlesungen über Differential- und Integralrechnung* [Differential and Integral Calculus] was published with the Zhonghua shuju publishing house.[49]

2.2.2.2. Introduction of Mathematical Logic of Hilbert and Ackermann, 1933-1936

In 1930s, Zhu published two lengthier articles introducing the essential concepts of mathematical logic. The first article, entitled "Essentials of Mathematical Logic" (*Shuli luoji gangyao* 數理邏輯綱要), was published in 1933 in the *Zhexue pinglun*. Here, Zhu's approach to mathematical logic was similar to his other publications. Zhu described mathematical logic as a version of formal logic which assimilated the most advanced knowledge from mathematics. Moreover, Zhu mainly ascribed its advantages to mathematics; in particular, its use of symbols and formulae, which endowed logic with a capacity to attain completeness, consistency, and a greater analytical capacity.

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[46] Nelson passed away in 1927. The above-mentioned booklet bore the title *Nelson – A Philosopher of Critical Rationalism (His Life and Teaching)*.

[47] Zhu produced a distilled translation of Dedekind's text and entitled the text "The Meaning of Numbers" (*Shu zhi yiyi* 數之意義). The translations were published in *Shuxue zazhi* in the year 1937.

[48] Title translated as "Lianxuxing yu wulishu 連續性與無理數".

[49] The 1949 translation was only the translation of the first volume. The publication of Zhu's translation of the second volume of Courant's book followed in 1952.

Even though his short overview of history of mathematical logic mentioned all important contributors to the field, from Leibniz to Russell, Zhu's focus remained with Hilbert, who, according to Zhu, was able to install the most advanced principles of mathematics into his logic. Even though Zhu did not explicitly indicate that fact, the content of the article derived heavily from Hilbert's and Ackermann's *Grundzüge der theoretischen Logik* (1928).[50] As a matter of fact, some parts of Zhu's "Essentials of Mathematical Logic" correspond entirely to individual sections of the 1928 edition of Hilbert's and Ackermann's *Grundzüge der theoretischen Logik*. Thus, Zhu's introduction to mathematical logic was, in fact, an introduction to the early Hilbert-Ackermann system of mathematical logic.

Zhu's article from 1933 covered the following aspects of Hilbert-Ackermann system of logic:

(1) Propositional logic (*lunduan luoji* 論斷邏輯)[51]

Which included:

(a) the definition of proposition,

(b) methods of elementary connectives (*jiben jiehe* 基本結合之法),[52]

(c) equivalence (*dengshi* 等式),

(d) a further discussion on the elementary connective methods (including Sheffer's stroke, Russell etc.),

(e) elementary forms [of logical expressions] (*jiben xingshi* 基本形式),[53]

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50 The first (1928) and the second (1938) edition of the book considerably differ from each other. The first book builds upon Hilbert's formalistic first-order logic and still included the *Entsheidungsproblem* and the question of completeness of logic as a system, which were ultimately left out from the later edition. The second edition was also translated into English and given the title *Principles of Mathematical Logic* (1950).

51 Here the term *lunduan* 論斷, otherwise meaning 'inference' or 'judgment', stands for 'proposition' or German *Aussage*, as in Hilbert's *Aussagenkalkül*.

52 Zhu's term *jiehe* 結合 is semantically motivated after the original German term *Verknüpfung* as in "logische Grundverknüpfungen" as used in Hilbert's and Ackermann's mathematical logic.

53 The original title of the section was: "Normalform für die logischen Ausdrücke" (i.e. Section 1, Chapter 3 of 1928 edition).

(f) tautological (always true) connections of propositions (*yongzhen zhi jiehe* 永真之結合),[54]

(g) the theorem of reciprocity (互易性之定理),[55]

(h) the ever-false connections of propositions (*yongmiu zhi jiehe* 永謬之結合)[56]

(i) special elementary propositions (*teshu zhi jiben xingshi* 特殊之基本形式)[57]

(j) a further discussion on the question of conjunction (always true) and disjunction (always false)

(k) the problem of how to draw conclusions (*ruhe xia duan'an zhi wenti* 如何下斷案之問題)

As indicated above, the structure and content of Zhu's presentation of the essential features of mathematical logic corresponds to that of Hilbert's and Ackermann's book from 1928. As Zhu himself also noted in the 1933 version of the article, his source were also his notes from Hilbert's lectures, taken when he was still a student at Göttingen. Maybe the only parts of the text which Zhu decided to modify were the examples of propositions, which Zhu adapted to fit the Chinese socio-political context.

The same article was reprinted in the year 1934 in the *Quarterly Journal of Science of the National Wuhan University* (*Guoli Wuhan daxue like jikan* 國立武漢大學理科季刊), which also happened to be one of the central means through which the group of mathematicians at Wuhan University promulgated their research, which in 1934 also encompassed set theory and foundational, mathematical, and mathematico-logical theories of David Hilbert.[58]

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[54] Originally: "Charakterisierung der immer richtigen Aussagenverbindungen."

[55] The original title of the section was: "Das Prinzip der Dualität" [The Principle of Duality].

[56] Originally: "Die disjunktive Normalform für logische Ausdrücke."

[57] This section appears to summarise the chapter 7 of the first section in the original book: "Mannigfaltigkeit de Aussagenverbindungen, die aus gegebene Grundaussagen gebildet werden können."

[58] Vol. 4 and 5 of the above-mentioned journal saw the publications of a Chinese translation of Hilbert's *The Theory of Algebraic Number Fields* by Hua Luogeng, a series of articles on "Set Theory" (集合論) by Xiao Wencan etc.

Two years later, in 1936, Zhu published another article on mathematical logic, "An Introduction to Mathematical Logic" (*Shuli luoji daolun* 數理邏輯導論), which represented a continuation of the article from 1933, where Zhu introduced the content of the remaining few chapters of the book by Hilbert and Ackermann. In this new article, however, Zhu's attitude towards logic slightly changed, at least in his manner of expression. This time, he compared mathematical logic to the method of "exhausting the principles" or "*qiongli* 窮理", a Neo-Confucian term which used to be linked to the Western concept of science. Zhu claimed that through logic one can extend already known laws to individual physical entities and distil the most fundamental principles of nature from known facts. In this context, mathematical logic represented the most advanced such method. He also remarked that mathematical logic takes the most elementary laws of science and translates them into relations between subjects and predicates, and between propositions.

The 1936 sequel introduced two new chapters from Hilbert's and Ackermann's book. It was divided into two main chapters: "The Axioms of Propositional Logic" (*Lunduan luoji zhi yuanli* 論斷邏輯之原理) and "Main Ideas of Predicate Logic" (*Weici luoji zhong zhi zhuyao sixiang* 謂詞邏輯中之主要思想). In the first chapter Zhu summarised the content of chapters 10 and 11 of the first part of Hilbert's and Ackermann's *Grundlagen*.[59] At the same time, Zhu seems to have slightly departed from their original train of thought, for in his description the axioms from the *Principia Mathematica* are given the role. He even added his own thoughts about the relationship between axioms of other branches of science and mathematical logic, where he maintained that mathematical logic represented a meta-scientific view on the axiomatic system, for it takes logical method as its main subject of enquiry. By being a meta-systemic science, it would thus be exempt from the rest of sciences, which must adhere strictly to the principles of logical method and depend upon the consistency of their axiomatic fundaments (Zhu Yanjun 1936b, 85). The second part of Zhu's article summarised the introductory parts of the second section of Hilbert's and Ackermann's *Grundlagen* (1928).[60]

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[59] "Die Axiome des Aussagenkalküls" and "Beispiele für die Ableitung von Formeln aus den Axiomen."

[60] As, for example: "Methodische Grundgedanken des Funktionenkalküls" etc.

2.2.3. Gao Xingjian – "ABC of Mathematical Logic"

In the 1930s, Gao Xingjian (高行健), a graduate in chemistry from the Central University (Zhongyang daxue 中央大學), a member of the National Institute for Compilation and Translation (Guoli bianyi guan 國立編譯館),[61] and a professor of mathematics at Guiyang Medical University (–1948), was another mathematician who greatly contributed to popularisation of modern mathematics in China. As a prolific contributor to the journal *World of Science* (*Kexue shijie* 科學世界) he composed a series of articles on different topics from mathematics, from mathematical games (*youxi shuxue* 游戲數學), interesting mathematical problems (*shuxue wenti* 數學問題), new records of most recent developments in mathematics (*jinnian shuxue zhi xin jilu* 近年數學之新紀錄), down to more specific topics from most fashionable branches of mathematics, such as mathematical logic. Gao also contributed a few articles to the famous *Kexue* journal, as for example a short article on Goldbach conjecture and some other shorter articles on number theory.

For the present discussion, the most relevant of Gao's article from 1930s was his "ABC of Mathematical Logic" (數理邏輯 ABC) from 1936. The article aims to introduce the main concepts from mathematical logic to a more general readership. Most importantly, it attempts to do so by threating mathematical logic as a branch of mathematics. Gao was well-aware of previous introductions to Hilbert's and Ackermann's mathematical logic made by Zhu Yanjun. The main source of Gao's guide to the principles of mathematical logic was probably J. S. Turner's *Mathematical Logic* from 1928. A further interesting feature of the above-mentioned article was Gao's notion of mathematical logic; he, namely, called logic the science of sciences, and science as such as an example of materialised logic. And a rather natural corollary to that position was that mathematical logic was the most advanced and modernised example of this method. As most important contemporary mathematical logicians Gao listed Russell and Hilbert, and enumerated the numerous synonyms for mathematical logic, which were in use at the time, such as "mathematical logic" (*shuxue luoji* 數學邏輯), the archaism "logistic" (*shuli luoji* 數理邏輯), as well as "symbolic logic" (*fuhao luoji* 符號邏輯), "theoretical logic" (*lilun luoji* 理論邏輯) and "algebra of logic" (*luoji daishu* 邏輯代數). Otherwise, Gao's article was

[61] Zhu was as a member of the group tasked with standardisation and compilation of a list of terminology in the field of chemical engineering – *Huaxue gongcheng mingci* 化學工程名詞 (1946). (Guoli bianyiguan 1937, 146)

extremely concise and simple. The first part[62] covered three main aspects: (I) Elementary Symbols, (II) Elementary Equations and (III) Proofs of Elementary Equations.

2.2.4. Conclusion

The above analysis reveals that, in the 1930s, mathematical logic assumed a "twofold character" in Chinese academia. Thus, juxtaposed against the, so to say, philosophical school of mathematical logic at Qinghua University, in Chinese mathematical circles arose a new current of research in mathematical logic, which gained its first unofficial centre at the National Wuhan University. Chinese mathematicians' rediscovery of mathematical logic filled a one-decade long gap, which followed their earliest engagement with the discipline or its branches (e.g. set theory) in the late 1910s and early 1920s. If, one decade earlier, Chinese mathematicians' interest in mathematical logic was kindled mainly by the work of Bertrand Russell on one side and Cantorian set theory on the other, the new chapter in their investigation of the field was initiated by an influx of Hilbertian philosophy of mathematics and logic through mathematicians who studied mathematics or mathematical logic at German Universities. In that way, while the Qinghua school acted as a platform for dissemination of mathematical logic related to Russell's *Principia Mathematica*, the discourse on symbolic logic of the Harvard school of logic and, later, also Gödel's contributions to logic, in the 1930s the mathematical current was primarily disseminating the so-called "Hilbertian" school of logic.

The propagation of the mathematical notion of mathematical logic in the 1930s consisted of two main directions: academic research and popularisation/propaedeutics. The first direction took shape at Wuhan University and was initiated by Tang Zaozhen, whose research was focused on topics from contemporary European and American mathematical logic and set theory. On the other hand, the work of Zhang's assistant Xiao Wencan represented an important new step towards introducing Cantorian set theory to Chinese mathematicians. The popularisation of Hilbertian mathematical logic was headed by Zhu Gongjin, a mathematician who studied under Hilbert in Göttingen, while another important contributor to elementary concepts of mathematical logic was also the chemist and lecturer of mathematics Gao Xingjian.

62 According to its title, Gao also planned to publish further parts of the article in the *Kexue shijie*. However, I was not able to affirm the existence of any sequels to the 1936 article.

2.3. Republican Educational Reforms and the Emergence of Mathematical Logic in the National System of Education

Another important aspect of the establishment and development of mathematical logic in Republican China was its gradual inclusion into secondary school, normal school and new standardised university curricula. According to the available historical sources, this inclusion had already occurred in the first bundle of reforms of the national system of education promulgated by the Nationalist government, whose aim was to unify and standardise education at Chinese schools and universities. Not long after the central government had moved to Nanjing in April 1927, the new nationalist Ministry of Education began devising new plans for large-scale reforms of the national system of education. In so doing, they consulted various Western models, from the American "pragmatical" model of education, propagated by Hu Shi and his adherents, to French and German models of education. Subsequently, first drafts of reforms were issued in the aftermath of the first national congress on questions of education in May 1928. A collection of documents issued following the National Congress on Education was epitomised in the document "Reorganisation of School System of the Republic of China" (Zhengli Zhonghua renmin xuexiao xitong an 整理中華人民學校系統案). In 1929, further documents stipulating new sets of regulations for institutes of higher education were issued – as for example, the "Regulations for Universities" (Daxue guicheng 大學規程), *Organisational Law for Universities* (*Daxue zuzhifa* 大學組織法) and so on. The abovementioned plans were revised at the Second National Congress on Education in 1930. Finally, new school laws for secondary, normal and vocational education were promulgated again in 1932. The education system reforms in the Nanjing period of Republic were not the first enterprise of this kind. In some respects, the first set of reforms promulgated in 1922, were only continuing previous plans for modernisation and standardisation of Chinese system of education.[63] (See Pepper 1996)

Curricular changes, proposed in the framework of the National Congress on Education of 1929 and 1930, were outlined in the *Curricular Standards for Junior and Senior Middle Schools* (Chuji gaoji zhongxue kecheng biaozhun 初級高級中學課程標準), *Curricular Standards for Normal Colleges* (Shifan xuexiao kecheng biaozhun 師範學校課程

[63] For developments related to teaching of logic, see, for example, Zhai Jincheng 2016, 59-63; He Qingqin 1989, 75-106.

標準). These were published in a number of consecutive publications from 1932 on. The above manuals were revised in early 1940s. For university curricula, there further existed a series of documents issued by the Ministry of Education entitled *List of University Courses* (*Daxue kemu biao* 大學科目表). These started to appear in 1933, when an original draft version of the publication was published by the Commercial Press in Shanghai (*Daxue kemu caoan* 大學科目草案 [A Draft of University Courses]). In this draft document, the list of proposed standard courses at universities was supplemented by a list of prescribed literature.

2.3.1. Mathematical Logic in Senior Middle Schools

The *Curricular Standards for Junior and Senior Middle Schools* from 1932, which were based on the reform plans drafted and ratified by the Ministry of Education in 1929, stipulate that an introductory course on logic was to be taught in the final years of the senior secondary schools.[64] The prescribed content of the course "Logic" (*Lunli* 論理) covered the following topics:

- The Scope of Logic (essential characteristics, classification of logic, the relationship between logic and "other sciences").
- Analysis of Human Thought (the relationship between thought and life, the origin and development of thinking, organisation of thought, the difference between true and false thought, the difference between simple and complex thinking, the relationship between thought and writing).
- Essentials of Scientific Method (comparison between common sense and science, the aims and attributes of science etc.).
- Induction (the concept of causality and critical review of the simple "five methods of induction", observation, analysis, conjecture, experiment and probability, the meaning and effect of scientific laws).

[64] The chapter of the manual, entitled "Gaoji zhongxue lunli kecheng biaozhun 高級中學論理課程標準" (Standard Curriculum in Logic for Senior Middle Schools) was later also issued as an independent document.

- Deduction (the new and old fields of induction ('old' refers to Aristotelian logic (*lunlixue* 論理學) and 'new' refers to mathematical logic (*luoji* 邏輯), propositions (*ci* 辭) and propositional forms, relationships between propositions (kinds of immediate inferences and mediate inferences, syllogism), criticism of the old method of deduction, an exposition of the new method of deduction (analytical structure of thought, symbolist reformation of thought, strict form of thinking)).
- System of Science (empirical science and pure science, natural science and social science, science and art, science, and philosophy).

As we can observe in the above outline of the content of the course on logic, at least in relation to the field of logic, the curricular reforms of the late 1930s embodied an extremely ambitious attempt to equip the future university level students with a concise knowledge about the scientific method on one hand and science of logic on the other, all attained within the framework of elementary courses on logic. Furthermore, the new standard curriculum, which was drafted in the late 1920s and promulgated in the 1930s, is devised in a manner similar to the propaedeutic writings of Wang Dianji which had been published in the first two years of the Nanjing period. As a matter of fact, the introduction of "new" mathematical logic into the curriculum might have been indirectly also facilitated also by Wang's contributions to logic education and his ideas about how logic and scientific method ought to be taught at different levels of education in China. Aside from that, the secondary school course on logic, as stipulated by the new standardised curriculum, conveys a certain evolutionary image of Western logic, where mathematical logic was not only treated as the only extant upgrade of the classic Aristotelian logic, but also a new version of logic, which ought to be used in everyday life. For, through the relationship between old and new, the purport and usefulness of logic was not believed to shift from the quotidian to the scientific sphere, but rather to retain the same sense of universality throughout the entire process. This implied a view that knowledge about the pattern of the universe was also seen as pertaining to the sphere of its practical use in everyday life. Maybe the only feature of curriculum which was critically aligned to the native discourse on the relationship between Western and Eastern thought was its strong emphasis on providing a clear delimitation between rational thought and the view on life.

Another striking feature of the above-described course resided in its seeming propensity towards the "Western idea of logic". Thus, in the context of the intellectual climate of the early 1930s, this could be considered as an extremely progressive, Western model which was still somehow immune to neo-traditional tendencies of the time. On the other hand, the manual from 1932 might have represented an unaltered version of the original draft from 1928, which was modelled in an intellectual and political climate consistent with the above-described content.

The above-described standard curriculum remained unaltered throughout the following decade,[65] until in the *Revised Curricular Standards for Junior and Senior Middle Schools* from 1942, for unknown reason the course "Logic" for senior middle schools was abolished in favour of more extensive courses on physics and chemistry.[66]

Following the curricular reforms at secondary level of education, from 1928 on, a series of new standardised textbooks on logic started to emerge. In accordance with the new model, these new textbooks apportioned a considerable part of their content to mathematical logic –referred to usually as *shuxue (de) lunlixue* 數學(的)論理學. First such secondary school textbook emerged in 1925. The book *Logic* (*Lunlixue* 論理學) was written by Wang Zhenxuan 王振瑄, a teacher at Peking Women's Higher Normal College (Beijing nüzi gaodeng shifan xuexiao 北京女子高等師範學校). It was included in the semi-official series *New Education System Senior Secondary School Textbooks* (*Xin xuezhi gaozhong jiaokeshu* 新學制高中教科書), published by the Commercial Press. At this stage, the textbook had not yet offered an overview of the content mathematical logic, neither did it mention any results of Russell's mathematical logic in the section on deduction. Nevertheless, mathematical logic had already been included in the historical overview of development of both Western and Eastern logics (Chinese and Indian logic). A substantial step forward was made in the standardised secondary school textbooks in the early 1930s. Thus, in 1935, Zhang Xizhi's (張希之, ?) book *Essentials of Logic* (*Lunlixue gangyao* 論理學綱要) from 1932 was abridged and upgraded into a textbook *Senior Secondary School Logic* (*Gaozhong lunlixue* 高中論理學). In 1935 it was reissued under the title *Gaozhong xin biaozhun lunlixue* 高中新標準論理學 (*New Standard Logic for Senior Secondary Schools*). Although Zhang's earlier book had only briefly mentioned mathematical logic, the new one, published only three years later, already included

[65] In 1933, 1936, and 1937 editions the structure and content of the course remained unaltered.

[66] Ministry of Education 1942.

an entire chapter devoted to the "contributions of new deductive method". Aside from a historical introduction into the concept of mathematical logic, Zhang's textbook also introduced the elementary concepts from Russell's *Introduction to Mathematical Philosophy* and *Principia Mathematica*, in particular a few elementary notions from the relational and propositional calculi, propositional functions, Sheffer stroke and so on (Zhang Xizhi 1935, 198-221). Apart from these concepts and principles, Zhang also extensively introduced Shen Youqian's rendition of Ladd-Franklin's theory of syllogism together with his *bagua*-based notation. Zhang's book was published in the *New Standard Senior Secondary School Textbooks* series with the Wenhua xueshe 文化學社 in Peking. Zhang's introduction to mathematical logic from secondary schools was not superseded by any new generation of Chinese textbooks. As a matter of fact, in the following years the same trend slowly declined. In the new generation of textbooks, starting with Zhu Zhangbao's (朱章寶) *New Edition Senior Secondary School Logic* (*Xinbian gaozhong lunlixue* 新編高中論理學) from 1940, even though mathematical logic was still mentioned in the historical overview of logic, the section on "new deductive method" (*yanyi xin fa* 演繹新法) was reduced to a less technical introduction of contemporary symbolic logic.

2.3.2. Normal Colleges and Universities

The implementation of early education system reforms in early 1930s brought similar curricular modifications to the general course on logic in the framework of national normal colleges. The document *Curricular Standards for Normal Colleges* from 1934,[67] provides the following outline of the prescribed content of the course on logic (called "Lunlixue 論理學"):

a.) Analysis of Thought (with an emphasis on the ability to identify fallacies and the so-called truth-standards etc.)

b.) Essentials of Scientific Method

c.) Induction

d.) Deduction:

   i. Deductive Systems

[67] See: Editorial Committee for Elementary and Secondary School Curricular Standards of the Ministry of Education, 1934.

ii. Terms and Classes

iii. Propositions and Propositional Forms

iv. Exposition of Formal Deduction:

1. Aristotelian Logic
2. **New Method of Mathematical Logic** (*shuxue luoji* 數學邏輯): Calculus of Classes, Calculus of Propositions, Calculus of Propositional Functions (*ci zhi hanshu* 辭之函數)

The course on logic was also cancelled from the basic curriculum for normal colleges, only a few years later than from secondary school curricula in 1946.

In early 1930s, introductory courses on logic (usually called "Lunlixue 論理學") became a common component of the general curriculum for the first-year undergraduate students. Initially, these were elective courses, conducted usually by members of the departments of philosophy. As in the case of Qinghua University, the course of logic was offered as a part of a bundle of elective courses in science or humanities. Later, the status of logic at universities increased, as it became an independent mandatory course for all first-year students at national universities.

Consequently, logic also became a topic of entrance exams, as well as general exams at the end of each academic year. The growing presence of logic in university curricula also entailed a growing need for standard elementary and advanced textbooks on logic. Following the reforms of the late 1920s, there was also an increase in number of translations of Western textbooks on logic as well as textbooks written by various Chinese authors. Moreover, because mathematical logic became a synonym for contemporary logic, in the 1930s there was also a growing need for Chinese textbooks which would include mathematical or contemporary symbolic logic. Beside the most important textbooks, such as those written by Wang Dianji and Jin Yuelin, the late 1930s and early 1940s saw the publication of further textbooks written by young Chinese philosophers, which included at least a section devoted to modern logic. The first such noteworthy book was Shen Youqian's short overview of *Contemporary Logic* (*Xiandai luoji* 現代邏輯) from 1933, and the other was Mou Zongsan's

Logical Paradigms (*Luoji dianfan* 邏輯典範) from 1940.[68] Throughout the 1920s and 1930s, translations of foreign works in modern logic kept emerging at a relatively steady pace. Despite the fact that already from the 1920s on, a relative abundance of new Chinese publications on modern logic was available to Chinese readers and scholars, the evolution of standard material prescribed for elementary courses in logic at Chinese universities seems not to have followed the same developmental trajectory. Instead, lecturers in logic at more marginal universities kept prescribing already outdated Western textbooks on logic, which did not include symbolic or mathematical logic at all. Often these universities tended to retain the earlier pragmatist approach towards teaching logic. Even at Qinghua, in 1933 the textbook on logic, which was prescribed for the entrance examination and the general exam at the end of the year, was Wolf's *Essentials of Logic* from 1926.[69]

On the other hand, the content of basic university courses on logic depended largely on the lecturers. A general view at Chinese universities in early 1930s reveals that, sometimes, the modern outlook of the course on logic was correlated to the lecturer's affiliation with Qinghua school of philosophy. A solid example of this would be Peking University, where Zhang Shenfu lectured on mathematical logic. Another example was the newly founded Wuhan university, where contemporary logic was taught by Wan Zhuoheng (萬卓恆) a former student of Qinghua College (class of 1923) and a holder of an MA degree in philosophy from Harvard. In 1930s and 1940s Wuhan University was known as one of the only few Chinese universities, where mathematical logic was taught both in the framework of the general course on logic and as a specialised course (advanced logic) at the department of philosophy.[70] Sometimes, however, the most important factor behind the development of more advanced courses on logic was, quite naturally, the lecturer's familiarity with the subject, mostly through first-hand experiences from Western universities.

The educational background of lecturers further greatly influenced the selection of specialised elective courses, both at undergraduate and graduate level, within the curricula at

[68] On Mou Zongsan's early work related to modern logic see Suter 2017; Vrhovski 2020c.

[69] See Qinghua daxue 1933.

[70] Wan Zhuoheng is also mentioned in He Lin's book *Modern Chinese Philosophy* (1947) as one of only a handful of Chinese experts in the field of mathematical logic. He's recognising Fan as a mathematical logician probably rested on his reputation as one of only few professors of logic, who attached great importance to mathematical logic of Russell's *Principia Mathematica*. (See He Lin 1947, 31)

departments of philosophy across the counties. Thus, for example, Qinghua's reputed status as the centre for mathematical logic in China was inextricably linked, not exclusively to Jin Yuelin's pedagogical and scientific work at the department, but maybe even more so to Zhang Shenfu's intensive propagation of the notion of mathematical logic, not only in courses within university but also in the framework of the lectures on the subject he was conducting outside the home institution. In short: a broad selection of lectures on logic was the first condition of development of the discipline of modern logic at the department, and more than on anything else this depended on the pedagogical effort of the lecturers and their effort in broader dissemination or popularisation of this new subject of learning.

According to documentary evidence and biographical material, by the early 1930s, Chinese logicians' efforts to popularise the notion of mathematical logic in China turned out as extremely fruitful. Various indications speak in favour of this assumption, the most important of which was, of course, the inclusion of mathematical logic into secondary and normal curricula. At the university level, the education system reforms of the early 1930s materialised mainly in the establishment of a mandatory general course in logic for all freshmen at the universities. Apart from that mathematical logic became gradually recognised as an integral part of curricula at national philosophical departments. Although the levels of inclusion varied between historical overviews and concrete theoretical introductions, mathematical logic also became a specialised, selective course at some philosophical departments.

However, this change did not occur just over night. Since at the beginning of 1930s, mathematical logic was taught only at an extremely small number of Chinese universities – as an individual (undergraduate) course probably only at Qinghua and Peking universities, some serious efforts were needed, before it was finally included into the standard curriculum. Thus, the draft version of the document *University Courses* (*Daxue kemu* 大學科目) from 1933, which enumerated the basic mandatory courses, still mentioned only the course "Logic" (*Lunlixue*).[71] The original content was extended and upgraded in the revised version of the *List of University Courses* from 1940, which provided a list of both obligatory and selective courses.

[71] The booklet *Draft of the University Courses* (*Daxue kemu caoan* 大學科目草案), issued by the Chinese Ministry of Education in 1933, also prescribed the basic literature for the course, namely the following two books: Josiah Royce*'s The Principles of Logic* (1913) and J. E. Creighton's *An Introductory Logic* (1919). Both were also available in Chinese language. The translators were Liu Qi and Tang Bohuang (唐擘黄, Tang Yue 唐鉞, 1891-1987), respectively.

In this document (or possibly even earlier) “Mathematical Logic” was listed as the standard selective course for undergraduate programs in philosophy, prescribed to be taught in the fourth year of study (Ministry of Education 1940, 48).

2.3.3. Conclusion

The above-described inclusion of mathematical logic into secondary school and university curricula, testifies about a more general establishment of the notion in Chinese intellectual world. It can be assumed that the rise in level of general recognition of mathematical logic as a concept was, above all, facilitated by its association with the prestigious Qinghua School of Philosophy and its numerous members and graduates. The above analysis further shows that the mentioned inclusion was significantly catalysed by the late 1920s and early 1930s reforms of Chinese secondary and higher education.

2.4. Terminological Twists and Turns: Logical Terminology in 1930s

When, in the context of the first national congress of representatives of the re-established (PRC) Chinese Mathematical Society in August 1951, Hua Luogeng reported on the establishment of the Working Committee for Scientific Term Standardization (Xueshu mingci tongyi gongzuo weiyuanhui 學術名詞統一工作委員會) and its future prospects for standardisation of mathematical terminology, the logical terminology used in mathematics and philosophy was still far from unified. On the contrary, in some cases the efforts of members of either the Translation Standardisation Committee (Yiming tongyi weiyuanhui 譯名統一委員會) or the National Institute for Compilation and Translation (Guoli bianyiguan 國立編譯館) have been hindered by some political factors. Even though, since its establishment in 1932, the National Institute for Compilation and Translation had been continuously publishing new terminological manuals, whose main purpose was to resolve the terminological inconsistencies in translation of Western material and the technical terminology used by individual Chinese scholars, by the late 1930s they were still rather unsuccessful.

With respect to terminology related to logic and especially mathematical logic, the main problem resided in general inconsistency between mathematical terms and philosophical terms, where the later turned out to be more in line with the contemporary science than the latter. This inconsistency was a direct consequence of uncoordinated efforts of the members of groups entrusted with compilations of mathematical and philosophical terminology, as well as the currently still existing inconsistencies between terminology used in mathematical literature and philosophical literature. Furthermore, the scarcity of existing literature on mathematical logic left the compilers with less terminological material to consider. In this way, the government-fuelled efforts at standardisation of scientific terminology in 1930s represented only one of the many contexts, in which we can observe the manifestation of the current prevalence of the philosophical notion of mathematical logic in China. Because at the time mathematical logic was treated as a part of philosophy or an offspring of traditional logic, all currently used terminology was consequently classified under philosophical terms. At the same time, the terms given in the final list of philosophical terminology were not consistent with those in the corresponding mathematical manual, which listed fairly antiquated variants of logical terminology.

Another important factor in terminological standardisation of the 1930s and 40s were the prevalent neo-traditional tendencies. These tendencies, that often entailed a propensity towards reintroducing concepts from Chinese tradition, had greatly affected the process of terminological standardisation in the domains of social sciences and philosophy. Thus, in many cases logical terminology was now (re)aligned with terminology extracted from Chinese logical thought. Herewith the terminological standardisation started to integrate past scholarly efforts of some Chinese philosophers to reinvent Chinese logic through modern textual exegesis. In the context government-supported ideological trends, sometimes these traditional terms or "traditionalised translations" overshadowed even most recent advances in terminology. In the 1930s, similar development befell the standard terms used in logic-related publications, which emphasized the link between modern or traditional Western logic and traditional Chinese logic. The same tendency can also be seen in the standardised curricula at all levels of education, which in the second half of the 1930s started using the term *lizexue* instead of *lunlixue* or *luoji* as the main term for "logic".[72] As a consequence, the lists of standardised philosophical terminology compiled in late 1930s and early 1940s usually listed two or more Chinese variants for each corresponding Western term.

The first official glossary of standardised philosophical terms was compiled by the National Institute for Compilation and Translation and published in 1939 under the title *Philosophical Terms* (*Zhexue mingci* 哲學名詞).[73] The glossary was 170 pages long. For each lexeme, the glossary also provided a corresponding expression in Western languages like English, German, and French. Sometimes the lexeme was also furnished with an explanation of its meaning. Finally, the glossary provided both "old [Chinese] translation" of a term as well as its alternative, revised translation. For the revised translation of the term "logic" the glossary lists two parallel Chinese: the modern *luoji* 邏輯 and the older expression *lunlixue* 論理學. Mathematical logic, on the other hand, is translated as *shuli luoji* 數理邏輯, as expected in line with later and current usage (Guoli bianyiguan 1939). Other examples of logic-related terms include:

[72] These changes were connected to the relaunching of the thought of Sun Zhongshan in the 1930s, a connection which shall be further explained in the following analysis.

[73] The *Guide to the National Institute for Compilation and Translation* from 1937 mentioned two editors in chief of the above-mentioned glossary: Wang Shaolun 汪少倫 and Dong Zhaofu 董兆孚. The *Philosophical Terms* was the book no. 29 of the terminological series *Geke xueshu mingci* 各科學術名詞.

English Term	*Old translation(s)*	*Revised translation(s)*
Algebra of logic	*Luoji daishuxue* 邏輯代數學 *Fuhao lunlixue* 符號論理學 *Lunli jisuan* 論理計算 etc.	*Fuhao luoji* 符號邏輯 [symbolic logic] *Fuhao de lunlixue* 符號的論理學
Axiom	*Gongli* 公理 *Yuanli* 原理 *Ziming zhi li* 自明之理 etc.	*Gongli* 公理
Categorical proposition	*Zhenyan mingti* 真言命題 *Dingyan mingti* 定言命題	*Dingyan de mingti* 定言的命題
Consistency	*Zhenghe* 整合 *Tong* 通 *Yizhi* 一致 etc.	*Yizhi* 一致
Constant	*Bubianxiang* 不變項 *Changxiang* 常項 *Changshu* 常數	*Changshu* 常數
Copula	*Xici* 繫辭	*Xici* 繫辭

	Lianci 連辭	
Deduction	*Yanyi* 演繹 *Yanyi fa* 演繹法	*Yanyi fa* 演繹法
Deductive fallacy		*Yanyi de miuwu* 演繹的謬誤
Deductive logic	*Yanyi de lunlixue* 演繹的論理學	*Yanyi de lunlixue* 演繹的論理學 *Yanyi luoji* 演繹邏輯
Dialectic logic		*Bianzheng luoji* 辯證邏輯
Disjunction	*Xuanli shi* 選立式 *Xuanyanshi liyan ci* 選言式離衍辭 *Keduanxing* 可斷性	*Xuanyan* 選言
Empirical logic		*Jingyan de luoji* 經驗的邏輯
Equivalence	*Dengjia* 等價 *Xiangdeng* 相等 *Dengzhi* 等值 etc.	*Xiangdeng* 相等
Extension	*Waifan* 外範 *Tijii* 體積 etc.	*Waiyan* 外延 *Yanchang* 延長
Fallacy	*Lunfa zhi cuowu* 論法之錯誤 *Weilun* 偽論 etc.	*Miuwu* 謬誤

Formal logic	*Xingshi lunlixue* 形式論理學 *Xingshi luoji* 形式邏輯	*Xingshi lunlixue* 形式論理學 *Xingshi luoji* 形式邏輯
Function		*Hanshu* 函數 (math.)
Immediate inference	*Zhijie tuili* 直接推理	*Zhijie de tuili* 直接推理
Inference	*Tuili* 推理 *Tuice* 推測 *Tuilun* 推論	*Tuili* 推理
Law of contradiction	*Maodunxing* 矛盾性 *Maodun lü* 矛盾律	*Maodun lü* 矛盾律
Law of excluded middle	*Chizhong lü* 斥中律 *Paizhong lü* 排中律	*Paizhong lü* 排中律
Logicism	*Lunli zhuyi* 論理主義	*Lunli zhuyi* 論理主義 *Luoji zhuyi* 邏輯主義
Logistic	*Lunli jisuan* 論理計算 *Jisuan fa* 計算法	*Shuli luoji* 數理邏輯
Mathematical logic	*Shuxue de luoji* 數學的邏輯 *Suanxue luoji* 算學邏輯 *Shuxue de lunlixue* 數學的論理學 *Shuxue luoji* 數學邏輯	*Shuli luoji* 數理邏輯

Negation	*Fouding lun* 否定論 *Feiyou* 非有 etc.	*Fouding* 否定
Proposition	*Siwei* 思惟 *Mingti* 命題 *Mingci* 命辭 etc.	*Mingti* 命題 *Ci* 辭
Relation	*Guanxi* 關係 *Lianyixing* 連誼性	*Guanxi* 關係
Type	*Xingfan* 型範 *Biaoxing* 標型 *Quxing* 區型 etc.	*Dianxing* 典型 *Leixing* 類型
Variable	*Kebian shu* 可變數 *Bianxiang* 變項 etc.	*Bianshu* 變數

Table 1: Logic-related terms from the glossary Philosophical Terms, published in 1939 by the National Institute for Compilation and Translation.

The above table reveals that in cases of some more specific logical terms, the compilers had already managed to eliminate a great number of older terms and replace them with terminological variants, which we can regard as modern. Nevertheless, as we have mentioned above, the term for "logic" was still translated with two different expressions, of which one represented a semantic translation and the other a phonetic transliteration of English "logic".[74] While in practice the first was used to refer to logic in general, as a science of the laws of reasoning, the latter was regarded as a more modern, fashionable term, and was used predominantly in connection to contemporary forms of logic, such as "mathematical logic", "logistic" etc.

[74] For a more complete view on the development of logical terminology one would also have to consider the developments in the discourse on traditional Chinese and Indian logic. See Vrhovski 2020b and 2020c.

Contrary to the philosophical terminology, where considerable advances had been made in the direction of standardisation and elimination of less suitable or rarely used synonyms, the logical terminology in the glossary *Mathematical Terms* (*Shuxue mingci* 數學名詞), which was published six years later (1945), was still somewhat antiquated. For example, the Chinese translation for the lexeme "mathematical logic" (symbolical logic) in the *Mathematical Terms* was *shuli mingxue* 數理名學 (Guoli bianyiguan 1945, 34).[75]

The reinvention of tradition in 1930s gave rise to another terminological trend, which was diametrically opposite to the terminological modernisation. The main characteristic of this manifestation of neo-traditionalist tendencies in Chinese philosophical and logical terminology was a strong proclivity towards a semantical redefinition of modern ideas with concepts and terms from traditional Chinese philosophy. This was underlined by the presupposition that the described concepts and categories were universal, and in their essence transcended cultural boundaries. Somehow paradoxically, this also implied a necessity to express these universal concepts and categories in Chinese terms, with semantic elements derived from Chinese culture. On the other hand, the rediscovery and redefinition of Chinese tradition also entailed increase of interest in traditional Chinese logic. This semi-historiographical endeavour, however, had to be conducted in a comparative perspective with the contemporary Western logic, which meant that traditional terms and concepts were also set within the same perspective, in alignment with corresponding modern (Western) logical concepts. In the late 1920s, the term *mingxue* 名學 ("logic" and "learning of names"), which also used to denote traditional Chinese logic, became regarded as inadequate name for "logic" in general and hence suitable only for denoting only the above-named Chinese school of logic. Consequently, "Chinese logic" became more emphatically pronounced as "logic" (*lunlixue* 論理學).

After 1928, when the Sun Zhongshan's (Sun Yat-Sen's) *Sanmin* became the main tenet of state-ideology and by the late 1930s its indispensable component, Sun's thought on political and spiritual construction of new China assumed the role of a guideline for a number of different matters, including terminology. In that way, in a more general sense, the neo-

[75] The glossary was comprised of 3426 mathematical terms. Among mathematicians, who contributed to the above-named glossary were also Zhu Gongjin, Hu Guofu, Jiang Zehan etc. The *Mathematical Terms* were the listed as book no. 9 of the *Geke xueshu mingci* 各科學術名詞 series.

traditional terminological tendencies of 1930s had also incorporated Sun's philosophical views on the nature of logic and questions of appropriate Chinese logical terminology. In his general plan for China's psychological reconstruction, epitomised in the book *Sun Wen's Doctrine* (孫文學説), Sun also addressed the question of logic and its role in his imagined Chinese spiritual renaissance. In the third chapter of the above-mentioned book, Sun mentions logic as the guiding-principle of truth that was supposed to stand behind the so-called "textual patterns" (*wenli* 文理) of any written (or spoken) doctrine. After Sun declared that logic is the key to the principles of the universe, which needs to be used as the binding-tissue of reasoning, he devoted much attention to the question of how "logic", that is *luoji* 邏輯, ought to be translated into Chinese, in order to achieve some sort of consistency between the semantical motivation behind the Chinese term and the most general meaning of logic. He claimed that the previous translations, like *mingxue* 名學, *bianxue* 辯學 and *lunlixue* 論理學, all failed to provide an adequate semantic correspondent to "logic", each of them referring only to certain aspects of what logic actually means. Instead, Sun proposed that the appropriate and adequate translation of logic was the term *lizexue* 理則學 or "the science of the principles/laws of reasoning". In Sun's opinion, such a comprehensive designation of logic was coherent with its true nature, for he understood logic as "the laws of all sciences and all matters". In consequence, only a more general reference to "the principles" of knowing and inferring, or the various (*zhong* 眾) *dao's* (道) that underly it, befitted the most appropriate Chinese translation. (Sun Zhongshan 1927, 33-5)

Even though Sun did not explicitly state that the term *lizexue* was a conceptual construction which was in accordance with the spiritual or cultural essence of traditional Chinese thought, in the 1930s Chinese "psychological" or "spiritual reconstruction" came to denote exactly this kind of return to the cultural essence, which in respect of terminological developments, ended up being a kind of cultural rectification of names (*zhengming* 正名). Perceived from another angle, the term *lizexue* 理則學 was also semantically closer to the way how reasoning and the notion of "logic" as an ontological guiding-principle of thought was considered (cosmological perspective) in traditional Chinese philosophy. Regardless of how Sun understood his own suggestion, and whether he perceived it as a modern or as a retro-traditional idea, in the 1930s it became some sort of a paragon for those intellectuals who became immersed in the current main-line ideology and those who attached great importance to a total Sinification of intellectual discourses. In our previous discussion, we have already mentioned how, in late 1930s, the important educator of logic in China, Wang Dianji, who in fact not only sympathised with the GMD but also participated in GMD-controlled governmental projects, took a significant turn towards the above-described paradigm. We must remind the reader that, after Wang had composed and published a considerably advanced textbook *Contemporary Logic* or *Xiandai luoji* 現代邏輯, in 1937 he also published his first textbook on general or elementary logic, which he chose to adorn with the title *Lizexue* 理則學, for *Logic*. In the 1940s, when Sun Yat-Sen teaching became even more strongly represented in university curricula, the elementary courses in logic were also officially called *Lizexue* 理則學. However, Wang's choice of title was only the tip of the iceberg, almost an external sign of more thorough terminological alterations that were manifested between the pages of the book itself. Such a re-traditionalization of logical terminology was a sporadic phenomenon, which was accompanied by the rise in publication of older Chinese books on logic and translations of Western works, where similar terminology and style of expression (old literary language) were also a common feature.

Nevertheless, the above-described tendencies were persistently countered by a number of Chinese progressive intellectuals and were also, as we have shown above, undermined by government's own standardisation projects – at least in part. With regard to logic-related Chinese terminology, Zhang Shizhao's *luoji* 邏輯, together with other more or less successful suggestions, reverberated through many decades and received their advocates in many important Chinese scholars. As the most important propagator of *shuli luoji* 數理邏輯 in the 1920s, Zhang Shenfu was certainly one of these intellectuals, who directly or indirectly guaranteed the survival of modern logical terminology through the twists and turns of the nationalist era. Already in 1928, Zhang Shenfu expressed his own response to Sun Zhongshan's ideas about logic in the third chapter of the above-mentioned book *Sun Wen's Doctrine*. In that year, Zhang published an article entitled "Mr. Zhongshan and Logic" (Zhongshan xiansheng yu luoji 中山先生與邏輯),[76] where, on one side he praised Sun's high regard for logic yet on the other side argued against Sun's terminological suggestion, emphasizing that the term *luoji* 邏輯 was not only already in common use in China, but also a

[76] The article was published in the first issue of *Publication on the Anniversary of President's Birthday* (*Zongli danchen jiniankan* 總理誕辰紀念刊) on November 20, 1928.

suitable choice for Chinese translation for the contemporary notion of logic. Zhang supported his claim by presenting Russell's views on logic as a normative and formal science. A significant effort towards "modernisation" of terminology, as opposed to the above described "traditionalization", was done within the Qinghua circle of philosophers and logicians, who abided by and maintained a common progressive terminology. First of all, the progressive attitude maintained by the members of Qinghua circle of logicians and New Realists was also manifested in the choice of terminology in their writings, like Jin Yuelin's textbook *Logic*, where *luoji* 邏輯 referred to both traditional as well as modern logic. Apart from that, it was also reflected in the early use of latter term as the title of the general first year course on logic, etc. Ultimately, it was partly because of the efforts of these highly influential Chinese scholars, who had made immeasurable contributions to dissemination and propagation of modern logic and philosophy in China, that the term *luoji* remained a synonym for logical modernity throughout the 1930s. I believe that it was exactly this sense of modernity, which insured its survival and final establishment as the only term for "logic". As regards the rest of the corpus of logic-related terms, thanks to the influence of certain circles of philosophers and the standardisation projects launched by the central government in the late 1928, the final situation in the beginning of the PRC period was essentially the same as in the provisional issue of the *Philosophical Terms* from 1939, where some problems related to the abundance of terms in the previous decades had already been solved, and which consistently reflected the state in most advanced contemporary Chinese literature.

2.5. Conclusion

The above analysis reveals that the advances in Chinese studies of mathematical logic was represented, most of all, by the so-called Qinghua school of mathematical logic. In its earliest years, as the central Chinese platform for research in Russell's philosophy and his *Principia Mathematica,* the Philosophical Department at Qinghua University defined the state of Chinese knowledge of the topic and at the same time assumed the role of the main disseminator of the Russellian notion of mathematical logic. To a certain degree, this early period of mathematical logic at Qinghua was epitomised in Jin Yuelin's work *Logic*, while, at the same time, it also marked an important transition of the research interest of the members of the school towards the developments in the framework of the Harvard school of logic on one side and trends in European mathematical logic on the other. Similarly, in the late 1930s, the new generation of logicians at Qinghua University also assumed the leading role in raising the Chinese research of the discipline unto a new level. This final chapter of mathematical logic at Qinghua was defined by the introduction of more recent advances in European mathematical logic into the curriculum at the department.

However, in the framework of the school of logic at Qinghua University mathematical logic was still emersed deeply in the context of philosophical studies, and consequently also generally explicated in a profoundly philosophical manner. Secondly, as a school of thought, the development of Qinghua School was also strongly inclined towards particular theories and currents in mathematical logic and therewith also more or less disassociated from specific other such theories. Thus, as an example of a theory which was not at the centre of inquiries at Qinghua was Hilbert's formalist project, which also offered its own solution to the foundations of mathematical logic. The task of introducing Hilbertian formalism, Cantorian set theory and other topics from mathematical logic to Chinese scholars was later assumed by a group of Chinese mathematicians, who were headed by Tang Zaozhen, a professor at Wuhan University, on the one side, and Zhu Gongjin, a mathematician who studied under Hilbert, on the other. The related developments which took part at Wuhan University and in the framework of popularisation and introduction of mathematical logic in mathematical journals can be described as a step in the direction of mathematisation of the notion of mathematical logic in China. Moreover, the research conducted by the leading figures in this motion, such as Tang Zaozhen and Xiao Wencan at Wuhan University was profoundly different from the that conducted at Qinghua School, in the regard that the notion of mathematical logic as well as its content were regarded within the context of mathematics, as a branch of mathematics related closely to the problems of its foundations. Based on its different conceptualisation, the notion of mathematical logic produced through this important turn can be described as the current of "mathematical notion" of mathematical logic.

Finally, the degree of establishment of the notion of mathematical logic in a more general intellectual discourse in late 1920s and 1930s China is further attested by the inclusion of its content into the standardised new secondary school and university curricula. In the context of standardisation and modernisation of the logical curricula, the integration of content from mathematical logic as a most highly developed form of deductive logic reached its peak in the first half of the 1930s, when several new standard textbooks for secondary schools already included elementary concepts from *Principia Mathematica* and other related works by Russell and others. Together with the rise of the notion of mathematical logic as a newest form of deductive logic a new terminology started to form, which possessed a strongly modern undertone. Although this distinction originated in the earliest introduction of the notion in the early 1920s, by the 1930s the difference between traditional and modern logic became expressed more uniformly in the terminology used to describe these two developmental stages in Western logic. On the other hand, the use of terminology in the 1930s also revealed an indirect influence of broader philosophical and political trends on logical terminology. An important such influence was that of the cultural relativism, which created the urge to differentiate the universal idea of logic from "culturally conditioned" evolutionary versions of logic, such as Indian, Chinese or Greek Aristotelian logic. When this first concerted attempt at standardising logical terminology was completed in 1939, some of these distinctions were still retained, while in actual literature, the terminological gaps were still considerable.

Unfortunately, the development of mathematical logic in the years following the outbreak of the Sino-Japanese war is, due to objective circumstances of the time, is very poorly documented. As a consequence, there is a wide and unsurmountable gap in our understanding of the later parts of the above-described trends and developments. In the end, however, with the profound changes that took place at the establishment of the PRC in 1949, which will serve as the starting point of the next part of this dissertation, the majority of the above-described developments were brought to an abrupt end. In this way, our treatment of these early developments will serve as a basis for assessment the degree of discontinuity and change rather than the main basis for describing a general continuity in Chinese studies of mathematical logic.

On the other hand, maybe the most indisputable dimension of continuity was retained through the key agents who contributed to the re-formation of mathematical logic in the first decade of the PRC, such as Hu Shihua, who obtained their basic training in the milieu of the Qinghua school (in late 1920s and early 1930s its members lectured on all other important Chinese universities) and whose work in mathematical logic was not sanctioned in the framework of the ideological transition in Chinese academia in the early 1950s.

3. Mathematical Logic in the 1950s China: From Marxist Philosophy of Science to Institutional Developments and Scholarly Advances

3.1. Introduction

The establishment of the People's Republic of China in 1949 was a major event in Chinese intellectual history, which marked a great change of its developmental trajectory. For Chinese scientific community, the transition from one political system to the other entailed a process of philosophical re-adaptation of their fields of studies from one worldview to another. As changes of worldviews are often attested to do, the ideological transition from Republic to a Communist state also gave rise to a new system of objectivity, with its own evolutionary cosmology, epistemology, theory of society and so on. And with it also a new period of ideational dissonance. The doctrinal fundaments of Marxist philosophy were embodied in theories of historical materialism and dialectical materialism; while the former represented Marx's theory of social order and development, the latter was a form of philosophy of natural sciences, founded upon Hegelian dialectics, early materialist philosophy and a collection of concepts extracted from contemporary science and mathematics. This philosophy also became the ideological building block of the new Chinese state, an ideological foundation on which all the future technological and scientific projects of the Chinese people were supposed to be constructed. It also represented the main doctrine about the laws of universe, with which all Chinese science and thought ought to be aligned with.

Because dialectical materialism was such an essential prerequisite for establishment of a Communist state, the new Chinese leadership had to rely heavily on the political experience and assistance of their historical predecessor and ideological patron, the Soviet Union. Even though political assistance had already been offered to the Chinese state by the Soviet Union already in the 1920s,[77] which eventually resulted in the establishment of minor channels of transfer of doctrinal material from the Soviet Union to China, after 1949 an entirely new chapter in Sino-Soviet relations was initiated. It initiated a new wave of transfer

[77] In the late 1920s, a generation of Chinese intellectuals returned home from their political training in the Soviet Union. The same group of young Chinese Marxists, who received a complete training in politically orthodox Stalinist doctrine, had later, in the 1930s, also conducted first extensive translations of the essential Soviet material on dialectical material into Chinese. (See McGuire 2010, 360-361)

of ideological material and scientific and technological knowledge.[78] However, this did not mean that the past efforts to popularise dialectical materialism and the autonomously developed Chinese discourse on Marxism and related issues would now be simply replaced by Soviet doctrine. On the converse, it turned out that in the initial period of the transfer of ideological material from the SU to China, a "naturalised" or "Sinicized" form of Marxism, which later crystallised into what we understand by the term Maoism, had undergone a more or less "passive" phase of development, a process of learning, emulation and finally also of radical dissimilation from the Soviet ideological doctrines.

The ideological and scientific transfer between the Soviet Union and PRC in 1950s can be divided into at least two different phases. Firstly, between 1949 and 1953, the transfer was based mainly on influx of published material provided by the Soviets and subsequently translated into Chinese. In the second phase, which started in 1953, the cooperation between the countries shifted to the institutional level, while scholarly exchange of experts gained priority over the transmission of published material. The academic and non-academic exchange of experts started to decline in 1957 and reached its lowest point between 1958 and 1959, as the Sino-Soviet split was becoming more intensive. (Goikhman 2010, 286-7) Some major projects of technological transfer from the SU to China, like computer technology, were initiated after 1956, in the same year when the Soviet government issued a document "Declaration of Further Strengthening of Foundations of Friendship and Cooperation between the Soviet Union and other Socialist Countries" and when Chinese government ratified the outline of the twelve-year plan for development of Chinese science (McGuire 2010, 287).[79]

The initial process of ideological and academic assistance, which was provided to the newly established Chinese Communist state by the Soviet Union, influenced Chinese science and humanities in various different ways. These influences can be summarised in the following main points:

- *Ideological influence:* dialectical materialism and later dialectics of nature became the only official **philosophical** foundations of science. In the fields of humanities, the first,

[78] We know that in the internal political conflict between the GMD and CPC, Stalin was actually more in favour of the former, and consequently initially had not provided enough political or material support to the latter.

[79] About the development of computer industry in China and transmission of Soviet computer industry to China, see Zhang Bochun et al. 2005, 205-228; Liu Yidong & Li Genqun 2005 and so on.

together with historical materialism, became the main allowed "philosophy" or "methodology" in general.

- *Institutional influence:* Chinese emulation of the institutional aspect of the so-called "Soviet model" resulted in drastic changes in Chinese system of education. At the institutional level this meant that former institutes of higher education were reformed after the Soviet institutional models. For instance, the 1952 reorganisation of colleges and departments instituted under the Soviet guidance resulted in massive reduction of humanities-related departments, [80] like departments of philosophy, at Chinese universities. At the same time, former Western-style universities, most notably the Qinghua University, were reorganised to fit the Soviet-style polytechnic institutes, devoted exclusively to teaching of natural sciences and technology.[81] The Soviet model also became manifested in the newly founded Chinese Academy of Sciences (CAS), one of the last strongholds from where Chinese scholars and scientists could, at least in accordance with their actual possibilities, defend their remaining shreds of autonomy.

- *Content-related influence:* As I have noted above, one of the main focuses of the Sino-Soviet academic exchange was on concrete scientific and ideological content (beside all other kinds of content). However, the introduction and appropriation of concrete scientific and technological achievements of Soviet science also entailed an import of the idea of scientific research related priorities and a led to an overall recognition of the essential role of science planning on the Chinese side.[82] The Chinese emulation of research priorities in Soviet-style science planning was very much evident in earliest Chinese research policies at institutes of higher education and the CAS and were later

[80] The reforms of the institutes of higher education, also known as "the reordering of colleges and departments" (*yuanxi tiaozheng* 院系調整), were a part of the First Five-year Plan, which was carried out between 1953 and 1957. (See Hayhoe 1996, 73-87)

[81] For the situation at Qinghua see, for example, Joel 2009, 42-45.

[82] Discussions on the importance of science-planning and establishment of general research priorities in the development of national science had already emerged in the wartime period. The Chinese awareness about soviet science planning was not only raised by the members of the Yan'an-based Communist party, but also by the intellectuals closer to the GMD-dominated central government, like Zhang Shenfu etc. In general, the discussions about science-planning were all conducted within the context of reflections on post-war reestablishment of Chinese state and society, and were as such also a part of the government's wartime public discourse.

also formalised in official plans for scientific development. Because of its ambivalent nature – parallel existence of a profoundly theoretical and an immensely practical content – one of the disciplines greatly affected by the new ideologically redefined research priorities was also mathematics.

The above listed three aspects are not mutually exclusive but constitute one single web of causes and effects. Thus, for example, especially in the early years of the PRC, the institutional and content-related transformations were all conceived within an ideological perspective, which served as the main source for justification of the new order. Analogically, due to the relatively absolutist nature of the Stalinist doctrine, when the Chinese scientists wanted to defend a particular part of their field of studies or a broader domain of their science, their apology needed to be expressed within the doctrinal confines of dialectical materialism. Apart from adopting the proper vocabulary this also entailed a necessity to emulate the critical apparatus inherent to the evolutionary aspect of dialectical materialism, to expose and eradicate the idealist elements of the fields or theories they wanted to defend.

Above everything else, the process of learning from the Soviets was not a linear or consistently conducted process of transmission at all. Mainly because of Chinese inner political developments and disruptions which ultimately materialised in various political movements, campaigns and collective "projects", for Chinese "intellectual elements" (*zhishi fenzi* 知識分子) as well as for the well-established experts, the path towards new horizons was full of twists and turns: From what use to appear as strict adherence to the Soviet model to developmental trajectories based on an emerging China-based model of socialist science, from socialist unity to a solitary path towards socialism set on China's own historical or evolutionary trajectory. Thus in the process of socialist construction with Soviet aid of the 1950s, it was often the case that soon after particular aspect of Soviet doctrine on science had been adopted into Chinese ideological discourse – in some cases with a delay of several years after it lost its relevance in the Soviet political discourse, due to one or another reason it was already dropped and replaced by another, sometimes also an entirely new, endogenous perspective spurred by that or the other political disruption.

The fate of mathematical logic in the early 1950s was a story similar to all other sciences and humanities. First of all, already in the 1930s China, mathematical logic started to gradually separate itself from both the discipline of philosophy as well as the philosophy-related notion of formal logic and consequently, together with the fundaments of mathematics, became a field of studies under the domain of mathematics. However, within the 1930s debates on dialectical materialism the division between philosophical notion of formal logic and a purely mathematical notion of mathematical logic had not yet been recognised as such. In their attacks on "formal logic" and related modern philosophies, the Chinese proponents of hard-line Marxist doctrine still treated mathematical logic as a direct offspring of idealist formal logic and needed consequently to be replaced by the so-called dialectical logic. In the framework of the 1930s discourse on logic the brothers Zhang Shenfu and Dainian propagated an alternative vision in which mathematical logic was to be joined in a perfect harmony with the aforementioned idea of dialectical logic. Nonetheless, although shortly before 1949 mathematical logic was still taught as a philosophical subject.[83] Already after a first few years under the new regime, it became institutionalised as a field of studies related almost exclusively to mathematics and the advancing computer technology. The final step in this transformation was made mainly under the protection of the CAS, or more correctly the Institute of Mathematics Chinese Academy of the Chinese Academy of Sciences (IMCAS) established in 1952, in the framework of which its first president Hua Luogeng was finally able to fulfil his vision of future Chinese mathematics, in which mathematical logic and computational mathematics were to play an important role. [84]

Through its divorce with classical formal logic and "reassociation" with mathematics, mathematical logic could avoid a huge variety of ideological difficulties that pestered the fields of philosophy and classical formal logic in the 1950s. However, only by means of disassociating from philosophy and the ideologically problematic logics of old, mathematical logic could not completely circumvent the standard mechanisms of ideological rectification. Moreover, in the new intellectual climate and alignment of ideas it became the target of the same criticisms and refutations as mathematics. The basic content of these ideological refutations was imported to China from the Soviet Union and further developed or commented on by some of the Chinese leading mathematicians, such as Hua Luogeng and

[83] Wang Xianjun and Shen Youding at Qinghua University and Hu Shihua at Peking University. About the latter, see Guoli Beijing daxue jiangshi jiangyuan zhujiao lianhehui 1948, 25-6.

[84] Already in the early 1940s, Hua had a vision of future Chinese mathematics, where pure mathematics would at the same time be in balance with applied mathematics and constitute its firm foundation. In 1944, Hua believed that the pillars of pure mathematics, which needed to be represented at the Institute of Mathematics of Academia Sinica, were: mathematical logic, analysis, algebra and geometry. (Wang Yuan 1999, 169)

Guan Zhaozhi (关肇直, 1919-1982), and the foremost Chinese mathematical logician Hu Shihua.

Even though the ideological fate of formal logic had already been more or less cocluded in Marxist classics and preceding Soviet ideological debates on logic, the extraordinary importance attributed to logic in the preceding three decades (see Tian Chenshan 2019) made it also an important topic of numerous debates between 1953 and 1960, which culminated around 1956-1957. The debates became known under the generic name *Luoji da taolun* 邏輯大討論 "Great Debates on Logic". According to historical sources, these intense logical debates together with a general increase in interest in logic were initiated by Mao himself. Interestingly, due to its newly attained status mathematical logic was not explicitly mentioned in these debates, with exception of a short-lived discussion on the object of mathematical logic from 1956 – which developed between the mathematical logicians Hu Shihua and Mo Shaokui and some other Chinese philosophers. On the contrary, public discussions on the nature of mathematical logic were regarded almost as a separate discourse, which was essentially a part of that related to philosophy of mathematics and later also on the foundations of mathematics. Furthermore, the majority of senior philosophers such as Jin Yuelin, Zhang Shenfu, Wang Dianji and others who used to be inextricably linked to the notion of mathematical logic in China, were now either preoccupied with self-critical re-evaluation of their past work or other significant issues promulgated by the government. Even Shen Youding and Wang Xianjun who, together with Hu Shihua, represented the front line of the new generation of modern Chinese logicians, were now deemed linked too closely with the dangerous field of "philosophy" and consequently forced to conduct criticism of philosophical aspects of the discipline of logic they used to study.

In the subsequent chapters of this dissertation, I shall first provide a brief overview of Marxist doctrine related to the nature of mathematics and mathematical logic, from the original works of Engels to Soviet contributions from the 1950s. In turn, I will review how the above-mentioned aspects of dialectical materialism were accepted and developed in China in the 1950s. In the third and fourth parts I will discuss the institutional and content-related aspects of development of mathematical logic in the 1950s. And finally, in the last part of this section of dissertation I shall take a closer look at the life and work of the leading figurehead of mathematical logic in the PRC, Hu Shihua.

3.2. Introduction to Marxist Philosophy of Mathematics and Mathematical Logic

Marxist philosophy of science was based on the very same theory as its other aspects, namely, the doctrine of dialectical materialism. Essentially, dialectical materialism was a form of philosophy of science based on Engels' synthesis of Hegel's dialectics and Feuerbach's materialism, and further developed Lenin and other Soviet philosophers. On the one hand, dialectical materialism expropriated Hegel's idea of dialectics, placing it into the context of Darwinian theory of evolution. On the other hand, it was founded on Feuerbach's and Marx's materialist interpretation of Hegel's dialectics, objectivised by the contemporary natural sciences. As a universalist and objectivist worldview, dialectical materialism claims to have distilled its dialectical laws and principles directly from the natural sciences. In its secondary philosophical extensions, in the framework of which the laws of dialectics and evolution were observed in the context of social relations, economy or politics, dialectical materialism had also discovered its philosophical adversary, idealism. If the former alleged to be a comprehensive philosophical worldview constructed on objective facts and natural laws, the latter was deemed an intentional abstractions and false interpretations of the material reality devised by the leading, capitalist classes in order to enslave the masses. Thus, in a political sense, dialectical materialism was a form of scientific objectivism, the purpose of which was to denounce and cleanse philosophy of all idealist elements. Moreover, in the idealised period of transition to a Communist social order, this ideological rectification ought to be conducted in line with the evolutionary cosmology encapsulated in dialectical materialism, which in itself defined the boundaries between truth and falsehood, ideological correctness and depravity etc. Because, historically, the emergence of dialectical materialism was the result of European philosophical discourses, in consequence, the nature of its ideological counterpart was also perceived as purely philosophical.

Nevertheless, in the 1950s, Marxist philosophy of science was far from a unified philosophical theory, but rather a collection of different works, from classics, like Engels' *Dialectics of Nature* and the early book known also as *Anti-Dühring* and Lenin's *Materialism and Empirio-Criticism* and *Philosophical Notebooks,* to interpretations and developments of it theoretical tenets by later Soviet philosophers and scientists. While dialectical materialism represented some sort of an umbrella term designating an extensive philosophical body, where all the different manifestations, laws and principles of materialist dialectics were brought together and combined into one single theoretical system, in Marxist philosophy there also existed a more specialised discourse on science, called dialectics of nature. Although dialectics of nature was the main scientific basis of dialectical materialism, the term later came to designate a form of philosophical enquiry into the dialectical principles as reflected in the natural sciences. Eventually it transformed into a special subcategory of dialectical materialism, a philosophical foundation of Marxist science. As such it also remained connected to its original work, Engels' *Dialectics of Nature.* This is also the reason why Engels' work is essential for understanding both dialectical materialism and later Marxist philosophy of natural sciences.

3.2.1. Mathematics and Formal Logic in Engels' Dialectics of Nature

Both Engels' and Marx's view of dialectics were built on Hegel's idea of the universe as an incessantly changing whole. According to Hegel, this perpetual revolution of the universe was driven by the inner contradictions within the thing itself. Marx's and Engels' reinterpretation of Hegel rested on the ontological definition of the place where these contradictions were supposed to be located in, which was also the main point through which Hegel's idealist positions were translated into materialist terms. Marx and Engels namely believed that the only source of these changes and the only real locus of inner contradictions was matter. Furthermore, looking at science and nature through the prism of Marx's materialism and Hegel's dialectics, Engels also posited the following three laws of dialectics:

- The law of the [evolutionary] leap of quantity into quality.
- The law of interpenetration of opposites and.
- The law of the negation of negation. (Engels 1987a, 356)

Akin to Hegel, both Marx and Engels also understood these laws as the sole and universal principles of every kind of development or change which occurs in the universe, and thereby binding together the developments in the society with those in the world of nature. Most importantly, given that they were describing the general laws of material evolution, these could only be observed through the perspective of time: natural history and social history. In the work *Dialectics of Nature* Engels deconstructed the former Hegelian context of the three laws of dialectics, where these were discussed strictly within the domain of human thought or logic, and re-contextualised them within a materialist perspective, tentatively aligned with the results of contemporary natural sciences. Thus, for example, using the findings from contemporary physics related to thermodynamics, kinetic energy etc. he reformulated the first law of dialectics to rest on the quantitative relations as expressed by physics. Using physics as an example, Engels wanted to show that every single change in the universe, which necessarily follows the abovementioned dialectical laws, can be expressed in terms of physical quantity. It can be expressed by an addition or subtraction of a certain quantity of movement (velocity) or matter. According to Engels, the principle of the leap from quantity to quality can be observed in the science of chemistry, where the qualitative changes of substance are studied through quantitative changes of its structure. Exactly in this "quantification" of the laws of dialectics resided the main characteristic of Engels' dialectics of nature, wherein the principles of Hegelian dialectics were combined with contorted conclusions of modern natural sciences. This was also the main viewpoint, from which Engels provided his dialectical evaluation of mathematics (ibid., 356-361).

For Engels, mathematics was an extreme example of a science, in which the spatial dimension of the material world was expressed in terms of quantitative relations. However, although Engels saw mathematics as a purely quantitative science, he still maintained that the idea of quantity, from which mathematics is derived, is not adequately defined in mathematics. Instead, the entire system of mathematics was made to rest on mathematical axioms. In his opinion, this critical shortcoming of mathematics becomes exacerbated by how elementary propositions are processed within the system of axioms and how elementary mathematical definitions are used as mathematically unprovable elements in the very same system. Engels also suggested that the problem of axiomatic foundations of mathematics would be solved by a proper analysis of the notion of mathematical quantity, which would show that all axiomatic definitions are necessary specifications of quantity (ibid., 536-551).

If Engels recognised the most problematic points of mathematics in its axiomatic foundations, he believed that, on the opposite, its most ontologically sound basis resided in mathematical operations. In Engels' eyes these were a direct reflection of the dialectical laws of nature, for, as he reasoned, mathematics shows that the operation of addition stands in a dialectical opposition to subtraction, as do multiplication and division or logarithms and exponentiation.

In addition to the notion of quantity, Engels also attached great importance to the idea of movement as expressed in natural sciences: "Motion is the mode of existence of matter"

(Engels 1987b, 55). While the dynamic aspect of the universe is abundantly expressed in natural sciences like physics and chemistry, it was only introduced to mathematics via Descartes' invention of the mathematical variable. Through mathematical variable movement had been brought to mathematics and consequently also natural dialectics. Following the discovery of movement in mathematical expression, an additional dialectical relationship found its expression in mathematics in the form of integration and differentiation (Engels 1987a, 536-551).

In his evaluation of the dialectical principles in mathematics Engels also critically revised Hegel's notion of arithmetic. Treating the concept of number as an important mean utilised by mathematics to express objective quantitative relations, he argued against Hegel's refutation of arithmetic as abstract nonsense. Furthermore, according to Engels, through the most problematic notions of infinitely large and infinitely small arithmetic introduces a purely qualitative difference, which is realised in the form of a dialectical opposition between quantities. The relationship which exists between these two versions of infinite quantities is not rational. Instead, they are essentially quantitatively incommensurable, as in the case of common incommensurability between a line and a circle. Most importantly, both in his *Dialectics of Nature* and his *Anti-Dühring*, Engels affirmed that the notion of infinity possesses an objective value, both in the sense of endless space and time as well as in the form of an infinite series in mathematics. Nonetheless, for Engels the real infinity behind an infinite series is inconceivable and, when one attempts to understand or formalised it, full of inner contradiction – as for example the fact that it is composed from finite elements, that it cannot be counted or that it can be limited in one direction. (Engels 1987b, 46-8; 1987a, 544-550) In *Dialectics of Nature*, Engels devoted an entire section to the notion of infinity in mathematics, pointing out that the way how the infinitesimal calculus had been used in physics to describe natural phenomena had demonstrated that there is an analogical relationship between concrete physical reality and the notion of infinity in mathematics. According to Engels, however, his objective commensurability of real and mathematical infinity is obscured within "the impenetrable fortress of abstraction, so-called pure mathematics", where some mathematicians tend to turn real concepts into mystical and incomprehensible abstractions (Engels 1987a, 549).

The last thought was also the starting point of another significant claim in Engels' philosophy of mathematics as well as science in general, namely that all its concepts, categories or laws which are derived from real world are prone to being critically disfigured in the abstractions of pure science. Although, Engels did not explicitly claim that this inner divergence in science would directly correspond to the division between, for example, applied and pure or theoretical mathematics, he still implied that its objectivity could be tested by its applicability in natural sciences and practice. The distinction between pure theory and practice, however, became much more emphasized in later doctrine of dialectical materialism, where it had been claimed to represent the difference between scientific objectivity and subjectivity, and between an idealist approach as opposed to the materialist approach to science. Furthermore, it was also a result of redefinition of science into a mere theoretical precondition for developing technology as the final vehicle for the social means of production.

Both above-discussed works also contain Engels' reflections on the nature and use of formal logic. Although in his work Engels did not consider formal logic as one of his primary focuses, in *Anti-Dühring* he wrote:

> Even formal logic is primarily a method of arriving at new results, of advancing from the known to the unknown – and dialectics is the same, only much more eminently so; moreover, since it forces its way beyond the narrow horizon of formal logic, it contains the germ of a more comprehensive view of the world. The same correlation exists in mathematics. Elementary mathematics, the mathematics of constant quantities, moves within the confines of formal logic, at any rate on the whole; the mathematics of variables, whose most important part is the infinitesimal calculus, is in essence nothing other than the application of dialectics to mathematical relations. (Engels 1987b, 125)

On the relationship between dialectical logic and formal logic, Engels further indicated:

> Formal logic itself has been the arena of violent controversy from the time of Aristotle to the present day. And dialectics has so far been fairly closely investigated by only two thinkers, Aristotle and Hegel. But it is precisely dialectics that constitutes the most important form of thinking for present-day natural science, for it alone offers the analogue for, and thereby the method of explaining, the evolutionary processes occulting in the nature, inter-connections in general, and transactions from one field of investigation to another. (Engels 1987b, 339)

The above two excerpts highlight all the main points that were to be reiterated in the forthcoming Marxist polemics on the relationship between materialist dialectics and formal logic. In the *Dialectics of Nature* Engels further elaborated on the notion of formal logic as outlined in *Anti-Dühring*. In the section of his notes entitled "On the Classification of Judgments", Engels pointed out:

> Dialectical logic, in contrast to the old, merely formal logic, is not, like the latter, content with enumerating the forms of motion of thought, i.e., the various forms of judgment and conclusion, and placing them side by side without any connection. On the contrary, it derives these forms out of one another, it makes one subordinate to another instead of putting them on an equal level, it develops the higher forms out of the lower. (Engels 1987a, 503-4)

What Engels was trying to say was that, only if the dialectical view of reality was to be integrated into one's method of reasoning, the process of making inferences about the material reality will also in itself reveal a deeper layer of truth, the very principles behind the endless process of becoming and internal transformation of things. Consequently, even if formal logic is capable to reveal what Engels called superficial "form of motion of thought", it still fails to grasp the aspect of inner contradictions in things. This view also played an important role in the later development of dialectical materialism and the notion of dialectical logic.

Possibly the most important conception that in some form or the other underpinned and reverberated through later Marxist reflections on mathematics and logic, was Engels' proposition that there is a correlation between higher mathematics or "mathematics of the variable" and dialectical logic, and between mathematics of constant magnitudes or "static mathematics" and formal logic. This thought was adopted most notably by Plekhanov, who, as we have already mentioned in the context of the 1930s debates, differentiated between dynamic and static variety of logic.

3.2.2. Lenin's Rendition of Engels' Philosophy

Under Lenin, the doctrine of dialectical materialism started gaining a more clear-cut and definite form. Consequently, Lenin's thought also delineated the future political and philosophical tendencies of dialectical materialism in the SU. In comparison to Engels, Lenin gave the essential principles of dialectics of nature a more precise philosophical and political definition. One of his main contributions was also a clearer definition of idealism in context of natural sciences, including mathematics, as well as a more fundamental elucidation of the problem of dialectical and formal logic from the point of view of his extensive philosophical theory of dialectical materialism. Even though Lenin was an incredibly avid and prolific writer (his *Collected Works* comprise 54 volumes), his philosophical views on mathematics and formal logic were epitomised in his *Materialism and Empirio-Criticism* (especially in the second part) as well as in parts of his *Philosophical Notebooks*.

In his *Materialism and Empirio-Criticism* Lenin's primary concern was to identify examples of idealist thinking in contemporary physics, based on the exposition of dialectics of nature as given by Engels. Hence, in the entire book there is almost no mention of mathematics, apart from a few sections, where the word is about the recent synthesis between pure mathematics and physics. However, in the above-named work Lenin still does make some rather important claims, in which he laid down the foundations for the future Marxist philosophy of logic and natural sciences. Thus, for instance, when Lenin spoke about the difference between the "objective law in nature" and "objective causality" as defined by Feuerbach, about its diametrical opposition, the subjectivist line of approach, he pointed out:

> For it is, indeed, clear that the subjectivist line on the question of causality, the deduction of the order and the necessity of nature not from the external objective world, but from consciousness, reason, logic, and so forth, not only cuts human reason off from nature, not only opposes the former to the latter, but makes nature a *part* of reason, instead of regarding reason as a part of nature. (Lenin 1977, 155)

Here, Lenin draws a clear line between human rationality and the states-of-affairs that manifest in concrete physical reality. In his view, a logicist epistemological approach, together with a general deductive approach towards the laws of nature, belongs, without question, to the domain of subjective philosophical inquiries into the physical world. Following

Engels, Lenin therefore suggests that such deductive forms of approach be replaced by a so-called objective logic or dialectical logic. (Ibid., 325)

In the collection of Lenin's philosophical reflection, known as the *Philosophical Notebooks*, a philosophical evaluation of Engels' philosophy of mathematics and natural sciences in general is given in a short text entitled "On the Question of Dialectics" (1915). In this text, Lenin's main aim was to emphasize the dialectical principles which interpenetrate various branches of natural sciences and to point at the dangers of "philosophical idealism", "a road of clerical obscurantism through one of the shades of the infinitely complex knowledge (dialectical) of man." (Lenin 1963, 363) Generally speaking, one of Lenin's main contributions to Marxist philosophy science within the dogmatic corpus of dialectical materialism was his definition of various forms of philosophical idealism in science. However, Lenin also expressed his own views on the problematic nature of mathematics in his "Notes on Rey's *Modern Philosophy*", in the section where he discussed the relationship between the idea of number in mathematics and quantitative properties of matter. Here, Lenin wrote:

> And in relation to true reality, which is living spiritual and creative, mathematics and science as a whole can hardly have more than an artificial and symbolic character. In any case, the fact remains that it was for action on matter, and not for cognition of its essence, that mathematics was created by the intellect, that first instrument forged under the pressure of practical requirements in relation to matter… Is it not mathematics, which, of all the sciences, has in our day most strongly inclined certain minds towards pragmatics, and towards that sophistry of pragmatism, namely scientific agnosticism? In point of fact, it is in mathematics that we feel furthest from the concrete and real, nearest to the arbitrary playing with formulas and symbols, so abstract that it appears empty. (Lenin 1963, 413)

In the part of the notes on Rey's *Modern Philosophy* concerned with Poincaré's idea of "arbitrary nature of mathematics", Lenin expressed an entirely different opinion about the nature of mathematics:

> Of course, our mathematics fully corresponds to reality, in the sense that it is adapted to the symbolic expression of certain relations of the real; strictly speaking, it was not prompted by experience; experience merely gave the mind the occasion for creating it. But, our mathematics, as it gradually became constituted for conveniently expressing

> what we needed to express, is only one of the infinitely numerous possible mathematics or, rather, a particular case of some much more general mathematics which the mathematicians of the nineteenth century have tried to attain. (Ibid., 415)

In the above excerpt as well as in several other places, Lenin saw mathematics, or science in general, as only one kind of possible attempts to create a symbolic description of a multifaceted, complex, and ever-changing reality. A major claim of his meditation on Poincaré's idea of mathematics was that, in essence, mathematics is a form of pure science, which does neither depend nor originate in experience, yet still only serves one purpose, human practice. In a similar manner, Lenin commented on the idea of axiomatic basis of mathematics, noting that:

> Axioms, postulates, definitions, conventions are, in essence, synonymous terms. Therefore, every imaginable mathematics can lead to conclusions which, when properly expressed by a suitable system of conventions, would permit us to discover absolutely identical applications to the real… (Ibid., 416)

Thus, for Lenin, mathematics is at most an attempt to deliver an ordered model of only a fraction of reality. A model, which could take many different shapes, and the only objective of which would be to illuminate the (quantitative) "relations between things from the point of view of order, number and extension." (Ibid., 420)

Furthermore, in parts of his "Conspectus of Hegel's *Science of Logic*", where he discussed Hegel's immensely critical attitude towards mathematics, Lenin defended Engels' positive evaluation of mathematical conceptions, such as, the notion of the infinitesimal, infinity etc.

In contrast to mathematics, Lenin devoted more attention to the idea of an "objective logic" or dialectical logic in Hegel's philosophy. In a lengthier text entitled "Conspectus of Hegel's *Science of Logic*" Lenin provided a closer reading of the essential points of Hegel's *Science of Logic*, through which he intended to develop a view on the relationship between objective (dialectical) logic and other kinds of logic, which would be more in line with the developing philosophy of dialectical materialism. Following the founding-fathers of dialectical materialism, Marx and Engels, Lenin adhered to Hegel's idea that the entire philosophy ought to be constructed on a so-called objective logic, which would have to be absolutely different from the methodological foundations of natural sciences or mathematics. Of course, in Lenin's belief, this new objective logic was the logic of dialectical materialism. In all other aspects, like Marx and Engels before him, Lenin consistently reformulated Hegel's idea of dialectical logic by overturning its ontological foundations. Thus, for example, he pointed out that, in a diametrical contrast with Hegel: "Logic and the theory of knowledge must be derived from 'the development of all natural and spiritual life'" (ibid., 88).[85] In consequence, in Lenin's materialist conversion of Hegel's notion of an objective logic, the latter was seen as:

> …the science of not external forms of thought, but of the laws of development "of all material, natural and spiritual things," i.e., of the development of the entire concrete content of the world and of its cognition, i.e., the sum-total, the conclusion of the *History* of the knowledge of the world. (Ibid., 92-3)

In other words: the dialectical logic as the sole foundation of an objective, materialist philosophy would have to incorporate the totality of the evolutionary laws of the universe, so as to be able to guaranty their adequate integration into every part of the tissue of such a philosophy. Thus, in comparison with Lenin's idea of dialectical logic, formal logic was seen just as a specialised abstraction of the totality of the laws of motion and development, a static image. One of its numerous shortcomings resided in its dependency on a so-called finitist formalism, which, in Hegel's and Lenin's views disagreed utterly with the infinite nature of truth and the universe. (Ibid., 93) In other respects, Lenin more or less adopted Hegel's cynical attitude towards the "old" formal logic, quoting the latter's comparisons of formal logic to a jig-saw game and a nonsensical generalisation of a subjective notion of identity, which had nothing to do with the real nature of reality.

Regarding the basic requirements of an objective dialectical logic, which could replace formal logic and rectify its misconceptions, Lenin reiterated Hegel's claims that these should include: (1) "*Necessary* connection, the objective connection of all the aspects, forces, tendencies, etc., of the given sphere of phenomena"; and (2) "The 'immanent *emergence* of distinctions' – the inner objective logic of evolution and of the struggle of the differences, polarity". (Ibid., 97)

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[85] "Conspectus of Hegel's *Science of Logic*".

Following Lenin's death in 1924, his views on dialectics of nature were taken over by the members of the dialectical school of Marxist philosophers, like Abram Deborin (1881-1963)[86] and others, who reused Lenin's notion of dialectical materialism in their intensive polemics against the so-called Mechanists. The philosophical debates on the proper doctrinal foundations of dialectical materialism were ended by Stalin in 1931, who declared that only the Marxist-Leninist notion of dialectical materialism ought to be regarded as the legitimate version of the doctrine. By 1938, Stalin codified the tenets of Marxist-Leninist dialectical materialism in a publication entitled *Dialectical and Historical Materialism*, a comprehensive exposition of the laws of dialectics in nature and human society, which became the official version of the philosophy dialectical materialism in Soviet Union, also known under the name "diamat".

Because of the above-mentioned establishment of a unified doctrine of diamat as official philosophy of the Soviet Union, in the following decades, the Soviet mathematicians and logicians, as well as other natural and social scientists, found themselves confronted by a more powerful and focused ideological apparatus, which located the source of its ideological reproduction in a constant redefinition of the ideological oppositions between idealism and materialism. Thus, if the Soviet mathematicians wanted to continue conducting their research along with the developmental lines of the current cutting-edge developments in world-mathematics, for them a direct confrontation with the tenets of Marxist philosophy of mathematics was unavoidable. The strategy that the Soviet mathematicians usually applied in their apologetic philosophical discussions on one or the other branch of theoretical mathematics

[86] Deborin's views on dialectical materialism, which were partially founded on philosophy of Lenin, were summarised in his works: *Introduction to the Philosophy of Dialectical Materialism* [*Vvedenie v filosofiiu dialekticheskago materializma*] (1916), *Hegel and Dialectical Materialism* (1929) and so on. Lenin was famously critical of Deborin's earlier writings on dialectical materialism. Later, Deborin was criticised for his inability to differentiate between Hegel's idealist notion of dialectics and a materialist notion of dialectics as conceived by Lenin. From 1929 on, the following works of Deborin have been translated into Chinese: in 1929, Lin Boxiu 林伯修 translated Deborin's *Dialectical Materialism and Natural Sciences* (*Weiwu bianzhengfa yu ziran kexue* 唯物辯證法與自然科學; in the following year, Lin also translated Deborin's *Introduction to Dialectical Materialism* (*Bianzhengfa de weiwulun rumen* 辯證法的唯物論入門); in the same year, Ling Yingfu 凌應甫 published his translation of a shortened version of Deborin's *Introduction*. In 1930s, Deborin's critical discussions of Ilych's dialectics and his booklet on Ulyanov and dialectical materialism have also been translated into Chinese, by Ren Baige 任白戈 and Peng Weisen 彭葦森, respectively.

mimicked the main reproductive mechanism of the state-philosophy, i.e. the application of some form of criticism, where the historical relationship between idealism and materialism was repeatedly redefined, always in a new theoretical context. While these Potemkinian criticisms of idealism in science professed to be carried out in an extreme conformity and abidance to the current ideology, consistently citing from Engels, Deborin and Lenin, in fact their goal was to produce such a definition of, let us say, mathematical idealism, which would actually entail no negative consequences for the theory of branch of their interest. In the cases when their goal was to attain an affirmation for a particular branch or theory, usually, their strategy was either to stress its utter necessity in developing applied mathematics, to portray it as some sort of an utility in the process of achieving more concrete quantitative or qualitative breakthroughs in science and technology, or to emphasize the philosophical nature of idealism historically affiliated with the discipline or theory under question. More or less, the philosophical nature of such debates consequently also required an involvement of some kind of a parallel notion (to dialectical materialism) of philosophy of mathematics, which due to its obvious contemporary status was usually identified in the discipline of *fundaments of mathematics*. Consequently, in order to achieve their goals, Soviet, and later also the Chinese mathematicians, would have to become well-read in the classical and contemporary foundation-works of Marxist philosophy as well as history of science, and skilled in developing philosophical discussions on the nature of science.

In the Soviet mathematical world, the roles of ideological protectors of diversity of theoretical mathematics in 1940s and 1950s were most notably assumed by two leading mathematicians of the Moscow school and later members of the Soviet Academy of Sciences, Andrey N. Kolmogorov (1903-1987) and Aleksandr D. Aleksandrov (1912-1999). In the field of mathematical logic, the same was carried out by Sofya A. Yanovskaya (1896-1966) and others. In the early discussions about the nature of mathematics under Marxist ideology, Yanovskaya and Ernst Kol'man developed a notion of mathematics compatible with Marxist philosophy. The basic features of such mathematics can be summarised by the following four points: (1) Mathematical axioms are based on concrete external reality; (2) Formalism, logicism and intuitionism are forms of mathematical idealism; (3) Mathematics is an empirically positive science. Applied mathematics is extremely important for science; (4) The advancement of mathematics is driven by material or social practice. (Cf. Vucinich 2000)

The present discussion shall focus on Aleksandrov's article "On Idealism in Mathematics" [Ob idealizme v matematike], published in 1951 in the Soviet journal *Priroda* [*Nature*]. Even though Aleksandrov composed numerous such philosophical articles on mathematics, the above-named article seems to have had the greatest influence on the ideological developments in relation to mathematical logic in 1950s China. Due to that reason, here we shall take a closer look at the above-mentioned work by Aleksandrov from the 1951.

3.2.3. Aleksandrov's "On Idealism in Mathematics" (1951)

Aleksandrov's article on mathematical idealism is a typical example of the above-mentioned form of ideological defence of theoretical mathematics or mathematical abstractness through a critical elaboration on the notion of idealism. In his article, Aleksandrov used Lenin's definition of idealism from his "On the Question of Dialectics" in order to show that what is meant by (philosophical) idealism is a form of one-sidedness in the way how knowledge is presented, which possesses one major feature: the divorce of knowledge from matter and nature. Subsequently, Aleksandrov also used another example from Lenin's *Materialism and Empirio-Criticism*, indicating that the latter did not believe in the possibility of autonomous development of idealism in science. Moreover, if Lenin maintained that the natural development of science cannot lead to idealism, about the origin of the latter, he was convinced that it was an exclusively social or philosophical phenomenon, an intentional distortion of facts generated by conditions of the capitalist society.

How does idealism then happen to emerge in mathematics? In Aleksandrov's view, all scientific theories, including mathematics, are abstractions of the reality as a whole. However, since, apparently, according to Lenin, abstractness alone does not yet make up idealism, the main characteristics of mathematical idealism must be a tendency to disconnect mathematical abstractness from the domain of practice. Another major feature of idealism resides in the failure to understand that mathematics is inextricably linked to practice and does not emerge out of the pure mind. By adopting Kant's views on the nature of mathematical knowledge, the capitalist mathematicians perceive mathematics as a purely rational. As an example of Kantian idealism in mathematics, Aleksandrov named Hilbert's contributions to fundaments of mathematics, like his idea of axiomatisation. Nevertheless, this idealism could be avoided by endowing Hilbert's theory with a practical orientation, so that instead of – akin to all idealist sciences – starting in abstractness and ending in abstractness, it would find its ultimate end and verification in practice.

Next example of mathematical idealism listed in Aleksandrov article was the set theory of Cantor or, more specifically, the concept of a set with infinite cardinality, which, according to Aleksandrov, proposed an existence of ideal individuality. However, because in reality there is no such thing as an isolated individual thing, Cantor's conception of an infinite set etc. must be an example of "set-theoretical idealism". As the example of Cantorian set theory clearly indicates, under the influence of the capitalist class mathematics experienced a profound crisis. Other two examples of idealism in mathematics, proliferated by the capitalist society, were the philosophical schools of formalism, logicism and intuitionism.

(1) Formalism: the greatest problem of Hilbert's formalism resided in its insistence of elimination of all contradictions that, in Aleksandrov's belief, stemmed from the natural "mathematical liberty". Such an elimination would further be necessary fallacious, because of the way how Hilbert tried to remake mathematics in the form of a formal calculus and to represent mathematical concepts and theorems using exclusively symbols and formulae. In his Potemkinian criticism, Aleksandrov claimed that by developing this kind of formalism Hilbert intended to facilitate an impression that, because they are written in symbolic form and do not have concrete content, inferences and formulae must be indisputably true. As a Marxist counterargument against mathematical formalism Aleksandrov named Lenin's thesis that dialectics is the property of all aspects of human knowledge, for, most importantly, dialectics is the essence of matter. Therefore, every single proposition must be seen as containing dialectics or, according to Aleksandrov, the "transformative momentous development" and infinity of knowledge. More importantly, this means that not everything can be written down using formulae and that no theory cannot be established with use of formal calculus. Aleksandrov goes on saying that, beside Lenin, the impossibility of formal basis of mathematics was also demonstrated by Gödel, who showed that such a representation of mathematics would be incomplete. The main objection against mathematical formalism was the way in which it propagated a divorce of mathematical form from matter.

(2) Mathematical logic and foundations of mathematics: Aleksandrov claimed that the formalisation of mathematical logic was a necessary stage in the development of mathematics. Nevertheless, mathematical formalism wanted to settle entire mathematics solely on this basis, transforming it into the fundaments of mathematics.

Because such theoretical efforts were deemed in a complete dissonance with the nature of reality, mathematical formalism of Hilbert and Russell are profoundly reactionary and need to be criticised and attacked.

(3) Intuitionism: according to Aleksandrov, in intuitionism "mathematical liberty" s scrutinised in the same way as the above-mentioned formalism. Quite naturally, from Marxist perspective, by basing mathematical knowledge on human intuition Brouwer's intuitionism fails to recognise the real origin of mathematical knowledge, that is in concrete, objective reality. Furthermore, the intuitionists also fail to understand that every kind of knowledge is the product of a collective historical development of the society and does not pertain to individual spheres of human existence. According to Aleksandrov, the most commendable aspect of mathematical intuitionism resided in the fact that they rejected Cantorian set theory.

As an important point of contention between the so-called set-theoretical idealism, formalism and intuitionism, Aleksandrov named the existence theorem in mathematics, that have the function to affirm the existence of particular mathematical objects. Aleksandrov pointed out that the real problem resides in a subgroup of existence theorems known as the "theorems of pure existence" that fail to define the practical aspects of the mathematical objects in question. By giving the example of pure existence theorems, Aleksandrov wanted to show how each of the above-named mathematical idealisms fails create a link between theory and the material world or to develop practical applications out of their theoretical abstractions.

In their essence, Aleksandrov's conclusions to the question of mathematical idealism allowed greater ideological "liberty" for theoretical mathematics. At the end of his reflection his main conclusion namely was that, regardless of whether we are speaking about existence theorems or any abstract mathematical objects or theories, they all come from and consequently also reflect a part of the complex whole of the material reality. Because such abstractions are the integral part of each natural science, the only important question which decides their ideological value is, in what way these abstractions are related to objective reality and, even more importantly, can these also be used in practice?

Maybe Aleksandrov's greatest defence of purely theoretical mathematics were the two points he made at the end of the article, indicating that: (1) Even if every abstract or general conclusion we make in science is a partial reflection of only one aspect of reality, in fact the things which exist in the particular and concrete are also abstract and general. So that, because practice is always related to concrete objects and phenomena, it cannot be used to disprove mathematical conceptions such as the existence theorem. (2) One of the basic requirements for science cannot be that every example scientific theory can produce practical results. As an example thereof, Aleksandrov mentions important methodological tools in science, such as mathematical logic and its notion of logical consistency.

In the 1940s and 1950s, a great number of other articles related to Marxist philosophy of mathematics were published in Soviet journals and magazines like *Priroda, Voprosy filosofii*, *Vestnik Leningradskogo universiteta* etc. For example, in early 1950s, Aleksandrov further published articles like "The Dialectics of Lenin and Mathematics" (Leninskaja dialektika i matematika) (1951)[87] and other similar articles which discussed scientific and philosophical state of mathematics in the SU. In the year of the publication of Aleksandrov's article "On Idealism in Mathematics", the journal *Priroda* also published Yanovskaya's article on the same subject, entitled "Progressive Ideas of N. I. Lobachevsky – An Instrument of Struggle against Idealism in Mathematics" (Peredovye idei N. I. Lobachevskogo – orudie bor'by protiv idealizma v matematike). However, because, after Aleksandrov's publications from 1950 and 1951, idealism in mathematics became inextricably associated with Cantorian set theory, Hilbert's formalist fundaments of mathematics, Brouwer's intuitionism, and most importantly Russell's logicism, the indirect effect of the ideological defence of mathematics was a subsequent rise in criticisms against mathematical logic and fundaments of mathematics, which from late 1940s on had already been considered as two aspects of one single part of mathematics. Consequently, in following years Soviet mathematical logic experienced another wave of ideological criticisms, in which mathematical idealism was reinvented over and over again and Russell's logicist tendencies which took form in his mathematical logic were branded as counter-revolutionary elements devised by the British capitalist class.

[87] This article was first published in 1950 in *Vestnik Leningradskogo universiteta*.

3.3. Mathematical Logic and Foundations of Mathematics in the Soviet Union (up to 1950s)

Akin to Soviet mathematicians, following the codification of dialectical materialism in late 1930, those Soviet mathematicians and logicians who studied mathematical logic and foundations of mathematics were also forced to realign the philosophical basis of these two fields with dialectical materialism and thereby to invent the demarcation between its historically inherent idealist elements and its "objective" scientific content. Before the 1950s, in so doing they had to rely mainly on the classical doctrine about the relation between diamat and logic, such as found in Engels, Lenin, Plekhanov and so on. However, after 1951, the harmful idealistic elements of mathematical logic have already been identified in the four types of mathematical idealisms mentioned above, while its theoretical irreproachableness was seen as disassociation with those harmful influences on one hand and its direct applications in technology on the other.

To a certain extent, the ideological character of mathematical logic in the Soviet Union had been settled already before the year 1948, when Yanovskaya's evaluation of the last three decades of Soviet mathematics was published as a part of the immensely important *Thirty Years of Mathematics in the USSR, 1917-1947* [*Matematika v SSSR za tridcat' let 1917-1947*]. Aside from an in-depth analysis of the results in the above-named branches of mathematics, Yanovskaya provided an outline of Soviet results in mathematical logic, based on the philosophy of dialectical materialism and Engelsian dialectics of nature. According to Yanovskaya's report, the Soviet mathematical logic derived from the supposition that the propositions of pure mathematics must necessarily correspond to reality – they have a necessary positive value. In the words of the logician George L. Kline, who reviewed Yanovskaya's report in 1951:

> On the Soviet view, the formal axiomatic systems of mathematics – which admit of many qualitatively different interpretations – rest on a material arithmetic, in which numbers ant the relations between them are univocally defined. The spatial forms of quantitative relations of the material world are the specific subject-matter of mathematics. In contrast to Carnap and the logic positivists, A. N. Kolmogorov asserts that a formal apparatus is valid only when it "corresponds to a real content." (Kline 1951, 46-8)

Furthermore, according to Yanovskaya, because of their strict adherence to the principles of dialectical materialism, Soviet mathematicians recognised no such thing as the "crisis" of mathematical foundations. What they did recognise were certain problems regarding the formalisation of mathematical foundations through mathematical logic, the problem with some ideas of mathematical infinity, and the law of excluded middle. Yanovskaya claimed that, with regard to the law of the excluded middle, some Soviet mathematicians like Shatunovsky and Kolmogorov had similar ideas and reservations like Brouwer and later Gödel. Kolmogorov's views on the law of the excluded middle, for instance, allegedly predated Gödel's findings from 1932 for about seven years. Albeit the notions of logical paradoxes as developed in Western mathematical logic and set theory indeed were recognised by Soviet mathematicians, but, form most part, their philosophical reliance on the principles of dialectics of nature had made them realise that these paradoxes were a main feature of reality, a mere reflection of the dialectical laws of nature. Ultimately, Yanovskaya also mentioned that the main focus of Soviet mathematical logicians were technological and practical applications of the results of mathematical logic in general. Therefore, in the last few years before 1948, Soviet logicians and mathematicians focused on topics like: applications of logical calculi and Boolean algebra in solving technological problems like "electrical relay-contact circuits", applications of many-valued logics, and theory of recursive functions and the completeness-problem of logical calculi (Markov and Zykov). (Ibid., 47-8)

While the first part of her report Yanovskaya focused on philosophical questions related to mathematical logic and the foundations of mathematics, trying to ascertain the ideological "orthodoxy" of Soviet experts in the field, in the second part of her discussion she tried to develop her own justification of mathematical logic as an important building-stone of the future Soviet science. Beside praising the philosophical significance of Karl Marx's *Mathematical Manuscripts* which had recently been (re?)translated into Russian, she provides three arguments in support of the above-mentioned motion for mathematical logic: Firstly, she tried to show that there was a great patriotic value in the great efficiency of mathematical logic, pointing out that, in the past, Soviet mathematicians like Kolmogorov had already made great contributions to the field. Secondly, she showed that dialectical materialism is highly compatible with mathematical logic. As an example, she mentioned Gödel's refutation of the formalist conception of mathematics. In relation to the problematic – from the standpoint of diamat – treatment of contradiction in mathematical logic, she argued "that an interpreted axiomatic system can, nevertheless, be contradictory if we do not take special precautionary measures concerning the formulation of the axioms and the applicable means of logic deduction." (Küng 1961, 40) In her opinion, the solution, which would enable a simpler fusion of dialectical materialism and mathematical logic, was to construct a system of axioms which exclude the validity of the *tertium non datur* principle. And thirdly, mathematical logic can be extremely usefully applied in mathematics and cybernetics. (Ibid., 39-40)

Even though, based on the 1948 report written by Yanovskaya it may appear to us that by the late 1940s mathematical logic had already been well-established at Soviet scientific institutes and universities, in fact its recognition had only been the product of some very recent developments that caused some minor alterations in the official educational policy in relation to logic. Thus, for instance, before 1947, in the Soviet Union there was no textbook on mathematical logic and mathematical logic was taught and research only at a handful of institutions. Yanovskaya, for example, had formerly taught mathematical logic at the School of Mechanics and Mathematics (in Moscow?), while it was only in 1946 that she was also allowed to teach the same subject in the framework of the School of philosophy (see Bocheński 1961, 31; 1973, 2). The change in institutional status of mathematical logic was spurred by the debates on the nature of logic in philosophical context of dialectical materialism which broke out in 1946, after the Central Committee of the Communist Party issued a directive by which the teaching of logic was to be introduced to secondary education. What seemed a fairly simple task entailed a vast array of ideological difficulties, all of which revolved around the problem how to interpret various forms of logic in context of dialectical materialism. In consequence, between 1946 and 1950 a series of all-Union conferences on logic were organised with one single goal, to develop an official doctrine about the nature of logic. The third and last such symposium took place in 1950, at which it was proclaimed that "a high degree of unanimity appears to have been reached upon the main issues." (Campbell 1952, 278) As in the case of the early Soviet debates on dialectical materialism the early discussions on logic were stopped by Stalin himself, who promulgated his philosophical views on language and linguistics, proclaiming that human language is not a class-bound phenomenon. (Bocheński 1961, 30) Because language, which had now become viewed as an entirely natural and objective entity, essentially pertains to the mechanism of thinking, the same could also be said about the nature of logic. Bocheński (1973, 6) noted that, because of these doctrinal developments, at the time Soviet philosophers recognised three different forms of logic: dialectical, formal and mathematical. He further noted that Stalin's declarations on language from 1950 had strongly legitimised formal logic, which consistently became a widely recognised as an important scientific tool.

Nonetheless, the debate did not stop there. After the conclusions of the symposia on the nature of logic were released into the public sphere, their main conclusions were critically revised by leading Soviet scientists, mathematicians and other kind of experts. One such recapitulation of the debates was I. I. Osmakov's "On the Logic of Thinking and the Science of Logic" from 1950. Among other, Osmakov's article was also sharply criticised by Aleksandrov, who responded to it by publishing an article "On Logic" in *Voprosi filosofii* in the following year.[88] In his article on logic Aleksandrov disputed against the main points made in Osmakov's article, including the sharp division between logic as the activity of human reason (or the logic of thinking) and science of logic, in the framework of which dialectical logic was portrayed as the sole objective science of logic.[89] Instead, Aleksandrov proposed that as a most advanced version of "formal logic", mathematical logic was to be provided with a new dialectical basis, derived from Hegelian notion of dialectical logic. Almost immediately, a wide-scale debate on idealism in mathematical and formal logic ensued. Within the same debate the classical questions on the relation between formal and dialectical logic and concept of logical contradictions were also raised.[90] One of the most influential articles published in the framework of the 1950-1951 debates, which also influenced the development of the discourse in 1950s China, was the essay entitled "Against Idealism in Mathematical Logic" by

[88] *Voprosi filosofii,* 3.

[89] This position was derived directly from Stalin's proclamation on the nature of language and linguistics. In analogy to language as a universal, natural phenomenon, the same position needed also to be reserved for logic. Nevertheless, if there is only one correct logic of thinking, in history there have been many different sciences of logic. But since the science of logic has only got one object of investigation - development of judgments, concepts and logical forms – which pertains exclusively to the realm of logic of thinking, and which in turn reflects the most principal laws of the universe, it follows that there can only be one single science of logic, an objective logic, which would also be able to embody the interpenetration and ceaseless development of all things. In other words: in the Soviet Union there can only be one officially recognised logic: dialectical logic. According to the views outlined in Osmakov's article (1950), formal logic was to be discarded from any such official form of logic.

[90] For a detailed account on these debates see, for example Wetter 1958, 523-535; Bocheński 1963, especially Chapter V, Subchapter 5 ("The Situation of Formal Logic") and Appendix I ("The Principle of Contradiction and Logistics"). On the discussion on contradiction see Lobkowicz 1959 and so on.

L. E. Majstrov and V. P. Tugarinov.[91] Basically, Majstrov and Tugarinov reiterated the conclusions of the early debates on logic as summarised by Osmakov, asserting that mathematical logic is an extreme example of a discipline which was infiltrated by idealism. The claimed that mathematical logic may well be a legitimate part of mathematics, but it is not logic (or science of logic). Beside their general objections against mathematical logic, Mojstrov and Tugarinov also developed a critical review of Yanovskaya's translations of Hilbert and Ackermann's *Grundzüge der theoretischen Logik* and Tarski's *Introduction to Logic*, which were created and published as a result of the changes in the status of formal logic in the final years of the 1940s. They labelled both works as examples of mathematical idealism, because they were allegedly only interested in the rules for using logical connectives and express their contempt of empirical science, respectively. In their view, however, the essential characteristics which made both work idealist was their lack of reference to reality. They further claim that the axioms used in mathematical logic ought to be only assumed following a practical proof, a view which was later emphatically disproved by Aleksandrov. Majstrov and Tugarinov even went one step further by claiming that there is no such thing as a purely deductive science, for as Lenin and Engels have shown even mathematics has got an empirical basis. Having been the most prominent mathematical logician in the country and the translator of the above-mentioned works, Yanovskaya was also not spared of their criticism. (Kline 1952, 128-9) Because they accused her of disseminating idealist convictions, Yanovskaya was forced to compose an essay, in which he repented for having had propagated idealist beliefs. She consequently admitted that mathematical logic was not general logic, not even the logic of mathematics, but just a set of tools for specialised mathematical research. (Bocheński 1973, 6) Later she attempted to reformulate what she was forced to admit in her self-criticism, arguing that mathematical logic can be essentially connected to the philosophical principles of Marxism-Leninism. (Ibid.)

An extended debate on the relationship between formal logic, which was opened by the editors of the *Voprosy filosofii,* went on up until December 1951, when it was also officially closed by an editorial statement. The most important contributors to this second leg of the discussion were B. M. Kedrov, V. K. Astaf'ev, B. I. Lozovsky etc. Among them, Kedrov

[91] Leonid Majstrov was a Soviet philosopher, who in late 1940s wrote a PhD dissertation on "The Struggle of Materialism against Idealism in the Theory of Probabilities", in which he set out to describe two historically opposing trends in theory of probability, namely a materialistic and an idealistic theoretical tendency.

called for revision of extreme positions on the relationship between formal and dialectical logic, emphasizing that Plekhanov's views on logic had essentially endangered the development of logic in the SU. Kedrov believed that the former's views have led to the development of the idea that formal logic is a lower form of logic, which can be integrated to form a single dialectical logic. According to Kedrov, another false belief in relation to formal and dialectical logic maintained that there existed two separate forms of logic, dialectical and formal, which meant that formal logic can be essentially "dialecticised". In exposition of his own views on the problem, Kedrov emphasized that, as Engels had stated, between formal and dialectical logic there existed the same relationship as between elementary and advanced mathematics, which meant that both ought to be treated like that. This meant, in short, that formal logic ought to be used in the scope of its limited capacities centred on the use its of four basic laws, and that, as the logic of change, as embodied in the concept of variable, dialectical logic ought to be used within its own scope. In many cases, though, Kedrov admitted, these two scopes overlap. In that case we must understand that dialectical logic possesses an objectivist precedence over the former, which is a highly abstract form of scientific tool.[92]

Far away from the ideological front and concealed within the discrete confines of theoretical mathematics, in the early 1950s, Soviet research in mathematical logic started to thrive. A strong epicentre of research in mathematical logic in Soviet Union was the circle of mathematicians gathered around Kolmogorov. In 1952, Kolmogorov's PhD student, Vladimir A. Uspensky started studying the theory of recursion, and in 1954, when his translation of Rózsa Péter's *Rekursive Funktionen*, also introduced the subject to a wider circle of Soviet mathematicians. Consequently, in 1953 a seminar on "Recursive Arithmetic" was started organised by Kolmogorov and Uspensky. (See Uspensky 1992)

The political developments following Stalin's death in 1953 were also in favour of mathematical logic. By 1955, among philosophers the interest in various aspects of mathematical logic grew considerably. In the same year a number of publications on mathematical and formal logic were published. Subsequently, in 1956 a seminar for logic was also organised at the Institute of Philosophy of the Soviet Academy of Sciences (IPSAS). (Bocheński 1961, 30) When in the same year the third all-Soviet mathematical congress took

[92] The debate was reviewed already in 1953 by George L. Kline. Kline's review of the second part of the debate was published in *The Journal of Symbolic Logic* (18(1), 83-86).

place in Moscow, there was already a panel for mathematical logic and foundations of mathematics. In the context of the panel around sixteen papers were presented by Soviet mathematicians and logicians.

By 1958, the circumstances in Soviet research in logic had already changed to such an extent that the main question raised at the national conference on logic, which was held under auspices of the philosophical section of the Scientific-Technical Council of the Ministry of Higher Education, was how to advance research in formal logic at a national level and how to increase the number of institutes, where logicians could be trained. The status of mathematical logic also changed in main scientific and philosophical journals, such as *Voprosy filosofii.* Furthermore, since the traditional cleavage between dialectical and formal logic was not anymore regarded as problematic all was set for more fundamental reforms in Soviet system of education. In the framework of the 1958 logical conference the conference board submitted a proposition for a five-year training program in the science of logic to the Soviet Ministry of Higher Education, a program which was based predominantly on mathematics and mathematical logic – some special courses on dialectical logic and cybernetics were also a part of the curriculum. (Ibid., 25-6) Finally, in 1959, on the occasion of the 40th anniversary of the founding of the Soviet Union, Yanovskaya submitted her second report on mathematical logic and the foundations of mathematics, mathematical logic was not an ideologically problematic discipline anymore. Thus, henceforth, authors like Russell, Wittgenstein, Carnap of Peirce were not anymore subjected to intensive criticism but put under meticulous analyses.

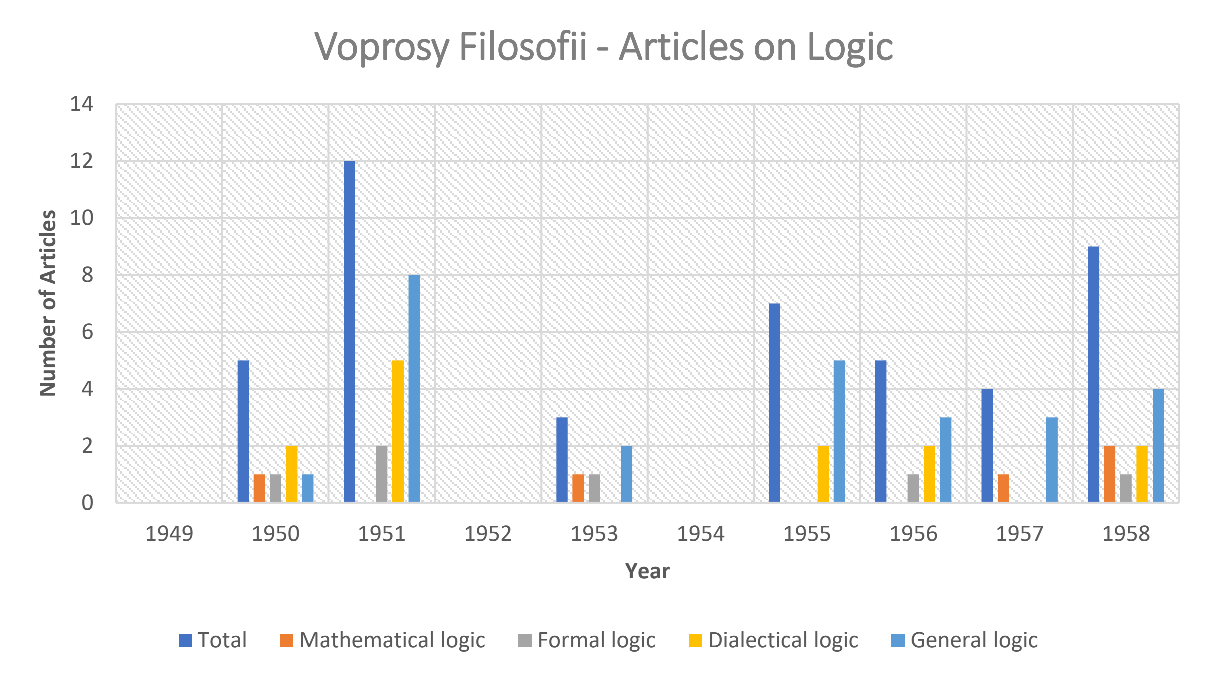

Table 2: Number of publications on different "kinds" or aspects of logic, published in the Voprosy filosofii between 1949 and 1959.

In her report from 1959, Yanovskaya could already openly stated that mathematical logic was no longer "a mere philosophical appendix to mathematics but has become a recognised branch of science" (Küng 1961, 41). Furthermore, topics like, for instance, intuitionist models of mathematical logic, which had recently gained great popularity among Soviet logicians, were not anymore considered to be idealistic. Yanovskaya also reports that from 1957 a special department for mathematical logic existed at the Institute of Mathematics of SAS. At Soviet universities, two main circles of mathematical logicians exited, one cantered around Kolmogorov at Moscow University and another around P. S. Novikov of the Leningrad University. Smaller groups studying mathematical logic were also organised in Riga, Ivanovo, Gorki etc.

As shown in Table 2, trends in publishing of logic-related articles and other monographs were consistent with the ideological situation in the Soviet Union. Of course, if viewed upon as an isolated phenomenon pertaining to the contemporary political climate in the SU, this kind of development was more than expected. However, if put in perspective with developmental twists and turns in, as it were, Chinese Marxist ideology, this might also explain some particular developments in Chinese Marxist notion of logic – at least in the earliest phase of emulation. As we shall try to illustrate in the subsequent parts of this discussion, in the period between 1949 and 1956, the above described trends in Soviet logic have had a significant influence on ideological developments in Chinese mathematics and logic, not only because of the fact that these publications represented the principal source of material, but also because in the process of emulation these fluctuations in quantity and contents of the publications also had a concrete ideological meaning for Chinese intellectuals as well as the leading government officials. In this context, it must be noted that the ideological vacuum which took place in the Soviet Union in the years immediately following Stalin's death, which also brought along a sudden drop in material which could be translated into Chinese, had also created a window of chance for the Chinese to develop their own autonomous discourse in dialectical materialism and start their own ideological trajectory. Since Chinese translations of Soviet articles had an average delay of one or two years, a sudden lack of material for ideological revision and translation would be felt in China only around 1955 or 1956, when Chinese intellectual climate was at the verge of entering into a period of severe changes and disruptions, starting with the Hundred Flowers Campaign. Furthermore, after a series of changes in Chinese scientific and educational policies which took place in China in 1956, the Chinese scientists imbibed with hope for a more open Chinese science, understood the ideological moderation which was steadily developing in Soviet science as an important point of reference in the arguments for ideological and scientific innovation, a clear sign that disciplines such as mathematical logic and foundation of mathematics were bound to attain a higher degree of freedom and ideological irreproachability.

3.4. Mathematics, Mathematical Logic and Marxist Philosophy of Science in China, 1949-1959

As I have already shown in the foregoing sections of this discussion, the transfer of Marxist philosophy of science to China had already started in the 1920s. In the framework of early Chinese-Soviet cooperation prior to 1928, the first generation of Chinese students was sent to the SU. Their subsequent return to the homeland was correlated with the sudden increase in treatises and translations of works of dialectical materialism.

As regards Marxist philosophy of mathematics and logic, before the year 1930 Chinese proponents of dialectical materialism had already produced translations of classics such as Engels' *Anti-Dühring*.[93] On the other hand, the first translation of Engels' *Dialectics of Nature* was published in form of fragments or pamphlets usually comprised of one or more chapters from the book. An early example of such translation was Lu Yiyuan's (陸一遠, ?) pamphlet "Marxist Theory of the Origin of Humanity" (Makesi zhuyi renzhong youlai xueshuo 馬克思主義人種由來學說) from 1928. As already mentioned, in 1932 a complete translation of Engels' *Dialectics of Nature* was published by Du Weizhi. In the early 1930s, a wide variety of different writings on dialectics of nature was further published in Chinese periodicals. At the same time, Chinese Marxists started producing their own discussions about the main principles of dialectical materialism and dialectics of nature. Towards the second half of the 1930s, Lenin's thought became an important focus of Chinese proponents of dialectical materialism. While Lenin's critique of physics had already been introduced to Chinese readership in 1930 through the translation of the book *Materialism and Empirio-Criticism* by Di Qiu (笛秋, ?) and Zhu Tiesheng (朱鉄笙, ?), a rise of interest in other aspects of Lenin's work, such as the content of his *Philosophical Notebooks*, was a phenomenon of the later years. A more than significant rise of Chinese translations of Lenin's works and Soviet books on

[93] Xu Yibao (2005, 220) wrote that the first translation of *Anti-Dühring* into Chinese was done by Qian Tieru (錢鉄如) in 1929. According to Xu, Qian created his translation on the basis of an earlier Japanese translation of the work. One year later, in 1930, however, another translation was made by Wu Liping (吳理屏), which in the years to come also became the standard translation of the work. Still, Qian's translation was republished in 1932 by the *Kunlun* publishing house in Shanghai. Wu Liping's standardised translation, in contrast, was re-issued for many times by different publishers as for example the *Bigengtang shudian* in Shanghai (1932) and the *Shenghuo shudian* (in late 1930s and 1940s). In addition, Engels' *Ludwig Feuerbach and the Outcome of German Classical Philosophy* was also translated for many different times in the early 1930s.

Lenin's philosophy occurred in 1938, when Stalin proclaimed Marxist-Leninist dialectical materialism the official philosophy of the SU. Between 1929 and 1948 almost 100 books on Lenin's thought were published in Chinese, including a few volumes of Lenin's *Collected Works*.

Apart from works by Engels and Lenin, in the 1930s, philosophical works of many other Soviet philosophers, such as Borisovich M. Mitin, Deborin and Vladimir Molodshii,[94] were also translated into Chinese. From 1930 on, translation activities and discussion of dialectical materialism was proliferated by the so-called Alliance of Chinese Social Scientists (Zhongguo shehui kexuejia lianmeng 中國社會科學家聯盟) organised by the CPC, with one objective, to disseminate dialectical materialism and propagate the Marxist discourse on social and natural sciences. (Xu Yibao 2005, 222)

All the above-described activities of the members of CPC and adherents of dialectical materialism in China led to the development of a series of public debates on different aspects of dialectical materialism throughout the 1930s. Since in my previous work I have already outlined the 1930s debates on dialectical and formal logic (see Vrhovski 2021b), here, I shall only note that, albeit that the influx of dialectical materialism in the 1950s differed considerably from the development of Chinese discourse on dialectical materialism in the 1930s, the earlier debates were an important segment of a continuous ideological development that bore its fruits after the period of emulation had ended and Chinese ideological trajectory took a new direction. In many different respects, the second round of debates on logic that took place in 1950s China continued the debates from 1930s. The early developments of dialectical materialism in China represented an indelible experience in the history of Chinese Marxist philosophy, which, although at first rather invisibly, manifested itself in future Chinese ideological trends.

Between 1937 and 1947, Chinese Marxist philosophy continued its development in the milieu of wartime Yan'an, where the headquarters of the CPC were located. In this period, another important ideological pillar of Chinese Marxism had also emerged in Yan'an, under the influence of the current Chinese discourse on dialectical materialism, namely Mao Zedong's interpretation of dialectical materialism.

[94] Vladimir N. Molodshii's *Effektivizm v matematike* (*Effectivism in Mathematics*) was translated by Chen Xiaoshi (陳曉時) in 1940.

3.4.1. The Bases of Maoism and the Problematics of Mathematics and Logic

Although, in the years following the establishment of the PRC, Mao did have an indirect influence on the development of formal or mathematical logic in China, this influence did not derive so much from his philosophical readings of dialectical materialism as much as it was a consequence of his personal decisions and views on logic and science as such. Nonetheless, formally, his philosophical works from the Yan'an period were extremely influential. As a matter of fact, even though Mao's writings from 1930 did not directly address any specific philosophical questions related to mathematics and logic, in the public discussions of the late 1950s they were referred to as important sources of ideological instruction necessary for resolving the most important doctrinal problems. Moreover, during the Great Leap Forward (GLF) campaign of 1958 and 1959, when the ideological developments took a "Chinese turn", their political significance grew even stronger. Therefore, a brief overview of main tenets of early Maoism is necessary for our analysis.

Mao's philosophical thought formed in the Yan'an period. His interest in dialectical materialism seems to have been the strongest in the years between 1936 and 1937, when he composed the famous political lectures delivered at the Anti-Japanese Military and Political College in Yan'an. (See Xu Yibao 2005, 231-7) In these lectures Mao provided his own interpretation of dialectical materialism, which he intended to use against those problematic members of the CPC who adhered to partial and incorrect interpretations of dialectical materialism. In other words: he wanted to use them as a weapon against his political rivals and establish his own vision of Chinese Marxism as the correct political doctrine of the CPC. Three parts of his lectures are relevant for the present discussion: "The Question of the Object of Dialectical Materialism", "On Practice" and "On Contradiction".[95]

[95] Mao's "On Practice" (Shijian lun 實踐論) and "On Contradiction" (Maodun lun 矛盾論) were written in July and August 1937 and published only on December 19, 1950, in the *Renmin ribao*. (Holubnychy 1964, 12) Originally, "On Practice" and "On Contradiction" were parts of the third chapter of Mao's notes of his lectures *Dialectical Materialism*. The first chapter and the first half of the second chapter were published in 1938. Other parts, including the parts on practice and contradiction, were also mimeographed during the Yan'an period and circulated in the Communist-controlled areas. (Xu Yibao 2005, 232) The part entitled "The Question of the Object of Dialectical Materialism" was originally a part of the second chapter of Mao's notes. See also Mao Zedong 1999, ci-cii.

Because Mao wrote his lectures before Stalin's codification of "Diamat" in 1938,[96] his views were still immersed in the earlier discourse centred on the Soviet debate between dialecticians and mechanists. At the same time, his views were also motivated by the current ideological trends in the CPC.

In his *Dialectical Materialism (Lecture Notes),* Mao juxtaposed the relationship between idealism and materialism with the opposition pertaining to two different views on the relationship between matter and spirit: idealism stresses spirit over matter and vice versa. Mao described this historical opposition as "the struggle between two armies of philosophy". (Mao Zedong 2004, 573-6) Contrary to idealist philosophy, dialectical materialism provides a unitary and objective philosophical outlook. In his definition of the nature of dialectical materialism, Mao closely followed Lenin's views. In the chapter on "The Question of the Object of Materialist Dialectics – What Does Materialist Dialectics Serve to Study", drawing from Lenin's *Philosophical Notebooks*, Mao described dialectical materialism as the "science dealing with the principles of the development of the objective world". (Ibid., 582) Moreover, this developmental aspect of reality was also considered the only possible comprehensive view of the world: everything is constantly changing. Furthermore, in Lenin's view, the objective perspective encapsulated in the science of dialectical materialism had also a corresponding logic, an objective dialectical logic, capable of reflecting not only on the static formal perspective of thought but being also "a science which deals with the principles of development of all material, natural, and spiritual phenomena" (ibid.).

Mao understood dialectical materialism as a synthetic totality of all objective principles and perspectives as otherwise contained in science. The scope of dialectical materialism was thus not limited to a single object of investigation, the laws of universe. Hence, it necessarily also embodies aspect such as epistemology, ontology, and logic. He recapitulated Lenin's thought, remarking that "materialist dialectics is the only scientific epistemology, and it is also the only scientific logic" (ibid., 584). According to Mao, the latter statement rested on the fact that: dialectical materialism also studied the "representations in human thought which reflect the principles of development of the objective world." Defined in that way the unified evolutionary perspective of the world inherently also encapsulates social history, which means that the principles of dialectical materialism must necessarily serve as the basis of both,

[96] A Chinese translation of Stalin's dialectical materialism appeared in 1939.

scientific development and social development. In this sense, all aspects of human knowledge and practice must be conducted in accordance with dialectical materialism as one single objective epistemology and logic. This practical social aspect of dialectical materialism is covered in Mao's lecture "On Practice".

Echoing the current Soviet philosophical discourse, in his lecture "On Practice" Mao asserted that practice of material production is the only source of knowledge and consequently also the basis of social production of science, politics or class struggle. Of these Mao considered class struggle as central for development of knowledge. (Ibid., 602) This view was also in consonance with the pre-1950 situation in Soviet philosophy, where every aspect of social practice was believed to have a class-related character. In other words: every aspect of social production could be connected to the ideology and social foundations of a particular social class. In turn, this also implied that, as Mao himself also noted, "social practice alone is the criterion of the truth of his knowledge of the external world." (Ibid., 603) In the context of early Marxist philosophy, this view could only hold because dialectical materialism was also considered a class-related phenomenon, as was material practice and proclivity to work in accordance with the objective laws on nature. As Mao himself remarked, "class nature" was only one aspect of Marxist philosophy, another important aspect was also "practicality", which stipulated that theory depends always on practice and must consequently also always serve practice. (Ibid.) Regarding the forms of knowing, which can arise from social practice, Mao noted:

> *The real task of knowing is not perceptual knowledge but rational knowledge.* The real task of knowing is, through perception, to arrive at thought, to arrive at the comprehension of the internal contradictions of the objective things, of their laws and of the internal relations between one process and another, *of internal relations between objective processes,* that is, to arrive at theoretical knowledge. To repeat, logical knowledge differs from perceptual knowledge in that perceptual knowledge pertains to the separate aspects, the phenomena, and the external relations of things, whereas logical knowledge takes a big stride forward to reach the totality, the essence, and the internal relations of things and discloses the inner contradictions in the surrounding world. Therefore, logical knowledge is capable of grasping the development of the surrounding world in its totality, in the internal relations of all its aspects. (Ibid.)

The above excerpt from Mao's "On Practice" reveals his positive disposition towards logic, which was one of the crucial factors behind the relatively unique development of Chinese discourse on logic after 1956. An important characteristic of Mao's thought was a lack of rigidity when it came to the classification of logic. He clearly envisaged an idea of "logic" as q method possessing the great potential of delivering a comprehensive view on the basic laws of reality. This might have been a direct consequence of the high status the notion of logic had enjoyed in the Republican period.

In the final lines of his lecture on practice, Mao emphasized:

> Produce the truth through practice, and again through practice verify and develop the truth. Start from perceptual knowledge and actively develop it into rational knowledge; then start from rational knowledge and actively guide revolutionary practice to change both the subjective and objective world. Practice, knowledge, again practice, and again knowledge. This form develops in endless cycles, and with each cycle the content of practice and knowledge rises to a higher level. Such is the whole of the dialectical materialist theory of knowledge, and such is the dialectical materialist theory of the unity of knowing and doing. (Ibid., 614-5)

Even though Mao essentially adopted the view that all knowledge originates in practice, the above-described dialectical process of development of knowledge acknowledges the importance of theoretical knowledge. A major corollary to the above statements is that theoretical science ought to be allowed and promoted, yet at the same time in theoretical science there also ought to always exist a strong practical orientation, an inclination to make its results applicable in practice (technology).

Mao's *Dialectical Materialism* consisted also of a chapter "On Contradiction". Mao's reflections on contradiction were far more complicated from his previous lectures on dialectical materialism. By the time, when the text was officially published in 1950, Mao already modified some of the sections of the original text and added an entirely new section entitled "The Law of Identity in Formal Logic and the Law of Contradiction in Dialectics" (ibid., xxxii). According to Stuart Schram (ibid., xxxii) this section was added "because he changed his view on formal logic after reading Stalin's *Marxism and Questions of Linguistics*." However, a close reading of Mao's exceptionally narrow discussion on the nature of formal logic reveals its close resemblance to the arguments of the 1930s debates. In fact, it seems that

Mao's writing meticulously summarised all the important points of criticisms raised by the proponents of dialectical materialism against formal logic.

Mao noted that the entire formal logic rests on the law of identity, where the notion of identity is devoid of the dialectical principle. Repeating after Plekhanov, Ye Qing and others, he claimed that formal logic is based on a fixed, static view of things, which makes it antagonistic to dialectics. (Ibid., 625-6) In contrast with formal logic, which rests on a reactionary notion of absolute identity, Mao believed that the most fundamental law of dialectics resided in the law of "interpenetration of the opposites" or the law of contradiction in dialectical logic. He believed that, as the second and third laws of formal logic can be derived from the law of identity, so can the law of mutual transformation of quality into quantity and the law of negation of negation be derived from the law of contradiction. Furthermore, contradiction was the most fundamental law of existence as such.[97] Otherwise, in his entire exposition of laws od dialectics Mao consistently adopted Engels' views from *Dialectics of Nature* as well as its extended interpretation developed by Lenin. Hence, in his contradiction he also mentioned examples of how the principle of contradiction is manifested in mathematics, mechanics, chemistry and so on.

Notwithstanding Mao's clear positioning on the question of formal logic as expressed in the later version of the lecture "On Contradiction", his later position towards formal and mathematical logic remains somewhat unexplained and mysterious. For, as we noted earlier, Mao was the main force which set in motion the great debates on logic in 1950s. Many sources from the time also mention that Mao was an ardent believer in the significance of "logic" as an important driving force behind the future Chinese scientific development. On one occasion in 1956, he allegedly said to Jin Yuelin that: "nonetheless, mathematical logic is a useful thing, which we need to go in for. I hope that in the future you will write a short booklet on mathematical logic. If you will, I will certainly read it." (Liu Peiyu 1995, 407) Now, although this does not explicitly prove that Mao was in anyway directly responsible for the prosperity of mathematical logic in China after 1956, it nonetheless reveals that Mao did have

[97] Mao remarked: "The law of contradiction in things, that is, the law of the unity of opposites, is the fundamental law of nature and of society and therefore also the fundamental law of revolution in the history of human knowledge. According to dialectical materialism, contradiction is present in all processes of objectively existing things and of subjective thought and permeates all these processes from beginning to end; this is the universality and absoluteness of contradiction." (Xu Yibao 2005, 234.)

a rather positive attitude towards mathematical logic and probably supported its advancement in Chinese science. Besides, it might also have been the case that Mao's position regarding certain aspects of science had changed in consonance with the current ideological situation in the SU. Otherwise, Mao was as known as an enthusiastic supporter of "revolutionary" scientific ideas, such as theories in particle physics that alleged to prove the Marxist belief in infinite divisibility of matter.[98]

3.4.2. Logic and Mathematics in Ideological Developments in 1950s China

Almost immediately after the establishment of the PRC in October 1949, various study groups, symposia and lectures on dialectical materialism were started to be organised at institutes of higher education across China. After the Qinghua university was reinstated in its former place, the former flagbearers of mathematical logic in China, such as the philosophers Jin Yuelin, Shen Youding and Wang Xianjun and others were all reassembled at the department of philosophy at Qinghua University. Aside from these Qinghua philosophers, in 1949 in China there were many other scholars who also specialised in mathematical logic. On the one hand, the circle of mathematicians specialised in mathematical logic was growing in Wuhan and Nanjing, while, on the other hand, since 1941 another important mathematical logician, Hu Shihua was back in China, teaching more "technical" courses on mathematical logic at Chinese wartime universities – in 1948 he was a professor of philosophy at Peking University. It is important to note that, in comparison with other Chinese experts in mathematical logic, Hu Shihua was less engaged in philosophical problems and focused almost exclusively on technical aspects of mathematical logic.[99]

At Qinghua University the preparations for the transition to the new ideological order had started relatively early on. Starting in 1948, philosophers at Qinghua had already started studying the principles of dialectical materialism. Due to the Marxists definition of idealism as a philosophical outlook as well as due to the dual nature of dialectical materialism as both the official *philosophy* and a form of scientific objectivism, in the new political order

[98] What we have in mind here is Mao's propagation of Sakada Shōichi's (坂田昌一) contributions to particle physics, which allegedly affirmed Engels' hypothesis about the infinite divisibility of matter. In 1960s, Mao interest in ideological aspects of particle physics promulgated research projects conducted by members of the IMCAS and IAP (Institute of Atomic Physics) which aimed at developing a so-called stratum model of elementary particles. (See Xu Yibao 2005, 235-239)

[99] For an overview of Hu's philosophical thought see Tang Binru 1999.

philosophers and social scientist were more exposed to various form of criticism. Consequently, they were also more often required to carry out self-criticism of their past work. Since many of the wrongs of the past were ascribed to a collective idealist philosophy, in the period of ideological re-education, Chinese philosophers were not able to continue with their usual work but were forced to devote all their attention to dialectical materialism and reinterpretation of Chinese intellectual past in the light of the new state-ideology.

Unfortunately, when they were still members of the Qinghua department of philosophy, the same also befell its former mathematical logicians.[100] Now they were all considered members of a capitalist philosophical elite, deluded by idealist ideas concealed deeply in the tissue of their philosophies of choice. This also meant that they were not anymore able to pursue their studies in mathematical logic in the same way as before. Thus, in early 1950s, they had to conduct public self-criticisms by composing articles in which they denounced their former views and work. Jin Yuelin, for instance, was extremely productive in that regard, for he not only produced a considerable number of political articles criticising his former work, but later also initiated and led a small-scale campaign against Russell's philosophy at IPCAS and Peking University.[101] Similarly, Wang Xianjun and Shen Youding were also required to compose articles denouncing the problematic philosophical views contained in various aspects of mathematical logic – such was, for example, Wang Xianjun's article "The Truth Functions in Mathematical Logic are [In Fact] Logical Abstractions of Complex Propositions" (1956).[102] After the year 1949, Shen Youding and Wang Dianji both focused on history of Chinese logical thought, interpreted through the prism of Marxist philosophy. Occasionally, Chinese philosophers were also required to join their forces in

[100] The establishment of the Institute of Philosophy of CAS in 1955 had drastically changed their research-possibilities.

[101] This campaign was launched at the IPCAS and was conducted between September 1956 and January 1957. Jin himself contributed articles like "Criticising the Thought of Idealist Philosophy about Logic and Language (A Criticism of Russell)". In the 1970s and 1980s, Jin kept on criticising Russell philosophy. In 1988 he published a book entitled *Russell's Philosophy* (*Luosu zhexue* 羅素哲學).

[102] In 1959, Wang also published an article entitled "Criticising the Theory of Meaning in Logical Positivism" (Pipan luoji shizheng zhuyi de yiyi lilun 批判邏輯實證主義的意義理論).

common campaigns against the formerly influential Chinese or foreign philosophers, such as Russell, Dewey, or even Confucius and Hu Shi.[103]

Regardless of what the actual output of the research of the members of the IPCAS really was, it is highly possible that in parallel to their official work, the philosophers also continued conducting their own research in logic. Several facts speak in favour of this possibility, most of which are related to the organisation of the IPCAS as well as the manner how this institution procured its study-material.[104]

On the other hand, in the 1950s, mathematical logic was forced to take shelter in the framework of mathematics and technology. Under the sponsorship and protection of some mathematical departments at Chinese universities it could continue developing in the direction of a more technical discipline. Moreover, following its establishment in 1952, the IMCAS under the leadership of Hua Luogeng became the most important stronghold of mathematical logic, from which flagbearers of new kind of mathematical logic, such as Hu Shihua, could more strongly defend the field and its necessity for general development of science in China. These institutional developments will be more closely examined in the following chapter.

Because mathematical logic had now been integrated into the science of mathematics, in the subsequent ideological developments it also came to share a common ideological battleground, on which the discipline of mathematical logic would soon have to fight its battle for survival. Due to that reason, in the subsequent discussion of ideological developments in the 1950s I shall focus exclusively on developments in the domain of Marxist philosophy of mathematics. However, in my review of the ideological circumstances surrounding the advancements of mathematical logic in the 1950s, I will also have to touch upon the more general debates on logic, which took place between 1953 and 1959.

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[103] With support of the Academy of Science a large-scale campaign against Hu Shi was launched in December 1954. It ended in 1955. See, for example, Chi Wen-Shun 1986, 124-126.

[104] Already at its preparatory level, the IPCAS consisted of four main research groups: dialectical materialism, historical materialism, history of Chinese philosophy and logic. In December 1954, the council members of preparatory institute of philosophy were Hu Sheng 胡繩, Feng Ding 馮定, Li Da, Du Guoxiang 杜國庠, Ai Siqi, Jin Yuelin, Feng Youlan, Pan Zinian, Zhao Jibin 趙紀彬 and others. (See "Zhongguo kexueyuan choubei chengli Zhexue yanjiusuo" 中國科學院籌備成立哲學研究所 (Chinese Academy of Sciences Prepares for Establishment of the Institute of Philosophy). *Renmin ribao*, December 22, s.d.)

3.5. Shadowlands of Dialectics: Mathematical Logic between Mathematics and Official Philosophy of Science in 1950s China

After the establishment of the PRC in 1949, Chinese mathematicians found themselves confronted with the numerous philosophical problems arising from the establishment of dialectical materialism as the official philosophy in the new Chinese state. At the beginning, the members of Chinese mathematical community came into contact with dialectical materialism either through organised ideological re-education at their universities, within the framework of the political activities at the newly founded Chinese Academy of Sciences, or at the meetings and conferences organised by the Chinese Mathematical Society.

Set within the perspective of philosophy of mathematics, Chinese mathematicians' encounters with dialectical materialism from the 1950s can be divided into following two periods:

1.) The period of passive learning and adoption of Soviet ideology, which lasted roughly between 1949 and 1955 – a possible exception was Hua Luogeng, the flagbearer of Chinese mathematical community, who, as the leading mathematician and director of the IMCAS, started expressing his own opinion already in this early period.

2.) The Period of a more open participation in the ideological discourse, between 1956 and 1960. In this period, Chinese mathematicians were already equipped with theoretical knowledge required for them to take an active part in politics of science. Recent changes in ideological circumstances in the SU and the Hundred Flowers Campaign had additionally catalysed their expression of ideological defences of purely theoretical mathematics and mathematical logic. Later, the Anti-Rightist campaign of 1957, spearheaded by its political persecutions, had gravely strained the relationship between mathematics and ideology. These sudden changes, however, did not entirely dismay the most ardent advocates of scientific freedom of mathematics, such as Hua Luogeng, Guan Zhaozhi and, in the case of mathematical logic, Hu Shihua. Soon, in the context of the Great Leap Forward, the voices emanating from Chinese mathematical community could re-enter the public discourse on science.

As early as in December 1949, the Chinese Alliance of Scientific Workers (Zhongguo kexue gongzuozhe xiehui 中國科學工作者協會) and China Science Society organised a symposium in Shanghai, at which the leading Marxist philosophers engaged in an open discussion with Chinese mathematicians and scientists on the relationships between science and dialectical materialism. The focal point of the discussions were the principles of dialectics of nature as described by Engels and Lenin, or more precisely, the relationship between natural sciences and materialist dialectics. The main objective of Marxist philosophers, who partake in the symposium as the experts in the official philosophy of science, was to convince Chinese scientists that dialectical materialism was the only true foundation of science and ought to be used as its only legitimate philosophical view. The scientists were further instructed that as workers in natural science they must at the same time also study dialectical materialism. If, initially, the discussion involved mainly dialectical principles in physics, the focus would soon turn to more ideologically delicate question of mathematics and formal logic. Sun Zeying (孫澤瀛, 1911-1981), a young Chinese mathematician from Shanghai, voiced his own reservations about the Marxist claims that there existed an opposition between formal and dialectical logic:

> Many people say that mathematics is formal logic, while in addition there also exists a dialectical logic. And now everybody is against formal logic. However, I am not well-read in books on dialectical logic. They call dialectical logic a dynamic logic and formal logic a static logic. But I believe that logic is logic, and that there are no such things as dynamic and static logic. This is because movement is a continuum of static [states]… Speaking about mathematics, after Newton discovered the perspective of calculus, mathematics has entered into a revolution. In the Greek period, geometry was static, but [in the time of] Newton and Descartes there was the idea of the infinitesimal. From numerous infinitesimals one can generate a finite quantity… How again did it come to static logic? In every kind of research, we must always have hypotheses. If we have hypotheses, we will also have laws. If the laws do not have provisions and in one moment in time are suddenly going to change, then there is no way we can conduct research… Law is like the length [of objects]; if it was to alter every day, we simply would not be able to measure it… Syllogisms are propositional calculus, laws of propositions are propositional theorems. Method of inference in natural sciences comes from mathematics and had also formerly been passed on from the static logic. I [would like to] emphasize that mathematical methodology is dialectics. That everything in the universe is in [the state of] movement and, at the same time, also has to make progress. In dialectics this is called the unity of contradictions. (Zhang Mengwen et al. 1950, 8)

Although the mathematical community did not explicitly subscribe under the above view, it may be argued that, in the early 1950s other Chinese mathematicians also espoused similar views on mathematics and formal logic. On one hand, they could not straightforwardly concur that dialectical materialism was the sole logical and epistemological foundation of natural sciences, while, on the other hand, they were probably aware that the ideological circumstances had changed, and that they had no other option but to agree with, at least some, stipulations of dialectical materialism.

In the early 1950s, several other symposia on dialectical materialism and science were also organised across the country. One such significant symposium was organised by the Mathematical Society in Peking in 1950. This time the symposium was organised exclusively by the mathematicians, who were now able to discuss the ideological problems pestering the idea of mathematics with philosophers. At the first such meeting of the Mathematical Society in 1950, mathematicians were still preoccupied with more general theoretical issues, such as Engels' view on the principal character and development of mathematics or the object of mathematical research in the context of socialist science. But most importantly, at these first symposia, the main purport of Chinese mathematicians was to inquire and learn about the most recent development in Soviet philosophy of mathematics. Thus, at the 1950 mathematical symposium, the mathematicians discussed Kolmogorov's definition of mathematics in the first edition of the *Great Soviet Encyclopaedia* (1927). In the same year, an excerpt from Yanovskaya's report from 1948, which spoke about Soviet mathematicians' research in philosophy of mathematics, was translated into Chinese by Guan Zhaozhi.

3.5.1. The Reform of Thought Movement, 1951-2

The Chinese Mathematical Society was also instrumental in the development of the ideological discourse on mathematics in the framework of the first large-scale political campaign, which befell Chinese intellectuals and scientists in 1951. The so-called "Reform of Thought Movement" (*Sixiang gaizao* 思想改造) of 1951 was directed against the bourgeois bases of mentality of Chinese scientists. A major ideological presupposition underpinning the movement was that, as an offshoot of the former capitalist or bourgeoise class, the Chinese intellectual elite was unavoidably deeply immersed into philosophical idealism. Accordingly, the idealism became the key concept of the CPC's project of ideological reformation of Chinese science. In the field of mathematics, a corresponding notion of mathematical idealism had been gradually distilled from the currently circulating Soviet material on Marxist philosophy of science. In the framework of discussions organised by the Mathematical Society as well as in the framework of special study groups at Chinese scientific institutes, which now assumed a form closer to guided political instruction, selected fragments from Soviet doctrine on mathematical idealism were gradually transformed into the current Chinese political discourse. In the very same context, a special repertoire of study material was prescribed to Chinese mathematicians them. In addition to Engels' *Dialectics of Nature,* the Chinese scientists were also supposed to study Mao's "On Practice" and "On Contradiction". Lenin's views on dialectical materialism were also viewed as an important source for ideological rectification.

In 1951, important translations were made of Soviet criticism of modern science, in particular the Soviet animadvert against idealism in physics, mathematics and mathematical logic. The representative such writing, was the translation of Majstrov and Tugarinov's "Against Idealism in Mathematical Logic" published in the sixth number of *Kexue tongbao* in 1951, which concurrently recapitulated the contemporary Soviet criticism of formal logic as well as mathematics. Again, the article was translated by Guan Zhaozhi, who in the coming years also played an important role in the ideological battles for the status of mathematics in China. Upon his return from his studies in France, Guan also became one of the leading members of Chinese Mathematical Society and a member of the editorial board of the society's journal *Acta Mathematica Sinica* (*Zhongguo shuxue xuebao* 中国数学学报).[105] As an editor of the above-named journal, Guan Zhaozhi was in charge of the content related to the foundations of mathematics, which at the time was subjected to most intense ideological criticisms – together with mathematical logic.

Because Majstrov and Tugarinov's article was considered of great importance for a correct Chinese discourse on questions of Marxist philosophy of science, in the same year a

[105] The first issue of the *Acta Mathematica Sinica* was published in 1951. The editorial board was comprised of 12 members. While Hua Luogeng served as the editor-in-chief, other board-members were each assigned to overview different branches of mathematics. Guan Zhaozhi was in charge of the content related to the foundations of mathematics (*shuxue jichu* 數學基礎). In 1952, the name of the journal was shortened to *Shuxue zazhi* 數學學報. (Ren Nanheng & Zhang Youyu 1995, 185)

condensed version of the article was also published in the *Xin jianshe* 新建設 (*New Construction*) magazine.[106]

The degree and extent to which this article had actually influenced the Chinese mathematical community are still a matter of debate. However, its content did help creating some sort of vacuum in public discourse on mathematics for the period of at least four years, where nothing but mathematical idealism was actively discussed. That at the time there was an utter lack of outspoken and influential advocates of mathematical logicians, who would dare to move against the political winds of change, is hinted at in Guan's foreword to the article, where he implores mathematicians who specialise on *fundaments of mathematics* to join their Soviet colleagues in their struggle to cleanse mathematical logic of idealism. (Hu Huakai 2006 I, 171)

Hu Huakai and Gou Wenzeng (2005, 87-8) maintain that the article did not considerably disturb the situation in Chinese philosophy of mathematics, because it had already been accepted that mathematical logic only dealt with logical relations in a way which disregarded all empirical content behind these relations, and that it as such it was a form of idealism. In my opinion this claim should be taken with some reservation, for one of the main purposes of the 1951 campaign still resided in codification of the Marxist notion of mathematical idealism. Apart from that, the fact that the movement was followed with a major reorganization of institutions is quite revealing, especially as regards the political motives behind the campaign. The 1951 campaign had clearly postponed many impending philosophical confrontations and prevented personal opinions of many Chinese mathematicians from being openly revealed. The lack of differing opinions does not mean that these did not exist and that it was generally accepted that mathematical logic *was* idealism, but rather that there the Marxist criticism of mathematical logic as a form of idealism had already been widely known amongst Chinese mathematicians.

Apart from Soviet publications on Marxist philosophy of mathematics, Chinese mathematical world experienced a great influx of Soviet theories on idealism in science in general. Conversely, maybe the most important impact Majstrov and Tugarinov's article from 1950 had on the general philosophical discourse on science was that it accentuated

[106] *Xin jianshe*, 4(5), 68-69.

mathematical logic and foundations of mathematics as the most ideologically controversial part of mathematics, and hence the main locus of the political struggle of mathematics. Moreover, from 1951 on, by virtue of writings similar to the abovementioned article, the concept mathematical idealism became inextricably connected to formalism, intuitionism and logicism, which were all recognised as integral parts of contemporary foundations of mathematics as well as intimately related to mathematical logic.

In the period of Chinese emulation of the Soviet model, the development of philosophical discourse on mathematics in China was deeply related to the activities of the Mathematical Society, which at the time acted as a common platform through which all members of Chinese mathematical community were able to access the newest developments in politics of mathematics and develop a common response to the questions and challenges of the new ideology. In that way, the ideological developments in mathematics in the early 1950s were probably best reflected in the activities organised by the CMS.

Thus, when the First National Meeting of the Representatives of the Chinese Mathematical Society was organised at Peking University between August 15th and August 20 1951, the philosophical debates on "three major questions" (*san da wenti* 三大問題), conducted at the conclusion of the event directly reflected the current ideological situation in mathematics. In their discussion of the third question,[107] namely the relationship between mathematics and dialectics, they all accepted the abovementioned idea of mathematical idealism. In the same context, they also expressed a common consensus over the correctness of Engels' views on mathematics, especially over the point that mathematics is a "science, which investigates the objectively existing spatial form and quantitative relationships."[108] Special attention was also given to the problem of abstractness of mathematics, which was described as one of the strongpoints of mathematics that provides insight into the essential nature of natural phenomena. At the same time, the mathematicians also agreed that mathematics was also a social phenomenon, and as such highly susceptible to the corruptive influence of the capitalist class. The possible outcome of such an influence was described as a

[107] The first two were: contribution of mathematics to the common welfare and scientific development of Chinese people, and the question of the relationship between theory and practice in mathematics.

[108] The discussions were summarised in Ren Nanheng & Zhang Youyu, 1995, 195-196. A report about the meeting was published in the first issue of the (*Zhongguo*) *Shuxue zazhi* in November 1951: Zhongguo shuxuehui diyici daibiao dahui zongjie baogao 1951, 37-53; for a summary of the debate see 45-46.

form of artificial mathematics, divorced from concrete reality and reduced to "formal games" (*xingshi youxi* 形式游戲). In this regard, as emphatically asserted in Tugarinov and Majstrov's article, mathematical logic was one of the most critical aspects of mathematics. (Zhongguo shuxuehui diyici daibiao dahui zongjie baogao 1951, 46)

The 1951 meeting of mathematicians also represented the first occasion, when the Chinese mathematical community acknowledged the significance of Mao Zedong's views on practice as important guiding principle for the future Chinese mathematical work. The importance of practical results of mathematical work was stressed for the first time in this very context. However, as noted above, following Engels' and Lenin's of mathematics, Chinese mathematicians at the time still emphasized the value of abstraction in mathematical work for production of knowledge about the laws of objective reality. (Ibid., 45)

The year 1952 saw the publication of further important translations. In 1952, Ye Yunli's (葉蘊理) translation of Aleksandrov's "On Idealism in Mathematics" (1951) was published in the *Zhongguo shuxue zazhi*. In the same year, a translation of B. M. Kedrov's article "On the Relation of Logic to Marxism" [Ob otnoshenii logiki k marksizmu], originally published in the *Voprosy filosofii* in 1951, appeared in the *Kexue tongbao.* Kedrov, who was one of the editors of the *Voprosy filosofii* and a professional logician, advocated a more moderate view on the relationship between formal and dialectical logic. Following Engels, he propagated the view that between formal and dialectical logic there was the same relationship as between elementary and advanced mathematics. At the time, Kedrov was also furthering the Stalinist position that logic can be subdivided into a logic of thought and science of logic.

In late 1951, the "Three-anti" (*san fan* 三反) campaign ensued out of the Reform of Thought movement. It was followed closely by the "Five-anti" (*wu fan* 五反) campaign at the beginning of 1952, which ultimately also concluded the Reform of Thought movement. In the context of the latter two campaigns, the political pressure on leading Chinese mathematicians further intensified. In the meantime, Zhou Enlai's "report" on the reform of the intellectual class directed additional pressure on the CAS, which, alongside with other scientific institutes, was branded a nesting-place of bourgeoise ideas and an epicentre of capitalist (American) sentiments in China. As one of the leading Chinese mathematicians and an important member of CAS, who in the late 1951 was working at the Preparatory Institute of Mathematics of the academy, Hua Luogeng himself also became a target of political attacks.

Because of later developments in the movement Hua and some other mathematicians were subjected to various kinds of harassment.

In the eyes of Chinese mathematicians and scientific workers in general, the Reform of Thought movement – especially the last waves of campaigns towards the end of 1951 – gave rise to a much darker intellectual climate, in which science in general was put under political scrutiny by a far more oppressive ideological machine, which disregarded the patriotic eagerness of Chinese scientists and their efforts to realign their fields with dialectical materialism. Furthermore, even Hua Luogeng himself had to learn that his earlier patriotic writings were far from adequate. At the same time, albeit that he was coerced into writing self-critical articles, this also caused him to develop a public voice, which in the following years he used to defend the entire mathematical community in China, whose political influence increased with each new political challenge. Although, for some members of the Chinese mathematical community, the year 1951 and 1952 were the time of profound demoralisation, on the other hand it also gave rise to shaping of a more realistic political awareness within the mathematical community.[109] This newly acquired awareness was channelled mainly through its foremost representatives at the IMCAS, founded in July 1952.[110]

3.5.2. Surge of Native Ideological Criticism, 1953-1955

By 1953, the recent political events had left a significant imprint on the political culture of Chinese mathematicians. In September, at the first symposium organised by the CMS the mathematicians unanimously accepted the undisputable role of Marxist philosophy in future of mathematics and mathematical education in China. In his opening address, Hua Luogeng spoke about the relationship between theory and practice in Soviet mathematics, stressing the importance of research in fields such as theory of functions with complex variables, theory of

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[109] Xu Yibao claimed that because of the 1951-1952 movement, some mathematicians became familiar with dialectical materialism. (Xu Yibao 2005, 242)

[110] For a more detailed account on Hua Luogeng's experiences during the Reform of Thought movement, see Wang Yuan 1999, 161-166. An important article written by Hua in 1952, which reflected the current ideological situation in Chinese mathematics, was "Initial Realisations of A Mathematical Worker in Studying 'On Practice' and 'On Contradiction'" (Yige shuxue gongzuozhe xuexi 'Shijian lun' he 'Maodun lun' de chubu tihui 一個數學工作者學習"實踐論"和"矛盾論"的初步體會).

differential equations and functional analysis due to their extreme relatedness to applied sciences. (See Ren & Zhang 1995, 201-203)

In the same year, a series of first Chinese articles on mathematical idealism were published in the *Shuxue tongbao*. By and large, these articles all derived from Aleksandrov's "On Idealism in Mathematics" and other Chinese translations of Soviet writings on the topic. First such criticism of mathematical idealism was composed by Luo Sifan (羅嗣蕃, ?). In the article entitled "Cleansing the Idealism in Chinese Mathematics" (Dengqing woguo shuxue zhong de weixinlun 澄清我國數學中的唯心論) Luo derived from Aleksandrov's proposition that the systematisation of scientific knowledge, its general interpretation, understanding and development all possessed social meaning, within which the class nature of science is formed. Considering the assumption that some aspects of mathematics can develop a class-nature, Luo expressed his suspicion that capitalist thought had been imported to China by Chinese students who studied mathematics abroad. It was the results of these exchanges that Luo was determined to cleanse away from Chinese mathematics. Luo enumerated three past examples of mathematical idealism in China. The first was Zhu Yanjun's translation of *Courant's Differential and Integral Calculus*. The aspect of this work, which Luo deemed extremely problematic was the axiomatic method which it introduced. Because, according to the Marxist belief, every axiomatic theory must be built on concrete grounds and verifiable in practice, Luo concluded that, axiomatisation of mathematics was derived from the empiricist worldview, and hence idealist in essence. The other two works criticised by Luo were: Qiu Pirong's (邱丕榮, ?) translation of Roger Johnson's *Modern Geometry* and Chen Jinmin's (陳藎民, 1895-1981) *Non-Euclidean Geometry* (*Fei-Ou jihexue* 非歐幾何學). About the latter, Luo remarked that it propagated axiomatisation of geometry, which is not verifiable in practice. Again, the non-verifiability of axioms was deemed an extreme example of idealism in mathematics.

In 1953, a few other articles on idealism in mathematics have been published in *Shuxue tongbao*. These included: Weng Xianbin's (翁賢濱) "In Practice of Teaching Geometry We Must Conduct a Persistent and Discording Struggle with Idealism and Formalism" (Zai jihe jiaoxue de shijian zhong, bixu yu weixinlun, xingshi zhuyi zhankai tejiu de he butiaohe de douzheng! 在幾何教學的實踐中必須與唯心論、形式主義展開特久的和不調和的鬥爭!), Xu Mofu's (许默夫) "How Marx Meticulously Studied Mathematics?" (Makesi zenyang zuanyan shuxue 馬克思怎樣鑽研數學), "A Few Questions about Marx's

Mathematical Manuscripts" (Guanyu Makesi shuxue shougao de jige wenti 關於馬克思數學手稿的幾個問題) and so on (Hu Huakai & Gou Wenzeng 2005, 87-8). The majority of these works adopted Aleksandrov's criticism of mathematical idealism, focusing their critical evaluation of mathematics on its non-practical tendencies and, as it were, idealist notion of axiomatisation.

Later in the same year, Yanovskaya's report on 30 years of mathematical logic and foundations of mathematics in the Soviet Union was finally translated into Chinese and published as a short booklet by the Chinese Academy of Sciences (Yanovskaya 1953). Beside many other translations of Soviet works and Chinese articles written in line with ideologically prescribed sources on philosophy, Hua Luogeng's article expounding on his preliminary understanding of Mao's "On Practice" and "On Contradiction" was re-published in the *Shuxue tongbao*.[111] By 1953, Hua already got accustomed to writing political articles.

As I have already claimed before, after its inauguration in July 1952, the IMCAS became the main ideological refuge for Chinese mathematicians. From 1953 on, when the first two research groups (for differential equations and number theory) were established, the IMCAS underwent further structural transformations. Alongside some organisational changes, in the early years, the activities at IMCAS were also revolving around ideological questions. The activities related to the ideological reformation also included collective courses of Russian language and dialectical materialism. At the institute, discussions about dialectical materialism were regularly conducted under the guidance of Ai Siqi. (Wang Yuan 1999, 172)

The year of Stalin's death (1953) was also an important milestone in the history of Sino-Soviet academic exchange, for, from this year on, academic exchanges and study-visits to the SU became the predominant form of academic cooperation between the countries.

During the following two years preceding the Hundred Flower Campaign of 1956, the ideological discourse related to mathematics and mathematical logic experienced no greater changes. By and large, in these two years the Chinese criticism of mathematics and logic was still in line with the former mainline Soviet discourse.

[111] *Shuxue tongbao*, 3(4) (1953), 2-11.

Although, in 1953, a few minor discussions on the nature and role of logic in Marxist science occurred, these were still set within the same discursive framework, echoing one and the same mantra. Concurrently, however, the discourse on logic became gradually infiltrated by the outgrowth of China's past Marxist discourse on logic, which was formed in the 1930s. On the other hand, the early disputations against idealist elements in Chinese mathematics were dominated by a set of reoccurring topics that were often centred on the problem of axiomatisation.[112]

3.5.3. The Harbinger of Change: Guan Zhaozhi's Defence of Mathematical Logic and Foundations of Mathematics, 1955

The straight trajectory of Marxist ideologization of philosophical discourse on mathematics was first disrupted in the year 1955, when Guan Zhaozhi published his first article in defence of mathematical science. In the article entitled "On Some Forms of Currently Existing Wrong Views on the Scientific Discipline of Mathematics" (Lun muqian dui shuxue zhe men kexue de jizhong cuowu kanfa 論目前對數學這門科學的幾種錯誤看法) Guan indicated that Chinese mathematicians were not adequately familiar with topics pertaining to Marxist philosophy of mathematics. He further noted that, instead of taking over the ideological battle against idealism in into their own hands, the mathematicians tended to entirely ignore the important questions of the relationship between dialectical materialism and mathematics. Therefore, Guan suggested that the mathematicians should start studying dialectical materialism and engage in the philosophical struggle against idealism by themselves, instead of irresponsibly "leaving the battleground to the adversary" (Hudeček 2012, 1).

In his article, Guan openly encouraged Chinese mathematicians to confront mathematical idealism through direct philosophical discussions of ideologically most problematic arguments against it, which were mostly related to mathematical logic and foundations of mathematics. In Guan's opinion, their passive attitude towards philosophy of mathematics had also manifested itself in their avoiding the above-mentioned disciplines. Guan noted that:

[112] This aspect has already been researched by Jiří Hudeček in his unpublished paper "Perspectives on Axiomatisation in Criticisms of Idealism in Mathematics, 1955-1974" from 2012.

> … most Chinese mathematicians do not pay any attention to questions of foundations of mathematics. And it is exactly because no one pays attention to it, that so many people hold so many different wrong opinions about the foundations. The most protruding expression of this is that many people do not dare to have something to do with mathematical logic. For example, after the liberation, some mathematicians even doubt that mathematical logic can still be studied. (Guan Zhaozhi 1955, 36)

Because of the strong association of mathematical idealism with formalism, logicism and intuitionism in conventional Marxist philosophy of mathematics, Guan argued that in Chinese advancement of mathematical logic the useful results of Russell’s logic or Hilbert’s proof theory ought to be systematically differentiated and contrasted against the corrupt idealist philosophies of logicism and formalism. Only by means of a philosophical struggle, the Chinese mathematicians would be able to defend the abovenamed disciplines against ideological denigrations of mathematical fields such as mathematical logic.

As an example of a positive approach towards mathematical logic and foundations of mathematics, Guan pointed out that the eminent Soviet mathematician A. N. Kolmogorov was not “scared away” by Brouwer’s intuitionism but even engaged in a thorough research of the “intuitionist logic” (*zhijue zhuyi luoji* 直覺主義邏輯), demonstrating that, if correctly used, Heyting’s intuitionist propositional calculus can be of great advantage for mathematics. On the correct use of intuitionist logic, Guan further remarked:

> By emphasizing “constructive” (*gouzao* 構造) possibilities, intuitionism tries, through delimiting the scope of mathematics, to eliminate those part of [mathematics] which it believes to be unacceptable… In that way, it could obviously only give rise to a negative effect on the development of mathematics, because many important parts of mathematical analysis were deemed incomprehensible by them and thus eliminated. Contrary to that, Soviet scientists believed that one ought to look upon constructivism as having a positive meaning, because with constructive or effective (*nengxing* 能行) methods one complements “the proof of pure existence”. That is, to prove the existence of any mathematical objects not solely with *reductio ad absurdum* or in some other manner, but also to indicate that with a correct procedure one can [always] seek out a mathematical object … (Ibid., 37)

In the above excerpt Guan used the example of Soviet mathematicians' critical acceptance of intuitionist logic with the intention to show that also mathematical logic, if interpreted correctly, can also be cleansed of all idealist points. Furthermore, if correctly interpreted, mathematical logic can also be used to disprove the most elementary theses of idealism. As an example of such a result Guan named Gödel's incompleteness theorem or, more precisely, his demonstration of undecidability of basic theorems of axiomatic systems.

In many ways, Guan's article from 1955 was a first considerable attempt of a Chinese mathematician to make a case for both mathematical logic and foundations of mathematics. In so doing, Guan strongly relied on the existing examples of positive practice from Soviet mathematics. Thus, he pointed out that in the SU "mathematical logic, as the scientific discipline which studies mathematical proof, has experienced a correct and healthy development," emphasizing the immense scientific significance of its theory of algorithms and theory of recursive functions for the development of computer science. (Ibid., 37)

In the final part of the article, Guan closely examined two "wrong views" on mathematics that underlay the three kinds of mathematical idealism. Both were derived from Lenin's view on idealism as expressed in his *Conspectus* on Hegel's *Science of Logic*. According to Guan, the first such view overstressed the meaning of abstractness in mathematics. He claimed that a "healthy" development would dialectically combine abstract mathematics with concrete practice. The second such view exaggerated the utilitarian aspect of mathematics: namely the mathematization of science. He proposed that this view could be rectified by the recognition that mathematics represented only one of instruments for grasping the truth about the universe. (Ibid., 40)

Guan's article from 1955 marked an important turning point in Chinese mathematicians' philosophical discourse on the nature and use of mathematics. Not only did it represent a daunting step towards reasserting some sort of autonomy of mathematical studies, but it also represented an attempt to circumvent the rationale of the Marxist critique of mathematics by a direct implementation of current Soviet developments in philosophy of science. This was also the reason why Guan was consistently quoting from Soviet sources and even listed Russian terminology. Guan openly opposed the current ideological situation in Chinese science, where some more theoretical branches of mathematics like mathematical logic and foundations of mathematics were completely excluded from research priorities, and instead proposed that the Chinese mathematicians take the matters into their own hands and expel all forms of idealism in order to secure a heathier and more positive development of mathematics. As Soviet mathematicians before him, Guan recognised the way out from the philosophical standstill in incising a sharp cut between idealist and objective components of mathematics. Because only when all "negative" elements of mathematical logic were thoroughly identified, the remaining parts can attain their true effectiveness.

3.5.4. Let the Flowers of Debate Bloom: The Defence of Mathematical Logic and Foundations of Mathematics during the Hundred Flowers Campaign, 1956-1957

The year 1956 represented an important turning point for mathematical logic in China. A new wave of open philosophical debate on mathematics had now become a part of a broader tide of intellectual change, whose direction was reinforced by major ideological reorientation in the Soviet Union, which was prompted by the 20th Congress of the Soviet Communist party. With respect to science, the shift in political circumstances was just another factor catalysing the transformation of the official ideology of science. In China, these changes became also materialised in the 12-year plan for development of science and technology (of "the long-term plan for the development of science for the years 1956 to 1967"). In the text, issued by the Central Committee of CPC on December 22, 1956, we can read:[113]

> Within the following twelve years, we must first, as quickly as possible, start a rapid development of those sections of mathematics that are important and urgently required but still represent a blank space or are still only weakly developed (including computational mathematics, theory of probability and mathematical statistics, theory of differential equations)… The development of fundamentally theoretical sections of mathematics, including number theory, algebra, theory of functions, differential geometry, topology etc., in which our country originally had relatively good achievements, ought to be continued. [Regarding] the new sciences that, in the recent years, had significantly influenced mathematics or other sciences, like functional

[113] Here, we are quoting from a document in the internet Archives of the Communist Party of China (CPC). The whole document can be accessed via the following link: http://43.250.238.143.0097e96k01ca.erf.sbb.spk-berlin.de/detail?record=3&channelid=10&searchword=%D5%FD%CE%C4%3D%CA%FD%C0%ED%C2%DF%BC%AD (Accessed on June 24th 2019)

analysis and mathematical logic, which are developing at an exceptionally high speed, in the past China did not pay enough attention to them, [so that they have] very weak bases. Henceforth, they should be given special attention, so as to make them gain an appropriate development at a proportional pace. Regarding the history of mathematics and philosophical questions in mathematics, they also need to be given a sufficiently important place…

In first months of the year 1956, following Zhou Enlai's report on problems associated with intellectuals from January 14, the CPC started devising a concerted, unified political solution for the problem of Chinese intellectuals. At first, Zhou Enlai's appeal to provide Chinese scientists with more favourable circumstances for their work resulted in what appeared to be a general suspense of ideological pressure. This temporary dissolution of former ideological constraints culminated in April, when Mao Zedong proclaimed the Hundred Flowers campaign with the resounding slogan "let the hundred flowers bloom and a hundred schools of thought contend" (*baihua qifang, baijia zhengming* 百花齊放，百花爭鳴).

The overall rhetoric used in the campaign endowed the scientists with a certain degree of hope that their ideas about the future of Chinese science will be heard and accepted by the regime. At the same time, the technological exchange between Soviet Union and China reached its highest point, opening up new possibilities for Chinese science in general.[114] On the other hand, this was also an important moment for the formation of China's own line of ideology. Following the initial divergence between ideology and political identity, the CPC started slowly organising a counterblow to the illusion of intellectual liberty, which arose in consequence of the Hundred Flowers. A major setback in the open debates on philosophy of science came in 1957, when the Anti-Rightist movement cut down the "hundred flowers" of thought that had bloomed for only a brief period of time, and returned the ideological remapping of China into the firm hands of the party elite.

Two more important developments related to mathematical logic took place in 1956. The first was the initiation of research in dialectics of nature. It must be noted that within

[114] Here we follow the findings presented in Bernstein et al. (2010) as well as the conclusions of Li Mingjiang (2012), who argued against conventional beliefs that 1956 actually marked the beginning of the Sino-Soviet split. See Li Mingjiang 2012, Chapter 3 "The Soviet 20th Party Congress and Emerging Disputes in 1958" and so on.

dialectical materialism, the dialectics of nature represented a theoretical domain governing the questions related to science. Moreover, dialectics of nature was the fundamental philosophy of science in Marxism-Leninism. Consequently, the establishment of Chinese Society for Studies in Dialectics of Nature in 1956 meant that the scientists who took part in the society were about to take greater control over the ideological discourse related to various branches of science. In other words: the establishment of the study-society represented a concrete attempt of Chinese scientists to get involved in the most delicate problems related to ideology, just as Guan Zhaozhi had suggested in 1955. Consequently, the *Journal of Studies in Dialectics of Nature* (*Ziran bianzhengfa yanjiu tongxun* 自然辯證法研究通訊), founded by the society in the same year, acted as the first medium through which Chinese scientists started forming a unified philosophical view on science, implicitly calling for revision of the hard-line ideological approaches towards science.

As the ideological tensions of past years were the result of Chinese emulation of Soviet ideology, the changes of 1956 were also in part also spurred by recent political developments in the SU. The Chinese scientists (mostly the members of CAS) who in 1956 decided to fill the current ideological vacuum with their own moderate philosophies of science seized the opportunity, when the former ideological imperative was crumbling, and set out to redefine the idealist labels attached to science in former criticisms. Thus, one of the main objectives of the study society, promulgated at the preliminary conference in Peking in December 1956, was also to ameliorate detrimental influence of Soviet animadvert against Theory of Relativity, cybernetics, quantum mechanics and, most importantly, mathematical logic. (Gong Yuzhi 1956) Furthermore, the society also aimed at solving the most pressing philosophical problems of science, including the problematic relationship between dialectics and logic.

Strikingly, most of articles, which appeared in the first issue of the *Journal of Studies in Dialectics of Nature*, revolved around idealism in mathematics. As indicated above, as early as in 1953, the notion of idealism in mathematics became associated with theories related to mathematical logic and foundations of mathematics, such as axiomatisation of mathematics, Cantorian set theory, and the three schools of mathematical philosophy (formalism, logicism and intuitionism). In 1956, these became the main subject of discourse on dialectics on nature. If in 1955, Guan Zhaozhi could be said to have been at the forefront of defence of mathematical logic, in 1956, this task was taken over by Hu Shihua, the leading Chinese expert in the field and a member of CAS (from July 1953 on). At the same time, other important Chinese mathematicians such as Guan Zhaozhi, Hua Luogeng, and the topologist Wu Wenjun (吴文俊, 1919-2017) also contributed to the discussion in the said journal.[115]

Another important phenomenon, which was inherently linked to mathematical logic, were the public debates on logic. These discussions, which culminated in the years 1956 and 1957, became later known under the generic term "great debates on logic" (*luoji da taolun* 邏輯大討論). Most importantly, the debates were endorsed and supported by Mao himself, who also took part at some of the regularly organised symposia on logic in Peking (at Renmin daxue and Beijing daxue) (see Wang Xinming 1999, 62-3; Wu Zhanxing 2014, 51-2; Xiao Weili 2010, 36-37). In many respects, these debates continued the polemics on dialectical logic and formal logic from 1930s. Even one of the most influential discussants, Zhou Gucheng (周穀城, 1898-1996), had already taken part in the 1930s debates. Zhou's article "Formal Logic and Dialectics" (Xingshi luoji yu bianzhengfa 形式邏輯與辯證法), published in February 1956 in the *New Construction* (*Xin jianshe* 新建設) review, caused Mao Zedong to officially set in motion the establishment of study groups for logic and order that public debates on logic be held on regular base in Peking (Wang Xinming 1999, 62).[116] With Mao's support, the debates on logic reached a high level of intensity by 1957, which persisted until the end of the GLF campaign in 1959. Content-wise, the debates consisted of more than 10 minor discussions on various aspects of relationship between formal and dialectical logic. Even though the notion of formal logic at the heart of the debates did not include mathematical logic, in 1956 a small-scale discussion broke out which touched upon the nature of mathematical logic in relation to formal and dialectical logic. The defence of mathematical logic, which was conducted by Hu Shihua, was related to

[115] The first 17 pages of the first issue of the journal were devoted to mathematics. These contained articles like: Guan Zhaozhi's "The Object of Research, Methodology, Characteristics and Use of Mathematics and its Place in the Classification of Sciences" (Shuxue de yanjiu duixiang, fangfa, tedian, zuoyong jiqi za kexue fenlei zhong de diwei 數學的研究對象、方法、特點、作用及其在科學分類中的地位), Zhao Zhongzhe's (趙仲哲) "Philosophical Questions in the Theory of Probability" (Gailülun zhong de zhexue wenti 概率論中的哲學問題), Qin Yuanxun's (秦元勛) "Philosophical Analysis of Some Important Concepts in Mathematics" (Shuxue zhong de ruogan zhongyao gainian de zhexue fenxi 數學中的若干重要概念的哲學分析) and Ding Shisun's (丁石孫) "Development of Mathematical Thought" (Shuxue sixiang de fazhan 數學發展的發展).

[116] According to Jin Yuelin's reminiscences, in April 1957, Mao requested that the circle of prominent philosophers in Peking, including Jin Yuelin, Feng Youlan and He Lin organise a discussion on questions of logic in the Zhongnanhai in Peking. (Liu Peiyu 1995, 409).

the central debates in the sense that they all addressed the notion of dialectical logic in contrast to alternative systems of logic.

3.5.5. Shifting Boundaries Between Science and Ideology: Mathematical Logic and the Formation of Studies in Dialectics of Nature

In late 1956, when the first number of the *Journal of Studies in Dialectics of Nature* (*JSDN*) the public discourse on mathematical logic was raised onto a new plane. Due to various reasons, the ideological discourse on science underwent a profound transformation. In this context, mathematical logic was now put under discussion as a prospective cutting-edge science. However, the first requirement for mathematical logic to be accepted into the scientific machinery of China's great socialist reconstruction was its ideological rectification.

In consequence, at the initial stage, the discussions on philosophy of mathematics (or dialectics of mathematics) still revolved around the idea of idealism. In the first issue of the *JSDN*, the mathematical logician Hu Shihua and Wu Guanglei (吳光磊, 1921-1991),[117] an assistant lecturer in differential geometry at Peking University, published a short article entitled "Criticism of Idealism 'in Mathematics'" ("'Shuxue zhong de' weixin zhuyi pipan" '數學中的'唯心主義批判). In the article, Hu and Wu claimed that idealism in mathematics developed as a result of capitalist ideology and the research in foundations of mathematics which took place in the imperialist period. Idealism in mathematics was also caused by its abstractness and the method of "setting out from the hypothesis" (*cong jiashe chufa* 從假設出發). According to Hu and Wu, the main objective of Marxist-Leninist criticism of idealism in mathematics was also to affirm the positive elements of mathematical logic. This purification of mathematical logic ought to be conducted in line with the guiding-principles provided by Lenin in his criticism of idealism. Finally, as mentioned above, the criticism needed to encompass: (a) critique of logicism, the goal of which is to establish the correct relationship between logic and mathematics; (b) critique of formalism, intended to clarify formalisation of mathematical

[117] Wu was an important member of the mathematical circles in Peking. He was a lecturer of mathematics at Peking University, and an expert for integral differential geometry. In 1942, he graduated in mathematics from the South-West Associated University. In Summer of 1946, he started working at Qinghua University which had been relocated back to Peking. He became an assistant lecturer in mathematics in 1952. In 1956, after the long-term developmental plan for Chinese science was accepted, Wu started researching the theory of differential geometry and initiated modern classes in differential calculus and geometry at Peking University.

language; (c) critique of intuitionism, whose aim is to clarify the meaning of "constructive method" and "effectiveness" in mathematics.

In the same issue of the *JSDN,* two more short articles related to mathematical logic were published. The first one, also composed by Hu and Wu, was entitled "On the Nature, Characteristics and Use of Mathematical Logic and the Philosophical Meaning of its Results" (Shuli luoji de xingzhi, tedian, zuoyong jiqi chengguo de zhexue yiyi 數理邏輯的性質、特點、作用及其成果的哲學意義). In comparison to the short writing on idealism in mathematical logic outlined above, this article was written in a more assertive tone. It emphasized the utmost importance of mathematical logic for development of science and technology. Rather than only a branch of mathematics, it portrayed mathematical logic as an independent science, with an object of research, which bears close relations to mathematics, formal and dialectical logic, electronic computer, linguistics, philosophy and so on. Maybe the most important statement of the article was that "mathematical logic started a new chapter in history of scientific progress". It was under the same premise that the Chinese mathematicians later offered their argument for mathematical logic and foundations of mathematics. Moreover, the argument I refer to had already been hinted at in the abovenamed article from 1956: "We know that whenever there are new important results in natural sciences, dialectical materialism must adopt a new form" (Hu and Wu 1956). In this regard, the authors claim that dialectical materialism ought to epitomise and integrate the results of mathematical logic.

The third paper which bore a fundamental connection to mathematical logic, was Hu Shihua's "Philosophical Questions of Cybernetics" (Kongzhilun zhong de zhexue wenti 控制論中的哲學問題). As I have mentioned in the previous parts of our discussion, the earlier reforms in scientific politics in the SU also entailed an ideological revision of the nature and use of cybernetics. By the 1950s, the discipline of cybernetics, which started as a hermetic study on "Behaviour, Purpose and Teleology" by a group of scholars at the IAS one decade earlier,[118] had become an important theory related to computer science, studying automatic control systems and communication in both machines and individual lifeforms.[119] Four years after the establishment of the IMCAS, mathematical logic became vitally connected to the developing discipline of computational mathematics, both of which constituted a theoretical

[118] See Dyson 2012, Chapter 7.

[119] For an in-depth study on the development of science of cybernetics in the SU see Gerovich 2002.

foundation for the development of electronic computer technology in China. In 1956, when the ideological map was being redrawn and the disciplines of mathematical logic, foundations of mathematics and cybernetics were partly rehabilitated, Hu Shihua assumed the task of commenting on the theoretical aspects of computer science, which included both mathematical logic and cybernetics. On the other hand, the demonstration of technological value of computer science was also an affirmation of positive ideological value of mathematical logic. It was namely by its concrete application in computer technology that mathematical logic could demonstrate its objectiveness and a correct, practice-oriented philosophical disposition.

In the aforementioned essay on the philosophical nature of cybernetics, Hu Shihua stressed that the importance of computer science could be compared to that of research of atomic energy. It can thus be regarded a great achievement of modern science and the "material basis of the Communist construction."[120] Furthermore, Hu claimed that the value of cybernetics resided not only in its industrial aspect (automated control system), but also in its transformative effect on scientific research (electronic computer). As the major point of confluence between mathematical logic and cybernetics, Hu Shihua highlighted the notion of "effectiveness" (*nengxing xing* 能行性), which was derived from intuitionism. In the following years, effectiveness became a significant concept through which various applications of mathematical logic in computer science were expressed. In Hu's opinion, the notion of effectiveness had "the potential to become an important category, which can be assimilated into the theory of categories of dialectical materialism" (Hu Shihua 1956a).

In the years following its establishment in 1956, the Chinese society for research in dialectics of nature together with its journal, assumed the role of an important platform for Chinese scientists' endeavours to reform the ideological character of certain branches of developing sciences and disciplines. By assuming the role of new philosophers of science, the Chinese scientists engaged in discussions of dialectics of nature not only to reshape the future outlook of Chinese science, but also to reformulate the tenets of dialectics of nature in accordance with most recent scientific discoveries and technological advances. With regard to mathematics, the journal *JRDN,* which was later renamed to *Journal of Dialectics of Nature* (*Ziran bianzhengfa tongxun* 自然辯證法通訊, *JDN*), continued to serve as the home-ground

[120] In Soviet scientific development the atomic power program was also deeply connected with the BESM program – Soviet large-model high-capacity electronic computer. (See Gerovich 2001, 267)

from which the Chinese scientists would defend their positions against new emerging political pressures (Table 3).

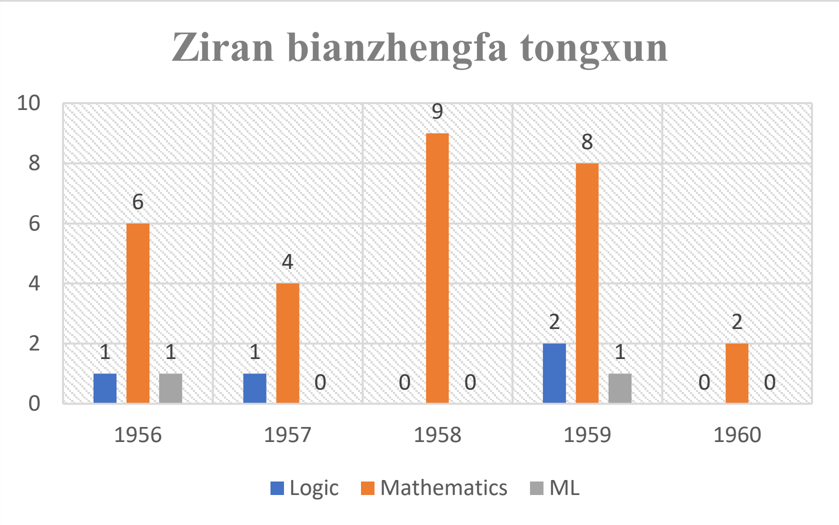

Table 3: Publications on philosophy of logic, mathematical logic, and mathematics in the Journal of Dialectics of Nature, from its establishment in 1956 up to 1960. The rise in publications on mathematics corresponds to mathematicians' and other scientists' response to the political pressure which emanated from the ideological premises of the Great Leap Forward campaign. The relatively high number of articles on mathematics in 1956 and 1957 was an expression of the political changes accompanying the Hundred Flowers campaign.

3.5.6. The "Great Debates on Logic" (1956-1959) and the Problems of Mathematical Logic

In early 1956, a series of debates on dialectical and formal logic broke out. As already noted, the debates reiterated the main arguments of the 1930s debates (see Vrhovski 2021b), with one major difference, namely, that the debates of 1950s extensively absorbed the recent Soviet discourse on logic and Mao's doctrine on practice and contradiction. Nevertheless, the arguments which emerged in the 1950s debate were to some extent still echoing the views of Deborin, Plekhanov and Lenin. In the context of recent ideological developments in China, the debates represented a direct continuation of the Chinese Marxist critical discourse which started in the year 1953.

Because the debates on logic of 1950s were an extremely broad and complex concatenation of phenomena, in this place I shall only briefly review the main discussions which made up the "great debates on logic" from 1950s. In addition, special attention shall be given exclusively to the discussion on mathematical logic of 1956.

Another important fact related to the 1950s debates was that the debates were endorsed and supported by Mao Zedong, who also personally attended some of the conferences organised in Peking following his own request addressed at some renowned members of the IPCAS. Concurrently, according to secondary sources, Mao also had a close personal relation to one of the leading Marxist theoreticians involved in the debates, namely, the historian Zhou Gucheng. (Wang Xinming 1999, 62) Because Mao openly supported Zhou's ideas, the debates on logic reached a high level of intensity already a few months before the proclamation of the Hundred Flowers campaign. In February 1956, Mao read Zhou's article "Formal Logic and Dialectics" published in the *Xin jianshe* magazine. In the article Zhou expressed a view on logic which was relatively close that of Osmakov (1950). Zhou claimed that formal logic is neither a form of metaphysics nor a form of dialectics, but a kind of inferential tool, which can be used only under certain circumstances. Shortly upon having read the article, Mao expressed his personal support for Zhou's views. His belief that his views are not shared by many other Chinese scholars, caused Mao to initiate the first large-scale public debate on logic. As mentioned before, the overall debate was fragmented into many minor debates on various topics. These debates reached another peak at the beginning of the year 1957, when Mao initiated further developments due to which the debates assumed a broader scope and became more intense.

A group of discussants occupying the place at the forefront of the debates was comprised from the former Qinghua logicians, who mostly became members of the IPCAS. Since the very same group of scholars was also subjected to more intense ideological pressures and treated as more risky political elements than their colleagues at the IMCAS, the former could not continue researching mathematical logic in the same way as before. Hence, most of their publications from the 1950s were examples of paradigmatic criticisms rather than their own views on logic.[121]

[121] However, there exists at least one indication that the research work at IPCAS still touched on positive aspects of mathematical logic. This is related to the official cooperation which was established between IPCAS and the Polish International Institute for Philosophy towards the end of 1957. The relationship between IPCAS and the Polish institute started developing earlier in the same year, when Jin Yuelin attended a philosophical conference in Warsaw. Most importantly, the first official request made by the IPCAS to its newly fraternised Polish institute was to send over all available material on mathematical logic and dialectical logic. (Liu Peiyu 1995, 410)

In 1978, the Resource Centre of Department of Philosophy at Fudan University compiled an extremely useful catalogue of Chinese academic philosophical debates, from the year 1949 on. Since the 1950s debates represented an extremely broad and extensive phenomenon, in my synoptic overview I shall rely only briefly summarise the data provided in the abovementioned *Brief Account of Important Academic Debates on Philosophy Since the Establishment of the PRC (October 1949 – May 1965).* According to this source, between the years 1953 and 1960, twelve debates on logic took place:

1.) On the question of object, nature and use of formal logic, 1953-1961:

    This was a large-scale, central debate, which took place in publications like *Xin jianshe, Zhexue yanjiu, Jiaoxue yu yanjiu, People's Daily* and *Guangming ribao*. The debate touched upon two main questions: a.) What is the object of formal logic? and (b) What is the nature and use of formal logic? To the first question four different answers were given: (i) formal logic is a science of the form and laws of thinking – it investigates concepts and judgments from perspective of extension; (ii) formal logic studies the structural laws of the forms of thinking; (iii) formal logic studies the form of thinking and its elementary laws as well as the general logical method; (iv) formal logic studies the correct form of thinking and its laws. To the second question two different views were expressed: (i) formal logic represents a tool which can only be used in argumentation but possesses no epistemic function; (ii) formal logic is both an epistemic tool and a tool used in reasoning.

2.) On the objective foundations of formal logic, 1956:

    In the framework of this debate, many different questions were touched upon the following questions: a.) What are the origins of the form and laws of thinking? b.) Does formal logic possess objective basis? c.) The law of identity and its objective foundations? d.) What is the scope of use of the laws of thinking?

3.) On the question of class nature in formal logic, 1956:

    The question discussed in the debate were: a.) Does formal logic have class nature? b.) If the theory of formal logic has got class nature, does this also mean that formal logic has class nature?

4.) The relationship between truthfulness and correctness in formal logic, 1956:

This discussion was sparked by Jin Yuelin's article "On the Unity of Truthfulness and Correctness" (1959). The questions discussed included: a.) What are truthfulness and correctness in formal logic? b.) Is there unity between the two? c.) Is formal logic concerned with true and false? d.) Can premises in syllogism correct false reasoning? c.) Can formal logic be in service to sophism?

5.) On the existence of activity of logical thinking at the intuitive level of knowledge, 1953-1958.

6.) On the question of AEO form of reasoning in formal logic, 1956-7:

This debate took place exclusively in the *Guangming ribao*.

7.) The question of contradiction between ourselves and the enemy and the antagonistic from the point of view of formal logic, 1958 – 1959.

8.) On the question of "revision" of formal logic, 1957:

The debate materialised in various academic and non-academic periodicals: *Guangming ribao, Wenhui bao, Xueshu yuebao, Jiaoxue yu yanjiu, Fudan, Dongbei daxue xuebao, Renwen zazhi, Baijing shida xuebao* and *Yunnan daxue xuebao*.

9.) On the question of dialectical logic, 1955:

The debate was conducted in the *Xin jianshe* and *Giangming ribao*. It touched upon the following questions: a.) What is the object of dialectical logic? This question was answered by seven different answered. b.) Does dialectical logic investigate concrete content of thought? c.) What is the main characteristic of dialectical thinking? d.) Is dialectical logic an integral part of Marxist philosophy? Does is contain class characteristics? e.) What kind of relationship exists between Marxist dialectics and dialectical logic? f.) How should one understand the Marxist principle of unity of dialectics, epistemology and logic?

10.) On the question of relationship between formal and dialectical logic, 1955:

The debate was conducted in the periodicals *Xin jianshe, Zhexue yanjiu, Guangming* *ribao* etc. It mainly touched upon the following questions: a.) What is the difference between formal and dialectical logic? b.) What kind of a relation is there between formal and dialectical logic?

11.) On the scope of application of the law of contradiction, 1957:

The debate encompassed the following major questions: a.) In dialectical thinking, is there still any use for formal logic? b.) What are the implications of the limitedness of the scope of use of the so-called "law of contradiction"? etc. (Fudan daxue zhexuexi ziliaoshi 1978, 154-195)

The last debate listed in the above-named book was the "debate on the question of mathematical logic". According to the source, the debate on mathematical logic, which allegedly started in June 1956, developed in the periodicals like *People's Daily*, *Guanming daily, Beida xuebao, Zhexue yanjiu*, *Ziran bianzhengfa tongxun* and others. The authors of the above-named book claim that the debate developed after Hu Shihua published his article entitled "Mathematical Logic is a Scientific Discipline which Needs to Be Taken Seriously" in the *People's Daily* in June 1956 (ibid., 194). Although, in my opinion, the abovenamed source from 1978 inadequately described the context in which the debate took place, it nonetheless managed to provide a comprehensive summary of the contemporary reactions to Hu Shihua's article. These public debates relating mathematical logic were also the debut of Mo Shaokui (莫紹揆, 1917-2011) as one of the few established authorities on mathematical logic in China, who set out to defend Hu's views. Mo specialised in intuitionistic logical calculi and was based at Nanjing University.[122] Regarding the abovementioned debate, Hu-s definition of the object

[122] Mo Shaokui was born in Guiping county in Guangxi province in 1917. In 1939, Mo graduated from the department of mathematics at the Central University in Chongqing. Right upon graduation, he remained at the wartime department of mathematics of the Central University, assuming the post of an assistant in mathematics. After two years had passed, Mo was promoted to the position of a lecturer in mathematics first at the Central University, and later on also at the Zhongshan University. In 1947, he travelled to Switzerland, where he resumed his studies at University of Lausanne and École polytechnique fédérale de Lausanne, as well as, at University of Paris in France. While he was visiting the above two institutes in Lausanne, he had the chance to study mathematical logic and foundations of mathematics under Hilbert's renowned collaborator Paul Bernays. In April 1950, he returned to China, where he was appointed professor of mathematics at the department of

of mathematical logic as indicated in his articles from 1956 and 1957, was criticised by philosophers such as Yan Chengshu (晏成書, ?), who argued that the object of mathematical logic is limited to the theory of mathematical proof (ibid.).[123] We also learn that, in the same discussion different opinions were raised regarding the question whether mathematical logic was a part of mathematics or a form of logic (ibid., 195).

Regarding the notion of dialectical logic defended in the debates on logic from the 1950s, contemporary Chinese scholarship on history of dialectical logic in PRC generally discerns between three currents (Zhang Jianjun 2011, 44-53): The first advocated the idea that dialectical logic was the method of dialectical materialism or that it incorporated an important aspect of the method of dialectical materialism (ibid., 45). This view is claimed to have been the prevalent view on dialectical logic in 1950s-60s China.[124] The focal point of the second current revolved mainly around the subject of dialectical logic, which was defined as the dialectical principle or form of thought. This was also the view emphasized in Lenin's works on dialectics.[125] Finally, the third current extended the scope of the dialectical logic to the laws, form and method of dialectical thinking.[126] This school was further divided into two branches:

mathematics of Nanjing University. He remained teaching there for the rest of his career. In 1960, at department of mathematics of Nanjing University, Mo founded a specialised course on mathematical logic. In his career, he specialised in following fields of mathematical logic: axiomatic systems for propositional calculi, intuitionist systems, modal logic, recursive functions etc. Mo was also a member of the American Association for Symbolic Logic, and a reviewer and board member of important international journals the *Mathematical Reviews* and *Zentralblatt für Mathematik.* Prof. Mo passed away in the year 2011 (Cheng Minde 2000, 305-311). Mo Shaokui's academic biography was written by his student and colleague Ding Decheng (丁德成, 1943-), who is a contemporary Chinese expert in mathematical logic and computational mathematics, working as a professor at the Department of Mathematics at Nanjing University.

123 On April 18th, 1956, Yan published an article entitled "What is Mathematical Logic?" in the *Guangming ribao.* Yan was also the one who retranslated Russell's *IMP* into Chinese. His translation (*Shuli zhexue daolun* 數理哲學導論) was published only in 1982 by the Commercial Press in Peking.

124 Philosophers who in their writings propagated this view were, for example, Ai Siqi, the renowned Li Da, Sun Shuping 孫叔平 etc. This view was also held by logicians such as Li Zhicai 李志才, Du Xiushi 杜岫石 and so on (ibid.)

125 This view is consistent with R. Rosenthal's idea that dialectical logic utilises dialectical method in studying thought and knowledge; "An important duty of dialectical logic is to show how one can represent movements of objective reality within the logic of concepts, categories, judgments, inferences etc." (Ibid.)

126 The Chinese adherents of this view were Jian Tianyi 江天驥, Qie Dayou 且大有, Zhang Pei 章沛 etc. (ibid)

the first branch stipulated that the research subject of formal logic was completely different from the dialectical form of thought, which implied that not only one type of form can be produced by a materialist analysis of thought. In this context, dialectical method encompassed dialectical concepts, judgments and inferences. The second position was coherent with the former two currents, advocating that dialectical form was a logical picture of the form of thought as embodied in dialectical concepts, judgments and inferences. (Ibid., 46) The common point of above three currents resided in the proposition that the method of dialectical thinking integrated oppositions such as: induction and deduction, analysis and synthesis as well as logic and history, and that dialectical logic was a method which departed "from the abstract in order to advance towards the concrete". (Ibid.)

One of the most important contributors to Chinese discourse on dialectical and formal logic in 1950s, was Zhou Liquan (周禮全, 1921-2008), a relatively influential Marxist logician and a former graduate of Qinghua department of philosophy, who in 1957 also published a book titled *On two Important Stages in the Development of Ideas – From Abstract Ideas to Concrete Ideas* (Lun gainian fazhan de liangge zhuyao jieduan – you chouxiang gainian dao juti gainian 論概念發展的兩個主要階段—由抽象概念到具體概念), in which he compared Aristotle's and Hegel's philosophy (and logic) in order to establish a clear historical definition of both notions. He concluded that because in the conceptual evolution the abstract stage occurred before the concrete one it was also inferior in value (see Zhou Liquan 1957). After the year 1956, Zhou devoted many writings to the to the problem of logic, stating that theories of logic imported from the SU needed to be revised through novel research on Aristotle and Hegel, which would redefine the relation between formal and dialectical logic (Zhang Jianjun 2011, 46).

3.5.7. Hu Shihua and the Ascent of Mathematical Logic during the Hundred Flowers Campaign, 1956-1957

As indicated above, from 1956 onwards, Hu Shihua assumed the role of the public advocate and propagator of mathematical logic, cybernetics and later also foundations of mathematics. Like Guan Zhaozhi, Hu was also a member of the IMCAS. Judging from the level and intensity of their participation in matters pertaining to philosophy of science, it appears that by 1956, the members of IMCAS had managed to obtain relative autonomy and yielded a relatively strong voice in the contemporary discourse on mathematics. As the IMCAS' only official expert in the field of mathematical logic, Hu Shihua was both obliged to publicly discuss and defend mathematical logic.

Nevertheless, Hu had not exposed himself before 1956. In fact, he had done so only after his colleague Guan Zhaozhi had set the stage for subsequent rehabilitation of mathematical logic and foundations of mathematics in his article from 1955. Once the time was ripe, Hu invested his efforts into the project of resetting the fate of mathematical logic in China. Moreover, since the ideological questions related to mathematical logic and foundations of mathematics represented the central battleground against idealism in mathematics, Hu's undertaking touched upon the very core of the problematics of Marxist philosophy of mathematics.

The first stage of Hu's propagation of mathematical logic was set within the context of intellectual climate of the Hundred Flowers campaign. The year 1956 represented a major turning point in the history of mathematical logic in PRC, while Hu's writings and lectures were predominantly still in the domain of its general character, searching for a definition which would enable mathematical logic to be included into Marxist classification of science. The early articles were thus concerned with the "nature, characteristics, object of research" and the philosophical "meaning" of mathematical logic. Concurrently, consistently with recent developments in the SU, Hu's apology for mathematical logic hinged heavily on the demonstration that it is practically applicable in science, most importantly computer technology.

The first in the series of Hu's articles on the philosophical and scientific meaning of mathematical logic was published in June 1956 in the central Chinese newspaper, the *People's Daily* (*Renmin ribao* 人民日報). In the article entitled "Mathematical Logic is a Scientific Discipline which Needs to be Taken Seriously" (Shuli luoji shi yinggai zhongshi de yimen kexue 數理邏輯是用改重視的一門科學) Hu addressed the problem of the discipline's past association with mathematical idealism, pointing out that only because it was imported to China together with logical empiricism, many people wrongly believed that it was related to idealist philosophy of mathematics. He further emphasized that the principles of mathematical logic "reside in many sciences," whereas its most important contemporary function was to serve as the theoretical basis for computer science and technology. In this sense its scientific meaning was identical to that of computer science in the sense that both emulated "the operations of human reason." Computers, Hu continued, are the most *effective* replacement for the human mind, and consequently a suitable model for those dialectical processes in nature which had generated the human mind.

The correlation between the propositional calculus on one hand and the human brain as a natural manifestation of laws of dialectics on the other, was Hu's chief argument for objectiveness of mathematical logic. Moreover, the major corollary of this assertion was even profounder: mathematical logic was merely a theoretical expression of the dialectical laws of nature, a role previously occupied by the dialectical logic. Nonetheless, in Hu's ambitious advocacy of mathematical logic there still existed one minor reservation, which pertained to the original nature of mathematics, namely the fundamental limitation to exclusively describe *quantitative* aspects of reality. Consequently, Hu indicated that the mechanisms of human reasoning are translated into mathematical logic based on:

(a) Quantitative abstraction of thought;

(b) Derivation of the laws of thinking;

(c) Conversion of the thought process into the computer process.

Apart from its applications in computer science Hu also mentioned its fundamental role in signal conversion theory, a vital component in development of industrial mechanisation and automated defence systems. Hu also presented a rather interesting solution for the problem of axiomatics in mathematics. First, he noted that, proof theory had been the greatest contribution of mathematical logic to mathematics. Then, as the representative result of proof theory he mentioned the discovery that "we cannot prove the consistency of a mathematical system by the means of its logical elements." (Hu Shihua 1956b) That is to say that the representative feature of proof theory in mathematical logic were Gödel's incompleteness theorems, which, as we have noted in the preceding discussion, in Marxist philosophy of mathematics were often brought up by the mathematicians as an anti-formalist element of mathematical logic. Hu went on saying that:

> Obviously, the discovery of this fact cannot make mathematicians abandon the elementary methodology of mathematics, like the method of logical proof, [moreover, it is the case that] the axiomatic method gives it (the methodology) a new estimation and consideration. This factual discovery had also refuted the idea of mathematical idealism, that the whole mathematics can be derived from a logical system. Moreover, [in the first place] this was had been asserted using a form of definite, strictly proven theorems. (Ibid.)

What Hu was implying was simply that mathematical logic was equipped with an advanced form of proof theory, the discoveries by Kurt Gödel, which enabled the mathematicians to use systems of theorems and axioms in a correct way. In that way, the proof theory of mathematical logic was also portrayed as an objective mean which could eradicate all elements of idealism from mathematics. In the article published in the *Renmin ribao*, Hu also addressed the question of relation between mathematical logic and science of logic. He claimed that mathematical logic was the next evolutionary stage of formal logic. Hu also used the opportunity to indicate that the study of mathematical logic was a necessary task for every Marxist philosopher, who endeavoured to "carry out Lenin's directive to rectify the principles of formal logic." (Ibid.) Still, in his first major article on philosophy of mathematical logic, Hu did not go so far as to say that mathematical logic surpassed dialectical logic. On the contrary, he conformed to the paradigmatic claim that mathematical logic was only second to dialectical logic. Yet still, at the same time, Hu emphasized that the former could vitally enhance the latter's objectiveness, which in itself was an even stronger claim. Hu further wrote that:

> The laws of dialectical logic are derived from advanced form of reasoning. Especially, they represent a synthesis of thought and methodology of concrete scientific research. They reflect the laws and characteristics of the essence of higher thought. However, they do not reflect its quantitative aspect. This is the task of mathematical logic, namely, to research advanced thinking from the viewpoint of quantity. It is exactly by the investigation of their quantitative aspects that the laws revealed by dialectical logic can be given a more exact description as well as a rigorous proof in the form of theorems.

> Thus, we can say that dialectical logic precedes mathematical logic and is also the leading form of logic and that the mathematical logic represents the next step in rendering the principles of dialectical logic more concrete and more "precise" from the quantitative point of view. From the Marxist point of view, the scope of effectiveness of formal logic is limited. In the form of theorems, mathematical logic describes the effectiveness of formal logic and its limitedness when it comes to mathematical truth… Mathematical logic contains an abundance of dialectical content and can also deliver much insight about [the nature] of dialectical logic. (Ibid.)

To put it short, Hu claimed that mathematical logic was the *quantitative* complement to dialectical logic, whilst concurrently affirming that, although mathematical logic was also related to formal logic, it did not inherit its inherent limitedness.

In the same year, Hu Shihua also published a lengthier writing, in which he outlined and explained the role of computational mathematics, and hence indirectly also mathematical logic, in contemporary technological challenges in development of an electronic computer. The text entitled "The Electronic Computer and Some Related Theoretical Questions" (Dianzi jisuanji ji yixie youguan de lilun wenti 電子計算機及一些有關的理論問題) was completed in August 1956 and published as a pamphlet by the Popular Science Publishing House (Kexue puji chubanshe 科學普及出版社) in February 1957 (Hu 2008, 107-121). The main goal of the publication was to introduce the current theoretical problems in development of the Soviet electronic computer technology, more specifically the BESM-model of electronic computer, and explain how computational mathematics and mathematical logic can serve to solve these problems. At the same time, Hu Shihua reiterated the importance and the main practical uses of developing such technology in China.

Hu completed his major essay on the nature of mathematical logic in December 1956. The 40 pages-long article entitled "Basic Characteristics and the Scientific Meaning of Mathematical Logic" (Shuli luoji de jiben tezheng yu kexue yiyi 數理邏輯的基本特徵與科學意義) was ultimately published in the first issue of the *Zhexue yanjiu*, in early 1957. The same paper was also presented at monthly "formal" discussions on logic, organised by IPCAS in Peking. In the article Hu developed an extensive overview of vital questions related to the scientific and ideological disposition of mathematical logic, from questions such as its essential relation to science, down to its philosophical value and idealism. Apart from that, Hu also addressed the question of its practical applications, which he narrowed down to computer science, technology, and linguistics. Other applications, such as the use of logical calculi or proof theory in natural sciences and mathematics, were in the domain of its theoretical applications.

The article summarised the theoretical and ideological basis of mathematical logic, representing the longest piece of writing on the topic in the 1950s China. Furthermore, the above-named article from 1957 can be described as the representative philosophical argument for mathematical logic in the Hundred Flowers campaign, in which a new image of the mathematical discipline had been developed from the perspective of Marxist philosophy. Although the article covered a wide spectrum of questions, its main thesis was that mathematical logic was "**a science which investigates correct forms and laws of thinking [deriving] from the quantitative perspective and definitive properties of thought**" (Hu 2008, 125). However, akin to mathematics, the investigation of quantitative properties of reasoning in mathematical logic is conducted via an initial "quantitative abstraction" (*liang de chouxiang* 量的抽象) of the form and laws of thought. It thus transforms the human thought, ideas and propositions into formulae, and the relations which occur between these propositions and inferences into formal structural relations between formulae and their constructions.

On the relationship between mathematical logic and mathematics Hu further claimed that, even though mathematical logic was deeply related to mathematics, mathematical logic was primarily a science of human thought. As such, in Hu's opinion, mathematical logic ought to be regarded both as a science of logic of mathematical thought and of thought in general (ibid., 126). Speaking about its more specific applications in mathematics, Hu pointed out that through set-theoretical and axiomatic method, mathematical logic was essentially connected to two important questions in mathematics: the nature of mathematical concepts and mathematical proof. Hu claimed that mathematical logic possessed the tools necessary to develop a more precise and complete analysis of the basic principles of set theory, as developed by Cantor.

Another important problem, to which Hu also devoted more attention, was the **axiomatic method**. He pointed out that the construction of systems of axioms was the vital ingredient of the logical systemisation of mathematics. Objecting against the negative labels that had been attached to axiomatisation in the past debates, Hu quoted from Engels' *Dialectics of Nature*, stressing that Engels recognised the axiomatic form as the "necessary provision" (*biran guiding* 必然規定) of the object of mathematics (ibid., 128). Akin to set theory, the axiomatic method was also portrayed as the decisive factor for solving the question of the nature of mathematical proof, where mathematical logic was described as the key vehicle for channelling the objective results of axiomatic method to the final resolution of the above-named question. Since a major step towards the resolution of the question of mathematical proof had already been made by Gödel's incompleteness theorems, Hu focused on Gödel's contributions as the quintessential demonstration of effectiveness of mathematical logic. As in all previous examples, the main argument for that was a theoretical compatibility between the main implications of Gödel's results and the earlier Marxist philosophy of mathematics and logic. However, Hu claimed that the main reason why he chose to present Gödel's theorem was that it was "relatively easy to explain" (ibid., 130).

On further applications of mathematical logic in mathematics, Hu pointed out:

> With the use of results of mathematical logic one can integrate the otherwise scattered results of (general) mathematics and hence give these results a meaningful generalization. In the same way Tarski used a type of calculus from mathematical logic[127] in order to establish an arithmetic kind of theory under which many results from algebra were integrated and given a meaningful generalization. Tarski, Henkin, Robinson have already on the basis of this theory proven many theorems in algebra. In algebra Robinson formulated the "transfer principle" (*yizhuan yuanze* 移轉原則)[128], according to which, if we can prove a true "elementary proposition" in a commutative field with the property *O*, the same goes for the appropriately larger field with the property *p*. (Ibid.)

Subsequently, Hu also noted that in the last two decades the implementation of mathematical logic in mathematics had already resolved all the problems of elementary algebra

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[127] Restricted predicate calculus.

[128] Robinson explained the meaning of his *transfer principle* as follows: "By a transfer principle we mean a metamathematical theorem which asserts that any statement of a specified type which is true for one particular structure or class, is true also for some other structure or class of structures. Thus a proposition that a particular set of axioms K is complete may be expressed in the form of a transfer theorem since it amounts to the assertion that any statement which is defined in K and which holds in one particular model of K, holds also in all other models of K" (Dauben 2014, 226).

and geometry, mentioning Post's and Markov's application of expanded version of Church's method in solving the problem of semigroups. The final important field of application of mathematical logic in mathematics, mentioned in Hu's article from 1957, was computational mathematics. Hu emphasized that the most important part of computational mathematics, which developed under the influence of proof theory and mathematical logic, was the theory of algorithms (*suanfa lun* 算法論).

Commenting on the relationship between mathematical and formal logic, Hu noted that the former was "more advanced, scientific and richer." Moreover, because of that, mastery of basic content of mathematical logic was of great advantage for philosophical evaluation and understanding of Lenin's revision of formal logic. Secondly, Hu emphasized that mathematical logic was diametrically opposed to traditional formal logic. On the contrary, mathematical logic could efficiently encompass the positive results of formal logic and was not a mere "by-product of idealist philosophy" (Hu 2008, 134). On their main difference, Hu pointed out:

> The area of dissonance between mathematical logic and traditional formal logic resides in the fact that the first derives from the quantitative aspect of thought (thinking) in order to research its forms and laws; it shows a special interest in the theories of technology of thought. Whereas, in the case of the second discipline, that kind of requirements are rather unclear, mainly due to the restrictions of the historical conditions. (Ibid., 131)

In order to explain his view, Hu claimed that mathematical logic had emerged as a result of Leibniz's departure from Aristotelian logic, which had been spurred by Leibniz's interest in natural sciences. In that regard, Aristotle's greatest contribution to the modern logic was his discovery of the possibility to formalize logical problems. Leibniz, on the other hand, "had imaginatively set up a logical theory equal or 'convenient' to mathematics" (ibid., 133). Furthermore, Leibniz set two crucial conditions for an advanced logic: It must be like geometry and arithmetic and should use mathematical operations. Subsequently, the marriage of a more advanced kind of formal logic with fundaments of mathematics gave rise to early mathematical logic.

Hu further remarked that in China mathematical logic was still poorly integrated into scientific discourse, the reason for which had been a capitalist scientific policy which praised formal logic and dismissed mathematical logic. Hu described this situation in the following manner:

> When we are visiting a historical museum, we can see all those old tools our ancestors used in their work, but we know that even though we now use much more advanced tools and machines, they have nevertheless developed from the former ones. We should respect this aspect of historical development. The same goes for the relationship between traditional logic and mathematical logic – there is no need to use these relicts from the past, which have their only place in a museum, instead of our modern tool, mathematical logic. But we should pay respect to the great works of the past, like Aristotle´s contributions…Due to our country´s stubborn rejecting attitude towards adoption of mathematical logic, it is hard to find people who work in logic. But there are also people who do not approve of our standpoint towards traditional logic. They will say something like: "there are some parts of traditional logic which are not contained in mathematical logic." Therefore, they will advocate the view that traditional logic is needed, and so is mathematical logic. Mathematical logic cannot replace traditional logic, and vice versa, traditional logic cannot replace mathematical logic. These people do not understand the basic characteristics of mathematical logic. There are some problems and parts of classical logic which cannot be included into mathematical logic. But there should be an analysis about whether they must be included into the questions of epistemology, knowledge or dialectical logic. There are also some true questions of classical logic which simply cannot be included into mathematical logic. (Ibid., 136)

Hu Shihua's advocacy of mathematical logic was unique in many aspects. Firstly, his main concern was with mathematical logic and not so much with the entire formal logic as such. The defence of formal logic was thus almost entirely omitted from his apology. Consequently, he argued exclusively for the extension of the two-partite classification of logic into a tripartite system, which would treat all three kinds of logic as outcomes of a natural, dialectical developmental process. As a synthesis between advanced form of formal logic, mathematics and fundaments of natural sciences, mathematical logic would be given a special place within this system. On the one hand, it was the most advanced logic, which dealt with quantitative aspects of thought and matter (according to Lenin's definition of the concept), and, on the other hand, it also contained incorporated laws from other branches of natural science, which made it extremely similar to dialectical logic. Secondly, in the 1950s, Hu was one of only few Chinese intellectuals to have philosophically defended mathematical logic. And thirdly, in his apology Hu aimed at intertwining mathematical logic with dialectical logic, indicating that mathematical logic might have been more scientific from the latter.[129] As the main reason for its evolutionary superiority Hu named its ability to formulate its fundaments and essential characteristics. Through its inner consistency mathematical logic could also extend the scope of its research to the domain of dialectical logic, both "in theory and in practice."(Ibid., 136) Another great achievement of mathematical logic was the systematization of the laws of formal logic (axiomatization), for which an analysis of relations between laws and concepts had to be conducted. All these facts brought mathematical logic closer to dialectical logic.[130] The axiomatic method is further listed as an example of how mathematical logic includes the laws of dialectical logic into the scope of its research. Hu gives another important example of how mathematical logic is interconnected with the subject and essence of dialectical logic, namely proof theory. Again, he stressed that the essence of proof theory resides in its results which convey the structure and laws of developing proofs.

Hu's second main assertion about the relationship between mathematical and dialectical logic was that: the laws of dialectical logic are ideas derived from concrete sciences, a higher form of thought, and are summarised from the history of knowledge and all scientific methodologies. "But this kind of laws do not reflect the quantitative aspect of the highest level of thought. Therefore, the laws of dialectical logic cannot or cannot yet be described in exact mathematical language" (Ibid., 138) and cannot be proven in the form of theorems. On the other hand, the results of mathematical logic as a science about the quantitative aspects of the laws of thought can be proven and described within an exact system. Hence, dialectical logic

[129] He wrote that mathematical logic relied more on scientific methodology, was more correct in its direction, had a better grasp over the essence of the living thought and had attained a higher form of language.

[130] "It (mathematical logic) had to introduce them in one common form, rendering them mutually subordinated to each other, from the elementary forms creating high level forms. What does that mean? This means that mathematical logic had already set foot into dialectical logic. Engels said: "Dialectical logic, in contrast to the old, merely formal logic, is not, like the latter, content with enumerating forms of motion of thought, i.e., the various forms of judgment and conclusion, and placing them side by side without any connection. On the contrary, it derives those forms out of one another, it makes one subordinate to another instead of putting them on an equal level, it develops the higher forms out of the lower." Evidently, mathematical logic must encompass this content of dialectical logic." (Ibid)

in some way “precedes” mathematical logic and mathematical logic is a more “advanced concretization” of the quantitative aspect, but still under the guidance of dialectical principles.

Hu then tries to illustrate how mathematical logic was engaged in research of the relations between content and form and was capable to systematically connect the subject of mathematical thought to ideas. This was also achieved by the discovery of limited application of laws of mathematics and Gödel’s Incompleteness theorem. To render his point dogmatically correct, Hu quotes Lenin’s thoughts which say that all relations between concepts are an important part of logic, and that these relations are reflective of the objective world. Although relations between concepts include not only contradiction, but also transformation (*zhuanhua* 转化), Hu insisted that mathematical logic created quantitative and concretised abstractions of the law of transformation of concepts central to dialectical logic (Lenin). Finally, Hu claims that these relations are also analysed within systems of theories in mathematical logic, such as axiomatic theory and theory of definitions.

At the end of his evaluation, Hu emphatically repeated that: the scope of research of mathematical logic includes dialectical logic and mathematical logic was still under the guidance of dialectical principles, but on the other hand represented a more advanced, concrete and exact description of the quantitative aspect of reality (ibid., 139). He added that this did not imply that dialectical logic was included in mathematical logic, but merely that the laws of thought in dialectical logic needed to be **proven in the form of theorems**, systematised and **described in terms of an exact mathematical language**. In strictest sense, however, mathematical logic could not be regarded as a part of Marxism-Leninism.

Apart from Hu, two other mathematicians set out to construct a more positive image of mathematical logic in Chinese public discourse. Mo Shaokui, for one, endeavoured to amend the negative image of intuitionism in mathematical logic. Back in the late 1940s, Mo visited Switzerland, where he also had the opportunity to study mathematical logic under Hilbert’s colleague Paul Bernays. His studies under Bernays gave Mo the knowledge needed to defend a positive value of intuitionist position for the foundations of mathematics. Thus, in 1957, he wrote a systematic overview of the major scientific results of intuitionist logic, entitled “A Simple Introduction to Intuitionist Logic” (Zhijue zhuyi luoji de jiandan jieshao 直覺主義邏輯的簡單介紹). The second article defending the practical value of mathematical logic was composed by Xu Chu (徐芻, ?), a Peking-based engineer working on the electronic computer project. In his article "Applications of Mathematical Logic in Engineering" (Shuli luoji zai gongcheng shang de yingyong 數理邏輯在工程上的應用) Xu expounded on the numerous applications of mathematical logic in engineering. The article was published in the second half of the year 1956 in the *Shuxue tongbao*.

Soon after Hu's articles had been published, their content became the main topic at one of the formal discussions on logic organised at the IPCAS (Qie Dayou 1957, 150-1). The main aim of the debate was to assess mathematical logic as both a natural phenomenon pertaining to human and a part of an abstract formal science. In a broader sense, the debate was inherently related to the questions of position of discourse on science within dialectical materialism. It seems that, at the same time, the supremacy of dialectical logic within a hierarchical order of logics was considered a given fact as was feasibility of its accord with mathematical logic. (Ibid.) What was still unresolved was the question of the latter's concrete position within such a hierarchy, and consequently also its destiny within the future Chinese philosophy of science, science, and technology. The debate revolved around three main questions: Can mathematical logic entirely incorporate classical formal logic? Did mathematical logic become a part of the domain of dialectical logic? Is it time to put the classical formal logic into a museum? (ibid.).

The majority agreed that mathematical logic was an advanced form of formal logic, but at the same time they argued that the two ought to be strictly distinguished from each other, because "basic predicate logic is derived from the everyday thought and linguistic categories," and hence in consonance with language as a natural phenomenon. On the contrary, mathematical logic was deemed divorced from the language as a whole, and thus incapable of processing the *qualitative* aspect of reality incorporated in language. This implied that mathematical logic could not incorporate formal logic. Some of the discussants even maintained that in consequence, mathematical logic should be regarded as subordinate to formal logic, which was not to be considered redundant at all, but a perpetually evolving component of nature.

Secondly, since most of discussants adamantly refuted the proposition that mathematical and dialectical logic in any way overlapped. Similarly, they also emphasized that only dialectical logic represented the unity of both history (evolutionary aspect of the universe) and logic, and was concurrently also a form of epistemology. Nonetheless, all the participants did agree on the point that the general classification of logic ought to be changed. Hence, they proposed the following classification: (i) Classical (deductive) logic, (ii) inductive logic, (iii) mathematical logic and (iv) dialectical logic. According to its fundamental nature, it should further be divided into two categories: **formal** (classical deductive and mathematical logic) and **dialectical logic** (dialectical logic, inductive logic).

Concurrently with these discussions on mathematical logic, the renowned members of the philosophical community led by former "Qinghua mathematical logicians" were launching intensive attacks against the former paragons of mathematical logic, such as for example Bertrand Russell.[131] These campaigns pushed the discipline of mathematical logic to the verge of its former identity, causing the new discipline of mathematical logic to divorce itself from its former notion and be completely reborn within the domains of mathematics and computer technology. When its rebirth was almost taken for granted, and its position at the pedestal of cutting-edge sciences and technologies already seemed to be settled, then suddenly, in June 1957, the Anti-Rightist campaign broke out, and the Chinese scientists and intellectuals received another "blow of the shoulder pole".

3.5.8. The Final Consternations: The Anti-Rightist Campaign, 1957

The enthusiasm sparked by the Hundred Flowers campaign had lost all its momentum in June 1957, when an attempt was made by the leadership of the party to limit the political influence of Chinese intellectual elite, proclaiming the Anti-Rightist movement. This turn did not come, so to say, over night, but was slowly brewing underneath the public political stage throughout the Hundred Flowers campaign. Partly, this harsh response was also catalysed by intellectual's eagerness to exercise the temporary freedom of expression, and thereby indirectly undermining the absolute authority of the party by attempting to map out the still unclaimed territories of

[131] This discrepancy between the circumstances in Chinese philosophy and mathematical logic at the time was for example also apparent in Hong Qian's article "We Don't Have to Fear Idealism", published on May 7th 1957 in the *Renmin ribao*. There, using almost aggressive language, Hong adamantly denounced Russell's logicism: "Russell had spent much effort, trying to *use* various theories of mathematical logic to prove a proposition like 'The king of France is a fat person.' What kind of philosophy is this? If this kind of philosophy is not an excessive attention to trivia, totally sapping the will, what else could it be then?" (Hong Qian 1957) One month later Hong Qian published another article in the *Renmin ribao*, in which he called for advancement of research in history of Western philosophy ("Importance Should be Attached to Research in History of Western Philosophy", Yinggai zhongshi Xifang zhexueshi de yanjiu 應該重視西方哲學史的研究).

ideological landscape with their own commentaries on Marxist philosophy. Already in the later stage of the Hundred Flowers campaign, the ideological apparatus started issuing individual slogans and political directives, which not only aimed at pinning down the direction of the debate but were eventually transmuted into one unified campaign pointed back against the formerly outspoken "intellectual elements" (*zhishi fenzi* 知識分子). More specifically, at the general political level, the Anti-Rightist campaign was organised as a counterblow against the Party Rectification campaign which ensued one month earlier at various institutes across the country, and which, somehow ironically, gained its full swing under the protection of Mao himself. He attempted to confront the "problem of emergence of the privileged elite in the party lines," while at the same he probably also launched the movement to deal with the political impact of China's intellectual elite (Joel 2009, 32).

The Communist elite launched their counterattack in mid-June 1957. At the early stage, the essence of the movement was highlighted by a political slogan from early 1957, which urged the intellectual workers to "examine the bureaucracy, sectarianism and subjectivism which tend to distance ourselves from the masses and from reality" (Wang Yuan 1999, 221). Later, the same political motto was upgraded and distilled into a general denunciation of "sectarianism and subjectivism" among intellectuals, the hearth of their rightist political orientation or class-identity. In the framework of the movement against rightist intellectuals the intensiveness of political pressure in PRC reached a new peak. Those intellectuals who only one year before had been warmly encouraged to contribute to the development of both national political discourse as well as scientific construction, were now branded with labels, such as "anti-Marxist", "poisonous weed", "anti-people" and so on. Measures which followed such political denunciations were usually equally as harsh as implied by their political undertone. At the same time, to ensure that the scientists did not succumb to the temptations of rightist elitism and subjectivism, the party established the institution of compulsory manual labour at plantations, manufactories, or factories.

This widescale campaign against intellectuals also signified a major turning point in party's attitude towards the question of scientific development as well as other general questions. The main characteristic of this new tendency resided the gradual development of a strong emphasis on practice or practicality, which lied at the centre of the project of transformation of Chinese scientists' identity from elite-centred rightist identity to leftist identity, which attached importance to the needs of the masses. In fact, the sought "leftist identity" can be understood as a fusion between objectivist enlightenment provided by Marxism and the essentially manual labour centred identity of the masses. I assume that it was exactly this aspect of the Anti-Rightist movement of 1957, which gradually led to the ideological developments of the GLF in the years 1958 and 1959.

In the realm of mathematics, by and large, the Anti-Rightist movement of 1957 reiterated and recapitulated the paradigmatic criticism of mathematical idealism from the past years, this time, with a slightly greater emphasis laid on class-related nature of idealism in Chinese mathematics. Among Chinese mathematicians most affected by the Anti-Rightist campaign was also the president of the IMCAS and the leading voice of Chinese mathematical community, Hua Luogeng. Over many months, Hua was once again forced to write apologetic and self-critical political writings (Wang Yuan 1999, 222-4). Apart from Hua, among the denounced mathematicians was also Fu Zhongsun, a senior Chinese mathematician, whose past work had been associated both with mathematical logic as well as foundations of mathematics and geometry. In the year under observation, Fu was a professor of mathematics at Peking University, where he, apparently, still lectured on selected topics from foundations of mathematics and geometry, which in general relied heavily on the concept of axiomatisation.

In the late 1957, on several occasions, the leading mathematicians and scientists gathered at officially organised discussions, which were devoted to most pressing political and philosophical questions related to science. One such public forum, at which the leading mathematicians discussed the question of reform of thought, was organised in December 1957 in Peking. The main topics, addressed by prominent members of the mathematical community such as Jiang Zehan, Zhang Sucheng, Guan Zhaozhi, Hua Luogeng and Hu Shihua, included: the role of ideology in mathematical work, the participation of intellectuals in physical work, and the party's "red and expert" policy and the development of mathematics. The official report, which was published a few months later in the *Shuxue tongbao*, also mentioned Hu Shihua's thoughts raised in the discussion.[132] Emulating the rhetoric of the anti-rightist movement, Hu emphasized that Chinese mathematicians needed to devote more efforts to studying philosophy, to enable Chinese mathematics to embark upon a more objective developmental path, for, as Hu claimed, the development of mathematics in China was severely obstructed by "vulgar

132 "Shuxue gongzuozhe mantan sixiang gaizao" 數學工作者漫談思想改造 (Mathematical Workers Discuss Reform of Thought). *Shuxue tongbao*, 3 (1958), 43-49.

philosophical views". In a nutshell: only if Chinese mathematicians were to jointly develop an "objective" philosophy of mathematics, Chinese mathematics would advance to the next developmental stage. At the same time, however, Hu also underlined the view that mathematics dealt with *quantitative* aspect of reality in a more profound manner than any other scientific discipline. Therefore, following the Soviet model, mathematics ought to be given the central place, for only a balanced development of both theoretical and applied aspects of mathematics can lead to the general scientific progress.[133]

In addition to their formative impact on the ideological aspect of the general discourse on philosophy of science, the disturbances of the Anti-Rightist movement had no greater influence on the course of development of mathematical logic in China – i.e. as a branch of mathematics. On the contrary, although in 1957 Hu Shihua's voice fell silent, in the same year mathematical logic had been reintroduced to Chinese universities. This time as special subject within the study of mathematics. Hu's public struggle resumed in 1958, when the GLF campaign was promulgated.

Another significant political event before the GLF campaign was the "campaign against white flags," also called the campaign against "bourgeois idealist academic thought." Among other things, the campaign, which was an outgrowth of the earlier Anti-Rightist campaign, targeted the foundations of mathematics. As already noted by J. Hudeček, these attacks were also directed against Fu Zhongsun and his work related to foundations of geometry, especially his old work *Studies in Elementary Mathematics* from 1930s.[134] These attacks, which revolved mainly around the role and the meaning of axiomatisation in the foundations of mathematics and the role of practice in development of mathematics,[135] subsequently also opened up a more

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[133] Ibid.

[134] Jiří Hudeček, an unpublished paper "Perspectives on Axiomatisation in Criticisms of Idealism in Mathematics, 1955-1974", 4-8.

[135] These criticisms were based on the, as it were, "classical" Marxist discourse on the nature and value of axioms in science, which maintained that the main problem of formalist axiomatisation in mathematics was that it was fundamentally divorced from concrete reality and practice. In other words, the foundations of mathematics as developed in parts of mathematics under criticism had no epistemological basis. In criticism of Fu Zhongsun, which was published under the title "Plucking a White Flag out from Mathematical Circles" (Badiao shuxuejie de yimian baiqi 拔掉數學界的一面白旗) published in the *Shuxue tongbao* in late 1958, the anonymous members of the Group for Foundations of Mathematics of Peking Normal University asserted that "Fu Zhongsun and other logicists exaggerate the use of logic inference and make it more absolute" than it really

general discussion on the role of the scientific discipline of foundations of mathematics in future Chinese philosophy of science and its relation with foundations of mathematics. Later, as the flag-bearer of both mathematical logic and foundations of mathematics at the IMCAS, between 1958 and 1959, Hu Shihua also took part in these debates.

In 1958, similar yet less intensive criticisms were also directed against those members of IMCAS, who had previously enjoyed more political protection than the rest of the mathematicians. These included the topologist Zhang Sucheng, Hua Luogeng, and others.

3.5.9. The Great Leap Forward Campaign and the Rise of Foundations of Mathematics

When the Great Leap Forward was promulgated in 1958, the old slogans, which only recently had still been used against intellectuals, were paraphrased and integrated into a more general ideological paradigm. The essence of the movement was derived from the idea of the dialectical "leap" forward. The idea originated in Hegel's thought, where it was defined as a leap (*Sprung*) which occurred between one quality and another in the dialectical evolutionary process. (Hegel 1986b, 438) In Marxist philosophy the term "leap" (Rus. *skachok*) still denoted a similar idea, though in the evolutionary or historical context of dialectical materialism it came to refer to the particular moment when the material production reaches a quantitative peak, causing a sudden leap from one quality into another, either in a particular or a general sense. In this very sense, by promulgating the "great leap forward" (*da yuejin* 大躍進) the CPC wanted not only to revolutionise the Chinese industrial or material production but more so the evolution of Chinese society as a whole. The goal was to initiate a general revolution of the society, to change the

is. By attaching great value to axiomatisation and logisation of mathematics, Fu Zhongsun and other "white flags" in mathematics violated against the Marxist notion of objectivity. The criticists pointed out that their theoretical perversions can be averted by "not overstating the use of symbolic logic in mathematics" and recognising that logical inference must always be based on epistemic foundations. Furthermore, the axioms of mathematics ought to be developed out of practice and objective inquiry into the nature of things, rather than on *a priori* speculations. What the authors believed were preventing by criticising Fu was the old capitalist plot to replace dialectics with formal logic and pronounce mathematical method as the general method of science. Another aspect of Fu's idea of mathematics which was put under scrutiny by the critics was his belief that the science of mathematics consists of three separate fields: foundations of mathematics (or philosophy of mathematics), theoretical and applied mathematics. This view was refuted as an example of capitalist disregard for practice. (Beijing shida shuxuexi shuxue jichuzu 1958, 9-11) disposition of Chinese people by increasing the level of practical work, communal labour, material production and so on. This was called for by the slogan "more, faster, better, and more economically" (*duo kuai hao sheng* 多快好省). At the economic level, these ideas were also cast in a more concrete form in the framework of the second five-year plan (1958-1962).

Considering its ideological development this call for practicality was the product of a gradual development, it sprouted in the political movements in the past and gained momentum in the climate of political antagonism between intellectuals and the party elite. This ideological struggle culminated in the Anti-Rightist movement of 1957 and the movement against the "white flags" in 1958. The GLF campaign represented a stage in development, when the politics the party had "successfully" used against the intellectuals was inaugurated as the official political doctrine. Hence, it was a stage of implementation of ideology, intended to prove its objectiveness and legitimise the current political rule.[136]

On another level, the GLF represented the first substantial attempt of the leaders of the Communist party to break away from the Soviet model and embark upon their own path in Communism. Thus, although a slogan voiced at the start of the movement propagated a disconnect from the past ("thick present, thin past"), at the same time, this was countered by the rising cultural and nationalist awareness, which also proliferated the production of new historiographies of Chinese cultural, social, and scientific traditions.

At the beginning of the movement, the Chinese scientific community was still grappling with the last political disturbances and the animadvert from the previous campaign still reverberated throughout the scientific community. On the other hand, it appears that these developments had no drastic effect on the course of institutional development of science outlined by the twelve-year plan from 1956. At the same time, a major slogan of the new movement announced the emergence of a new obstacle for Chinese science. This slogan advocated that purely theoretical endeavours had to be abandoned for the sake of practical and applicable scientific work. Because of that, Chinese scientists working in theoretical fields were confronted with the difficult challenge to demonstrate the value and necessity of theoretical work for advancement of science and technology in general.

[136] On the political background of the GLF see, for example Chan 2008.

Probably more than in other branches of science the weight of this challenge felt in mathematics, which consists in great part of theoretical disciplines. Whilst Hua Luogeng, as the first mind of Chinese mathematics and the guardian of the central fortress of mathematics at the IMCAS, was actively engaged in development of the open debate on the value of theoretical work in mathematics,[137] the advocates of mathematical logic and foundations of mathematics, like Guan Zhaozhi and Hu Shihua, gradually engaged with an entirely different challenge: the foundations of mathematics. In 1958, for a brief period of time, Hu Shihua's focus was on main implications of the political slogans of the GLF and their call for practicality in scientific work. In the same year, Hu published two articles: "An Opinion Regarding the Duty to Research Dialectics of Nature" (Dui ziran bianzhengfa yanjiu renwu de yijian 對自然辯證法研究任務的意見) and "Where Is Mathematics Going?" (Shuxue wang hechu qu? 數學往何處去？). In both articles Hu argued for the importance of theoretical research in philosophy of natural sciences and mathematics, respectively. In the second article Hu discussed the role of mathematics in the GLF. He referred extensively to examples from history of Chinese mathematics, mentioning the entirely novel path in development of materialist science in China initiated by the movement, emphasizing mathematics should be aligned with this new direction to contribute more directly to the socialist construction. Hu further pointed

[137] Hua Luogeng started writing on related issues already when the campaign to reform "bourgeoise individualist academic thought" reached the IMCAS. In the context of the same political pressures that were extended to the IMCAS, Hua Luogeng also became a target of less intensive criticism. In response he composed a series of articles, where he set out to defend a wider community of mathematicians by providing several reports on the political situation at the IMCAS and the state of progress in Chinese mathematics in general. In his article "Notes on the Criticism of Capitalist Academic Thought Conducted at the IMCAS", published in the *Shuxue tongbao* in 1958, Hua proclaimed that the "non-class" ideology had already been victorious at the IMCAS, and the rightist thought had already been expelled from mathematical research. He claimed that the direction of the current research at the IMCAS was aligned with the goal to derive from practice and produce results which "return back to practice." Hua also claimed that, after the IMCAS had been liberated from rightist thought, they can continue with development of applied mathematics, such as, for example: hydro-computation, linear programming, quality control and logical programming, which was developed by the groups of computational mathematics and mathematical logic (Hua Luogeng 1958a, 4). In 1959, Hua published an article entitled "The situation of Research Work in Chinese Mathematics in Last Ten Years", in which, following the example of similar Soviet reports on anniversaries of the founding of SU, he described the developments in Chinese mathematics from 1949 on, implying the importance of developing theoretical aspects of mathematics for an overall progress of science. He also mentioned that the Chinese mathematical logicians had been working on various theories related to computer science and technology. (Hua Luogeng 1959, 565)

out that mathematics cannot fulfil its duty to the people without its purely theoretical parts being constantly researched and advanced. Moreover, purely theoretical research is the driving force behind revolutions in mathematics. According to Hu, the problem of theoretical research was the difficulty to efficiently implement abstract branches of mathematics. As a solution for that Hu suggested comprehensive research in the general characteristics, developmental laws and history of mathematics or the development of foundations of mathematics. Soon, the problem of foundations became the main focus of Hu and Guan, who became the most important participants in the subsequent polemics on the same topic at the end of 1950s.

These polemics emerged as a response to intense criticisms which befell mathematicians such as Fu Zhongsun, the main theme of which was also foundation of mathematics. However, in the wider perspective of development of Marxist philosophy of mathematics in China, these polemics were in line with the mathematicians' attempt to engage in discourse on philosophy of science in order to gain political control over certain ideological endangered fields of mathematics. In that sense, the debates about the foundations of mathematics echoed the struggle for the status of mathematical logic in Chinese science and represented a direct continuation of the organised research in dialectics of nature which started in 1956.[138]

[138] This claim is supported not only by the objectives and claims of mathematicians, who took part in the debate, which in the following years gained became more and more explicitly stated, but also by the institutional drive behind the polemics. As we will show in the forthcoming analysis, the public discussions in 1959 and 1960 were fuelled by the IMCAS or, more specifically, the group for mathematical logic at the IMCAS. One of the main objectives of the debate was to institutionalise foundations of mathematics as an important part of university curricula, on one hand, and as the main embodiment of Marxist philosophy of mathematics, or an upgraded version of dialectics of nature for mathematics, on the other. As regards the work of the society for studies in dialectics of nature founded in 1956, during the GLF period its work continued and even advanced to a higher level. Hu Shihua, for example, was one of the most outspoken and active members of the society. (See, for example "Zhexue yanjiusuo zhaokai zuotanhui taolun ziran bianzhengfa yanjiu gongzuo yuejin wenti he ziran bianzhengfa zu de wunian gongzuo chubu jihua" 1958)

3.5.10. Mathematical Logic and the Establishment of the Foundations of Mathematics, 1958-1960

Between late 1958 early 1959, in periodicals such as the *Shuxue tongbao* and the *Journal of the Dialectics of Nature* articles started to appear addressing the question of institutionalisation of foundations of mathematics. These were the first inklings signifying the occurrence of a stronger current that emanated from the circles of mathematicians at the IMCAS and their colleagues at the departments of mathematics at various universities in Peking. At the philosophical level, the advocates of foundations derived from their former experience in the ideological debates and their recent research in dialectics of nature. In 1959, the group for mathematical logic started organising symposia propagating the foundations of mathematics. Following a relatively short period of successful rebranding of foundations of mathematics, the space for philosophical manoeuvre narrowed down again. The mathematicians' response to this new consternation was the proliferation of new kind of research in foundations of mathematics, based on the principles of dialectics of nature and cleansed of all idealism. Concurrently, the ideological pressure on mathematical logic was suspended, enabling Hu Shihua and Guan Zhaozhi to redirect their attention to foundations of mathematics, which was historically indissolubly linked to mathematical logic.

In 1960, the members of the group for mathematical logic at the IMCAS wrote a report, which offers a retrospective insight into the beginnings of the campaign for foundations of mathematics at IMCAS in time of the Anti-Rightist campaign.[139] According to the report, the campaign aimed at introducing foundations of mathematics into the curriculum and research topics at Chinese universities. The report further explained why this discipline was deemed so important. The 1959 lectures on the foundations of mathematics recapitulated the same views and arguments as raised by Hu and Guan between 1955 and 1958. It was thus posited that foundations of mathematics could provide a correct understanding of developmental laws of mathematics, which could enable the mathematicians to develop mathematics in a positive and efficient way. In other words: the foundations of mathematics would serve as an advanced replacement for dialectics of nature. The report from 1960 further defined the foundations of mathematics as a science which "studies the questions of the object, characteristics, and the laws of development and emergence of mathematics",[140] the same role as ascribed to dialectics

[139] See "Zhongguo kexueyuan shuxue yanjiusuo shuli luoji shi juban shuxue jichu jiangzuo" 1960, 42.

[140] Ibid.

of nature. In consequence the rise of interest in foundations of mathematics also caused an increase in publications on history of mathematics. Now, an important question set by Chinese mathematicians was: Could its proposed nature and philosophical function give the foundations of mathematics the ideological precedence required to resolve problems of mathematics such as axiomatisation?

Earlier in 1958, numerous translations of Soviet works on the foundations were published in Chinese periodicals. Amongst translators of Soviet material was also Guan Zhaozhi. A representative example of a translation was Qiu Jilong's (邱季龍, ?) and Chen Suitong's (陳隨同, ?) translation of L. E. Majstrov's "On Mathematical Abstractness and Axiomatic Method" (Lun shuxue de chouxiang he gonglifa 論數學的抽象和公理法).

Apart from producing translations of Soviet works, Guan Zhaozhi also wrote extensively about Hilbert's formalism and axiomatic foundations of mathematics – e.g. the article "Spontaneous Materialistic Tendencies in Epistemology Expressed by Mathematicians since the 19th Century" (Shijiu shiji yilai de shuxuejia zai renshilun shang suo biaoxian de zifa weiwu zhuyi qingxiang 十九世紀以來的數學家在認識論上所表現的自發唯物主義傾向).[141] Following the publication of the first proposals of inclusion of foundations of mathematics into university curricula in the *Journal of Dialectics of Nature* and *Shuxue tongbao* in 1958, Guan wrote the article entitled "Introducing Soviet Autor V. N. Molodshii's *An Outline of Questions in Foundations of Mathematics* – Being also a Discussion on Setting up a Curriculum in Foundations of Mathematics" (Jieshao Sulian B. H. Moluodexi zhu "Shuxue jichu wenti gangyao" – Shu jian lun shuxue jichu kecheng de shezhi 介紹蘇聯 B. H. 莫洛德希著"數學基礎問題綱要"-書兼論數學基礎課程的設置). Guan introduced the content of Molodshii's work *Ocherki po voprosam obosnovaniya matematiki* from 1958 as a

[141] In 1958, Guan also published other articles related to the current philosophical issues in mathematics, as for example "Research in History of Mathematical Thought Ought also be Connected to Practice" (Shuxue sixiangshi de yanjiu ye yingdang lianxi shiji 數學思想史的研究也應當聯係實際), "A Few Realisations about the Questions of Dialectics in Advanced Mathematics" (Guanyu gaodeng shuxue zhong de bianzhengfa wenti de jidian tihui 關於高等數學中的辯證法問題的幾點體會) etc. All these articles related to philosophy of mathematics were published either in the *Journal of Dialectics of Nature* or the *Shuxue tongbao*. In 1958, Guan also started publishing a series of "reading notes on history of mathematical thought" (數學思想史禮記), articles on idealism or materialism in different periods of history of mathematics.

model example of how ideological guidelines should be applied in Marxist theory of foundations of mathematics. Guan recapitulated Molodshii's thoughts about the purport and object of foundations of mathematics as follows:

> In the research of foundations of mathematics, one needs to pay special emphasis on seeking methods, by means of which truthfulness and generality of theoretical premises of mathematics. At the same time, [these methods need to] promote the development of mathematical content and application and improve the methodology of proof. This kind of research needs to possess two closely related aspects: philosophical and mathematical. Primarily the philosophical questions of foundations of mathematics answers the following few questions: What does mathematics investigate? Under the influence of which causes and in accordance with which laws does it develop? What are the criteria of truthfulness of mathematical theory? What kind of characteristics does the establishment of the methodology of foundations of mathematics require? Etc. … Research of the mathematical aspect of foundations of mathematics is related to special concepts and methods of mathematics. It is particularly related to the following three questions: 1. Axiomatic method, its use in mathematics and the scope of application. 2. Constructive method in mathematics (above all the theory of algorithms). 3. Mathematical logic (mathematical proof theory). (Guan Zhaozhi 1959, 18)

According to the above text, a Marxist science of foundations of mathematics would, on the one hand, ascertain that mathematical theory was founded on objective fact or dialectical laws of the universe and, on the other hand, provide an ideological basis for most critical aspects of mathematics, such as axiomatic method and mathematical logic. A major corollary to that was that, as the ultimate source for mathematical objectiveness, the foundations of mathematics could serve as an adequate substitute for dialectics of nature. As such, foundations of mathematics would be able to establish axiomatic method and mathematical logic. In other words: dialectical materialism would not be able to surpass the foundations of mathematics in its ability to resolve the philosophical problems of mathematics.[142]

The actual preparations for establishment of foundations of mathematics as a field of studies had started already one year earlier. It seems that these were initiated at the same

[142] A similar role of foundations of mathematics when it came to axiomatic method and mathematical logic was also proposed in the second part of Molodshii's book. (Ibid., 19-20)

institution where the campaign against Fu Zhongsun was started in 1958. Taking into account that the propagation of foundations of mathematics as dialectical meta-mathematics was an extremely progressive undertaking, the campaign against Fu was almost unavoidable. The remodelling of Marxist philosophy of mathematics could not be completed without a process of denunciation of the negative, idealist elements. In a nutshell: process of establishment of foundations of mathematics was conducted as if it was a dialectical process. The same could also be said about mathematical logic.

Thus, in early 1958, the members and senior graduates of the department of mathematics at Peking Normal University composed a tentative "School Syllabus of Foundations of Mathematics" (Shuxue jichu jiaoxue dagang 數學基礎教學大綱) and called for a subsequent initiation of studies in foundations of mathematics at all Chinese universities.[143] The compliers of the syllabus launched their initiative within the context of the GLF campaign, concurrently evoking the spirit of the Hundred Flowers. They claimed that the foundations were indispensable for making mathematics efficiently serve the party and its socialist construction. The concise outline of foundations of mathematics encompassed all important aspects of "dialectics of mathematics", as well as its history, characteristics, and use. Perceived from that angle, they understood the foundations as a branch of mathematics synonymous with the crown philosophical theory of mathematics.[144]

The campaign reached its peak in 1959, when the group for mathematical logic at IMCAS became the epicentre of largescale polemics on foundations of mathematics. The leading roles in debates were played by Guan Zhaozhi and Hu Shihua. While the former took care of providing a general theoretical background, introducing past or most recent achievements of Soviet mathematical philosophy, the latter engaged in discussions about more concrete theoretical questions related to a potential new field of foundations of mathematics.

[143] "Shuxue jichu jiaoxue dagang" 1958, 33-34.

[144] In the months following the publication of this tentative school syllabus, the group of mathematicians who had taken over the task to of compiling the work, published further reports about their findings and results in the course of developing the syllabus. One such report was written by Zhou Guoxin 周國新, a young lecturer of mathematics (see Zhou Guoxin 1958).

Hu Shihua's Campaigning for Foundations of Mathematics and the Discussions Organised at the IMCAS in 1959

The abovementioned report from 1960 mentioned that, in November 1959, a symposium on foundations of mathematics had been organised at the at the IMCAS. Four panels were organised at the symposium: (I) Introduction to the foundations of mathematics, (II) An outline of the history of mathematics (including China), (III) Content, methodology and meaning of mathematics. (IV) The method and special features of contemporary mathematics and criticisms of mathematical idealism (the question of relationship between logic and mathematics, criticism of logic, mathematical constructivism and intuitionism, criticism of axiomatisation, formalism, Vienna School).

The first panel was presided over by Hu Shihua, who also delivered an introductory lecture on scientific and philosophical value of foundations of mathematics. Beside the members of the IMCAS, the lectures organised in the framework of the 1959 symposium were attended by representatives of philosophical and mathematical departments of universities in Peking, such as Peking University, Qinghua University, Peking Normal University and the People's University (Renmin daxue), altogether more than 200 members of around 20 institutes of higher education.

Although, before 1958, Hu Shihua had not explicitly mentioned the importance of foundations of mathematics, his articles from 1958 had indeed emphasised similar solutions as later recognised in a "dialectisized" theory of foundations of mathematics. Instead, in 1958, Hu had still been focusing on development of foundations of mathematics within the sphere of dialectics of nature. His main concern was the political definition of the role of mathematics, both theoretical and applicative parts, in the changing circumstances of the GLF. He claimed that in the ideological realignments of the GLF the development of Chinese mathematics needed the assistance of research in dialectics of nature. Another significant feature of Hu's vision from 1958 was the revival of Chinese cultural identity in future Chinese mathematics. The argument was that a materialist transformation of Chinese traditional qualities would cause a boost in the nation's quantitative production. In another article from 1958, Hu's concerns were related to the preservation of purely logical parts of mathematics.[145]

Although it was Guan Zhaozhi who started propagating foundations of mathematics much earlier than Hu and had probably been the first to recognise the potential in a reformed field of foundations of mathematics, at the 1959 symposium Hu Shihua was the main speaker at the panel on foundations of mathematics. In a lecture entitled "Introduction to Foundations of Mathematics" (Shuxue jichu yinlun 數學基礎引論) Hu the field of foundations in consonance with Guan Zhaozhi's outline of Molodshii's work on foundations of mathematics. Hu said that:

> Foundations of mathematics is a science which investigates the object, characteristics and the general laws of emergence and development of mathematics. It sums up historical development and content of mathematics. Its duty is: exposing the essence of mathematics, its material bases and its developmental laws, and hereby enables us to better use these laws in directing its advancement, rendering mathematics to be of better service to humanity. To put it briefly: foundations of mathematics is the philosophy of mathematics as well as a summary of mathematical science. (Liu Liangguan and Jin Zhenhong 1960, 19)

Hu further emphasised that foundations of mathematics were a battleground of idealism and materialism. Therefore, in Chinese foundations of mathematics the materialist worldview must represent the only basis, it needed to incorporate the tenets of dialectical materialism and object against the idealist elements that had infiltrated its theory in the past. Hu also pointed out that knowledge of its history was essential for assessing the nature of the science of foundations of mathematics. Its historical background revealed that its research usually consisted of two different aspects: the philosophical and mathematico-logical aspect. While its philosophical aspect revealed its epistemological basis, its object of research, nature, and use, the mathematical or logical aspect was concerned with its **logical structure and characteristics**. (Ibid.)

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[145] In the article "Where is Mathematics Going?" (1958), Hu remarked that: "… we cannot deny that a vast majority of important parts of mathematics were a product of pure logic … There are [even] some theories, produced as a result of pure logical generalisations, which are not entirely without meaning. Some can [even] resolve mathematical problems and even start new branches [of mathematics]."

The mathematical aspect of foundations of mathematics aimed at synthesising the results of its theoretical research and illuminate its logical structures and special characteristics. According to Hu, this kind of research started with Euclid, who used the axiomatic method to turn geometry into a deductive system. After that, two major discoveries happened in mathematics: axiomatics and set theory. Hu also mentioned Russell's theory of paradox and theory of types. Because, in Marxist philosophy resolving logical paradoxes was commonly seen as violation of laws of dialectics and hence associated with idealism, Hu defended Russell by stating that: "if the form of Russell's theory of paradox was only slightly modified, a logical contradiction can be obtained." To which he added:

> Let's say that an attribute contains its own attributes, then we can call it "self-conditioned" (*zizhuang de* 自狀的). In the opposite case it is non-self-conditioning. Now we can set the following question: is non-self-conditioning self-conditioning or not?
>
> We may also put it like that: an attribute A is called self-conditioning, if A has got the attribute A. Otherwise, we can call A non-self-conditioning. In that way it can be deduced that: to be non-self-conditioning is both self-conditioning and non-self-conditioning. In that way we obtain a contradiction. (Ibid., 21-2)

Although, on the surface, this excerpt seems to represent a criticism of Russell's approach to resolving logical paradoxes, however, what it actually proves is that his theory inherently did contain the dialectical principle of contradiction. This implied that Russell's mathematical logic could be used without opposing the principles of dialectics. Hu also claimed that all set-theoretical problems had already been resolved by axiomatic and set-theoretical methods. Its resolution caused the emergence of two new research directions in foundations of mathematics: (1) Research on the nature of mathematical concepts and logic: (a) Foundations of set theory and axiomatic set theory – the question of more suitable application of set theory. (b) Axiomatics – the question of independence and non-contradiction in axiomatic systems. (c) Theory of logical structures. (2) Proof theory: (a) Question of logical research in mathematics. (b) Question of inference, the laws of proof theory from mathematical logic. (Ibid.)

Hu contrasted the above directions in foundations of mathematics against the schools of formalism, intuitionism, logicism and the philosophy of Vienna School, stressing that Marxist philosophy should antagonise their theoretical endeavours. In Marxist foundations of mathematics, its research **cannot be separated from its developmental history, it cannot depart from the aspects of social practice** related to its development, for without these it cannot describe the object, characteristics and developmental laws of mathematics. Hu claimed that proof theory alone cannot answer the question of mathematical truth, for the only standard of truth is practice.

Subsequently, Hu also made his suggestions on how Chinese foundations of mathematics should be developed. A science of foundations of mathematics based on Marxism-Leninism should combine two main aspects: history of mathematics and applications of mathematical methods. Another important object of research in foundations of mathematics should also be the notion of contradiction in mathematical development. Beside contradiction, special attention should be given to the theory of practice and epistemological and logical aspects of mathematics. Finally, foundations of mathematics should also cover two important aspects: History of mathematics and study of logic of mathematics and its characteristics (proof theory, axiomatic method and set theory). (Ibid., 23) In the final remarks, Hu concluded that the aim of foundations of mathematics should be directing the development of mathematics towards practical applications and into the harmony with major forces of mathematical progress: necessity of realism and the necessity of theory. In other words: in the progress of Marxist mathematics its theoretical parts should be in balance with its applicative parts.

In the framework on the symposium on foundations of mathematics from 1959, a lecture was also given by Guan Zhaozhi. Guan's lecture on history of mathematics, entitled "Epochs in History of Mathematics: Rudimentary Period of Mathematics" (Shuxueshi de huaqi: shuxue de mengya shiqi 數學史的劃期：數學的萌芽時期), outlined the main characteristics and developments of earliest period of its history, while Guan further recognised the periods of elementary mathematics, variable mathematics (*bianliang shuxue* 變量數學), modern and contemporary mathematics. (Guan Zhaozhi 1960)

At the remaining two panels of the symposium, reports on topics of general characteristics of mathematics and the question of mathematical idealism were delivered by Wu Xinmou (吳新謀, 1910-1989), Tian Fangzeng (田方增, 1915-2018), the pioneer of Chinese history of mathematics Qian Baocong (錢寶琮, 1982-1974), historian of mathematics

Yan Dunjie (嚴敦傑, 1917-1988),[146] and Wu Guanglei, Ding Shisun (丁石孫, 1927-) and Wang Xianjun from Peking University.[147]

3.5.11. The Year of High Hopes – Hu Shihua's Propagation of Mathematical Logic in 1960

Hu started writing about mathematical logic again in 1960. By 1958, the discipline of mathematical logic had already been established at Chinese universities, where specialized courses started to be organised. Moreover, at the time, its cutting-edge nature and its key role in prioritized technological programs was no longer disputed. Concurrently, as indicated above, the focus of public discourse had shifted to foundations of mathematics. Thus, after 1958, when the former ideological problems of mathematical logic were as good as resolved and direct criticism ceased, Hu Shihua and others were finally able to publicly discuss the optimal developmental path for mathematical logic. In 1960, Hu's propagation of mathematical logic was further stimulated by the fluctuation in political pressure in 1959 caused by the first evaluation of the negative consequences of the GLF and its subsequent cancelation in 1960.

In the days between February 24 and March 4, the Second National General Meeting of the Chinese Mathematical Society was held in Shanghai. Following the ideological commotions and developments of late 1950s, the main themes of discussion were the future directions in Chinese mathematics. On February 24, after the opening address by the representative of Shanghai branch of the society and a professor of Fudan University, Su Buqing (蘇步青), Guan Zhaozhi delivered a speech on developmental directions of mathematics,[148] which inaugurated an extensive debate on development of essential branches of mathematics. These were: partial differential equations, ordinary differential equations, functional analysis, probability and mathematical statistics, programming theory (*guihua lun* 規劃論), computational mathematics, and mathematical logic. Reports on the situation and

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[146] Qian and Yan were currently members of the Research Institute for history of natural sciences of the CAS (Ziran kexueshi yanjiushi 自然科學史研究室).

[147] Ideological debates at the symposium were also summarised by Shi Tingxun (1960a).

[148] Guan's speech was published in *Guangming ribao* (April 27th, 1960). The title of the speech was "Guanyu woguo dangqian fazhan shuxue de fangxiang de yijian" 關於我國當前發展數學的方向的意見 (A View About the Future Direction of Development of Chinese Mathematics) (Ren Nanheng and Zhang Youyu 1994, 232-3).

future developmental requirements of above-mentioned branches relied heavily on reviews of past developments in mathematics in Western socialist countries. In the following days the discussions revolved around developments in Soviet electric computer technology and reforms of Chinese system of mathematical education (Ren Nanheng & Zhang Youyu 1994, 225-6).

As the leading mathematical logician Hu Shihua delivered a speech on future development of Chinese mathematical logic. The speech was entitled "To Rapidly Develop Chinese Undertakings in Mathematical Logic" (Gao sudu fazhan woguo shuli luoji shiye 高速度發展我國數理邏輯事業) (Hu 2008, 180-192). After Hu recapitulated the developmental history, research directions and principal scientific duties of mathematical logic, he underlined three main developmental directions which needed to be perpetuated in Chinese mathematical logic. Hu listed three such directions:

1. Cybernetics and engineering logic (logic of automatization (logical programming, theory of logical networks), information logic, mathematical analysis of computability (*ke jisuan* 可計算)).

2. Proof theory and foundations of mathematics (theory of algorithms of theory of effectiveness (theory of recursive functions, Turing's computer theory etc.), axiomatics and theory of formulation, constructive logic and mathematical systems, theory of foundations of mathematics).

3. Science of logic and linguistics (deductive logic (propositional logic, predicate logic, modal logic, many-valued logic), linguistic logic (syntax, semiotics, machine translation)) (Shi Tingxun 1960b, 190).

As the most important of above-listed directions Hu named the following three: research on the "logical machine" (*luoji ji* 邏輯機), research on solutions for computer technology, automatization, large-model electronic systems, and machine translation (ibid., 190). The above-described classification of research directions within mathematical logic conveys an image of the discipline as shaped after its practical applications. Thus, instead of enumerating separate branches or theories of mathematical logic, Hu derives from areas of its application as the main "Marxist" points of departure in accordance with which a new inner classification of the discipline is developed. In this reversed image of the discipline Hu managed to find a justification for more abstract, purely theoretical aspects of mathematical logic such as many-valued calculi or propositional calculus in the domain of "linguistic applications". In this regard, it must reiterate that the domain of language had been de-ideologized by Stalin's proclamation from 1950 ("Marxism and Problems of Linguistics"), which defined language as a class-neutral natural phenomenon. Another important feature of Hu's outline of research in mathematical logic, was related to the second aspect, which portrays foundations of mathematics as an integral subject of research in mathematical logic.

In support of his report on current and future developmental trends in mathematical logic, in the following months Hu also wrote a reviewed account of historical and current developmental circumstances in mathematical logic. In his article "An Outline of Occurrence, Development and the Current Situation of Mathematical Logic" (Lüelun shuli luoji de fasheng, fazhan he xiankuang 略論數理邏輯的發生、發展和現況),[149] Hu delivered a condensed outline of the most important historical aspects of mathematical logic,[150] its position within the classification of natural sciences, as well at its recent developments in other socialist countries. (Hu Shihua 2008, 205-6)[151]

In 1960, four younger mathematicians and members of CAS, Wan Zhexian (萬哲先, 1927-), Tang Zhisong (唐稚松, 1925-2008), Lu Zhongwan and Yang Cixiao (楊慈孝, ?)

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[149] The article was originally published in the *Kexue tongbao*, 6 (1960), 172-180. I use the article reproduced in *Collected Writings of Hu Shihua* (2008), 204-212.

[150] He distinguished between three periods in history or three historical orientations of mathematical logic: In Leibniz's time mathematical logic was still in the domain of general science of logic. The second period or direction was marked by the use of mathematical methodology in its research of logical problems of mathematics (Proof-theoretical orientation). Finally, in 1940s, a new direction was started, in which mathematical logic converged with technological developmental directions. Hu located a new, "socialist" mathematical logic, within this period. According to Hu, in this period, mathematical logic became an autonomous scientific discipline, which differentiated itself from general logic, philosophy and even slightly distanced itself from general mathematics. (Ibid.)

[151] After the ideological liberation of mathematical logic in late 1950s, the influx of material on mathematical logic from other socialist countries intensified. In the few years which followed the rise of mathematical logic in Chinese science, in 1959, László Kalmár, the Hungarian expert in the field, visited IMCAS as an official advisor for the question of advancement of mathematical logic from the SU. Kalmar was also probably the source behind Hu's new insight into the developments in mathematical logic in Western-most republics of the SU. In 1959, when Kalmar was visiting the IMCAS, one of his writings were translated into Chinese (see Kalmár 1959).

composed a short article "Mathematical Logic and Its Applications" (Shuli luoji jiqi yingyong 數理邏輯及其應用), where they especially emphasized the following four areas of its application: theory of effectiveness, algorithms or control processes and theory of programming, and logical networks.

3.5.12. Conclusion

The analyses given in the preceding four chapters show that in Chinese socialist construction in the 1950s, mathematical logic took an important place in both general political and internally academic (within the academic community) discourse relating to philosophy of science, in particular ideological issues of the theoretical aspects of modern mathematics. Although in the first few years following the founding of the People's Republic, the great part of the published or publicly expressed discourse on mathematical logic was reserved for either introductions of principles of dialectical materialism, past and current Soviet discussions on the topic, and examples of animadvert on idealist aspects of science, this initial period of learning and doctrinal appropriation was followed by a surge of publications which revealed the Chinese scholars' own reflections about the ideological issues of science. In the field of mathematics, first examples of defences against ideological attacks came from the members of IMCAS, especially its director Hua Luogeng. More importantly, through the introduction of Soviet animadvert against "mathematical idealism" in the Reform of Thought movement (1951-1952), which was latter reused and reiterated in the earliest examples of ideological criticism raised by Chinese Marxist intellectuals (1953-1955), mathematical logic gradually became the notion central to the ideological problematics of modern mathematics. Whilst, on the one hand, this development was a direct consequence of the Chinese emulation of the Soviet model, the gradual rise of native mathematician's resistance revealed a relatively unique intellectual atmosphere in the community, one that was still deeply immersed in the intellectual trajectory of the late Republican period. Thus, in contrast to the Soviet mathematicians, under the leadership of the IMCAS, the Chinese mathematical community took decisive measures to simultaneously counter the ideological incisions into the mathematical science by taking mathematical logic under its protection. In this sense, mathematical logic as a discipline completed its transition from a philosophy to mathematics, by becoming an integral branch of mathematics at IMCAS.

This uniquely Chinese development is evident from the way in which the members of IMCAS, like Hu Shihua, Guan Zhaozhi, and others, conducted their public defence of both theoretical mathematics and mathematical logic in the years following the inauguration of the Hundred Flowers Campaign. To put it more specifically, the defence of mathematical logic and the related field of foundations of mathematics became one of the central topics of the public debates of philosophy of mathematics in the years following 1955. Moreover, it also became one of the central tools or concepts in the mentioned mathematicians' initiative to regain the control over the philosophy of mathematics by establishing their own version of theory of dialectics of nature. Thus, in 1956, when such studies were officially inaugurated, the representative mathematical logician in the country and one of the founding members of the new society for the research of dialectics of nature, Hu Shihua, also took over the task of the leading public defenders of the discipline. While in the years to come these public endeavours would be temporarily halted by the "rectification" campaigns of 1957 and 1958, Hu's work would continue in the wake of the Great Leap Forward, when his ideological apologetics for mathematical logic would blend into his new theory of "socialist" foundations of mathematics, a discipline integrating mathematical logic which would be able to surpass and reform all previous notion of dialectical materialism.

Another important indication that the reestablishment of mathematical logic in the early 1950s was a direct consequence of the intellectual developments in the late Republican period was its special status in the framework of the great debates on logic, where, due to its special status in the republican period, it was treated as separate from "general" philosophical logic and endowed with profound scientific objectiveness. This was probably the direct result of the establishment of a notion of mathematical logic as the most advanced scientific method in the early circles of the CPC and, as some biographical sources reveal, the fact that this notion of mathematical logic was also maintained by Mao himself. From this it follows that in historical research of mathematical logic in China more emphasis ought to be given to the pioneering contributions of Zhang Shenfu, who can be credited for having induced and integrated this important concept into the early leftist intellectual discourse in China. On the other hand, the fact of conceptual continuity in certain segments of intellectual discourse also highlights the centrality of a sphere of awareness maintained by means of personal ties and communities in instances of objectivist transitions such as that between the late-Republic and the PRC. In this sense, the sense of objectiveness or (epistemologically) positive worldview is subsisted by or even existentially dependent on the ties and relations within the community. This can also be regarded as the main reason for calling the early period of the socialist reconstruction a period of "emulation".

Apart from what was said above, the development of the entire discourse on Marxist philosophy of mathematics, and hence also mathematical logic, was also influenced by the ebbs and flows in Chinese politics, both internal and international. Hence, one of the major political events which enabled Hu and others to express their ambitious visions of Chinese mathematics and mathematical logic more openly was the Sino-Soviet split, which ushered in a new wave of "Sinization" of Marxism and rendered some of the past ideological paradigms imported from the SU as obsolete.

To complete our understanding of the discipline and idea of mathematical logic in the 1950s, in the next part of this dissertation we shall take a closer look at the institutional and content-related developments that either resulted from or coincided with the above-described ideological developments.

3.6. Institutional and Content-Related Influences and Developments

Other two aspects of development of the discipline of mathematical logic in 1950s China, which were also deeply related to the process of intellectual exchange between China and the SU, were its development at Chinese scientific institution and its content-related trends, which were formed under the influences of Soviet contemporary science and technology. The developments in the context of the latter aspects were further proliferated by the transmission of Soviet computer technology to China.

In this section I will first examine how, in confluence with both ideological changes and restructuring of Chinese scientific and educational institutes in accordance to the Soviet model, mathematical logic slowly re-established itself at Chinese scientific institutes and reappeared in mathematical curricula at Chinese universities.

3.6.1. From Decline to Rebirth: Mathematical Logic at the IMCAS and Chinese Universities, 1949-1960

In the first years after the founding of the PRC, the initial institutional reorganisations and curricular reforms had completely excluded mathematical logic from university curricula. Specialised courses on mathematical logic were thus for the last time mentioned in the curricula of philosophical departments at Qinghua and Peking Universities in 1948,[152] after which they gradually, at least officially, disappeared from the lists of main subjects and specialised courses at Chinese universities. Nonetheless, it may be assumed that, in the earliest period of ideological transition, lectures on mathematical logic were probably still given in the framework of, let us say, general courses on logic or history of Western logic. However, with some certainty we can also assume that after, in the in the initial few years, an anachronistic form of Soviet Marxist discourse on science was being introduced to China, the notion of mathematical logic was completely removed from *philosophical curricula*.

Nevertheless, as we have previously noted, with the founding of the PRC, the discipline of mathematical logic entered an entirely new stage of development, in which it transformed from a philosophy and logic related discipline into a branch of mathematics, and lastly also

[152] According to the available sources last such course at Peking University was taught in 1948 by Hu Shihua. (Guoli Beijing daxue 1948, 25-27)

became considered as an independent scientific discipline situated between mathematics and computer technology. Within this very context, mathematical logic was given refuge at the newly forming bastion of mathematics in China, the IMCAS in Peking. Under the auspices of the Institute of Mathematics of the CAS, mathematical logic thus managed to survive the initial period of ideological transformations and slowly readapt to the scientific needs and philosophical worldview of new China, and reappear on the eve of the most intensive philosophical battles for the entire mathematics in 1956. As such, the IMCAS was also the stronghold of institutional life and the epicentre of development of mathematical logic. In particularly, in the time between 1949 up to its subsequent reestablishment in the years following 1957, when mathematical logic was gradually restored at Chinese universities.

3.6.1.1. Mathematical Logic at the CAS

The Chinese Academy of Sciences (CAS) was founded in November 1949, almost exactly one month after the proclamation of the PRC, as a new type of academy intended to succeed and effectively replace the republican institutions of Academia Sinica and Peiping Academy. After its establishment, the preparatory work for setting up individual institutes of the CAS was conducted under indirect control of the State Council, which in the years to come continued to serve as the main organ supervising activities and developments at the CAS.

From 1950 on, the CAS was at the centre of academic exchange between China and the SU. Consequently, in this early period of Chinese emulation of the Soviet model of science, the institutional formation of CAS was conducted with the assistance of Soviet advisors, who started visiting the academy in the first months of 1950. (See Wu Yan 2008) Under the directives of Chinese government, whose science-related policies adhered strongly to the Soviet example, and following the paragon of the Soviet Academy of Science, the organisational structure and research orientations at the CAS were gradually adopting the same shape as in the SU. However, with the establishment of individual institutes, the development of the CAS had lost its former general direction, as the institutes assumed a certain degree of autonomy over their future developmental orientation.

Between 1950 and 1953, the CAS gradually appointed altogether 253 Chinese scientists, who in the initial period served as professional advisors at the preparatory institutes and subsequently also became their first full-time members. Among these first employees there were 192 natural scientists and 61 experts in the field of social sciences. (Cao Cong 2004, 54)

While the actual research was conducted at affiliated research institutes, the tasks of administering scientific research, allocation of manpower and funding of research institutes was initially overseen by the so-called Special Advisory Committee, founded in June 1950. Later these tasks were taken over by the "academic divisions" (*xuebu* 學部), which were set up after the Soviet model in 1955. By then, 130 of the original research advisors became members of the established divisions. (Ibid.) In the year of first election, 30 new members were elected to the academic division for physics and mathematics, while two years later, in 1957, only 6 new members were elected. (Ibid., 2)

Following the reorganisation of Chinese institutes of higher education in 1952, the role of research at the Chinese universities had been drastically reduced, as these eventually began to focus exclusively on education. Consequently, the duty to conduct research was transferred to the CAS, which thus became the chief official bearer of Chinese scientific development. Because the CAS became such an important agent of Chinese scientific and technological progress, at the same time, it was both the target of political pressures and enjoyed a relatively privileged status. Anyway, the impact of formation of new official policies, which reached its height between the years 1949 and 1957, was also greatly felt at the CAS. On the other hand, the simultaneousness of political exposedness and privilege were also the very constellation which caused members of individual institutes such as IMCAS to take an active part in shaping of new philosophy of science, which would decisively delineate the domain of their political influences and challenge the existing ideological constraints imposed upon their scientific fields. In that sense, the development at the CAS rested greatly on the current ideological and political circumstances and was directly influenced by the stipulations of overall plans for development of science and technology in China, promulgated in form of first (1955) and second (1958) five-year plan and the long-term (12-year) plan from 1956.

Another major consequence of the above-described status of CAS was that, by necessity, the academy and its members would usually find themselves in position to serve as the defenders of the status of Chinese intellectual community in general, and thereby felt a strong duty to conduct political discussions in the name of the sciences they were representing. Examples of scholars such as Hua Luogeng, Hu Shihua and Guan Zhaozhi can more than adequately illustrate this fact.

IMCAS and the Section for Mathematical Logic

The Institute of Mathematics (IMCAS) was formally established on July 1st, 1952. Upon his return from the US, in late 1951, Hua Luogeng was named the new president of the preparatory institute of mathematics. The first head of the Preparatory Office of the Institute of Mathematics (*Shuxue yanjiusuo choubeichu* 數學研究所籌備處), which was set up in July 1950, was the mathematician Su Buqing.

In December 1952, Guan Zhaozhi and Wu Wenjun were appointed the first two members of the institute. Guan assumed the position of a librarian and manager of the general office. (Wang Yuan 1999, 167) Concurrently, since Guan was also allowed to conduct research – as an associate research member, he took over the responsibilities of the institute's specialist in the foundations of mathematics. By January 1953, the institute already employed eight research associates, among whom there were also Hu Shihua and Min Naida (閔乃大, 1931-). While Hu Shihua worked as the specialist for mathematical logic and foundations of mathematics, Min, who was appointed already in 1952, became one of the first mathematicians to specialise on the cutting-edge science of computational mathematics.[153] These appointments were most probably a direct result of the progressive views of Hua Luogeng, who on his earlier education path had come twice into contact with the new technological phenomenon of analog and electronic computer.[154] Hence, even though the CAS had not yet possessed the necessary

[153] Min was a graduate of electrical machine engineering from Qinghua University. In 1936, he travelled to Germany, where continued his studies at the Berlin Charlottenburg Technical University, where in 1944 he was awarded a PhD degree in engineering.

[154] Hua's first contact was in 1930s, when Norbert Wiener (1894-1964) was visiting Qinghua University, who supervised Hua's studies on Fourier transforms (Wang Yuan 1999, 61). During the time Wiener was staying at Qinghua, he helped the members of mathematical and technical departments of the university formulate a plan for researching and developing an analog computer – this project was the earliest such undertaking in China. (See Liu Quihua 2010, 118-129) For the second time, Hua had the chance to learn about modern technological wonder of electronic computer, when he was visiting the US. Finally, under influence of John von Neumann, whom he met in the US, Hua developed an interest for electronic computer technology. (Zhang Bochun et al., 2005, 205) We also know that Hua's vision of how mathematics ought to be developed in China had already developed during the war-years, when Hua formulated a developmental plan, where mathematical logic, machine calculation and other theoretical branches were balanced with applied mathematics. Thus, we can see how mathematical logic and computational mathematics both fitted into Hua's vision of research work at the IMCAS. Because of ideological pressures, Hua, however, later denied his high regard for mathematical logic,

resources and capacities, with appointment of Min Naida in 1952, Hua started to assemble Chinese mathematicians and scientists who would be able to contribute to the project of electronic computer. At first, though, the group of researchers in computational mathematics gathered around Min Naida had devoted their research to electronic circuits and calculators. (Wang Yuan 1999, 171) As an expert for mathematical logic, Hu Shihua was also appointed to provide theoretical solutions for these projects related to computer technology and "mathematical machines". After, as a result of the implementation of the measures proposed in the 12-year plan, in 1956, a separate Institute of Computer Technology was set up at the CAS (ICTCAS), members of the group were gradually transferred from IMCAS to this new institute of the CAS.

From its establishment in 1952 on, the members of IMCAS took part in several formal visits to the SU. First such visiting delegation, which was organised at the level of the entire CAS, arrived in Moscow in March 1953. Among the 26 members of the delegation of was also Hua Luogeng. In the following years, between 1954, five more delegations from the IMCAS were sent to the countries of the Eastern Block to attend mathematical conferences and congresses, and visit Soviet scientific institutions: to Bulgaria in 1954 and 1956, Poland in 1955, Romania in 1956 and the Soviet Union in 1956. (Hudeček 2012, 61) In these visits the Chinese mathematicians learned about the newest research trends in Soviet science, gathered material and were informed about organisational circumstances at leading national scientific research institutes.

Otherwise, from the beginning the research work at the IMCAS was closely connected to the activities of the Chinese Mathematical Society, which was working under leadership of most prominent members of IMCAS. In that way, the directional influences, trends, and ideological discourses developed at the institute had been spreading to local mathematical communities across China, using the vast network of the Mathematical Society. Another aspect, which tied IMCAS closely together with the mathematical society was the fact that the latter took over the organisation of all Chinese national conferences on mathematics in early 1950s, and, on the other hand, also oversaw the publication of an important mathematical periodical. The main scientific journal in China, which was dedicated to publishing relevant results of

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claiming that he had not consider mathematical logic important prior to having learned that it is closely connected to computers, not long before he drafted the plan for scientific development in 1953 (Hua Luogeng 1958b, 7)

Chinese mathematicians, was the *Acta Mathematica Sinica* (*Shuxue xuebao* 數學學報), published by the IMCAS.

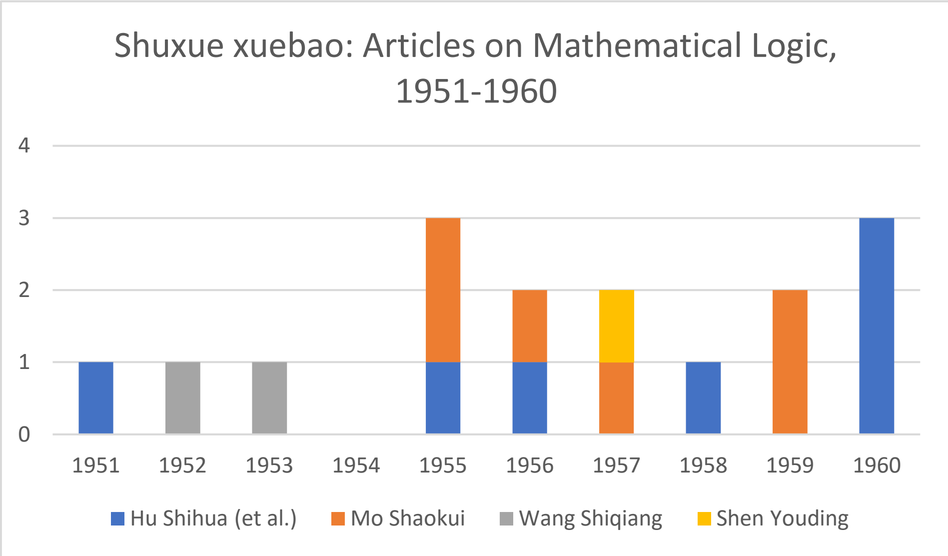

Table 4: Articles on mathematical logic published in the Shuxue xuebao between 1951 and 1960. Four different colours represent the main four contributors: Hu Shihua, Mo Shaokui, Shen Youding and Wang Shiqiang 王世強.

Thus, the first mathematical conference was organised by the Chinese Mathematical Society, in September 1953. The first conference included 15 reports and 17 research papers, in which the word was mostly about problems from mathematical analysis and calculus. In August 1956, when the second conference was held in Peking, 161 papers were presented. Furthermore, at the second conference six separate panels were organised, namely: (1) Number theory and algebra, (2) geometry and topology, (3) theory of functions, (4) differential and integral equations, (5) functional analysis, probability and mathematical statistics, and computational mathematics, (6) and mathematical logic, foundations of mathematics and history of mathematics. (Ren & Zhang 1994, 208-9)

Among 16 reports given at the conference, there was also Hu Shihua's "On Length of Numerical Computations". (Ibid., 208)

Another important point in organisational development of the IMCAS was reached in 1953, when the first research groups were established. This important move was also a result of Hua Luogeng's visit to the SU in July of the same year, where he got familiar with the organisational structure of the mathematical institute at the Soviet Academy of Sciences (SAS).

After his return, a meeting was convened (October 15th) at which the future development of the IMCAS was discussed. Hua Luogeng stressed the necessity to emulate the Soviet experience and that, in accordance with current scientific needs, eight new groups should be established at IMCAS, the eight of which was computational mathematics. Hua particularly emphasised the latter as the most important yet still least developed field of studies. (Zhang Bochun et al. 2005, 207-8) Later, a research group on mathematical logic was also established, which at the time employed only Hu Shihua and a research group for computation science led by Min Naida.[155] Subsequently, the growth of IMCAS reached its highest point during the Hundred Flowers campaign. A significant developmental boost came as a result of the promulgation of the twelve-year plan. Consequently, by 1958, when research groups were upgraded to research departments (*yanjiushi* 研究室, also "research sections"), the number of members of the research section for mathematical logic had already increased to 16. This developmental trend was significantly disrupted, when Hua's plans for Chinese mathematics were seriously challenged during the GLF campaign, and when in 1959, there suddenly a political initiative for reduction of staff-numbers at the academy were set in motion. Concurrently, with the rise of a recently established ICSCAS – the institute was officially established in May 1959 – researchers in computational mathematics and later also mathematical logic (in 1962) were also transferred there from the IMCAS. At the IMCAS, the research activities related to foundations of mathematics, history of mathematics and dialectics of nature were also conducted in the context of the department of mathematical logic.

3.6.1.2. Reintroduction of Mathematical Logic to Chinese Universities, 1957-1960

When the discipline of mathematical logic was fully rehabilitated and its advancement at Chinese scientific institutions was set into motion again, these changes also initiated a reestablishment of specialised courses on mathematical logic at Chinese universities. In 1957, a specialised curriculum on mathematical logic was organised again at the Department of Mathematics and Mechanics at Peking University. Soon afterwards, in 1958, courses on mathematical logic were also reintroduced to the Department of Philosophy at Peking University, Department of Mathematics of Nanjing University, Peking Normal University and

[155] Officially, though, the group for mathematical logic at the IMCAS was established only in 1956, after the twelve-year plan was put into effect. E.g. Hu Shihua's article "An Outline of Occurrence, Development and the Current Situation of Mathematical Logic". (Hu Shihua 2008, 212)

so on. (Lin & Zhang 1983, 172-82) In 1960, under the supervision of another influential contemporary Chinese mathematical logician, Mo Shaokui, a cathedra for mathematical logic was established at mathematical department of Nanjing University.

As we have already noted, after 1949, having been branded an ideologically problematic science, mathematical logic temporary disappeared from university curricula. At universities like Qinghua and Beida topics from mathematical logic, most probably, merged into general courses on logic or similar. After an initial period of ideological rectification, mathematical logic was entirely removed from the courses in philosophy, some of its theories probably still surviving in the framework of mathematical curricula at marginal universities, which in past had some connection with mathematical logic, like Wuhan university and Nanjing University, which became one of the most important centres of mathematical logic in 1950s China. Another blow to its existence at Chinese university came in form of reorganisation of institutes and departments in higher education of 1952, which greatly influenced former centres of Chinese science, like Peking and Qinghua universities. In the framework of readjustments of departments at those universities, the number of philosophical departments decreased in favour of studies in technology and natural sciences. Furthermore, such studies like philosophy had been centralised at only a few universities, by which the governmental control over problematic aspects of social sciences was further increased, as their contents were slowly taken under the absolute dominion of the prevalent ideology, dialectical materialism. On first sight, mathematical logic did not survive these transformations, but in the safe retreat of the institutes of the CAS some old notions managed to preserve themselves until its revival in late 1950s.

After, in the context of the reforms of 1952, the departments of philosophy and mathematics at Yanjing, Qinghua and Peking university merged into one department of philosophy and one department of philosophy and mechanics at Peking University, Qinghua university lost its fundamental connection with mathematical logic. After both, the department of philosophy and mathematics moved to Peking University, Qinghua entered a period of Soviet-assisted transformation into a polytechnic, or Soviet-style engineering school. Under the mindful governance of Jiang Nanxing (after 1952), who managed to avoid the major political dangers of the early years of PRC, Qinghua ultimately opened up to political discourse in May 1957, when the rectification campaign was brought to life among its teachers and students. Thus, in 1957, students started circulating a petition demanding that the Soviet-style restructuring of the university be reversed and Qinghua be restored as a comprehensive university. Unfortunately, their efforts were crushed by the measures inflicted on teachers and students by the Anti-Rightist campaign of 1957 and the campaigns against "rightist deviationism" of 1959, so that, in the 1950s, the circumstances at Qinghua had not been "normalised" again and mathematical logic could not return to its former centre.[156]

Contrary to the general circumstances at Chinese universities, at Peking University a certain possibility of revival of mathematical logic in mathematical or philosophical curricula remained open. Following the unification of mathematical departments under the wings of Peking University, it now possessed one of the strongest departments of mathematics in the country. However, to a certain degree, the political circumstances in the country, seemed to have reset the developments at former departments and, at least if the diversity of content is considered, brought it back to a rudimental stage. In 1952, in accordance with the Soviet model, the curriculum was thus centred mainly on fields like: algebra, analysis, geometry, topology, statistics and probability, mechanics and astronomy. (Ding et al. 1993, 79) New teaching plans were designed, in which the main emphasis was placed on the "proper" relation between theoretical and practical work. Consequently, the curriculum encouraged the students to focus more on applicative aspects of mathematics, like its applications in physics or mechanics, and less on theoretical subjects such as geometry or algebra. In fact, in the initial three years of studies the curriculum for mathematics was identical to that of mechanics. (Ibid., 80) Subsequently, in 1953, the so-called "Teaching-Research Sections" (*jiaoyanshi* 教研室) were set up at the departments. In 1953, the department of mathematics and mechanics had following teaching-research sections: analysis (Cheng Minde), algebra, geometry (Jiang Zehan), advanced mathematics and mechanics (Zhou Peiyuan). In 1955, additional sections for theory of functions, probability theory and computational mathematics were established. To a certain extent, these structural reconfigurations enabled research activities to return to Chinese universities. (Ibid.) Thus, in 1958, in the above-named department even a section for computational mathematics was established, which, together with the electric engineering

[156] Political struggles at Qinghua were much more complex as hinted above. For example, in response of political pressures of 1957 and 1958, Jiang Nanxiang relaunched the "red (and) expert" campaign, through which the intellectuals at Qinghua attempted to regain political power and re-establish their identity as intellectual elite in the new, socialist socio-political order. (See Joel 2009, 51-3)

departments at the university, engaged in the project of developing the Red Flag electronic computer.

Finally, in 1956, the ideological atmosphere in the capital changed not only in favour of mathematical logic, but mathematical research in general. After the twelve-year plan had been approved by the government, the IMCAS enhanced its research cooperation with mathematical departments at universities. This also meant that, for example, the department of mathematics and mechanics at Peking University started organising joint discussions, study groups and courses with the IMCAS. (Ibid., 80-1) As a result of this cooperation, in 1956, after seven years of absence, mathematical logic returned to Peking University, initially in form of lectures given by visiting members of the IMCAS, and then in the form of regular courses as a part of the basic curriculum.

As indicated above, following Peking University, mathematical logic was gradually reintroduced to mostly mathematical departments of Chinese universities.

The field of foundations of mathematics, the institutional development and ideological notion of which was tightly intertwined with the science of mathematical logic, underwent a similar path of establishment as a part of inner classification of mathematics and a subject taught at Chinese universities. The similarity between two processes does not only originate in their common content, but also resides in the same underlying mechanisms of ideological establishment. Although, in the final instance, the project of foundations of mathematics was unfolding itself under different political circumstances and had a different political aim.

3.6.1.3. Conclusion

The above overview of the development of mathematical logic at the IMCAS and Chinese universities in the 1950s confirms the assumption that the defining feature of mathematical logic as a discipline in that period was a transition from a philosophical science to a branch of mathematics. Although, as a field of research, mathematical logic became a part of mathematics already with its inclusion into the newly established IMCAS, its complete rehabilitation outside the CAS took place only after the above-discussed developments in the context of the Hundred Flowers Campaign. The defence of mathematical logic lead by Hu Shihua as the head of the research group for mathematical logic and foundations of mathematics at IMCAS was vital for completion of the “mathematisation” of mathematical logic beyond the confines of academic research. This fact is a further indication that, in comparison with Chinese universities, the IMCAS enjoyed a greater degree of intellectual autonomy and thus proved to be the optimal environment for the preservation of mathematical logic in the time of Chinese socialist reconstruction. It could even be claimed that, neither as a philosophical or mathematical discipline, mathematical logic would not have been preserved without the support of the first president of IMCAS, Hua Luogeng, who was probably the main agent behind its inclusion into the first research program of the institute. Furthermore, as we have shown in the foregoing section, the rehabilitation or re-establishment of mathematical logic as a part of mathematical science in the socialist system hinged entirely on its status in the current discourse on philosophy of science or, more specifically, discourse on idealism in mathematics on the one hand and the advancement of Chinese scientists' apologetic discourse on dialectics of nature on the other. Eventually, in its newly acquired form, mathematical logic was allowed to return to Chinese universities. This time, it was regarded as a discipline completely divorced from both philosophy and the general "formal" logic, which was now officially research in the context of philosophical studies of dialectical materialism and dialectical logic. The above-described developments, however, have also been a result of or reflected a further set of changes appertaining to its internal identity as a part of, as it were, "socialist" mathematics. These content-related shifts and transformations will be closely studied in the following chapter.

3.6.2. Content-Related Developments: From International Trends to Socialist Science

The third aspect of development of mathematical logic in the PRC was related to newly arising research trends and priorities, which originated from theoretical needs of modern technological progress, on one side, and changing Marxist (ideological) definition of mathematical logic on the other. Towards the end of 1950s, the general propensity towards the former aspect increased due to the ideological courses, which stressed practice and applicability of science over its theoretical aspects. At the same time, some questions in mathematical logic were more or less developed in response to contemporary political challenges. Although many aspects of the so-called "old" mathematical logic were denounced as idealist, the common tendency in Chinese mathematical logic was a philosophical defence of its disputed branches.

In parallel to its transition from a notion related to philosophical studies to a technical science related to mathematics, in the PRC period, mathematical logic in China additionally underwent a substantial change in developmental trends. Both chief contributors to Chinese mathematical logic in the 1950s, Hu Shihua (late 1930s) and Mo Shaokui (late 1940s), had spent their formative years in Europe, where they came into contact with the contemporary international trends in the field. In the late 1930s, the cutting-edge research in mathematical logic was still, in general, revolving around the notion of many-valued logical calculi or axiomatic systems. The outbreak of the Second World War had caused not only a temporary standstill of previous trends, but with its technological innovations that were contrived during the gave rise to new applications of its former purely theoretical aspects. From another point of view, many of these technological advances were also a direct outcome of pre-war developments in mathematical logic, which were put to use by mathematical logicians or mathematicians, who were involved in some of many warfare-related projects. Without doubt, the most important such example was the development of computer technology, cybernetics, and machine automation.

Consequently, after the war, for a short period of time the international research in mathematical logic experienced a continuation of pre-war trends in research, such as, for example, the many-valued logical calculi, axiomatisation, intuitionist logical calculi and so on.

Initially, Western-educated Chinese mathematical logicians managed to follow these international trends. After 1949, however, this process was interrupted, as research priorities were imported together with the Soviet Marxist notion of mathematical logic and its current place in the great machinery of Soviet science and technology.

In the years following the establishment of the PRC, despite the ideological stigmatisation of the field of study, the leading Chinese mathematical logician, Hu Shihua, managed to keep pace with the current developmental trends in the SU. Thus, considerably early on, Hu already started to work on most progressive theories in mathematical logic, such as theory of **recursive functions** and theory of **algorithms**. Subsequently, these theoretical fields also became mathematical logic's main link with the novel technological field of computer technology, which, in the second half of the 1950s, was being gradually imported from the Soviet Union.

3.6.2.1. Soviet Conferences and Congresses

Apart from the influx of Soviet material on mathematics and logic, from its rehabilitation in 1956 on, the development of content-related trends in the field was also shaped by academic exchange, which in the case of mathematical logic, rested predominantly on experience and knowledge gained by the delegations from IMCAS attending conferences in the SU. At this visits, Chinese experts did not only get familiar with the current research conducted at Soviet scientific institutes, the results of which were presented in forms of papers at these conferences, but had usually, at the same time, also visit Soviet institutions, where they could consult Soviet scientists on other important aspects of current technological and scientific trends in the SU. Since in early 1950s, mathematical logic was considered more as a theoretical tool or supplement to computer technology, as a rule, this kind of academic exchange influenced the trends in mathematical logic only indirectly, that is via computer technology or computational mathematics.

In 1950s, three such visits had the potential to influence or even change the research trends in Chinese mathematical logic, all of which took place in 1956.[157]

First such occasion was in February 1956, when a delegation of four Chinese mathematicians attended a conference on functional analysis organised at the Moscow State University. Although the main topic of the conference had not been directly related to

[157] On other instances of exchange between Soviet and Chinese scientists related to computer technology etc., between years 1956 and 1958, see also Wu Yan 2008, 405-413.

mathematical logic or computational mathematics, Xi Lizhi's (徐利治, 1920-2019) consultations with L. V. Kantorovich facilitated the future transfer of Soviet knowledge on computational mathematics to China, because Kantorovich consequently decided to send his student Moesovski to China to lecture about computational mathematics at the IMCAS. (Liu Quihua 2010, 265)[158]

On second occasion, in March 1956, a group of six Chinese mathematicians and engineers working on computational mathematics and electronic computer attended an international conference on "Ways of Development of Soviet Mathematical Engineering and Instrument Making" (Puti razvitiya sovetskogo matematicheskogo mashinostroeniya I priborostroeniya). Since Hu Shihua was one of the members of the Chinese delegation, this visit also directly influenced his understanding of the theoretical needs of Soviet computer technology and different ways in which mathematical logic could be applied to assist the development of Chinese electronic computer. In the framework of their visit to the SU, the group was also invited to the Institute of Exact Mechanics and Computer Technology of the SAS and Center for Computer Science at Moscow State University, where they could examine the Soviet BESM model electronic computer and consult the leading scientists working on the project. Xu Xianyu (徐獻瑜, 1910-2010), a professor from Peking University, also inquired about the computer science curriculum at the University of Leningrad as well as other general characteristics of computer science study-programs at Soviet universities. (Ibid., 278; Zhang Bochun et al. 2005, 208) In their visit at the above-named Soviet institutions, the Chinese delegation also received counselling about necessary preparations for launching research in computer science and technology in China.

Third such occasion was the Third Soviet Mathematical Congress held in Moscow between June 24th and July 4th 1956. Nine members of IMCAS attended the congress, at which more than 800 papers were presented at thirteen different panels. Among Chinese mathematicians who attended the congress were also Hua Luogeng, Qian Xuesen, Wu Wenjun, Cheng Minde and Guan Zhaozhi. (Liu Quihua 2010, 266) Five members of the Chinese group also presented their own research papers at the congress. Again, the most important aspect of the group's visit to Moscow resided in their consultation with the leading members of Soviet

[158] Moesovski ultimately visited China between 1957 and 1959. According to Liu Quihua (2010: p. 279) he spent most of his visit lecturing at Jilin University.

mathematical community, such Ivan M. Vinogradov (1891-1983), who was also presiding over the congress. Allegedly, at these consultations the role of computational mathematics was stressed, as well as some other aspects of contemporary mathematics that could be applied in technology, physics etc. However, for Chinese mathematical logic, the most important thing was that at the same congress the members of Chinese delegation would be able to witness the first concrete outcomes of Soviet revival of the field. These changes, which were greatly facilitated by both ideological changes and the rapid rise of importance of computer science and technology, had materialised in the fact that among the thirteen panels at the conference, there were also “Computational Mathematics”, “History of Mathematics” and finally “Mathematical Logic and Foundations of Mathematics”. This congress was also the first occasion on which Soviet contributions on cybernetics had been presented in the framework of the panel on mathematical logic. (Akademiya nauk SSSR 1956, 65-73, 145-50) At the congress altogether 28 research papers and reports on mathematical logic were presented in the framework of the panel on “Mathematical Logic and Foundations of Mathematics”.

Thus, we can see how in the context of Chinese mathematicians’ visit to Soviet Union in 1956, computational mathematics was deemed to occupy an important place in Sino-Soviet scientific exchange and at the same time also in the development of Chinese mathematics. As a result, in the following years, immense support was given to development of computer technology in China. The consequent proliferation of research institutes and sections for research related to computer science had also become the main vehicle of future development of mathematical logic. Since, beside computational mathematics, mathematical logic was one of the main theoretical tools needed in computer science, following a boost in state-controlled computer science programs and the start of transmission of Soviet computer technology to China, for Chinese mathematical logicians it became vital to specialise and further develop relevant theories and fields in mathematical logic, which had already been considerably developed in the West. As already mentioned, most important such theories were: theory of algorithms and theory of recursive functions.

3.6.2.2. Development of Chinese Computer Technology

Even though, in the late 1950s, the group of mathematical logicians which formed at the CAS was still located at the IMCAS and beside the theoretical applications of mathematical logic in computer science also devoted their research and interests to other aspects of mathematical logic, nonetheless, for our understanding of the future directions of development of mathematical logic in China it is also necessary to take into account the development of computer technology in the final years of the 1950s in China.

Chinese research in computer science started in the late 1930s at Qinghua University, where mathematicians and engineers, following Norbert Wiener's advice, started working on simulations of, basically analog, computer. Between second half of 1952 and March 1953, after the major reforms in higher education had been carried out, the former members of the research group which used to work on Qinghua telecommunication network program, and most probably also the computer science program, Min Naida, Xia Peisu and Wang Chuanying joined the IMCAS. In October, they were joined by two more members: Wu Jikang and Wang Tingliang. Zhang Bochun and others (2005, 205) claim that Min and Xia already started their research in 1952, so that by 1953 the group was already familiar with English and American literature on electronic computer technology and were now able to conduct experiments involving electronic circuits. They also started designing the main plan for the electronic computer.

Then, in the same year, except for Min Naida, all members of the group working on the electronic computer were temporarily transferred to the Institute for Modern Physics. On the contrary, Min Naida remained at the IMCAS, where he continued his research in computational mathematics. Owing to the support of the director of the IMP, Qian Sanqiang (錢三強), by 1956 the electronic computer research group already consisted of thirteen members. Similarly, the group for computational mathematics at the IMCAS was also increased to include almost ten members.

The year 1956 marked the beginning of major changes in Chinese research related to computer technology. Already months before the twelve-year plan was approved by the government, Sino-Soviet exchange in the field of computer science had been significantly enhanced by the means of academic exchange and exchange of vital theoretical material. In the same year, the preparatory Institute of Computer Technology was established at the CAS. The members of the preparatory committee worked together with the Second Ministry of Machines, which helped with mobilisation of the suitable cadres, Peking University, IMCAS and Qinghua University, that offered assistance in the fields of computational mathematics and digital computer research.

Before 1956, research of the electronic computer research group at the IMP revolved around two important objectives: (1) Designing an oscilloscope tube data storage device and (2) systematic analysis of existing material on electronic computer technology. Whereas the latter relied mainly on consistent translation of principal Soviet writings on computer science, the first results related to the first objective were achieved only in 1956, when the group succeeded to construct their first data storage device. (Ibid., 206-7)

After 1956, Chinese research in computer science received the much-needed assistance of the Soviets, with whose help in the following years the preparations for production of first Chinese electronic computer started. In other to assist the Chinese in constructing an advanced electronic computer D. J. Panov was sent to China. Finally, a decisive step forward had been made after the Sino-Soviet agreement on joint scientific and technological progress had been signed in January 1958. The implementation of the 1958 agreement meant that Soviet would help China developing its own computer technology and industry in a more substantial manner. Among other things, a new level of cooperation also implied that the Soviet would provide the Chinese side with all technological means needed for research and development of electronic computer, including their advanced BESM technology.[159]

The transfer of Soviet BESM-II computer started in 1958. The introduction of this large model electronic computer to Chinese electronic computer project was overseen by a four-member group of Soviet scientists, who stayed in China until 1959. This stage in development of Chinese computer science represented the final period of preparations and learning from the

[159] Starting with 1957, older models of Soviet electronic computers were being, piece after piece, imported to China or reproduced in Chinese laboratories. First such computer was the M-3, which was constructed out of 700 electronic valves (*dianziguan* 電子管). This was followed by an introduction of the larger model, M-20, which was soon dropped due to technical difficulties. Instead, the Soviet side decided to hand over to the Chinese the BESM-II computer, which was an advanced version of the BESM-I computer which was first constructed in 1952. The transfer of BESM-technology started in 1958. (Liu and Li 2006, 99-100)

Soviets. At the same time, this was also the last phase of development, which still encompassed work on electronic valves.

First direct results of Chinese adoption of Soviet knowledge and technology were produced in October 1959, when Chinese scientists managed to construct their first large-model electronic computer, named "Number 104" (104 機). Afterwards, Chinese computer industry embarked upon a path of autonomous development. In the early 1960s, the Chinese then developed a series of their own models of electronic computers, including: machines number 107 and 119, which were developed at the ICTCAS, "Number 911" developed at Qinghua University, and the "Red Flag" developed at Peking University. (Liu & Li 2006, 103)

The of first Chinese electronic digital computer was developed between June 1959 and June 1964 at the ICTCAS under the supervision of Wu Jikang (吳幾康). The computer "Number 119" was using crystal diodes that constituted a highs speed logical circuit (*gaosu luoji dianlu* 高速邏輯電路). The same computer was used in development of the hydrogen bomb and was successfully used in also for other purposes. (Ibid., 104)

In 1962, when work on electronic computer technology at Chinese scientific institutes culminated, the members of the department of mathematical logic at IMCAS were finally transferred to the ICTCAS, with the aim to provide greater assistance to the research and developmental work on computer technology carried out at the latter institute of the CAS.

3.6.2.3. Scientific Contributions and Developments in the Field of Mathematical Logic in 1950s China

Finally, the developmental trends in a field of research are best illustrated by concrete results and contributions by the leading scientists in the field. In the 1950s, three Chinese mathematicians were the leading contributors to the field: Hu Shihua, Wang Shiqiang[160] and Mo Shaokui. Most of their representative contributions to mathematical logic from 1950s were published in leading Chinese scientific periodicals, such as the *Shuxue xuebao*. On the other hand, some less important works of Mo Shaokui were, for instance, also published in the university journal *Nanjing daxue xuebao* (南京大學學報). Some less technical or more philosophical articles on mathematical logic were also published in journals like *Beijing daxue xuebao (Zhexue shehui kexue xuebao)*, *Shuxue tongbao*, *Kexue tongbao, Ziran bianzhengfa yanjiu tongxun*, *Zhexue yanjiu* and so on.

Some of their most cutting-edge contributions were even published in the prestigious *Journal of Symbolic Logic*. Thanks to Wang Hao's great renown in international logical circles

[160] Wang Shiqiang (王世強) was born in the year 1927 in Shijiazhuang city in Hebei province. In 1944, Wang enrolled into the provisional Northwestern Normal University in Lanzhou, where he studied mathematics. After the war, he then switched to the department of mathematics at Peking Normal University, from which he graduated in the year 1948. In the following year, after the proclamation of the PRC, Wang was invited to join the department as a lecturer in mathematics. While working at the department, due to the influence of Hu Shihua, Mo Shaokui and Wang Xianjun, he soon developed a deep interest in mathematical logic and subsequently also started doing research on some of its theoretical questions. At the time, his research was also assisted by older members of the mathematical circle in Peking, like the geometrician Li Enbo (李恩波) who earned his doctoral degree at University of Leipzig in Germany, or Duan Xuefu (段學復), the Princeton-educated Qinghua expert in algebra. Furthermore, Fu Zhongsun, a senior member of the same department, also helped Wang acquire a sound basis in various aspects of foundations of mathematics. Beside mathematical logic, from 1950s on, Wang conducted research in lattice theory and general algebra, logical calculi, model theory and applications of model theory in number theory and algebra. In his entire career, he published around 40 scientific papers on these topics. In the field of mathematical logic, due to prof. Duan Xuefu's influence, in 1940s and 1950s, Wang was mostly interested in the work of the Princeton logic Alonzo Church. Subsequently, in the early 1950s, he further discovered the work of other mathematical logicians, such as Tarski, Kleene, Robinson and Gödel. While mathematical logic was one of his first academic infatuations, in the later years he also published extensively on questions related to Birkhoff's lattice theory, Goldbach conjecture, lattice-valued model theory etc. In 1956, Wang was promoted to the title of professor of mathematics. (Cheng Minde 1998, 388-398)

and his influential position in the Association for Symbolic Logic, reviews of Chinese logicians' writings published in Chinese periodicals were also regularly published in the *Journal of Symbolic Logic,* creating some sort of a bridge through which the Chinese logicians remained connected to the international academic community. However, due to this Western journals' general orientation, the overly technical and specialised work of Chinese mathematical logicians became either overly specialised or overly propaedeutic to be published there. As such, in comparison with its developmental trends in the West, the results of Chinese mathematical logic became exceedingly specialised and technical and thus aligned better with the developmental trends in the Soviet Union.

Between 1951 and 1960, the following articles related to mathematical logic were published in the leading Chinese mathematical scientific periodicals:

Year	***Title***	***Author(s)***	
1951	"A Note on the 4-Valued Propositional Calculus and the Four Colour Problem" Sizhi mingti yansuan yu sise wenti 四值命題演算與四色問題	Hu Shihua Chen Qiangye (陳強業)	*many-valued logical calculi*
1952	"A System of Axioms for Propositional Calculus" Mingti yansuan de yixi gongli 命題演算的一系公理	Wang Shiqiang	*propositional calculus*
1953	"Notes on the Permutability of Congruence Relations" Guanyu hetong guanxi de kehuanxing 關於合同關係的可換性	Wang Shiqiang	*Boolean algebra*
1955	"Axiomatic Systems for Propositional Calculus" Mingti yansuan de gongli xitong 命題演算的公理系統	Mo Shaokui	*propositional calculus*
	"On the Definition of the Primitive Recursive Functions"	Mo Shaokui	*recursive functions*

	Yuanshi digui hanshu de dingyi 原始遞歸函數的定義		
	"Finitely-Valued and Functionally Complete Subsystems of $\aleph_0$- Valued Propositional Calculus" $\aleph_0$ zhi mingti yansuan de youqiongzhi de juyou hanshu wanquanxing de zixitong $\aleph_0$ 值命題演算的有窮值的具有函數完全性的子系統	Hu Shihua	*many-valued propositional calculus*
1956	"On the Primitive Recursiveness of Certain Recursions" Yizhong diguishi de yuanshi diguixing 一種遞歸式的原始遞歸性	Hu Shihua	*theory of recursion*
	"On the Explicit Forms of General Recursive Functions" Yiban digui hanshu de goucheng 一般遞歸函數的構成	Mo Shaokui	*recursive functions*
1957	"Modal Systems with a Finite Number of Modalities" Juyou youqiong ge motaici de motai xitong 具有有窮個模態辭的模態系統	Mo Shaokui	*(modal) many-valued logical calculi*
	"The Basic Calculus" Chuji yansuan 初級演算	Shen Youding	*Intuitionistic logical calculus*
1958	"Normal Forms of General Recursive Functions" Yiban digui hanshu de fanshi 一般遞歸函數的範式	Hu Shihua Lu Zhongwan (陸鍾萬)	*recursive functions*
1959	"Modal Systems and Systems of Implications" Motai xitong yu yunhan xitong 模態系統與蘊涵系統	Mo Shaokui	*modal logical calculi*

	“N-Generalisable, Intuitionistic, Co-Denial, Pseudo-Modal and Co-Δ Systems” Pufou xitong, zhijue xitong, gongfou xitong ji qita 普否系統、直覺系統、共否系統及其他	Mo Shaokui	*(intuitionistic) logical systems*
1960	“Recursive Algorithms – Theory of Recursive Algorithms I” Digui suanfa – Digui suanfalun I 遞歸算法：遞歸算法論 I	Hu Shihua	*recursive functions / theory of algorithms*
	“Kernel Functions – Theory of Recursive Algorithms II” Hehanshu – Digui suanfalun II 核函數 – 遞歸算法論 II	Hu Shihua Lu Zhongwan	*recursive functions / theory of algorithms*
	“Normal Forms of Recursive Functions – Theory of Recursive Algorithms III” Digui hanshu de fanshi – Digui suanfalun III 遞歸函數的範式 – 遞歸算法論 III	Hu Shihua	*recursive functions / theory of algorithms*

In my view, the above table accurately reflects the prevalent research trends in Chinese mathematical logic: the articles published in the earliest issues of the journal still partly reflect the pre-PRC research trends. Topics, such as many-valued logical calculi, propositional calculi or Boolean algebra, constituted the most popular research topics that dominated the academic research in mathematical logic when the above-mentioned authors were still in their formative phase of education. Later, new research topics gradually replaced older types of investigations. Chinese mathematical logicians’ relatively early discovery of theory of recursive functions reveals their familiarity with the recent developments in Western republics of the Eastern bloc, for their discovery of, for example, recursion theory founded by Hungarian logician and mathematician Rózsa Péter, came almost immediately after its spread in the SU.

Concurrently, Mo Shaokui's articles also reveal that sporadically the directions in research were influenced by the changes in the ideological or political atmosphere. These were at the same time also a direct outcome of fluctuations in philosophical status of mathematical logic in the Soviet Union, where the ideological tags on some concepts from mathematical logic, as for example axiomatisation, intuitionist calculi proof theory etc, had gradually been removed. As a result, following Kolmogorov's example, some concepts related to intuitionism and axiomatic systems reappeared as topics in Chinese contributions to the field. Furthermore, Mo Shaokui started writing about intuitionist logic in the warm intellectual atmosphere of the Hundred Flowers campaign. (See Mo Shaokui 1957)

Before the founding of the important journal *Shuxue xuebao*, Hu Shihua had already published a few articles on mathematical logic in various Chinese scientific periodicals. These included:

- "What is Indicated by Propositional Calculus" (1944).

- "New System of Recursive Arithmetic and Its Common Logical Terms" (1947).

- "Theoretical Objects" (1948).

- "A Construction of $\aleph_0$-Valued Propositional Calculus" (1950).

Among the above listed articles, the second was extremely important for advancement of more technical branches of mathematical logic in China, mainly because it represented a comparatively early introduction of Rósza Péter's theory of recursive functions to Chinese mathematical world.[161]

Hu's most internationally influential article was published in 1949, in the prestigious *Journal of Symbolic Logic*, and was written while he was still a professor of logic at Peking University. The article was titled "*m*-Valued Sub-System of *(m+n)*-Valued Propositional Calculus" and was later reviewed by A. R. Turquette. In the 1950s, almost all Hu's articles written in Chinese language were reviewed by either Wang Hao or C. C. Chang (Zhang

[161] Rósza Péter first presented her theory of recursive functions in early 1930s at an international mathematical congress in Zurich. By 1936, she already developed a theory of recursive functions of the second grade. Her major work on recursive arithmetic, *Rekursive Funktionen* was published only in 1950.

Chenzhong 張晨鈡, 1927-2014). The reviews were published in the *Journal of Symbolic Logic* and other American scientific periodicals.

Later, in 1952, Hu's younger colleague Mo Shaokui also managed to publish an article in the prestigious *The Journal of Symbolic Logic*. Mo's contribution was entitled "A Note on the Theory of Quantification" and received its due review by Vaclav Edvard Beneš in June 1953. Otherwise, reviews of Mo's Chinese articles were also regularly published in *The Journal of Symbolic Logic*.

In the second half of the 1950s, Mo also started publishing his articles on mathematical logic in the official scientific journal of Nanjing University, the *Nanjing daxue xuebao*. Thus, in the years between 1956 and 1960, the following Mo's articles were published:

- "Bipolar Odd Elliptic Functions" (Shuangji qi tuoyuan hanshu 雙極奇橢圓函數) (1956).
- "Axiomatisation of Finite-Valued Matrix Systems" (Youxian zhi fangzhen xitong de gonglihua 有限值方陣系統的公理化) (1957).
- "On the Question of General Laws of Logical Systems" (Luoji xitong de dingze wenti 邏輯系統的定則問題) (1957).
- "On Structure of Functions in Number Theory" (Guanyu shulun hanshu de goucheng 關於數論函數的構成) (1958).
- "An Alternative Theory of Limits" (Jixian de ling yige shuofa 極限的另一個説法) (1958).

While Hu Shihua worked at the frontline of development of mathematical logic at scientific institutes in Peking, Mo Shaokui contributed to its institutional development at Nanjing University.

Apart from the above two mathematical logicians in Peking, Wuhan and elsewhere in China, other mathematicians, computer engineers and philosophers also contributed to development of mathematical logic in China. Wang Shiqiong, who was introduced to the subject in late 1940s and early 1950s, also wrote a number of technical articles on mathematical logic which were published in journals like *Shuxue tongbao*. These included: "An Alternative Method of Proving the Resultant Theorem" (Jieshi dingli de yizhong zhengfa 結式定理的一種證法), "About the Axiomatic Constitution of Theory of Determinants" (Guanyu xinglieshi lilun de gongli goucheng 關於行列式理論的公理構成) from 1955, "Set Theory and Bijection" (Jihelun yu yiyi duiying 集合論與一一對應), co-authored with Luo Libo (羅里波, ?), in 1956. From 1959 on, Wang also published a series of articles in the scientific journal of Peking Normal University (*Beijing shifan daxue xuebao (Ziran kexue ban)*). Thus, in 1959, he published an article titled "Electronic Circuits and Algebra" (Dianlu yu daishu 電路與代數) and "Initial Construction of Calculus of Certain Logical Electronical Circuits" (Yizhong luoji dianlu yansuan de chubu gouzuo 一種邏輯電路演算的構作) and so on. Hence, we can see that, over time, Wang Shiqiang's contributions had also gradually turned to aspects of mathematical logic and its concrete applications in computer technology. In the final years of the 1950s, Wang thus wrote about the algebraic features of logical electronic circuits.

Translations and Textbooks

With the ideological rehabilitation of mathematical logic and its growing relevance for technological development, the need for translations of relevant material also increased. Concurrently, the advancement of research projects in mathematical logic also meant a growing need for new, properly educated cadres. The consequent reintroduction of mathematical logic to the curricula and study programs at Chinese universities, which considerably facilitated the process of training new experts in the field, also gave rise to a pressing need for new, modernised and updated textbooks for mathematical logic.

The commencement of a new round of translations of foreign material on mathematical logic coincided with the political reaffirmation of the field during the Hundred Flowers campaign. The translation activities encompassed two main directions: translations of "classical" but still relevant works, which had not yet been translated into Chinese, and translations of material relevant for current developments in the field (mostly computer technology).

The first major translation, produced in the late 1950s, was that of Hilbert and Ackermann's quintessential work *Gründzuge der theoretischen Logik*, of which, until then, only some fragments had been translated by Zhu Gongjin in the 1930s. The 1958 translation was the first complete Chinese translation of the work. The book, which was translated by Mo Shaokui, was published in July 1958 with the Science Press (*Kexue chubanshe* 科學出版社) publishing agency of the CAS. In Chinese version, the title was modified to *Foundations of Mathematical Logic* (instead of *Theoretical Logic*).

In the same year, in accordance with the current developmental trends, the same publishing house also published Mo Shaokui's translation of Rósza Péter's *Rekusive Funktionen* (*Digui hanshulun* 遞歸函數論). Not long after, in 1959, Hu Shihua's assistant Lu Zhongwan (陸鍾萬) published his translation of Alfred Tarski's *A Decision Method for Elementary Algebra and Geometry* (1951).

Finally, in the years 1959 and 1960, the Science Press also published the translations of two volumes of A. A. Markov's major work *The Theory of Algorithms* (*Teoria algorifmov*). While the first volume was translated by Hu Shihua and published in 1959, the second volume was translated by He Chengwu (何成武, ?) and published one year later.

First new-style textbooks, however, were published only in the 1960s. In 1962, the Science Press in Peking published Wang Hao's masterpiece *A Survey of Mathematical Logic*. The book, which was printed in English language, consisted of four major parts: (1) General Sketches (axiomatic method, history of foundational studies, formalisation, axiomatisation of arithmetic and computation); (2) Calculating Machines (Turing machines, automata, Boolean algebra, mechanical mathematics etc.); (3) Formal Number Theory (predicate calculi, arithmetisation of mathematics etc.) and (4) Impredicative Set Theory.

Later, in 1965, Mo Shaokui published his *Introduction to Mathematical Logic* (*Shuli luoji daolun* 數理邏輯導論), in which he outlined the main characteristics of propositional and predicate calculi as developed in the framework mathematical logic. In Mo's textbook a major emphasis was also given to the notion of axioms and axiomatic systems in logical calculi. The textbook was published by the Science and Technology Press in Shanghai (Shanghai kexue jishu chubanshe 上海科學技術出版社). In the same year, the very same publishing house also published Mo's textbook on *Theory of Recursive Functions* (*Digui hanshulun* 遞歸函數論).

Probably the most important Chinese textbook on mathematical logic from the time was Hu Shihua's extremely technical survey *Foundations of Mathematical Logic* (*Shuli luoji* *jichu* 數理邏輯基礎), which had been originally drafted as a script for Hu Shihua's lectures on mathematical logic at Peking University in 1957. Later, the text was revised and supplemented by Hu and Lu Zhongwan. The textbook, which in its ultimate form consisted of two separate volumes, was published by the Science Press in 1982.

3.6.2.4. Conclusion

As the above analysis has shown, in the 1950s Chinese research in mathematical logic underwent considerable change, in which the research topics described in the opening section of this dissertation were replaced with more "technical" research topics pertaining to its, as it were, mathematical part. These changes were fuelled not only by the undergoing ideological transformation of Chinese national science, that is "socialist" reconstruction, but, more importantly, by the general trends in the science of mathematical logic as such. These trends were in turn facilitated by the rise of foundation studies in the 1930s and gained their final shape under the influence of the emerging field of computer technology and machine automatization (initially cybernetics), which saw their rise in the wartime scientific institutes and laboratories in the West (see Dyson 2012). Through its eventual association with computer science and the novel field of computational mathematics, mathematical logic became gradually liberated from the ideological confines of its former identity, while at the same time its "rebirth" also ushered in new possibilities for state-supported research, recruitment of new researchers, and cooperation with other branches of science and technology. When all these possibilities started to become effective around the year 1956-7, the development of mathematical logic was further catalysed by the development of Chinese computer industry, which was launched on the basis of Soviet technology. Because the program of developing a Chinese version of electronic computer represented the main area of application of mathematical logic as researched at the IMCAS, as a consequence, the research conducted by the IMCAS's leading mathematical logicians like Hu Shihua revolved mainly around theories and research questions quintessential for software development, such as the theory of recursive algorithms, kernel functions and so on. The research in the later-half of the 1950s thus differed considerably from the slightly outdated research conducted by Chinese logicians in the early 1950s, which still revolved mainly around the questions of completeness of various systems of axioms or well-ordedness of many-valued calculi. Because by 1956 the purely theoretical research in these topics was deemed ideologically nonproblematic, outside of the IMCAS, which spearheaded the applicative research in mathematical logic in the country, some authors like Mo Shaokui continued to research questions like systems of intuitionist logic well after the described turn towards computer science. By the end of 1950s, this old research directions were almost completely replaced by research relevant for technological and industrial applications of logical calculi and axiomatic systems in computer programming etc.

As regards the overall scientific value of Chinese contributions to contemporary mathematical logic, in the period under discussion, these can be more or less determined based on their publications in internationally renowned scientific periodicals such as the *Journal of Symbolic Logic*. What is evident from the number of original articles and review articles about Chinese work in mathematical logic published in this journal is that the latter considerably outweighed the former. This is a clear indication that a strong interest in Chinese development was maintained in the group of logicians behind the said periodical. Probably the main agent behind these relatively regular updates on the development of mathematical logic in China was Wang Hao, who also the author of most of these reviews. On the other hand, as pointed out above, the original articles which did appear in the international journals were at the time already slightly outdated and thus of minor theoretical relevance. However, taking into account the substantial transformation of mathematical logic as conducted at the IMCAS in the later-half of the 1950s, it also needs to be noted that in this form Chinese "socialist" discipline of mathematical logic differed greatly in character from symbolic or mathematical logic conducted and developed by the overall community in the West. Probably, the main difference resided in the strong uniformity of research as well as the almost complete inclination towards practical applicability research in Chinese mathematical logic. Especially after 1958, in the forefront of Chinese advances in mathematical logic purely theoretical research became rather an exception or conducted predominantly by scholars at marginal institutes who were not involved directly in the main developmental current in the field – e.g. Mo Shaokui of Nanjing University. In that way, the Chinese mathematical logician's contributions to the international research on mathematical logic was obscured by means of the extreme specialisation of its "socialist" version, while the results of Chinese mathematical logicians delivered after the Sino-Soviet split also could not attain an international acclaim even in the framework of discipline as conducted in SU and other Communist countries. In its socialist version, Chinese mathematical logic of the late 1950s adopted on a somehow unique path of development, which consisted of several intertwining aspects, from the uniqueness of its role in the Chinese discourse on philosophy of science and mathematics, to its deep roots in the various schools in the West established in the time of the Qinghua school, its early turn towards mathematical science which occurred in the framework of the IMCAS, down to its “socialist” transformation under the influence of Soviet computer technology and related research.

In the subsequent and the final section of our discussion, I shall take a closer look on life and work of the leading Chinese mathematical logician in the 1950s, Hu Shihua.[162]

[162] For later Chinese achievements and results in mathematical logic see, for example, Lin & Zhang, 1983; Song Wenjian, 2000.

3.7. **Hu Shihua: Life and Work of the Pioneer of the Socialist Notion of Mathematical Logic (up to 1960)**

As I have tried to illustrate in the preceding sections of this survey, Hu Shihua was the leading advocate and propagator of mathematical logic in the Chinese ideological discourse of the 1950s. As one of the most outspoken members of the IMCAS, together with his colleague Guan Zhaozhi, with whom he shared an office at the institute, Hu pawed a way of a new philosophy of mathematics, which would, for a short time, also become an important instrument of Chinese mathematicians' struggle for political autonomy. Hu's philosophical efforts started at the wake of the Hundred Flowers campaign and slowly transformed into a, so to say, "philosophical campaign" for recognition of importance of purely theoretical branches of mathematics. In his political endeavours after the year 1956, Hu Shihua did not only participate in Chinese scientists' novel research in dialectics of nature, but also endeavoured to contribute to the establishment of the branch of foundations of mathematics as the basic Marxist philosophical outlook on mathematics, Chinese mathematicians' own doctrine of dialectics of mathematics.

In addition to his immensely significant role in shaping the ideological landscape of Chinese mathematics in the 1950s, Hu can also be credited for having made a considerable contribution to various aspects of the new form of mathematical logic, which emerged in the 1950s. Because this new kind of logic heavily relied on contemporary Soviet notion of mathematical logic, which in turn developed in strong confluence with computer science and related technology, one of Hu's main duties as the leading mathematical logician at the CAS resided in advancement of Chinese mathematical logic aligned partly with the progress made in the SU and partly with China's own needs. Concurrently, in his introductory work Hu also conducted concrete research of both theoretical questions raised in the field and demands that emanated from computer technology. However, because in the late 1950s Chinese electronic computer research program relied increasingly on Soviet computer technology, Hu's main duty was to provide Chinese engineers with the same crucial theoretical material that had already been developed in Soviet computer science. In that regard, if we consider only the part of his career up to the year 1960, the time when Hu delivered his most important scientific contributions was in the 1940s and early 1950s. Through these technical contributions, a contemporary scientific relevance was bestowed upon Chinese mathematical logic, which consequently also gained a new developmental trajectory.

In this chapter I shall closely examine Hu's educational background and main events in his academic career, focusing on the period between early 1940s and 1960.[163] Subsequently, in the last part, I will also briefly review his most important scientific contributions prior to the year 1961.

3.7.1. Hu Shihua's Intellectual Biography, 1912-1960

Hu Shihua (胡世華, also called Zihua 子華) was born on January 28th 1912 in Wuxin, Zhejiang. His father Hu Weide (胡惟德) was an important official in late Qing dynasty, who served at a post of an assistant minister and an imperial envoy to tsarist Russia. Shihua grew up in a large family, having had two stepmothers and eleven brothers and sisters. In his early years Hu attended elementary and junior secondary school at the so-called Nanyang Model School (Nanyang Mofan 南洋模範, also referred to as Nanmo) in Shanghai. (Cheng Minde 2000, 173)

In 1927, when his father returned from diplomatic mission abroad, the whole family moved to Peking. Hu continued his secondary education first at the Beijing Chongshi (北京崇實) secondary school and from 1928 onwards also at the Nankai (南開) secondary school in Tianjin. At Nankai secondary school Hu was exposed to a modern education and was greatly influenced by progressive ideas taught by Jiang Gongwei (姜公偉,?) and others. Already in his second year in the secondary school in Tianjin, Hu managed to skip one year, so that, by the end of 1929, he could already enrol into the first year of the preparatory school of the local Nankai University. Because of his profound interest in mathematics, Hu chose the program in

[163] For a survey on Hu Shihua's academic achievements, see: Yang Dongbing 1992.

natural sciences and engineering. In the same year, he changed his name to Zihua 子華 (Tzu-hua). (Ibid., 174)

In 1931, under the influence of patriotic student movements which broke out at the university following the Mukden Incident, Hu decided to change his major, abandoning a study of mathematics for philosophy. According to his own reminiscences, another reason behind this decision was his father's dissent with the fact that if he were to pursue his studies in mathematics it would have taken Shihua additional four years to graduate. Thus, in 1931, like many other students at Nankai who wanted to study modern philosophy, Hu decided to enrol into the second year of philosophy at the National Peking University. As a student at the department of philosophy at Peking University, Hu was influenced by philosophers like Jin Yuelin, Zhang Shenfu, He Lin, Deng Yizhi and so on. (Ibid., 174-5)

Under the influence of Jin Yuelin, who emphasized the connectedness between philosophy and mathematics, Germany-educated philosopher Zheng Xin's (鄭昕, 1905-1947) encouragement, and Zhang Shenfu's lectures on mathematical philosophy, Hu decided to revive his interest in mathematics by starting attending multiple courses at the department of mathematics. Thus, before his graduation from the department of philosophy, Hu regularly attended as many lectures in mathematics as possible, including all lectures by professors Jiang Zehan (江澤涵) and Zhao Song (趙松). Hu continued attending courses in mathematics even after his graduation in 1935. (Ibid., 175)

Under the influence of the contemporary philosophical currents that dominated philosophical circles at Peking and Qinghua Universities, after his graduation in 1935, Hu Shihua decided to continue his studies in modern philosophy and logic in Europe. In 1936, together with his newlywed wife, Xia Haoren (夏好仁), Hu departed for Austria. His original intention was to continue his postgraduate research in mathematical logic at the University of Vienna under the mentorship of Moritz Schlick. However, when Hu and his wife were still travelling, Schlick was assassinated by a former student while ascending the steps in front of the university. Consequently, after Hu finally arrived in Vienna, Hu's contact person there, Hong Qian, advised him to continue his studies under the renowned German expert in modern logic Heinrich Scholz, a professor at Westfalische Wilhelms Universität Münster in Germany. At the time, University of Münster was regarded to be a most important centre of research on mathematical logic in Germany. After having spent one year in Vienna, where he attended lectures in philosophy and mathematics, Hu decided to follow Hong Qian's advice and move to Münster.

In his first year (1937) in Münster, Hu studied mathematical logic, physics and mathematics under Heinrich Scholz. Then, in the second year, Hu started preparing for his PhD research under the supervision of professors Scholz and Gottfried Köthe (1905-1989), an Austrian expert in functional analysis and algebra. Under their guidance, Hu was able to obtain an official approval for starting a dissertation on pseudo-Boolean algebra and foundations of topology.[164] As described by Hu in his letter to Hong Qian from 1941, the precise title of his dissertation was "Quasi-Boolean Algebra and the Foundations of Geometry" (Gaosi Boer de daishuxue yu 高斯駁兒的代數學與幾何學的基礎). It is uncertain, however, whether Hu ever managed to officially submit his dissertation and whether he was also officially awarded a PhD degree from the University of Münster.[165] Nevertheless, regardless of whether Hu actually managed to obtain a certificate confirming the level of his education from a German

[164] In this way, Hu's thesis had been described in his biography, written by Lu Zhongwan. See Cheng Minde 2000, 176 and Xu Yibao 2005, 201.

[165] Xu Yibao claims that Hu was awarded a PhD degree from the University of Münster in 1941. His biography, however, circumvents any explicit mentioning that Hu was awarded a PhD degree, but rather that in 1939 his dissertation was "passed" or "approved" (*tongguo* 通過), and that, due to the wartime disturbances Hu was unable to immediately publish the thesis. At the same time, the biography also mentioned that after the Chinese New Year of 1941, Hu had already returned to China and that in June 1940, Hu was already boarding a ship in Marseilles. This fact is somehow contradicted by what is implied in Hu's letter to Hong Qian, which was allegedly written in January 15th 1941, and in which Hu tells to Hong Qian that: "Last year [1940], at a symposium presided hosted by professor Scholz, I delivered a report on the general idea of the content of my dissertation "Quasi-Boolean Algebra and the Foundations of Geometry." Now, after I have spent long time researching, I have already managed to write it up into an article. After the article will be published, I will first send it to my older brother [you], and ask you for some comments." In the letter, Hu further adds that the content represents a brief outline of the results obtained in his dissertation. Finally, in the introduction to the article, in which Hong Qian reproduced the content of Hu's letter and which was published in the *Academic Quarterly* (*Xueshu jikan*) in 1942, Hong claims that the letter, signed by Hu in January 1941, was sent from Germany. If this is true, the information in his biography must be incorrect. The last, and the most important, indication that it might have been the case that due to political reasons Hu could not be awarded a PhD degree derives from unclear recordings in Hu's official dossier kept at the university's archives (See: Image 21). Hu's dissertation also is not listed in: Renate Tobies. *Biographisches Lexikon in Mathematik promovierter Personen WS 1907/08 bis WS 1944/45*. Augsburg: Rauner Verlag, 2006.

university during the time of Nazi regime or not, the evidence shows that during his studies in Münster Hu definitely did carry out advanced scholarly research in which he also obtained some rather original results. Without any doubt, the research, which Hu had conducted at the very centre of German research in mathematical logic, as well as the type of mathematics-centred education he obtained there, made Hu one of the most technically well-versed Chinese mathematical logician at the time.

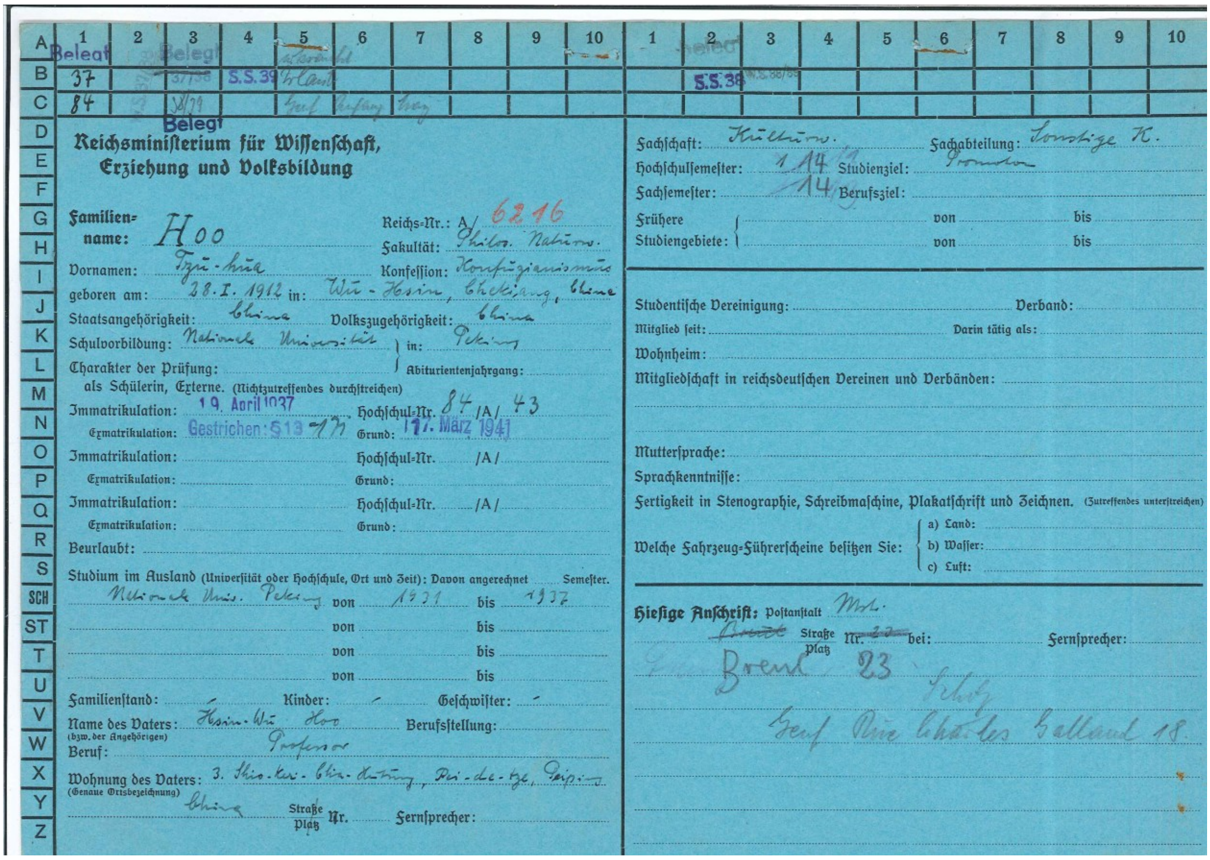
Reichsministerium für Wissenschaft, Erziehung und Volksbildung
Familienname: Hoo
Reichs-Nr.: A/ 6216
Fakultät: Philos. Naturw.
Vornamen: Tzu-hua
Konfession: Konfuzianismus
geboren am: 28. I. 1912 in: Wu-Hsin, Chekiang, China
Staatsangehörigkeit: China
Volkszugehörigkeit: China
Schulvorbildung: Nationale Universität in: Peking
Charakter der Prüfung: als Schülerin, Externe. (Nichtzutreffendes durchstreichen)
Abiturientenjahrgang:
Immatrikulation: 19. April 1937
Hochschul-Nr. 84 /A/ 43
Exmatrikulation: Gestrichen: 513
Grund: 17. März 1941
Immatrikulation:
Hochschul-Nr. /A/
Exmatrikulation:
Grund:
Immatrikulation:
Hochschul-Nr. /A/
Exmatrikulation:
Grund:
Beurlaubt:
Studium im Ausland (Universität oder Hochschule, Ort und Zeit): Davon angerechnet Semester.
Nationale Univ. Peking von 1931 bis 1937
von bis
von bis
von bis
Familienstand: –
Kinder: –
Geschwister: –
Name des Vaters (bzw. der Angehörigen): Hsin-Wu Hoo
Berufsstellung:
Beruf: Professor
Wohnung des Vaters (Genaue Ortsbezeichnung): 3. Shio-ku-Chin-hutung, Pi-de-tze, Peiping China
Straße Platz Nr.
Fernsprecher:
Fachschaft: Kultur
Fachabteilung: Sonstige K.
Hochschulsemester: 14
Studienziel: Promotion
Fachsemester: 14
Berufsziel:
Frühere Studiengebiete: von bis
Studentische Vereinigung:
Verband:
Mitglied seit:
Darin tätig als:
Wohnheim:
Mitgliedschaft in reichsdeutschen Vereinen und Verbänden:
Muttersprache:
Sprachkenntnisse:
Fertigkeit in Stenographie, Schreibmaschine, Plakatschrift und Zeichnen. (Zutreffendes unterstreichen)
Welche Fahrzeug-Führerscheine besitzen Sie: a) Land: b) Wasser: c) Luft:
Hiesige Anschrift: Postanstalt Mst.
Straße Platz Nr. bei:
Fernsprecher:
Brend 23
Genf Rue Charles Galland 18.

Figure 1: First two pages of Hu Shihua's file at University of Münster. Beside all other things, it also shows that the date of Hu's (Hoo Tzu-hua) first enrolment at the university was 19th April 1937 and that he was exmatriculated on March 17th, 1941. It also tells that Hu's last listed address before exmatriculation was in Geneva: Rue Charles-Galland 18. However, this might have been the address of Chinese embassy in Switzerland. (Courtesy of the University Archives of the Westfälische Wilhelms-Universität Münster)

After Hu had returned to China, he was first offered a post of a professor at the department of mathematics and astronomy at the Zhongshan University. According to his biography, he was only allowed to lecture general courses on calculus, because at marginal Chinese universities mathematical logic was still a completely unknown discipline. In 1943, Hu was transferred to the department of philosophy at Central University in Chongqing. In his third year in Chongqing (1945), Hu started researching theoretical questions of computer science and also taught at the department for electrical machinery at the Central Industrial Polytechnic in Chongqing (Zhongyang gongye zhuanke xuexiao 中央工業專科學校).

After the war, in 1946, Hu's former professor Tang Yongtong invited him to join his *alma mater* as an assistant professor in philosophy. In the last years of the Chinese Republic, back at the prestigious Peking University Hu Shihua took over all curricular activities related to logic. Beside the obligatory general course in logic (Luoji 邏輯), Hu was also allowed to carry out a specialised course on mathematical logic. Because, at that time, among the progressive Chinese philosophers at Peking universities it was generally accepted that between logic and philosophy on one side and mathematics on the other, there was an intricate theoretical connection, the students studying logic at the department of philosophy were also strongly encouraged to take advanced courses in analysis, algebra and geometry at the department of mathematics. (See Guoli Beijing daxue 1948, 25-6) When the study and research of philosophy at Chinese universities just began taking new steps forward, the Communist troops arrived at the gates of Peking and a brief reverberation of gunfire announced the beginning of a new era.

Hu continued teaching at Peking University until 1953. According to his biography, in these years he already started working for the preparatory committee of the IMCAS as an external expert on mathematical logic, until in 1953, he was also officially appointed as a researcher at the IMCAS. (Cheng Minde 2000, 178)

In comparison to other members of former philosophical elite, Hu became a member of the CPC quite early on after the initial phase of the ideological transformation had been completed. Actually, he was accepted into the party only one year after he became a member of the CAS.

After 1956, together with Wang Xianjun, Hu Shihua started organising workshops in mathematical logic for students of philosophy and mathematics at Peking University. In 1957, he started concurrently teaching at Peking University, where he established a specialised study course in mathematical logic at the department of mathematics. Concurrently, in the year following 1958, he also taught engineering logic at the department of applied mathematics at the University of Science and Technology of China (中國科學技術大學). Finally, in 1963, together with all other members of the section for mathematical logic at IMCAS he was transferred to the Institute of Computer Technology at CAS (ICTCAS). Hu Shihua passed away in February 1998, in Peking.[166]

3.7.2. **Hu Shihua's Contributions to Mathematical Logic, 1940-1960**

In the previous sections of this work, where we have outlined the development of content of mathematical logic in the 1930s China, we have already shown that, in his formative years at Peking University, Hu most probably learned about mathematical logic through the prism of a curriculum which was based mostly on Russell's *Principia Mathematica* and the so-called "logistic" of the Vienna School logicians like Rudolf Carnap etc. In fact, in his autobiographical essay, Hu stated that he discovered the importance of mathematical logic only after having read Carnap's *Grundriß*, which was recommended to him by his close friend and colleague, Wang Xianjun. (Cheng Minde 2000, 166) At the same time, under the influence of Jin Yuelin and Zhang Shenfu, Hu also started studying Russell and Whitehead's *Principia Mathematica*.

However, as it has been already shown, in early 1930s when Hu was a student at Peking University the notion of logical empiricism and the philosophy of Vienna School had just started gaining influence among some notable members of the Qinghua department of philosophy. Around the year 1933, the Zhang brothers became China's foremost propagators of this important Western school of philosophy. And by 1935 Zhang Shenfu, Feng Youlan and others had already distilled some ideas or concepts from the writings of its representative members such as Carnap, Schlick, Neurath and integrated them into their own thought, or sometimes even more so, their vocabulary. When Hu was still at the university, the foremost Chinese expert in philosophy or logical empiricism of Vienna School and former student of Qinghua University, Hong Qian had still been studying and working under the Austrian leader of Vienna School, Moritz Schlick.

It was in this very intellectual climate, that Hu Shihua's interest for mathematical logic was first kindled. His propensity towards this relatively popular notion was enhanced by his original interest in mathematics, which in his years at Beida was rekindled, so that Hu ended up parallelly attending both, the study of philosophy as well as mathematics at his home university. Moreover, it was also his mastery of mathematics which differentiated him from

[166] Because of the scope of this, we have to conclude our narrative on Hu Shihua's life in the year 1960.

the majority of his philosophical colleagues at Beida, who subsequently also specialised in mathematical logic. At the same time, his knowledge of mathematics gave Hu another perspective on the field, which ultimately also led him to specialise into more "technical" aspects of mathematical logic, which had less to do with philosophy and more with pure mathematics and its applications in computer science.

Hu's academic character was not forged straight away. As a matter of fact, his specialisation was a result of coincidence rather than scholarly determination, because after Hu concluded his studies in China, his choice to continue his studies under Moritz Schlick in Vienna still reflected his deep infatuation with a semi-philosophical notion of mathematical logic, namely mathematical or symbolic logic as maintained in the Vienna School of philosophy.

It is possible that this decision was connected to Hu's interest in philosophy of Rudolf Carnap, whose thought he discovered in the early years of his acquaintance with mathematical logic. Regardless of what the motivation behind Hu's choice to study in Vienna really was, the fact is that Hu had already been in contact with the Chinese member of the Vienna Circle, Hong Qian before his arrival to Austria. Eventually, Hong was to play an important role in Hu's formation as a mathematical logic, for Hong had not only advised him to continue his studies in Münster but in the years to come also played the role of his academic patron and mentor. With his important connections, in the 1930s and 1940s, Hong also helped Hu establish personal correspondences with influential Western mathematical logicians such as Rudolf Carnap and Alonzo Church (1903-1995), who assisted Hu in writing his first and maybe most important article on many-valued logic, which was published in *The Journal of Symbolic Logic* in 1949. Beside with his academic connections, in early years Hong Qian also helped Hu with his professional advice. Hence, with Hong's help Hu also published his first scientific paper in Chinese academic periodical. In 1942, Hong decided to reproduce a short summary of main results of Hu's doctoral research in the journal *Academic Quarterly*.[167]

As we have already shown in the foregoing chapter, generally speaking, in late 1940s and early 1950s, the work of Chinese mathematical logicians revolved mainly around various kinds of propositional calculi, their structures and axiomatic bases. In turn, starting in early 1950s, new directions or areas of research started to emerge in Chinese mathematicians' work,

[167] Hong was one of the editors of the journal. Later, in the same journal Hu also published some other articles.

which reflected the current developmental trends in both the SU and, in part also, international academic circles. Among other, these include: the theory of recursive functions and theory of algorithms. As the leading researcher in Chinese mathematical logic, Hu was at the very forefront of development of these research directions in China. Thus, between early 1950s and the year 1960, together with some other younger researcher, he produced a number of writings, through which some important aspects of the above-mentioned research directions had been introduced to China for the first time.

In this final section of the present discussion, we shall give a brief overview of most important of Hu's scientific papers and introductory articles, which were published between the year 1942 and 1960. These articles and writings can be divided into following four categories:

(1) Hu's doctoral research,

(2) Early inquiries into classical philosophical questions of mathematical logic,

(3) Many-valued propositional calculi,

(4) Theory of recursive functions and recursive arithmetic.

3.7.2.1. Doctoral Research: "Quasi-Boolean Algebra and the Foundations of Geometry"

Unfortunately, in the course of our research we were not able to procure or even affirm the existence of Hu Shihua's original dissertation, which had been allegedly composed under the mentorship of renowned professors Heinrich Scholz and Gottfried Köthe. Consequently, the only source of information which remains available to us is Hu's letter from January 1941, in which he summarised the main conclusions obtained in the framework of his doctoral research. In the letter, which was sent to his informal mentor Hong Qian, Hu also revealed that one year earlier (1940) he had already presented his findings at a discussion (conference) held by his mentor H. Scholz in Münster. Hu also told Hong Qian that he was currently preparing an article, in which the results would be concentrated into one concise theory, however, it seems that due to unknown reasons Hu never managed to complete such an article. (Hu Shihua 1942, 191)

The content of article “Quasi-Boolean Algebra and the Foundations of Geometry”, which was published in the *Academic Quarterly* in 1942, reveals that one of the principal aims of Hu’s dissertation was to develop a theoretical supplementations for Tarski’s theory of Boolean algebra, as raised in his paper “Zur Grundlegung der Boole’schen Algebra” from 1935. In addition to providing theoretical supplements to Tarski’s theory, Hu also managed to simplify some of the calculation procedures as suggested by Tarski.

Nevertheless, as suggested both by its title and the findings summarised in the above mentioned-letter to Hong Qian, the central topic of his dissertation appears to have been a certain type of theory of algebraic topology or more specifically: application of a modified version of Tarski’s Boolean algebra (which Hu chose to call “quasi-Boolean” (高斯駁兒)) to axiomatic foundations of topology, using also categories and instruments from Russell’s *Principia Mathematica*, like for example its notation, definition of concepts and, essentially, Russell’s theory of types.

Maybe one of the most important original contributions of Hu’s dissertation consisted in its development of a new concept of an *incomplete point* in a topological space, conceived in relation with concept of “point-likeness” (Ger. *Punktformigkeit*, i.e. “to be shaped like a point”). As noted by Lu Zhongwan (1996), some scholars had compared Hu’s concept of incomplete point to the concept of “non-standard point” in non-standard analysis, as conceived by Abraham Robinson in the 1960s. (Lu Zhongwen 1996, 268; Xu Yibao 2005, 202)

3.7.2.2. Philosophical Articles: From Philosophy of Language to Metatheoretical Research

The first article published after Hu’s return to China was entitled “On Artificial Languages” (*Lun renzao de yuyan* 論人造的語言). (Hu Shihua 2008, 6-20) Akin to Hu’s letter from 1942, the article was published in the *Academic Quarterly* in 1943. The article was a summary of Hu's lecture given at a philosophical and psychological conference organised by Yanjing University. In some respects, the article still reflects the influence of Hu's education in Germany is still evident in the form of many examples of terms in German language, which are only accompanied by corresponding English expressions. Even the phrase "artificial language" which is used in the title is explained with the German phrase *künstliche Sprache* and so on. Among a number of German terms in the article there are even more vestiges of Hu's experiences in Germany, such as examples of propositions, which include sentences like "如果 einer ein Neger ist 則 ist er auch ein Mensch" [If one is a black person, he is also a human being] expressing Hu's political views and at the same time giving an example of a proposition. (Ibid., 16)

In the article Hu argues that even though natural languages are a very complex system for expressing facts or reality, the complexity is not in itself consistent and ordered. Subjectivity of an expression or sentence of natural language produces meaning-related problems, which create ambiguities of reference. As an example of such a messy referential aspect of a natural language Hu lists classical Chinese poems and the realms of thought (*jingjie* 境界) that these are expressing. After having depicted the limitedness of natural languages Hu then introduces the formal characteristics of the structure of an artificial language based on logics and, especially, Theory of types. In explaining the philosophical meaning of the application of types in an artificial language he refers to authors such as Herman Weyl, Carnap, Russell and Scholz.

One of the important notions which Hu thought he was among the first to introduce to the Chinese readership was the system of semiotics or *fuhaoxue* 符號學 as developed by his esteemed mentor H. Scholz. He mentioned it as a new system, a new field of research, which can be called the study of symbols or "the basis of language". (Ibid., 20)

Hu concludes the article with an explanation that a natural language based on a rigorously structured logical system has the ultimate inherent capability to express the truth and the states of affairs in the natural world. It also helps eliminating logical mistakes or paradoxes which arise in the natural languages (Russell), and thus clarifying the human thought. Finally, in his conclusions to the article, he called any such research on the artificial languages *logistic*. (Ibid., 19)

The next article which was in any regard connected to the philosophical principles of logicism was published in 1947 and bore the title "The Object of Theory" (*Lilun de duixiang* 理論的對象).[168] Similar to the previous article it was a summarised version of some lectures

[168] The article was published in the *Xue yuan* 学原 journal, Vol. 1, No. 11.

delivered at Peking University's philosophical department. Originally, Hu was asked to deliver a series of lectures on the research of history of philosophy from the logical point of view. Hu responded to this request with the excuse that he did not know much about the history of philosophy, and that, since the basis of any kind of investigation of history of philosophy is the research of a construction of a philosophical system as such, one must first know how to research philosophical system or a philosophical theory. Consequently, he composed a two-part course "The Object and the system of theory", of which the above article was meant to be the summarised version of the first part.

In the article Hu points out that the word "object" has got two different meanings: theory as an object of research and the object of a theory. Therefore, he suggests that the notion of object be approached from both perspectives. Hu's analysis of the notion of object is following the logical atomist way, since his analysis of the objects starts with an introduction to the primitive elements of the object of a theory. He points out that every definition can be explicit or implicit. This difference delineates the boundaries between the analysable and non-analysable integral parts of an object, which is supported by the atomist statement that any "x can be analysed to its most basic parts which are not analysable". (Ibid., 2) The latter are called the primary elements (*yuanshi fenzi* 原始分子) of an object. About the relationship between the primary and secondary elements he further adds in an atomist manner:

> What does it mean that these primary elements cannot be analysed? It means that the elements are not attributes of other elements of this object. They are not another class of elements within this object… Attributes and classes are analysable… elements of the attributes and classes are less analysable… These primary elements are not relations... Speaking logically, an object must be constructed from these primary elements. (Ibid., 3)

Hu continues introducing further analysable elements of the object, arriving at the end to the notions of type and the theory of types with the use of which the elements of the object of theory can be systematized and analysed in an ordered way.

As "real" examples for the systematization of the relationships between elements and classes of the objects Hu lists Hilbert's rigorous construction of the Euclidean system of geometry in the *Grundlagen der Geometrie*, Hilbert's method of extensive abstraction (*waiyan* *chouxiang fa* 外延抽象法) from his enquiry about the principles of natural knowledge, and Landau's analysis of the object of mathematics.

Hu further introduces the notion of individual constants in the framework of theoretical categorization or classification of the integral elements of an object, and then proceeds towards the last part of his discussion, where he introduces the non-primary elements of an object in accord with Russell's Theory of types (*leixing lun* 類型論). The paper concludes with a subchapter on relations of isomorphism (*tongtai* 同態) and homomorphism (*sitai* 似態) within the universe of types.

3.7.2.3. Propositional Calculi

Upon his return to China in 1941, Hu Shihua developed a strong interest in research of propositional calculi. Published in 1943, his article "What is Indicated by Propositional Calculus" (Mingti yansuan zhi suozhi 命題演算之所指) was one of few Chinese articles devoted exclusively to question of propositional calculus published in the 1940s.[169] The article represents the first step in the succession of articles on propositional calculus, through which Hu progressed towards more specialised scientific topics within the array of theories of propositional calculi, one of which found its place among the internationally most important contributions to investigation of propositional calculi, more specific, multi-valued propositional calculus.

However, the first among the articles dedicated to propositional calculus is of a propaedeutic nature, revealing Hu's motivation to terminologically and theoretically introduce the above-mentioned calculus to Chinese readership.

[169] As already described in the previous sections of this dissertation, earliest extensive elaboration of propositional calculi can be found in works of Wang Dianji, Jin Yuelin etc. In the period of seven years which elapsed between the publications of the two works, the term designating the notion of calculus has changed from *tuiyan* 推演, as used by Jin, to *tuisuan* 推算 in Hu's usage. Whereas Jin in his description of the structure and particular concepts of calculi takes predominantly from *Principia Mathematica*, with some minor references to later works on logic (mathematical or symbolic) are used, Hu already uses more contemporary and specific contributions to various aspects and variations of propositional calculi. A feature, which can be contributed to his precious experience and study at one of the centres of research on mathematical logic in Europe (Münster).

With a more philosophical than mathematical approach, Hu sets out with the question whether the propositional calculus was about propositions at all. In other words: what was the philosophical meaning of propositional calculus? In a classical manner, he introduced the notion of a strictly axiomatized system (system A) of propositional calculus and the concepts with which such a calculus had to operate. In that regard, some of the fundamental definitions of notions or concepts Hu introduced were taken from *Principia Mathematica*. In the article Hu explained mathematical and logical concepts related to propositional calculus such as: infinite progression (*wuqiong ji* 無窮級), finite sequence (*youxian chang de chuan* 有限長的串), constant (*changci* 常詞), expression (*shizi* 式子), propositional variable (*mingti bianci* 命題變詞), implication (*hanyun shi* 含蘊式), disjunction (*xiqu shi* 析取式) etc. In the second chapter Hu introduces the axioms of the system A, altogether twelve axioms as required in the first class of propositional calculus, and which were taken, together with the notation, from the Hilbert's and Ackermann's *Gründzuge der theoretischen Logik*. This is then followed by a chapter expounding on the proof of such system's non-contradiction and independence of the axioms. Further Hu also devotes a chapter to the derivation of the system A, its simplification and extension, and its relationship to the propositional calculus as such. In many places Hu refers to Łukasiewicz, Quine, Boethius etc. and uses examples from their writings. Among the terms Hu had cited both in English and Chinese were material implication (*shizhi hanyun shi* 實質含蘊式), functor (*hanci* 函詞), propositional junction (*mingti jieheci* 命题結合詞), ordinal similarity (*shunxu xiangsi de lianxi* 順序相似的聯係) and isomorphism (*chen tongtai guanxi* 稱同態關係).

First in the succession of Hu's articles on multi-valued calculi was also the most influential one. The article I am refereeing to was "*m*-Valued Subsystem of *(m+n)*-Valued Propositional Calculus," published in *The Journal of Symbolic Logic* in 1949. In the process of writing the article Hu was assisted by Rudolf Carnap, who had reviewed the first draft of the article, as well as the American logician Alonzo Church who, according to Hu, suggested many improvements to the structure and content of the article. Later, after the article was published, it was also reviewed by A. R. Turquette, whose assessment was published in the same journal the following year.[170] Together with J. B. Rosser, Turquette was one of the most prolific contributor to research on the construction, axiomatic foundations etc. of many valued calculi

[170] Journal of Symbolic Logic, 14(4) (Jan. 1950), 261.

in the 1940s. Apart from Łukasiewicz and Tarski's early work on propositional calculus, in the above-mentioned article Hu also heavily relied on the results delivered in previous years by Rosser and Turquette.[171]

The article provides a set of definitions which can be used to construct a system of an m-valued propositional calculus, which is a subsystem of an *(m+n)*-valued propositional calculus – as formulated by J. Łukasiewicz and A. Tarski in their article *Untersuchungen über den Aussagenkalkül* (1930). Definitions provided in the article were designed to be used in all many-valued systems of propositional calculus designed by the time the article was published (and which were also mentioned in the article), as for example the three-valued Wajsberg-Słupecki system.[172] Beside that the main objective of the article was to prove that an m-valued propositional calculus is a proper subsystem of an *(m+n)*-valued propositional calculus and that the former grows (becomes fuller) with the increase in the number of truth-values.

Soon afterwards, Hu's attention turned from the question of possible internal systemic constructions in finite-valued propositional calculi, to problems of total constructions of infinite-valued logical calculi. Thus, by the year 1950, Hu produced his first Chinese article on many-valued propositional calculi entitled "Construction of an $\aleph_0$-Valued[173] Propositional Calculus" (Yige $\aleph_0$-zhi mingti yansuan de gouzao 一個$\aleph_0$值命題演算的構造). The article was published in the newly founded central periodical of the CAS, the *Acta Scientia Sinica* (*Zhongguo kexue* 中國科學).

Essentially, the article represented a theoretical expansion of the previous article, where Hu was still applying the same methodological instruments and derived from the same theoretical background. In the article, using Łukasiewicz's notation, Hu tried to deliver a comprehensive description of the formation rules (*zucheng guiyze* 組成規則), the relations of replacement and the sets of axioms necessary to set up a complete and functionally complete $infinite$-valued propositional calculus. This article was also the first among Hu's articles on

[171] For instance, Rosser & Turquette 1945.

[172] Hu also followed the treatment and use of the Slupecki connective as given in J. B. Rosser and A. R. Turquette. "Axiom schemes for m-valued propositional calculi". *The Journal for Symbolic Logic*, vol. 10 (1954): 61-82.

[173] In Cantorian set theory the symbol $\aleph_0$"aleph zero" represents the smallest possible infinite cardinality, namely the cardinality of natural numbers.

multi-valued logic which contained references to Soviet works on multivalued logics, namely D. A. Bočvar's articles from 1939 and 1943.

One year later Hu and his student Cheng Qiangye 稱強業 co-authored a short article entitled "A note on the 4-valued propositional calculus and the four-colour problem" (Sizhi mingti yansuan yu sise wenti 四值命題演算與四色問題). The article represents an enthusiastic attempt to use mathematical logic to resolve mathematical problems in other branches of mathematics, like in this example combinatorial topology. In the article the authors suggest that the four-colour problem, at that time still unsolved, could be understood in terms of a four-valued propositional calculus. In the article Hu and Cheng gave eleven definitions, based on axiom schemes of finite-valued propositional calculi as proposed by Rosser and Turquette (1945), on the basis of which they then derive a "Theorem A" in the context of which the formula $\exists^n \prod_1^k P_i \ldots Q$ – in accordance with Rosser and Turquette (1945: 69) – is a formal theorem of a complete four-valued propositional calculus. The authors concluded that in their "Theorem A" the formal relationship between the above-mentioned propositional calculus and the four-colour problem had been adequately established in the form of a proof that the point (a) (i.e. $\zeta \in \mathbf{gr}$ (n)) implies the point (d) (i.e. $\zeta \in \mathbf{col}$) of the theorem. Furthermore, the solution to the four-colour problem can be given in the form of a proof that propositions (a) and (b) of the "Theorem A" imply the existence of the above-named formula.

In 1955, Hu delivered his final academic contribution to the theory of many-valued calculi in a piece of writing, where the conclusions of his previous articles from 1949 and 1950 were aggregated into one integrated whole. Thus, in the article published in 1955, entitled "The Finite-Valued and Functionally Complete Sub-Systems of an $\aleph_0$ -Valued Propositional Calculus" Hu endeavoured to develop an efficient method by means of which all finite-valued propositional calculi could be integrated into one infinitely ($\aleph_0$)-valued propositional calculus.

Hu starts by listing proposing the existence of kinds of finite-valued propositional calculi: an ordinary P^n PC with n= 2,3, ... and a PC named P_*^n, which is also complete and functionally complete as the previous one, but much simpler, for it only contains one basic connective $F^n \cdot C^n$. Subsequently, the main objective of Hu's was article to embed both P^n and P_*^n into an infinite-valued PC, named P_*. After the formal construction of the method of integration, Hu uses propositional calculi like Frege-Łukasiewics (classical L_2), the three-valued Wajsberg-Slupecki system and Bočvar's three-valued system to demonstrate how the PCs can be integrated into theP_*.

Since after 1940s there was a general decline in the interest in many-valued calculus, Hu's contributions to these theories were not launched in the most opportune moment in history and did not receive much critical feedback from the academic community. (See Gottwald 2012, 682) Another important factor which probably also represented a hindrance in establishing international academic transfer in form of a written debate etc., was the political and ideological turn which influenced Chinese science after 1949. Even though for some years after the establishment of the PRC some Chinese mathematicians like Hu Shihua and Mo Shaokui, continued working on problems which occupied their minds before the ideological turn had decisively changed the outlook of Chinese science. Their contributions were published almost exclusively in Chinese journals, which, albeit these were equipped with abstracts written in English, German or French were now accessible mainly for the scientists of the other Socialist countries.[174]

On the other hand, in the Chinese mathematical community Hu had at least one interlocutor, with whom he could interchange opinions and ideas about axiomatic systems and propositional calculi, Mo Shaokui from Nanjing university who had boldly shared his knowledge of intuitionist axiomatic systems with the Chinese community, even in the period when intuitionism in general was considered an entirely idealist view.[175] Akin to the sudden disconnection Hu had made with the theories of many-valued logic, after 1955 Mo seems to have undergone the same tendency and had turned towards issues of mathematical logic which could be more easily applied to the industrial production and technology. On the other hand, the semi-clandestine voices which started echoing through the academic community even before the Hundred flowers have possibly moved the focus of the scientists to questions and problems related to Marxist ideology and Dialectical materialism or Dialectics of nature as new vehicles of an objective meta-scientific ontology, which was the most important political

[174] One such mathematician who commented and reviewed Hu's work was the Yugoslav mathematician Vladeta Vučković (1923-2012).

[175] Mo Shaokui (1917-) allegedly studied mathematical logic under Paul Bernays (1888-1977) when he was studying at ETH Zurich (*Eidgenössische Technische Hochschule Zürich*) and University of Lausanne Switzerland (after 1947). Bernays was famous for his contributions to the axiomatic set theory, mathematical logic and fundaments of mathematics, especially his cooperation with D. Hilbert in his "*Grundlagen* project".

question for the future of some idealist-branded scientific disciplines at Chinese academic institutions.

3.7.2.4. Theory of Recursive Functions and Recursive Arithmetic

The area of research related to the last category of Hu Shihua's work in the 1950s, to which we shall devote our attention, became one of the most important points of confluence between the socialist discipline of mathematical logic and advances in computer technology in 1950s and 1960s: the theory of recursive functions, and later also recursive arithmetic. Because, generally speaking, the majority of most important contributions to the filed came from countries of the Eastern Bloc, the sudden flood of research in studies of recursive functions coincided with the process of Sovietisation of Chinese technology and the general alignment of research priorities of Chinese science with the developmental trends of its counterpart in the Soviet Union. In China, the interest in recursive functions started increasing with the year 1956 and culminated during the GLF campaign, between 1958 and 1960, when the Chinese research programs in electronic computer technology were in their full swing.

As the chief representative of Chinese mathematical logic, Hu Shihua was again at the forefront of both activities related to adoption of Western material on the topic as well as in the work related to more autonomous aspects of theoretical work. While in the late 1950s, the first task was mainly covered by Hu's colleague in Nanjing, Mo Shaokui, who translated some of the key works in the field and in 1965 even published a textbook on the theory of recursive functions, already from the early 1950s on, Hu Shihua had focused more on providing the Chinese mathematical world with interpretations of most relevant aspects of theory of recursive functions and recursive arithmetic. Still, even if Hu's focus was more on developing interpretations and key systemic derivations of Western theories, he can still be credited for being the first Chinese scholar to have introduced the theory of recursion to China.

Already in 1947, three years before Rósza Péter synthesized the results of her work on recursive functions in her key work *Rekursive Funktionen* (1950), Hu outlined the main advances in studies of recursive functions, which was initiated by Peter in the second half of 1930s,[176] in an article entitled "New System of Recursive Arithmetic and Its Common Logical

[176] Rósza Péter first presented her theory of recursive functions in early 1930s at an international mathematical congress in Zurich. By 1936, she already developed a theory of recursive functions of the second grade.

Terms," published in the *Xueyuan* journal. The above-mentioned Hu's introduction to the study of recursive functions represented a critically early such introduction in China. As a matter of fact, its earliness is strongly expressed also in choice of terminology Hu used to translate the entirely novel concepts into Chinese. The most obvious such example was his Chinese translation for the term "recursion" or "recursive", which he rendered as *zaixian* 再現. His translation of the phrase "recursive arithmetic" was thus *zaixian suanshu* 再現算術. Later, in the 1950s, the term "recursion" started being translated as *digui shi* 遞歸式.[177] Otherwise, in the article, Hu outlined the following aspects of a system of recursive arithmetic: rules of formation, rules of derivation and basic theorems.

Hu's first contribution to the study of theory of recursion was published only in 1956. In an article entitled "On the Primitive Recursiveness of Certain Recursions" (Yizhong digui de yuanshi diguixing 一種遞歸的原始遞歸性), Hu researched the notion of "primitive recursiveness" in Rósza Péter's theory of recursive functions, trying to prove that a certain function is primitively recursive (*yuanshi digui* 原始遞歸) under specific conditions. The article was published in the journal *Shuxue xuebao*. (Hu Shihua 2008, 96-103)[178]

In the next article on theory of recursive functions, written in cooperation with Lu Zhongwen, Hu attempted to define the normal forms for general recursive functions. In the article "Normal Forms of General Recursive Functions" (Yiban digui hanshu de fanshi 一般遞歸函數的範式), published in 1958 in the *Shuxue xuebao*, Hu and Lu had already extended their theoretical horizon, and also integrated into their research the work of S. C. Kleene, E. L. Post, J. Robinson and A. A. Markov – the majority of which, however had been published back in 1930s and 1940s.

Two years later, in 1960s, Hu Shihua published five articles in which he developed a rather unique *theory of recursive algorithms*. In the first two, published in the *Science Records* (*Kexue jilu* 科學記錄), Hu outlined the main characteristics and laws of recursive arithmetic and introduced the concepts "kernel function" (he hanshu 核函數) and the normal form of a

[177] Or only *digui* 遞歸 for "recursive".

[178] The article was originally published in *Shuxue xuebao*, 6(1).

recursive function. These articles were intended as general introductions to the three main articles, which were later published in the *Shuxue xuebao*. (Hu Shihua 1960c; 1960d)

Finally, in 1960s, Hu also published three articles on recursive arithmetic in the prestigious Chinese journal *Shuxue xuebao*. In these three articles Hu Shihua developed a theory of recursive algorithms, which essentially integrated the results of the so-called Skolem-Gödel-Herbrand-Kleene theory of recursive functions, Church's λ-calculus, Markov's theory of algorithms, and Turing and Post's theory of computation, and combined them into a complex body of a theory recursive algorithms. About the relationship between the above-listed theories and his own theory of recursive algorithms, Hu pointed out:

> We can construct a theory of recursive algorithms (which will be equivalent to each of the above-mentioned theories) which possesses the good points and which does not have to minimise the bad points of each of the above theories. (Hu Shihua 1960a, 66)

Thus, the mentioned Hu Shihua's introductory trilogy entitled "Theory of Recursive Algorithms" encompassed following three parts: "Recursive Algorithms" (Digui suanfa 遞歸算法), "Kernel Functions" (He hanshu 核函數) and "Normal Forms of Recursive Functions" (Digui hanshu de fanshi 遞歸函數的範式). The second article on kernel functions was co-authored by Lu Zhongwan.[179]

In his review of the articles C. C. Chang noted that the notions of recursive algorithms and functions were defined on a "free semi-group freely generated by a finite alphabet." One of the main objectives of Hu's first article was also to show that his theory of recursive algorithms corresponded to Markov's notion of normal algorithms and Turing's idea of computability. In the second part, Hu and Lu develop a more specific kind of recursive functions, described as "kernel functions," that correspond to primitive recursive functions. Referring to their results from 1958, Hu and Lu then try to prove that all kernel functions can be represented in corresponding "normal forms" (*fanshi* 範式). At the same time, using the same demonstration, Hu and Lu develop a proof "that there exist universal normal algorithms and universal Turing machines." In the third part, Hu discusses "representation theorems" for

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[179] A review of Hu and Lu's articles was written by C. C. Chang (1961). See: https://mathscinet.ams.org/mathscinet/search/publdoc.html?pg1=INDI&s1=464088&sort=Newest&vfpref=html&r=9&mx-pid=112835

recursive functions considering theories developed by various authors. Finally, he shows that every one of his recursive functions can be represented with a kernel function and certain operators.[180]

3.7.2.5. Conclusion

The above overview of Hu Shihua's work in the period between 1940s and 1960 reveals an inherent consistency with the developmental trends described in the previous sections of this dissertation. In the early period, Hu was still deeply immersed in the interests and research trends furthered in the so-called Qinghua school of logic. Although, originally, Hu was not a student of Qinghua University, from the early-1930s on, the influence of latter extended also to the National Peking University, where the leading members of Qinghua department of philosophy taught all courses related to logic. A strong association between mathematical logic, as taught by Zhang Shenfu and others, with the advances in the Vienna School resulted in Hu's decision to continue his studies at University of Vienna. While his decisions and his research interests can be explained within the context of the above-described "philosophical" notion of the discipline of mathematical logic in the late Republican China, in the subsequent phase of his career, which followed his decision to pursue studies in mathematical logic in Münster, gradually approached the aforementioned "mathematized" and more technical discipline of mathematical logic. Probably, Hu was originally introduced to research focused on calculi and problematics related to algebraic systems of logic during his stay in Münster, which at the time was known to be one of the main centres of research in mathematical logic in Europe. The final step in his gradual shift towards more technical research, however, represented his acceptance into the IMCAS in early 1950s. His initial year as a member of IMCAS were also marked with his most distinguished contributions to mathematical logic, his studies on multi-valued calculi a part of which was also published in the prestigious *Journal of Symbolic Logic*. Finally, his work in the latter half of the 1950s reflects his leading role in the advancement of mathematical logic in China as a branch of mathematics with profound applicative value in contemporary Chinese computer technology, having been comprised mainly of studies relating to theory of recursion, kernel functions and so on. In this later period, one of Hu's main contributions was a relatively early and comprehensive introduction of theory of recursion to Chinese

[180] Summarised after C. C. Chang, 1961: Ibid.

mathematical logic and computational mathematics, as well as his original ideas pertaining to the so-called kernel functions.

4. Conclusions

The above study highlighted several different aspects of development of mathematical logic as a notion and a discipline in the period between 1930s and the year 1960. It revealed some important circumstances, characteristics, biographical and other aspects of its first institutional establishment in Chinese academia and followed its development throughout its second establishment in the first decade of Peoples Republic. Moreover, it confirmed an inherent developmental intertwinement between a *notion* of mathematical logic in general philosophical discourse(s) on one side and its, so to say, "internal" advancement as a field within the confines of the academic communities at Chinese Republican universities and the CAS in the PRC. In other words, in the turbulent period between the 1930s and the establishment of the PRC, which was underlined but major ideological, social, and political change, the intellectual developmental trajectory within the context of which the *notion* of mathematical logic was understood and evaluated retained a considerable degree of conceptual and objectivist continuity. Whilst this continuity, which was one of the main research foci of the present dissertation, was limited more or less to the notion of mathematical logic and its value in the scientific objectivity, which was gradually introduced to Chinese intellectual world since the May Fourth period (1917-1921), the identity of mathematical logic as a field of study underwent significant change in the period of transition from the Republic to People's Republic. However, although the continuity was broken with regard to its institutional life and its scientific (content-related) identity, these new shifts and detours in its advancements as a field of studies were more or less in consonance with its conceptual establishment in the aforementioned general intellectual or ideological discourse.

In addition to these general findings regarding the continuities and discontinuities in mathematical logic in the period under examination, the above investigation led us to the following particular conclusions, upon which the above-mentioned general conclusions are also founded. To present a consistent historical narrative of the vicissitudes of our interest, these conclusions shall be listed in chronological order.

By the early-1930s, mathematical logic became established in Chinese intellectual world not only as one of the key concepts of the contemporary intellectual discourse (this has been additionally demonstrated in Vrhovski 2021b-f) but also in Chinese academia and the newly standardised national system of education. The main and only paragon of its establishment and advancement in Chinese academia was the so-called Qinghua School of logic, a generic term for a group of philosophers gathered at the department of philosophy at Qinghua University, whose common denominator resided in their research or teaching of specific aspects of modern logic. From its establishment in late 1920s on, the department of philosophy at Qinghua was the place of confluence of different approaches to mathematical logic as adopted by its most senior lecturers in logic, such as Zhang Shenfu and Jin Yuelin. Although, by the early 1930s, when a new generation of logicians had been formed, the research interests at the department had diversified considerably, the majority of research and teaching was still grounded on Russell's and Whitehead's *Principia Mathematica*, whilst, at the same time, the rise of a new generation of scholars who gained their formative research experiences at European and American universities led to introduction of more recent theories and research trends relating to mathematical logic. Apart from the new research trends and theoretical advances imported from Europe (many-valued logical calculi, theoretical contributions to axiomatisation of mathematics and symbolic logic by the Vienna School etc.), the 1930s Qinghua school of logic also possessed a strong inclination towards the so-called "Harvard school of logic" and other advances in "symbolic logic" made in American academia.

Another important aspect of mathematical logic in the late Republican period was its strong association with the discipline of modern philosophy, which was grounded not only in the fact that, in the 1920s, the idea of mathematical logic was first introduced to China as a part of the modern scientific outlook embodied in the *philosophy* of Bertrand Russell, but more so by the fact that, prior to the blossoming of the positivist notion of philosophy in the Western academia, all kinds of logic were generally regarded as a part of philosophy or an independent discipline – i.e. science of the laws of reasoning – closely related to either philosophy or psychology (see Vrhovski 2021f). Concurrently, due to the considerably wide-reaching impact of Russell's visit to China as well as Zhang Shenfu's strenuous efforts at propagating the general idea of mathematical logic in the years to follow, as early as in the 1920s, mathematical logic acquired a special status in Chinese intellectual world. As not only the manner of its nation-wide inclusion into the secondary school, normal school, and university school curricula, but also its overall treatment in the general intellectual discourse on logic (1930s) suggest, mathematical logic was viewed as a form of logic which was considerably more advanced than other known forms of logic, in the sense that it was believed to embody the principles of the most recent advances in the natural sciences etc. This *notion* of mathematical logic was inherently attached to a "dynamistic" variety of structural scientific objectivity (Daston and Gallison 2002, 253-308), which was prevalent in the Chinese intellectual world at the time.

Aside from the notion of mathematical logic as expounded on in treatises written by its proponents in China, this special status became probably most clearly apparent in the Chinese Marxists led debates on dialectical and formal logic from the 1930s (see Vrhovski 2021b), where it was exempt from Marxists' criticism directed against "formal logic" and sometimes described as equal in value – in its quantitative aspect – to dialectical logic. As the above-given summary of the early history of mathematical logic in the Soviet Union reveals, such special status was in complete opposition to the developments in the Soviet philosophy of logic at the time, and thus a uniquely Chinese feature, explainable only in the context of China's own intellectual developmental path and its own ideational spheres of influence. Contextualised into the very core of China's intellectual modernisation, the general idea of mathematical logic, as established in Chinese intellectual discourse and Chinese academia by the 1930s, continued its existence even under the unlikely conditions of the socialist construction in the 1950s.

In parallel to mathematical logic as a part of philosophical field of studies, the 1930s also saw the emergence of Chinese mathematicians' interest in the field. The rise of mathematical research was centred around a group of mathematicians at Wuhan University, who were connected to the current trends in research in set theory and foundation-related questions at German universities. Similarly, mathematical logic also found its way into the writing of two other prominent Chinese popularisers of modern mathematics, Zhu Gongjin and Gao Xingjian. The common point connecting these two "channels" of mathematicians' introductions of mathematical logic was Hilbert's and Ackermann's formalist system of symbolic logic. Although, it is unclear whether or in what manner these introductions prepared the stage for the later complete "mathematisation" of the discipline of mathematical logic, it is doubtless that they at least forecasted these later developments.

As it has been demonstrated in the second part of the above analysis, the developments in mathematical logic in the 1950s can be best understood when reflected upon through the prism of three main aspects: ideological, institutional, and content-related developments. By and large, these three aspects all illuminate either instances of causative conjunctions or interdependence of that so-called "internal" and "external" developments in the field. Such tight interconnectedness between the "external" character of a discipline and its "internal", development as a discipline within the scientific community on one side and its establishment at national institutions on the other, is an expected feature of such transitory periods between one objectivist system to another. In other words: this interconnectedness can be defined as a consequence of the ideological transformation which underlined the early decades of the socialist China. While this seems to be a self-evident, the above analysis shows that this link between general intellectual discourse and the inner life of the discipline of mathematical logic existed continually from its first introduction into the modern Chinese intellectual discourse onwards. Several different explanations can be offered for this phenomenon, of which the following two general explanations are most pertinent for our discussion: it can either be assumed that such an interconnectedness is an inherent feature of every such notion which at the same time also represents a scientific field of study etc., or, assuming that the latter is not the case and, consequently, that such a link is only established under special circumstances, then the continuity of the profound interconnectedness between these two aspects in the case under analysis may be explained by assuming the continuous existence of these special circumstances. Regarding the latter point, in our concrete case this would imply that in Republican Period and then again in the time of the socialist construction in the 1950s, the idea of mathematical logic was an essential component of a worldview which was still subject of appropriation or contention (from the perspective of tradition) into both Chinese public and intellectual discourse. In other words, mathematical logic was still part of the ongoing process of *intellectual modernisation*. It represented an important concept in the objectivity, which was being acquired by means of modern Western scientific, socio-political, and ethical worldview. Consequently, especially in the earliest period, the conceptual life of mathematical logic in China was deeply entwined with the traditional Chinese worldview or cultural perception into which the conceptual constituents of the above-mentioned worldview were contextualised in the due process, and whose concepts and categories have been used to decipher these foreign concepts in the first place. In this sense, this essential part of mathematical logic in China had a profound link to the discourse on modernisation. While this relation was eventually materialised in its inclusion into modern Chinese academia, its identity underwent a considerable transformation through the formation of China's first community of modern logicians. It was exactly this aspect which represented the main point of divergence between mathematical logic as a part of general intellectual discourse and a scientific discipline. However, due to nature of the ideological turnover which marked China's transition into a socialist country, the above-mentioned link became again of vital importance for the formation of a new community of experts and its reestablishment as a scientific discipline.

The second part of this dissertation affirms both the quintessential link between mathematical logic as an objectivist concept – as extant in the general intellectual discourse – and a scientific discipline, as well as its inherent continuous connectedness with China's own intellectual developmental trajectory. The first is apparent from the above analysis of the role of mathematical logic in Marxist philosophy of mathematics in the 1950s. Especially the Chinese mathematicians' and mathematical logicians' defence of mathematical logic, which started in the Hundred Flowers Campaign, indicates that the initial period of introduction of Soviet results in philosophy of logic and mathematics were more or less conducted at a level of a superficial and automatic emulation of foreign doctrine, while at the same time the Chinese mathematical community sought not to blindly emulate its tenets but to use them as a means for making the case for their own theories and ideas. What is here referred to by "their own theories and ideas" appertains to the notion of mathematical logic acquired in their former training in European, American, or Chinese universities of the Republican Period. A similar attitude towards the notion of mathematical logic could even be attributed to Mao Zedong, whose formation as a young Communist took place under the influence of the circle of Communists at National Peking University (1918-1919), which included the first propagator of mathematical logic in China, Zhang Shenfu, who served as Mao's supervisor during his work at the Peking University Library. Having a strong interest in modern logic, in 1956 Mao inaugurated the "Great Debates on Logic", the main ideological focus of which lay on the relationship between formal and dialectical logic, a relationship which seems to have excluded mathematical logic, which was still regarded as one of the most advanced forms of logic exempt from the idealist problematics of philosophical thought. In this regard, the development of the philosophical discourse on mathematical logic in China did not follow the Soviet example. However, at the same time, the results of the past Soviet discourse, such as animadvert and other philosophical treatises discussing the relationship between dialectical materialism and logic, did from an important referential basis for the later developments in Chinese discourse on philosophy of mathematics and dialectics of nature.

Another aspect of mathematical logic in socialist China, which distinguished it strongly from its Soviet counterpart, was related to its rapid, institutionally driven transition into a branch of mathematics. Most probably, this early establishment of mathematical logic at the CAS was the direct result of the above-discussed intellectual prestige which linked to the notion of mathematical logic in the late Republican period. Its inclusion into the preparatory IMCAS could namely probably be credited to Hua Luogeng, a former student of Qinghua University who held mathematical logic in hight esteem. The same process of mathematisation also vitally catalysed its scientific remodelling into a socialist-style technological discipline, due to which mathematical logic was also able to return to Chinese universities and other levels of Chinese national education.

Both, its unique path in ideological discourse as well as its rapid transition to a ground-breaking scientific discipline, enabled Chinese mathematical logic to attain a higher level of political autonomy, which was particularly visible in its relative exemption from the mainstream Marxist discourse imported from the Soviet Union. Amongst other, the relatively autonomous path of Chinese mathematical logic is reflected also in the low number of translations of Soviet textbooks (in the first half of 1950s) on the one hand and a stronger propensity towards theoretically more relevant and ideologically less pressing or acceptable sources from the West (after 1958). Among the sources from the Eastern Bloc which were translated into Chinese in the 1950s were prevalent those related to the ground-breaking theoretical contributions to the theory of recursion or recursive arithmetic (R. Peter and Kalmar).

Regarding the institutionalisation and the content related developments in the 1950s, the following conclusions can be drawn: Firstly, the return of mathematical logic to Chinese scientific and education institutes was initiated at the IMCAS, which already at its preparatory stage employed the mathematical logician Hu Shihua. Around scholars like Hu, Guan Zhaozhi and Min Naida, mathematical logic at the IMCAS gradually gained momentum both in their philosophical (especially Hu and Guan) and mathematical research. Because, under Hua Luogeng's leadership, from early 1950s on, IMCAS was also the centre of Chinese mathematicians' efforts to contribute to the general discourse on Marxist philosophy of mathematics, it can be established that the same institute had a pivotal role in re-establishing both the general notion and the discipline of mathematical logic in 1950s China. Moreover, as the foremost researcher in the new-type mathematical logic, Hu Shihua was probably the scholar who can be most credited for carrying out its socialist transformation. What is even more important is that, by taking on an important role in shaping the public discourse on mathematical logic and foundations of mathematics in the framework of dialectics of nature studies following 1956, Hu was also at the forefront of the Chinese scientists' community to regain direct control over the political discourse on science. In this sense, mathematical logic was also one of the pivotal concepts in mathematicians' struggle for greater intellectual freedom and freedom of research in Chinese academia.

Secondly, the turning year in the process of its ideological rehabilitation and institutional reestablishment was the year of the Hundred Flowers, 1956. This points not only at the vital importance of the current internal political atmosphere for the return of mathematical logic to Chinese universities, but also at the impact of China's own way of socialism on the manner in which mathematical logic was liberated from the constraints of Soviet Marxist doctrine. Thus, subsequently, starting in the year of the Giant Leap Forward, mathematical logic embarked more completely upon a path of an applicative, technology-related discipline on the one hand, and a concept if Chinese version of Marxist philosophy of science on the other.

Thirdly, as mentioned above, in the 1950s, the research trends in Chinese mathematical logic – and thus also its identity as a ground-breaking discipline – took a radical turn towards its applications in computer technology and industrial automatization. This was not only the result of all above-described changes, but also a natural development which was prompted by the global rise of electronic computer technology and its applications in industry and military defence technology. In its newly acquired form, alongside computational mathematics, mathematical logic was mainly applied in the field of computer programming. Since in the late 1950s Chinese computer industry was still at its early stages, accordingly, the theoretical questions researched by Chinese mathematical logicians all pertained to the basics of computer programming, such as recursive arithmetic, logical calculi, theory of systems, algorithms, functions and so on. At the same time, research of some questions of more theoretical value was still being pursued on the fringes of the community of mathematical logicians. Apart from Hu Shihua, the main representatives of this new research in mathematical logic were Mo Shaokui from the Nanjing University, Lu Zhongwan, and Wang Shiqiang.

In summary, it can be claimed with some certainty that the various shifts and changes which underlay the development of mathematical logic in China between late-Republic and early-PRC can shed some important new light on the entire process of intellectual change in this pivotal period of Chinese modernisation. As an idea rooted in the modernist worldview that defined the May Fourth intellectual world, the notion of mathematical logic changed in cohesion with the trajectorial ebbs and flows in the evolution of the entire Chinese intellectual discourse. At the most fundamental level, this deep cohesion with the fundaments of Chinese modernity did not cease to exist even under the new "ideological order". Apart from many other particular features in its development, this instance of continuity in Chinese intellectual evolution is probably one of the most important indices of both complexity as well as a certain degree of logical linearity within the entire process of scientific modernisation in China. It reveals the very vitality of the intertwinement between the general, culture-dependent intellectual discourse on one side and the formal existence of an academic discipline on the other. In this way, under intellectual circumstance akin to the period of Chinese modernisation, the life of a scientific discipline cannot be reduced to its concrete contributions to its global extension, but, in order to understand its advantages and inadequacies, must also be regarded in its complete form of existence, from its beginnings a notion embedded in the shifting or inter-merging external and native objectivist paradigms, down to the formation of the academic communities, its institutionalisation, teaching, and finally also concrete research. A major corollary to this is that, in studies relating to trans-cultural intellectual history, we must not only focus on the seemingly universal conceptual surface (e.g. existence of modern terminology), but must always try to delve deeper into the very epistemic, or as it were "cultural", foundations of the entire objectivist systems which are made up of individual concepts, categories, or theories. Sometimes, to discover the contour of these underlying patterns, we must try to combine all available aspects related to a concept's existence in a social or cultural environment. Although, in each and every case history of science as such does not necessarily include its relevant socio-historical aspects, this might well be the case in research of intercultural migration of scientific ideas and especially examples of appropriations of entire worldviews of systems of objectivity as in the case of the longstanding process of Chinese intellectual modernisation.

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