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Faculty of Social Sciences
Institute of Economic Studies

MASTER'S THESIS

The Strengths and Limitations of Input-Output Analysis in Evaluating Fiscal Policy

Author: **Bc. Lenka Líšková**

Supervisor: **PhDr. Jaromir Baxa, Ph.D.**

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Declaration of Authorship

The author hereby declares that he compiled this thesis independently, using only the listed resources and literature, and the thesis has not been used to obtain a different or the same degree.

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Prague, January 3, 2015

Signature

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Abstract

The thesis addresses the recent debates on suitable macroeconomic policy and calls for an alternative evaluation and forecasting method of economic impact, by assessing the applicability of Leontief's input-output model. We concentrate on providing an insight into the entire process of input-output analysis, which yields computation of simple input-output multipliers - output, gross value added and income multipliers. Thanks to the ability to capture linkages in the economy, computed multipliers are used as a tool to evaluate the effects of vehicle scrappage schemes and ICT infrastructure investment subsidies applied within a sample of diverse developed countries - Australia, Germany, Japan, UK and USA. We also aim to provide a sufficient explanation of the input-output model and a computation manual based on the example of the Leontief open model and calculation of simple multipliers. In our research, we numerically evaluate the effects of fiscal stimulus measures in the automobile industry and ICT sector and provide their comparison among 5 countries with different industry structures. Most importantly, the thesis provides a suggestion for policy makers to consider applying input-output analysis, as an alternative method, accounting for its strengths and limitations, when evaluating the effects of fiscal policy.

JEL Classification	C67, E62, H30, E66
Keywords	input-output analysis, fiscal policy, anti-crisis measure, multiplier, applicability, input-output table

Author's email	lenuska.liskova@gmail.com
Supervisor's e-mail	jaromir.baxa@gmail.com

Abstrakt

Diplomová práce adresuje nedávné diskuze týkající se vhodné makroekonomické politiky a požadavky alternativních metod hodnocení a předpovídání ekonomických dopadů, posouzením použitelnosti Leontiefovho input-output modelu. Zaměřujeme se na poskytnutí náhledu do celého procesu input-output analýzy, který ústí v kalkulaci jednoduchých input-output multiplikátorů - multiplikátory produkce, hrubé přidané hodnoty a příjmů. Díky schopnosti zachytit vazby v ekonomice, se použijí spočtené multiplikátory jako nástroj na hodnocení efektů šrotovného a dotací pro rozvoj infrastruktury informační a komunikační technologie (ICT) na vzorku rozdílných rozvinutých zemí - Austrálie, Německo, Japonsko, Velká Británie a Spojené státy americké. Naším cílem je také poskytnutí dostatečného vysvětlení input-output modelu a výpočtového manuálu založeného na příkladu Leontiefovho otevřeného modelu a kalkulace jednoduchých multiplikátorů. V našem výzkumu, numericky hodnotíme efekty fiskálních stimulačních opatření v automobilovém a ICT sektoru a poskytujeme porovnání v rámci 5 krajin s rozdílnými struktury průmyslu. V nejdůležitější radě, diplomová práce poskytuje návrh pro tvůrce politiky, aby zvážili využití input-output analýzy jako alternativní metody s příslušnými výhodami a nevýhodami, při hodnocení efektů fiskální politiky.

Klasifikace JEL	C67, E62, H30, E66
Klíčová slova	input-output analýza, fiskální politika, protikrizové opatření, multiplikátor, použitelnost, input-output tabulka

E-mail autora	`lenuska.liskova@gmail.com`
E-mail vedoucího práce	`jaromir.baxa@gmail.com`

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Acronyms

AUD Australian Dollar

B-SBAR Bayesian Structural Vector Autoregression

DSGE Dynamic Stochastic General Equilibruim

ECB European Central Bank

EU The European Union

EUR Euro

G20 The Group of Twenty

GBP British Pound Sterling

GDP Gross Domestic Product

GVA Gross Value Added

ICT Information and Communications Technology

ISIC International Standard Industrial Classification

IMF International Monetary Fund

IO Input-Output

JPY Japanese Yen

OECD The Organisation for Economic Co-operation and Development

UK The United Kingdom

USA The United States of America

USD The United States Dollar

USSR The Union of Soviet Socialist Republics

STAN Structural Analysis

VAR Vector Autoregressions

Master's Thesis Proposal

Author	Bc. Lenka Líšková
Supervisor	PhDr. Jaromir Baxa, Ph.D.
Proposed topic	The Strengths and Limitations of Input-Output Analysis in Evaluating Fiscal Policy

Topic characteristics

Recent financial crisis has raised questions among policy makers concerning measures needed to stimulate and revive the country's economy. Specific anti-crisis measures were dependent on the actual socio-cultural, economic and political environment as well as industry structure of the country.

Although input-output analysis has been used in environmental research to quantify the environmental impacts, there is a little work related to measure fiscal policy effects by input-output analysis. Therefore my motivation is to examine its applicability on fiscal policy impact measurement. To be more specific, master thesis will focus on anti-crisis measures, which were introduced to mitigate effects of financial crisis on the economy. Since there has been a little attention paid to input-output analysis applicability, the literature used for this master thesis will be partly non-recent.

Input-output analysis catches real and final flows between particular sectors and simultaneously the flow of intermediate products in firm's sector. Using input-output analysis, the effects of fiscal policy can be numerically evaluated and suitability of concrete measures can be assessed.

In order to objectively find strengths and limitations of the input-output analysis to assess and quantify fiscal policy impact on economy, countries with different economic environment will be chosen. Moreover the analysis will be extended for several industries, which is expected to lead to clearer results concerning model applicability across sectors and countries.

As a result of the master thesis, critical review of input-output analysis

abilities will be provided together with the suggestion to what extend and in which cases is input-output analysis suitable to describe the effects of fiscal policy and used as a tool for further policy making decisions.

Hypotheses

Is input-output analysis applicable to numerically evaluate the effects of fiscal policy?

Do the results of input-output analysis of fiscal policy impact provide and accurate feedback for policy makers?

Is it possible to compare the results of input-output analysis of anti-crisis measures across sectors and countries and decide on the most suitable fiscal policy as a reaction to crisis?

Methodology

Methodology, which will be used in master thesis, is input-output analysis. This method was designed by Wassily Leontief and originally was used to study GDP in several ways or as a helpful tool for counting gross and final consumption. To my best knowledge there is a little work studying fiscal policy effects using input-output analysis, however it has been used in environmental research to quantify the environmental impacts.

Data used for the calculation will be obtained from input-output tables, which are provided in OECD database. In my master thesis I will focus on studying the strengths and limitations of input-output analysis when evaluating the effects of fiscal policy on the economy.

The results of my analysis will show if input-output analysis captures linkages in economy through changes based on fiscal policy.

Results of the master thesis will provide a suggestion for policy makers to realize applicability of the input-output analysis when evaluating the effects of fiscal policy implemented at national or international level.

Outline

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3. Theoretical Background
4. Fiscal policy in chosen countries
5. Data describtion

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7. Elaboration on the Results and Implications
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Author Supervisor

Chapter 1

Introduction

The worldwide impact of the economic crisis has raised questions among policy makers concerning measures required to take to stimulate and revive the country's economy. Specific anti-crisis measures have depended on the actual socio-cultural, economic and political environment as well as industry structure of the country. Moreover, the crisis has triggered a growing literature on the features of the events of the financial crisis and debates on appropriate policy interventions to boost the economy and eliminate the impacts of crisis on the national economy.

Even though mainstream macroeconomic policy views have suggested that stabilisation policy should be performed by monetary policy pursuing credible policy rules with a focus on inflation, insufficient performance of monetary policy has drawn attention to fiscal policy, its necessity, effectivity and extent.

Another source of disputes has been the size of fiscal multipliers used in fiscal planning, which have been shown to be systematically low. Further errors in growth forecasting methods and fiscal multipliers' size calculated before crisis, have demonstrated a need for alternative methods, to provide more accurate results ex-post and ex-ante analysis of anti-crisis policies and specific measures taken.

Raising the need for experimental methods in evaluating economy, Colander (2000a) predictes evolution of new millennium economics. He summarises that models, which were used for policy analysing purposes were diverging from the underlying formal general equilibrium models at their core resulting into controversy over how to interpret models, and clearly calls for experimental economics and complex models to match the complex economy.

In the thesis, we address the need of alternative method of economic impact analysis, to supplement general equilibrium and vector autoregression models, which were underperfoming. We draw attention to an analytical framework called input-output analysis introduced by Wasily Leontief in 1938. The motivation to put Leontief's input-output model under scrutiny was mainly inspired by 3 following factors - first convergence on the general framework for analysing policy and forecasting towards vector autoregression and general equilibrium models, second errors in estimation of fiscal multipliers by such models, and third the discussions on the future evolution of analysing methods in economics.

Input-output analysis, as a supplement of other economic models, provides a complete picture of the economy as a whole, enabling studying the inter-industrial relationships within the domestic economy and assessment of the national output system. The input-output model enables the calculation of sets of multipliers, which are a tool to further evaluate the economy.

Although input-output analysis has recetly been popular analysis tool in environmental research to quantify the environmental impacts, there is a little work related to measure fiscal policy effects by input-output analysis. Therefore our motivation is to examine its applicability on fiscal policy impact measurement. To be more specific, the thesis focuses on anti-crisis measures, which were introduced to mitigate effects of financial crisis on the economy. Since there has been a little attention paid to input-output analysis applicability, the literature used for this master thesis will be partly non-recent.

We follow up on previous literature, where we find evidence input-output analysis application to study the individual country's economy in few developed countries, where input-output tables are part of system of national accounts, for example in research of Feldman *et al.* (1976), Tsoukalas (2011), Keogh & Quill (2009). We also find evidence, that identifying key sectors ex-ante is particularly important in emerging countries to achieve effectively targeted policy, reduce poverty, boost economic growth and limit unemployment, see for example Bensaid *et al.* (2011) and Lapeyre (2010). A comparison of an industry's multiplier's performance has also been in interest of researchers (Pietroforte & Gregori 2003).

In order to provide more diverse results and implications of our analysis in comparison with previous studies, we choose to evaluate economies with different economic environments and structure of industries - Australia, Germany, Japan, UK and USA. We seek further diversification of results by studying two

independent fiscal stimulus packages, aimed at the automobile and ICT sectors. As a result of the thesis, we provide calculation of input-output multipliers accompanied by a brief computation manual to raise awareness of calcuation methods. Based on the data collected and computations of simple input-output multipliers following the description of methodology by McLennan (1995)., we draw implications of the application of input-output analysis to evaluate fiscal policy. Last, but not least we present an overview of the strengths and limitation of input-output analysis.

The thesis contributes to the portfolio of input-output analysis based literature. In comparison with the reviewed studies, thesis captures multiple countries and sectors and thus provides wider portfolio of results and opportunity for fiscal stimulus packages comparison. We numerically evaluate the effects of fiscal policy, compare the results across countries and sectors, and show the decision making points on the most suitable fiscal policy reaction tailor-made for a specific country based on the key output, gross value added and income generating industries.

The thesis is structured as follows: Chapter 2 provides a review of existing relevant literature on evaluating policy impact on economy and summary of main findings. Chapter 2 is divided into 3 sections, where first we introduce the financial crisis and debates about the policy responses and fiscal manoeuvring. Second, we comment on recent trends in policy analysis frameworks and lastly introduce Leontief's input-output model and the existing literature. Chapter 3 relates to fiscal policy measures taken in the examined countries and presents a sample of countries and chosen fiscal stimulus packages, which are later examined. Chapter 4 of the thesis begins to link the theory with practice. Divided into 3 main sections,in Chapter 4 firstly we formulate hypotheses development which is the main focus of our thesis. Secondly, we introduce the data source and describe input-output tables. The last part of Chapter 4 is dedicated to the methodological background of the input-output analysis application, and an explanation of the approach to input-output multipliers calculation, which has been used to compute our results. Finally, Chapter 5 shows the empirical analysis itself, reveals computed multipliers and elaborates on the results. Chapter 5 analyses, based on calculated multipliers, the effects of fiscal stimulus packages examined by our thesis in the sample of countries. In Chapter 5 we identify implications of using input-output model to evaluate fiscal policy, in the form of strengths and limitations of input-output analysis itself. Lastly, Chapter 6 concludes the thesis and provides the critical review of input-output

analysis abilities in evaluating the effects of fiscal policy.

Chapter 2

Literature Review

Before we start discussing the applicability of input-output analysis for measuring fiscal policy, it is vital to understand the fiscal policy measures taken as a response to the financial crisis. After the hit of the financial crisis a basic challenge for policy makers was to rebuild confidence, largely by moving away from an incremental approach to policy making and addressing the many downside risks to global activity with strong medium-term fiscal and structural reform programs. Substantial progress and success of such programs applied is necessary to regain confidence and strengthen demand in the major advanced economies. Investors will be reassured that public debt is a safe investment and that advanced economy central banks have scope to use monetary policy to maintain low inflation to forestall renewed bouts of financial instability (IMF 2012)

2.1 Financial Crisis

The sudden impact of the financial crisis on most of the world economies has caused a growing literature on the features of the events of 2008-2009 related to financial crisis in general, as well as on the collapse of international trade in particular. Levchenko *et al.* (2010) observe the exceptionality of collapse, modeling both input-output linkages and systematic differences in the sectoral composition of production and trade pattern. In times of economic distress when interest rates are at a lower bound and monetary policy is questionable, alternative fiscal policy can be used to boost economic activity.

As a response to financial crisis, policy interventions were associated with a reduction in interbank risk premia, most significantly for recapitalisation programs and most policy announcements had spillovers of international reach. Using input-output Kuroiwa & Kuwamori (2010) reveal the effects of the financial crisis, more specifically the sharp decline in U.S. imports on the industrial output of nine East Asian countries. They conclude that the most seriously hit countries were the ones, which are deeply involved in production networks and the transmission in East Asian industries was done widely through the triangular trade (Kuroiwa & Kuwamori 2010).

2.1.1 Policy Response to the Great Recession

Financial crisis has turned into a world-wide economic crisis, accompanied by plummeting growth and unemployment rates in all OECD countries.

Increasing political interest and high expectations as to what fiscal policy can accomplish have created a debate on the need for fiscal stimulus, its magniture and its composition and there has been calls for its revival by the G20 as well as the EU Commission. Andersen (2009) summarises that the mainstream view on macroeconomic policy claimed that stabilisation policy should be left to monetary policy pursuing credible policy rules with a focus on inflation. Fiscal policy should rely on the automatic stabilisers leaving only discretionary fiscal policy to very special circumstances with a clear need for policy intervention. However monetary policy could not deliver sufficient stabilisation and attention is drawn to fiscal policy.

National fiscal policies directed at aggregate demand may lose its effectivity due to close financial and trade links resulting in increased demand leakages via trade and specialisation of production. Importantly the need and scope for discretionary fiscal policy depend on the nature of the shock and on the value added, which it may contribute to monetary policy responses and automatic budget reactions. Although globalisation plays an important role, and loss of effectivity of fiscal multipliers is in place, the driver remains national interests, and the positions of various countries simply differ too much to make it likely that a reasonable common policy approach can be agreed upon (Andersen 2009).

Barrell *et al.* (2009) show that the size of country-specific fiscal multipliers is inversely related to the openness of that country. Hence in more open countries,

a larger share of domestic demand turns to foreign production and the effect of fiscal policy is reduced.

Appropriate fiscal interventions depend both on the nature of shocks, the capability of monetary policy and the strength of automatic stabilisers. Requirements of a discretionary fiscal policy are that it should be well-timed to the business cycle situation, which includes that it should be adapted to the nature of the shocks, it should be temporary, the specific instruments applied should be effective towards the policy goals, and medium-to long-run constraints should be taken into account (Andersen 2009).

2.1.2 Debate about the Fiscal Policy Manoeuvering

Fiscal problems can be based in structural problems that take time to address, and sharp expenditure cutbacks or tax increases can set off vicious cycles of falling activity and rising debt ratios, ultimately undercutting political support for adjustment. IMF (2012) suggests that governments should commit to measures and medium-term targets that are actually under their control. Budget forecasts must also be based on realistic, not optimistic assumptions about the negative short-term impact of adjustment on output and employment.

Thus fiscal policy must be realistic, transparent and predictable with medium-term aims, as well as being a stabilising factor against short-term downturns or booms. IMF (2012) provides several comments regarding the necessity of strong commitment to a sound fiscal framework. Such recommendations include specifying adequately detailed medium-term plans for lowering debt ratios, backed by binding legislation or fiscal frameworks, addressing the issue of reduction of the growth of aging-related expenditures to improve debt dynamics without effects on short-term demand as well as defining targets in structural or cyclically adjusted terms and preparing contingency plans for coping with shocks. The need for fiscal policy is lower in emerging markets and developing economies - the reason is lower public debt. The room for fiscal manoeuvering should still be rebuilt in such countries.

Developments and activity over the past few years suggests that fiscal multipliers, used in fiscal planning have been systematically low. IMF (2012) shows that the aforementioned relationship holds for different components of GDP: unemployment rate and forecasts made by different institutions. IMF (2012) elaborates on the issue of underestimation of short-term fiscal multipliers and

focuses on the recent episode of widespread fiscal consolidation. By regressing the forecast error for real GDP growth duration 2010-11 on forecast of fiscal consolidation for 2010-11 that were made in early 2010, IMF (2012) finds, that if the multipliers underlying the growth forecast were about in a range of $0,4$ - $1,2$, results of the article indicate that multipliers have actually been in the range of 0.9 to 1.7 since the Great Recession. Such findings are consistent with research suggesting that in today's environment of substantial economic slack, monetary policy constrained by the zero lower bound and synchronized fiscal adjustment across numerous economies, multipliers may be well above 1. Authors find that there was no systematic tendency for economies with larger initial fiscal consolidation plans to implement greater additional consolidation.

Another evidence of growth forecast errors is provided by Blanchard & Leigh (2013) who find that in advanced economics, stronger planned fiscal consolidation has been associated with lower growth than expected, with the relation being particularly strong, both statistically and economically, early in the crisis. Blanchard & Leigh (2013) suggest there is no single multiplier for all times and all countries and the values may vary across time and suggest that actual multipliers were substantially above 1 early in the crisis. The smaller coefficient we find for forecasts made in 2011 and 2012 could reflect smaller actual multipliers or partial learning by forecasters regarding the effects of fiscal policy.

West (1995) evaluates the practical application of the different methodological approaches and concludes, that the differences among results can be quite substantial even when the data and impact scenario equal.

As there is an evidence of error in form of underestimation of multipliers and too wide intervals of multipliers calculated by forecasters before crisis, an alternative methods shall be examined to provide more accurate ex-post and ex-ante analysis of various policies aimed at stimulation of the economy, as well as creating savings in the economy.

2.2 Macroeconomic Effects of the Fiscal Policy

Here, we discuss applying input-ouput analysis to evaluate fiscal policy. We comment on present trend in the macroeconomic analysis and on the development in this field. Moreover, we name what are the main models used to conduct analysis of monetary and fiscal policy and forecasting methods.

Caldara & Kamps (2008) in their working paper react to the fact, that while a consensus view has emerged with regards to the empirical effects of monetary policy shocks, the empirical literature has struggled so far to provide robust stylized facts on the effects of fiscal policy shocks. Their main concern is that, there is no agreement on even the qualitative effects of fiscal policy shocks on those macroeconomic variables (private consumption, real wage and private employment), which would be helpful to discriminate among competing theories. The paper presents an extensive comparative study on the empirical literature using vector autoregressive models to assess the effects of fiscal policy shocks.

2.2.1 Recent Main Policy Analyzing Frameworks

Main frameworks, which have been used to simulate policies and forecast its effects have been quantitative macro model, stochastic simulations, national expectations and intertemporal optimization (Colander 2000a), (Colander 2000b). An alternative method which has been applied to empirical problems and forecasting has been vector autoregressions (VAR). The main difference between DSGE and VAR models is that DSGE model is structural, whereas VAR is atheoretical, based on statistical properties of the data.

Sbordone *et al.* (2010) brings more awareness of a DSGE framework to a broader public by introducing its basic structure, logic and application on the example of its use as a tool for monetary policy analysis, more specifically the sudden raise in inflation in the first half of 2004. Due to its aim of raising awareness, Sbordone *et al.* (2010) worked with a small model in order to make the transmission mechanism of monetary policy as transparent as possible. The model focuses on the behavior of only three major macroeconomic variables - inflation, GDP growth and short-term interest rate. Sbordone *et al.* (2010) mention a drawback of DSGE models, highlighted by the financial crisis - the inclusion of a more sophisticated financial intermediation sector. Authors conclude, that DSGE models have the potential to broaden the understanding by adding a quantitative assessment of the link between current policy, expectations, and economic outcomes, and thus to clarify the effect that different systematic approaches to policy have on those outcomes.

The popularity of VAR models can be demonstrated by the ECB, in its study of the fiscal policy shocks effects, based on the evidence of USA over the

period 1995-2006. Afonso & Ricardo (2012) investigate the macroeconomics effects of fiscal policy in USA, UK, Germany and Italy, using B-SBAR[1] approach. The results of their research show, that government spending shocks, in general, have a small effect on GDP. This leads to crowding out effects, that have various impact on housing prices and generate a quick downturn in stock prices (Afonso & Ricardo 2012).

Parker (2011) elaborates on the appropriate framework to measure the effects of fiscal policy in a recession, debating on VAR and DSGE models, using several papers as examples of their application. Parker (2011) argues that a fruitful avenue for ongoing and future research is to build, possibly highly, nonlinear models and match their implications not just to correlations in aggregate or microeconomic data, but also to estimates from microeconomic studies of the causal effects of policies on economic outcomes taking prices as given.

Colander (2000a) published an fruitful article on the development of new millenium economics focusing on changes that occurred both, because of the internal tensions in the profession in the late 20th century and technological changes affecting the research methods of economics and the structure of higher education in general. A comparison of applied and theoretical economics was done in 1990s, predicting how the situation will be in 2050. The article among other remarks adds that a huge drop in the relative costs of computation has had a dramatic effect on the way in which applied and theoretical economics is performed[2].

In the late 1990s and 2000s, there has been a convergence among researchers, central banks and other institutions on the general framework for analysing the policy and forecasting, mainly in terms of methodology. Nowadays, central banks around the world present their economic outlook and policy strategies to the public, introducing into the policy process modern analytical tools and advanced econometric methods in forecasting and policy simulations.

See how Colander (2000a) forecasts economics of the new millenium in his article New Millennium Economics: How Did it Get This Way, and What Way is It? (2009) and provokes discussion over alternative methods in evaluating economy:

> ...However, in the closing decades of the 20th century, it became clear that the models actually being used for policy purposes were

[1] Bayesian Structural Vector Autoregression

[2] The lower costs of computations and technological progress are later mentioned in Chapter 5, when we evaluate strengths and limitations of input-output analysis.

> diverging from the underlying formal general equilibrium models at their core. With some justice, the policy models became viewed as more and more ad hoc. Instead of being closely tied to underlying general equilibrium core models, policy models embodied selectively chosen empirical regularities and principles. As a result, controversy arose over how to interpret policy models... ...Experimental economics is now an extremely important way of creating data; interestingly, it only began in the late 20th century... ...New Millennium economists do not believe that they are testing a particular model which was deduced from first principles; instead they are simply looking for possibly exploitable patterns in the data... ...By 2020, complexity science had developed to the point where most scientists accepted the view that the old-style research path worked well for structurally simple systems, but the complexity path was necessary for complex systems...

Upon the discussion which arose regarding alternative methods of quantifying impact in the economy, and based on the errors in estimated fiscal multipliers (see Subsection 2.1.2), in the thesis we reach out to Leontief's input-output analysis to evalute fiscal policy.

2.3 Input-Output Model

When Wasilly Leontief in 1936 published his article Quantitative Input and Output Relations in the Economic System of the United States in The Review of Economic Statistics, he laid the basis for the future research in the field of an analytical framework called input-output analysis. Leontief (1936) visualises the economic activity of the whole country as if it was being covered by one huge accounting system, including all the branches of industry, agriculture, transportation and all private persons. Leontief in his original study provides a reasoning and detailed explanation of the industrial distribution of the accounts into input-output tables. Developed methodology he later applied to the detailed study of the structure of the USA economy. Leontief's model was a demand-driven input-output model, generalising interdepencies between industries and an economy under the assumptions of a competitive market system and non-scarce resources.

Gosh (1958) has reviewed Leontief's approach and developed a similar model, however Gosh's model was supply-driven. Supply-driven model is applied when the assumptions for demand-driven model are not met, in monopolistic or centrally planned economy with scarce resources for all but one sector. Gosh (1958) suggests a model, where the assumptions are fixed allocation coefficients not affected by final demand changes and scarce capacity for all industrial sectors except the sectors targeted (Park 2006).

Leontief (1970) continues his focus on input-output model and comments on the possibility of incorporating the externalities into the conventional input-output picture of a national economy. In Environmental Repercussions and the Economic Structure: An Input-Output approach, Wassily Leontief (1970) demonstrates that the conventional input-output calculation can result in concrete answers to some of the fundamental factual questions that should be asked and answered before a practical solution can be found to problems raised by the undesirable environmental effects of modern technology and uncontrolled economic growth.

Leontief's wide research and numerous publications resulted in the award of a Nobel Prize in Economics in 1973 for the development of the input-output method and for its application to important economic problems.

Input-output analysis allows us to study these structural changes in the economy and provides the tools necessary to evaluate sectors, including their relationships to the rest of the economy and the effects of international trade on those relationships. Guo & Planting (2000) have taken advantage of the ability of the aforementioned qualities of IO analysis and analysed structural changes in the USA economy and the role of international trade on those changes using a set of six input-output tables prepared over the 1972 to 1996 period. The structural change is measured by the multiplier product matrix which provides a measure of linkages between industries comparing industries among each other, or industry itself at different points in time.

Although the input-output and econometric models have been found to be supplements instead of complements, Miller *et al.* (1991) comment that despite Leontief's model to be more closed with respect to households, the early empirical work in this field was more industry-oriented. Comprehensive social account matrices have been used as the basis for the United Nations system of national accounts.

Theoretical and empirical discussions on input-output analysis were published by Miernyk & Rose (1989), Ten Raa (2005) and many others. While

Miller *et al.* (1991) provide an overview of the state of input-output analysis at that time, Park (2006) comments that the input-output models are attractive because they can be made operational and accessible at low cost.

Even though vast research relating to input-output analysis was done by its inventor, we provide an overview of some empirical studies conducted on various countries' economies using the input-output model. Kubursi *et al.* (1975) aimed to evaluate the economic impact of government expenditure by department using the Ontario input-output table as a starting point. Final demand categories of Ontario provincial government expenditures are adjusted to correspond with government expenditure by department. Moreover, differential impacts of government expenditure by department is analysed. Kubursi *et al.* (1975) suggest that the magnitude of the effects of different departmental expenditures substantially varies and therefore the variations in the expenditure allocation over departments should be considered as a possible policy variable.

Keogh & Quill (2009) used input-output tables to see what structural changes have occurred in the Irish economy since 1975. More studies, in which the input-output model has been applied to evaluate developed economies include for example the study conducted by Tretyakova & Birman (1976) on the USSR economy, Feldman *et al.* (1976) on the US economy and Tsoukalas (2011) who examined the UK economy using the input-output approach.

Alternatively, input-output analysis has been used widely e.g. in Australia (West 1995) as a basis of economic impact studies. Even though attention has been drawn to more sophisticated models, presented as substitutes to input-output, the main contenders are integrated input-output and econometric and computable general equilibrium models. With respect to variety of models and alternative applications, Baumol (2000) claims that input-output analysis is one of the major contributions to economics in the 20th century that accomplished the mutual support theory, data and application.

2.3.1 Application of IO Analysis in Emerging Countries

Emerging countries are constrained by IMF structural adjustment and macroeconomic guidelines, when facing unemployment, underempoloyment and poverty. A strict macroeconomy policy framework of Poverty Reduction Strategies creates a binding constrain to monetary policy, fiscal pocliy, exchange rate management and financial regulation in emerging countries. Policy makers in

emerging countries encounter problems when deciding on the appropriate IMF macroeconomic framework to achieve set development goals on a national level to boost the economic growth, reduce poverty and create jobs. Effective strategy should target sectors within the national economy that generate the most value added and employment, and have large multiplier effects and linkages to the domestic economy (Lapeyre 2010). In order to better understand the structure and connections within economy, input-output analysis has been widely used by emerging countries. We introduce examples of studies examining Gabon economy, and economy of Madagaskar.

Analysing the differential contributions of various sectors of a domestic economy helps to formulate an appropriate macroeconomic and sectoral policy to take effective measures and support key sectors of the economy. Bensaid *et al.* (2011) were thanks to technique input-output, able to analyse income generated by the Gabon economy by proceeding to the calculations of income multipliers. The total significance of sectors in the economy and thus determining the key generating sectors within country's economy, can be estimated by examining the inter-industry linkage effect (see further inforation in Subsection 2.3.2 below). Bensaid *et al.* (2011) find that the total income multiplier for the overall economy is 1,3 which is very weak. The total income multiplier is the lowest for the agriculture sector with 1,04 and therefore, agriculture is not generating too much extra additional output in comparison with other industries.

Epstein *et al.* (2009) call for a need for understanding of the economic structure of Madagascar, in particular sectors that generate value added, employment, multipliers, and linkages. In the research, the authors construct a standard input-output model for Madagascar and incorporate employment data from the 2001 household survey. Epstein *et al.* (2009) assume that households would finance their consumption out of the value added produced, i.e. wages and self-employment income. Interestingly, due to a high self-employment ratio in Madagascar, the impact will likely take the form of increasing value added instead of increasing the number of jobs. Such problem is unique, in comparison with Gabon economy study. Calculation of the input-output multipliers is performed - output multiplier, value added multiplier and the employment multiplier. The authors identified a number of key sectors, where more investment could generate higher employment and income. Industries with high wage employment multipliers include garments, business services, communications, education, health, and recreation services. On contrary, industries with low

value added or low employment multipliers include metal and stone working, chemicals, paper products, and, somewhat surprisingly, building and construction (Epstein *et al.* 2009). The paper by Epstein *et al.* (2009), in addition to Bensaid *et al.* (2011), explains that different industrial sectors have different links to the domestic economy, which causes the variations in the size of multipliers.

2.3.2 Linkages and Leakages in the Economy

As suggested above, in the research done by Epstein *et al.* (2009), the input-output framework allows measuring domestic intersectoral linkages, as well as evaluate the importance of international trade in the production process. Moreover, the interaction between domestic linkages and leakages resulting from international trade can also be analysed Reis & Rua (2009). As the thesis is focused on studying 5 countries, the extend of the thesis does not allow for proper analysis of backward and forward linkages in the economies. Additional research of single countries' economies is recommended[3].

Reis & Rua (2009) measure, within input-output framework, the backward and forward linkages in Portuguese economy by separating the intermediate transactions matrix according to the source of products, domestic or foreign. Such process allows for accounting for domestic linkages properly and thus better measurement of both linkages. Reis & Rua (2009) claim, when focusing on single country, only domestically supplied inputs should be taken in consideration because the impact on the domestic economy is of concern. Furthermore, the interaction between domestic Portuguese linkages and leakages steaming from international trade was also examined. Temurshoev (2004) studies the production structure and the linkages among sectors of Kyrgyzstan economy for year 1998. In the paper few methods were described, i.e Chenery-Watanabe, Rasmussen, and Dietzenbacher and van der Linden, and afterwards used as a basis for calculation of type I and type II output multipliers and indices of backward and forward linkages.

[3]Methodology of studying linkages and leakages can follow Epstein *et al.* (2009)

2.3.3 Cross-Country and Sectoral IO Analysis

The macroeconomic effects of using the cross-country input-output analysis of intersectoral relationships between manufacturing and services and their employment implications suggest that the intersectoral relationships between manufacturing and services generally characterise asymmetrical dependence (Park & Chan 1989). In their research, Park & Chan (1989) discovered that service activities usually depend on the manufacturing sector as a source of input to a far greater extent than vice versa. Furthermore they claim that the employment absorptive capacity of the manufacturing sector is seriously underestimated, when one only measures the direct employment effect of the manufacturing sector and ignores the intersectoral demand of the manufacturing sector for service inputs and its income induced demand for various types of services.

Relevant for the thesis is also a sectoral input-output analysis performed by Pietroforte & Gregori (2003), using the OECD input-output tables of eight highly industrialized countries, Australia, Canada, Denmark, France, Germany, the Netherlands, Japan and the USA, in the 1970s and 1980s to assess the construction sector's diminishing role in terms of share in gross output, value added and GNP, focusing also on technologies emphasising the relative role of manufacturing and services inputs.

Input–output analysis has been widely used to assess sectoral economic performance and production interdependence. Kulatunga *et al.* (2006) uses input–output tables in Sri Lanka to analyse the significance of construction in a developing economy and its relationships with other sectors of the national economy. The study is carried out based on 5 input-output tables compiled for the Sri Lankan economy to date, aggregating sectors into 5 main divisions based on ISIC for analytical purposes. The research shows that the trend of the profile of inputs and outputs are correlated to the economic policy regime in operation. Kulatunga *et al.* (2006) explains the process of calculation of multipliers used in his study. The direct input coefficient matrix is constructed by dividing each flow shown in the input-output table by its column sum. Direct output coefficient matrix is obtained when each flow is divided by the row sum. Kulatunga *et al.* (2006) uses direct input and output coefficient matrices to establish the direct linkages in Sri Lanka's economy. Inverting direct input-output coefficient matrices, the total input and output coefficient

matrices are constructed. The elements of an inverse matrix represent both direct and indirect flows between two sectors. The total input coefficient matrix shows the total impact of changes in final demand on sectoral output, while the total output coefficient matrix shows the total impact of changes in value added on sectoral input Kulatunga *et al.* (2006).

Impacts of fiscal stimulus in form of home insulation package has been analysed by Zamecnik & Hlavac (2010) who intend to numericaly evaluate the effect of home insulation stimulus package in construction industry. Using input-output model authors estimate the multiplier of home insulation package in construction industry to be 2,47. The reasoning behing such large multiplier is that home insulation stimulus package is targeting little construction sector, which is labor intensive and creates multiple small projects.

Input-output analysis is widely used by Japanese economists in impact analyses. Suga (2012) consults input-output tables to access how many dispatched employees, hired to work on manufacturing production lines and fired in large numbers, lost their jobs when final demands, including exports decreased significantly as a result of the global financial crisis that affected Japan in October 2008. Financial crisis has been transmitted as well to Asian emerging markets, China and India, whose business cycles are little synchronized with the ones of OECD countries.

Fidrmuc & Korhonen (2010) when applying dynamic correlations, found a substantial effect of financial crisis on economic developments in emerging Asian economies as well as a significant link between trade ties and dynamic correlations of GDP growth rates in emerging Asian countries and OECD countries. The Chinese system has a unique set of harmonised tables that inspired Xuemei (2011) to analyse 10 survey-based input-output tables constructed by regional statistical bureaus in China, being a dynamic economy characterised by large disparities between regions and a country with strong concentration of ICT industries. Because of a great diversity within China itself and the existence of multiple China input-output tables, China will not be included in the thesis and the effects of fiscal policy within the country should be analysed separately.

2.3.4 Other Application of IO Analysis

Based on the previous evidence, the applicability of input-output analysis

has widely developed since its first introduction in 1936 and has been applied by researchers at a local, regional, national as well as international level. Recently the input-output model has been extended to accommodate more explicitly, topics such as international and interregional flows of products and services or accounting for energy consumptions and environmental pollution associated with inter-industry activity which can be observed from the exceeding number of environmentally oriented studies using input-output analysis.

A dynamic econometric model based on an input-output table is used for forecasting the amount of CO2 caused by economic activities in Japan (Sasai *et al.* 2012). Input-output data is used because it is critical to know the amount of energy consumption of industries by energy source. The work of Sasai *et al.* (2012) can be an inspiration for the predictions of CO_2 emmisions related to appropriate fiscal policy use.

Chapter 3

Fiscal Policy as a Reaction to Financial Crisis

3.1 Fiscal Policy in Chosen Countries

The eruption of the financial crisis in 2008, which started in the United States' financial sector, and spilled over to the economies of many countries, triggered a sharp global depression of real activity which changed the international economic environment leaving no country unaffected. The direct result of the global economic crisis has been a fall in GDP, trade and employment.

The ultimate goal of wide-ranging central bank and government interventions was to address the fragility of banking systems and restore confidence in financial markets (Ait-Sahalia *et al.* 2012). The reaction of governments was sizable fiscal stimulus in the form of various measures as well as massive governmental and central bank interventions to support key financial institutions. Most policy discussions are focused on muting the impact effect of the crisis based on the perception that this will lower both the immediate cost and the length of the crisis (Andersen 2009).

The crisis has highlighted the need for a better understanding of the international transmission channels of economic disturbances, and for more innovative and dramatic policy responses to large shocks in the presence of strong cross-country linkages and dysfunctional financial markets (Bussiere *et al.* 2013). In times of economic distress when interest rates are at a lower bound and monetary policy is questionable, the alternative avenue is fiscal policy. According to Cook & Devereux (2011) many countries followed significant expansions in gov-

ernment deficits, reducing taxes and simultaneously or alternatively increasing government spending. Cook & Devereux (2011) claim that at the beginning of the downturn, there was a concerted effort to coordinate these fiscal expansions across countries, through the G20 process and other venues, however the ensuing fiscal responses were far from uniform across different countries. When determining the scope for fiscal policy intervention, it is important to take medium to long-term effects into account. Expansionary fiscal policy in combination with budget deteriorations implied by automatic budget reactions will drive up public debt, which, in turn, may create future adjustment problems Andersen (2009).

Blanchard *et al.* (2009) comment that sustainability of fiscal policy can be assessed based on whether it fulfills certain characteristics - being timely, large, lasting, diversified, contingent, collective and sustainable. See the reasoning and explanation of the characterisctics given by Blanchard *et al.* (2009) (Fiscal Policy for the Crisis, 2009) give:

> Timely, because the need for action is immediate after the shock, financial crisis; large, because of the extended decrease in private demand; diversified because of the unusual degree of uncertainty associated with any single measure; contingent because the necessity to reduce the probability of another Great Depression requires an extensive action; collective, since the crisis has effected the economy globally and countries with fiscal space should take action; and lastly sustainable to prevent a debt explosion or adverse reactions of financial markets.

Blanchard *et al.* (2009) add that spending increases and targeted tax cuts and transfers are likely to have the highest multipliers, whereas general tax cuts or subsidies to consumers or firms are likely to have lower multipliers and present several examples of fiscal policy reacting to financial crisis around the world and its strengths and limitations in trying to access the appropriate composition of fiscal stimulus package. Specific fiscal response to the financial crisis, its magnitude and distribution across countries is examined in the thesis using input-output tables and computation of multipliers.

3.2 Sample of Countries

For the purpose of the thesis five countries of the G20 have been chosen, specifically Australia, Germany, Japan, United Kingdom (UK) and United States of America (USA). The selection of countries is based on the 3 criteria relevant for the purposes of the study. The first criteria is diversity of the sample, which takes into account that each country has a completely different socio-cultural, economic and political environment as well as different industrial structures in each country.

Uhlig (2002) comments on the diversity of fiscal policy in the EU and outlines that even when the currency is the same, the possibility of coordination failures resulting from potentially excessive deficits to coordination failures in a European fiscal or banking crises occurs and calls for more coordination. Uhlig (2002) states that fiscal policy should respond to the country-specific fiscal demand shocks and even with the ECB intervening, each fiscal authority within the EU will be tempted to try to improve the situation for its country by e.g. expanding government demand or government deficits precisely when the ECB needs to combat cost-push shocks via higher interest rates, and the situation instead of stabilising, can get worse.

Another important criteria when performing analysis, in order to obtain accurate results is data availability. Data availability increases for highly developed countries, as the input-output tables have been constructed in a timely manner and historical as well as up-to-date tables are available. Lastly, the selected sample is based on the previous experience as the relevant literature suggests that input-output analysis has been widely applied for the studies of Asian economies, the Australian economy, and the USA economy.

The size of packages across countries reflects the severity of the financial crisis, the fiscal position before the impact of the crisis and the size of automatic stabilizers. The crisis-related fiscal stimulus was strongest in 2009, although exceptions apply. As a share of GDP, the size of the economic stimulus packages ranges between 0,1 percent of GDP to over 5 percent of 2008 GDP (OECD 2009). Table3.1 provides an overview of initial conditions before the onset of the economic crisis, spending in 2009 and total size of stimulus in selected countries - Australia, Germany, Japan, UK and USA.

OECD countries mostly adopted broad-ranging stimulus programs, adjusting various taxes and spending programs simultaneously in order to boost the

Table 3.1: Economic stimulus plan overview

	Initial conditions		Spending in 2009			Total size of stimulus		
	Gross Public Debt (percent 2008 GDP)	Fiscal Balance (percent 2008 GDP)	USD amount (bn)	Percent 2008 GDP	Tax cut share	USD amount (bn)	Percent 2008 GDP	Tax cut share
Australia	15,4%	0,3%	8,5	0,8%	47,9%	19,3	1,8%	41,2%
Germany	62,6%	0,9%	55,8	1,5%	68,0%	130,4	3,4%	68,0%
Japan	170,4%	-3,1%	66,1	1,4%	30,0%	104,4	2,2%	30,0%
UK	47,2%	-4,8%	37,9	1,4%	73,0%	40,8	1,5%	73,0%
USA	60,8%	-3,2%	268	1,9%	44,0%	841,2	5,9%	34,8%

Source: data retrieved from Prasad & Sorkin (2009)

economy. See how OECD (2009) categorises the nature of governmental, economic crisis, responses into 5 categories (Policy Responses to the Economic Crisis, July 2009):

> *i)* measures aimed at saving banks and the financial system - excluded from the scope of this document, where possible;
>
> *ii)* measures aimed at supporting businesses (tax cuts - including cuts in value-added tax rates, short- term credit guarantees, reduction of non-wage labour costs, stimuli for retaining or hiring staff);
>
> *iii)* measures aimed at particular industrial sectors (notably the automobile and the construction sectors);
>
> *iv)* measures to support household consumption and reduce their exposure to the crisis (including tax cuts, cash payouts to households, unemployment benefits, support to low earners such as pensioners, cuts in healthcare costs, home owners' grants); and finally
>
> *v)* measures relating to innovation and long-term growth. Certain measures also take the form of regulatory adjustments (e.g. non-financial measures to stimulate green technologies).

3.3 Policy Response in Selected Countries

In our research, the attention and is drawn to the aforementioned measures aimed at particular industrial sectors and measures relating to innovation and long-term growth. We chose to closely examine 2 packages which were used in the most countries - vehicle scrappage scheme and package of investing in ICT infrastructure. Description of the schemes follows.

3.3.1 Vehicle Scrappage Scheme

The impact of the economic crisis has been substantial in certain industries, especially the automobile and construction industries. The automobile industry is particularly noteworthy of attention and will be further examined in Chapter 5. The sharp decline of demand, the difficulty of firm to remain competitive, and a business environment with demand for more efficiency and value for money was a condition at which the automobile industry stood prior the crisis. The economic crisis only increased the fear of overcapacity of automobile industry, as well as in the construction sector.

OECD (2009) asserts that unlike a crisis driven by, supply factors, innovation and industrial renewal an economic crisis caused by demand factors does not automatically translate into an opportunity nor is it always synonymous with creative destruction as described by Schumpeter (1942). The article adds that on the contrary, such crisis often generates destructive forces that slow down economic growth and weaken the dynamics of innovation and industrial renewal. The crisis also provides an opportunity for both governments and the private sector to help transform the automotive industry. It may help accelerate the development of strategic alliances, leading to more integrated supply chains, a more effective division of labour, and more joint R&D and production platforms. It may also provide an opportunity for suppliers in existing automobile supply chains to diversify their business portfolio, for new or emerging players to enter the market and for a greater focus on meeting consumer demand for cleaner cars (OECD 2009).

As a response to the above, government packages in the automobile industry were oriented towards stimulating the investments in green technology and fuels. Such anti-crisis measure thus is not only aimed at boosting economic activity, but also at reducing energy consumption and carbon dioxide emissions. Numerous governments have taken measures to stimulate demand for new and cleaner cars by providing credit facilities to stimulate the demand in the automobile industry and bonus payments to replace old cars with new ones. In addition, some firms in difficulty have received loans or other support from governments (OECD 2009).

Scrapping schemes[1] were introduced in many countries, including our sam-

[1]Scrapping schemes were in several countries were also referred to as car scrappage scheme, car allowance rebate scheme, or even cash-for-clunkers.

ple countries. The timing with respect to the impact of the crisis was almost immediate and the packages were released between December 2008 and April 2009. Scrapping schemes were designed to mainly stimulate consumer demand while also supporting policies to reduce emissions. The schemes were offering rebates on older vehicles that were replaced for new, less polluting, and safer vehicles.

3.3.2 Investing in ICT Infrastructure

Governmental response to the financial crisis should to not only stabilise the economy and initiate a rapid recovery, but also make sure the recovery is based on sustainable growth. OECD (2009) highlights the importance of integrating long term concerns in short term stimulus packages and implementing specific policies aimed at stimulating the supply-side of the economy. The foundation for these medium and long-term initiatives consists of fostering innovation through promoting entrepreneurship, investing in smart infrastructure, encouraging RD, green investment, upgrading the skills of workers, steering market actors towards innovation-related investments, and accelerating activities for which barriers may have been too high otherwise (OECD 2009).

OECD (2009) suggests that innovation is clearly one of the keys to emerging from the economic downturn and putting countries back on a path to sustainable and smarter growth. Using the downturn as a chance to work on improving energy efficiency, many governments have incorporated measures to strengthen innovation in their stimulus packages.

Table 3.2: Overview of support packages: Vehicle scrappage scheme and ICT infrastructure support package

	Vehicle scrappage scheme	**ICT infrastructure support package**
Australia	AUD 6 200 000 000	AUD 40 000 000 000
Germany	EUR 5 000 000 000	EUR 150 000 000
Japan	JPY 370 000 000	JPY 185 000 000 000
UK	GBP 300 000 000	GBP 200 000 000
USA	USD 3 000 000 000	USD 7 200 000 000

Source: retrieved from OECD (2009) and IHS Global Insight (2010).

Many countries responded to the financial crisis by applying measures relating to innovation and long-term growth. The emphasis has been put on deploying the ICT infrastructure and so called networked recovery - i.e. the notion that ICT infrastructure and its use are a tool to revive the economy

through new innovative services and offer solutions to pressing social challenges. Aformentioned packages include expanding broadband to those areas which lack connectivity and upgrading current networks to support high-speed communication OECD (2009).

Table 3.2 provides an overview of above mentioned support packages in national currencies[2].

[2]The exchange rate used for conversion to USD to has been taken on the date: 31.12.2009 due to the fact, that most of the stimulus packages were released throughout the year 2009. See Chapter 5

Chapter 4

Methodology

We dedicate the following chapter to formulation of our hypotheses. Later, we share the source and compilation process of data necessary for our reseach. The core of Chapter 4 presents methodological background[1] consisting of introduction to input-output tables, description of input-output method' means of measuring the impact on the economy, and theoreticaly shows calculation of multipliers, which are later presented in Chapter 5. We aim to explain the methodological background of application of input-output method. The reader should keep in mind that not all theoretical background will be taken in practice in scope of this thesis. Focus is brought to calculation of output, gross value added and income multipliers in open Leontief model (see Subsections 4.3.3 and 4.3.4)

4.1 Hypotheses Development

In the following section we formulate the research hypotheses based on our predictions about abilities of input-output analysis, construction of input-output databases, existing literature and previous findings.

As outlined in previous sections, the main frameworks used to analyse policies and forecast its effects have been DSGE and VAR models and the input-output framework has been found as a complement. Several empirical and theoretical discussions were published on the applicability of input-output analysis,

[1]The methodology follows description by McLennan (1995) in Information Paper: Australian National Accounts: Introduction to Input-Output Multipliers, 1995

e.g. Miernyk & Rose (1989) and (Ten Raa 2005). Reviewed studies, e.g. by Kubursi *et al.* (1975) on the Ontario economy, show the applicability of input-output analysis to measure the effects of policies. Bensaid *et al.* (2011) followed the input-ouput framework to analyse income generated in sectors of the Gabon economy on the basis of income multipliers' calculations. We combine the previous findings applied to single economies and suggest to numerically evaluate the effects of fiscal policy on countries' economies, and calculate the output, gross value added and income multipliers. Moreover, based on the reviewed literature, we calculate the output, gross value added and income generated by the comparative fiscal stimulus packages applied in Australia, Germany, Japan, UK and USA in order to provide cross-country evidence.

Hypothesis 1: *Is input-output analysis applicable to numerically evaluate the effects of fiscal policy?*

McLennan (1995) informs, that it takes few, i.e. 2 or 3, years after the reference period for most countries to compile a set of input-output tables. The input-output tables, offer together with supply and use tables the most detailed and complex portrait of the economy. The length of the compilation period is dependent on the large amount of data required and the complexity of the tasks involved. Due to the fact, that technological change does not occur very rapidly in most sectors, there is a possibility to obtain reasonable results for the most recent years even though the latest released input-output tables may be a few years old, which is the case in this thesis. The multipliers generally remain relatively stable over time. The exceptions to stability of multipliers can be found in industries producing commodities that are dependent on large price fluctuations on the world market, such as petroleum products. Other exceptions are agricultural industries which are the most affected by adverse climatic conditions, e.g. sheep and wheat McLennan (1995).

Our second and third hypotheses follow the industry specification, availability of the tables as well as the possibility of comparing policy impacts with another country, in case the division of industries varies at national level of IO tables. Moreover, due to the long time frame, there may be a set of events, together with a specific policy introduction which may have an impact on the multipliers.

Hypothesis 2: *Do the results of input-output analysis of fiscal policy im-*

pact provide and accurate feedback for policy makers?

Anti-crisis measures taken on national level depend on the actual socio-cultural, economic and political environment and importantly on the industry structure of the country. Moreover, as we have outlined in Chapter 2, appropriate fiscal interventions depend both on the nature of shocks, the capability of monetary policy and the strength of automatic stabilisers. The openness of the economy and other various factors influence the effectivity of applied fiscal policy on a national level. For the purposes of our analysis, measures aimed at particular industrial sectors - automobile sector, and measures relating to innovation and long-term growth - ICT sector, were chosen. Both of the aforementioned types of stimulus packages were adopted in all selected countries - Australia, Germany, Japan, UK and USA. This allows us to calculate the output, gross value added and income multipliers and identify the output, GVA and income generated by the fiscal stimulus investment in each of the economies of the selected countries. Hypothesis 3 debates on the comparability of 2 different fiscal stimulus packages effects measured by IO analysis among countries, on example of Australia, Germany, Japan, UK and USA.

Hypothesis 3: *Is it possible to compare the results of input-output analysis of anti-crisis measures across sectors and countries and decide on the most suitable fiscal policy as a reaction to crisis?*

4.2 Data Description

Here, we provide information on source of data, followed by a short overview of compilation process and methods, to introduce the input-output tables and provide a brief background on their structure. We mention supply and use tables, which are not analysed into more detail in the scope of the thesis[2].

[2]For more information on supply and use tables, plese refer to Eurostat (2008)

4.2.1 Source Data

The source of data information for the thesis's purposes is the OECD's structural analysis industry database available at OECD.StatExtracts[3].

Currently, the latest set of OECD input-output tables covers the years 1995, 2000 and 2005 or nearest years and includes matrices of intersectoral flows of transactions of, both domestically produced and imported, goods and services in current prices for all OECD countries (except Iceland) and 15 non-member countries.

The industry classification of the IO database slightly changes throughout the time, and it is compatible with the OECD's structural analysis (STAN) industry database and Bilateral Trade Database, International Energy Agency's energy consumption data and other OECD industry-level databases. The number of industries in the latest IO database reaches 48 in order to provide a more detailed and specified industry information. Unfortunately, due to the lack of detailed statistical sources or disclosure restrictions, all 48 industrial sectors information cannot be obtained by every country and some imperfect conformity exist between national IO industrial sectors and the industrial sectors set by ISIC revision. The latest revision of International Standard Industrial Classification of All Economic Activities was published in 2008 by United Nations (2008).

National IO tables are also available, however due to standardisation, we will work only with OECD sourced tables in our research. The thesis uses MS Excel to calculate the input-output multipliers. The Excel tool is used also by Plumstead (2012) using the input-output tables from Statistics Canada. He claims the IMPLAN and REMI software is more flexible, and facilitates regional and local analysis, however access to this software is limited. A research based on national IO tables may be needed, in case of actual analysing and forecasting fiscal stimulus on a national level.

Input-output tables available at OECD.StatExtracts are measured in USD or in national currencies with prices valued in producer prices[4].

[3]The path to access the full IO tables dataset on OECD.StatExtracts is following: "Industry and Services" - "Structural Analysis (STAN) Databases" - "Input Output Database".

[4]Producer prices are the prices, that the producer of a good receives rather than what a consumer pays to buy the good produced, which can include transportation and retail mark-ups (Plumstead 2012).

4.2.2 Compilation of IO Tables

The process of compiling the IO tables database begins with requests to national statistical institutes to provide data in accordance with a harmonised industry structure based on ISIC. A number of countries do not produce input-output tables but do produce supply and use tables[5], which can be easily converted into input-output tables using some standard assumptions. Therefore OECD requests provision of supply-use tables as well as input-output tables from national statistical institutes to create an OECD standardised IO tables database.

A detailed and comprehensive manual on compilation of supply-use and input-output tables and its application is provided by Eurostat (2008) to foster quality and stimulate harmonisation of methods. The document discusses 4 different models for the transformation of supply and use tables to symmetric IO tables. Eurostat (2008) categorises the four basic models for the transformation of supply and use tables to symmetric IO tables, based on the assumptions. There are two technology models, which will generate product-by-product input-output tables.

- *Model A: Product technology assumption* Each product is produced in its own specific way, irrespective of the industry where it is produced.
- *Model B: Industry technology assumption* Each industry has its own specific way of production, irrespective of its product mix.

The other 2 basic models are based on assumptions of fixed sales structures and generate industry-by-industry input-output tables.

- *Model C: Fixed industry sales structure assumption* Each industry has its own specific sales structure, irrespective of its product mix.
- *Model D: Fixed product sales structure assumption* Each product has its own specific sales structure, irrespective of the industry where it is produced.

[5]Supply and use tables provide a detailed picture of the supply of goods and services by domestic production and imports and the use of goods and services for intermediate consumption and final use (consumption, gross capital formation, exports). Supply and use tables give detailed information on the production processes, the interdependencies in production, the use of goods and services and generation of income generated in production (Eurostat 2008).

Each type of the input-output tables has its advantages. Product-by-product IO tables are believed to be more homogeneous, industry-by-industry IO tables are closer to statistical sources and actual observations (Eurostat 2008). In our empirical research, industry-to-industry input-output tables[6] are more feasible, as the anti-crisis measures studied within the scope of this thesis are aimed at specific industries, e.g. automobile industry.

4.3 Methodological Background

4.3.1 Leontief's Model

Wassily Leontief introduced the intput-ouput model, in August 1936, in the article Quantitative Input and Output relations in the Economic System of the United States, in the recognition of which (1936, 1941) he received a Nobel Prize in Economic Science in 1973. Leontief (1936) points at the obvious nature of the economic transactions that each revenue item of an enterprise or household must reappear as an outlay item on the account of some other enterprise or household and explains the possibility of a presentation of the whole system of interconnected accounts in a single two-way table.

Input-output analysis catches real and final flows between particular sectors and simultaneously the flow of intermediate products in firm's sector. Using input-output analysis, the effects of fiscal policy can be numerically evaluated and suitability of concrete measures can be assessed. Leontief (1936) states that the classification of accounts into industrial distribution used in his statistical study was a compromise between a theoretical ideal and practical necessity. Foreign commodity trade within the model is divided into export and import rows.

Many years have gone by since the introduction of input-output and the development of information technology has allowed easier computation and widespread use of input-output models, that are nowadays applied at any geographic levels – local, regional, national as well as international. A good example of a highly developed economy applying the input-output is the USA,

[6]OECD presents input-output tables in industry-to-industry format at OECD.StatExtracts.

where the input-output framework is applied to national economic analysis by the US Department of Commerce as well as in regional economic planning and analysis by states, industry and the research community. The United Nations itself has promoted input-output as a practical tool for developing countries and has sponsored a standardised system of economic accounts for constructing input-output tables (Miller 2009). Since the input-output framework is used to study the interdependence of industries in the economy, the term inter-industry analysis is also used (Miller 2009).

4.3.2 Organisation and Interpretation of IO Tables

Input-output tables are presented in a two-dimensional matrix format with rows and columns. Rows represent the output of each sector, while columns show each sector's input. Input-output tables are helpful when estimating how an increase in demand for a product of one industry impacts other industries and the whole economy itself. Such tables are then a basis for calculation of input-output multipliers, which can be used to estimate the economic impacts of incremental spending in an economy. [7] (Plumstead 2012).

Find below a description of the industry-by-industry table by its quadrants:

- *First quadrant: Intermediate usage sub-matrix* measures the flows between industries. The columns of intermediate usage sub-matrix show all intermediate inputs into an industry's output in form of goods and services. The rows of first quadrant depict parts of an industry's output absorbed as an intermediate input into other industries.

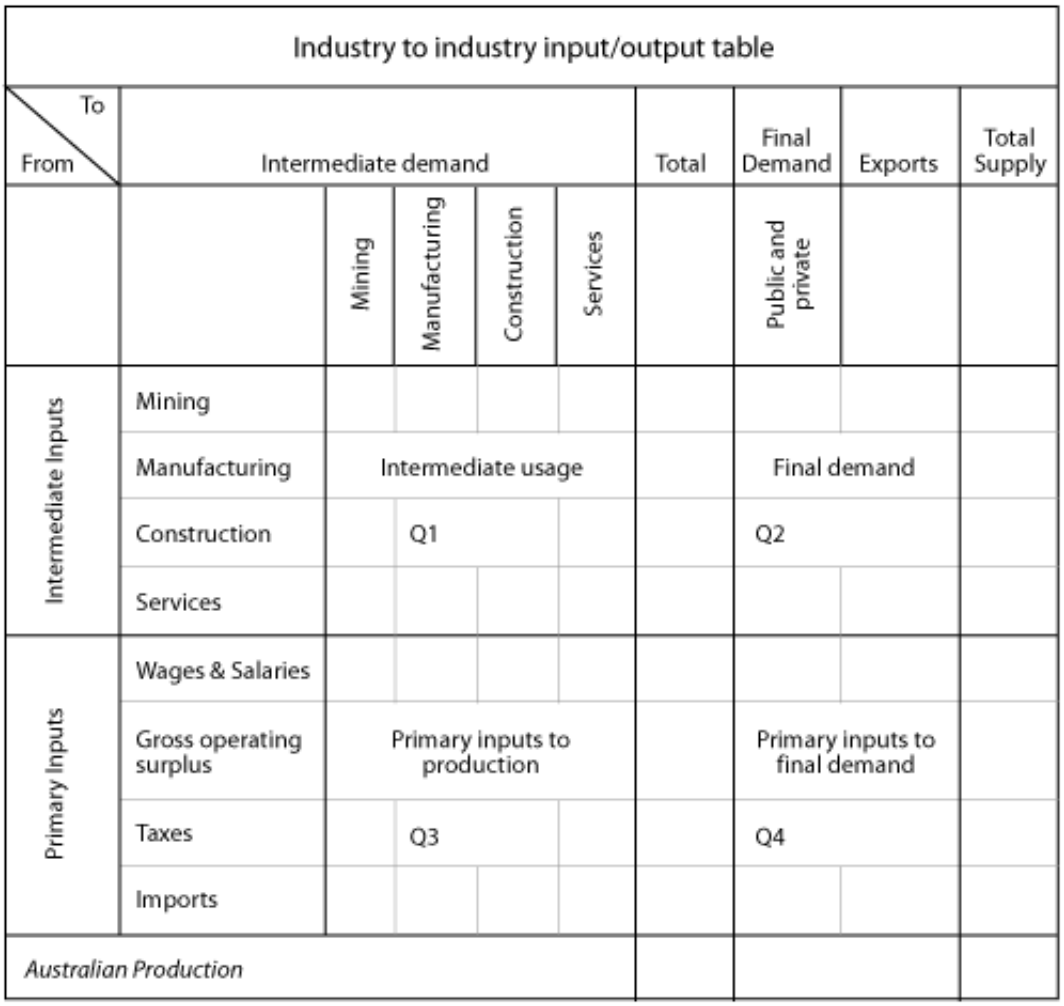
- *Second quadrant: Final demand sub-matrix* shows the disposition of output into categories of final demand. First and second quadrant together describe the total usage of goods and services supplied by each industry.

- *Third quadrant: Primary input to production sub-matrix* shows all primary input into productions, such as compensation of employees, gross operating surplus, value added at basic prices, various taxes, which are not part of the current output process.

- *Fourth quadrant: Primary inputs to final demand sub-matrix* describes all primary inputs into final demand.

[7] Current spending is already factored into the input-output tables which are derived on an annual basis.

Figure 4.1: Basic Structure of Input-Output Tables, Example of Australian Basic Input-Output Table



Source: retrieved from (National Institute of Economics and Industry Research, Australia)

In order to be realistic, the imports and exports have to be included in the input-output tables. Input-output tables used in our analysis have direct allocation of imports. This means that imports are regarded as being induced by final demand, when an import row is included, with the imports shown as direct inputs to the industries that use them. Figure 5.1.2 provides a basic structure industry-by-industry input-output table.

McLennan (1995) also remarks that indirect allocation of imports can be used in input-output tables, when the imports are regarded as part of the final demand, being netted off the exports. In this case, the imports are shown as being produced by the industry that would have produced them if they had been domestically produced.

Practical advantages of using indirect allocation of imports is that the technical coefficients, matrix A, remain the same whatever changes may occur in the relative proportions of domestically produced and imported inputs. If we are trying to estimate, the employment that might be induced by a proposed increase in an industry's output, the indirect allocation input-output model will always give a higher result than the corresponding direct allocation model. The reason is that it will include the extra employment required to produce those goods and services that would have been regarded as induced imports in the direct allocation model.

Input-output tables are part of the national accounts (e.g. Australia) and contain the information about the supply and disposition of commodities in the economy and structure of, and interrelationships between the industries for a specified economy and period. Detailed data on supply and use of commodities, inter-industry flows and a range of derived data, such as input-output multipliers, are provided for economic planning and analysis, and construction of models for forecasting purposes.

The guidelines for application of input-output are provided by several publications, such as Eurostat (2008) and McLennan (1995). Ten Raa (2005) provides the mathematical background needed for the calculations as well as an overview of the model development over time, commenting on the closed model introduced by Leontief (1936) and open model later introduced by Leontief himself Leontief (1967) and Leontief (1970). Goga (2009) among others, describes in his book in detail, theoretical background, computations and application of input-output analysis.

4.3.3 Effects and Multipliers

Using input-output tables, multipliers can be calculated to provide a simple means of working out the flow on effects of a change in output in an industry on one or more of imports, income, employment or output in individual industries or in total. The multipliers can show just the first-round effects, or the aggregated effects once all secondary effects have flowed through the system.

Input-output analysis uses input-output multipliers as summary measures for predicting the total impact on all industries in an economy of changes in the demand for the output of any one industry. It is important to realise that

multipliers show average effects, not marginal effects. Therefore economies of scale, unused capacity or technological change is not taken into account.

Input-output analysis results rely on the input-output multipliers and awareness of their shortcomings. In our research, calculated multipliers, output, gross value added and income multipliers, helps us to study change in output, GVA and income in industries, see results and implications in 5.

Classification of multipliers, it's naming convention and application varies across reviewed literature. Type I and Type II multipliers are categorised depending on the openness of the IO model.

- *Type I multipliers* describe the combined effect of direct and indirect impacts caused by the interdependency only within the industrial sector. The total economic effect is comprised of direct and indirect impact and is applicable to an open Leontief model[8].

- *Type II multipliers* can be calculated, once households are added to the input-output table as if it were another industrial sector. Type II multipliers describe in addition to direct and indirect (Type I multipliers), also induced effect by endogenising households in the model, closed Leonfied model[9]. The induced effects include the effects of household income and spending.

As mentioned above, input-output multipliers are able to describe the chain of effects - direct, indirect and induced effects. See description of the individual effects measured by Type I and Type II multipliers below.

- *Direct effects* measure an increase in the output of a product as a response to an increase in final demand for that particular product, as producers react to meet the increased demand.

- *Indirect effects* arise from changes in activity of suppliers. As producers increase their output, increase in demand on their suppliers occurs and causes a ripple effect in the economy.

- *Induced effects* measure shifts in spending on goods and services as a consequence of increase of the household income throughout the economy caused by direct and indirect effects.

[8]In an open Leontief model, there is an outside demand for the production of the industries involved in the model.

[9]The closed Leontief model assumes that there is no external demand and all productions stays within the economy.

As previously mentioned, in the thesis, we calculate output, gross value added and income multipliers to evaluate impacts of fiscal stimulus packages on respective industries in Australia, Germany, Japan, UK and USA (see Subsection 4.3.4 and Section 5 for results). Firstly, we explain and define individual simple multipliers to better understand results in Section 5.

- *Output multiplier* shows the total amount of output from all industries in the economy, to produce output to satisfy the demand for an extra dollar of output from an industry. Output multiplier brings up a problem of double counting which can be off-set by using gross value added multiplier.

- *Gross value added multiplier* presents the relationships between the initial increase in output required from an industry and total increase in gross value added by all industries. The changes in gross value added are corresponding to changes to gross domestic product, accounting for that GDP includes GVA and net taxes (Raabova 2010).

- *Income multiplier* shows total value of compensation of employees (wages, salaries and supplements) necessary to satisfy one unit of currency's worth of final demand of the output of the industry. Because compensation of employees is a part of GVA, results should show that income multipliers are lower than GVA multipliers (see Chapter 5).

4.3.4 Leontief Open Model and Calculation of Simple Multipliers

In an open Leontief model where only the productive sectors of the economy are assumed to be endogenous, i.e. determined by factors inside the productive system,then all final demands including private final consumption expenditure, government final consumption expenditure, public gross fixed capital expenditure, increase in stocks and exports are assumed to be decided by factors outside the productive system.

Our aim is to describe the process of calculation of simple multipliers step by step from the industry-to-industry input-output tables in an open Leontief model. Following the process described below, results in Chapter 5 were obtained using MS Excel tool.

A preliminary step is the aforementioned compilation of input-output tables (see Subsection 4.2.2) in order to systematically define all transactions of each industry in country's economy. Due to the availability of compiled industry-to-industry input-output tables at OECD.StatExtracts, the step of compilation of input-output tables was not necessary to be executed. Further on, we will refer to such tables, as transaction tables with number of industries defined as n and numerical entries measured in national currencies or USD (see Subsection 4.3.2 and Figure 5.1.2).

The next step involves the construction of direct requirements table out of the transaction table of a particular country. Let x_{ij} be consumption of goods or services produced by i-th branch and bought by firms of the j-th branch and x_j the total output of the j-th branch.

The intermediate usage sub-matrix (first quadrant) of the transaction table has to be normalised according to formula

$$a_{ij} = x_{ij}/x_j \tag{4.1}$$

where $i, j = \overline{1, n}$. The coefficients in a given industry's column of the table show the amount of extra output required from each industry to produce an extra one unit worth of output from that industry. The calculated matrix A is known as the direct requirements coefficients matrix.

In order to proceed with computations, a compilation of an identity matrix I of size n. For the further computations to be successful, matrix I has to be the same size as the direct requirements coefficient matrix A.

Simply by subtracting $I - A$, we get a technology matrix, with positive values on the diagonals and negative values in all the other cells.

Once we have calculated the technology matrix, we need to invert it[10] to create the open Leontief inverse matrix $(I - A)^{-1}$. The resulted open Leontief inverse matrix $(I - A)^{-1}$, frequently referred to as the total requirements coefficients matrix is the classical predictive multiplier model. We form the columns totals necessary to calculate simple multipliers.

If for $I - A$ holds that $|I - A| \neq 0$, then the inverse matrix $(I - A)^{-1}$ exists and the output of each good will be given by the solution:

$$X = (I - A)^{-1}Y \tag{4.2}$$

[10]Please note to use the function minverse in MS Excel and use command control-shift-enter/command-shift-enter.

where X denotes the output column vector which is endogenous and Y is the column final demand vector and is exogenous.

Using the matrix open Leontief matrix, we can compute the simple output[11] multipliers (4.3), gross value added multipliers (4.4) and income multipliers (4.5). The corresponding formulas for calculation of aforementioned simple multipliers are

$$M_y = (I - A)^{-1} \tag{4.3}$$

$$M_v = v(I - A)^{-1} \tag{4.4}$$

$$M_i = h(I - A)^{-1} \tag{4.5}$$

where I is an identity matrix, v is the vector of coefficients that is obtained by dividing the added value in each sector by the corresponding sector output, h is the vector of household coefficients, which is obtained by dividing the households income generated by each sector by the corresponding sector's output (Raabova 2010).

The multipliers can show just the first-round effects, or the aggregated effects once all secondary effects have flowed through the system. In our thesis, we will calculate simple multipliers using Leontief inverse matrix as shown by formulas 4.3, 4.4, 4.5. First round effect are calculated applying the same logic using matrix A instead of open Leontief inverse matrix. Total multipliers are then calculated applying the same logic using closed Leontief matrix $(I - B)^{-1}$ (see Subsection 4.3.5).

Others, than the above mentioned multipliers, can be calculated analogically for the remaining rows and indexes described by the input-output tables, i.e. gross operating surplus, imports, taxes, etc.,or using other statistical data which can be attributed to the industries, such as employment. Due to the unavailability of the employment data by industry sectors in all selected countries - Australia, Germany, Japan, UK and USA, the employment multiplier will not be calculated within the scope of this thesis.

4.3.5 Leontief Closed Model

In comparison with the open Leontief mode, the closed Leontief model is

[11]The output multipliers of the sectors are sums of the columns of the matrix M_y. The other multipliers are the particular elements of the resulting vectors.

closed with respect to households. Closed Leontief model allows for Type II multipliers to be calculated, which expess not only the direct and the indirect (see Subsections 4.3.3 and 4.3.4), but also the induced effects .

By including in the matrix A one more column and row, for household consumption and income respectively, this will form a new matrix denoted by B with m columns and rows. Utilising the same approach as above, creating the identity matrix I of size m and subtracting $I-B$, we receive a closed technology matrix. By inverting $I - B$ we receive $(I - B)^{-1}$, which is referred to as the closed Leontief inverse matrix. In comparison with the open inverse matrix $(I - A)^{-1}$, the closed inverse matrix has one more column and row. The last column of the closed Leontief inverse matrix is interpreted as the consumption multiplier[12] and the last row as the household income multiplier[13].

The remaining rows and columns of the closed inverse matrix, contain larger elements than those of the open inverse. This is due to the fact that the closed inverse matrix elements contain additional output required to meet consumption induced output effects, as a result of closing the model with respect to households. The matrix $(I - B)^{-1}$ is used to derive input-output multipliers in the closed Leontief model (see Subsection 4.3.4 for calculation guidelines).

[12]Consumption multiplier refers to the effect on the output of each sector of an additional dollar of consumption

[13]The household income multiplier stands for the income created by each dollar of sales of each sector

Chapter 5

Results and Interpretation

5.1 Results

In this chapter, we follow up on the methodology introduced in Chapter 4 and present results based on our own calculations. Firstly, we provide an overview of the calculated multipliers - output multiplier, gross value added multiplier and income multiplier for each country. Secondly, we estimate the effects of fiscal expansion packages in form of vehicle scrappage schemes and ICT infrastructure stimulus in Australia, Germany, Japan, UK and USA. On the aforementioned example, we explain the implications of our computations. Lastly, we provide an overview of strengths and limitations of input-analysis in evaluating fiscal policy together with a comparison among different countries.

5.1.1 Underlying Assumptions

Before we present our calculations, first we define basic assumptions in input-output analysis[1] which should be noted when interpreting results of input-output analysis.

Firstly there exists a fixed input structure in each industry which is described by fixed technological coefficients. Evidence shows that whereas material input requirements tend to be constant and change moderately, requirements for primary factors of production, (i.e. labour and capital) are probably less stable. Fixed structure assumption is vital, due to the latest availability

[1]The underlying assumptions follow description by by McLennan (1995) in Information Paper: Australian National Accounts: Introduction to Input-Output Multipliers, 1995

of input-output tables for mid 2000s, i.e. year 2005 in most cases, which were used for the purposes of the thesis.

Secondly, all products of an industry are identical or are produced proportionally, in fixed proportions, to each other. With respect to returns to scale in production, the underlying assumption of input-output analysis states that it is constant in each industry. No limitations to labour and capital availability at fixed prices apply in IO model[2]. Lastly, we assume no other constrains on the response of each industry to stimulus, i.e. vehicle scrappage scheme, ICT infrastructure stimulus in our case, such as balance of payments or actions of governments.

When interpreting results of input-output analysis, we refer to Subsection 4.3.3 and stress that multipliers describe average effects, not marginal and hence are expected to result in higher values. Industry-to-industry input-output tables are based on the interdependence, i.e. sales and purchases among industries in the model[3].

Due to the above mentioned assumptions, overestimation can occur, when the calculated multipliers are higher than it would be realistically.

5.1.2 Output, Gross Value Added and Income Multipliers

In the thesis, we use the open Leontief model and calculate simple multipliers. We effectively work under the assumption that household spending is not taking place inside the model and there exists an external demand for production (see Section 4.3.4 for definition of open Leontief model and guidelines for calculation of simple output, gross value added and income multipliers).

It is important to keep in mind that the simple output multiplier involves double-counting, as the increased output of one industry can be used as an input into another industry, and hence can be counted more than one time. Hence the output multiplier can overstate the economic impact resulting from the fiscal stimulus packages.

Most appropriately, we can interpret calculated simple IO multipliers as a

[2]In reality, constraints such as limited skilled labour or investment funds lead to competition for resources among industries, which in turn raises the prices of these scarce factors of production and of industry output generally in the face of strong demand.

[3]Other interdependence such as collective competition for factors of production, changes in commodity prices which induce producers and consumers to alter the mix of their purchases and other constraints which operate on the economy as a whole are not generally taken into account(McLennan 1995).

relative measure of the interdependence between one industry and the rest of the country's economy, which is based on the purchases and sales of industry output based on the estimate of transactions occurring over a recent historical period of time.

An overview of output multipliers calculated for selected countries' economies using input-output tables from the most recent period available, mid 2000s is provided on Figure 5.1.2 for Australia, Figure 5.1.2 for Germany, Figure 5.1.2 for Japan, Figure 5.1.2 for UK, Figure 5.1.2 for USA[4]. Even though we can see diversity among each countries' economies, output multipliers in the automobile industry[5] show highest values in comparison with other industries' multipliers within economies[6].

We generally expect high multipliers not only in automobile industry, but also in construction. As we can see in Figure 5.1.2, the construction industry's multiplier is substantially higher in Australia than in other countries. Due to the low multipliers in the construction industry in other selected countries, no substantial policies to boost the activity in construction were applied in response to the economic crisis in any of the countries except Australia and therefore multipliers in the construction industry and fiscal policy aimed at a construction industry boost is not analysed within the scope of this thesis. For an input-output analysis of the impacts of fiscal stimulus in construction in the form of home insulation, see for example Pietroforte & Gregori (2003) and Zamecnik & Hlavac (2010).

Overviews of the output multipliers calculated for the mid 2000s (Figure 5.1.2 for Australia, Figure 5.1.2 for Germany, Figure 5.1.2 for Japan, Figure 5.1.2 for UK and Figure 5.1.2 for USA) suggest that the ICT sector[7] multipliers do not belong among the highest output multipliers. Based on the example of Australia (Figure 5.1.2) and USA (Figure 5.1.2) we notice that the output multiplier for computer and related activities is relatively high in comparison with other industries' multipliers. On the basis of such an observation, we can summarise that the ICT sector has a high potential in terms of output generation within the economies of Australia and USA.

Additionally, we can see from Figure 5.5 that Australia and the USA have

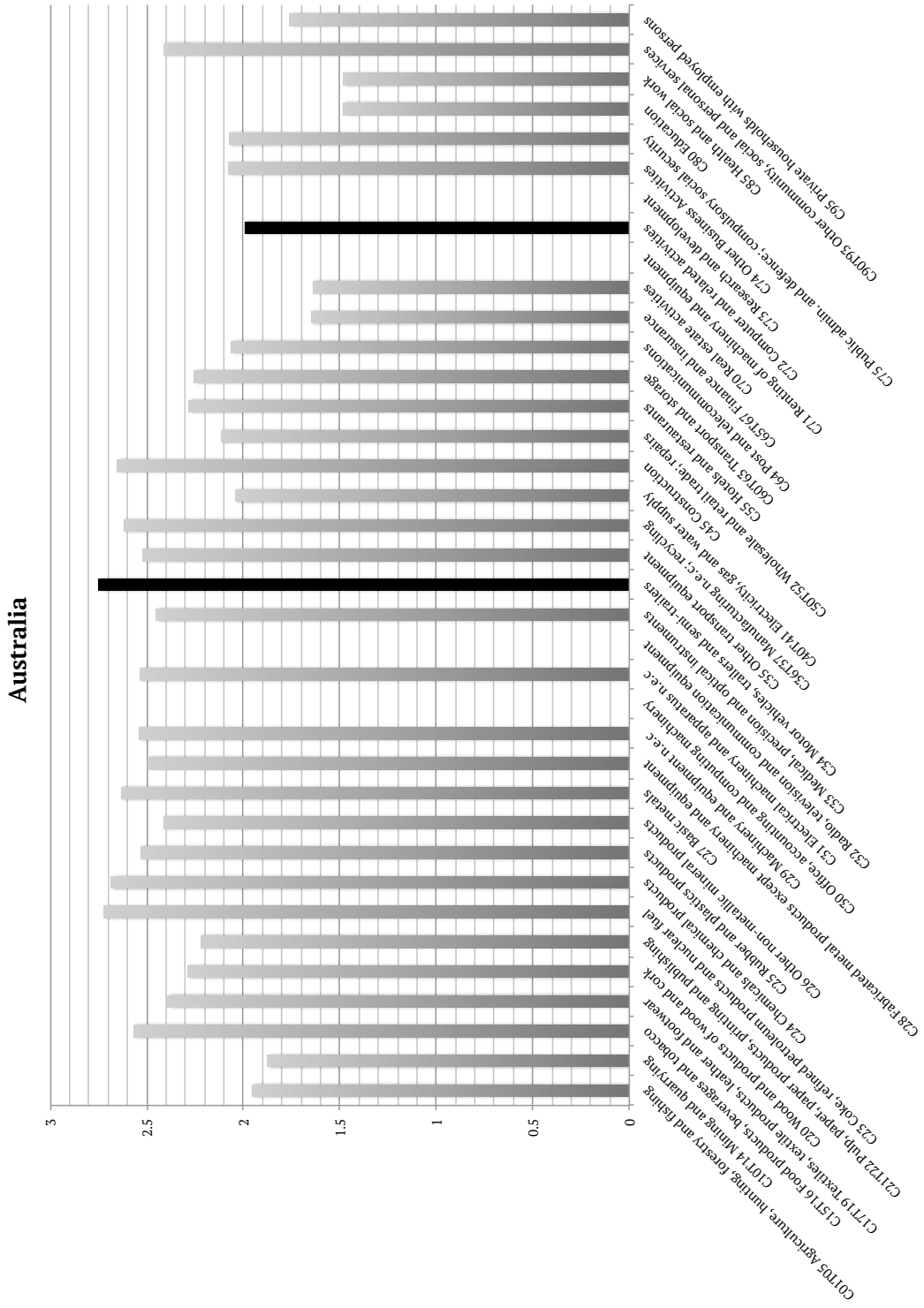
[4]Output multipliers for automobile industry and computer and related activities is highlighted for reader's convenience in black.

[5]Motor vehicles, trailers and semi-trailers sector

[6]In Germany, surprisingly the highest output multiplier is not the automobile industry, but the output multiplier for coke, refined petroleum products and nuclear fuel.

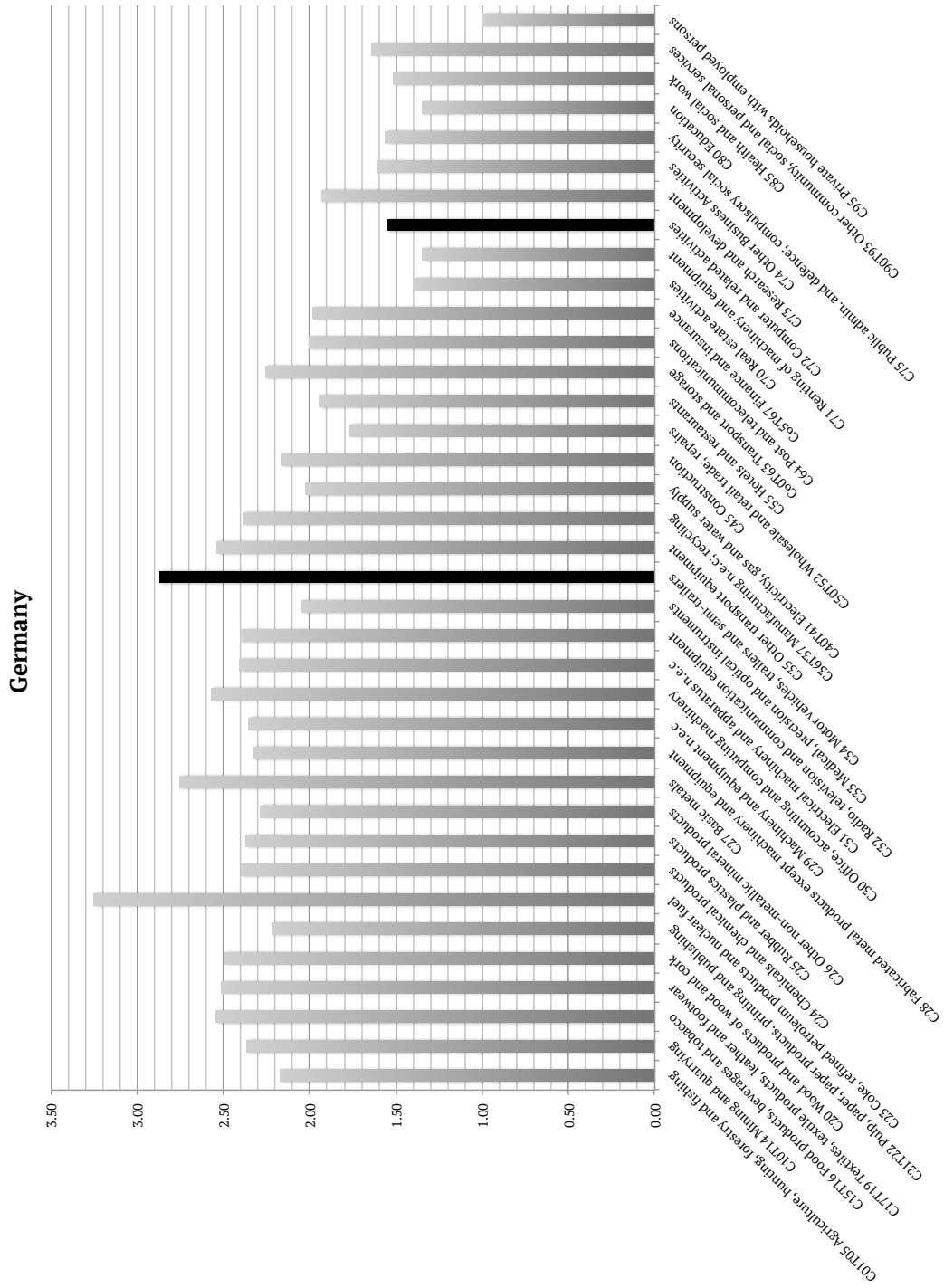
[7]Computer and related activities

Figure 5.1: Overview of ouput multipliers calculated for Australia's economy in mid 2000s



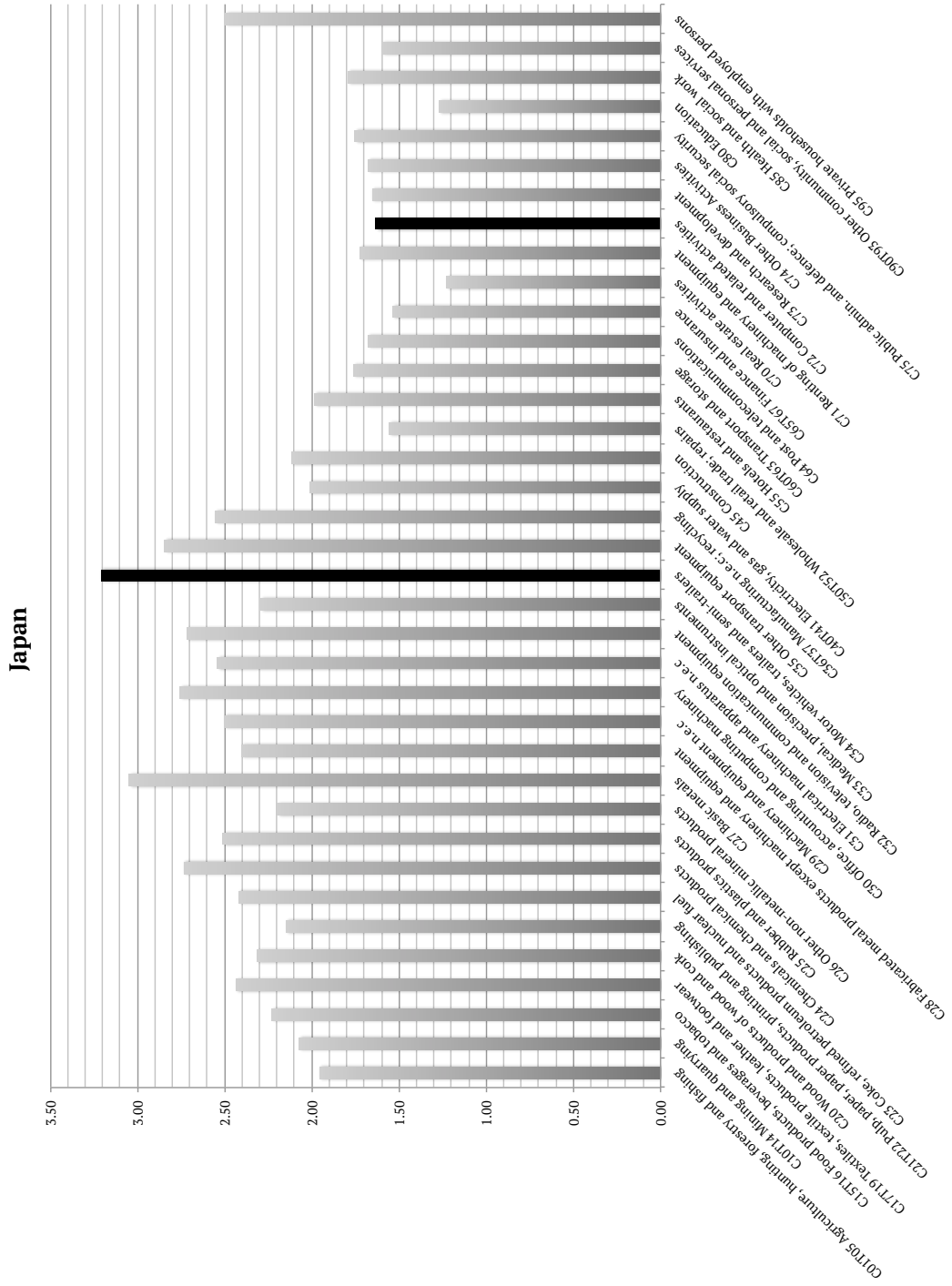
Source: data retrieved from OECD.StatExtracts, own calculation

Figure 5.2: Overview of ouput multipliers calculated for Germany's economy in mid 2000s



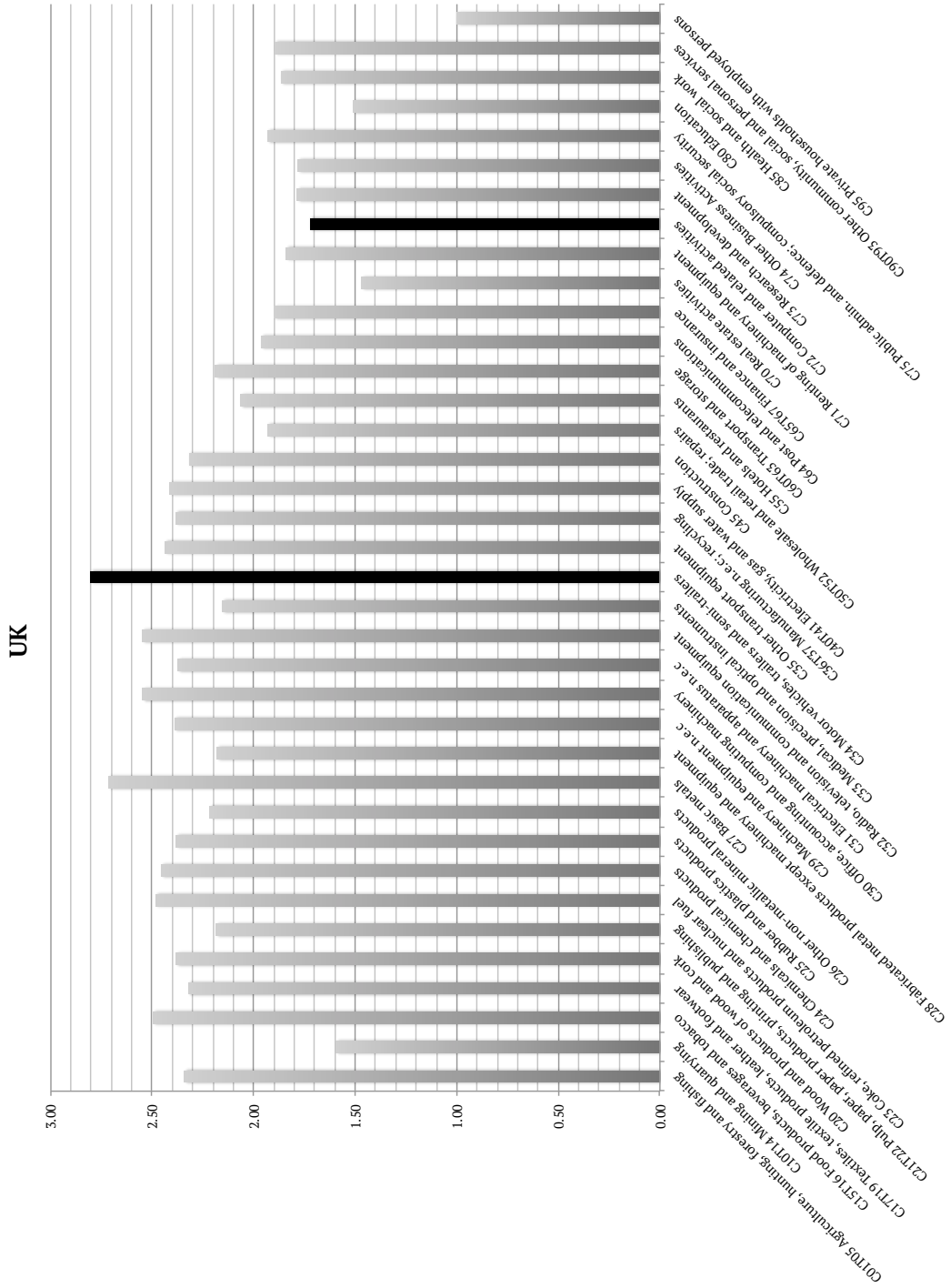
Source: data retrieved from OECD.StatExtracts, own calculation

Figure 5.3: Overview of ouput multipliers calculated for Japan's economy in mid 2000s



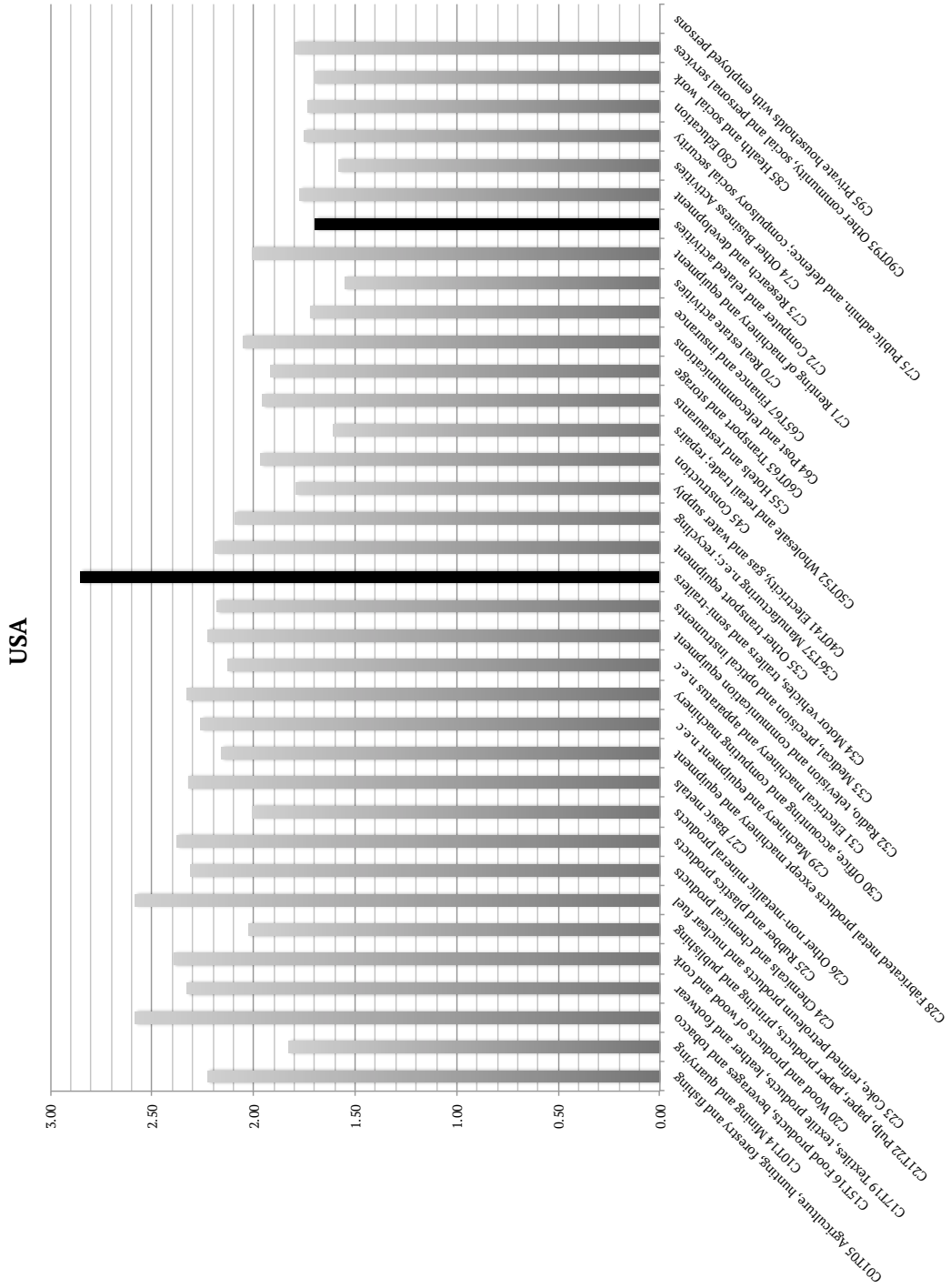
Source: data retrieved from OECD.StatExtracts, own calculation

Figure 5.4: Overview of ouput multipliers calculated for economy of UK in mid 2000s



Source: data retrieved from OECD.StatExtracts, own calculation

Figure 5.5: Overview of ouput multipliers calculated for economy of USA in mid 2000s



Source: data retrieved from OECD.StatExtracts, own calculation

invested in ICT infrastructure substantially more than other countries within the sample. The ICT infrastructure stimulus package is approximately 6,1 times higher than the vehicle scrappage scheme investment. In the USA the ICT infrastructure stimulus package is only 2,4 times higher than the vehicle scrappage scheme.

Although it was an intention of the OECD to impose consistency in the allocation of activities among industry sectors, confidentiality restrictions, lack of detailed data and an inability to cleanly allocate national sectors to the ISIC scheme specified by the OECD, in case of several countries, this results in missing values, i.e. one industry is included in another. An overview of output multipliers computed for Australia (Figure 5.1.2) provides evidence of this and industries for which the output multiplier is calculated at 0, are included in another sectors.

5.1.3 Industry Multipliers and Fiscal Policy Effects

As we have mentioned in Subsection 3.3.1 the automobile industry has experienced turbulent times, for example it has suffered a sharp decline in demand, even before the crisis which impacted the production of cars even more. Generally, we expect high multipliers for the automobile industry, as an industry with high potential in terms of output, income and employment generation within the economy. Such theory supports the fiscal stimulus measures which have been taken among vast countries as a response to the economic crisis.

Table 5.1: Multipliers in motor vehicles, trailers and semi-trailers sector in mid 2000s

	Australia	**Germany**	**Japan**	**UK**	**USA**
Output multiplier	2,75100	2,87357	3,20990	2,80261	2,85171
GVA multiplier	0,71648	0,69091	0,68599	0,64588	0,56608
Income multiplier	0,41239	0,55093	0,44648	0,52051	0,43782

Source: data retrieved from OECD.StatExtracts, own calculation

Table 5.1 provides an overview of multipliers in the motor vehicle, trailers and semi-trailers sector calculated for Australia, Germany, Japan, UK and USA using mid 2000s input-output tables. Evidence shows high output multipliers, as already indicated by output multiplier overviews (Figure 5.1.2 for Australia,

Figure 5.1.2 for Germany, Figure 5.1.2 for Japan, Figure 5.1.2 for UK and Figure 5.1.2 for USA).

We provide an interpretation of calculated multipliers, using one example per multiplier. The interpretation is then used analogically to interpret other multipliers among countries and sectors.

The output multipliers in Table 5.1 and Table 5.2 show the total amount of output induced by the requirement fom all industries to produce output to satisfy the demand for an extra dollar of output from the industry. For example, the automobile industry output multiplier for Japan (see Table 5.1) shows that USD 3,20990[8] of extra output in the Japanese economy is induced by an additional output of USD 1,00 in the automobile industry (motor vehicles, trailers and semi-trailers). In Japan, the output multiplier for the car industry results in highest values, whereas in Australia the output multiplier is the lowest out of the selected countries. The differences can be caused by the structure of the economy. Using the same analogy, we interpret the GVA and income multipliers.

As previously mentioned in Subsection 4.3.3, a more reliable measure of the economic impact is gross value added, which does not include intermediate consumption. Hence we can see the evidence that GVA multipliers are lower than output multipliers. GVA multipliers (Table 5.1 and Table 5.2) correspond to the extra gross value added stimulated by an additional output of USD 1,00. See Table 5.2 example of GVA multiplier calculated for computer and related services sector in the UK. Firstly, we can see the GVA multiplier is lower than the output multiplier, which is in line with our assumptions. We can conclude therfore,that USD 1,07160 of gross value added in the UK is created from working on producing USD 1,00 of output.

Lastly, we provide a comparison of the USA's income multipliers calculated for the automobile (Table 5.1) and ICT sectors (Table 5.2) in the mid 2000s. Comparing values of income multiplier computed, we can summarise that USD 0,36307 more of income[9] is induced by working on producing USD 1,00 of output in the ICT sector than in the automobile sector. Hence we can conclude, that the ICT sector has a higher potential in terms of income generation within the economy of the USA than the automobile industry.

Further, we analyse the theoretical effects of vehicle scrappage schemes and

[8]In the thesis we use 5 decimal places numbers for multipliers values, due to the fact that fiscal stimulus packages are presented millions and billions.

[9]Income is defined as wages, salaries, supplements or compensation of employees.

Table 5.2: Multipliers in computer and related activities sector in mid 2000s

	Australia	**Germany**	**Japan**	**UK**	**USA**
Output Multiplier	1,99184	1,54859	1,63379	1,72230	1,69700
GVA multiplier	1,05260	1,04888	1,03859	1,07160	1,04666
Income multiplier	0,80350	0,72369	0,65137	0,76227	0,80089

Source: data retrieved from OECD.StatExtracts, own calculation

ICT infrastructure investment packages in our particular chosen countries, using the already calculated output, GVA and income multipliers from Subsection 5.1.2. We are interested in the amount of output, GVA and income generated by the fiscal stimulus packages in these selected countries. For the purposes of comparison among countries, the amounts of subsidies were converted from national currencies to USD. The exchange rate used for the conversion of national currencies to USD has been taken on the 31.12.2009 as most of the stimulus packages examined in the thesis were released in 2009. A numerical evaluation of the effects of fiscal policy measures, in the form of vehicle scrappage scheme and ICT infrastructure stimulus packages, is provided within the rows: output in USD, GVA in USD and income in USD.

Table 5.3: The theoretical effects of the vehicle scrappage schemes

	Australia	**Germany**	**Japan**	**UK**	**USA**
Subsidy in USD	5 565 679 507	7 167 831 917	3 975 068	485 093 874	3 000 000 000
Output in USD	15 311 190 195	20 597 296 034	12 759 555	1 359 529 867	8 555 141 076
GVA in USD	3 987 671 154	4 952 342 579	2 726 846	313 313 409	1 698 246 582
Income in USD	2 295 244 835	3 948 962 349	1 774 791	252 494 158	1 313 468 046

Source: data retrieved from OECD (2009), own calculation

Table 5.3 presents the assumed effect of vehicle scrappage schemes in Australia, Germany, Japan, UK and USA. Subsidies are stated in billions or millions of USD, to enable comparability between countries.

Our results (Table 5.3) show that in Germany the vehicle scrappage scheme stimulus, in the approximate amount of USD 7,168 bn contributed to the generation of USD 20,597 bn in the form of extra output in the automobile industry, which is the highest output generation among all selected countries. The high value of the output multiplier in Japan is such because, even though the initial fiscal stimulus package was the lowest among all the other selected countries, a USD 3,975 mil vehicle scrappage scheme induced USD 12,759 mil of extra output in the automobile industry of the Japanese economy. However, GVA which is a more accurate measurement of GDP shows an approximately USD

10 mil lower contribution to GVA than output induced by the vehicle scrappage scheme in Japan.

As we have previously stated,an output multiplier for Germany (Figure 5.1.2) was not computed as the highest among other industries' output multipliers in German economy. However, we can see that the high income multiplier for the German automobile industry allows for the generation of an extra USD 3,948 bn in wages, salaries and supplements by working on producing an additional USD 7,168 bn[10] of output.

Table 5.4: The theoretical effects of ICT infractructure stimulus packages

	Australia	**Germany**	**Japan**	**UK**	**USA**
Subsidy in USD	35 907 609 720	215 034 958	1 987 534 186	323 395 916	7 200 000 000
Output in USD	71 522 250 099	333 001 538	3 247 215 863	556 985 187	12 218 385 645
GVA in USD	37 796 335 641	225 544 860	2 064 239 093	346 549 696	7 535 954 263
Income in USD	28 851 702 404	155 619 531	1 294 617 360	246 513 780	5 766 373 815

Source: data retrieved from OECD (2009), own calculation

Table 5.4 reflects the amount of ICT infrastructure stimulus packages in USD and the extra output, gross value added and income generated within the ICT sector (computer and related activities) by producing additional output in the amount of subsidy. In all selected countries, extra gross value added induced by the additional production equal to the amount of particular subsidies, is higher than such. For the interpretation of the assumed effects of ICT infrastructure stimulus packages, we use an analogical process as when presenting effects of the vehicle scrappage schemes presented by Table 5.3 above.

5.2 Interpretation

Based on the data collected and computations of simple input-output multipliers, we draw implications of the application of input-output analysis in evaluating fiscal policy.

Table 5.5 shows an overview compiled from Tables 5.1, 5.2, 5.3 and 5.4 to enable comparison of computed simple multipliers; amount of subsidies in USD; and output gross added value and income in USD generated as an effect of expansionary fiscal measures taken in the automobile and ICT sector. Table 5.5 not only shows the numerical evaluation of the fiscal policy effect, but also provides a possibility to compare results of input-output analysis of chosen

[10]Vehicle scrappage scheme subsidy in Germany in USD.

anti-crisis measures across sectors (i.e. automobile industry, ICT sector) and countries (i.e. Australia, Germany, Japan, UK and USA). The interpretation of economic impacts, together with a comparative analysis of multipliers allows for a better understanding of the main output, GVA or income generating sectors and helps determine the most suitable fiscal policy for a particular country, as a reaction to crisis. We assume that structure of economies are not changing rapidly, and hence the input-output model enables calculation of assumed effects of considered fiscal policy on the national economy and application of the most effective measure.

Our results support Lapeyre (2010) who concludes that an identification of what the primary constraints on growth and job creation are at any particular conjuncture can allow for the prioritisation of sectors that are especially relevant to inducing or supporting a job-rich growth. He adds that data could be applied to financial markets and institutions, to show that the current allocation of credit in the economy is not well suited to expand investment in sectors having high multipliers. Strong evidence of need of major reform in allocation of funds in the financial sector can be provided. Possible reform based on input-output analysis could lead to larger effects on poverty reduction and sustainable increases in decent jobs.

When comparing the amount of subsidies, we notice that in Germany, the fiscal stimulus in the form of the vehicle scrappage scheme outnumbered the investment in ICT infrastructure by almost USD 7 bn. The reasoning is not only the structure of the economy, but also a higher output multiplier in the German automobile industry. As we have already pointed out, in the Australian economy the output multiplier for the ICT sector has attained high values (in comparison with other selected countries) and the ICT sector has hence been identified as one of the key sectors to be targeted by fiscal policy. We can ex-post evaluate, that the high amount of subsidy invested in ICT infrastructure development in Australia hence corresponds to the fact that the ICT industry is identified to generate large amounts of extra output, gross value added and income.

Upon analysis of the UK example, we can equally see that the amount of particular subsidies provided to support the automobile and ICT sectors (USD 485 mil for vehicle scrappage scheme, USD 323 mil for ICT sector development) corresponds to the value of output multipliers. If we however consider, that GVA and income multipliers are better evaluation multipliers of the economy, we can conclude that the ICT sector has been identified as generating

more gross value added and income in form of extra compensation of employees. Hence the fiscal stimulus invested into ICT infrastructure generates USD 0,24176 per USD 1,00 invested in extra income, and a USD 0,42572 larger gross value added per USD 1,00 of additional investment (see Table 5.5).

Table 5.5: Overview of the calculated multipliers and theoretical effects

Vehicle scrappage scheme					
	Australia	**Germany**	**Japan**	**UK**	**USA**
Output multiplier	2,75100	2,87357	3,20990	2,80261	2,85171
GVA multiplier	0,71648	0,69091	0,68599	0,64588	0,56608
Income multiplier	0,41239	0,55093	0,44648	0,52051	0,43782
Subsidy in USD	5 565 679 507	7 167 831 917	3 975 068	485 093 874	3 000 000 000
Output in USD	15 311 190 195	20 597 296 034	12 759 555	1 359 529 867	8 555 141 076
GVA in USD	3 987 671 154	4 952 342 579	2 726 846	313 313 409	1 698 246 582
Income in USD	2 295 244 835	3 948 962 349	1 774 791	252 494 158	1 313 468 046
ICT infrastructure stimulus package					
	Australia	**Germany**	**Japan**	**UK**	**USA**
Output Multiplier	1,99184	1,54859	1,63379	1,72230	1,69700
GVA multiplier	1,05260	1,04888	1,03859	1,07160	1,04666
Income multiplier	0,80350	0,72369	0,65137	0,76227	0,80089
Subsidy in USD	35 907 609 720	215 034 958	1 987 534 186	323 395 916	7 200 000 000
Output in USD	71 522 250 099	333 001 538	3 247 215 863	556 985 187	12 218 385 645
GVA in USD	37 796 335 641	225 544 860	2 064 239 093	346 549 696	7 535 954 263
Income in USD	28 851 702 404	155 619 531	1 294 617 360	246 513 780	5 766 373 815

We notice variation in multipliers between the automobile and ICT sector as well as among countries themselves. One of the reasons for the variations in the size of the multipliers, particularly the output multipliers, is that different industrial sectors have different linkages to the domestic economy. For further information on computation of linkages of industries to the economy, see for example Epstein *et al.* (2009). In his paper Employment, Poverty and Economic Development in Madagascar: A Macroeconomic Framework (2009), he explains that some sectors use a large amount of domestically produced inputs in their production processes. Hence such sectors have a large number of upstream linkages to other activities. Other sectors, which outputs are used by other domestic firms to produce final goods and services, have downstream linkages[11]. Sectors, which use imported inputs in their production, may have

[11]Terminology forward and backward linkages is also used, see Subsection 2.3.2.

lower multipliers. This is one of the principal linkages that occurs in a standard input-output model.

Lastly, based on the underlying assumptions, abilities of input-output analysis, reviewed literature[12] and practical computations, strengths and limitations of the input-output analysis are outlined below.

We identify following strengths of applying the input-output model to evaluate fiscal policy:

- *Comprehensive, consistent and real data* The compilation of input-output tables is a resourceful and complicated process, which has to in the vast majority of countries comply with international guidelines. Because of the large amount of sources used to complete IO tables and the fact that IO tables play a fundamental role in the construction of a system of national accounts, the accuracy of tables is required and thoroughly checked (see Subsection 4.2.2). Ex-ante application of input-output model is often used by decision-makers and governments, to predict the economic, as well as environmental, impacts of suggested policies. Input-output tables, compiled based on real data, allow for better projections of economic impact, than models based on theoretical assumptions.

- *Ability to analyse the intersectoral connections and direct, indirect and induced effects* The multipliers can show just the first-round effects, or the aggregated effects once all secondary effects have flowed through the system (see Subsection 4.3.3).

- *Decomposition of structural change allowing for detection of source, direction and magnitude of change* The design of IO tables (see Subsection 4.3.2 and Figure 5.1.2) allows researchers and governments to analyse the change, accounting for complex production processes, which involve interactions of various businesses at different stages of production. Input-output tables enable the tracing of linkages among sectors within the economy, and allows us to numerically evaluate direct, indirect and induced effects.

Interestingly, Christ Carl (1955) in his Review of Input-Output Analysis (1955) addresses the main issues connected with IO analysis results. In 1955

[12]The strengths and limitations of input-output analysis follow description by Fatemi (2002) in Input-Output Economics

the main weaknesses of input-output analysis was computation problems, resulting from lack of technology to collect and process data - errors due to rounding, errors due to approximation formulas and errors due to inaccurate data. Technological progress has allowed researchers to overcome these issues with computations of multipliers using input-output analysis.

Finally, we focus on the weaknesses of input-output analysis at the date, mostly based on the limitations of underlying assumptions (for further description please refer to Section 4.2 and Subection 5.1.1):

- *Underlying assumptions* Limitations of input-output analysis lie among its assumptions (for further description please refer to Subection 5.1.1) - fixed technological coefficients, identical and fixed products, constant return of scale, no constrains on resources, efficient employment of all local resources.

- *Time availability of input-output data* Another possible limitation of input-output analysis is timeconsuming compilation of input-output tables and late availability of input-output tables. Time availability limitation is a trade-off for previously mentioned strength of complexity and accuracy of input-output tables.

- *Double-counting problem of output multiplier* The problem of double-counting, when the increased output of one industry can be used as an input into another industry, and be counted more than once. Problem of double-counting of output multiplier, can be off-set by using gross value added multiplier.

Chapter 6

Conclusion

The main focus of the thesis is the applicability of input-output analysis itself. Therefore, we have concentrated on providing an insight into the entire process of input-output analysis, which has yielded computation of simple input-output multipliers. Due to the ability to capture linkages in the economy, computed multipliers have been later used as a tool to evaluate the effects of vehicle scrappage schemes and ICT infrastructure investment subsidies on output, gross value added and income. For more diverse results and implications of our analysis in comparison with previous literature, we have chosen to evaluate economies with different economic environments and structure of industries - Australia, Germany, Japan, UK and USA. We have also aimed to provide a sufficient explanation of the input-output model and a computation manual based on the example of calculation of simple multipliers in the Leontief open model, in order to contribute to the clarity of the practical uses of this model.

Among reviewed literature, further groups of multipliers or measurement tools are provided for explanatory purposes; however detailed computation of all defined input-output multipliers has not been an aim of this thesis. Our goal has rather been to contribute to the debate on the application of alternative forecasting and evaluation methods of policies, in times when there has been a large convergence towards general equilibrium and vector autoregression models.

In the thesis, we have studied fiscal stimulus packages applied among the selected countries, which were aimed not only at boosting economic recovery, but also provided an opportunity to transform the targeted industries by stimulating green technology and fuels (vehicle scrappage schemes in the auto-

mobile industry) and promoting innovation and offering solutions to pressing social challenges (investing in ICT infrastructure in the computer and related services sector). In contrast with previous literature, we have provided the application of input-output analysis on a cross-country and intersectoral example to ensure diversity and show comparability of results.

We have stressed that input-output analysis measures aggregate, not marginal effects, and therefore any fiscal multiplier results acquired by use of another model may differ with our results. The calculated multipliers show the total amount of output, gross added value and income (wages, salaries and supplements) induced by the requirement from all industries to produce output to satisfy demand of an extra unit of currency of output in the industry.

In the thesis, we have fulfilled our hypotheses, when we have numerically evaluated the effects of aforementioned sample of anti-crisis fiscal policy packages on the example of Australia, Germany, Japan, UK and USA. Furthermore, we have compared the results of input-output analysis of anti-crisis measures across sectors and countries. In line with Bensaid *et al.* (2011), we have demonstrated identification, which industry is generating higher output, gross added value and income in the national economy and we have shown the decision making points on the most suitable fiscal policy for a particular country as a reaction to economic downturn.

The thesis concludes that thanks to freely available, standardised, comprehensive and consistent input-output tables based on real data, the input-output model provides an accurate means of analysing intersectoral connections in an industry-to-industry input-output model. Direct, indirect and alternatively also induced effects of changes within the economy can be calculated, allowing for detection of source, direction and magnitude of change based on the interaction within the economy captured by input-output tables.

Technological progress has reduced the weaknesses of input-output analysis to limitation by its underlying assumptions, such as fixed technological coefficients, identical and fixed products, constant return of scale, no constrains on resources, and efficient employment of all local resources. Although time availability of data can also be perceived as a limitation, it can be considered as a trade-off for accurate real data. Double-counting of the output multiplier is a minor problem, rather than limitation of the input-output model, because it can be easily off-set by using gross value added multiplier instead.

The thesis provides a suggestion to policy makers to consider applying input-output analysis, as an alternative method, when evaluating the effects

of fiscal policy implemented at a national level, and possibly making comparisons at international level. More detailed analysis of a domestic economy is suggested in order to ensure targeting of the key output (or alternatively gross value added, income, employment) generating industries and effective performance of policy.

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