Charles University in Prague

Faculty of Social Sciences
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Dissertation

Empirical Essays in Institutional Microeconomics

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Academic Year: **2016/2017**

Thank you!

I have benefited from the comments of many colleagues while working on papers included in the dissertation. I thank them at the beginnings of the respective chapters. But I wouldn't be probably writing this acknowledgment at all without a number of friends and colleagues who deeply stimulated my interest in economics and in the role of institutions in everyday life. Martin Froněk, David Lipka, Josef Šíma, and Dan Šťastný are among the most important ones and I have to thank them for being around and helping me cultivate my thinking. I also thank my wife, Petra, for letting me do research on evenings and over weekends. And, last but not least, my thanks go to my advisor, Michal, for being patient and providing me with many useful comments and suggestions.

This dissertation benefited from the European Union's Horizon 2020 Research and Innovation Staff Exchange programme under the Marie Sklodowska-Curie grant agreement No. 681228.

Bibliographic Record

Schwarz, Jiří: *Empirical Essays in Institutional Microeconomics.* Dissertation thesis. Charles University in Prague, Faculty of Social Sciences, Institute of Economic Studies. June 2017, pages 126. Advisor: PhDr. Michal Bauer, Ph.D.

Contents

Abstract

The dissertation consists of three empirical papers in institutional microeconomics. The first paper examines the role of institutional quality in international trade, the second paper focuses on unintended consequences of intellectual property rights for social welfare, and the last one addresses the impact of banking on corporate financing and investment. An introductory chapter puts these three papers into perspective.

In the first paper I analyze the role of institutions in price dispersion among cities in the European region in the 1996–2009 period. Using a number of institutional quality measures I find that the better the institutions, the lower the predicted dispersion. The result is robust to different specifications of the regression model and is consistent with a hypothesis that arbitrage, as an entrepreneurial activity and the main power behind the law of one price, is influenced by institutional quality.

In the second paper I use a large data set of U.S. patents applied for between 1980 and 2007 by 22 large technology companies to study development of strategic patenting over time and across industries. Using two complementary methods I reveal strong evidence against the hypothesis of more strategic patenting after 1995. Contrary to the expectations, aerospace patents appear to be on average more strategic in the post-1995 period than software patents. A firm-level approach, which allows to take into account the firms' R&D capacity using data envelopment analysis, confirms the findings and shows an increasing focus on patent social value since the end of 1980s.

In the last paper I focus on the 2008 crisis which was followed by a sharp drop in bank credit flows to Czech non-financial corporations. An analysis of investment–cash flow sensitivities over the period 2006–2011 doesn't reveal any change in financial constraints in 2008. Companies going bankrupt had significantly higher levels of external debt and bank loans, and do not manifest any investment–cash flow sensitivity in the pre-crisis period, which indicates that they were probably not financially constrained at all. After the 2008 crisis, companies we know are going to declare bankruptcy start to get financially constrained, too.

List of Tables

List of Figures

Chapter 1

Economic Analysis of Institutions

New institutional economics studies social and legal rules, norms, and strategies which exist, as Ostrom (2005, p. 825) emphasizes, in a nested structure of multiple levels. On the top level, institutional economics has much in common with the works of public choice theorists (see, e.g., Buchanan & Tullock 1962; Tullock 1967) trying to find an answer to the famous question posed by the Roman poet Juvenal: *Sed quis custodiet ipsos custodes?* But who will watch the watchmen?

Even in liberal democracy there is an inherent principal-agent problem present, where the principal – demos, the people – has only limited ability to monitor and correctly motivate the agents – politicians and bureaucrats. Weingast (1995) calls it the fundamental political dilemma of an economic system: Institutions are needed that would give the state enough power to make the fulfillment of its tasks, such as the protection of property rights, possible but, at the same time, minimize the possibility of misusing this given power and confiscate the wealth of its citizens.[1] Hayek (1960) argues that the essential ingredient for a well-functioning society is freedom. Only a free society with predictable development of government's coercive power constrained by general rules applied equally to all individuals is able to set and preserve some limits to collective action. In a similar sense, Munger (2008, p. 508, emphasis in the original) summarizes the public choice arguments by stating that "we can never rely on political *means* to guard the borders of private choice against invasion by political *ends*."

The reason is that without clearly set limits to politics, any interest group is able to gather enough political power to pursue its ends at the expense of others by influencing the development of formal institutions, such as various policies and property rights. In some situations, minorities are even able to dominate the majority and invoke institutional change (Olson 1965). On an example of the regulation of

[1] We analyze one of the methods used to ensure that new regulation is not constructed to benefit a particular interest group at the expense of others, called the regulatory impact assessment, in Jára & Schwarz (2012).

in-kind wages in Britain, Tan (2005) shows the importance of interest groups in influencing the shape and time of legislative changes. The easier it is for special interest groups to persuade policymakers to implement institutions beneficial only for a small part of the society, the more will institutional quality and the degree of business friendliness deteriorate.

Analyzing the process of obtaining benefits through unproductive means, the rent seeking, Benson (1984) points out that it creates the need to use the same tools for defensive purposes. Calling this activity *rent avoidance*, Benson describes how the conflicting interests lead to rising complexity of formal institutions through creation and continuous redefinition of laws and regulations. An instructive example is the case of Czech Act No. 586/1992 Coll. on Income Taxes. When adopted in 1992, article 4 defined 18 personal income tax exemptions using 532 words (29.5 words per exemption). In 2016, after 110 amendments, the same article defines 37 exemptions with 2943 words (79.5 words per exemption). This development reflects the struggle of various interest groups: one succeeds in creating a hole in the law, another immediately fights back to patch it and create a different one.

Such development has material impact on real economy: Weber (2015) estimates the impact of increasing complexity of the U.S. federal tax code on entrepreneurial activity and finds that a standard deviation increase in tax code length is associated with a 5 percent decline of business entry and exit rates. Decreased flexibility of the economy then negatively impacts the welfare of the whole society. Coming up with various ways of dealing with the endogeneity problem when estimating the causal effect of institutions on economic growth, numerous works confirm such a link (see, e.g., Acemoglu *et al.* 2001). Estimating the contribution of institutions, geography, and trade in determining income levels around the world by combining the approaches of Acemoglu *et al.* (2001) and Frankel & Romer (1999), Rodrik *et al.* (2004) find that the quality of institutions is even more important than trade.

Similarly, going through all articles which use the Economic Freedom of the World index as a proxy for institutional quality, Hall & Lawson (2014) find that the vast majority of studies link more economic freedom with positive outcomes such as faster growth, better living standards, or more happiness. Bjørnskov (2016) reveals that the effect of income inequality, which is sometimes perceived as a negative consequence of economic freedom, on growth is in fact conditional on the size of the government – the smaller the government, the more likely does inequality contribute positively to economic growth.

Recently, empirical literature has started to address the issue of conditionality more often, especially in connection with informal institutions. The impact of individualistic values on the attitude toward government interventions is found to be influenced by trust in the state (Pitlik & Rode 2017), the impact of government size on economic growth seems to be conditional on perceived government legitimacy

(Berggren *et al.* 2015). The mutual relationship of various aspects of informal and formal institutions is another important subject of institutional literature – be it, for example, the impact of religiosity on property rights (Berggren & Bjørnskov 2013), or the influence of culture in general (Tabellini 2010).

Another important stream of literature, closely related to the essays included in this dissertation, focuses on describing and analyzing the core mechanism behind the impact of institutions on real economy – the entrepreneur (for a discussion of different theoretical approaches to entrepreneurship see Klein 2008). Whether it is the Kirzner's equilibrating or the Schumpeter's disrupting function of entrepreneurs, the common theme is that the entrepreneurial spirit, even though always present, can be channeled to different uses depending on prevailing institutions (for a recent review of empirical literature in this field see Bjørnskov & Foss 2016).

Building on existing literature analyzing the impact of institutional quality on entrepreneurial activity and real economic outcomes, I argue in Chapter 2, which was published in the Review of World Economics (Schwarz 2012), that institutional quality can help to partly explain two major puzzles in international economics: home bias in trade, and size and persistence of deviations from the purchasing power parity. Many authors explain the role of various factors influencing cross-border price dispersion and assume that after we control for the most important sources of distortions, the prices in different places should equalize as a consequence of arbitrage existence.

But arbitrage is not an automatic equilibrating process, the goods do not travel from where they are cheaper to where they are more expensive by themselves. Arbitrage is an entrepreneurial activity and should be influenced by the quality of institutions (Kirzner 1997; Baumol 1990). And indeed, I show that the effect of institutions on price dispersion is not only statistically significant but also economically relevant. Only the change of the regulatory quality variable in 2009 when switching from the Prague–St. Petersburg to Prague–Stockholm city pair induces a decrease in price dispersion by almost one standard deviation.

Using a different methodology based on trade flows instead of price dispersion and focusing on countries of the South-Eastern Europe and the Commonwealth of Independent States, Kucharčuková *et al.* (2012) confirm my finding that low quality institutions account for a considerable portion of their below-potential trade. Moreover, they use policy simulations to identify potential channels of improvement and conclude that one feasible road to follow would be to focus on improving institutional quality. Taking a more dynamic view of the influence of institutions, Söderlund & Tingvall (2014) show that Swedish firms are more likely to export to countries with better institutional quality. Also, the duration of exports tends to be longer with higher export volumes. However, this effect is relatively short-lived: Firms acquire knowledge about the business climate in the recipient country and during the first

two years exports increase quickly and tend to level out. Using a data set of Belgian firms, Araujo *et al.* (2016) reach the same conclusions. Moreover, they find that due to higher export growth, the level of exports to countries with lower institutional quality would keep increasing and eventually surpass the level of exports to countries with better institutions.

An implicit institutional dimension is also present in papers estimating the impact of membership in the euro zone. Fischer (2012) uses prices and sales volumes of washing machines in 17 European countries and find that even within the European Monetary Union, deviations from the law of one price are still statistically and economically significant. Moreover, he is unable to provide any evidence in favor of price convergence across euro area countries. On the other hand, Cavallo *et al.* (2015) consider the case of Latvia, which dropped its currency peg and joined the euro zone in 2014, and find that price dispersion of goods sold by the clothing retailer Zara dropped significantly: the percentage of goods with nearly identical prices in Latvia and Germany increased from 6 to 89 percent. Glick & Rose (2016) estimate the effect of entering the euro zone and conclude that is has boosted exports by around 50%.

Even if we put the issue of robustness of the findings aside, interpreting the results from the point of view of institutional quality would require the assumption that currency and market integration leads to higher-quality institutions which make arbitrage more feasible. But such assumption is never explicitly stated nor tested in this stream of literature. As a consequence, the available results don't allow us to directly address the causal effect of institutional quality on price dispersion or trade flows.

So far, I have been focusing predominantly on productive entrepreneurship. But as explained by Baumol (1990), entrepreneurs can pursue also unproductive, or even destructive goals. Moreover, we can also talk about institutional entrepreneurship (Pacheco *et al.* 2010) if an economic actor is not satisfied with the current institutional framework and uses his entrepreneurial skills to alter it. Depending on the specific set of available actions and their payoffs, such an institutional change may increase or decrease the institutional quality – recall the example of the amendments to the Czech Income Taxes Act (for a detailed description of all combinations, which may arise, see Henrekson & Sanandaji 2010).

Whether an entrepreneur chooses to abide by the existing institutions and invest in a productive activity, or tries to alter the institutions in an unproductive way, for example by lobbying for new regulations to protect his/her industry, depends not only on institutional quality, but also on other factors. For example, Wiseman & Young (2014) address the role of religiosity and find that several religious variables significantly and negatively correlate with productive entrepreneurship. The share of atheists/agnostics is found to be positively correlated with productive entrepreneurship.

One of the core elements of institutional quality is the property rights security. There is a wide agreement that the ability to define and enforce private property rights enables division of labor, long-term investment, and economic growth – it creates conditions for productive entrepreneurship. But there is no consensus regarding the overall welfare effects of intellectual property rights, such as patents and copyrights. Boldrin & Levine (2010) argue that they hinder the competitive forces of the free market, thereby slowing down innovation and economic development. One of the reasons why patents do not boost innovation (Bessen & Meurer 2008; Lerner 2009; Mokyr 2009) would probably be the existence of strategic patenting confirmed by many authors (Cockburn & MacGarvie 2011), which is connected with a number of socially harmful activities.

Whereas obtaining patents to protect technologically valuable inventions has at least the potential to enhance social welfare by providing incentives to innovators, investing in strategic patents is an unproductive entrepreneurial activity. The usefulness of strategic patents is in their litigation potential: They can be used to either threaten or even sue another company with the goal of preventing its market entry or extracting rent through licensing fees and royalties. Without a valuable patent to protect, such activities clearly have detrimental impact on social welfare. However, distinguishing between these two types of patents empirically is not an easy task.

Until now, this topic has been predominantly analyzed theoretically, or in a case study settings with an emphasis on litigation. Therefore, there is no answer to the question whether strategic patenting is a new phenomenon, brought about as an unintended consequence of some relatively recent policy changes, or if it only became more visible due to the overall sharp growth in patenting over the last decades. Also, the existing literature doesn't show whether any trends in strategic patenting are universal, or limited only to some industries. Not being able to track strategic patenting over time and across fields seriously restricts the ability to evaluate policy changes and formulate recommendations for the future.

Litigation statistics show that the number of patent cases per year is on the rise at least since the 1980s, with a clearly observable acceleration during the 1990s. Patent litigation is also very unevenly distributed across industries. In Chapter 3 (co-authored with Martin Štěpánek) I introduce a novel method of two complementary approaches to identify strategic patenting and address its development over time and across industries using a data set of more than 168,000 U.S. patents applied for between 1980 and 2007 by 22 companies from four technological fields: aerospace, computer manufacturing, semiconductors and software industry.

The first approach – a patent-level approach – allows to directly address the link between the patent private and social value and check for breaks in this relationship. A firm-level approach enables us to take into account the firms' R&D capacity and estimate the relative importance of strategic versus protective patenting using data

envelopment analysis. Contrary to my expectations, I find strong evidence against the hypothesis of more strategic patenting after 1995. The conclusion is that we do not observe a rising tendency of large technology companies to engage in socially harmful strategic patenting.

However, the mere existence of strategic patenting provides an example of unintended and unwanted consequences of institutions with completely different official goals. And not only entrepreneurial activities, but every individual action follows an implicit and often even unconscious decision – a choice from the available set of options. The major problem of every institutional change is that it influences the set of choices and their expected outcomes often in an unintended way. The more narrow is the view of the regulator proposing some institutional modification, the larger is the risk of materialization of unwanted consequences which may even outweigh the original goals. Being able to predict reactions of economic actors to the planned institutional modification becomes crucial.[2]

One of the most important policy-making organizations heavily influencing the institutional environment but, at the same time, with a very narrow view, are central banks.[3] In the last years, especially following the 2008 crisis, central banks started to use instruments which are much less developed and described compared to the usual open market operations. In particular, the increasing focus on macroprudential policy led to a considerable broadening of the spectrum of tools they are able to utilize, such as various new capital requirements, limits on debt to income, or loan to value ratios.

Focusing solely on the supply side of bank loans with the emphasis on reduction of network risks or procyclical behavior of the banking sector as such can lead to omitting that there are real individuals and real firms on the other side of the counter. Individuals and firms in need of loans to, for instance, finance an investment. An increase in capital requirements and the subsequent drop in lending can then fall particularly on companies, which tend to get financially constrained in economically more difficult periods. Therefore, in order to predict the consequences of such a regulatory change on real economy, we need information regarding the presence and the importance of financial constraints of various types of companies.

In Chapter 4 (co-authored with Martin Pospíšil), which has been resubmitted

[2]For example, in Havranek *et al.* (2016) we explain that to correctly estimate the reaction of tax revenue to changes in the corresponding tax base – the so-called tax revenue elasticity – we need to first obtain estimates of the effects of past tax reforms and tax policy changes. And, moreover, due to various imperfections in the tax system, the instantaneous reaction of tax revenue may differ from the long-run elasticity.

[3]In Schwarz & Šíma (2011) we provide an example of how influential monetary policy goals may be in shaping the general institutional climate: One of the most striking points of Czech and Slovak institutional departure after the breakup in 1993 was the Slovak adoption of the euro in 2009 while the Czechs opted to retain their national currency, the koruna. The adoption of the euro-area accession strategy in Slovakia coincided with a trend break and a sizable improvement in institutional quality perception. We argue that the plan to adopt the euro worked as a commitment device in Slovakia and helped the then pro-reformist government to push through institutional reforms.

after revision to the Eastern European Economics, I address this issue and study the 2008 crisis from the viewpoint of Czech companies' financial constraints. The sharp drop in credit flows to non-financial companies observed after September 2008 may have been an indication of difficult access to external finance during the time of economic distress. However, it is difficult to identify and correctly estimate the severity of financial constraints from aggregate data. A decrease, no matter how strong, in aggregate lending does not say anything about a credit crunch, as it may have been caused by a decrease in the demand for credit; for example due to negative expectations regarding future business opportunities.

Using investment–cash flow sensitivity as a proxy for the existence of financial constraints, I show that firms were, in fact, more likely to invest in new assets if they generated enough funds of their own. In other words, Czech firms seem to be, on average, financially constrained. But the data also reveal that companies which went bankrupt actually did not face financial constraints, which is in contrast with previous findings. Positive investment–cash flow sensitivity of companies which we know are going to declare bankruptcy is observable only in the post-crisis period.

The finding that companies which are going to declare bankruptcy in the future were not financially constrained before the 2008 crisis, that is during the boom period, should be a warning not only for banks, but also for the regulator. From this point of view, policies forcing the banks to create sufficient buffers during the good times may be able to limit the extent of procyclical behavior and also mitigate potential problems during the bust period. Information regarding the existence of financial constraints of companies nearing bankruptcy can be used as one of the inputs for evaluating how successful central banks are in their effort.[4]

Considering the rising importance of monetary and macroprudential policies, I believe that institutional economists should focus more on this field. The transmission of monetary policy changes, as well as the reactions to various macroprudential instruments are probably conditional not only on policies related to the financial sector and the financial organizations themselves,[5] but also on the characteristics of the end users – the firms.

Another area, which I believe should receive more attention and is, for the time being, slightly undervalued, is the empirical analysis of the effects of informal institutions and their interplay with formal institutions. Especially in transition countries, policy makers sometimes have the intention of importing institutions from abroad. And, as the literature shows, the effects of formal institutions may be highly conditional on some aspects of the informal institutional environment, such as the pre-

[4] Another potentially important subject from the point of view of banking sector stability may be the effects of various unconventional monetary policy tools, such as the exchange rate commitment (Lízal & Schwarz 2013).

[5] For example, Žigraiová (2015) shows that the management board composition of banking institutions in the Czech Republic affects their risk-taking behavior.

vailing level of trust, religiosity, or various cultural aspects. As a consequence, the same set of formal institutions, which may lead to the development of productive entrepreneurship in one country, may create incentives for unproductive or even destructive use of entrepreneurial skills elsewhere.

From the most crucial questions of political institutions, down to the no less important topic of reactions to monetary policy shifts, economics explains that individuals always strive to improve their well-being and do not always act as the policy maker intended. As I try to show in this dissertation and in the other papers I co-authored, institutions play a major role in defining the set of available paths individuals can take. But we tend to forget how intertwined institutions are; that without a careful empirical analysis, it is often practically impossible to discover the resulting set of available choices and understand, explain, and predict human action.

References

Acemoglu, D., S. Johnson, & J. A. Robinson (2001): "The Colonial Origins of Comparative Development: An Empirical Investigation." *The American Economic Review* **91(5)**: pp. 1369–1401.

Araujo, L., G. Mion, & E. Ornelas (2016): "Institutions and export dynamics." *Journal of International Economics* **98**: pp. 2–20.

Baumol, W. J. (1990): "Entrepreneurship: Productive, Unproductive, and Destructive." *The Journal of Political Economy* **98(5)**: pp. 893–921.

Benson, B. L. (1984): "Rent Seeking from a Property Rights Perspective." *Southern Economic Journal* **51(2)**: pp. 388–400.

Berggren, N. & C. Bjørnskov (2013): "Does religiosity promote property rights and the rule of law?" *Journal of Institutional Economics* **9(2)**: pp. 161–185.

Berggren, N., C. Bjørnskov, & D. Lipka (2015): "Legitimacy and the cost of government." *Public Choice* **162(3-4)**: pp. 307–328.

Bessen, J. & M. J. Meurer (2008): "Do Patents Perform like Property?" *Academy of Management Perspectives* **22(3)**: pp. 8–20.

Bjørnskov, C. (2016): "Growth, Inequality, and Economic Freedom: Evidence from the U.S. States." *Contemporary Economic Policy.* Advance online publication. doi: 10.1111/coep.12199.

Bjørnskov, C. & N. J. Foss (2016): "Institutions, Entrepreneurship, and Economic Growth: What Do We Know and What Do We Still Need to Know?" *The Academy of Management Perspectives* **30(3)**: pp. 292–315.

Boldrin, M. & D. K. Levine (2010): *Against intellectual monopoly.* Cambridge: Cambridge Univ. Press.

Buchanan, J. M. & G. Tullock (1962): *The Calculus of Consent: Logical Foundations of Constitutional Democracy.* University of Michigan Press.

Cavallo, A., B. Neiman, & R. Rigobon (2015): "The Price Impact of Joining a Currency Union: Evidence from Latvia." *IMF Economic Review* **63(2)**: pp. 281–297.

Cockburn, I. M. & M. J. MacGarvie (2011): "Entry and Patenting in the Software Industry." *Management Science* **57(5)**: pp. 915–933.

Fischer, C. (2012): "Price convergence in the EMU? Evidence from micro data." *European Economic Review* **56(4)**: pp. 757–776.

Frankel, J. A. & D. Romer (1999): "Does Trade Cause Growth?" *The American Economic Review* **89(3)**: pp. 379–399.

Glick, R. & A. K. Rose (2016): "Currency unions and trade: A post-EMU reassessment." *European Economic Review* **87**: pp. 78–91.

Hall, J. C. & R. A. Lawson (2014): "Economic Freedom of the World: An Accounting of the Literature." *Contemporary Economic Policy* **32(1)**: pp. 1–19.

Havranek, T., Z. Irsova, & J. Schwarz (2016): "Dynamic elasticities of tax revenue: evidence from the Czech Republic." *Applied Economics* **48(60)**: pp. 5866–5881.

Hayek, F. A. (1960): *The Constitution of Liberty.* Chicago: The University of Chicago Press.

Henrekson, M. & T. Sanandaji (2010): "Institutional Entrepreneurship: An Introduction." *IFN Working Paper No. 853*, Research Institute of Industrial Economics (IFN).

Jára, K. & J. Schwarz (2012): "Does Regulatory Impact Assessment (RIA) Really Evaluate Regulatory Impact? The Case of the Czech Republic." *IES Working Paper 29/2012*, IES FSV, Charles University.

Kirzner, I. M. (1997): "Entrepreneurial Discovery and the Competitive Market Process: An Austrian Approach." *Journal of Economic Literature* **35(1)**: pp. 60–85.

Klein, P. G. (2008): "Opportunity discovery, entrepreneurial action, and economic organization." *Strategic Entrepreneurship Journal* **2(3)**: pp. 175–190.

Kucharčuková, O. B., J. Babecký, & M. Raiser (2012): "Gravity Approach for Modelling International Trade in South-Eastern Europe and the Commonwealth of Independent States: The Role of Geography, Policy and Institutions." *Open Economies Review* **23(2)**: pp. 277–301.

Lerner, J. (2009): "The Empirical Impact of Intellectual Property Rights on Innovation: Puzzles and Clues." *American Economic Review* **99(2)**: pp. 343–348.

Lízal, L. & J. Schwarz (2013): "Foreign exchange interventions as an (un)conventional monetary policy tool." In "Market volatility and foreign exchange intervention in EMEs: what has changed?", BIS Papers No 73, pp. 127–143. Bank for International Settlements.

Mokyr, J. (2009): "Intellectual Property Rights, the Industrial Revolution, and the Beginnings of Modern Economic Growth." *American Economic Review* **99(2)**: pp. 349–355.

Munger, M. C. (2008): "Economic choice, political decision, and the problem of limits." *Public Choice* **137(3-4)**: pp. 507–522.

Olson, M. (1965): *The Logic of Collective Action.* Harvard University Press.

Ostrom, E. (2005): "Doing Institutional Analysis: Digging Deeper Than Markets and Hierarchies." In C. Menard & M. M. Shirley (editors), "Handbook of New Institutional Economics," pp. 819–848. Springer US.

Pacheco, D. F., J. G. York, T. J. Dean, & S. D. Sarasvathy (2010): "The Coevolution of Institutional Entrepreneurship: A Tale of Two Theories." *Journal of Management* **36(4)**: pp. 974–1010.

Pitlik, H. & M. Rode (2017): "Individualistic values, institutional trust, and interventionist attitudes." *Journal of Institutional Economics.* Advance online publication. doi: 10.1017/S1744137416000564.

Rodrik, D., A. Subramanian, & F. Trebbi (2004): "Institutions Rule: The Primacy of Institutions Over Geography and Integration in Economic Development." *Journal of Economic Growth* **9(2)**: pp. 131–165.

Schwarz, J. (2012): "Impact of institutions on cross-border price dispersion." *Review of World Economics* **148(4)**: pp. 617–645.

Schwarz, J. & J. Šíma (2011): "The Euro as a Hindrance to Recovery? A Comparative Analysis of the Czech Republic and Slovakia." In D. Howden (editor), "Institutions in Crisis: European Perspectives on the Recession," Edward Elgar Publishing.

Söderlund, B. & P. G. Tingvall (2014): "Dynamic effects of institutions on firm-level exports." *Review of World Economics* **150(2)**: pp. 277–308.

Tabellini, G. (2010): "Culture and Institutions: Economic Development in the Regions of Europe." *Journal of the European Economic Association* **8(4)**: pp. 677–716.

Tan, E. S. (2005): "Ideology, interest groups, and institutional change: the case of the British prohibition of wages in kind." *Journal of Institutional Economics; Cambridge* **1(2)**: pp. 175–191.

Tullock, G. (1967): "The Welfare Costs of Tariffs, Monopolies, and Theft." *Economic Inquiry* **5(3)**: pp. 224–232.

Weber, R. (2015): "The Effect of Tax Code Complexity on Entrepreneurship." *Journal of Private Enterprise* **30(2)**: pp. 83–102.

Weingast, B. R. (1995): "The Economic Role of Political Institutions: Market-Preserving Federalism and Economic Development." *Journal of Law, Economics, & Organization* **11(1)**: pp. 1–31.

Wiseman, T. & A. Young (2014): "Religion: productive or unproductive?" *Journal of Institutional Economics* **10(1)**: pp. 21–45.

Žigraiová, D. (2015): "Management Board Composition of Banking Institutions and Bank Risk-Taking: The Case of the Czech Republic." *CNB Working Paper 2015/14*, Czech National Bank.

Chapter 2

Impact of Institutions on Cross-Border Price Dispersion

Abstract

This paper analyzes the role of institutions in price dispersion among cities in the European region in the 1996–2009 period. An overview of the literature on the border effect reveals that the role of institutions is completely neglected. Using the Worldwide Governance Indicators as explanatory variables I find that the better the institutions, the lower the predicted dispersion. The result is robust to different specifications of the regression model and it is consistent with a hypothesis that arbitrage, as an entrepreneurial activity and the main power behind the law of one price, is influenced by institutional quality.

An earlier version of the paper was published in the Review of World Economics [2012, 148(4), pp. 617–645]. I would like to thank Štěpán Jurajda, Michal Bauer, and seminar participants at Charles University for their helpful comments.

2.1 Introduction

There are two major puzzles in international economics that are closely related to each other. First, there seems to be a large home bias in trade. And second, real exchange rates seem to be much more volatile, and deviations from the purchasing power parity (PPP) more persistent than justifiable by economic theory. The amount of the unexplained missing trade, size and persistence of the PPP deviations, and the factors influencing them are the subject of this text.

"How is it possible to reconcile the extremely high short-term volatility of real exchange rates with the glacial rate ... at which deviations from PPP seem to die out?" (Rogoff 1996, p. 664). The answer to this question is linked to the so-called law of one price (LOP), a disaggregated version of the PPP. The reason why the LOP should hold is that if it were possible to buy a particular good in one place, transport it to another place and still sell with profit, such arbitrages would tend to equalize the prices in both locations. It is not surprising that in a world of high transportation and other transaction costs the deviations from the LOP were large and very long-lived, as Volckart & Wolf (2006) show in their example of Medieval Europe.

However, even today the functioning of the LOP is still very slow and imperfect with long-lasting price dispersion between states. A vast literature deals with this paradox, calling the unexplained part of price differentials a "border effect", i.e. the impact of the existence of national borders on trade. The general conclusion is that there isn't nearly as much international trade as the standard models suggest there should be, while the formal barriers such as various tariffs are too low to explain the revealed missing trade (Anderson 2000, p. 115). The first wave of studies in the second half of the 1990s only addressed the size of this border effect (McCallum 1995; Engel & Rogers 1996). Only recently have authors started to explain it, i.e. look for other explanatory variables in addition to transportation costs and reduce the extent of the unexplained residuum.

Many authors estimate the size of the border effect and explain the role of various factors influencing cross-border price dispersion (Bergin & Glick 2007; Parsley & Wei 2007; Wolszczak-Derlacz 2008). The underlying idea in their studies is that arbitrage is a process which should automatically equalize the prices in different places once we remove the influence of these factors. However, arbitrage is an entrepreneurial activity and as such should be influenced by institutional quality. The reason is that low-quality institutions can impose prohibitive costs to arbitrage in the same way as large distances between cities or high tariffs. And contrary to, e.g. distance or language differences, the institutional quality is improvable making it a potentially interesting subject to economic policy. However, the role of institutions is completely neglected by existing literature on the border effect. The main hypothesis of this pa-

per is that institutional quality significantly influences the extent of price dispersion. As Engel & Rogers (2001) explain, price dispersion – a measure of deviations from the LOP – causes a deadweight loss to the economy. But this loss cannot be eliminated by simply fixing the exchange rates, because the underlying source of inefficiency is the price stickiness. They argue that only reduction of real barriers to trade implies welfare improvement.

In the next Section, I provide an overview of the existing literature and various approaches to border-effect analysis and present the existing results. In Section 2.3, I propose a theoretical explanation of the role of institutions in the functioning of the LOP. Section 2.4 describes the used data. In Section 2.5, I construct the price dispersion measures and point out their differences. In Section 2.6, I carry out a regression analysis to empirically assess the impact of several factors, including institutional quality on the cross-border price dispersion. Section 2.7 provides a number of robustness checks. I conclude in Section 2.8.

2.2 Review of related literature

2.2.1 Trade approach

Formally, research takes on two distinct ways of estimating and explaining the border effect. The first stream of authors, starting with McCallum (1995), try to explore how borders affect trade by looking at the difference between intra- and international trade after controlling for distance and some other variables. First studies found that the trade inside countries is, controlling for distance, more than twenty times larger than trade with a foreign country McCallum (1995); Helliwell (1996). With more consistent data the border effect on trade is lowered to about one half using the same model specification (Anderson & Smith 1999), controlling for the remoteness of trading partners further lowers the unexplained portion of missing trade (Wei 1996; Helliwell 1997).

A serious problem with the gravity model specification used is that it estimates significant border effects also at the subnational level between individual US states (Wolf 2000). But, using more theoretically grounded measures of effective internal distance, the border effect among US states drops significantly to about a half of its former value (Head & Mayer 2002). The separation of wholesale and manufacturing shipments together with the use of actual distances of shipments lowers the border effect, i.e. the ratio of actual to predicted trade flows inside the US, to 1.5 (Hillberry & Hummels 2003). The border effect in the EU decreases with the use of effective distance measures from about 20 to 4.2 (Head & Mayer 2002). Technical barriers to trade and currency barriers also have a sizable impact on the magnitude of the border effect (Chen 2004; de Sousa & Lochard 2005).

To sum up, the missing trade stemming from the gravity model is to a large degree caused by incorrect internal distance data. The correct internal distance measure and suitable data on trade flows leads to a reasonably small border effect, which has its source mainly in various trade barriers.

2.2.2 Price approach

Another way of measuring the border effect was introduced by Engel & Rogers (1996) who showed that the standard deviation of relative prices in US and Canadian cities is systematically higher for cross-border city pairs than for city pairs within the same country. According to their estimates, the US-Canada border adds a variability equivalent of 75,000 miles of distance.[1] The big advantage of this approach is that it does not suffer from the above-mentioned problems with distance measures and intranational trade – the geographical distance between two cities is easy to obtain. It has been found that short-run deviations from the PPP are strongly linked to the nominal exchange rate variability (Engel & Rogers 2001), but the explanatory power is considerably reduced when looking at long-run deviations (Parsley & Wei 2001; Bergin & Glick 2007; Wolszczak-Derlacz 2008). Even though the fixation of exchange rates through the introduction of a common currency should evidently reduce price dispersion, empirical investigations of euro introduction lead only to mixed results (Allington *et al.* 2005; Engel & Rogers 2004; Wolszczak-Derlacz 2010).

Some parts of the border effect can be explained by various biases and arbitrage costs such as tariffs (Bergin & Glick 2007; Parsley & Wei 2007), transportation costs per unit of distance (Parsley & Wei 2001; Bergin & Glick 2007), or language, tax, and income differences in respective countries (Wolszczak-Derlacz 2008). Also, it has been found that the aggregation of prices tends to bias the estimated border effect upwards (Imbs *et al.* 2005; Broda & Weinstein 2008), but when comparing the results obtained using disaggregated price data and official price indexes, the differences are relatively minor (Crucini & Shintani 2008). Controlling for the share of non-traded inputs decreases the border effect significantly (Crucini *et al.* 2005; Crucini & Shintani 2008). Introducing sticky prices and sticky information into the model can further decrease the unexplained part of the price dispersion credited to the existence of national borders (Crucini *et al.* 2008).

Gorodnichenko & Tesar (2009) point out that cross-country heterogeneity in price dispersion can bias the border effect upwards due to the incorrect identification of the effect in the used models. However, a significant border effect between the US and

[1] Engel & Rogers (1996) was the first paper estimating the importance of national borders on price deviations between two cities. The only explanatory variables they use are distance, existence of border, and city fixed effects. Therefore, their border variable captures all the various aspects that the other studies specify explicitly, such as institutional, cultural, or language barriers, tariffs, tradability of goods and their inputs, etc. What the result indicates is that these non-physical aspects are of much higher importance for cross-border trade than mere geographical distance.

Canada is also found using the regression discontinuity approach, which is immune to this identification problem (Gopinath *et al.* 2009), as well as by countries that have very similar within-country price dispersion patterns (Horváth *et al.* 2008).

To conclude the literature review, there is a consensus that the border effect exists and is substantial even after controlling for many potential sources of this excess price variability.

2.3 The role of institutional quality

The studies introduced in the previous section use a number of factors to explain the observed dispersion of prices between cross-border city pairs. The underlying idea is that after we control for the most important sources of distortions, the prices in different places should equalize as a consequence of arbitrage existence. However, arbitrage is not an automatic equilibrating process, it is an entrepreneurial activity. As Kirzner (1997, p. 70) points out, "each market is characterized by opportunities for pure entrepreneurial profit. The ... entrepreneur ... buys where prices are 'too low' and sells where prices are 'too high'. In this way ... price discrepancies are narrowed in the equilibrative direction."

In a similar manner, Baumol *et al.* (2007, p. 3) understand an entrepreneur to be "any entity, new or existing, that provides a new product or service or that develops and uses new methods to produce or deliver existing goods and services at lower cost". The goods do not travel from where they are cheaper to where they are more expensive by themselves; the prices do not automatically equalize. It is a process run by the entrepreneurs who have to discover profit opportunities. The profitability of arbitrage is then influenced by a number of different costs, such as tariffs or transportation costs. However, it is not the lack of entrepreneurship that leads to deviations from the LOP. Building on the concept of entrepreneurship formulated by Schumpeter and later developed by Kirzner, Baumol (1990, p. 894, emphasis in the original) notes that, "Entrepreneurs are always with us and always play some substantial role. But ... some of those roles do not follow the constructive and innovative script that is conventionally attributed to that person. ... How the entrepreneur acts at a given time and place depends heavily on the rules of the game – the reward structure in the economy – that happen to prevail."

In other words, if the institutional framework induces prohibitive costs to engage in innovative or arbitrage activities, the entrepreneurs will direct their efforts to other activities, often unproductive, such as rent seeking. As a consequence, in addition to the already-introduced costs of arbitrage such as those caused by the distance between cities, language differences, or trade barriers, the quality of institutions should also influence the attractiveness of arbitrage activities. But its role in the existing literature on the border effect is almost completely ignored.

Note, that the Kirznerian and the Schumpeterian views of entrepreneurship focus on different aspects. Whereas Kirzner stresses the arbitrage-based equilibrating behavior of entrepreneurs, Schumpeter emphasizes their ability to create new markets and disrupt the existing equilibria (Sundqvist *et al.* 2012). In reality, both types of entrepreneurial activity coexist side by side. However, given how globalized the today's world is, there is no reason to believe that a Schumpeterian "disruptive" entrepreneur would aim only on one market and increase cross-border price dispersion if he or she didn't have to face institutional obstacles. The same reasoning regarding the effect of institutional quality on deviations from the LOP should, therefore, apply to this type of entrepreneur, too.

Due to the unavailability of suitable data, I will not test the direct link from institutions to entrepreneurship and price dispersion, but only indirectly from institutions to price dispersion. It is, therefore, possible that the institutional quality influences the price differentials through some other channel. Research on the topic of entrepreneurial productivity, however, suggests that the link between institutional quality and the activities of entrepreneurs indeed exists. Baumol (1990) provides several examples of various historical periods and shows how changing institutional frameworks through the allocation of resources between the productive and unproductive affected the innovativeness and spread of technological discoveries.

Aidis & Estrin (2006) address the relationship of institutions and productive entrepreneurship in today's Russia. Even though they do so very informally, they emphasize several interesting differences between Russian and Chinese self-help institutions based on social networks. While in China this system has evolved into a tool used to overcome the absence of well-defined property rights and contract enforcement, this was not the case in Russia, where the network is primarily used as a means for corruption (Hsu 2005; Wu & Huang 2006). Aidis and Estrin find that the entry rates of new firms in Russia are deep below the rates commonly observed both in developed and developing countries.

A more formal test of the link between institutional quality and the productivity of entrepreneurship is provided by Sobel (2008). He uses the Economic Freedom of North America index as a measure of institutional quality and several proxies for productive and unproductive entrepreneurship. As proxies for the productive, Sobel uses venture capital investments per capita, patents per capita, the growth rate of self-employment activity, the establishment birth rate, and the large firm establishment birth rate. To proxy for unproductive entrepreneurship, he uses three different measures of the number of political and lobbying organizations in each state's capital and an index measuring judicial quality, where states scoring poorly have generally significant levels of legal fraud and abuse. As expected, institutional quality is positively correlated with measures of productive entrepreneurship, and negatively with measures of unproductive entrepreneurship, no matter what measure

is used.[2]

Literature analyzing how currency unions and market integration influence international trade and price dispersion also implicitly estimates the impact of institutional changes. However, the effect doesn't seem to be particularly robust: Some authors find a sizable effect of currency unions and integration (Rose 2000; Allington *et al.* 2005; Goldberg & Verboven 2005; Cavallo *et al.* 2014; Glick & Rose 2016), whereas others don't (Engel & Rogers 2004; Wolszczak-Derlacz 2010; Havránek 2010). Even if we put the issue of robustness of the findings aside, interpreting the results from the point of view of institutional quality would require the assumption that currency and market integration leads to higher-quality institutions which make arbitrage more feasible. But such assumption is never explicitly stated nor tested in this stream of literature. As a consequence, the available results don't allow us to directly address the link between institutional quality and deviations from PPP or LOP.

In this text I use the theory of productive and unproductive entrepreneurship to argue that institutional quality may be one of the determinants of the size of the border effect. In order to test this hypothesis, I will express the quality of institutions as one of the factors influencing the total costs of arbitrage by including various measures of institutional quality into the set of variables used to explain price dispersion. The theoretical prediction is that the better the institutions, the smaller the deviations from the LOP.

2.4 Data

In the analysis I use data on actual retail prices, not price indexes. The information on prices comes from the Worldwide Cost of Living surveys conducted twice a year by the Economist Intelligence Unit (EIU). The main target market for the data source is managers who use it to compare the costs of living in different world cities and estimate compensation for relocating employees. Even though the goods included in the survey to some degree reflect this target, the sample overlaps sufficiently with a typical urban consumption basket. Generally, the use of actual prices could be problematic mainly because a) the price data are collected from a small number of stores compared to the number of outlets surveyed by national statistical agencies when constructing various indexes, b) the price data come only from large cities which do not have to be fully representative of whole countries, and c) the list of

[2]Institutions positively influencing venture capital investments or the number of produced patents do not have to necessarily increase the scope of arbitrage, as these activities are probably often pursued by different entities aiming at different goals. But in order to start importing or exporting goods, a company usually has to be set up first. If institutional quality influences establishment birth rate, it should also influence the costs of arbitrage and, consequently, price dispersion.

tracked items does not represent the whole consumption basket (Engel & Rogers 2004; Wolszczak-Derlacz 2010).

In order to test the reliability of the EIU data, Crucini & Shintani (2008) compare the half-lives of aggregated EIU prices with the official consumer price index (CPI) statistics and find that both data sets are practically identical. Similarly, Rogers (2002) finds out that a) price indexes constructed from the EIU data share important characteristics with the Penn World Tables and OECD intersectoral data sets, and b) the correlation between EIU price changes and the annual official CPI inflation rate is positive and large. Moreover, PPP rates resulting from EIU prices are comparable to the PPP rates reported by the OECD. It seems, therefore, that it is possible to use the EIU data set without inducing any type of bias into the results.

Filer & Hanousek (2000) point out that transition economies, which form a part of the data set, report more upward-biased inflation compared to developed countries. Among the sources of the bias is imperfectly estimated impact of quality improvements, new goods, or substitution in favor of lower-priced goods and outlets. The use of individual retail prices of comparable items, instead of a price index or inflation rate, should help, at least partly, to avoid such bias.[3]

The major advantage of using actual prices compared to the use of price indexes is the possibility to construct a measure of the average dispersion of the individual prices between two places in one time period. Price indexes also have the disadvantage of including both traded- and non-traded goods and lack important pieces of information due to the aggregation – price deviations with opposite signs can cancel each other out.

The survey covers 140 cities in 93 countries and consists of local prices for more than 160 individual goods. Among the goods are products such as "white bread (1 kg)", "paperback novel (at bookstore)", and "women's cardigan sweater" or services like "man's haircut (tips included)". The prices of many goods in the survey are collected from two types of outlets: supermarkets and mid-priced stores. In this paper, only prices from the supermarket or lower-price outlets are used, since they are more likely to be comparable across different regions. The data are annual and collected since 1990, but due to limitations of institutional quality data only the 1996–2009 period is used in the analysis. All prices are expressed in euros.

Forty cities from 31 countries in the European region are chosen, together with 134 goods (listed in Tables 2.A1, 2.A2, and 2.A3 in Appendix).[4] The choice of cities

[3]Section 2.7 provides a robustness check with city×year interaction dummies which should capture all city-related fixed effects, including a different level of goods quality or prices, and their development over time.

[4]Some of the available items were not included: Prices of cigarettes, tobacco, electricity, gas, water, heating oil, road tax and automobile registration fees are often regulated and therefore cannot be expected to converge. The second group of excluded items consists of goods and services which are not very suitable for international comparison because their quality can vary significantly: cars, office and residential rents, insurance, and prices of schools, healthcare, and sports.

is based on the availability of both price data and institutional quality data. Products and services are grouped into eight different categories to allow for a more detailed overview of price development. The distinction between traded and non-traded goods is a common sense one and follows the classification used by other authors (Engel & Rogers 2004; Bergin & Glick 2007).

In order to study the impact of institutional quality, data from the Worldwide Governance Indicators project (WGI) are used. They cover six dimensions of governance over the 1996–2009 period: voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption. The first two dimensions capture the processes by which governments are selected, monitored, and replaced. Government effectiveness and regulatory quality assess the capacity of governments to effectively formulate and implement sound policies. The last two indicators measure the respect of both citizens and the state for the institutions that govern economic and social interactions between them (Kaufmann *et al.* 2010, p. 4).

There is a number of other sources of institutional quality indicators also focusing on economic institutions: the International Country Risk Guide (ICRG), The Heritage Foundation's Index of Economic Freedom, the Fraser Institute's Economic Freedom of the World, the World Bank's Country Policy and Institutional Assessment (CPIA), etc. However, none of them provide any clear advantage over the WGI data. ICRG data are subject to payment and are collected by a small number of experts, which makes it prone to misinterpretation error. The same is true for CPIA, where the World Bank's staff assigns a rating to each country based on some input data. Both economic freedom indexes are based on a number of various data sources which is then translated into country score. But in order to use them as a proxy for institutional quality, an assumption must be made that better institutions equal to more economic freedom, and, therefore, less regulation. This would unnecessarily incorporate an ideological aspect into the analysis.

On the other hand, the WGI data are free and come from 31 different sources of four kinds: commercial business information providers, surveys of firms and households, non-governmental organizations, and public sector data providers. Altogether, more than 400 variables are used to compute the indicators. This should lead to greater precision of data compared to any individual data source.[5]

2.5 Measuring price dispersion

My goal is to measure the scope of deviations from the LOP across cities in different markets and its development over time. Moreover, I want to estimate the influence of various city- and country-specific factors on the size of the deviations. In order to

[5]The WGI data are widely used in academic literature – the methodological paper by Kaufmann *et al.* (2010) has been cited more than 2700 times until March 2017 according to Google Scholar.

do so, following the other studies (Engel *et al.* 2003; Bergin & Glick 2007; Horváth *et al.* 2008), relative log prices between all available city pairs are formed. To be more specific, let $P_{i,t}^k$ be the price of good k in city i at time t expressed in euros. For a given pair of cities (i, j), the relative price for a given good and time is:

$$q_{ij,t}^k = p_{i,t}^k - p_{j,t}^k, \tag{2.1}$$

where the lower case denotes logs.

In order to capture the costs of arbitrage, a price dispersion measure is constructed. Existing papers generally use two types of average dispersion measures. I decided to use both as a robustness check and find out if the choice of dispersion measure affects the final results. The first measure is a standard deviation (SD) of $q_{ij,t}^k$ across all products k:

$$SD_{ij,t} = \left(\sum_{k \in K} \left(q_{ij,t}^k - q_{ij,t}^{\bar{k}} \right)^2 / K_N \right)^{1/2}, \tag{2.2}$$

where K is the set of products, K_N is the number of products, and $q_{ij,t}^{\bar{k}}$ is the average relative price over all the products from the set for city pair ij.

The second measure is a mean square error (MSE) of $q_{ij,t}^k$ across all products k:

$$MSE_{ij,t} = \sum_{k \in K} \left(q_{ij,t}^k \right)^2 / K_N, \tag{2.3}$$

where K is, again, the set of products and K_N is the number of products. The only difference between the standard deviation and mean square error is that the standard deviation removes the city-pair fixed effects. That is, the mean square error not only measures dispersion, but also the average distance of relative prices from zero. Potentially, there are 820 city pairs, each with up to 20 yearly observations. This gives us a sample of a maximum of 16,400 observations. After the exclusion of missing observations, 13,004 observations of price dispersion are left. Appendix Table 2.A4 provides a brief statistical summary of both measures – there is, obviously, enough variance in the sample.

Some studies directly use the relative log price as a measure of price dispersion between the two cities (Engel *et al.* 2003). However, this approach is not consistent with the theory behind the LOP. Deviations from an equilibrium price level of a good exist because for some reason the forces of arbitrage are not functioning. Whatever the sources of arbitrage failure may be, it is possible to represent them by a band of no-arbitrage, within which the differences in the price of one good between two places are too small to enable arbitrage with profit (Parsley & Wei 2001).

As a simple example, we can imagine a world where there are only two barriers

Figure 2.1: Relative prices in the band of no-arbitrage (example)

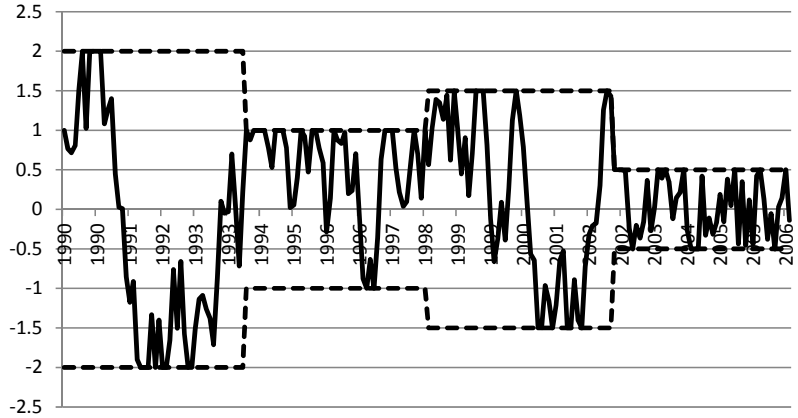
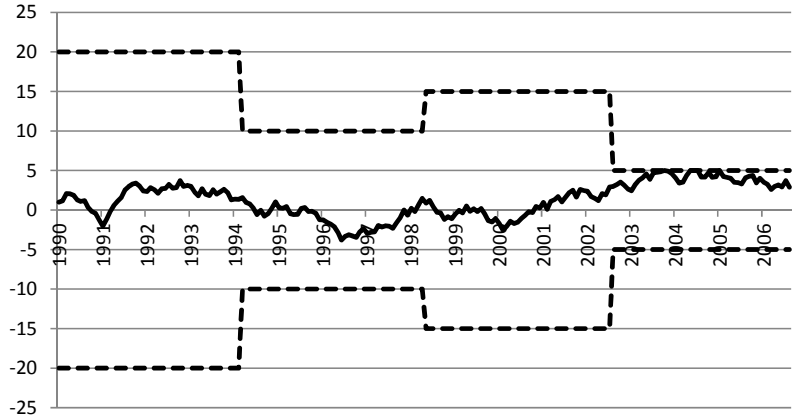


Figure 2.2: No-arbitrage band unidentifiable (example)



to trade: transportation costs and tariffs. These two costs give rise to a band, or interval, where the prices of a particular product in two distinct cities are too close to each other, i.e. the relative price is too close to zero, to allow for a profit-making arbitrage. Arbitrage would start to work only after the relative price leaves this band. In a world of no other obstacles to trade, the correction of an excess price difference would be instantaneously bringing the relative price back into the band where no further profitable arbitrage would be possible. The situation is illustrated in Figure 2.1. However, the band's width does not have to be constant all the time. Suppose, for example, that in 1994 the tariff is lowered. As a consequence, arbitrage would be profitable with the lower absolute values of relative prices, i.e. with a smaller price difference. The band of no-arbitrage can also widen, for example due to higher oil prices that then increase transportation costs.

The relative price inside the band of no-arbitrage follows a random walk process. As long as it is inside the band, the price difference can move in any direction regardless of the arbitrage constraints symbolized by the band's width. Using the

Figure 2.3: Standard deviation

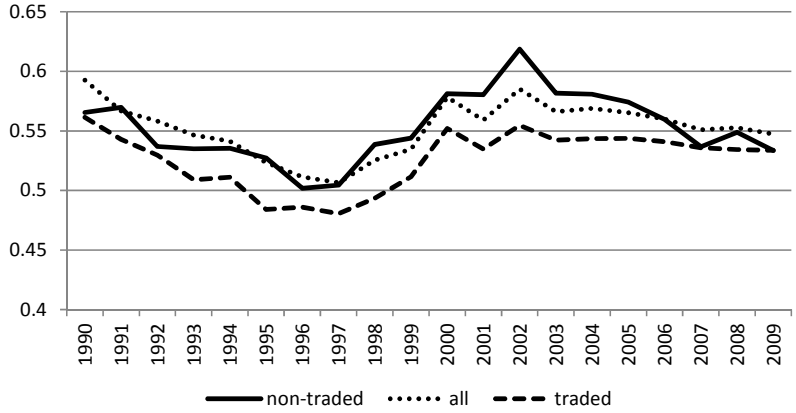
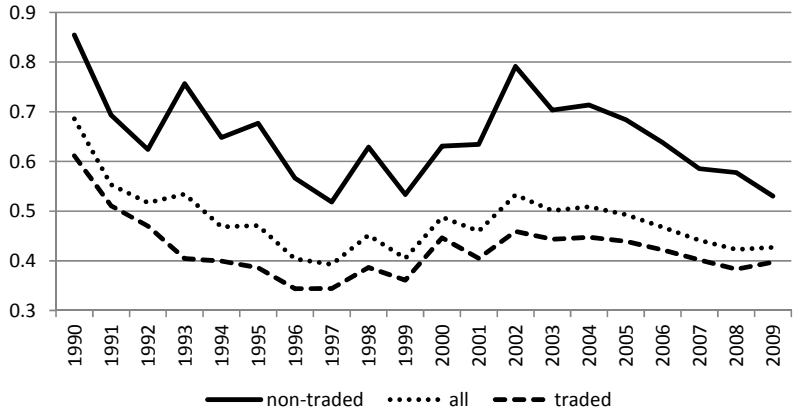


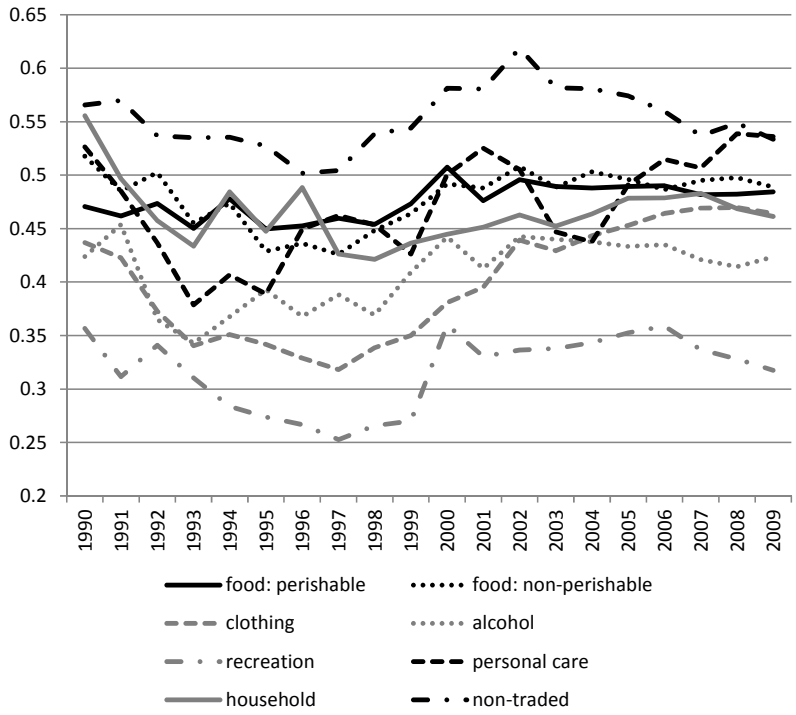
Figure 2.4: Mean square error



absolute value of the relative price itself as a measure of dispersion is, therefore, not appropriate because we are not able to observe the width of the no-arbitrage band and distinguish between the random movement of the relative price inside the band and the change of the width of the band. But, only the second case is a phenomenon that could be explained by changes in external factors.

It is possible to estimate the width of the no-arbitrage band by observing the many realizations of relative prices between two cities and calculating their dispersion. There is, of course, an implicit assumption that the relative price fluctuations use the whole band width. In other words, if due to any reason the prices move in a band narrower than the no-arbitrage band both before and after the change of external factors influencing the costs of arbitrage, as illustrated in Figure 2.2, then even this method fails. Such a situation is, however, very improbable given the level of world market integration as would happen only in the case of immense trade barriers. Both measures of dispersion are formed for ten different product sets: 1) perishable food and non-alcoholic beverages, 2) non-perishable food and non-alcoholic beverages, 3)

Figure 2.5: Standard deviation for different categories



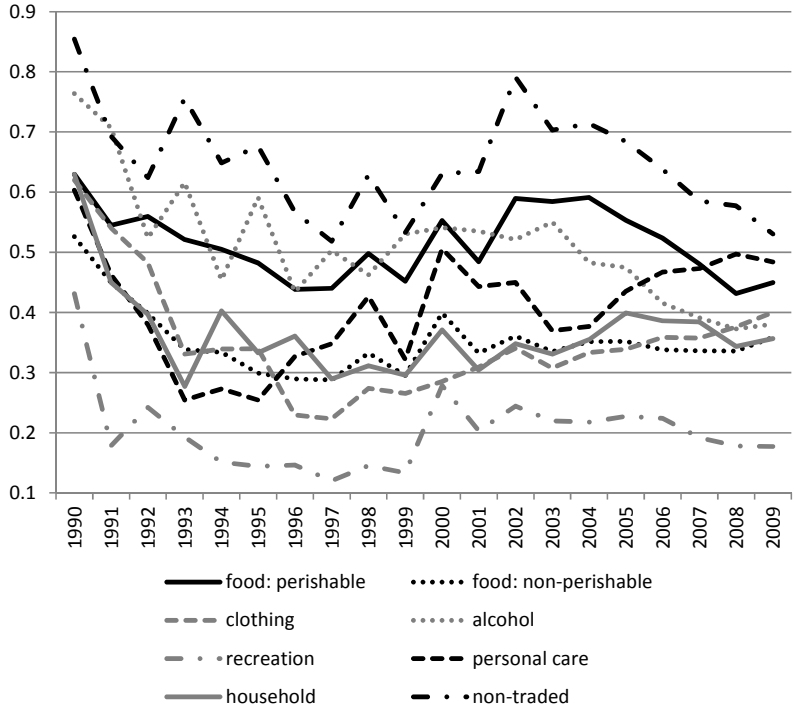
clothing and footwear, 4) alcoholic beverages, 5) recreational products, 6) personal care products, and 7) household supplies together with a few other items form the group of 8) traded goods which, together with 9) non-traded goods and one other item, form group 10) all items.

Figures 2.3 and 2.4 present both dispersion measures averaged over all city pairs, i.e.:

$$\begin{aligned} SD_{\bar{ij},t} &= \sum_{ij \in C} SD_{ij,t}/C_N \\ MSE_{\bar{ij},t} &= \sum_{ij \in C} MSE_{ij,t}/C_N, \end{aligned} \tag{2.4}$$

where C is the set of city pairs, and C_N is the number of available city pairs in time t. A U-pattern is evident for both dispersion measures during the 1990-2002 period, which corresponds to the findings of other authors using micro-data (Engel & Rogers 2004; Wolszczak-Derlacz 2008). Bergin & Glick (2007) find it especially surprising given the rise of Internet usage and the continuous integration of markets leading to higher price transparency. However, as I have explained above, the known existence of a non-zero relative price is only a necessary, but not a sufficient condition for arbitrage to take place. The evidence merely suggests that after a period of arbitrage-costs decrease, since 1997 the zone of no-arbitrage has widened again.

Figure 2.6: Mean square error for different categories



Figures 2.5 and 2.6 show that the rough pattern is also present when disaggregating to individual product groups. Not surprisingly, the highest dispersion over the whole observed period is shown in the group of non-traded goods. On the other hand, the lowest variation in relative prices belongs to the group of recreational products, which is also expected given the items included (Time magazine, paperback novel, or color television).

There is one interesting difference between the two used dispersion measures. At the beginning of the 1990s, a sharp decline in the mean square error is documented which is not mirrored in the standard deviation. The rest of the series development is very similar for both measures. As I mentioned before, the only difference between the two measures is that the standard deviation ignores the mean, i.e. the city-pair fixed effect. Because we averaged across all city pairs, a decline in the mean square error which is not accompanied by a decline in the standard deviation signals that, on average, the no-arbitrage band moved closer to zero without changing its width.

Given the time period, one hypothesis suggests itself: Price levels in countries that opened their markets by the fall of Socialism at the end of 1980s should converge with a higher pace to price levels in other economies. Suppose, for example, that in 1990 all prices in West Germany were higher than in the Czech Republic. If between 1990 and 1991 all prices in the Czech Republic (expressed in ECU) increase by approximately the same proportion, the standard deviation of the relative prices

would remain intact but the mean square error would decrease substantially. And, indeed, the data seem to provide support for this hypothesis. Table 2.1 shows city pairs with the highest differences between the 1993 and 1990 dispersion measured as mean square error. The first 61 positions are occupied by pairs where one of the cities is Warsaw, Prague, or Budapest. No such pattern is observable using the standard deviation.

Table 2.1: Top MSE differences between 1993 and 1990

#	City 1	City 2	Δ MSE	#	City 1	City 2	Δ MSE
1.	Helsinki	Warsaw	2.534066	11.	Barcelona	Warsaw	1.678679
2.	Helsinki	Prague	2.464104	12.	Paris	Warsaw	1.622458
3.	Prague	Stockholm	2.256737		...	...	...
4.	Stockholm	Warsaw	2.236346	40.	Budapest	Helsinki	1.254125
5.	Oslo	Warsaw	2.007358		...	...	...
6.	Warsaw	Zurich	1.997984	48.	Budapest	Stockholm	1.072657
7.	Oslo	Prague	1.979630		...	...	...
8.	London	Warsaw	1.835583	62.	Moscow	Zurich	0.654976
9.	Dublin	Warsaw	1.729069		...	...	...
10.	Prague	Zurich	1.711344	66.	Helsinki	Lisbon	0.602652

2.6 Explaining price dispersion

Authors of existing studies came up with a large number of different variables to explain the excessive cross-border price dispersion. Distance as a proxy for transportation costs is included in all of them. The nominal exchange rate volatility also proved to be positively correlated with price dispersion (Engel & Rogers 2001; Parsley & Wei 2001; Bergin & Glick 2007; Parsley & Wei 2007; Wolszczak-Derlacz 2008). Other factors explaining some part of the border effect are a common language in cities, taxes and income levels in respective countries, as well as the trade intensity between them (Wolszczak-Derlacz 2008).

Tariff rates significantly correlate with price dispersion (Bergin & Glick 2007; Parsley & Wei 2007). Furthermore, the consideration of inputs tradability allows a more precise classification of products, revealing that a part of the dispersion attributed to the existence of borders may be explained by the existence of non-traded inputs, even to highly tradable goods (Crucini *et al.* 2005; Crucini & Shintani 2008). Last but not least, distance is not an ideal proxy for transportation costs because the real costs per unit of distance do not have to be constant in time. The inclusion of a measure of unit transportation costs also explains part of the cross-border price dispersion (Parsley & Wei 2001; Bergin & Glick 2007).

I will focus on the neglected role of institutions influencing the business environment, as explained in Section 2.3, and will control for the usual variable – the distance

between cities. As a robustness check, I will control for potential non-institutional sources of the variation in the institutional quality measure.

The distance between cities is used as a proxy variable for transportation costs, which are expected to influence the width of the no-arbitrage zone. I calculate the distance between cities using the great circle formula. The problem of distance as a proxy for transportation costs is not only the absence of unit costs, but also the fact that types of transport, as well as the quality of infrastructure can drastically vary case to case. Some kind of effective distance measure would be more appropriate. However, due to data limitations, simple geographical distance is used.

All six available measures of institutional quality from the WGI project are highly correlated, with the lowest correlation coefficient over 88%. Based on the theory presented in Section 2.3, the regulatory quality measure should best represent the analyzed quality of economic institutions. According to Kaufmann *et al.* (2010, p. 4), it captures "perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development" (see Table 2.A4 for definitions of the other variables). In order to test this hypothesis, I ran the regression (2.5) with the standard deviation as the dependent variable and with each of the six institutional measures in place of the institutional explanatory variable. Appendix Table 2.A5 shows that the regulatory quality measure is indeed able to explain the largest part of the variation in the price dispersion. The regulatory quality measure also has the largest estimated coefficient, even after rescaling all of the institutional measures to [0-1] variables.

The regulatory quality from the WGI project is therefore used as an institutional quality measure. Until 2002 the indexes were calculated only every other year. The values in 1997, 1999, and 2001 are averages of the value in the previous and the following year. For each city pair, the institutional measure is constructed as a plain sum of levels attributed to the countries in which the cities are located. The higher value of institutional measure indicates better institutional quality, which means that the ability of the government to implement sound policies and regulations that permit and promote private sector development is perceived to be higher compared to other governments. A better quality of institutions is expected to be correlated with lower price dispersion because good regulations lower the expected costs of entrepreneurial activity, making the costs of arbitrage smaller.

The standard deviation and mean square error of traded goods are used as dependent variables:

$$X_{ij,t} = \alpha_0 + \alpha_1 \ln(distance)_{ij} + \alpha_2 border_{ij} + \alpha_3 institutions_{ij,t} + \sum_{t=1997}^{2009} \beta_t Y_t + \epsilon_{ij,t}, \tag{2.5}$$

where $X_{ij,t}$ is either $SD_{ij,t}$, or $MSE_{ij,t}$ and Y_t are year fixed effects to capture the time-varying factors influencing all city pairs. Variance is clustered on the country-pair level to allow for intra-group correlation. All estimates are done using the OLS estimator.

Table 2.2 presents the regressions results. Column 1 shows a regression with the standard deviation as the price dispersion measure, Column 2 shows results when using the mean square error. In both cases the coefficients are highly significant and have expected signs. Cities further apart and those separated by a national border have a higher price dispersion. The institutions effect is not only statistically significant but also economically relevant. Only the change of the regulatory quality variable in 2009 when switching from the Prague–St. Petersburg to Prague–Stockholm pair induces a decrease in the price dispersion measured as the standard deviation by 0.108, which is almost one standard deviation of the measure. This result confirms the hypothesis formulated in Section 2.3.

I plot the coefficients for year dummies to see whether the used explanatory variables are sufficient to model the pattern observed in the price dispersion measures. Figures 2.7 and 2.8 show that the pattern is still observable. To formally test it, I replace the year dummies with a quadratic time trend.

Column 3 of Table 2.2 reports that the time trend is statistically significant and forms a parabola opened down with its peak in 2004. Qualitatively the same results are obtained when using the mean square error as the dispersion measure, and are, therefore, not reported.

On the one hand, the role of institutions should be more important in the case of cross-border city pairs. No special permission in most cases is needed to trade among cities inside one country. It is, therefore, not necessary to communicate with the regulatory authorities in such cases. Moreover, existing retailers already buy their goods from some wholesalers in their countries. Switching to a different wholesaler or arbitrage from another retailer in the case of lower prices and, as a consequence, higher profit margins shouldn't be a complicated process dependent on institutional quality.

On the other hand, trade across borders is connected with significantly larger risks. The arbitrageurs have to deal with people they don't know, often with completely dissimilar cultural backgrounds. They cannot use the social networks they use in their domestic country. They have to be familiarized with unknown regulations and deal with customs and tax officers. In a nutshell, when trading across national borders, institutional quality should become much more important. To test this hypothesis, I add an interaction term *border* × *regulatory quality* among the explanatory variables. Columns 4 and 5 in Table 2.2 present the results of this amended regression. The interaction term is significant and negative for both specifications, which is consistent with the theoretical expectation. However, it has to be kept in

Table 2.2: Regression results

Dependent variable:	(1) SD	(2) MSE	(3) SD	(4) SD	(5) MSE	(6) SD	(7) MSE	(8) SD	(9) SD	(10) MSE
Regulatory quality	−0.051***	−0.093***	−0.051***	0.015	0.004			−0.048***	−0.045***	−0.076***
	(0.003)	(0.008)	(0.003)	(0.010)	(0.010)			(0.005)	(0.006)	(0.014)
Border × reg. quality				−0.067***	−0.098***					
				(0.010)	(0.012)					
Diff. in regulatory quality						0.080***	0.155***			
						(0.005)	(0.013)			
Border	0.105**	0.107**	0.105**	0.275***	0.355***	0.078**	0.055*	0.105**	0.088***	0.034
	(0.044)	(0.050)	(0.043)	(0.028)	(0.035)	(0.032)	(0.029)	(0.043)	(0.028)	(0.027)
Log distance	0.047***	0.074***	0.047***	0.047***	0.073***	0.040***	0.056***	0.047***	0.069***	0.123***
	(0.006)	(0.013)	(0.006)	(0.006)	(0.013)	(0.005)	(0.012)	(0.006)	(0.006)	(0.014)
Year			3.841***							
			(0.332)							
Year^2			−0.001***							
			(0.000)							
GDP per capita								−0.222		
								(0.264)		
City fixed effects									✓	✓
Observations	10,088	10,088	10,088	10,088	10,088	10,088	10,088	9,955	10,088	10,088
Adjusted R^2	0.527	0.321	0.522	0.534	0.324	0.548	0.356	0.526	0.696	0.561

Notes: Robust standard errors in parentheses; variance is clustered at the country-pair level. All specifications but (3) include year fixed effects. Year effects are plotted in Figures 2.7 and 2.8.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 2.7: Year fixed effects (incl. 95% conf. int.), specification (1)

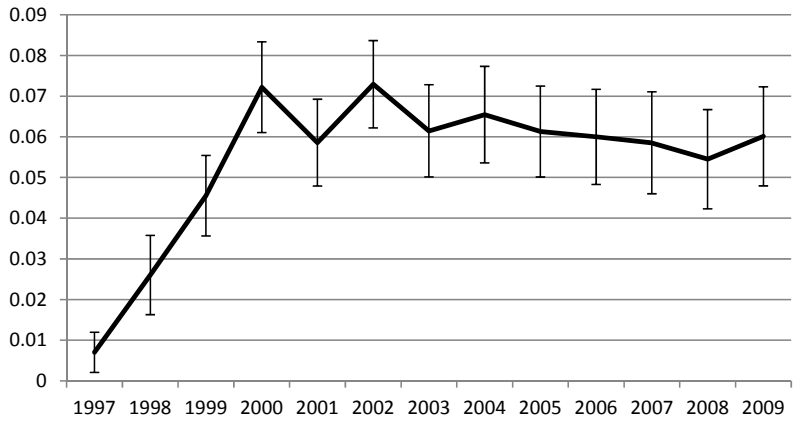
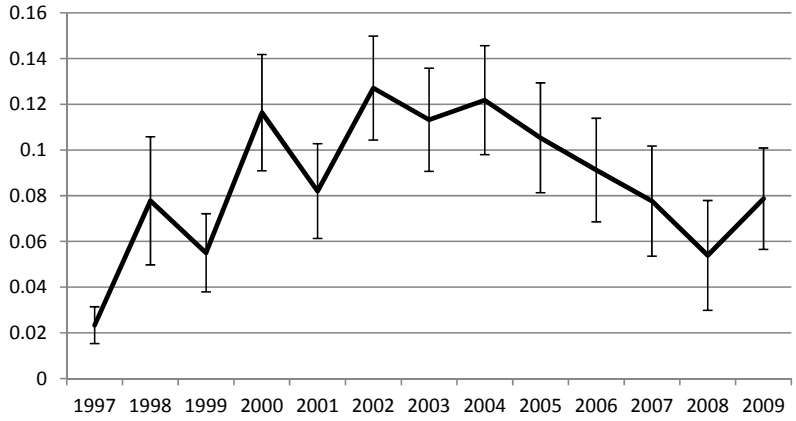


Figure 2.8: Year fixed effects (incl. 95% conf. int.), specification (2)



mind that the number of city pairs within one country is very small (222) compared to the number of cross-border city pairs, which can also cause the loss of significance of the original regulatory quality explanatory variable.

2.7 Robustness checks

Appendix Table 2.A6 reports the results for individual product categories. All of them show the significant impact of border and institutional quality on price dispersion. Distance is also significant in all but two cases. However, certain categories have a very low R-squared which indicates that the model used to explain the extent of price dispersion is not very suitable for these categories. A low goodness of fit can have two sources: First, the width of the no-arbitrage band may be incorrectly identified, since the number of included items is very limited in categories other than perishable and non-perishable food, clothing, and non-traded goods. And second, some categories of products may have a specific process of price setting which is not

captured by the model. This could be the case of alcoholic beverages which have, together with personal care products, a larger estimated border effect than non-traded goods.

Many authors include city fixed effects to their regressions. Results with city fixed effects are in Columns 9 and 10 in Table 2.2. The impact of institutional quality is still statistically significant for both dispersion measures, but the border loses its explanatory power when using the mean square error measure. Given the fact that the only difference between the measures is that the mean square error includes city-pair fixed effects, the city fixed effects probably are able to explain a large part of them and take on the explanatory power of the border.

The robustness of the proposed model is also checked by including the GDP per capita as a measure of the respective country's wealth. The reason is that the model could suffer from endogeneity – the wealth of the country could influence both the price dispersion and the quality of institutions. It is true that the GDP per capita and the quality of institutions are highly correlated; their correlation coefficient is above 0.73. However, the GDP per capita is able to explain only 54.3% of the variation in the quality of institutions. And as Column 8 in Table 2.2 shows, including the GDP per capita doesn't remove the explanatory power of the institutional quality.

As described above, the regulatory quality measure for each city pair is constructed as a sum of both cities' indicators. The reason for this is that we expect city pairs with better institutions, conditional on their distance, to be more arbitrage-friendly, thereby with lower differences in the prices of traded products. One other approach of estimating the role of institutions is, however, also possible: we can, instead of sums, look at differences in institutional quality. The larger the difference, the more dispersed the prices should be.

To illustrate this idea in an example, suppose we choose two cities, e.g. Dublin and Moscow. If there are better quality institutions in Dublin, then the deviations from the LOP should be smaller there than in Moscow, where the institutional quality is lower, because Dublin is easily accessible for arbitrage activities. As a consequence, relative prices should be more dispersed between these two cities, conditional on distance and other factors, than between e.g. Dublin and Berlin.

Columns 6 and 7 in Table 2.2 report the results for the regression where for each city pair the sum of institutional indicators is replaced with their absolute-value difference. Regardless of the dispersion measure used, the impact of differences in institutional quality is significant and of expected direction.

Moreover, including both the sum and the difference of regulatory quality measure simultaneously reveals (see Column 1 in Table 2.A7) that the lowest price dispersion is among cities which not only have the best regulatory quality, but also, at the same time, achieved similar quality levels. In other words, not only level, but also distribution matters. In a hypothetical situation of two cities with regulatory quality

of 0.5, the impact on price dispersion would be $(0.5+0.5)\times(0.014-0.045)+|0.5-0.5|\times 0.053 = -0.031$, whereas for one city with regulatory quality 1 and the other with 0, the impact on price dispersion would be 0.022. Even though the average institutional quality is the same, the larger "institutional distance" causes significantly higher price dispersion.

To make sure the results are not driven by upward-biased prices in transition countries (Filer & Hanousek 2000), Column 2 in Table 2.A7 shows the result of estimating Equation 2.5 with city, year, and city×year interaction dummies. These should capture all city-related fixed effects, including a different level of goods quality or prices, and their development over time. The effect of regulatory quality on price dispersion is even stronger in this specification, even though the additional effect of being from two different countries loses significance. If goods in one city share a similar level of quality, such finding confirms the expectation that potential quality differences do not qualitatively change the results of the analysis.

Column 3 in Table 2.A7 reports the result of specification without any institutional measures. Interestingly, the border dummy coefficient doesn't increase, but the explanatory power of the model decreases sizably.

We might also be interested in a more detailed analysis of the various aspects of the institutional framework. In order to test the robustness of the findings, I used a number of indicators provided by the World Bank.[6] Columns 1 and 2 of Appendix Table 2.A8 present the results of regressions with five additional explanatory variables rescaled to [0-1] to allow a comparison of the size of their impact. The tertiary school enrollment rate is chosen to test whether the used aggregate institutional quality indicator isn't only a proxy for the level of development of the economy. The other used variables capture tax and the tax administration burden, tariffs, and importation costs. Even though it is revealed that the school enrollment rate and some of the other variables do play a significant role in explaining deviations from the LOP, the regulatory quality is still statistically significant and of expected sign.

Only after adding the importation time as another independent variable, the explanatory power of the regulatory quality disappears regardless of the dispersion measure used as reported in Columns 3 and 4 of Appendix Table 2.A8. However, importation time captures the time needed for importing a 20-ft container load of general cargo and includes the waiting time at a border or seaport, the handling of the container, customs and technical/health clearance time, and transportation to a warehouse. Therefore, it also contains an institutional aspect and it is not surprising that the time to import is able to explain the part of the LOP deviation caused by differences in institutional quality. This finding doesn't refute the fact that institutional quality matters.

[6] All variables used are described in Appendix Table 2.A4.

2.8 Conclusion

Building on the literature on the effects of national borders on deviations from the law of one price, I formulate the hypothesis that arbitrage is not an automatic equilibrating process, but rather an entrepreneurial activity. I argue that once we understand arbitrage as a productive entrepreneurial activity, institutional quality should be one of the determinants of arbitrage attractiveness and should, therefore, influence international price dispersion.

To test this hypothesis, I express the quality of institutions as one of the factors influencing the total costs of the arbitrage. The regression analysis of the data in the 1996–2009 period proves that institutional quality explains a significant part of the observed price dispersion defined either as a standard deviation or mean square error. I find that the better are the institutions, the lower is the predicted dispersion. This shows that institutional quality explains another part of the price dispersion previously attributed solely to the existence of borders. The result is robust to changes in the specification of the estimated model.

The major disadvantage of the institutional quality measure used is its high level of aggregation, which can lead to endogeneity and misidentification problems. Nevertheless, the fact that the regulatory quality indicator is able to explain more of the variation in the price dispersion than any of the other Worldwide Governance Indicators is consistent with the central hypothesis of this paper introduced in Section 2.3. Furthermore, the effect of the regulatory quality on the price dispersion is robust to the addition of variables explaining the general level of the development of the economy, and also stays significant when the tax and tax administration burden, tariffs and importation costs are included as explanatory variables.

The hypothesis that institutional quality influences the extent of the deviations from the LOP through the costs of arbitrage is further confirmed by the fact that the explanatory power of regulatory quality is lost only when the importation time is added to the set of explanatory variables. The reason is that this variable incorporates, for example, customs and technical/health clearance time which is expected to be correlated with the overall institutional quality of the respective country. Furthermore, it has to be admitted that due to data availability limitations it was not possible to directly verify the link through entrepreneurship even though the obtained results are consistent not only with the existence of such a link, but also with the empirical literature on entrepreneurship confirming the impact of institutions on entrepreneurial activity.

References

Aidis, R. & S. Estrin (2006): "Institutions, networks and entrepreneurship development in Russia: an exploration." *WDI Working Papers 833*, William Davidson Institute, University of Michigan.

Allington, N. F. B., P. A. Kattuman, & F. A. Waldmann (2005): "One Market, One Money, One Price?" *International Journal of Central Banking* **1(3)**: pp. 73–115.

Anderson, J. E. (2000): "Why Do Nations Trade (So Little)?" *Pacific Economic Review* **5(2)**: pp. 115–134.

Anderson, M. A. & S. Smith (1999): "Do National Borders Really Matter? Canada-US Regional Trade Reconsidered." *Review of International Economics* **7(2)**: pp. 219–227.

Baumol, W. J. (1990): "Entrepreneurship: Productive, Unproductive, and Destructive." *The Journal of Political Economy* **98(5)**: pp. 893–921.

Baumol, W. J., R. E. Litan, & C. J. Schramm (2007): *Good Capitalism, Bad Capitalism, and the Economics of Growth and Prosperity*. Yale University Press.

Bergin, P. R. & R. Glick (2007): "Global price dispersion: Are prices converging or diverging?" *Journal of International Money and Finance* **26(5)**: pp. 703–729.

Broda, C. & D. E. Weinstein (2008): "Understanding International Price Differences Using Barcode Data." *NBER Working Paper 14017*, National Bureau of Economic Research, Cambridge, MA.

Cavallo, A., B. Neiman, & R. Rigobon (2014): "Currency Unions, Product Introductions, and the Real Exchange Rate." *The Quarterly Journal of Economics* **129(2)**: pp. 529–595.

Chen, N. (2004): "Intra-national versus international trade in the European Union: why do national borders matter?" *Journal of International Economics* **63(1)**: pp. 93–118.

Crucini, M. J. & M. Shintani (2008): "Persistence in law of one price deviations: Evidence from micro-data." *Journal of Monetary Economics* **55(3)**: pp. 629–644.

Crucini, M. J., M. Shintani, & T. Tsuruga (2008): "Accounting for Persistence and Volatility of Good-Level Real Exchange Rates: The Role of Sticky Information." *NBER Working Paper 14381*, National Bureau of Economic Research, Cambridge, MA.

Crucini, M. J., C. I. Telmer, & M. Zachariadis (2005): "Understanding European Real Exchange Rates." *American Economic Review* **95(3)**: pp. 724–738.

Engel, C. & J. H. Rogers (1996): "How Wide Is the Border?" *American Economic Review* **86(5)**: pp. 1112–1125.

Engel, C. & J. H. Rogers (2001): "Deviations from purchasing power parity: causes and welfare costs." *Journal of International Economics* **55(1)**: pp. 29–57.

Engel, C. & J. H. Rogers (2004): "European product market integration after the euro." *Economic Policy* **19(39)**: pp. 347–384.

Engel, C., J. H. Rogers, & S.-Y. Wang (2003): "Revisiting the Border: An Assessment of the Law of One Price Using Very Disaggregated Consumer Price Data." *International Finance Discussion Papers 777*, Board of Governors of the Federal Reserve System, Washington, DC.

Filer, R. K. & J. Hanousek (2000): "Output Changes and Inflationary Bias in Transition." *Economic Systems* **24(3)**: pp. 285–294.

Glick, R. & A. K. Rose (2016): "Currency unions and trade: A post-EMU reassessment." *European Economic Review* **87**: pp. 78–91.

Goldberg, P. K. & F. Verboven (2005): "Market integration and convergence to the Law of One Price: evidence from the European car market." *Journal of International Economics* **65(1)**: pp. 49–73.

Gopinath, G., P.-O. Gourinchas, C.-T. Hsieh, & N. Li (2009): "Estimating the Border Effect: Some New Evidence." *CEPR Discussion Paper 7281*, Centre for Economic Policy Research, London.

Gorodnichenko, Y. & L. L. Tesar (2009): "Border Effect or Country Effect? Seattle May Not Be So Far from Vancouver After All." *American Economic Journal: Macroeconomics* **1(1)**: pp. 219–241.

Havránek, T. (2010): "Rose effect and the euro: is the magic gone?" *Review of World Economics* **146(2)**: pp. 241–261.

Head, K. & T. Mayer (2002): "Illusory Border Effects: Distance Mismeasurement Inflates Estimates of Home Bias in Trade." *CEPII Discussion Paper 02-01*, Centre d'Études Prospectives et d'Informations Internationales, Paris.

Helliwell, J. F. (1996): "Do national borders matter for Quebec's trade?" *Canadian Journal of Economics* **29(3)**: p. 507.

Helliwell, J. F. (1997): "National Borders, Trade and Migration." *Pacific Economic Review* **2(3)**: pp. 165–185.

Hillberry, R. & D. Hummels (2003): "Intranational Home Bias: Some Explanations." *Review of Economics & Statistics* **85(4)**: pp. 1089–1092.

Horváth, J., A. Rátfai, & B. Döme (2008): "The border effect in small open economies." *Economic Systems* **32(1)**: pp. 33–45.

Hsu, C. L. (2005): "Capitalism without contracts versus capitalists without capitalism: Comparing the influence of Chinese guanxi and Russian blat on marketization." *Communist and Post-Communist Studies* **38(3)**: pp. 309–327.

Imbs, J., H. Mumtaz, M. O. Ravn, & H. Rey (2005): "PPP Strikes Back: Aggregation and the Real Exchange Rate." *Quarterly Journal of Economics* **120(1)**: pp. 1–43.

Kaufmann, D., A. Kraay, & M. Mastruzzi (2010): "The Worldwide Governance Indicators: Methodology and Analytical Issues." *Policy Research Working Paper 5430*, World Bank, Washington, DC.

Kirzner, I. M. (1997): "Entrepreneurial Discovery and the Competitive Market Process: An Austrian Approach." *Journal of Economic Literature* **35(1)**: pp. 60–85.

McCallum, J. (1995): "National Borders Matter: Canada-U.S. Regional Trade Patterns." *American Economic Review* **85(3)**: pp. 615–623.

Parsley, D. C. & S.-J. Wei (2001): "Explaining the border effect: the role of exchange rate variability, shipping costs, and geography." *Journal of International Economics* **55(1)**: pp. 87–105.

Parsley, D. C. & S.-J. Wei (2007): "A Prism into the PPP Puzzles: The Micro-Foundations of Big Mac Real Exchange Rates." *The Economic Journal* **117(523)**: pp. 1336–1356.

Rogers, J. H. (2002): "Monetary Union, Price Level Convergence, and Inflation: How Close is Europe to the United States?" *International Finance Discussion Papers 740*, Board of Governors of the Federal Reserve System, Washington, DC.

Rogoff, K. (1996): "The Purchasing Power Parity Puzzle." *Journal of Economic Literature* **34(2)**: pp. 647–668.

Rose, A. K. (2000): "One money, one market: the effect of common currencies on trade." *Economic Policy* **15(30)**: pp. 7–46.

Sobel, R. S. (2008): "Testing Baumol: Institutional quality and the productivity of entrepreneurship." *Journal of Business Venturing* **23(6)**: pp. 641–655.

de Sousa, J. & J. Lochard (2005): "Do Currency Barriers Solve the Border Effect Puzzle? Evidence from the CFA Franc Zone." *Review of World Economics/Weltwirtschaftliches Archiv* **141(3)**: pp. 422–441.

Sundqvist, S., K. Kyläheiko, O. Kuivalainen, & J. W. Cadogan (2012): "Kirznerian and Schumpeterian entrepreneurial-oriented behavior in turbulent export markets." *International Marketing Review* **29(2)**: pp. 203–219.

Volckart, O. & N. Wolf (2006): "Estimating Financial Integration in the Middle Ages: What Can We Learn from a TAR Model?" *The Journal of Economic History* **66(01)**: pp. 122–139.

Wei, S.-J. (1996): "Intra-National Versus International Trade: How Stubborn Are Nations in Global Integration?" *NBER Working Paper 5531*, National Bureau of Economic Research, Cambridge, MA.

Wolf, H. C. (2000): "Intranational Home Bias in Trade." *Review of Economics & Statistics* **82(4)**: pp. 555–563.

Wolszczak-Derlacz, J. (2008): "Price convergence in the EU—an aggregate and disaggregate approach." *International Economics and Economic Policy* **5(1)**: pp. 25–47.

Wolszczak-Derlacz, J. (2010): "Does One Currency Mean One Price?" *Eastern European Economics* **48(2)**: pp. 87–114.

Wu, J. & S. Huang (2006): "The entrepreneurship and institutions: a perspective to interpret China's economic growth in its transformation." In "American Economic Association Meeting - William Baumol Special Session on Entrepreneurship, Innovation and Growth III: International Approach," .

2.A Appendix

Table 2.A1: Cities in sample

Almaty	*Kazakhstan*	Geneva	*Switzerland*	Moscow	*Russia*
Amsterdam	*Netherlands*	Hamburg	*Germany*	Oslo	*Norway*
Athens	*Greece*	Helsinki	*Finland*	Prague	*Czech Rep.*
Baku	*Azerbaijan*	Istanbul	*Turkey*	Paris	*France*
Barcelona	*Spain*	Copenhagen	*Denmark*	Rome	*Italy*
Berlin	*Germany*	Kiev	*Ukraine*	Reykjavik	*Iceland*
Belgrade	*Serbia*	London	*UK*	Sofia	*Bulgaria*
Bratislava	*Slovakia*	Lisbon	*Portugal*	St. Petersburg	*Russia*
Brussels	*Belgium*	Luxembourg	*Luxembourg*	Stockholm	*Sweden*
Bucharest	*Romania*	Lyon	*France*	Tashkent	*Uzbekistan*
Budapest	*Hungary*	Madrid	*Spain*	Vienna	*Austria*
Dublin	*Ireland*	Manchester	*UK*	Warsaw	*Poland*
Düsseldorf	*Germany*	Milan	*Italy*	Zurich	*Switzerland*
Frankfurt	*Germany*	Munich	*Germany*		

Table 2.A2: Non-traded items in sample

Non-traded	Moderate hotel, single room, one night including breakfast	Taxi rate per additional kilometre
Laundry (one shirt)	Babysitter's rate per hour	One drink at bar of first class hotel
Dry cleaning, man's suit	Cost of developing 36 colour pictures	Two-course meal for two people
Dry cleaning, woman's dress	Daily local newspaper	Simple meal for one person
Dry cleaning, trousers	Three-course dinner for four people	Fast food snack: hamburger, fries and drink
Man's haircut (tips included)	Four best seats at theatre or concert	Hire car, weekly rate for lowest price classification
Woman's cut & blow dry (tips included)	Four best seats at cinema	Hire car, weekly rate for moderate price classification
Telephone and line, monthly rental	Cost of a tune-up (but no major repairs) (low)	
Hourly rate for domestic cleaning help	Cost of a tune-up (but no major repairs) (high)	*Not included in the category*
Maid's monthly wages (full time)	Regular unleaded petrol (1 l)	Telephone, charge per local call from home (3 mins)
Business trip, typical daily cost	Taxi: initial meter charge	
Hilton-type hotel, single room, one night including breakfast		

Table 2.A3: Traded items in sample

Food and non-alcoholic beverages: perishable	Peanut or corn oil (1 l)	Gin, Gilbey's or equiv. (700 ml)
White bread (1 kg)	Peas, canned (250 g)	Vermouth, Martini & Rossi (1 l)
Butter (500 g)	Tomatoes, canned (250 g)	Cognac, French VSOP (700 ml)
Margarine (500 g)	Peaches, canned (500 g)	Liqueur, Cointreau (700 ml)
Spaghetti (1 kg)	Sliced pineapples, can (500 g)	
Flour, white (1 kg)	Chicken: frozen (1 kg)	*Recreation*
Sugar, white (1 kg)	Frozen fish fingers (1 kg)	Compact disc album
Cheese, imported (500 g)	Instant coffee (125 g)	Television, colour (66 cm)
Cornflakes (375 g)	Ground coffee (500 g)	Kodak colour film (36 expos)
Milk, pasteurised (1 l)	Tea bags (25 bags)	International foreign daily newspaper
Potatoes (2 kg)	Cocoa (250 g)	International weekly news magazine (Time)
Onions (1 kg)	Drinking chocolate (500 g)	Paperback novel (at bookstore)
Tomatoes (1 kg)	Coca-Cola (1 l)	
Carrots (1 kg)	Tonic water (200 ml)	*Personal care*
Oranges (1 kg)	Mineral water (1 l)	Aspirins (100 tablets)
Apples (1 kg)		Razor blades (five pieces)
Lemons (1 kg)	*Clothing and footwear*	Toothpaste with fluor. (120 g)
Bananas (1 kg)	Business suit, two piece, medium weight	Facial tissues (box of 100)
Lettuce (one)	Business shirt, white	Hand lotion (125 ml)
Eggs (12)	Men's shoes, business wear	Lipstick (deluxe type)
Beef: filet mignon (1 kg)	Men's raincoat, Burberry type	
Beef: steak, entrecote (1 kg)	Socks, wool mixture	*Household supplies*
Beef: stewing, shoulder (1 kg)	Dress, ready to wear, daytime	Soap (100 g)
Beef: roast (1 kg)	Women's shoes, town	Laundry detergent (3 l)
Beef: ground or minced (1 kg)	Women's cardigan sweater	Toilet tissue (two rolls)
Veal: chops (1 kg)	Women's raincoat, Burberry type	Dishwashing liquid (750 ml)
Veal: fillet (1 kg)	Tights, panty hose	Insect-killer spray (330 g)
Veal: roast (1 kg)	Child's jeans	Light bulbs (two, 60 watts)
Lamb: leg (1 kg)	Child's shoes, dresswear	Batteries (two, size D/LR20)
Lamb: chops (1 kg)	Child's shoes, sportswear	Frying pan (Teflon or good equivalent)
Lamb: stewing (1 kg)	Girl's dress	Electric toaster (for two slices)
Pork: chops (1 kg)	Boy's jacket, smart	
Pork: loin (1 kg)	Boy's dress trousers	*Not included in any category*
Ham: whole (1 kg)		Yoghurt, natural (150 g)
Bacon (1 kg)	*Alcoholic beverages*	Mushrooms (1 kg)
Chicken: fresh (1 kg)	Wine, common table (1 l)	Shampoo & conditioner in one (400 ml)
Fresh fish (1 kg)	Wine, superior quality (700 ml)	
Orange juice (1 l)	Wine, fine quality (700 ml)	
	Beer, local brand (1 l)	
Food and non-alcoholic beverages: non-perishable	Beer, top quality (330 ml)	
White rice (1 kg)	Scotch whisky, 6 y old (700 ml)	
Olive oil (1 l)		

Table 2.A4: Description of used variables

Variable	Description	N	Mean	SD
Border	A dummy variable indicating whether the two cities in question have a national border between them. 12,696 city pairs do, 308 don't.	13,004		
SD	Standard deviation of relative log prices across all traded products for a given pair of cities. Source: EIU	13,004	0.529	0.121
MSE	Mean square error of relative log prices across all traded products for a given pair of cities. Source: EIU	13,004	0.421	0.298
Distance	Geographical distance between cities.	13,004	7.121	0.709
Voice and accountability	Dimension of governance from the WGI. Captures to which extent a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media. Ranging from -2.5 (worst/least) to 2.5 (best/most). For each city pair the sum of levels attributed to the respective countries is calculated. Source: WGI	10,088	1.840	1.175
Political stability	Dimension of governance from the WGI. Captures likelihood that the government will be destabilized or overthrown by unconstitutional or violent means. Ranging from -2.5 (largest) to 2.5 (smallest). For each city pair the sum of levels attributed to the respective countries is calculated. Source: WGI	10,088	1.243	1.067

Table 2.A4: Description of used variables (continued)

Variable	Description	N	Mean	SD
Government effectiveness	Dimension of governance from the WGI. Captures the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Ranging from -2.5 (worst) to 2.5 (best). For each city pair the sum of levels attributed to the respective countries is calculated. Source: WGI	10,088	2.217	1.318
Control of corruption	Dimension of governance from the WGI. Captures the ability of the government to control corruption. Ranging from -2.5 (worst) to 2.5 (best). For each city pair the sum of levels attributed to the respective countries is calculated. Source: WGI	10,088	2.116	1.535
Rule of law	Dimension of governance from the WGI. Captures the quality of contract enforcement, the police, the courts, and the likelihood of crime and violence. Ranging from -2.5 (lowest quality/highest likelihood) to 2.5 (highest quality/lowest likelihood). For each city pair the sum of levels attributed to the respective countries is calculated. Source: WGI	10,088	1.961	1.349
Regulatory quality	Dimension of governance from the WGI. Captures the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Ranging from -2.5 (worst) to 2.5 (best). For each city pair the sum of levels attributed to the respective countries is calculated. Source: WGI	10,088	1.935	1.130

Table 2.A4: Description of used variables (continued)

Variable	Description	N	Mean	SD
Diff. in reg. quality	See above. For each city pair an absolute-value difference of levels attributed to the respective countries is calculated. Source: WGI	10,088	0.841	0.792
School enrollment, tertiary	Gross enrollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Tertiary education, whether or not to an advanced research qualification, normally requires, as a minimum condition of admission, the successful completion of education at the secondary level. For each city pair the sum of levels attributed to the respective countries is calculated. Source: UNESCO Institute for Statistics	9,015	96.377	27.779
Total tax rate	Total tax rate measures the amount of taxes and mandatory contributions payable by businesses after accounting for allowable deductions and exemptions as a share of commercial profits. Taxes withheld (such as personal income tax) or collected and remitted to the tax authorities (such as value added taxes, sales taxes or goods and service taxes) are excluded. For each city pair the sum of levels attributed to the respective countries is calculated. Source: World Bank	3,981	97.197	20.259
Time to prepare and pay taxes	Time to prepare and pay taxes is the time, in hours per year, it takes to prepare, file, and pay (or withhold) three major types of taxes: the corporate income tax, the value added or sales tax, and labor taxes, including payroll taxes and social security contributions. For each city pair the sum of levels attributed to the respective countries is calculated. Source: World Bank	3,981	561.246	400.458

Table 2.A4: Description of used variables (continued)

Variable	Description	N	Mean	SD
Tariff rate	Simple mean applied tariff is the unweighted average of the effectively applied rates for all products subject to tariffs calculated for all traded goods. For each city pair the sum of levels attributed to the respective countries is calculated. Source: World Bank	10,056	7.418	3.218
Importation costs	Cost measures the fees levied on a 20-foot container in U.S. dollars. All the fees associated with completing the procedures to export or import the goods are included. These include costs for documents, administrative fees for customs clearance and technical control, customs broker fees, terminal handling charges and inland transport. The cost measure does not include tariffs or trade taxes. Only official costs are recorded. For each city pair the sum of levels attributed to the respective countries is calculated. Source: World Bank	3,981	2,552.818	977.335
Importation time	Time is recorded in calendar days. The time calculation for a procedure starts from the moment it is initiated and runs until it is completed. If a procedure can be accelerated for an additional cost, the fastest legal procedure is chosen. It is assumed that neither the exporter nor the importer wastes time and that each commits to completing each remaining procedure without delay. Procedures that can be completed in parallel are measured as simultaneous. The waiting time between procedures – for example, during the unloading of cargo – is included in the measure. For each city pair the sum of levels attributed to the respective countries is calculated. Source: World Bank	3,981	37.713	26.691
GDP per capita	PPP GDP per capita in current international dollar. Source: IMF	9,955	49,062.32	18,255.91

Table 2.A4: Description of used variables (continued)

Variable	Description	N	Mean	SD
SD of food: perishable	Standard deviation of relative log prices across perishable food items for a given pair of cities. Source: EIU	13,004	0.478	0.125
SD of food: non-perishable	Standard deviation of relative log prices across non-perishable food items for a given pair of cities. Source: EIU	13,004	0.482	0.126
SD of clothing	Standard deviation of relative log prices across clothing and footwear items for a given pair of cities. Source: EIU	12,886	0.408	0.120
SD of alcohol	Standard deviation of relative log prices across alcoholic beverages for a given pair of cities. Source: EIU	12,973	0.414	0.162
SD of recreation	Standard deviation of relative log prices across recreation products for a given pair of cities. Source: EIU	13,004	0.320	0.177
SD of personal	Standard deviation of relative log prices across personal care products for a given pair of cities. Source: EIU	12,973	0.477	0.233
SD of household	Standard deviation of relative log prices across household supplies items for a given pair of cities. Source: EIU	13,004	0.464	0.143
SD of non-traded	Standard deviation of relative log prices across non-traded items for a given pair of cities. Source: EIU	13,004	0.556	0.186
SD of all	Standard deviation of relative log prices across all items for a given pair of cities. Source: EIU	13,004	0.554	0.140

Table 2.A5: Worldwide Governance Indicators' explanatory power

Dependent variable: SD	(1)	(2)	(3)	(4)	(5)	(6)
Control of corruption	−0.032***					
	(0.002)					
Rule of law		−0.038***				
		(0.003)				
Regulatory quality			−0.051***			
			(0.003)			
Government effectiveness				−0.042***		
				(0.003)		
Political stability					−0.042***	
					(0.003)	
Voice and accountability						−0.049***
						(0.003)
Border	0.092**	0.098**	0.105**	0.098**	0.105**	0.110**
	(0.046)	(0.044)	(0.044)	(0.043)	(0.043)	(0.043)
Log distance	0.058***	0.054***	0.047***	0.052***	0.060***	0.045***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)
Observations	10,088	10,088	10,088	10,088	10,088	10,088
Adjusted R^2	0.489	0.500	0.527	0.520	0.462	0.523

Notes: Robust standard errors in parentheses; variance is clustered at the country-pair level. All specifications include year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.A6: Robustness checks: individual product categories

Dependent variable:	(1) SD of food: perishable	(2) SD of food non-perishable	(3) SD of clothing	(4) SD of alcohol	(5) SD of recreation	(6) SD of personal	(7) SD of household	(8) SD of non-traded	(9) SD of all
Regulatory quality	0.022**	0.014**	−0.033***	0.013*	−0.002	0.038***	0.051***	0.006	0.013
	(0.010)	(0.007)	(0.007)	(0.007)	(0.008)	(0.013)	(0.016)	(0.004)	(0.009)
Border × reg. quality	−0.068***	−0.052***	0.001	−0.080***	−0.083***	−0.112***	−0.058***	−0.076***	−0.076***
	(0.010)	(0.008)	(0.008)	(0.008)	(0.009)	(0.015)	(0.016)	(0.006)	(0.010)
Border	0.235***	0.250***	0.083***	0.336***	0.265***	0.387***	0.256***	0.321***	0.305***
	(0.028)	(0.029)	(0.025)	(0.028)	(0.026)	(0.041)	(0.026)	(0.024)	(0.026)
Log distance	0.057***	0.041***	−0.001	0.008	0.040***	0.036***	0.021***	0.067***	0.052***
	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)	(0.013)	(0.007)	(0.008)	(0.006)
Observations	10,088	10,088	9,970	10,088	10,088	10,088	10,088	10,088	10,088
Adjusted R^2	0.441	0.317	0.287	0.284	0.474	0.199	0.069	0.399	0.552
ME of reg. quality for border = 1	−0.046***	−0.037***	−0.032***	−0.068***	−0.085***	−0.074***	−0.007*	−0.070***	−0.063***
	(0.004)	(0.004)	(0.003)	(0.005)	(0.005)	(0.009)	(0.004)	(0.006)	(0.004)
|ME| vs. "all"	<	<	<	=	>	=	<	=	.

Notes: Robust standard errors in parentheses; variance is clustered at the country-pair level. All specifications include year fixed effects. ME denotes the marginal effect of regulatory quality on price dispersion for cross-border observations. |ME| vs. "all" row compares the absolute values of marginal effects using their 95% confidence intervals with the marginal effect of regulatory quality on price dispersion of the all items category.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.A7: Robustness checks: additional specifications

Dependent variable: SD	(1)	(2)	(3)
Regulatory quality	0.014	−0.882***	
	(0.011)	(0.315)	
Border × reg. quality	−0.045***	−0.014	
	(0.012)	(0.014)	
Diff. in regulatory quality	0.053***	0.046***	
	(0.006)	(0.005)	
Border	0.207***	0.115***	0.089***
	(0.029)	(0.033)	(0.033)
Log distance	0.032***	0.046***	0.086***
	(0.005)	(0.005)	(0.007)
Observations	10,088	10,088	10,088
Adjusted R^2	0.594	0.816	0.347

Notes: Robust standard errors in parentheses, variance is clustered on the country-pair level. All specifications include year fixed effects. Specification (2) includes also city fixed effects and interaction term of city and year.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.A8: Robustness checks: various aspects of the institutional framework

Dependent variable:	(1) SD	(2) MSE	(3) SD	(4) MSE
Regulatory quality	−0.021***	−0.052***	0.008	−0.002
	(0.006)	(0.013)	(0.008)	(0.019)
School enrollment, tertiary (% gross)	−0.294***	−0.400***	−0.291***	−0.394***
	(0.030)	(0.070)	(0.029)	(0.066)
Total tax rate (% of commercial profits)	0.093**	0.046	0.069	0.003
	(0.046)	(0.100)	(0.042)	(0.094)
Time to prepare and pay taxes (hours)	0.110***	0.083	0.099***	0.063
	(0.032)	(0.067)	(0.033)	(0.070)
Tariff rate, applied, simple mean,	0.028	−0.244**	0.049	−0.207*
all products (%)	(0.051)	(0.111)	(0.051)	(0.112)
Importation costs (US$ per container)	−0.063	0.241*	−0.344***	−0.251
	(0.054)	(0.130)	(0.064)	(0.153)
Importation time (days)			0.447***	0.784***
			(0.074)	(0.174)
Border	0.189***	0.180***	0.183***	0.168***
	(0.051)	(0.044)	(0.048)	(0.038)
Log distance	0.035***	0.063***	0.029***	0.053***
	(0.007)	(0.014)	(0.007)	(0.013)
Observations	1,896	1,896	1,896	1,896
Adjusted R^2	0.493	0.349	0.532	0.377

Notes: Robust standard errors in parentheses; variance is clustered at the country-pair level. All specifications include year fixed effects. All explanatory variables but regulatory quality, border, and distance recalculated to [0-1].

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Chapter 3

Technology Companies and Strategic Patenting: Two Complementary Approaches

Abstract

Using two complementary methods, this paper utilizes a data set of 168,172 U.S. patents applied for between 1980 and 2007 by 22 large technology companies to study development of strategic patenting over time and across industries. A patent-level approach addresses the link between the patent private and social value and reveals strong evidence against our hypothesis of more strategic patenting after 1995. Contrary to our expectations, aerospace patents appear to be on average more strategic in the post-1995 period than software patents. A firm-level approach, which enables us to take into account the firms' R&D capacity and estimate relative importance of strategic versus protective patenting using data envelopment analysis, confirms our findings and shows an increasing focus on patent social value since the end of 1980s.

The paper was co-authored with Martin Štěpánek. We acknowledge support from the Grant Agency of Charles University (grant #1578214). We are grateful to Michal Bauer, František Brázdik, Gokhan Oz, Steffen Juranek, Michal Franta, Lubomír Lízal, seminar participants at Charles University and the Research Institute of Industrial Economics (Stockholm), and conference participants at the 2014 Italian Society of Law and Economics Conference (Rome), the 2015 European Association of Law and Economics Conference (Vienna), the 2016 WINIR Symposium (Bristol), and the 2016 Society for Institutional & Organizational Economics Conference (Paris) for their helpful comments. An earlier version of this paper circulated under the title "Patents: A Means to Innovation or Strategic Ends?"

3.1 Introduction

Patents are almost universally accepted method of providing incentives to innovators because, as the argument goes, the amount of innovation would be socially suboptimal without defining and enforcing intellectual property rights. In some industries patents play a much more important role than in others. For example, it is hard to imagine what a world without the patent institution would look like in the case of pharmaceutics, where the reliance on patent protection has always been very strong due to the nature of products. But during the 1980s almost everyone started to patent all but the most elementary inventions (Macdonald 2004). This led to patent inflation which is often perceived as a socially wasteful phenomenon (Farrell & Shapiro 2008).

Boldrin & Levine (2010, p. 62) quote results of Carnegie Survey of R&D directors conducted in 2000 which show that only about one third of respondents see patents as an effective method of appropriating gains from an innovation. As we would expect, the two industries with the highest importance of patents are the pharmaceutical and medical equipment industries. But even there, the proportion of respondents rating patents as an effective method was only slightly above 50%. More than 370 years after the English parliament established the modern patent institution (Boldrin & Levine 2010, p. 43), over half of the respondents still saw secrecy as an effective means of appropriating gains from an innovation.

Modeling the innovation discovery process as a decreasing returns technology, Boldrin & Levine (2009) argue that introducing a patent doesn't increase the rate of innovation at all and is actually damaging to welfare – a finding consistent with empirical evidence that patents do not have much impact on innovation (Bessen & Meurer 2008; Lerner 2009; Mokyr 2009).

One of the reasons why patents do not boost innovation would probably be the existence of strategic patenting confirmed by many authors (Cockburn & MacGarvie 2011), which is connected with a number of socially harmful activities. The first manifestation of strategic patenting is patent aggregation – hoarding of patents in order to assert them against companies using or planning to use technologies protected by such patents – often exercised by non-practicing entities (NPEs), i.e. companies which do not manufacture products nor supply services based upon the patents they hold (Nicholas 2013). For both defensive and offensive reasons, companies build patent thickets – networks of overlapping patents owned by all important entities in the respective field (Bessen 2003). Their primary task is to obstruct entry to the market and act as a leverage in case of patent disputes. Moreover, patent thickets contribute to fragmentation of patent rights which then increases the transaction costs of patent enforcement (Noel & Schankerman 2013).

Whereas obtaining patents to protect technologically valuable inventions has at

least the potential to enhance social welfare by providing incentives to innovators, investing in strategic patents is an unproductive entrepreneurial activity (Baumol 1990). The usefulness of strategic patents is in their litigation potential: They can be used to either threaten or even sue another company with the goal of preventing its market entry or extracting rent through licensing fees and royalties. Without a valuable patent to protect, such activities clearly have detrimental impact on social welfare.

Cohen *et al.* (2014) show that on average, NPEs behave opportunistically and sue cash-rich firms, even when these firms earn their profits from business segments unrelated to the allegedly infringed patents. Damages awards for NPEs have been almost three times greater than for practicing entities over the last couple years (PricewaterhouseCoopers 2016). and lawsuits filed by NPEs increased from 22% of the cases filed in 2007 to almost 40% of the cases filed in 2011 (Jeruss *et al.* 2012). Overall, incidence of rent-seeking through patent litigation (for a thorough discussion of this type of rent-seeking behavior see, e.g., Merges 2009), one of the clear manifestations of strategic patenting, seems to be increasing and is unevenly distributed across industries (PricewaterhouseCoopers 2013; Unified Patents 2015).

On a theoretical basis, the difference between an innovation-protecting patent and an strategic patent is clear. However, distinguishing between these two types of patents empirically is not an easy task. Some authors focus on strategic behavior as a manifestation of strategic patents (e.g., Munari & Toschi 2014; Hegde *et al.* 2009; Gallini 2002). Others reveal that valuable innovation-protecting patents tend to receive more citations (Trajtenberg 1990; Blind *et al.* 2009; Moser *et al.* 2015). Abrams *et al.* (2013) suggest that there is a difference between the private and the social value of a patent, similarly to how we perceive private and social costs of an externality, as they find an inverted U-shaped relationship between economic value and the number of received citations.

But the existing studies do not empirically address strategic patenting over a longer time period; until now, this topic has been predominantly analyzed theoretically, or in a case study settings with an emphasis on litigation. Therefore, there is no answer to the question whether strategic patenting is a new phenomenon, brought about as an unintended consequence of some relatively recent policy changes, or if it only became more visible due to the overall sharp growth in patenting over the last decades. Also, the existing literature doesn't show whether any trends in strategic patenting are universal, or limited only to some industries. Not being able to track strategic patenting over time and across fields seriously restricts the ability to evaluate policy changes and formulate recommendations for the future.

Litigation statistics show that the number of patent cases per year is on the rise at least since the 1980s, with a clearly observable acceleration during the 1990s. Then there was a temporary break in the growth trend between 2004 and 2009, followed

by its sharp renewal. Development of the average number of forward citations per year, often used as an approximation of patent value, reveals a peak around the year 1995 (see Section 3.4). Available anecdotal evidence indicates that patent wars and increased activity of various NPEs gained in importance especially in the last decades, and only in some industries.[1]

Because litigation is the primary channel of the strategic use of patents, we formulate two hypotheses based on these facts: First, we expect strategic patenting to be more prevalent in the post-1995 period. And second, we expect aerospace companies to participate the least in strategic patenting and produce more socially valuable patents than the rest of our sample. To be able to address the hypotheses, we introduce a novel method of two complementary approaches that allow us to identify strategic patenting and address its development over time and across industries. Following the literature, we use the number of received citations per year of patent lifetime as the main proxy for patent social value, and patent maintenance fee payment events as indicators of patent private value. Our data set comprises of more than 168,000 U.S. patents applied for between 1980 and 2007 by 22 companies from four technological fields: aerospace, computer manufacturing, semiconductors and software industry.

The first approach – a patent-level approach – allows us to directly address the link between the patent private and social value and check for breaks in this relationship. Contrary to our expectations, we find strong evidence against our hypothesis of more strategic patenting after 1995. Also, aerospace patents appear to be on average more strategic in the post-1995 period than software patents.

A firm-level approach enables us to take into account the firms' R&D capacity and estimate the relative importance of strategic versus protective patenting using data envelopment analysis (DEA). By comparing the efficiency of producing socially valuable patents with that of producing strategically useful patent quantities, we are able to track firms' propensity to patent strategically over time. The results confirm our findings and show that companies on average started to increase their focus on patent social value at the end of 1980s. Aerospace and software companies practically do not differ in terms of strategic patenting after 1995 even after taking into account their R&D capacity. We therefore reject both hypotheses and conclude that we do not observe a rising tendency of large technology companies to engage in socially harmful strategic patenting.

Our contribution to the existing literature consists of two components: We introduce a novel approach to identification of strategic patenting based on two complementary methods, a patent-level and a firm-level one, which allows the study of

[1] Sorting by the number of cases in the period 1995–2012, computer hardware/electronics ranks 4th with 173 cases, software 7th with 112 cases, and aerospace/defense 18th with only 14 cases (PricewaterhouseCoopers 2013).

strategic patenting in the panel settings. And second, using this approach we show that the incidence of strategic patenting has not increased since 1980.

The remainder of the paper is structured as follows: in Section 3.2 we review related literature on this topic. Section 3.3 introduces the data set, Section 3.4 explains the method of patent value estimation and describes the data on patent forward citations and renewals in detail. We describe our method in Section 3.5, discuss our results in Section 3.6 and present additional robustness checks in Section 3.7. Section 3.8 concludes the paper.

3.2 Related literature

Reviewing existing research on the economics of patents, Hall & Harhoff (2012) reveal that patents serve as an incentive for innovation only in a few sectors, and relatively few firms find them an important tool of securing the returns from their innovation activities. But, at the same time, firms in all other industries also respond to the presence of the patent institution, either by using patent as a means to other ends, or by adapting their innovation strategies. For example, Peeters & Potterie (2006) notice that patents and their characteristics are imperfect indicators of innovation not only because of the effects of different firm size, age, ownership type, market power, or technological opportunities, but also because firms pursue different innovation strategies. To put it simply, industries and individual firms vary significantly in the average number of patents generated by each dollar of R&D investment (Levin *et al.* 1987).

Hall & Ham (1999) interviewed patent managers and executives from several types of semiconductor firms. In general, they were told that patents are considered extremely important, but not because patents enable the firms to profit from the current-generation products or motivate to conduct R&D: "As one interviewee noted, 'semiconductor firms do not rely on patents [to profit from innovation or appropriate returns from R&D], but patent rights are still of critical importance to firms in this industry.'" (Hall & Ham 1999, p. 10) One of the strategic uses of patents is their ability to directly influence competition. Gallini (2002) shows that the more areas some particular patent is involved in, the harder it is for other companies to enter the market with their own innovations without violating the original patent. Munari & Toschi (2014) analyze the nanotechnology industry and reveal that firms gather broad patents in the early stages of an emerging technology to be able to get a better position within the market in the later stages. The existence of broad patents then leads to the emergence of patent thickets around key technologies, which create further barriers to entry. Cockburn & MacGarvie (2011) estimate that a 10% increase in the number of patents relevant to the market reduced the rate of entry by 3%–8% in the software industry from 1990–2004.

The possibility, and even need, to use patents strategically has led to larger numbers of patent applications and grants, as well as an increasing focus on patent aggregation – the practice of purchasing patents to either mitigate the risk and cost of litigation, or extract licensing fees from subjects using inventions protected by the patents. Nicholas (2013) argues that patent aggregation is a self-reinforcing process because ever larger patent portfolios accumulated for offensive or defensive purposes increase the demand for intermediaries, often called non-practicing entities (NPE). Their activities then further increase the demand for their own services. Bessen *et al.* (2011) find that NPE lawsuits were associated with half a trillion USD of lost wealth to defendants between 1990–2010 and that a very small part of this sum goes to small inventors. However, Mazzeo *et al.* (2013) point out that neither NPE damage awards, nor patent assertion entities (PAE) awards, significantly differ from other damage awards, although patent assertion represents a novel way of exploiting patent rights.

Even though each of the largest NPEs has accumulated tens of thousands of patents worldwide in the last couple of years (Ewing & Feldman 2012), the surge in patenting activity is visible among the practicing entities, too. Around the time a specialized appellate court to hear patent cases, the Court of Appeals of the Federal Circuit, was established by the US Congress in 1982, the number of patent applications and grants started to grow steeply (Kortum & Lerner 1999). Some industries, like pharmaceutics, have always relied on patents due to the nature of their products. But since 1982, companies in other industries, like semiconductors, started to increasingly patent their inventions in all but the most worthless cases as well, and would have been pushed out of the market by their competitors if they hadn't (Macdonald 2004). As a consequence, the number of patent applications received by the USPTO more than tripled between 1983 and 2003, but the number of USPTO examiners did not keep that pace (Chan & Fawcett 2005). Moreover, over forty percent of the 355,000 new applications filed in 2004 had more than twenty claims each. Limited resources of the examiners lead to very high approval rates of filed applications and a high percentage of examiner decisions overturned on appeal (Chuang 2006).

Granting weak patents not justified by the applicant's novel invention induces significant social costs as it often leads to costly litigation, creates danger of patent hold-up, and motivates defensive patenting, thus creating a socially wasteful vicious circle of strategic patenting (Farrell & Shapiro 2008) and a buildup of patent thickets with shared ownership of technologies (Bessen 2003). The software industry is believed to be especially prone to the inflation of patents of low technological value, a lot of litigation, and a high percentage of patent trolls (Rai 2013; Graham & Vishnubhakat 2013).

However, the identification of the above mentioned weak or low quality patents is not a trivial task. Generally, the term *patent value* can have two very different

meanings. First, we can be interested in *private value* of a patent – meaning how valuable the patent is for its owner in terms of profit potential. Hall *et al.* (2005) find that the number of received *(forward)* citations from other patents, obtainable from the patent offices' databases, works as a proxy for the private value of a patent indicated by the firm's stock market valuation. Other authors confirm that the number of forward citations, and if a patent is repeatedly renewed by paying a maintenance fee, are correlated with the valuation of patents by their respective owners (Harhoff *et al.* 2003; Bessen 2008; Zeebroeck 2011). Forward citations and the patent's family size also explain a part of the private value obtained from real-world auction prices (Fischer & Leidinger 2014).

Second, we can focus on whether a particular patent increases social welfare by protecting a technologically valuable innovation and, therefore, has some *social value*. We expect most patents to be privately valuable because of their social value, but private value doesn't necessarily imply social value. Overproduction of patents of low social but high private value then leads to inefficiency and social welfare losses, because social benefits and social costs do not equalize in the patent market equilibrium – negative externalities arise. It has been shown that the number of forward citations is positively correlated with the social value of patents (Carpenter *et al.* 1981; Trajtenberg 1990; Moser *et al.* 2015), analogically to how we perceive citations in science (Stephan 1996; Gaulé & Maystre 2011). A clear advantage of using the number of forward citations as a proxy for social value is that it is not determined by the patent applicant, owner, or any other single stakeholder.

Blind *et al.* (2009) find that the more intensively companies use patents to protect their valuable innovation, the more citations their patent portfolio receives. If they obtain patents for strategic reasons, such as blocking their competitors and aiming at patent exchange, their portfolios receive less citations. De Rassenfosse (2013) confirms that firms face a trade-off between patent quantity and the quality of their research. If a firm focuses on the strategic use of its patents, we can expect that its patent portfolio would be of a lower social value and, consequently, receive less forward citations.

Our distinction between the private and the social value of patents is also in line with the recent findings of Abrams *et al.* (2013), who analyze the relationship between forward citations and the economic value of NPE-owned patents. Rather than the generally assumed monotonic relationship, they reveal there is an important amount of extremely valuable patents with a low number of citations. The authors conclude that their findings suggest that some patents are obtained for purely strategic purposes.

To sum up, the topic of strategic use of the patent institution is very lively in the literature. Many authors agree that the production and acquisition of patents for strategic purposes induces sizable social costs. However, the existing literature

doesn't address the development of strategic patenting over time and across industries.

3.3 Data

Our analysis is based on 168,172 U.S. patents which were applied for between 1980 and 2007. The data were downloaded from the U.S. patent office database and cover whole patent portfolios of 22 companies from aerospace, computer manufacturing, semiconductors and software industries listed on NASDAQ Stock Exchange which exceeded market value of USD 2 billion and had operated for more than 10 years. Although such data set doesn't necessarily form a representative sample of the whole economy with regard to patenting strategies, the selection was made in order to be able to capture development in the firms' ability to pursue inventions over time using statistical analysis of their patent portfolios. One of our identification strategies crucially depends on the ability of comparing decision-making units – the companies, not individual patents.

Also, it appears that firm size has an impact on patent value (Bessen 2008). Focusing on large technology companies only should, therefore, ensure better comparability of their patents. The chosen industries are known to be more innovative than others (Griliches 1980), promising a high degree of competition and a fast pace of patenting, yet they differ in aspects such as dependency on older patents or product complexity, which leads to inter-group variance. The full list of the used companies, together with basic descriptive statistics, is in Table 3.A1.

For every patent we gathered data on its number, assignee, application and grant date, classification, number and distribution of forward citations, and renewal. The information about the citations has been extracted from the U.S. patent office website, data on renewals have been obtained from the patent maintenance fee events database available on the USPTO Bulk Downloads Google page.[2] Our data on forward citations and renewals cover the information available in March 2015. Forward citations statistics include all citations from other U.S. patents or their applications published by that date. The number of patents and the number of forward citations constitute outputs of production for our efficiency analysis we use to identify strategic patenting. For the patent-level approach we use forward citations and patent renewal data.

The companies with the lowest number of patents in our sample are Citrix (241), Intuit (243), Logitech (243) and Nuance (276). On the other end of the sample are Intel (20,665), HP (22,826), and IBM (60,361). Figure 3.A6 doesn't show any relationship between the number of patents a company produced over the observed

[2] `https://www.google.com/googlebooks/uspto-patents.html`.

period and the average number of citations per year, nor is there any statistically significant linear relationship.

The usual inputs used in innovation efficiency literature are R&D expenditure or R&D capital stock, and the number of employees or specifically R&D personnel (Cruz-Cázares *et al.* 2013). Because we didn't obtain data on R&D personnel, we utilize the total number of employees as a proxy for the size of the company. The second input variable we use is R&D expenditure deflated using the time series of industry-level prices of intermediate inputs from the World KLEMS data set for the US (Jorgenson *et al.* 2012). Time series of both input variables were obtained from the Compustat database. Following the recent literature, we use one-year lags of the input variables to take into account the time it takes before R&D projects are completed and patentable outputs are achieved. The maximum time span of the sample used for the efficiency analysis is 1980–2007, but our panel is unbalanced due to the limited availability of older non-patent data.

3.4 Measuring patent value

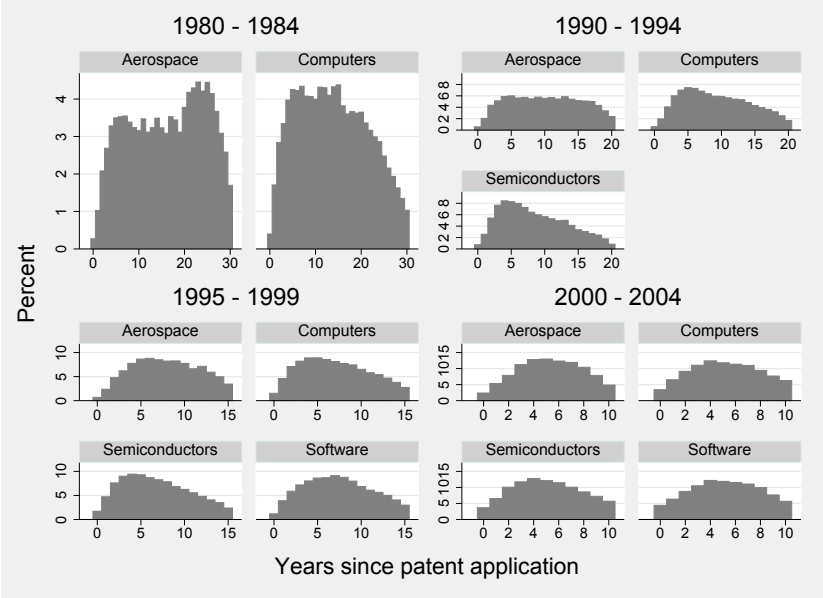
The number of received (*forward*) citations is a generally accepted proxy for patent social value (Trajtenberg 1990; Blind *et al.* 2009; Abrams *et al.* 2013; Moser *et al.* 2015), whereas decisions of patent owners regarding the payment of patent maintenance fee (*patent renewal*) are understood as an indicator of patent private value (Pakes & Schankerman 1984; Lanjouw 1998; Bessen 2008; Van Zeebroeck & Van Pottelsberghe de la Potterie 2011).

A major complication when analyzing forward citations is the fact that they keep appearing long after a patent is granted. Some authors (Lanjouw & Schankerman 2004; Sapsalis *et al.* 2006; Gambardella *et al.* 2008; Zeebroeck 2011; Squicciarini *et al.* 2013) propose a comparison of forward citations obtained only during the first few years. Figure 3.1 shows the distribution of citation lags for individual industries and reveals that patents receive citations even 30 years after their application. Moreover, the distributions seem to differ for individual industries and change over time.[3] As a consequence, cutting off the tails of citation distributions inevitably induces a bias. Hall *et al.* (2005) deal with this problem by estimating the shapes of the citation-lag distributions, and calculating the total number of citations a patent would probably receive over its lifetime if the distributions were stationary. But as we illustrate in Figure 3.1, this stability assumption is also questionable.

Therefore, in order to keep the methodology as simple as possible, we opted to

[3]Epps-Singleton two-sample test for the equality of distributions rejected the equality of distributions of citation lags during the first 10 years after application between 1995–1999 & 2000–2004 at the 1% level, and also between 1985–1989 & 1995-1999 at the 1% level with the exception of software patents, which started to appear in our sample during the second half of the 1990s.

Figure 3.1: Time distribution of forward citations

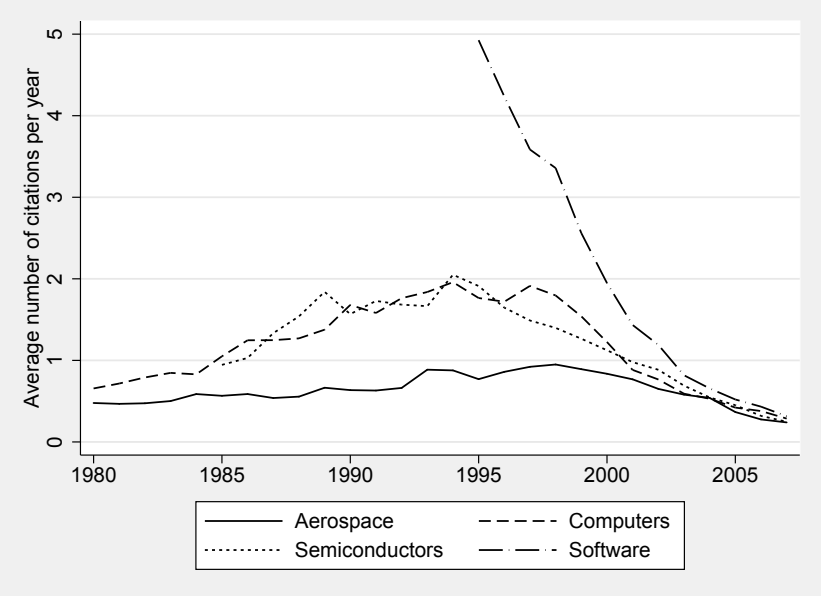


follow Grimaldi *et al.* (2015) and use the number of forward citations per year of patent lifetime after patent application as our baseline variable. Such an approach is common in literature dealing with comparison of the quality of academic publications (see, e.g., Havránek 2015). Given the fact that the patents in our sample mostly received the highest percentage of citations around five years after their application, this method probably creates an upward bias for newer patents if observed for at least five years. As a robustness check, we also use the number of forward citations during the first seven years after patent application and the results seem very stable.

We use the patent application year as the base for our citation analysis. The reasons are twofold: First, we are interested in the link between patents and their source in the form of R&D activities. If we focused on the date of patent grant, our results would be biased by the changing delay between the patent application and its subsequent grant. Based on the patents in our sample, the average grant lag reached its minimum of around 700 days in the late 1980s and gradually increased to 1538 days in 2004. Moreover, starting in November 2000, USPTO publishes almost all applications for patents 18 months after their earliest filing date. To ensure comparability, we count forward citations from the patent application year for all patents in our data set. Arguably, this could have biased the number of forward citations per year of pre-2000 patents downward.

Figure 3.2 depicts the average numbers of citations per year for our four industries and patents applied for between 1980 and 2007, and shows that there was an increasing trend for aerospace, computer, and semiconductor patents until the second

Figure 3.2: Average number of forward citations per year by industry



half of the 1990s.[4] The patent applications of software companies in our data sample started to appear only in the 1990s, and their forward citations statistics indicate that the first software patents were probably of high social value and formed the base of subsequent research in this field. But around the year 1995 we observe a break in the trends and the number of forward citations per year started to deteriorate quickly.[5]

Even more is happening in the distribution of forward citations per year (Figure 3.3). The majority of patents get cited only a very few times – in the 1980–1984 cohort, more than 25% of patents in aerospace and computer industries received less than 0.25 forward citations per year of their lifetime, meaning they probably did not carry much social value.[6] Generally, the distribution of patent social value is extremely skewed to the right with a small number of very valuable patents (see, also, Scherer & Harhoff 2000). The distribution of forward citations in the 1995–1999 cohort confirms that the proportion of almost-not-cited software patents applied for in this period was much lower compared to other industries. This means that the high average we observe in Figure 3.2 was not caused solely by a small number of extremely well cited and, therefore, socially valuable patents.

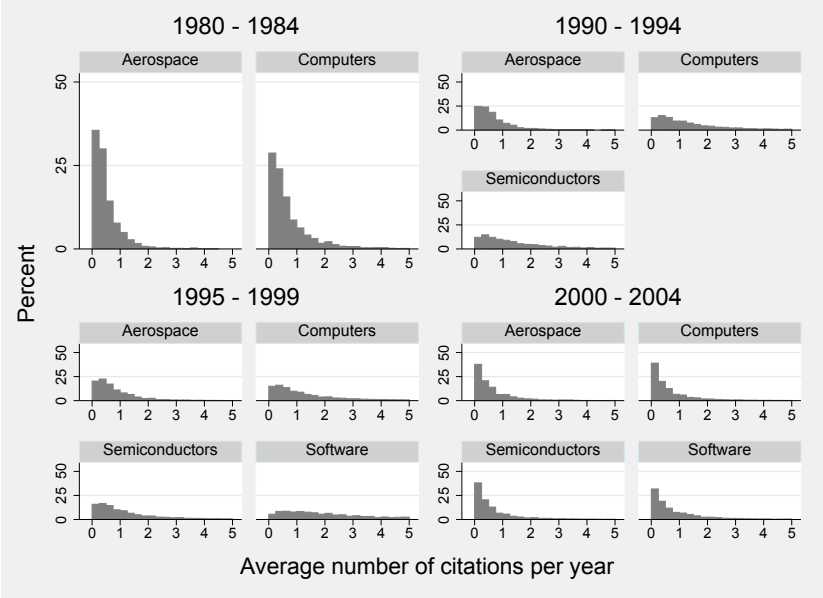
In the last cohort of 2000–2004, we observe a sharp increase in the proportion of patents with up to 0.25 citations per year. It coincides with the drop in industry

[4] See Figure 3.A1 for the number of citations during the first seven years since patent application.

[5] Mean-comparison test rejects the hypothesis of equality of means between 1990–1995 and 2000–2005 for all industries.

[6] Aerospace patents from this cohort received on average 0.5 citations per year and computer patents 0.77 citations per year of their lifetime.

Figure 3.3: Distribution of average number of forward citations per year



averages in the late 1990s, as described above. Figure 3.4 and Figure 3.A2 show that this increase was mostly caused by patents ceasing to receive any citations at all. Given the fact we recorded the forward citations in 2015, and the proportion of patents getting their first citation more than five years after their application was well below 20% in 2000, the absolute lack of citations should not be caused by censoring.[7]

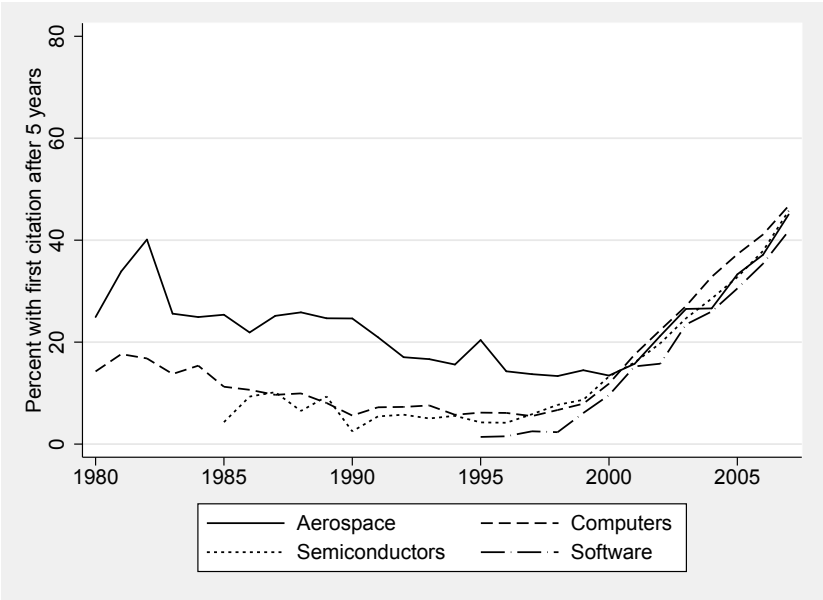
U.S. utility patents generally expire 20 years after the application filing date. But to keep a patent in force, repeated maintenance fee payment is required for all patents based on applications filed after December 12, 1980. We call this act of maintenance fee payment *patent renewal*. If a maintenance fee is not paid, the patent is not renewed and the rights protected by a patent are no longer enforceable.[8] Therefore, patent renewals positively correlate with the private value of a patent. During the lifetime of a patent, it is possible to renew it three times by paying a maintenance fee: 3–4 years, 7–8 years, and 11–12 years after the date of patent issue. Therefore, we cannot observe any renewals for patents younger than 3 years, more than one renewal for patents younger than 7 years, and more than two renewals for patents younger than 11 years. We limit the data by the upper deadline for each category to allow for all potential renewals.

Figure 3.5 shows renewal patterns averaged over whole industries for patents applied for between December 12, 1980 and 2007. Even though the maintenance

[7] Figure 3.A3 shows the proportion of patents getting their first citation more than five years after application only on patents that did get cited at least once. It indicates that if censoring played a role, it was probably not before 2005 and, therefore, cannot explain the change in the trend in the second half of the 1990s.

[8] See `http://www.uspto.gov/patents-maintaining-patent/maintain-your-patent` for more information regarding maintenance fees.

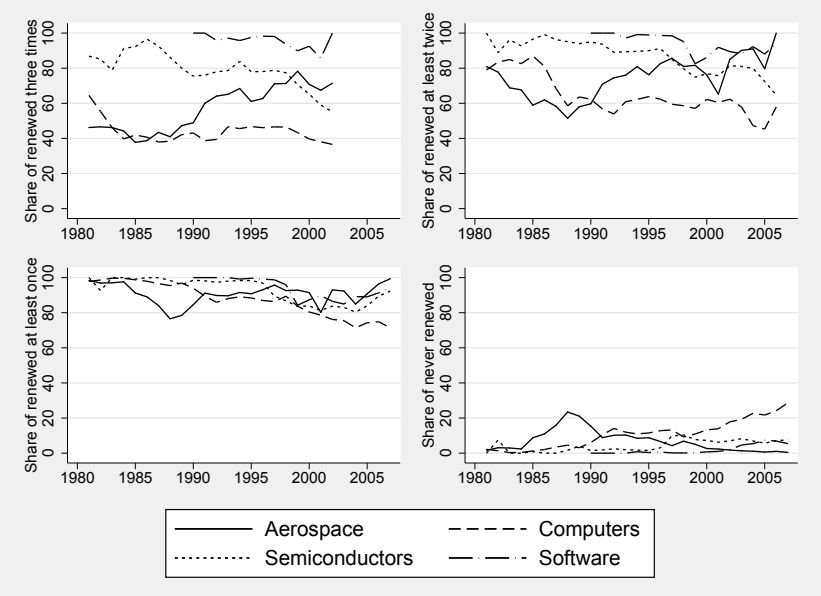
Figure 3.4: Proportion of patents getting their first citation more than five years from application or not cited at all



fees, especially for the large companies that form our data set, probably do not constitute prohibitively high costs, we see differences among individual industries. Lanjouw (1998) argues that a profit maximizing patentee only pays the renewal fee if the returns from protection in that age plus the expected value of maintaining the option to have protection in the future exceed the costs. But given the possibility of patent infringement, the patentee must also take into account the expected costs of possible litigation. As a consequence, the total cost entering the renewal decision may be higher by several orders of magnitude compared to the fee.

Only 40% of computer patents were renewed three times over the observed period. Moreover, the proportion of computer patents not renewed even once increased from 1% to its peak of 40% in 2008. On the other hand, whereas just 40% of aerospace patents applied for in the 1980s were kept in force for the whole 20 years period, their proportion increased to 70% by 2002. The only industry in which we observe a drop corresponding to the one in forward citations is semiconductors. After a decrease in the proportion of patents renewed for three times in the 1980s, we observe stability until the end of the 1990s and a subsequent decrease to under 60%. The share of never renewed semiconductor patents increased from zero in the 1980s to 10% in 1998 and fluctuates around 7% thereafter.

Figure 3.5: Proportion of patents renewed three times, at least twice, once, and never



3.5 Methodology

3.5.1 Patent-level approach

In order to identify strategic patenting, mere citation counts or renewal statistics are insufficient. If a patent's private value is derived from its social value, we should be able to observe a positive relationship between these two. But Abrams *et al.* (2013) show an inverted U-shaped relationship between the private and the social value of patents held by large NPEs. This means that there are patents – we call them strategic patents – for which the positive relationship between the two measures of value is not present. We build on this finding in our first identification approach which uses panel data of all 168,172 patents from our sample applied for between 1980 and 2007. We let the private–social value relationship differ across industries and in the pre- and post-1995 periods and our baseline specification is:

$$\begin{aligned} citations = \alpha_0 &+ \sum_{i=1}^{3} \beta_i industry_i + \gamma_1 after1995 + \sum_{j=1}^{3} \delta_j renewal_j + \\ &+ \sum_{j=1}^{3} \lambda_j renewal_j \times after1995 + \sum_{i=1}^{3} \zeta_i industry_i \times after1995 + \\ &+ \sum_{i=1}^{3}\sum_{j=1}^{3} \eta_{ij} industry_i \times renewal_j + \\ &+ \sum_{i=1}^{3}\sum_{j=1}^{3} \vartheta_{ij} industry_i \times renewal_j \times after1995 + \epsilon, \end{aligned} \tag{3.1}$$

where *citations* is the number of forward citations per year, α_0 is the intercept which also captures the base effect of non-renewed aerospace patents applied for before 1995, $industry_i$ stands for industry dummies (computers; semiconductors; software), dummy *after1995* equals 1 for all patents applied for after 1995, and $renewal_j$ represents dummies for renewal categories (renewed after 4 years; renewed after 8 years; renewed after 12 years). β_i and ζ_i capture industry fixed effects before and after 1995, γ_1 is the post-1995 fixed effect. δ_j, λ_j, η_{ij}, and ϑ_{ij} capture the relationship between patent renewal (private value) and forward citations (social value), the differences of this relationship across industries, and its change in 1995.

We winsorize the top 5% of forward citations per year to limit the impact of outliers which are naturally present in this type of data and estimate the equation using OLS with heteroskedasticity-consistent standard errors. For better readability of the results, we then calculate the marginal effects of switching from a never renewed patent to a patent renewed once, twice, or three times before and after the year 1995 for every industry. In Section 3.7 we provide a robustness check with a narrower definition of industries.

3.5.2 Firm-level approach

One shortcoming of the patent-level approach is its sole focus on the output side of R&D activities. However, the inputs, such as the amount of resources allocated to such activities, aren't stable over time and vary across individual companies. As a consequence, not all changes of the relationship between the private and the social value are necessarily a manifestation of changing inclination toward strategic patenting – R&D inputs influence the quality of patent production which then can have an effect on social value of patents.

There is literature estimating the efficiency of technological innovation (see, for example, Cruz-Cázares *et al.* 2013) using the quantity of patents as one of the observed outputs of the innovation process. But due to data limitations, the existing efficiency studies do not take into account the value of patent outcomes. We follow this literature and estimate firm-level efficiency of transforming inputs into outputs using input-oriented data envelopment analysis (DEA), a method introduced by Farrell (1957) and further developed by Charnes *et al.* (1978), which has been extensively applied to evaluate performance in manufacturing and service operations.

Comparing estimates of relative efficiency among companies or industries over time would enable us to address the issue of strategic patenting from a different perspective. In order to interpret the obtained efficiency estimates as measures of strategic patenting, we assume that the companies in our sample are able to undertake R&D with comparable efficiency. That doesn't necessarily mean that they are equally

innovative. But it means that they all have access to the best available technologies, researchers, engineers, knowledge, or know-how.

We are convinced that our sample of high-tech companies meets such an assumption: almost all of them have their headquarters or research departments in the Silicon Valley area, almost all of them rank on the Forbes' World's biggest public companies list, they are often named among the best companies to work for in the U.S., etc. Therefore, if such a company produces less socially valuable patents with the same inputs, it does so as a conscious choice of the management and not because it is forced to.[9]

DEA is a non-parametric method which makes it suitable to estimate the best-practice production frontier without assuming a specific form of the production function. This may be useful especially in sectors and areas of the economy where prices, or other common nominators, are not available or reliable. The method has been repeatedly used in a very similar context on data samples comparable to ours (Guan *et al.* 2006; Hashimoto & Haneda 2008). DEA proceeds by assuming decision-making units (DMU) capable of processing inputs into outputs and estimating the relative efficiency score of each DMU p by solving a fractional program defined as a ratio of weighted sum of outputs to weighted sum of inputs:

$$\begin{aligned} \max \quad & \frac{\sum_{k=1}^{s} v_k y_{kp}}{\sum_{j=1}^{m} u_j x_{jp}} \\ s.t. \quad & \frac{\sum_{k=1}^{s} v_k y_{ki}}{\sum_{j=1}^{m} u_j x_{ji}} \leq 1 \quad \forall i, v_k, \quad u_j \geq 0 \quad \forall k, j, \end{aligned} \tag{3.2}$$

where y_{ki} denotes amount of output k produced by DMU i, x_{ji} denotes amount of input j used by DMU i, v_k and u_j are weights given to output k and input j. The fractional program (3.2) may be solved by transforming into the linear program

$$\begin{aligned} \max \quad & \sum_{k=1}^{s} v_k y_{kp} \\ s.t. \quad & \sum_{j=1}^{m} u_j x_{jp} = 1, \quad \sum_{k=1}^{s} v_k y_{ki} - \sum_{j=1}^{m} u_j x_{ji} \leq 0 \quad \forall i, v_k, \quad u_j \geq 0 \quad \forall k, j. \end{aligned} \tag{3.3}$$

In practice, most of the DEA-solving programs use the dual form of the linear program (3.3) which lowers the number of constraints and computational demands:

[9] In the sense as, for example, a Chinese company may face limitations regarding the supply of best-skilled labor.

$$\begin{aligned} &\min \quad \theta_p \\ &s.t. \quad \sum_{i=1}^{n} \lambda_i x_{ji} - \theta_p x_{jp} \leq 0 \quad \forall j, \quad \sum_{i=1}^{n} \lambda_i y_{ki} - y_{kp} \geq 0 \quad \forall k, \quad \lambda_i \geq 0 \quad \forall i, \end{aligned} \tag{3.4}$$

where θ is the efficiency score, and λ are the dual variables derived from the primal form of the linear program (3.3). Program (3.4) assumes constant returns to scale (CRS). Even though the assumption of CRS is widely used in literature, it correctly reflects the reality only in the case of no scale inefficiency. In our specific case it would mean that in order to remain fully efficient, an inventor employing 10 units of R&D input and producing 10 patents would have to produce 100 patents when increasing the R&D expenditure to 100 units. But there is no reason to expect this assumption to be true. We can even argue in favor of both decreasing and increasing returns to scale: larger amount of R&D activities can create positive synergy effects and, as a consequence, increase efficiency with scale. On the other hand, there is no reason why diseconomies of scale should not be present also in R&D. For example, an additional unit of innovation may be harder and more costly to produce if the innovator optimizes his activities and starts with projects with the best cost/benefit ratio (e.g., Bound *et al.* (1982) find evidence compatible with decreasing returns to scale in patenting).

Because we assume that scale inefficiency is present, we use the model developed by Banker *et al.* (1984), allowing for variable returns to scale (VRS) by imposing a restriction $\lambda_p = 1$ for $p = 1, ..., n$ to (3.4). VRS model excludes scale inefficiency from the final efficiency scores which makes them, by definition, larger than or equal to efficiency scores obtained using the CRS model.[10]

As we have already mentioned, DEA estimates relative efficiency of each DMU defined by a vector of inputs and a vector of outputs. By not including any control variables capturing, for example, the changing environment where the DMUs operate and the technological progress, DEA in its basic form expects solely cross-sectional data. In order to follow and compare the DMUs over time, a special model is needed. Generally speaking, there are two main approaches to panel DEA. First, Färe *et al.* (1994) shows that it is possible to use DEA to calculate the Malmquist Productivity Index for individual DMUs and decompose the obtained productivity growth into efficiency changes and technology shifts. But, as a consequence, we would lose the ability to carry out cross-sectional comparison (Chen & Iqbal Ali 2004). Therefore, we use a moving average approach introduced by Charnes *et al.* (1985), called the window analysis.

[10] See Figure 3.A4 for results obtained using the CRS model. We believe that the VRS model is more appropriate.

The rationale behind DEA window analysis is that technology development is usually gradual and doesn't cause abrupt year-on-year changes in the production process. It is therefore possible to pool a couple of years of observations together and treat a DMU, for example, in year t and in year $t+1$ as two separate DMUs. Suppose the DMUs are observed for T years and the window length is set to K years. In every period $t = 1, ..., T-K+1$ we pool observations of DMUs from periods $t, ..., t+K-1$ and estimate their efficiency scores using the linear program (3.4). Thus we obtain between 1 and K efficiency score estimates for each DMU and time period, depending on the position of the moving window. To get a time series of mutually comparable estimates, we follow the literature by calculating a simple mean over the estimates in each period for each DMU.

For our analysis of patent production efficiency, we chose window length $K = 3$.[11] This means that the first window is composed of DMUs with observations from 1980, 1981, and 1982, the second window from 1981, 1982, and 1983, and so on.

We use two specifications with one output variable each – the average social value of patents applied for in the given year measured by the number of forward citations,[12] and the number of patent applications in the given year – to obtain two sets of efficiency scores. We do not include both output variables in a single efficiency score estimation because we are not interested in estimating the efficiency of innovative activities *per se*. Our goal is to identify differences in patenting strategies among individual companies by comparing the efficiency in the production of patent social value to the efficiency in the production of patent quantity. In both specifications, real R&D expenditure and the number of employees are used as inputs, and an observation of a DMU is included only if the DMU produced at least five patents in the respective year. Our final sample is an unbalanced panel of 374 observations.

We get two estimates of efficiency for each company and year, totaling 748 estimates of efficiency scores. In order to identify the strategic decisions regarding patent-value production, we produce a *doubly relative* measure of efficiency: First, we estimate efficiency scores of patent value production and patent quantity production and thereby get the relative efficiency vis-à-vis the most efficient unit in each period. Following de Rassenfosse (2013), who shows that firms face a trade-off between the quantity and the quality of their research output, we calculate percentage differences between these two efficiency scores.

Therefore, by using the difference, we implement a second level of relativity: We understand a DMU relatively more efficient in producing valuable patents if it is relatively more efficient in patent social value production than in patent quantity

[11] As a robustness check, we also performed the analysis with $K = 2$ and $K = 4$. The efficiency scores differed slightly, the final relative efficiencies were smoother with longer window. But the results did not change qualitatively.

[12] With the top 5% of observations winsorized in order to limit the impact of outliers.

production. In this way, we are able to deal with the role of R&D inputs and the company-level fixed effects. If a company, in comparison to its competitors, puts a smaller emphasis on patents and protects its intellectual property using trade secrets or other methods, it will channel only a small part of its R&D expenditure to patenting. As a consequence, the model may see it as less efficient in producing both patent value and patent quantity. For the sake of simplicity, let's assume it will reach only 50% efficiency compared to the most efficient DMU in both categories. The resulting relative score $50\%/50\% = 100\%$ then indicates no preference for either patent value, or patent quantity.

On the other hand, if a company reaches 50% efficiency in patent social value production but 80% efficiency in patent quantity production, then the resulting relative score $50\%/80\% = 62.5\% < 100\%$ signals the extent of the company's preference for the production of patent quantity at the expense of patent value – again, relative to all the other companies in the sample. To sum up, final relative efficiency score above 100% indicates a higher relative efficiency in producing valuable patents than mere patent quantity. We interpret this finding as a probable preference of the company to produce valuable patents, when compared to other companies in the sample.

3.6 Results

The first column in Table 3.1 presents the results of our baseline patent-level regression (3.1). The constant shows that non-renewed aerospace patents applied for before 1995 received on average 0.5 forward citations per year of their existence. Patents granted to companies from other industries get cited more, and those applied for after 1995 get cited less. But to address the issue of strategic patenting, we need to analyze the effect of renewals on forward citations. As we have already explained, each patent carries two types of value: private value important for its holder, which is captured by the decisions to renew the patent after 4, 8, or 12 years by paying an increasing maintenance fee; and social value, or the degree of innovativeness of the patent, captured by the number of received citations.

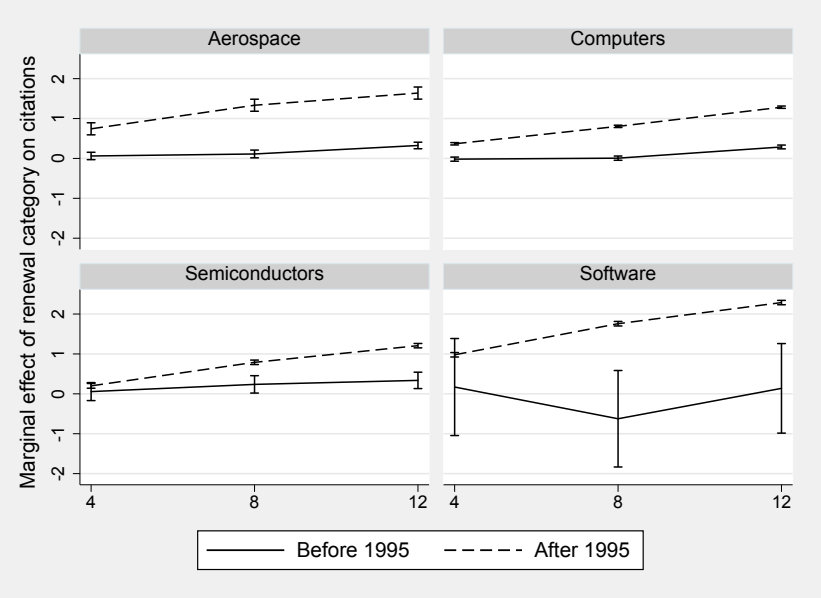
To better visualize the results, we calculate the marginal effects of switching from not renewed to once, twice, or three times renewed patents for every industry before and after 1995. Figure 3.6 shows semi-elasticities of these effects and reveals that the link between private and social value of patents is significantly stronger in the post-1995 period (see also Table 3.A2). The effect of the first renewal on citations is not significantly different from zero in any of the four industries before 1995. The same is true for the second renewal after 8 years of computer patents. The standard errors of pre-1995 software patents are very large due to a low number of observation in this category. After 1995 we observe much stronger correlation between private and social value of patents. Not only is it statistically significant for all categories,

Table 3.1: Patent-level regression results

Dependent variable: Forward citations per year	(1) Baseline		(2) Narrow	
Constant	0.503***	(0.019)	0.525***	(0.035)
Before 1995	ref.		ref.	
After 1995	−0.325***	(0.023)	−0.400***	(0.037)
Not renewed	ref.		ref.	
Renewed 1x	0.032	(0.024)	0.029	(0.047)
Renewed 2x	0.059**	(0.026)	0.017	(0.046)
Renewed 3x	0.193***	(0.023)	0.153***	(0.038)
Aerospace	ref.		ref.	
Computers	0.584***	(0.031)	0.552***	(0.047)
Semiconductors	0.504***	(0.106)	0.587***	(0.123)
Software	1.330	(1.049)	1.307	(1.049)
Renewed 1x × Computers	−0.051	(0.037)	−0.004	(0.060)
Renewed 1x × Semiconductors	0.026	(0.120)	0.051	(0.146)
Renewed 1x × Software	0.309	(1.172)	0.311	(1.173)
Renewed 2x × Computers	−0.052	(0.039)	0.042	(0.060)
Renewed 2x × Semiconductors	0.210*	(0.119)	0.168	(0.140)
Renewed 2x × Software	−0.911	(1.073)	−0.840	(1.077)
Renewed 3x × Computers	0.169***	(0.036)	0.204***	(0.053)
Renewed 3x × Semiconductors	0.211*	(0.108)	0.154	(0.126)
Renewed 3x × Software	0.077	(1.050)	0.150	(1.051)
Renewed 1x × After 1995	0.164***	(0.029)	0.249***	(0.052)
Renewed 2x × After 1995	0.437***	(0.033)	0.608***	(0.055)
Renewed 3x × After 1995	0.544***	(0.035)	0.659***	(0.055)
Computers × After 1995	−0.346***	(0.034)	−0.209***	(0.050)
Semiconductors × After 1995	−0.314***	(0.107)	−0.233*	(0.125)
Software × After 1995	−1.289	(1.049)	−1.209	(1.049)
Renewed 1x × Computers × After 1995	0.040	(0.041)	−0.107*	(0.065)
Renewed 1x × Semiconductors × After 1995	−0.141	(0.121)	−0.329**	(0.149)
Renewed 1x × Software × After 1995	−0.141	(1.172)	−0.226	(1.173)
Renewed 2x × Computers × After 1995	0.069	(0.045)	−0.203***	(0.069)
Renewed 2x × Semiconductors × After 1995	−0.265**	(0.121)	−0.432***	(0.145)
Renewed 2x × Software × After 1995	1.465	(1.074)	1.292	(1.078)
Renewed 3x × Computers × After 1995	0.180***	(0.046)	−0.084	(0.069)
Renewed 3x × Semiconductors × After 1995	−0.086	(0.113)	−0.251*	(0.134)
Renewed 3x × Software × After 1995	1.123	(1.051)	1.016	(1.052)
Observations	168,172		89,401	
R^2	0.182		0.186	

Notes: Robust standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 3.6: Average marginal effect of renewal on forward citations (semi-elasticity)



Notes: The capped spikes represent 95% confidence intervals.

but the marginal effect increases for each additional renewal – the most privately valuable patents in our sample, which have been renewed three times, are also the most socially valuable ones measured by their citation rates.

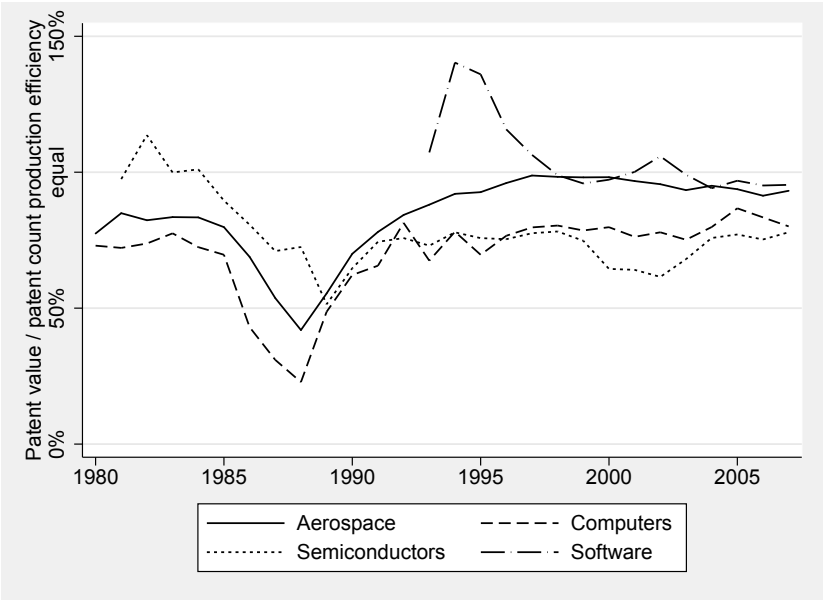
This result holds even if we use the number of forward citations during the first seven years since patent application as the measure of social value (see Section 3.7 for additional robustness checks).[13] Recall that strategic patents tend to have large private but low social value. Our results indicate that the share of strategic patents very probably did not increase in the post-1995 period, even though the citation counts decrease. Also, the increases in citations correlated with additional renewals are larger by software patents than by aerospace patents, as we expected.

However, it is still possible that the result of our patent-level approach is biased by neglecting the input side of patent production. In Figure 3.7, we take the final doubly relative scores of our firm-level DEA approach and average them over whole industries in each year. The results corroborate our patent-level analysis: There is no evidence of strategic patenting being more common in the post-1995 period. We observe a decrease of relative preference for patent value production up until the end of 1980s and a gradual turn towards socially valuable patents afterwards. It is true, that aerospace companies prefer socially valuable patents more than computer and semiconductor companies since 1990, but still less than software companies.

Figure 3.8 depicts the development of relative efficiency for individual companies

[13] Again, we winsorize the top 5% of the citation count to limit the impact of outliers.

Figure 3.7: Relative efficiency of industries in producing patent value vs. patent quantity

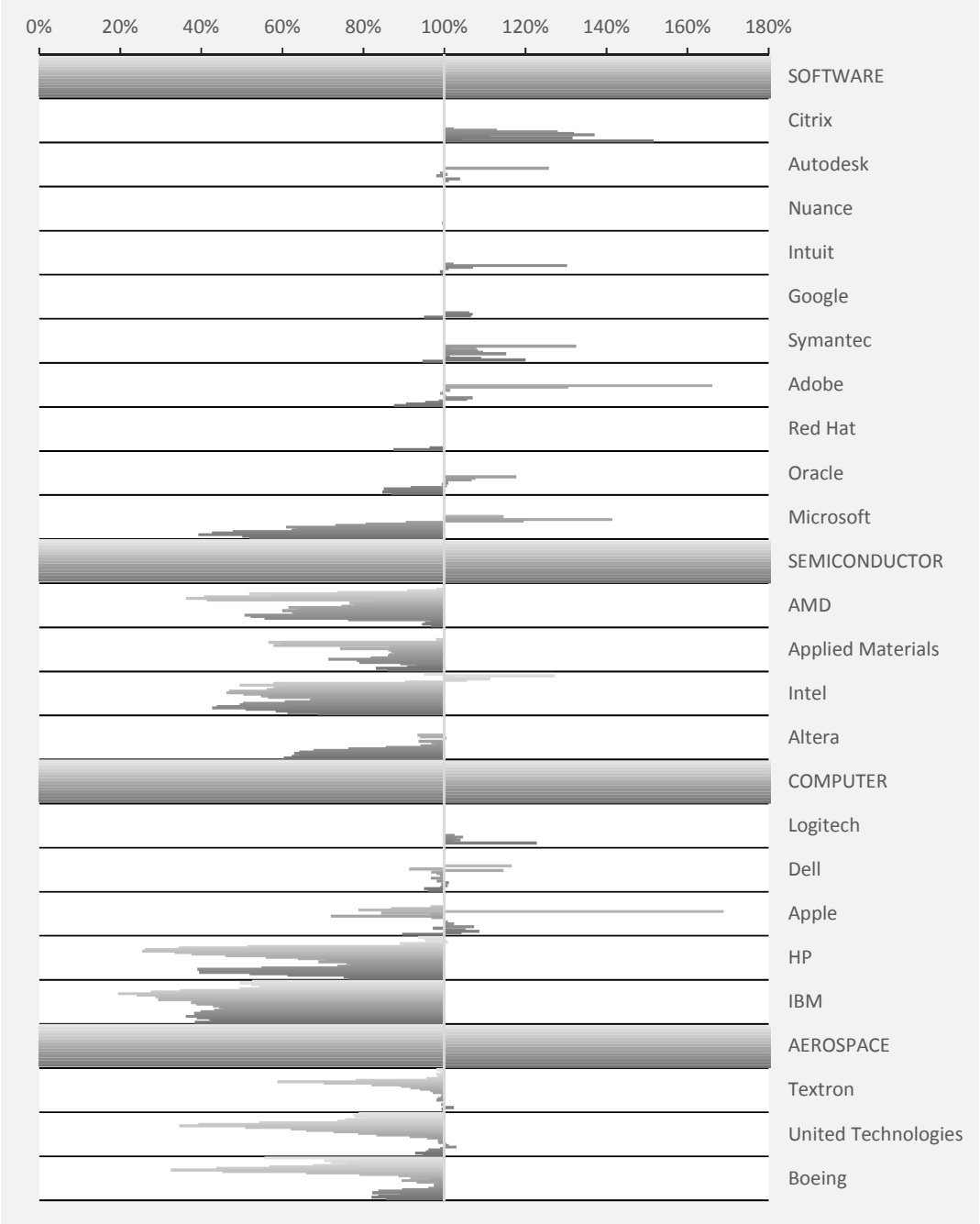


Notes: The relative efficiency of a company in a given year is calculated as the percentage difference between the efficiency score of the company with forward citations per year as the output variable and the score of the same company with patent quantity as the output variable. Score above 100% (denoted as *equal*) means higher relative efficiency in producing valuable patents than mere patent quantity. For industry-level results, this relative efficiency score is averaged over the whole industry in each year.

and sorts them by industries and their relative efficiency in 2007. The first message the figure conveys is that companies from the semiconductor and the aerospace industries tend to follow very similar strategies. Semiconductor companies focus more on patent quantities production, with the exception of Intel during the beginning of 1980s. Aerospace companies, as the average already revealed, went through a period of increasing preference for patent quantity production with its peak in the second half of 1980s, and started to turn their attention toward socially valuable patents afterwards. The patent strategies in the software and the computer industries are more heterogeneous.

Moreover, it is true that the strategy is stable for some companies. Citrix, Symantec, or IBM systematically focus strongly either on patent value production, or on patent quantity production. But there are a number of companies in our sample which seem to adjust the patenting strategy to their changing needs. For example, majority of software companies recently started to focus more on patent quantities. To sum up, patenting strategy seems to depend in many cases on managerial decisions of individual companies' managers or owners. External or industry-wide factors do probably play a role but are not strong enough to fully harmonize the divergence in strategies.

Figure 3.8: Relative efficiency of companies in producing patent value vs. patent quantity



Notes: The relative efficiency of a company in a given year is calculated as the percentage difference between the efficiency score of the company with forward citations per year as the output variable and the score of the same company with patent quantity as the output variable. Score above 100% (denoted as *equal*) means higher relative efficiency in producing valuable patents than mere patent quantity. Sorted by the industry and relative efficiency in 2007.

Both approaches strongly reject the first hypothesis of higher prevalence of strategic patenting in the post-1995 period. The correlation between citations and renewals is stronger, and the relative efficiency of producing more cited patents is higher after 1995. The evidence regarding our second hypothesis that aerospace companies participate the least in strategic patenting and produce more socially valuable patents than the rest of our sample is not as convincing, but software companies seem to focus slightly more on socially valuable patents and software patents' private value correlates more strongly with their social value. As the software industry is believed to be prone to strategic patenting, we expected the aerospace patents to differ much more.[14]

Utilization of strategic patenting may be influenced by changes in patent protection in the U.S. Gallini (2002) points out a couple of important court decisions affecting the strength of patent protection and discusses, whether these changes encouraged more innovation, disclosure, and technology transfers. She mentions extension of patentability to genetically engineered bacteria (in 1980), software (1981), or business methods and financial service products (1998). Following the 1998 decision in *State Street Bank and Trust v. Signature Financial Group*, other business methods started to receive patents, such as the Amazon's one-click Internet ordering process (Gallini 2002, p. 134). Another landmark Gallini mentions is the establishment of the Court of Appeals of the Federal Circuit in 1982. And finally, the Hatch-Waxman Act of 1984 and the adoption of a 20-year patent term in compliance with the Trade-Related Aspects of Intellectual Property (TRIPs) agreement provided longer patent protection and, consequently, increased the expected return to patenting.

According to Gallini, opposite effect on protection strength could have had the American Inventors Protection Act passed by Congress in 1999, which requires all patent applications to be published 18 months from the filing date. Potentially protection-weakening was also the 2000 Court of Appeals decision in *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co., Ltd.*. Mezzanotti (2017) analyzes the 2006 Supreme Court decision in *eBay v. MercExchange* which ended the practice of granting a permanent injunction[15] automatically after a patent infringement. The intention was to reduce abusive patent lawsuits and Mezzanotti shows that it led to an increase in quality and quantity of patenting. But it would be very complicated to link any of these policy changes to the obtained development of strategic patenting given the delay between patent application and its subsequent grant, which may be several years. Moreover, the relationship between stronger patent protection and more innovation itself has been questioned by a number of authors (see, e.g., Bessen & Meurer 2008; Lerner 2009; Mokyr 2009).

[14] Excluding self-citations doesn't have any impact on our findings, even though they constitute 14.8% of all citations.

[15] An order forcing firm to stop any operation related to the violated patent.

3.7 Robustness checks

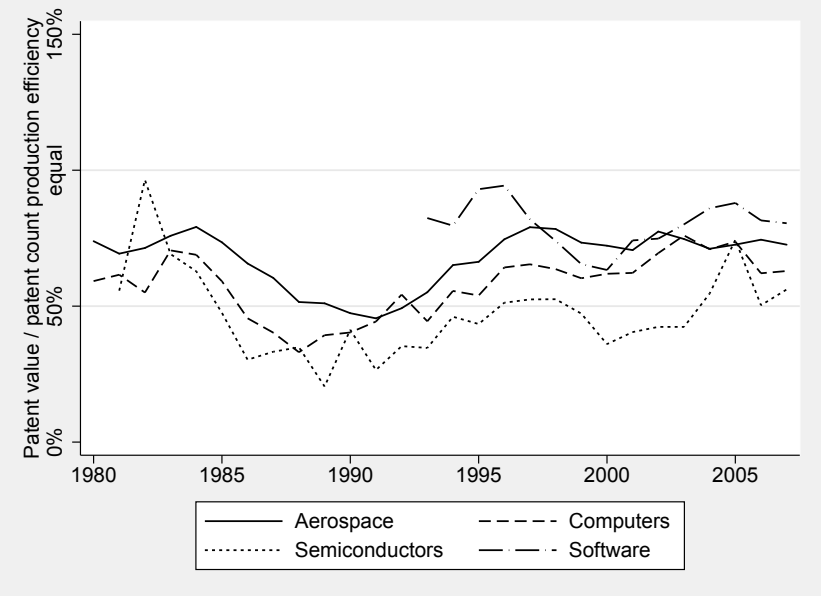
In this section we present two additional robustness checks. The first one deals with the issue of patent classification into industries. For the patent-level approach, the predominant industry of individual companies may not be the most appropriate classification. Every company in the sample produced patents from many various technological areas. To make sure we do not introduce a bias into our analysis, we narrowed our sample only to software patents granted to software companies, hardware patents granted to computer and semiconductor companies, and aerospace patents granted to aerospace companies.

The selection of appropriate patents has been made on the basis of U.S. patent classification numbers – each granted patent is assigned to at least one patent class according to its technical features, to make patent searching easier. Because it is a very complex task to rigorously define some technological field (see, e.g., Hall & MacGarvie 2010, for discussion on classification of software patents), we went through the most frequent classes of each firm-level industry and sorted the most common classes into three categories according to our expert judgment: software, hardware, and aerospace patents.[16] Results of estimating the regression (3.1) on the narrow sample are presented in column 2 of Table 3.1 and Table 3.A2. The marginal effect of software patents of software companies is unchanged, whereas the marginal effect of aerospace patents of aerospace companies is higher after 1995 but with wider confidence intervals due to a lower number of observations. The marginal effect of renewal category on citations is slightly lower in the case of hardware patents of computer and semiconductor companies.

The second robustness check addresses the issue of possible outliers in the firm-level DEA approach by obtaining efficiency scores using the partial frontier approach of order-α efficiency. DEA, and non-parametric approaches to efficiency estimation in general, are highly vulnerable to outliers and measurement errors due to their deterministic character. order-α efficiency reduces the sensitivity to outliers by allowing for super-efficient DMUs located beyond the estimated production-possibility frontier. Such super-efficient DMUs then get efficiency score larger than 1. Under input-oriented order-α efficiency (Aragon *et al.* 2005; Daouia & Simar 2007), we do not look for minimal inputs, but use inputs of the $(100-\alpha)^{th}$ percentile peer DMUs as the reference value. Moreover, whereas DEA envelops data by convex hull, order-α relaxes the convexity assumption which makes it a more general estimator. The efficiency score for each DMU $i = 1, \ldots, N$ is calculated as:

[16] Software classes: 345, 380, 382, 700, 701, 702, 703, 704, 705, 706, 707, 709, 713, 715, 717, 719, 725, 726; hardware classes: 118, 257, 326, 327, 361, 365, 438, 708, 710, 711, 712, 714, 716, G9B; aerospace classes: 60, 244, 415, 416.

Figure 3.9: Relative efficiency of industries in producing patent value vs. patent quantity – order-α, $\alpha = 90$



Notes: See Figure 3.7. Estimated using order-α.

$$\hat{\theta}_{\alpha i} = P_{\substack{(100-\alpha) \\ j \in B_i}} \left\{ \max_{k=1,\ldots,K} \left\{ \frac{x_{jk}}{x_{ik}} \right\} \right\}, \tag{3.5}$$

where $x_{i1}, \ldots, x_{iK}$ is a set of inputs and $y_{i1}, \ldots, y_{iL}$ is a set of outputs of DMU i, and $j = 1, \ldots, N$ are all other peer DMUs producing at least as much of any output as DMU i, i.e. satisfying the condition $y_{jl} \geq y_{il} \forall l \in L$ denoted as B_i (Tauchmann 2012). For $\alpha = 90$, the results differ slightly (Figures 3.9 and 3.A5). The development over time is very similar even after allowing the most efficient decile to lie beyond the estimated production-possibility frontier. But all the relative efficiencies are lower, which means that this method estimates the companies on average focused less on patent social value as it identifies more DMUs as super-efficient in patent quantity production.

3.8 Concluding remarks

During the nineteenth century countries started to adopt laws focused on protection of intellectual property with the goal of providing a means to innovation. However, the ability of patents to motivate innovation has started to be questioned in the last years with a broad stream of literature analyzing the concept of strategic patenting. The argument goes that the existing institutions of intellectual property, and especially patents, are becoming ends instead of means.

In order to study this phenomenon, we built a data set of more than 168,000 U.S. patents applied for between 1980 and 2007. These patents were granted to 22 companies from aerospace, computer manufacturing, semiconductor and software industries. In our patent-level approach we use the number of received citations as a proxy for patent social value and patent renewal events as a measure of patent private value to examine their relationship and its change around 1995. In the firm-level approach we estimate the relative importance of strategic versus protective patenting of individual companies by comparing the efficiency of patent social value production and patent quantity production using data envelopment analysis (DEA). Our hypotheses are that strategic patenting is more prevalent in the post-1995 period and that aerospace companies participate the least in strategic patenting and produce more socially valuable patents than the rest of our sample.

The results of both approaches strongly reject the first hypothesis: The link between social and private value of patents is significantly stronger, and the relative efficiency of producing more cited patents is higher after 1995 which is a clear evidence against more prevalent strategic use of patents. We do not observe a rising tendency of large technology companies to engage in socially harmful strategic patenting.

Interestingly, software patents' private value correlates more strongly with their social value compared to the patents of any other industry. Also, software companies in our sample do not focus less on socially valuable patents production than aerospace companies, even though the software industry is believed to be prone to strategic patenting (Rai 2013; Graham & Vishnubhakat 2013).

The second hypothesis of aerospace companies producing more socially valuable patents than others seems to be, therefore, also rejected, albeit less strongly. Weak private–social patent value correlation and a stronger focus on patent quantity production of computer and semiconductor companies clearly indicate that companies from these two industries use more of their patents as strategic ends compared to aerospace and software companies.

To sum up, our findings mean that the observed increase in patent litigation over the last decades had to be driven by factors other than strategic patenting of large technology companies. Part of the growth in patent cases may be attributed to patent trolls and other non-practicing entities. However, the vast majority of court decisions, even in the fields we study, seem to be related to practicing entities (PricewaterhouseCoopers 2016, p. 12). How to reconcile growing incidence of phenomena connected with strategic patenting, such as patent aggregation, creation of patent thickets, and more litigation, with a decrease in strategic patenting?

One possibility is, that these phenomena are predominantly caused by other market entities – smaller companies or NPEs. In other words, the sector of large technology companies may not be behind the socially harmful unproductive activities; or at least not more, than in the 1980s. The policy recommendation would be to target

those parts of the market, which are responsible. The second possible interpretation of our result is that large technology companies use strategically patents which are not different from innovation-protecting patents in terms of their social value. In such a case, the welfare implications and policy recommendations would be unclear. Strengthening patent protection may in fact encourage the unwanted use of patents, and vice versa.

A clear limitation of our study is the restriction of our sample to only 22 large companies, which was needed for the firm-level approach to strategic patenting identification. It is possible, that smaller companies with short history choose their patenting strategy differently. On the other hand, if we set aside non-practicing entities (also known as patent trolls), to use patents strategically, a company must be ready to exert considerable resources related to patent litigation. Not many practicing smaller companies would be able to do that on a sizable scale.

Also, our identification of strategic patents hinges on the assumption that the number of forward citations a patent receives is a meaningful proxy for its social value. Even though forward citations have become the standard measure of the value of innovation (some authors call it the size of the inventive step) only a couple of authors provide evidence in favor of such assumption (see, e.g., Carpenter *et al.* 1981; Trajtenberg 1990; Moser *et al.* 2015). We understand that coming up with a credible measure of patent social value is complicated – were it not, we would not have to be content with the necessarily imperfect measures based on patent indicators. But we hope that further research in this field would bring more supportive evidence in favor of forward citations.

We believe that our method of combining patent-level and firm-level approaches to identify strategic patenting may be useful not only in the debate about the extent of this phenomenon, but also for authors estimating the efficiency of technological innovation; because up to now, they have focused merely on patent quantity as one of the outputs of innovation process. But as we argue in this paper, the production of a high number of patents may be a result of strategic patenting, rather than socially valuable innovations.

References

Abrams, D. S., U. Akcigit, & J. Popadak (2013): "Patent Value and Citations: Creative Destruction or Strategic Disruption?" *Working Paper 19647*, National Bureau of Economic Research.

Aragon, Y., A. Daouia, & C. Thomas-Agnan (2005): "Nonparametric Frontier Estimation: A Conditional Quantile-Based Approach." *Econometric Theory* **21(2)**: pp. 358–389.

Banker, R. D., A. Charnes, & W. W. Cooper (1984): "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis." *Management Science* **30(9)**: pp. 1078–1092.

Baumol, W. J. (1990): "Entrepreneurship: Productive, Unproductive, and Destructive." *The Journal of Political Economy* **98(5)**: pp. 893–921.

Bessen, J. (2008): "The value of U.S. patents by owner and patent characteristics." *Research Policy* **37(5)**: pp. 932–945.

Bessen, J. & M. J. Meurer (2008): "Do Patents Perform like Property?" *Academy of Management Perspectives* **22(3)**: pp. 8–20.

Bessen, J. E. (2003): "Patent Thickets: Strategic Patenting of Complex Technologies." *Working paper*, Social Science Research Network, Rochester, NY.

Bessen, J. E., M. J. Meurer, & J. L. Ford (2011): "The Private and Social Costs of Patent Trolls." *Boston University School of Law Working Paper 11-45*.

Blind, K., K. Cremers, & E. Mueller (2009): "The influence of strategic patenting on companies' patent portfolios." *Research Policy* **38(2)**: pp. 428–436.

Boldrin, M. & D. K. Levine (2009): "A Model of Discovery." *American Economic Review* **99(2)**: pp. 337–342.

Boldrin, M. & D. K. Levine (2010): *Against intellectual monopoly*. Cambridge: Cambridge Univ. Press.

Bound, J., C. Cummins, Z. Griliches, B. H. Hall, & A. B. Jaffe (1982): "Who Does R&D and Who Patents?" *Working Paper 908*, National Bureau of Economic Research.

Carpenter, M. P., F. Narin, & P. Woolf (1981): "Citation rates to technologically important patents." *World Patent Information* **3(4)**: pp. 160–163.

Chan, J. & M. Fawcett (2005): "Footsteps of the Patent Troll." *Intellectual Property Law Bulletin* **10**: p. 1.

Charnes, A., C. T. Clark, W. W. Cooper, & B. Golany (1985): "A developmental study of data envelopment analysis in measuring the efficiency of maintenance units in the U.S. air forces." *Annals of Operations Research* **2(1)**: pp. 95–112.

Charnes, A., W. Cooper, & E. Rhodes (1978): "Measuring the efficiency of decision making units." *European journal of operational research* **2(6)**: pp. 429–444.

Chen, Y. & A. Iqbal Ali (2004): "DEA Malmquist productivity measure: New insights with an application to computer industry." *European Journal of Operational Research* **159(1)**: pp. 239–249.

Chuang, A. (2006): "Fixing the Failures of Software Patent Protection: Deterring Patent Trolling by Applying Industry-Specific Patentability Standards." *Southern California Interdisciplinary Law Journal* **16**: p. 215.

Cockburn, I. M. & M. J. MacGarvie (2011): "Entry and Patenting in the Software Industry." *Management Science* **57(5)**: pp. 915–933.

Cohen, L., U. Gurun, & S. D. Kominers (2014): "Patent Trolls: Evidence from Targeted Firms." *Working Paper 20322*, National Bureau of Economic Research.

Cruz-Cázares, C., C. Bayona-Sáez, & T. García-Marco (2013): "You can't manage right what you can't measure well: Technological innovation efficiency." *Research Policy* **42(6–7)**: pp. 1239–1250.

Daouia, A. & L. Simar (2007): "Nonparametric efficiency analysis: A multivariate conditional quantile approach." *Journal of Econometrics* **140(2)**: pp. 375–400.

Ewing, T. & R. Feldman (2012): "The Giants Among Us." *Stan. Tech. L. Rev.* **1**.

Farrell, J. & C. Shapiro (2008): "How Strong Are Weak Patents?" *The American Economic Review* **98(4)**: pp. 1347–1369.

Farrell, M. (1957): "The measurement of productive efficiency." *Journal of the Royal Statistical Society. Series A (General)* **120(3)**: pp. 253–290.

Fischer, T. & J. Leidinger (2014): "Testing patent value indicators on directly observed patent value-An empirical analysis of Ocean Tomo patent auctions." *Research Policy* **43(3)**: pp. 519–529.

Färe, R., S. Grosskopf, M. Norris, & Z. Zhang (1994): "Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries." *The American Economic Review* **84(1)**: pp. 66–83.

Gallini, N. T. (2002): "The Economics of Patents: Lessons from Recent U.S. Patent Reform." *The Journal of Economic Perspectives* **16(2)**: pp. 131–154.

Gambardella, A., D. Harhoff, & B. Verspagen (2008): "The value of European patents." *European Management Review* **5(2)**: pp. 69–84.

Gaulé, P. & N. Maystre (2011): "Getting cited: Does open access help?" *Research Policy* **40(10)**: pp. 1332–1338.

Graham, S. & S. Vishnubhakat (2013): "Of Smart Phone Wars and Software Patents." *The Journal of Economic Perspectives* **27(1)**: pp. 67–85.

Griliches, Z. (1980): "Returns to research and development expenditures in the private sector." In "New developments in productivity measurement," pp. 419–462. University of Chicago Press.

Grimaldi, M., L. Cricelli, M. Di Giovanni, & F. Rogo (2015): "The patent portfolio value analysis: A new framework to leverage patent information for strategic technology planning." *Technological Forecasting and Social Change* **94**: pp. 286–302.

Guan, J. C., R. C. M. Yam, C. K. Mok, & N. Ma (2006): "A study of the relationship between competitiveness and technological innovation capability based on DEA models." *European Journal of Operational Research* **170(3)**: pp. 971–986.

Hall, B. H. & R. M. Ham (1999): "The Patent Paradox Revisited: Determinants of Patenting in the US Semiconductor Industry, 1980-94." *Working Paper 7062*, National Bureau of Economic Research.

Hall, B. H. & D. Harhoff (2012): "Recent Research on the Economics of Patents." *Annual Review of Economics* **4(1)**: pp. 541–565.

Hall, B. H., A. Jaffe, & M. Trajtenberg (2005): "Market Value and Patent Citations." *The RAND Journal of Economics* **36(1)**: pp. 16–38.

Hall, B. H. & M. MacGarvie (2010): "The private value of software patents." *Research Policy* **39(7)**: pp. 994–1009.

Harhoff, D., F. M. Scherer, & K. Vopel (2003): "Citations, family size, opposition and the value of patent rights." *Research Policy* **32(8)**: pp. 1343–1363.

Hashimoto, A. & S. Haneda (2008): "Measuring the change in R&D efficiency of the Japanese pharmaceutical industry." *Research Policy* **37(10)**: pp. 1829–1836.

Havránek, T. (2015): "Measuring Intertemporal Substitution: The Importance of Method Choices and Selective Reporting." *Journal of the European Economic Association* **13(6)**: pp. 1180–1204.

Hegde, D., D. C. Mowery, & S. J. H. Graham (2009): "Pioneering Inventors or Thicket Builders: Which U.S. Firms Use Continuations in Patenting?" *Management Science* **55(7)**: pp. 1214–1226.

Jeruss, S., R. Feldman, & J. Walker (2012): "The America Invents Act 500: Effects of Patent Monetization Entities on US Litigation." *Duke Law & Technology Review* **11**: p. 357.

Jorgenson, D. W., M. S. Ho, & J. D. Samuels (2012): "A Prototype Industry-Level Production Account for the United States, 1947-2010." Second World KLEMS Conference, Harvard University.

Kortum, S. & J. Lerner (1999): "What is behind the recent surge in patenting?" *Research Policy* **28(1)**: pp. 1–22.

Lanjouw, J. O. (1998): "Patent Protection in the Shadow of Infringement: Simulation Estimations of Patent Value." *The Review of Economic Studies* **65(4)**: pp. 671–710.

Lanjouw, J. O. & M. Schankerman (2004): "Patent Quality and Research Productivity: Measuring Innovation with Multiple Indicators." *The Economic Journal* **114(495)**: pp. 441–465.

Lerner, J. (2009): "The Empirical Impact of Intellectual Property Rights on Innovation: Puzzles and Clues." *American Economic Review* **99(2)**: pp. 343–348.

Levin, R. C., A. K. Klevorick, R. R. Nelson, S. G. Winter, R. Gilbert, & Z. Griliches (1987): "Appropriating the Returns from Industrial Research and Development." *Brookings Papers on Economic Activity* **1987(3)**: pp. 783–831.

Macdonald, S. (2004): "When means become ends: considering the impact of patent strategy on innovation." *Information Economics and Policy* **16(1)**: pp. 135–158.

Mazzeo, M. J., J. H. Ashtor, & S. Zyontz (2013): "Do NPEs Matter? Non-Practicing Entities and Patent Litigation Outcomes." *Journal of Competition Law and Economics* **9(4)**: pp. 879–904.

Merges, R. P. (2009): "The Trouble with Trolls: Innovation, Rent-Seeking, and Patent Law Reform." *Berkeley Technology Law Journal* **24**: p. 1583.

Mezzanotti, F. (2017): "Roadblock to Innovation: The Role of Patent Litigation in Corporate R&D." *Mimeo*. `http://www.kellogg.northwestern.edu/faculty/mezzanotti/documents/innovation.pdf`. Accessed: 2017-03-15.

Mokyr, J. (2009): "Intellectual Property Rights, the Industrial Revolution, and the Beginnings of Modern Economic Growth." *American Economic Review* **99(2)**: pp. 349–355.

Moser, P., J. Ohmstedt, & P. W. Rhode (2015): "Patent Citations and the Size of the Inventive Step - Evidence from Hybrid Corn." *NBER Working Paper 21443*, National Bureau of Economic Research, Inc.

Munari, F. & L. Toschi (2014): "Running ahead in the nanotechnology gold rush. Strategic patenting in emerging technologies." *Technological Forecasting and Social Change* **83**: pp. 194–207.

Nicholas, T. (2013): "Are Patents Creative or Destructive?" *Working Paper 14-036*, Harvard Business School.

Noel, M. & M. Schankerman (2013): "Strategic Patenting and Software Innovation." *The Journal of Industrial Economics* **61(3)**: pp. 481–520.

Pakes, A. & M. Schankerman (1984): "The Rate of Obsolescence of Patents, Research Gestation Lags, and the Private Rate of Return to Research Resources." In Z. Griliches (editor), "R&D, Patents, and Productivity," pp. 73–88. National Bureau of Economic Research, Inc.

Peeters, C. & B. v. P. d. l. Potterie (2006): "Innovation strategy and the patenting behavior of firms." *Journal of Evolutionary Economics* **16(1-2)**: pp. 109–135.

PricewaterhouseCoopers (2013): "2013 Patent Litigation Study." `http://www.pwc.com/us/en/forensic-services/publications/assets/2013-patent-litigation-study.pdf`. Accessed: 2016-02-07.

PricewaterhouseCoopers (2016): "2016 Patent Litigation Study: Are we at an inflection points?" `https://www.pwc.com/us/en/forensic-services/publications/assets/2016-pwc-patent-litigation-study.pdf`. Accessed: 2017-03-16.

Rai, A. (2013): "Improving (Software) Patent Quality Through the Administrative Process." *Houston Law Review* pp. 503–543.

de Rassenfosse, G. (2013): "Do firms face a trade-off between the quantity and the quality of their inventions?" *Research Policy* **42(5)**: pp. 1072–1079.

Sapsalis, E., B. van Pottelsberghe de la Potterie, & R. Navon (2006): "Academic versus industry patenting: An in-depth analysis of what determines patent value." *Research Policy* **35(10)**: pp. 1631–1645.

Scherer, F. M. & D. Harhoff (2000): "Technology policy for a world of skew-distributed outcomes." *Research Policy* **29(4–5)**: pp. 559–566.

Squicciarini, M., H. Dernis, & C. Criscuolo (2013): "Measuring Patent Quality." *OECD Science, Technology and Industry Working Papers*, Organisation for Economic Co-operation and Development, Paris.

Stephan, P. E. (1996): "The Economics of Science." *Journal of Economic Literature* **34(3)**: pp. 1199–1235.

Tauchmann, H. (2012): "Partial frontier efficiency analysis." *Stata Journal* **12(3)**: pp. 461–478.

Trajtenberg, M. (1990): "A Penny for Your Quotes: Patent Citations and the Value of Innovations." *The RAND Journal of Economics* **21(1)**: pp. 172–187.

Unified Patents (2015): "1st Half 2015 Patent Troll Dispute Report." `http://unifiedpatents.com/1st-half-2015-patent-dispute-report/`. Accessed: 2016-02-07.

Van Zeebroeck, N. & B. Van Pottelsberghe de la Potterie (2011): "Filing strategies and patent value." *Economics of innovation and new technology* **20(6)**: pp. 539–561.

Zeebroeck, N. v. (2011): "The puzzle of patent value indicators." *Economics of Innovation and New Technology* **20(1)**: pp. 33–62.

3.A Appendix

Figure 3.A1: Average number of citations during the first 7 years

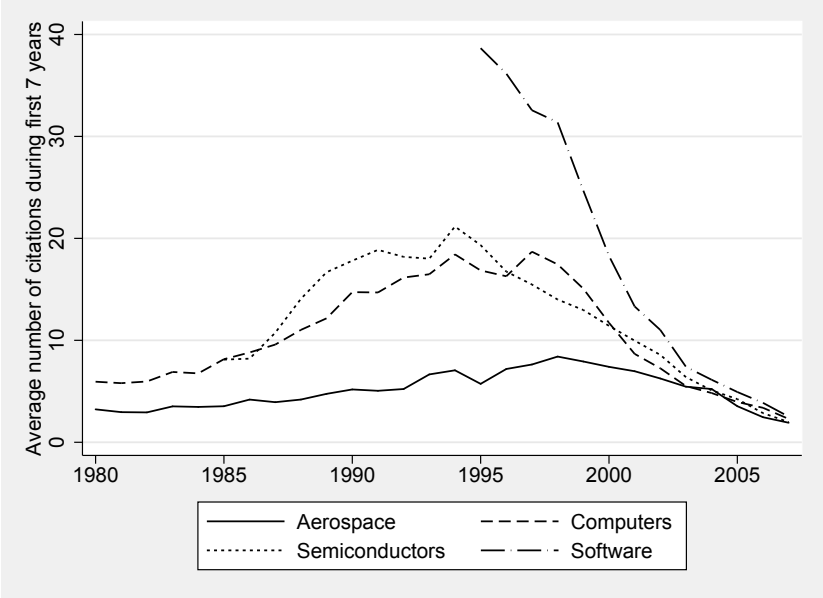


Figure 3.A2: Proportion of patents with no forward citations

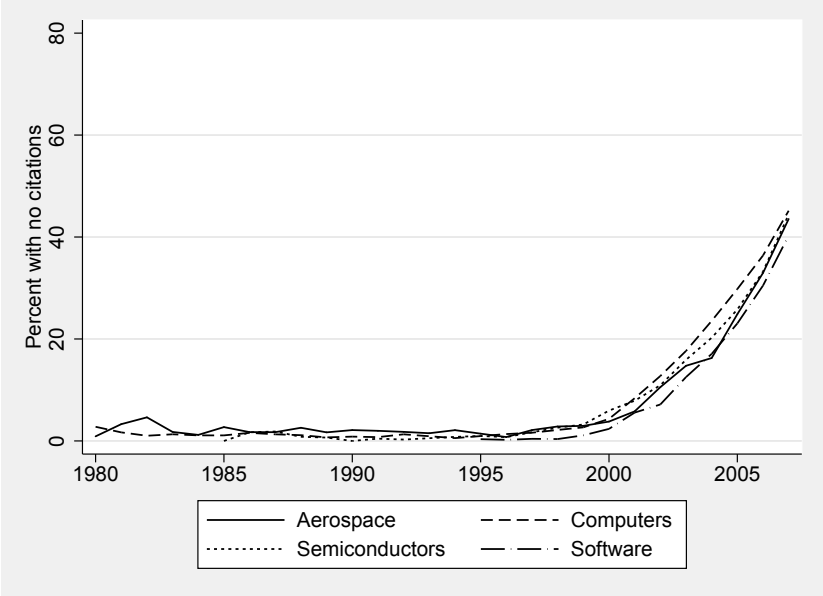


Figure 3.A3: Proportion of patents getting their first citation more than five years from application if cited

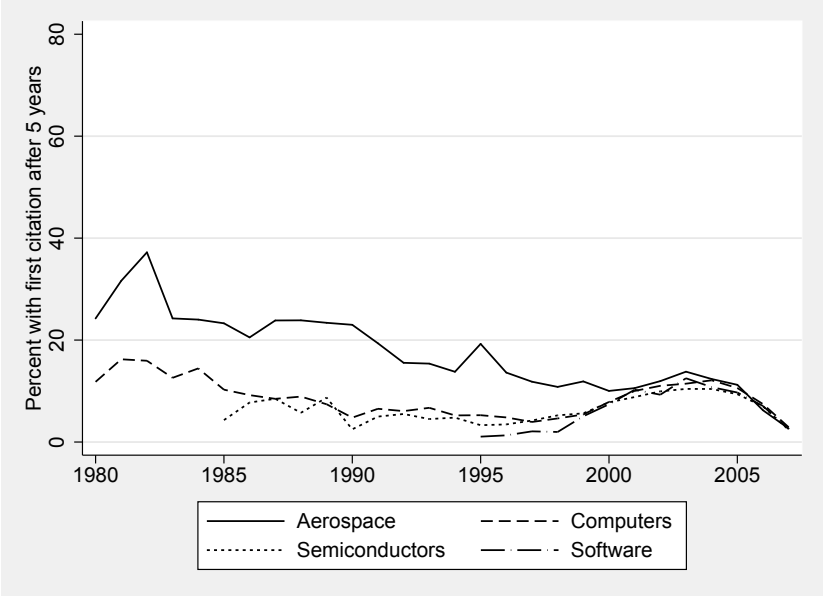
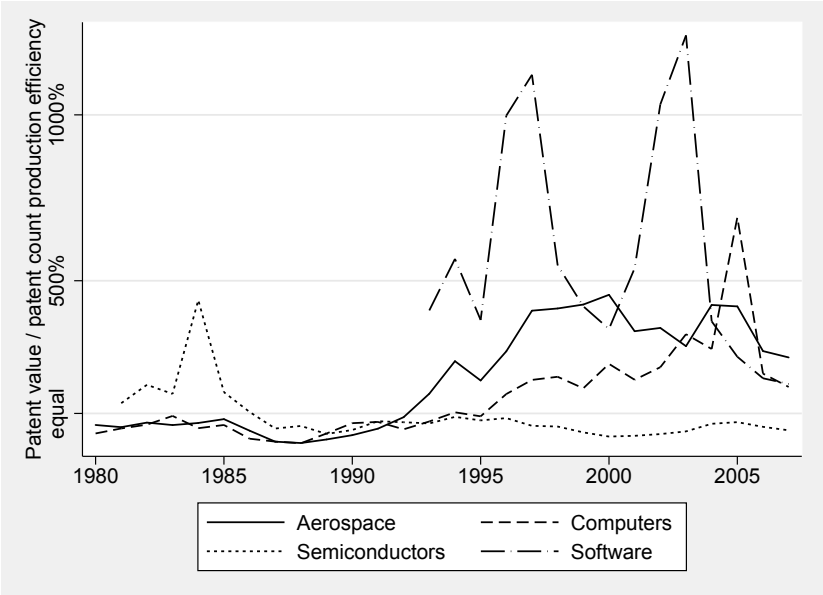
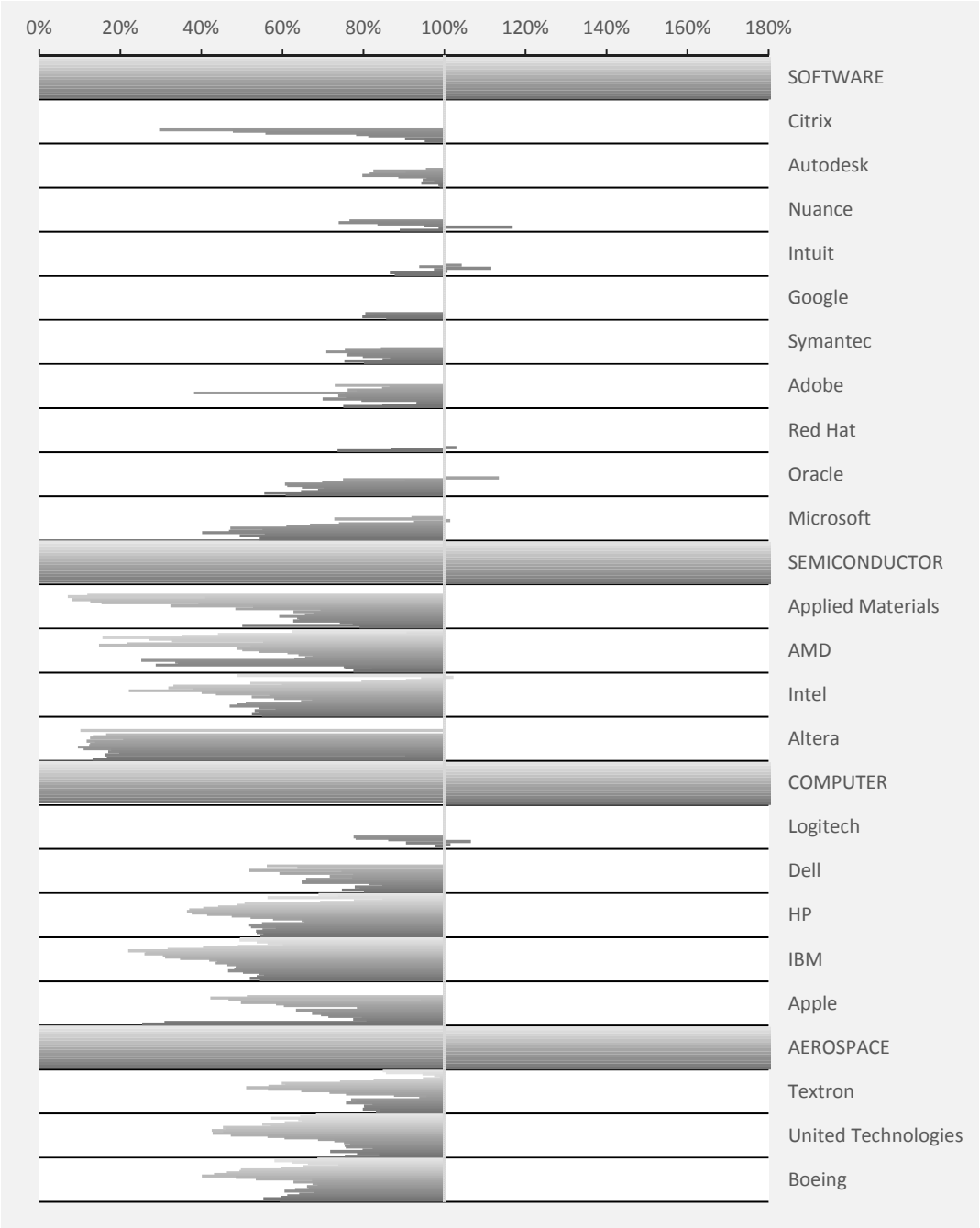


Figure 3.A4: Relative efficiency of industries in producing patent value vs. patent quantity – CRS



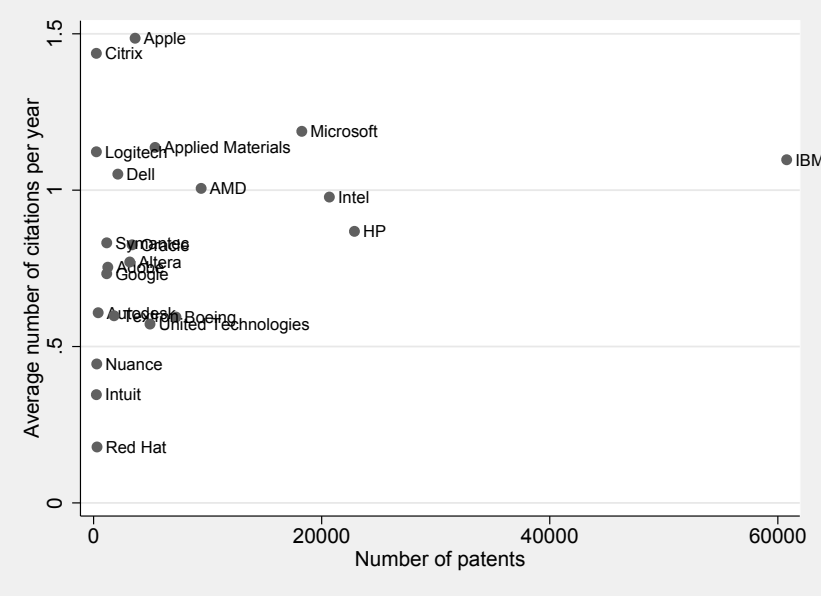
Notes: See Figure 3.7. Estimated using constant returns to scale assumption.

Figure 3.A5: Relative efficiency of companies in producing patent value vs. patent quantity – order-α



Notes: See Figure 3.8.

Figure 3.A6: Number of produced patents and their average number of citations per year



Notes: There is no statistically significant linear relationship.

Table 3.A1: Descriptive statistics

Assignee	Industry	Data coverage	# of patents	Citations per year (mean)	Citations per year (SD)	Employees (mean; thousands)	Real R&D expense (mean; USD millions)
AMD	Semiconductors	1981–2007	9428	1.01	1.45	13.29	494.01
Adobe	Software	1990–2007	1244	0.75	1.21	2.85	239.07
Altera	Semiconductors	1987–2007	3172	0.77	1.47	1.25	95.88
Apple	Computers	1988–2007	3639	1.49	2.48	14.11	504.38
Applied Materials	Semiconductors	1985–2007	5392	1.14	1.62	9.12	521.56
Autodesk	Software	1992–2007	400	0.61	1.11	3.36	209.38
Boeing	Aerospace	1980–2007	7098	0.60	0.78	148.38	1592.52
Citrix	Software	1995–2007	241	1.44	1.98	1.79	74.55
Dell	Computers	1989–2007	2126	1.05	1.78	30.51	247.04
Google	Software	1999–2007	1149	0.73	1.24	7.62	745.67
HP	Computers	1980–2007	22826	0.87	1.79	104.31	2038.16
IBM	Computers	1980–2007	60361	1.10	1.86	331.66	4193.71
Intel	Semiconductors	1981–2007	20665	0.98	1.88	48.24	2037.83
Intuit	Software	1999–2007	243	0.35	0.71	6.40	279.40
Logitech	Computers	1990–2007	243	1.12	2.69	6.14	53.76
Microsoft	Software	1990–2007	18257	1.19	2.30	36.83	3492.68
Nuance	Software	1998–2007	276	0.44	0.96	0.97	33.37
Oracle	Software	1995–2007	3379	0.83	1.54	46.66	1378.60
Red Hat	Software	2000–2007	300	0.18	0.46	1.16	43.76
Symantec	Software	1996–2007	1150	0.83	1.33	6.98	360.90
Textron	Aerospace	1980–2007	1769	0.60	0.70	53.30	222.95
United Technologies	Aerospace	1980–2007	4814	0.57	0.70	185.66	1255.35

Table 3.A2: Patent-level average marginal effects (semi-elasticity)

Dependent variable: Forward citations per year	(1) Baseline		(2) Narrow	
Renewed 1x				
Aerospace × Before 1995	0.062	(0.047)	0.054	(0.088)
Aerospace × After 1995	0.742***	(0.077)	1.167***	(0.117)
Computers × Before 1995	−0.018	(0.026)	0.023	(0.034)
Computers × After 1995	0.367***	(0.015)	0.303***	(0.022)
Semiconductors × Before 1995	0.056	(0.115)	0.069	(0.122)
Semiconductors × After 1995	0.200***	(0.030)	−0.001	(0.039)
Software × Before 1995	0.170	(0.621)	0.170	(0.621)
Software × After 1995	0.979***	(0.028)	0.963***	(0.030)
Renewed 2x				
Aerospace × Before 1995	0.112**	(0.050)	0.031	(0.086)
Aerospace × After 1995	1.333***	(0.077)	1.786***	(0.115)
Computers × Before 1995	0.007	(0.027)	0.053	(0.035)
Computers × After 1995	0.804***	(0.015)	0.688***	(0.022)
Semiconductors × Before 1995	0.237**	(0.111)	0.154	(0.116)
Semiconductors × After 1995	0.790***	(0.029)	0.561***	(0.037)
Software × Before 1995	−0.625	(0.617)	−0.597	(0.621)
Software × After 1995	1.758***	(0.029)	1.758***	(0.031)
Renewed 3x				
Aerospace × Before 1995	0.325***	(0.042)	0.256***	(0.070)
Aerospace × After 1995	1.638***	(0.078)	2.010***	(0.116)
Computers × Before 1995	0.287***	(0.024)	0.286***	(0.032)
Computers × After 1995	1.284***	(0.015)	1.095***	(0.022)
Semiconductors × Before 1995	0.337***	(0.105)	0.244**	(0.107)
Semiconductors × After 1995	1.207***	(0.028)	0.914***	(0.036)
Software × Before 1995	0.137	(0.573)	0.153	(0.573)
Software × After 1995	2.288***	(0.028)	2.285***	(0.030)

Notes: Robust standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Chapter 4

Bankruptcy, Investment, and Financial Constraints: Evidence from the Czech Republic

Abstract

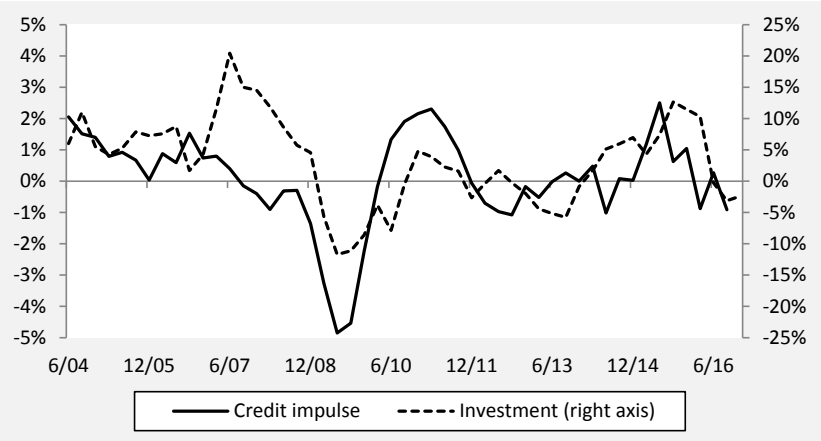
Using investment–cash flow sensitivity to analyze financial constraints over the period 2006–2011 in the Czech Republic we find that healthy companies were financially constrained both before and after the 2008 crisis. There is robust evidence that cash flow and the level of debt have a positive and significant impact on the investment rate. Companies going bankrupt had significantly higher levels of external debt and bank loans, but do not manifest any investment–cash flow sensitivity in the pre-crisis period, which indicates that they were probably not financially constrained at all. After the 2008 crisis, companies we know are going to declare bankruptcy start to get financially constrained, too.

The paper was co-authored with Martin Pospíšil. We acknowledge support from the Czech National Bank (project #C6/12). Martin Pospíšil acknowledges support from the Grant Agency of Charles University (grant #616812). We are grateful to Jan Hanousek, Randall Filer, Oleksandr Talavera, Miroslav Plašil, and two anonymous referees for a thorough review of the paper. We would like to thank Jan Kmenta, Evangelia Vourvachaki, Evžen Kočenda, Jakub Kastl, Jacek Cukrowski, Štěpán Jurajda, Andreas Ortmann, Jakub Kastl, Beyongju Jeong, Jan Švejnar, Lubomír Lízal, Iryna Momotenko, and Avner Shaked, and seminar participants at the 2013 IES Economic Meeting, the Bratislava Economic Meeting 2012, CERGE-EI, and the Czech National Bank for useful comments and suggestions. Martin Pospíšil would like to thank Organizational Dynamics at the University of Pennsylvania for their hospitality during his research stay. An earlier version of this paper was published as Czech National Bank Working Paper 1/2014 under the title "Bankruptcy, Investment, and Financial Constraints: Evidence from a Post-Transition Economy"

4.1 Introduction

In a country with a small stock market such as the Czech Republic, firms have limited access to capital and need to use bank credit extensively as their principal form of external financing.[1] As there are not many other options for firms to get credit, a significant decline in bank loans, such as the one experienced after September 2008, characterized by severely contracted liquidity in global credit markets, constrains the whole economy and may lead to an increased incidence of bankruptcy, which was actually observed in 2008.

Figure 4.1: Credit impulse and investment in the Czech Republic



Notes: Year-on-year changes in quarterly bank credit flows to non-financial corporations and their investment.
Source: Czech National Bank, authors' calculations.

Generally, the most volatile part of GDP, which is strongly linked to external credit provision, is investment – investors usually do not have enough internal funds for their projects. Financial constraints influence investment to a varying degree over the business cycle. As a consequence, financially constrained firms may be forced to forgo good investment opportunities and the whole economy can suffer. Figure 4.1 reveals that a drop in credit flows to the non-financial sector usually precedes a drop in investment and vice versa.

However, it is difficult to identify and correctly estimate the severity of financial constraints from aggregate data. A decrease, no matter how strong, in aggregate lending does not say anything about a credit crunch, as it may have been caused by a decrease in the demand for credit; for example due to negative expectations regarding future business opportunities. Although surveys can be generally used to distinguish between the supply and the demand effects, those that covered the topic

[1] Loans constituted 18% of total Czech non-financial corporations' liabilities over the 2006–2011 period, and temporarily increased to 20% by the beginning of 2009. That is about 40% of their external funds.

of financial constraints development in the Czech Republic around the time of crisis provide diverse results.

Whereas the Czech Statistical Office survey on the barriers to growth does not report sizable financial constraints, nor their significant increase after summer 2008 (see Figure 4.B1), Czech National Bank survey (Galuščák & Babecký 2009) reveals that 27.2% of companies perceived difficulties in financing due to the 2008 crisis. In the 2009 round of the EBRD-World Bank Business Environment and Enterprise Performance Survey (BEEPS), 18% of Czech companies perceived finance as the biggest constraint on their economic growth.[2]

Knowing more about the link between finance, investment, and bankruptcy can help policy-makers understand how to mitigate the consequences of such a credit crunch.[3] Recognizing this, we link balance-sheet data with original information on bankruptcy, and by testing for the presence of investment–cash flow sensitivity as an indicator of supply-side credit constraints offer a new perspective on this important relationship in the economy emphasizing the firms' reaction to the 2008 crisis.

Our contribution to the existing literature consists mainly of two components: By gathering information on bankruptcies, we are able to show that companies which go bankrupt face different credit constraints than healthy companies. And second, the 2008 crisis was a purely exogenous event for the Czech Republic. This allows us to show how credit constraints and the impact of bankruptcy events changed with the onset of the crisis, i.e. with credit contraction, without facing potential problems of model endogeneity.

The Czech Republic is a small and open economy. As such, it is highly vulnerable to external economic shocks such as the financial and economic crisis after September 2008. Even though the Czech banking sector didn't have any significant problems, Czech companies had to face a decline in lending after the fall of Lehman Brothers in 2008 (see the substantial negative credit impulse followed by a long disinvestment period in Figure 4.1).[4]

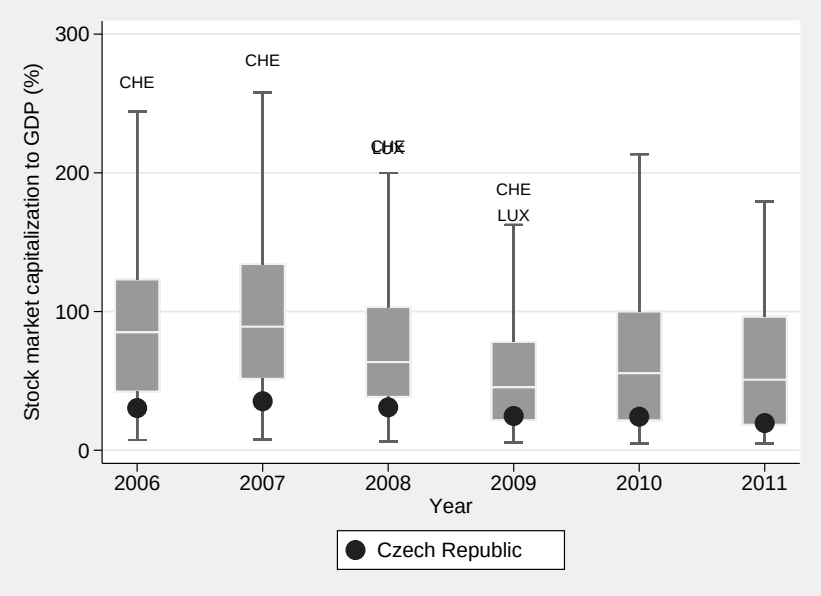
The Czech Republic is also a good example of a country with small stock market. In Figure 4.2 we plot stock market capitalization against GDP in selected OECD

[2]Even though BEEPS 2009 was effectively surveyed in 2008 and asked about the fiscal year 2007, the interviews among the Czech firms were conducted from late 2008 to early 2009. Answers regarding the current biggest obstacles should, therefore, already cover the onset of the crisis. Financial constraints remained relatively stable between 2002 and 2009 in the Czech Republic, while they increased dramatically in Russia, for example. In the majority of countries we observe a temporary increase of financial constraints in the 2009 round.

[3]As Bernanke *et al.* (1999) note, Fisher (1933) argued that the severity of the Great Depression was due to a heavy debt burden and financial constraints.

[4]The 2008 crisis hit firms in the Czech Republic hard. For example, in 2009 they were complaining that they were being hit by a credit crunch, with banks reluctant to lend money (`http://goo.gl/r2ulZA`). It was observed that the decline in credit after the events of 2008 was due to higher economic uncertainty, more prudent lending because of pressure from parent banks from abroad, and lower demand for credit in general due to low aggregate demand.

Figure 4.2: Stock market capitalization in high-income OECD countries



Notes: The top of the boxes indicates the upper quartile, the bottom is the lower quartile. The dividing line is the median. The whiskers represent the highest and the lowest data point still within 1.5 IQR of the upper and lower quartiles. Outliers are denoted by their country code. The black circle indicates stock market capitalization to GDP of Czechia.
Source: The World Bank (`http://go.worldbank.org/X23UD9QUX0`), authors' calculations.

countries. Comparing the Czech Republic to its peers, only Slovakia had substantially lower, and Estonia and Hungary slightly lower stock market capitalization during the observed period. The Figure also shows that the already low Czech stock market capitalization decreased further after 2008. Because of this, bank lending is crucial for investment and growth in the country. This is also the reason, why we focus solely on bank credit and use the term financial constraints as a synonym for credit constraints in this paper. Even though it is true that there are potentially other sources of external financing, which may play an important role in relaxing financial constraints, such as public (Colombo *et al.* 2013) or equity financing (Bertoni *et al.* 2015; Engel & Stiebale 2014). But these are of marginal importance for Czech companies.

The Czech banking crisis of 1997 and the subsequent privatization of Czech banks to Western global banking groups[5] helped the Czech banking sector learn how to better assess risk and was one of the reasons why the Czech banking sector weathered the 2008 crisis relatively well. Therefore, it is assumed that Czech banks know how to assess the risk of investment projects and we should expect to see companies going bankrupt face higher credit constraints. And finally, the Czech Republic is a

[5]Large state-owned banks were privatized to foreign investors (e.g. KBC, Erste, and Société Générale).

typical post-transition country.[6] As such, an analysis of this country can help us understand other Central and Eastern European countries that are catching up in terms of development but still have very shallow stock markets and corporations heavily reliable on bank credit.

Our results show that companies which went bankrupt in the period 2007–2013 had lower cash flow, a higher level of overall debt, and a higher level of bank loans compared to healthy companies. Their level of bank loans started to decrease only shortly before they declared bankruptcy. The level of debt and change in sales, as well as turnover, had a positive impact on the investment rate. We also find that firms were, in fact, more likely to invest in new assets if they generated enough funds of their own. In other words, Czech firms seem to be, on average, financially constrained. But our data also reveal that companies which went bankrupt actually did not face financial constraints before 2008, which is in contrast with findings of Mach & Wolken (2012), or Musso & Schiavo (2008). Positive investment–cash flow sensitivity of companies which we know are going to declare bankruptcy is observable only in the post-crisis period.

The remainder of the paper is organized as follows. The next section reviews the related literature and formulates the research question. In Section 4.3 we explain our research methodology and in Section 4.4 we describe our data and data management. Section 4.5 presents and discusses the results, and Section 4.6 introduces robustness checks. Section 4.7 concludes.

4.2 Literature review

The concept of financial constraints and credit rationing were first well analyzed theoretically by Stiglitz & Weiss (1981).[7] The outcome of their research is that under financial imperfections, the Modigliani-Miller theorem[8] does not hold, firms can be constrained, and overall economic growth may slow down. Over time, credit rationing theory has become highly important, especially in macroeconomic models with financial frictions.[9] The logic of credit rationing is that there is no linear relationship between the interest rate on loans and a bank's profitability. Beyond a

[6] At the end of 2007, the Czech Republic opted out of funding from the European Bank for Reconstruction and Development (EBRD).

[7] As lenders cannot perfectly distinguish between good and bad borrowers, when the interest rate increases, relatively good borrowers drop out of the market. Lenders' profits can then decrease since this "drop out" can lead to an increase in the default probability on loans made.

[8] The Modigliani-Miller theorem in its basic form states that, under a certain market price process, in the absence of taxes, bankruptcy costs, agency costs, and asymmetric information, and in an efficient market, the value of a firm is unaffected by how that firm is financed.

[9] Bernanke *et al.* (1999) show how credit-market frictions can significantly amplify both real and nominal shocks in the economy. Other economists who stand outside the standard macroeconomic models and focus on the importance of credit in the economy include Keynes, Minsky, and Stiglitz.

certain interest rate, any higher rate is considered too risky from the perspective of the bank and therefore the credit market does not clear.

Bernanke & Gertler (1995) were among the first to claim that the credit view approach aims to identify the propagation mechanism of the conventional interest rate effect. As Chatelain *et al.* (2003) note, however, standard macro-models usually do not include balance-sheet information on firms' behavior and are, therefore, not good enough to test for broad-credit-channel effects and imperfections.

Good evidence on how financial constraints affect economic growth is provided by Love (2003), for example. Several other studies (e.g. Oliner & Rudebusch 1996; Gertler & Hubbard 1989; Agca & Mozumdar 2008; Kashyap *et al.* 1994) confirm the robustness of the variation in the severity of financial constraints over time. However, it remains difficult to identify credit rationing from the aggregate data. A decline in lending may be driven either by unwillingness of lenders to lend or by low demand for new loans due to pessimistic expectations (Bernanke 1993).

In recognition of that, there has been a recent shift in economics from aggregate data toward the use of micro-level, balance-sheet data to test for the effects of financial constraints. For example, Bernanke & Blinder (1992) show how the credit rationing concept is related to the balance-sheet effect. At the same time, financial constraints are empirically unobservable and there is no balance-sheet item that will direcly indicate their presence. Therefore, to test for financial constraints, several authors (e.g. Hobdari *et al.* 2009) use the presence of investment–cash flow sensitivity as an indication of firms being credit constrained – an approach developed and popularized by Fazzari *et al.* (1988).

Other authors use survey data to get firm-level information on credit denial (e.g. Gaiotti 2011; Holton *et al.* 2012). But as Campello *et al.* (2010) point out, survey-based analysis is strongly limited by the ability of surveyed personnel to correctly assess credit constraints. Also, their analysis reveals that the differences between constrained and unconstrained firms became more significant during the 2008 crisis. Mach & Wolken (2012), in their study based on survey data on credit experiences, report that there is a link between credit access and the likelihood of bankruptcy, even though the authors themselves admit that their data on bankruptcy are not fully reliable. Similar results are obtained by Keasey & Watson (1991) and Musso & Schiavo (2008).

Literature on the investment behavior and financial constraints of firms in countries with larger stock markets is rich (e.g. Chava & Roberts 2008; Whited 2001; Hovakimian & Titman 2006). For example, in a recent paper focused on Italy, Gaiotti (2011) finds that the elasticity of a firm's investment to the availability of bank credit has been significant in periods of economic distress but not in other periods. He concludes that a credit crunch strongly affects investment and the whole economy. Carpenter & Guariglia (2008), using UK data, show that finance con-

strains firms' investment decisions after controlling for investment opportunities and distinguishing between internal and external constraints.

Recently, Clarke *et al.* (2012) focused on how country and firm characteristics affected firms' financial constraints and their likelihood of survival during the early phase of the recent global financial crisis in Eastern Europe and Central Asia. Generally, firm characteristics are found to be an important factor influencing the degree of financial constraints. For example, small firms are more likely to be credit rationed as they are usually younger, more opaque, often unable to provide audited financial statements, and therefore face higher constraints due to information asymmetries (Gertler & Gilchrist 1994). Also, due to fixed costs on the side of the banks, large firms taking out large loans are preferred (Avery *et al.* 1998). Colombo *et al.* (2012) or Behr *et al.* (2013) even use firm size as one of the criteria for identifying financially constrained firms.

On the other hand, there is scarce empirical literature on financial constraints in post-transition countries. Geršl & Jakubík (2011) focus on the question of how Czech firms obtain financing from domestic banks. Their results show that the vast majority of non-financial corporations obtain finances from just one lender. Plašil *et al.* (2013) apply an error-corection model on macroeconomic data to disentangle demand and supply effects on the amount of loans and describe the evolution of their mutual relationship. They reveal sizable credit restrictions by Czech banks following the onset of the 2008 financial crisis which has been later followed by a fall in credit demand. Noth & Gauselmann (2016) use survey information to identify financial constraints of foreign-owned firms in selected Central and Eastern Europe and test the impact of varying distribution of decision-making powers between the foreign headquarters and the home subsidiaries. In 2013, 7.45% of Czech firms covered by their dataset reported that they face financial constraints.

Using a panel of Czech firms from 1996 to 2002 to study the balance sheet channel of monetary policy transmission, Fidrmuc *et al.* (2010) find that monetary policy has stronger effects on smaller firms than on medium and larger ones. Lízal & Svejnar (2002) focus on investment behavior of Czech firms in the period 1992–1998 and find positive relationship between profit and investment, which they interpret as evidence of financing constraints, only in the category of cooperatives and smaller private firms. Pruteanu (2004) uses aggregate monthly data to identify credit rationing in the Czech Republic over the period 1/1997–6/2002. She finds evidence of credit rationing in the period 1/1999–12/2000. The results suggest that the the rest of the covered period is characterized by excess supply of loans. Konings *et al.* (2003) use investment–cash flow sensitivity to identify financial constraints over the period 1994–1999 and find that Czech firms seem to have been constrained. But they do not try to narrow their research to individual categories of firms. Gugler & Peev (2010) study financial constraints in 13 transition economies over the period 1993–2003,

focusing on the impact of firm ownership and constraints development over time. They find that investment–cash flow sensitivities declined over transition years.

To conclude, studies analyzing financial constraints focus usually on publicly traded companies and make heavy use of various market value measures. This approach is unfortunately an unusable one for countries such as the Czech Republic, where the very small share of publicly traded companies makes this kind of information unavailable. As a consequence, we have to rely solely on microeconomic balance-sheet data.

Moreover, the topic of bankruptcies is tackled only rarely, and authors often admit the limited reliability of their bankruptcy data. To our knowledge, there is no study using Czech data, or data from a comparable country, to link bankruptcy information with financial constraints or to investigate the impact of the 2008 crisis, which was a purely exogenous event for the Czech Republic, on financial constraints. We link balance-sheet data with information on bankruptcy, and test for the presence of investment–cash flow sensitivity as an indicator of supply-side credit constraints emphasizing the impact of future bankruptcy and the firms' reaction to the 2008 crisis.

4.3 Research methodology

4.3.1 Investment–cash flow sensitivity

The core belief in the financial growth literature is that investment should be determined by future investment opportunities rather than by the firm's internal funds (net worth). There is a lively discussion, however, about how much cash flow matters. The standard empirical approaches recognize not only the importance of liquidity constraints, but also the fact that they are not evenly distributed across firms. Some firms simply face higher costs of raising capital. Financially constrained firms should, therefore, prefer internal financing to external financing. To test this hypothesis, authors usually look for the presence and scope of investment–cash flow sensitivity as an indicator of being financially constrained. Poncet *et al.* (2010) argue that the larger the sensitivity of investment to cash flow, the more constrained the firm is because it has to rely more on its internal funds to finance investment.

Moreno Badia & Slootmaekers (2009) argue that if a firm is financially constrained, the impact of cash flow on the intertemporal allocation decision will be positive. The more financially constrained a firm is, the larger will be the impact of its available cash stock on the cost of capital. In other words, an increase in cash stock will lower the implied cost of capital, making investment today more attractive than investment tomorrow. Although cash stock may be a proxy for future profit opportunities, it has been argued that this would only be the case in the presence of

financial constraints (see, e.g., Love 2003) since holding liquid assets is costly. Therefore, a firm anticipating profitable investment opportunities will accumulate liquid assets only if it expects to be financially constrained.

There is also extensive literature on prediction of businesses' default and its determinants (see, e.g., Mach & Wolken 2012, for a thorough review of various approaches). Liquidity, profitability, leverage, solvency, or activity ratios have been found to predict corporate bankruptcy by one stream of authors focusing on financial data. Others focus on management issues and the question of corporate governance, and often arrive at the conclusion that small firms are particularly prone to failure. The third stream of authors make a case for the role of capital market imperfections, including credit and other financial constraints, in particular in relation to small firms which are usually younger, more opaque, often unable to provide audited financial statements, and therefore face higher constraints due to information asymmetries (Gertler & Gilchrist 1994). Credit constrained firms may be forced to use more expensive and uncertain forms of external financing, such as trade credit or credit cards, which further increases the probability of default.

The investment–cash flow sensitivity literature explains that a company which has to wait for internal funds to finance investment is financially constrained. As financial constraints are often found to influence the probability of bankruptcy, we can turn the problem and ask whether companies which we know are going to declare bankruptcy in the future face different financial constraints than healthy companies, for example because they have weaker balance sheets. Mizen & Vermeulen (2005) find that creditworthiness is, in fact, the main driving force behind the investment–cash flow sensitivity. Also, the literature shows that small companies are more likely to be financially constrained than large ones. And finally, it is probable that financial constraints increased in the post-2008 crisis period compared to the pre-2008 boom, as there was a visible drop in credit flows to the non-financial sector.

This set of information motivates our empirical analysis: We check if financial constraints differ for healthy companies and companies going bankrupt, for the subsamples of small and large companies, and for the subsamples of pre- and post-2008 observations. If we find a significant and positive effect of cash flow on investment rate for any of these subsamples, we argue that it means that companies in the subsample are financially constrained. As banks should be able to assess the creditworthiness of loan applicants, we expect that financially constrained will be especially small companies going bankrupt, and companies in the post-2008 period.

Regarding the investment–cash flow sensitivity, Kaplan & Zingales (1997) are skeptical about its ability to capture financial constraints, while Fazzari *et al.* (2000) counter-argue that these sensitivities matter.[10] Agca & Mozumdar (2008) empiri-

[10]For a discussion about this so-called monotonicity hypothesis see the original paper by Fazzari *et al.* (1988), the Kaplan and Zingales critique emanating from Kaplan & Zingales (1997), the

cally showed a significant decline in investment–cash flow sensitivity over time, corresponding with reduction in capital market imperfections. But Chen & Chen (2011) document that the investment–cash flow sensitivity completely disappeared in recent years for U.S. manufacturing firms, even during the 2007–2009 credit crunch. They argue that if we believe that financial constraints have not disappeared, investment–cash flow sensitivity cannot be a good measure. Moshirian *et al.* (2017) argue that the decline is a result of slow capital formation and less predictable income flow in the developed world, rather than an indication of financial constraints. Hovakimian (2009) even reveals that firms having negative investment–cash flow sensitivity are more financially constrained than those having positive sensitivity. Cash flow insensitive firms appear to be the least constrained.

As the dispute over the usability of investment–cash flow sensitivity as a measure of financial constraints still seems to be far from settled, we take the conservative approach of Kaplan & Zingales (1997) and refrain from interpreting the magnitude of the sensitivity as an indicator of the degree of financial constraints. Therefore, we only focus on whether the impact of cash flow on investment is statistically significant and positive. The ability of investment–cash flow sensitivity to capture financial constraints has been confirmed by a number of authors (Agca & Mozumdar 2015)

Based on the existing literature and the observed decline in lending to non-financial companies right after September 2008, we expect that investment rates of Czech firms will display positive and significant sensitivity to the availability of internal funds (Konings *et al.* 2003), with the result being driven mainly by micro and small enterprises (Fidrmuc *et al.* 2010; Lízal & Svejnar 2002) after the onset of the 2008 crisis (Plašil *et al.* 2013; Campello *et al.* 2010; Gaiotti 2011). We also expect that companies going bankrupt face higher financial constraints (Mach & Wolken 2012; Musso & Schiavo 2008).

4.3.2 Our framework: the Q model

To empirically test for financial constraints, one can use the Q model derived from the Euler equation[11] and an investment–cash flow relation. Under the assumptions of perfect competition, capital as the only input, and constant returns to scale, and

reply by Fazzari *et al.* (2000), and the answer by Kaplan & Zingales (2000). Kaplan & Zingales (1997) theoretically show that even in a one-period model, investment–cash flow sensitivities do not necessarily increase in the degree of financial constraints. They also claim that in a multi-period case, for example, precautionary savings make it even more difficult to justify this relationship. They finally argue that this relationship may be more complicated, with overly risk-averse firms preferring to invest their own cash flow. Using simulated data, Bond & Söderbom (2013) find that the relationship between financial constraints and the sensitivity of investment on cash flow, conditional on a measure of marginal Q, is monotonic.

[11] The derivation of the Euler equation is given in Section 4.A.

conditional on average Q,[12] no other variable should matter for investment. Under quadratic adjustment costs, the investment equation can be written as (i stands for firm index and t stands for time index):

$$\frac{I_{it}}{K_{it-1}} = \beta_0 + \beta_1 Q_{it} + \beta_2 \frac{CF_{it}}{K_{it}} + e_{it} \tag{4.1}$$

where I_{it}/K_{it-1} denotes the investment rate, β_0 is the non-stochastic additive parameter, β_1 is the multiplier in the adjustment-cost function, and CF_{it} is the cash flow in the same year. Tobin's Q_{it} is a proxy for the availability of investment opportunities and is often calculated using information on firms' market values, and e_{it} is the stochastic additive component (assumed to be an *i.i.d.* process).

However, as noted above, we focus on a post-transition country where large information asymmetry is still assumed. Also, Tobin's q would be available only for a very limited sample of publicly listed companies. Therefore, our baseline equation follows a large body of literature (Behr *et al.* 2013; Carbó-Valverde *et al.* 2009; Hobdari *et al.* 2009; Cinquegrana *et al.* 2012) and makes use of the available balance-sheet data, especially sales growth, to instrument for Tobin's q.[13] Such a specification resembles the traditional sales accelerator model linking investment to the development in a firm's output or sales (see, e.g., Fazzari *et al.* 1988):

$$\frac{I_{it}}{K_{it-1}} = \beta_0 + \beta_1 \frac{I_{it-1}}{K_{it-2}} + \beta_2 (\frac{I_{it-1}}{K_{it-2}})^2 + \beta_3 \frac{\Delta S_{it}}{K_{it-1}} + \beta_4 \frac{CF_{it-1}}{K_{it-1}} + \beta_5 \frac{D_{it-1}}{K_{it-1}} + \mu_k + \nu_t + e_{it} \tag{4.2}$$

where I is investment, K is end-of-period fixed assets, ΔS is change in sales, CF is cash flow, D is total debt, μ_k is a sector specific effect, and ν_t is a time specific effect.[14] Coefficient β_4 is of interest to us because for financially-constrained firms, internal cash flow is expected to be relevant in the investment rate equation. This implies that a firm is considered to be financially constrained if the cash flow coefficient is

[12] The ratio of the market value of existing capital to its replacement cost. Usually, we can only observe average Q (even this can be difficult, especially for non-listed companies). Marginal Q, on the other hand, is the ratio of the market value of an additional unit of capital to its replacement cost. It is possible to estimate marginal Q (Gugler *et al.* 2004), but most empirical work use average Q as the proxy for marginal Q. Berglund (2011) points out that the proposed methods of estimating marginal Q are likely to produce biased estimates.

[13] We add lagged investment rate and squared investment rate to control for its autoregressive nature – past investments influence today's investments. The squared term is there to capture potential non-linear relationship. We also use turnover instead of sales growth in one of the robustness checks.

[14] In the Albertina database, cash flow is calculated as current year profit (loss) + depreciation of tangible and intangible fixed assets. There are generally two approaches to calculating cash flow: direct and indirect. For direct calculation of cash flow, balance-sheet information is clearly insufficient. Indirect calculation starts with the information available on the balance sheet, but usually adjusts for revenues and costs which should be included in net income but are not, or, on the other hand, should not be included but are. However, such adjustments cannot be made based on data available to an outside observer who has access only to the financial statements of firms. As a consequence, for the purposes of financial constraints analysis, cash flow is usually calculated in the same way as in Albertina.

estimated to be positive. Including change in sales among the explanatory variables enables us to approximate investment opportunities and also acts as a measure of firm-specific perception of macroeconomic environment.

To reduce potential omitted variable bias and to get more information on the relation between investment, bankruptcy, and cash flow, we also include information on future firm bankruptcy as an explanatory variable. While there may be a potential problem with reverse causality (e.g. lower investment leading to bankruptcy), including information on future firm bankruptcy can have the power to capture unobserved variables that can be related to bankruptcy and determine investment rates.

At the same time, we believe that the reverse causality problem can arise for a dummy capturing whether a firm goes bankrupt sometime during our observed period, but not for a dummy capturing whether the firm goes bankrupt in the next period. The reason is that the insolvency proceedings in the Czech Republic take on average more than 600 days. Due to the length of the bankruptcy process, it is, therefore, highly unlikely that this year's investment rate would affect next year's bankruptcy. Moreover, we show that the investment rate does not significantly differ among healthy companies, companies going bankrupt in the future, and companies going bankrupt during the following year (see Table 4.1). Also, including one of the bankruptcy dummies in the regression doesn't influence the stability of other coefficients.

4.4 Data description

4.4.1 Data

Our analysis uses Czech firm-level microdata. We take the firms' **balance-sheet data** from the Albertina database.[15] This is a Czech database containing financial and ownership structure information on major public and private companies in all sectors of the economy in the Czech Republic.

The database is updated monthly and each version features only currently registered (existing) entities, i.e., if any entity has gone successfully through a process of bankruptcy or liquidation ending in an act of deregistration in the past, it will no longer be available in the most recent version of the database. Even though it is not unusual for the bankruptcy process to take several years, ignoring enterprises which have gone through a swift bankruptcy and have already left the dataset can bias our results. In order to overcome the issue of entry and exit we obtained and combined historical versions of the database to capture the state of enterprises at the beginning of 2007, 2008, 2009, 2010, 2011, and 2012. Together with the data available in June

[15]Operated by Bisnode Česká republika, a.s., `www.albertina.cz`. We would like to thank the Czech National Bank for access to this dataset.

2013, these versions form the data source used in this study. The period covered by our dataset differs and depends on the particular firm. For the needs of our analysis, the most relevant variables are the book value of the firm's total, tangible and fixed assets, employment, total debt, bank loans, sales, turnover, and cash flow.

We also assembled original **data on bankruptcy** in the Czech Republic, available from 2006. This and the limited availability of post-2011 financial data justifies the choice of our time span (2006–2011). It is not a simple task to create a reliable measure of bankruptcy. The legal status provided in the Albertina database for every entity indicates whether the entity is healthy, is going (or has gone) through the bankruptcy process, or is in liquidation. This attribute is supplemented with the date of the status change. However, in a number of cases no date was provided. Therefore, in order to fill in the missing observations, we extracted the date from the record in the Insolvency Register, which is attached to each entity in the database. In cases where there were multiple dates of insolvency declaration in the Register, we used the most recent one. Such a situation can arise if, for example, a declaration of insolvency was cancelled by a court due to deficiencies in the insolvency proposal and was then followed by a revised proposal. The date extracted from the Register is given priority over the one provided in the database in the event of data conflict.

In a significant number of cases this process revealed serious inconsistencies in the database. Sometimes, for example, bankruptcy was not declared by a court in the end, but still appeared in the legal status of the firm in the Albertina database. Going through the details in the Insolvency Register allowed us to cleanse the data and remove all incorrect observations. We should note that studies relying solely on information on bankruptcy taken from the Albertina database will probably be misleading.[16] We therefore correct for potential bias related to bankruptcy information.

To get consistency in the data, the following entities are not used: entities in liquidation, entities having no property when declaring insolvency, entities with uncertain insolvency status, and entities with an unknown date of insolvency declaration. Observations of entities with insolvency status are included in the dataset only before the declaration of insolvency. Linking the bankruptcy information with balance-sheet data we get our final sample.

We distinguish between three types of companies:

- "healthy", i.e., companies that do not go bankrupt during the period studied
- "at some point going bankrupt", i.e., companies that go bankrupt during the period studied (i.e., in $n + t$, where $n \in \{2006; 2011\}$ is the fiscal year and $t \in \{1; 6\}$)

[16] A similar problem would arise if Amadeus, a European-wide, firm-level dataset, was used. Amadeus is compiled by Bureau Van Dijk (BvD) by harmonizing companies' annual reports obtained from various European vendors. Again, the information on bankruptcy is not accurate for the above-mentioned reasons.

- "next year going bankrupt", i.e., companies that go formally bankrupt during the following period[17] (i.e., in $n+1$, where $n \in \{2006; 2011\}$ is the fiscal year)

As the dependent variable, we have a measure of the investment rate defined as the percentage change in net fixed assets (this follows, for example, Julio & Yook 2012; Cai & Harrison 2011; Moreno Badia & Slootmaekers 2009).

4.4.2 Data management

Our data management follows previous work in this field. We drop all observations which do not cover a 12-month-long fiscal year. We also drop firms in the public administration, defense, and compulsory social security sectors (88 observations). We exclude firms with less than CZK 1,000 in total assets (2,977 observations) or with negative tangible or intangible assets (3,212 observations), and drop all observations for which the balance-sheet equation does not hold (i.e., assets do not equal liabilities and shareholders' funds; 17,245 observations). In some cases, financial data for one year were provided from several sources for one entity. In order to remove these duplications, the source with more filled-out information was chosen. We deflate all financial variables by the relevant producer price indices taken from the EBRD.[18]

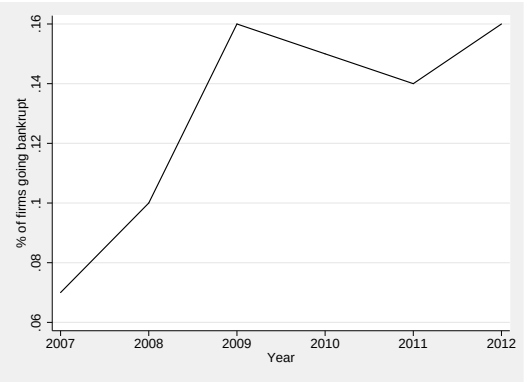
Another potential problem with our dataset is outliers. While performing a random check of the data, we found a significant number of cases where typos and wrong order of numbers render the observations unusable. This is mainly due to the source of the data, as they mostly come from forms filled out by hand by employees of individual companies. An effective way of detecting outliers in multivariate data is the blocked adaptive computationally efficient outlier nominators (BACON) algorithm proposed by Billor *et al.* (2000) and described in Weber (2010). We identify outliers with respect to the following variables: total assets, fixed assets, employment, turnover, total debt, and cash flow (on the 1% level). Out of 826,108 observations, we drop 22,863. We also winsorize the extreme 0.1 percentile of investment rate and all explanatory financial variables (cash flow, total debt, change in sales, and turnover, all normalized by fixed assets).[19]

[17] As noted, due to the length of the bankruptcy process, it makes more sense to assign the bankruptcy to the fiscal year just preceding the year when the firm formally goes bankrupt. Therefore, companies in our dataset can go bankrupt in the years 2007–2012.

[18] We cannot use the possibly most relevant deflators based on the EU KLEMS database in order to obtain country-sector-specific output and intermediate input deflators, as EU KLEMS data are available only until 2007. We believe that using EBRD deflators will be sufficient. However, these deflators vary only on the country level, which is a drawback.

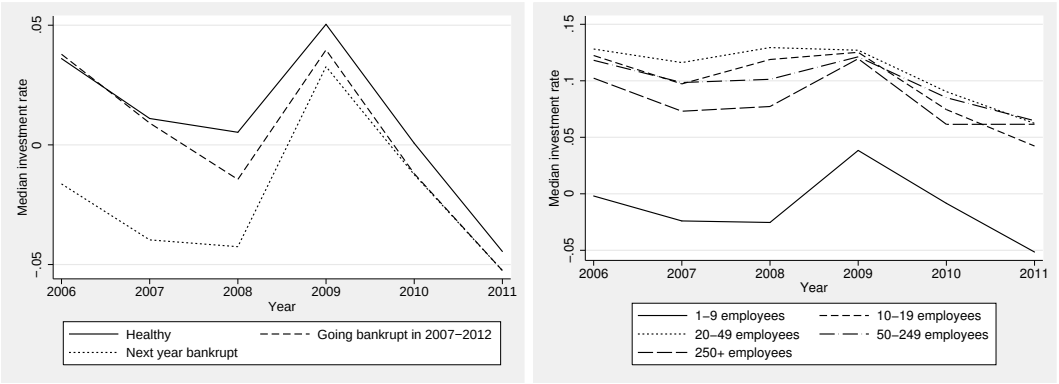
[19] Observations of companies that will go bankrupt at some point in the future constitute 1.93% of our final dataset after data management (including observations older than 2006 which are used as instruments). Companies that will go bankrupt the following year constitute 0.14%. Due to above described data management we drop 44,030 observations older or equal than 2011. Observations of companies going bankrupt at some point constitute 5.81%, and companies going bankrupt the following year constitute 0.4%. This means we lose slightly above-proportional amount of observations related to companies going bankrupt, probably due to higher error rate in their financial statements

Figure 4.3: Evolution of bankruptcy in the Czech Republic



Notes: The figure depicts the share of bankrupt companies in the sample for the particular year.

Figure 4.4: Evolution of investment rate for healthy and bankrupt companies and for firms of different sizes



4.4.3 Summary statistics

Altogether, we have 642,340 observations in our sample, which spans from 2006 to 2011. We have 635,895 observations on healthy companies, 6,445 observations on companies that will go bankrupt at some point in the future and 833 companies that will go bankrupt the following year.[20] Figure 4.3 depicts the evolution of bankruptcy incidence in our dataset. The coincidence between macroeconomic development, credit restriction (see Figure 4.1), and bankruptcy is clearly visible.

Figure 4.4 shows that after 2009 the investment rate started to decline. The median investment rate for companies that will go bankrupt the following year is negative with the exception of 2009. Table 4.1 summarizes the balance-sheet items of interest in the final dataset always for the whole sample, for healthy companies, for companies which go bankrupt, and for companies which go bankrupt the following

data. But the unreliability of the data which have been dropped make it impossible to seriously estimate the scope and the direction of the potential selection bias.

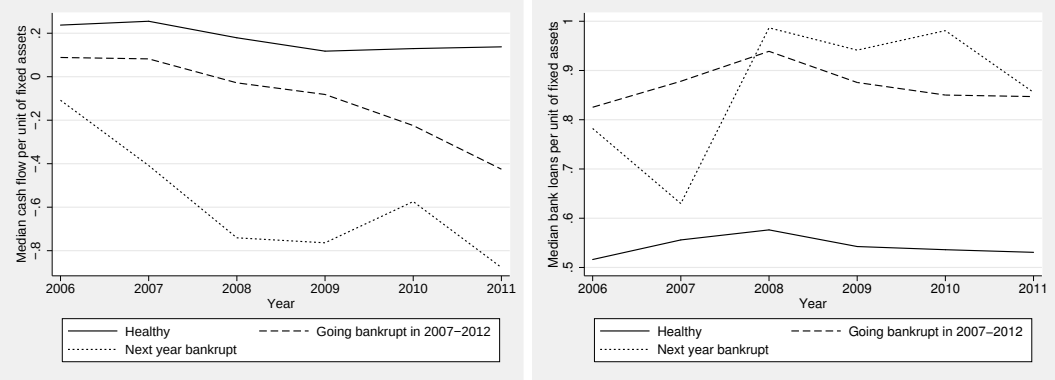
[20]The numbers differ because "at some point going bankrupt" are the yearly observations for the companies which we know will go bankrupt (i.e., go bankrupt between 2007 and June 2013).

Table 4.1: Summary statistics of relevant variables for the whole sample, healthy firms, and firms going bankrupt (2006–2011)

Variable	Sample	Mean		Std. Dev.	N
Investment rate	all	1.767		17.398	393,173
	healthy	1.764		17.379	388,854
	going bankrupt	2.061		19.088	4,319
	next year bankrupt	1.030		19.095	546
Cash flow	all	1.781		150.458	469,331
per unit of	healthy	1.857		150.929	464,155
fixed assets	going bankrupt	-4.982	***	99.285	5,176
	next year bankrupt	-11.406	***	70.710	564
Debt	all	29.918		547.562	469,331
per unit of	healthy	29.300		541.171	464,155
fixed assets	going bankrupt	85.289	***	959.626	5,176
	next year bankrupt	96.726	***	433.450	564
Bank loans	all	5.268		127.623	186,409
per unit of	healthy	4.991		118.310	183,087
fixed assets	going bankrupt	20.500	**	377.256	3,322
	next year bankrupt	11.074	***	43.114	354
Turnover	all	0.096		1.352	448,060
per unit of	healthy	0.095		1.343	443,002
fixed assets	going bankrupt	0.163	**	1.992	5,058
	next year bankrupt	0.083		0.278	542

Notes: Hypothesis of equality of means with healthy companies tested using a t-test.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 4.5: Evolution of cash flow and bank loans for healthy and bankrupt companies



year. We also test the hypothesis of equality of means with healthy companies. Asterisks mean that the hypothesis of equality is rejected (see the table notes).

Interestingly, we do not find significantly differing investment behavior of healthy firms and firms which go bankrupt (see Table 4.1).[21] The cash flow of companies going bankrupt is negative (see also Figure 4.5).[22] On average, we can say that firms with negative cash flow are on the path to bankruptcy. However, companies going bankrupt on average have higher bank loans than healthy ones. This indicates that companies which are going to declare bankruptcy during our sample period appear not to have problems with obtaining bank credit. Companies going bankrupt are significantly more indebted than healthy ones.

4.5 Regression results and discussion

We have a classical situation with a panel of small T (limited time periods) and large N (many companies). Our lagged dependent variable, the investment rate, is not strictly exogenous, meaning it is correlated with past and possibly current realizations of the error. We also have fixed effects, heteroskedasticity, and autocorrelation within companies. In this case, the most relevant estimators appear to be the Arellano–Bond (Arellano & Bond 1991) and Arellano–Bover/Blundell–Bond (Arellano & Bover 1995; Blundell & Bond 1998) dynamic panel estimators.

All specifications are estimated by a two-step system GMM estimator with collapsed instruments and robust standard errors corrected using the Windmeijer correction. Assuming that lagged investment rate and lagged squared investment rate are endogenous, we instrument for them using their $t-2$ to $t-5$ lags. The results of Arellano-Bond test for second-order correlation, and Sargan and Hansen tests reported in Tables 4.2 and 4.3 signal that the models are specified correctly. Even though in most specifications the autoregressive term turns insignificant, both lagged investment rate coefficients are significant in some specifications when estimated using a fixed-effects model. Ignoring the autoregressive nature of investment rate would therefore lead to biased results.

First, we apply the GMM estimator on the whole sample with the interaction of a dummy capturing whether the firm goes bankrupt with the cash flow (see Table 4.2). Change in sales should approximate firm-specific investment opportunities and the positive coefficients are in line with such expectation. If a company observes growing sales, its investment appetite is increased and it faces two alternatives: wait for enough internal funds, or finance the investment using external sources, mostly bank

[21] The hypothesis of equality of means between these two types of companies is rejected at the 10% confidence level only in the pre-crisis period.

[22] Negative cash flow means that cash inflow from sales is lower than cash outflow of cash payments. The common reasons for negative cash flow are usually thought to be low sales, high operating expenses, wrong investments, or unattractive financing conditions.

loans. The results indicate that there is a positive statistical correlation between the investment rate and cash flow for Czech firms in the period 2006–2011. Firms are, therefore, more likely to invest in new assets if they generate enough funds of their own. As we argue above, such a finding means that financial constraints exist and are binding. The coefficient shows the impact of a unit cash flow increase on the investment rate, both normalized by the capital stock of the company (proxied by its fixed assets). As we explain in the literature review, there is no clear consensus regarding the relationship between the coefficient size and the severity of the financial constraints faced by a firm.

An alternative interpretation that poor economic results of firms reduce their investment appetite or even lead to negative investment is not in contradiction with the financial constraints theory. Because even in such situation, banks should be willing to finance profitable investment projects. If they are not, and the prospective borrowers expect that they won't, the firms first have to improve their balance sheets and forgo the investment opportunities. In this scenario, the source of financial constraints would be high information asymmetries and consequent prohibitive transaction costs on the side of both lenders and borrowers.

Because we are interested in the link between bankruptcy and financial constraints, we add interaction terms between cash flow and going bankrupt during the whole observed period, or during the following year. This term captures the additional impact of cash flow on investment if the company is a bankrupting one. The results reveal that investment activities of companies going bankrupt at some point during our observed period do not depend on their own funds: the marginal effect of their cash flow on investment rate is no longer positive and significantly different from zero (it is -0.028 with p-value 0.63).

A possible interpretation is that they actually face lower financial constraints than healthy companies. This finding would be in line with the fact that companies going bankrupt are more indebted, have higher level of bank loans and do not invest less than healthy ones (see Table 4.1 and Figure 4.5). It indicates that Czech banks may have problems with correctly assessing the riskiness of investment projects. Financial constraints reappear only shortly before declaring bankruptcy (specification in column (3) of Table 4.2, the marginal effect of cash flow of firms going bankrupt next year on their investment rate is 0.151; p-value 0.037).

However, we are particularly interested in the impact of the 2008 crisis. Therefore, we apply this model on separate periods 2006–2008 and 2009–2011 (Table 4.3, columns (1)–(4)). The results show that healthy firms were on average financially constrained both before and after the 2008 crisis. But there is a clear difference in case of firms going bankrupt. Statistically insignificant marginal effect (-0.038; p-value 0.596) of cash flow in the pre-crisis period signals that companies which we observe going bankrupt in the 2007–2013 period did not face financial constraints

Table 4.2: All companies

Dependent variable: Investment rate	(1)	(2)	(3)
Investment rate$_{(t-1)}$	-0.23	0.0094	-0.23
	(0.54)	(0.47)	(0.54)
Squared investment rate$_{(t-1)}$	-0.000092	-0.00047	-0.000090
	(0.0015)	(0.0016)	(0.0015)
Change in sales$_{(t)}$	0.020***	0.020***	0.020***
	(0.0038)	(0.0035)	(0.0038)
Cash flow$_{(t-1)}$	0.096***	0.10***	0.096***
	(0.017)	(0.013)	(0.017)
External debt$_{(t-1)}$	0.024***	0.025***	0.024***
	(0.0033)	(0.0021)	(0.0033)
At some point bankrupt		-0.10	
		(0.35)	
(Cash flow)$_{(t-1)}$×(At some point bankrupt)		-0.13**	
		(0.053)	
Next year bankrupt			-0.45
			(0.50)
(Cash flow)$_{(t-1)}$×(Next year bankrupt)			0.055
			(0.072)
Constant	1.47**	1.19***	1.47**
	(0.58)	(0.38)	(0.58)
Number of instruments	37	39	39
AB test for AR(2) in first diffs p-value	0.37	0.45	0.37
Sargan test p-value	0.23	0.28	0.23
Hansen test p-value	0.81	0.79	0.81
Observations	305249	305249	305249
Sample	2006–2011	2006–2011	2006–2011

Notes: Heteroskedasticity and autocorrelation consistent standard errors in parentheses. All specifications include year and industry fixed effects. All variables are normalized by the respective firm's capital stock (fixed assets).
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

and engaged in very risky investment projects during the boom despite low internal cash flow. The sensitivity of investment rate on cash flow becomes positive only shortly before declaring bankruptcy. Given the observed period of economic boom, such finding is not surprising. As is usual at the peak of the business cycle, risks appeared to be negligible, lending standards were low and money was easily available to almost anyone.

The overall tightening of credit supply, together with the fall in investment and bank loans demand after 2008 probably closed the gap between healthy companies and companies which go bankrupt and interaction term effect is no longer significantly different from zero (marginal effect stays positive and significant: 0.059; p-value 0.057). The marginal effect of cash flow on investment rate stays positive and

Table 4.3: Separate results for 2006–2008, 2009-2011, and companies of different sizes

Dependent variable: Investment rate	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Investment rate$_{(t-1)}$	-0.68	-0.81	0.85*	0.84*	-0.18	-0.17	0.27	0.65
	(0.54)	(0.65)	(0.44)	(0.44)	(0.39)	(0.37)	(0.51)	(1.14)
Squared investment rate$_{(t-1)}$	0.0017	0.0019	-0.0028	-0.0028	-0.00024	-0.00051	-0.00050	-0.0015
	(0.0015)	(0.0015)	(0.0018)	(0.0018)	(0.0015)	(0.0016)	(0.0014)	(0.0028)
Change in sales$_{(t)}$	0.023***	0.023***	0.020***	0.020***	0.016***	0.016***	0.035***	0.028***
	(0.0044)	(0.0046)	(0.0042)	(0.0042)	(0.0035)	(0.0037)	(0.0075)	(0.0061)
Cash flow$_{(t-1)}$	0.11***	0.10***	0.11***	0.11***	0.10***	0.096***	0.10***	0.097***
	(0.016)	(0.017)	(0.015)	(0.015)	(0.013)	(0.016)	(0.020)	(0.022)
External debt$_{(t-1)}$	0.021***	0.021***	0.029***	0.029***	0.025***	0.024***	0.026***	0.029***
	(0.0025)	(0.0032)	(0.0028)	(0.0028)	(0.0022)	(0.0030)	(0.0036)	(0.0048)
At some point bankrupt	0.56		-1.21***		-0.51		0.34	
	(0.51)		(0.45)		(0.51)		(0.45)	
(Cash flow)$_{(t-1)}$×(At some point bankrupt)	-0.15**		-0.049		-0.15**		-0.013	
	(0.072)		(0.033)		(0.062)		(0.029)	
Next year bankrupt		-0.028		-0.44		-0.18		-1.19
		(0.98)		(0.40)		(0.68)		(1.71)
(Cash flow)$_{(t-1)}$×(Next year bankrupt)		0.18***		-0.061***		0.094		-0.069
		(0.048)		(0.024)		(0.062)		(0.046)
Constant	1.37***	1.52***	0.46	0.46	1.64***	1.75***	0.70**	0.50
	(0.44)	(0.56)	(0.33)	(0.33)	(0.45)	(0.53)	(0.34)	(0.78)
Number of instruments	36	36	36	36	39	39	39	39
AB test for AR(2) in first diffs p-value	0.69	0.41	0.79	0.78	0.21	0.23	0.33	0.49
Sargan test p-value	1.00	0.99	0.24	0.24	0.72	0.75	0.49	0.97
Hansen test p-value	0.64	0.74	0.76	0.76	0.49	0.52	0.72	0.99
Observations	124379	124379	180870	180870	172045	172045	133204	175493
Sample	2006–2008	2006–2008	2009–2011	2009–2011	1–19 empl.	1–19 empl.	20+ empl.	20+ empl.

Notes: Heteroskedasticity and autocorrelation consistent standard errors in parentheses. All specifications include year and industry fixed effects. All variables are normalized by the respective firm's capital stock (fixed assets).

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

significant also for companies going bankrupt in the next year (0.045; p-value 0.034).

To better understand the potential impact of firm heterogeneity, we also split the sample according to firm size (Table 4.3, columns (5)–(8)). Whereas we do not observe any differences in case of healthy firms, the results reveal that financial constraints differ for firms which are going to declare bankruptcy in the future. As in the pre-crisis period, micro and small enterprises of up to 19 employees were not financially constrained if they ended up declaring bankruptcy. Large companies face financial constraints even if they are going to declare bankruptcy in the future. Only in the year before declaring bankruptcy do financial constraints of large companies disappear (marginal effect 0.028; p-value 0.463). Firms are probably trying to evade looming insolvency by relying more on debt. And due to their good relationships with banks, they are able to obtain loans even in such situation.

This finding is in sharp contrast to the existing literature that not only finds, but also sometimes assumes that small firms face more severe financial constraints than large ones. One possible source of our result may be the chosen time period: compared to standard times, firms and banks can behave differently both during the peak of an economic boom and the subsequent recession. Moreover, financial constraints may be more likely to be present in a country such as the Czech Republic, where bank credit is by far the major external source of finance available for non-financial companies.

To sum up, the results indicate that the 2008 crisis didn't increase financial constraints of Czech companies. This is in line with the results of the Czech Statistical Office survey on the barriers to growth which also didn't find any sizable change. It means that the observed drop in bank loans provision after September 2008 was mainly demand driven. Moreover, in the pre-crisis period, banks were willing to finance even those companies which ended up bankrupt.

4.6 Robustness checks

In order to ensure the robustness of our results, we introduce three different robustness checks. In the first one, we use turnover, instead of change of sales, as an alternative proxy for the Tobin's q. Tables 4.B1 and 4.B2 show that the main results stay unchanged. Healthy firms are on average financially constrained, but firms which are going to declare bankruptcy in the future are not. As in our baseline specification, the notable exception is the post-crisis period.

The second robustness check addresses the issue of estimation stability. System GMM estimator is known to be rather sensitive to the choice of the instruments' lag structure. In Tables 4.B3 and 4.B4 we present results obtained by using only lags 2–3 to instrument for the endogenous variables. Two specifications (with the

subsample of small companies) fail to pass the Arellano-Bond test of no second-order correlation, but the results stay qualitatively the same.

In the third robustness check we drop the system GMM estimator altogether and estimate our baseline Equation 4.2 using three different approaches (see Table 4.B5). First, we use the fixed effects estimator with individual firms as the panel variable. Second, we copy our system GMM approach and run an OLS estimator with sector fixed effects with variance clustered on the firm level. Both specifications also include year fixed effects. And third, we estimate the model using OLS without any fixed effects, only with variance clustered on the firm level to allow for within-cluster correlation. Table 4.B6 reports results of the second approach (sector and year fixed effects) for the two time periods and companies of different sizes. Again, the results seem to be highly robust and do not change qualitatively.

4.7 Conclusion

In this paper, we used balance-sheet data to empirically study the relationship between investment, cash flow, and bankruptcy in a post-transition country. Specifically, we looked at the evolution of investment with respect to financial constraints. Our paper links balance-sheet microdata with original bankruptcy data, which allows us to study the evolution of firms' behavior and their reaction to the 2008 crisis from a new perspective.

Companies which went bankrupt in the period 2007–2013 had significantly lower cash flow and, maybe surprisingly, a higher level of bank loans than healthy companies. This indicates that companies which were going to declare bankruptcy did not have problems obtaining bank credit. We find that they did not face more severe financial constraints than healthy companies. On the contrary, especially in the pre-crisis period and in the category of micro and small enterprises there is no significant dependence of investment on own funds. We could even speculate that the lack of financial constraints in some companies led to excess accumulation of external debt and subsequent financial difficulties. At least, this hypothesis is not falsified by our analysis. Our results clearly suggest that a lack of external financing was not the primary reason for bankruptcy.

Regarding the factors which influence the rate of investment, we conclude that there is robust evidence that cash flow, the level of debt, and change in sales, as well as turnover, have a positive and significant impact on the investment rate. At the same time, future bankruptcy as a proxy for unobserved variables does not seem to have any significant impact on the investment rate.

Investment–cash flow sensitivities, which are used as an indicator of financial constraints, are significant for healthy companies in all specifications both before and after the 2008 crisis. Positive and statistically significant investment–cash flow

sensitivity of companies which we know are going to declare bankruptcy is observable only in the post-crisis period. Also, the impact of cash flow on investment rate becomes positive the year before bankruptcy. An interesting finding is that large companies in our sample face financial constraints even if they are going to declare bankruptcy in the future. Their financial constraints disappear only shortly before declaring bankruptcy.

Even though present, financial constraints are probably not very severe in the Czech Republic. This would be in line with the quarterly survey in the non-financial corporations' sector published by the Czech National Bank since March 2011. The results covering the first quarter of 2011 show that problems with obtaining external financing restricted investment decisions of less than 2% of respondents. This was far less than the influence of insufficient expected demand (28.2%).[23]

Due to the nature of available data, our identification of financially constrained companies is only indirect. But if combined, for example, with survey data or data on firms' credit, it would be possible to identify a more direct link between credit and investment. Such research would then have potential policy implications. Good identification of financially constrained companies and sectors can help, for instance, in times of economic crisis to support the argument for well-targeted policy intervention (loan provision, guarantees) on the credit market.[24] Our current results indicate that there was no need for such policies in the aftermath of the 2008 crisis in the Czech Republic. One reason is probably the fact that Czech banks hold excess liquidity and stayed profitable even after 2008. Therefore, they didn't have to substantially alter their lending behavior.

The finding that companies which are going to declare bankruptcy in the future were not financially constrained before the 2008 crisis, that is during the boom period, should be a warning not only for banks, but also for the regulator. Such procyclical behavior is actually the reason why central banks recently started to pursue financial stability as another important goal of monetary and newly emerging macroprudential policy (see, e.g., Frait *et al.* 2015). As the risks seem to be negligible when nearing the peak of the boom, microprudential approach is generally not able to correctly asses riskiness of individual loans. Policies forcing the banks to create sufficient buffers during the good times may be able to limit the procyclical behavior and also mitigate the potential problems during the bust period. Information regarding the existence of financial constraints of companies nearing bankruptcy can be used as one of the inputs for evaluating how successful central banks are in their effort.

The analysis could be taken even further in the future. It is, for instance, probable that the division between potentially credit-constrained and credit-unconstrained

[23]The data are available in the ARAD data series system of the Czech National Bank.

[24]As Oliner & Rudebusch (1996) note, the research on the credit channel stresses that central bank actions affect output, in part, by causing shifts in the supply of loans.

companies is in fact much more complicated than just according to their size. It may be possible to link some of the above-mentioned survey results on whether companies feel financially constrained with balance-sheet data and other firm characteristics, and use them to estimate threshold values for splitting the sample into constrained and unconstrained regimes. An estimation of investment–cash flow sensitivity on these subsamples could lead to even more precise answers regarding the severity of financial constraints in the Czech Republic.

References

Agca, S. & A. Mozumdar (2008): "The Impact of Capital Market Imperfections on Investment-Cash Flow Sensitivity." *Journal of Banking & Finance* **32(2)**: pp. 207–216.

Agca, S. & A. Mozumdar (2015): "Investment Cash Flow Sensitivity: Fact or Fiction?" *SSRN Scholarly Paper ID 1695972*, Social Science Research Network, Rochester, NY.

Arellano, M. & S. Bond (1991): "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations." *Review of Economic Studies* **58(2)**: pp. 277–97.

Arellano, M. & O. Bover (1995): "Another look at the instrumental variable estimation of error-components models." *Journal of Econometrics* **68(1)**: pp. 29–51.

Avery, R. B., R. W. Bostic, & K. A. Samolyk (1998): "The role of personal wealth in small business finance." *Journal of Banking & Finance* **22(6–8)**: pp. 1019–1061.

Behr, P., L. Norden, & F. Noth (2013): "Financial constraints of private firms and bank lending behavior." *Journal of Banking & Finance* **37(9)**: pp. 3472–3485.

Berglund, T. (2011): "The elusive marginal q." *Applied Financial Economics* **21(20)**: pp. 1489–1493.

Bernanke, B. & M. Gertler (1995): "Inside the black box: The credit channel of monetary policy transmission." *Journal of Economic Perspectives* **9(4)**: pp. 27–48.

Bernanke, B. S. (1993): "Credit in the Macroeconomy." *Federal Reserve Bank of New York Quarterly Review* **18(1)**: pp. 50–70.

Bernanke, B. S. & A. S. Blinder (1992): "The Federal Funds Rate and the Channels of Monetary Transmission." *American Economic Review* **82(4)**: pp. 901–21.

Bernanke, B. S., M. Gertler, & S. Gilchrist (1999): "The financial accelerator in a quantitative business cycle framework." volume 1, part C of *Handbook of Macroeconomics*, chapter 21, pp. 1341–1393. Elsevier.

Bertoni, F., A. Croce, & M. Guerini (2015): "Venture capital and the investment curve of young high-tech companies." *Journal of Corporate Finance* **35**: pp. 159–176.

Billor, N., A. S. Hadi, & P. F. Velleman (2000): "BACON: blocked adaptive computationally efficient outlier nominators." *Computational Statistics & Data Analysis* **34(3)**: pp. 279–298.

Blundell, R. & S. Bond (1998): "Initial conditions and moment restrictions in dynamic panel data models." *Journal of Econometrics* **87(1)**: pp. 115–143.

Bond, S. R. & M. Söderbom (2013): "Conditional Investment-Cash Flow Sensitivities and Financing Constraints." *Journal of the European Economic Association* **11(1)**: pp. 112–136.

Cai, J. & A. Harrison (2011): "The Value-Added Tax Reform Puzzle." *NBER Working Papers 17532*, National Bureau of Economic Research, Inc.

Campello, M., J. R. Graham, & C. R. Harvey (2010): "The real effects of financial constraints: Evidence from a financial crisis." *Journal of Financial Economics* **97(3)**: pp. 470–487.

Carbó-Valverde, S., F. Rodríguez-Fernández, & G. F. Udell (2009): "Bank Market Power and SME Financing Constraints." *Review of Finance* **13(2)**: pp. 309–340.

Carpenter, R. E. & A. Guariglia (2008): "Cash flow, investment, and investment opportunities: New tests using UK panel data." *Journal of Banking & Finance* **32(9)**: pp. 1894–1906.

Chatelain, J.-B., M. Ehrmann, A. Generale, J. Martínez-Pagés, P. Vermeulen, & A. Worms (2003): "Monetary Policy Transmission in the Euro Area: New Evidence From Micro Data on Firms and Banks." *Journal of the European Economic Association* **1(2-3)**: pp. 731–742.

Chava, S. & M. R. Roberts (2008): "How Does Financing Impact Investment? The Role of Debt Covenants." *Journal of Finance* **63(5)**: pp. 2085–2121.

Chen, H. & S. Chen (2011): "Investment-Cash Flow Sensitivity Cannot Be a Good Measure of Financial Constraints: Evidence from the Time Series." *Journal of Financial Economics* **103(2)**: pp. 393–410.

Cinquegrana, G., C. Donati, & D. Sarno (2012): "Financial constraints and relationship lending in the growth of Italian SMEs." *MPRA Paper 39825*, University Library of Munich, Germany.

Clarke, G. R., R. Cull, & G. Kisunko (2012): "External Finance and Firm Survival in the Aftermath of the Crisis: Evidence from Eastern Europe and Central Asia." *Policy Research Working Paper 6050*, The World Bank.

Colombo, M. G., A. Croce, & M. Guerini (2012): "Is the Italian Government effective in relaxing the financial constraints of high technology firms?" *Prometheus* **30(1)**: pp. 73–96.

Colombo, M. G., A. Croce, & M. Guerini (2013): "The effect of public subsidies on firms' investment–cash flow sensitivity: Transient or persistent?" *Research Policy* **42(9)**: pp. 1605–1623.

Engel, D. & J. Stiebale (2014): "Private equity, investment and financial constraints: firm-level evidence for France and the United Kingdom." *Small Business Economics* **43(1)**: pp. 197–212.

Fazzari, S. M., R. G. Hubbard, & B. C. Petersen (1988): "Financing Constraints and Corporate Investment." *Brookings Papers on Economic Activity* **19(1)**: pp. 141–206.

Fazzari, S. M., R. G. Hubbard, & B. C. Petersen (2000): "Financing Constraints and Corporate Investment: Response to Kaplan and Zingales." *NBER Working Papers 5462*, National Bureau of Economic Research, Inc.

Fidrmuc, J., R. Horvath, & E. Horvathova (2010): "Corporate Interest Rates and the Financial Accelerator in the Czech Republic." *Emerging Markets Finance and Trade* **46(4)**: pp. 41–54.

Fisher, I. (1933): "The debt-deflation theory of great depressions." *Econometrica* **1(4)**: pp. 337–357.

Frait, J., S. Malovaná, & V. Tomšík (2015): "The interaction of monetary and macroprudential policies in the pursuit of the central bank's primary objectives." In Czech National Bank (editor), "Financial Stability Report 2014/2015," pp. 110–120.

Gaiotti, E. (2011): "Credit availability and investment in Italy: lessons from the Great Recession." *Temi di discussione (Economic working papers) 793*, Bank of Italy.

Galuščák, K. & J. Babecký (2009): "Ad-hoc firm-level survey on wage and price setting." Czech National Bank mimeo.

Geršl, A. & P. Jakubík (2011): "Relationship Lending in Emerging Markets: Evidence from the Czech Republic." *Comparative Economic Studies* **53(4)**: pp. 575–596.

Gertler, M. & S. Gilchrist (1994): "Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms." *The Quarterly Journal of Economics* **109(2)**: pp. 309–340.

Gertler, M. L. & R. G. Hubbard (1989): "Financial Factors in Business Fluctuations." *NBER Working Papers 2758*, National Bureau of Economic Research, Inc.

Gilchrist, S. & C. Himmelberg (1999): "Investment: Fundamentals and Finance." In B. S. Bernanke & J. J. Rotemberg (editors), "NBER Macroeconomics Annual 1998, volume 13," pp. 223–274. MIT Press.

Gugler, K., D. C. Mueller, & B. B. Yurtoglu (2004): "Marginal q, Tobin's q, Cash Flow, and Investment." *Southern Economic Journal* **70(3)**: pp. 512–531.

Gugler, K. & E. Peev (2010): "Institutional Determinants of Investment-Cash Flow Sensitivities in Transition Economies." *Comparative Economic Studies* **52(1)**: pp. 62–81.

Harrison, A. E., I. Love, & M. S. McMillan (2004): "Global capital flows and financing constraints." *Journal of Development Economics* **75(1)**: pp. 269–301.

Hobdari, B., D. C. Jones, & N. Mygind (2009): "Capital investment and determinants of financial constraints in Estonia." *Economic Systems* **33(4)**: pp. 344–359.

Holton, S., M. Lawless, & F. McCann (2012): "Firm Credit in Europe: A Tale of Three Crises." *Research Technical Paper 04/RT/12*, Central Bank of Ireland.

Hovakimian, G. (2009): "Determinants of Investment Cash Flow Sensitivity." *Financial Management* **38(1)**: pp. 161–183.

Hovakimian, G. & S. Titman (2006): "Corporate Investment with Financial Constraints: Sensitivity of Investment to Funds from Voluntary Asset Sales." *Journal of Money, Credit and Banking* **38(2)**: pp. 357–374.

Janda, K. (2011): "Inefficient Credit Rationing and Public Support of Commercial Credit Provision." *Journal of Institutional and Theoretical Economics JITE* **167(2)**: pp. 371–391.

Julio, B. & Y. Yook (2012): "Political Uncertainty and Corporate Investment Cycles." *Journal of Finance* **67(1)**: pp. 45–83.

Kaplan, S. N. & L. Zingales (1997): "Do Investment-Cash Flow Sensitivities Provide Useful Measures of Financing Constraints." *The Quarterly Journal of Economics* **112(1)**: pp. 169–215.

Kaplan, S. N. & L. Zingales (2000): "Investment-Cash Flow Sensitivities Are Not Valid Measures Of Financing Constraints." *The Quarterly Journal of Economics* **115(2)**: pp. 707–712.

Kashyap, A. K., O. A. Lamont, & J. C. Stein (1994): "Credit Conditions and the Cyclical Behavior of Inventories." *The Quarterly Journal of Economics* **109(3)**: pp. 565–92.

Keasey, K. & R. Watson (1991): "The State of the Art of Small Firm Failure Prediction: Achievements and Prognosis." *International Small Business Journal* **9(4)**: pp. 11–29.

Konings, J., M. Rizov, & H. Vandenbussche (2003): "Investment and financial constraints in transition economies: micro evidence from Poland, the Czech Republic, Bulgaria and Romania." *Economics Letters* **78(2)**: pp. 253–258.

Lízal, L. & J. Svejnar (2002): "Investment, Credit Rationing, And The Soft Budget Constraint: Evidence From Czech Panel Data." *The Review of Economics and Statistics* **84(2)**: pp. 353–370.

Love, I. (2003): "Financial Development and Financing Constraints: International Evidence from the Structural Investment Model." *Review of Financial Studies* **16(3)**: pp. 765–791.

Mach, T. L. & J. D. Wolken (2012): "Examining the Impact of Credit Access on Small Firm Survivability." In G. Calcagnini & I. Favaretto (editors), "Small Businesses in the Aftermath of the Crisis," pp. 189–210. Physica-Verlag HD.

Mizen, P. & P. Vermeulen (2005): "Corporate Investment and Cash Flow Sensitivity: What Drives the Relationship?" *ECB Working Papers No. 485*.

Moreno Badia, M. & V. Slootmaekers (2009): "The Missing Link Between Financial Constraints and Productivity." *IMF Working Papers 09/72*, International Monetary Fund.

Moshirian, F., V. Nanda, A. Vadilyev, & B. Zhang (2017): "What drives investment–cash flow sensitivity around the World? An asset tangibility Perspective." *Journal of Banking & Finance* **77**: pp. 1–17.

Musso, P. & S. Schiavo (2008): "The impact of financial constraints on firm survival and growth." *Journal of Evolutionary Economics* **18(2)**: pp. 135–149.

Noth, F. & A. Gauselmann (2016): "Decision-Making Power in Foreign Subsidiaries and its Effect on Financial Constraints: An Analysis for Selected European Transition Economies on the Basis of the IWH FDI Micro Database 2013." *Eastern European Economics* **54(6)**: pp. 459–472.

Oliner, S. D. & G. D. Rudebusch (1996): "Is there a broad credit channel for monetary policy?" *Federal Reserve Bank of San Francisco Economic Review* **1996**: pp. 3–13.

Plašil, M., Š. Radkovský, & P. Řežábek (2013): "Modelling bank loans to non-financial corporations." In "CNB Financial Stability Report 2012/2013," Czech National Bank.

Poncet, S., W. Steingress, & H. Vandenbussche (2010): "Financial constraints in China: Firm-level evidence." *China Economic Review* **21(3)**: pp. 411–422.

Pruteanu, A. (2004): "Was There Evidence of Credit Rationing in the Czech Republic?" *Eastern European Economics* **42(5)**: pp. 58–72.

Stiglitz, J. E. & A. Weiss (1981): "Credit Rationing in Markets with Imperfect Information." *American Economic Review* **71(3)**: pp. 393–410.

Weber, S. (2010): "bacon: An effective way to detect outliers in multivariate data using Stata (and Mata)." *Stata Journal* **10(3)**: pp. 331–338.

Whited, T. M. (2001): "Is It Inefficient Investment that Causes the Diversification Discount?" *Journal of Finance* **56(5)**: pp. 1667–1691.

4.A Appendix A: Derivation of the Euler Equation

Here we derive the Euler equation of the firm's problem.

Following Poncet *et al.* (2010), Moreno Badia & Slootmaekers (2009), Gilchrist & Himmelberg (1999), and Harrison *et al.* (2004)[25] we can define the value of the firm as

$$V_t(K_t, \xi_t) = \max_{I_t}\{D_t + E_t(\sum_{s=1}^{\infty} \beta_{t+s} D_{t+s})\} \tag{4.3}$$

subject to

$$D_t = \Pi(K_t, \xi_t) - C(K_t, I_t) - I_t \tag{4.4}$$

$$K_{t+1} = (1-\delta)K_t + I_t, \tag{4.5}$$

where ξ_t is the productivity shock, D_t are dividends paid to shareholders, K_t is investment, I_t is capital, $\Pi_t(\cdot,\cdot)$ is the profit function, $C_t(\cdot,\cdot)$ is the adjustment cost function, and β_t is the discount factor.

The Q model of the investment Euler equation is:

$$1 + \frac{\partial C(I_t, K_t)}{\partial I_t} = \beta_t\{\Psi_t \frac{\partial \Pi_{t+1}}{\partial K_{t+1}} + (1-\delta)(1 + \frac{\partial C(I_{t+1}, K_{t+1})}{\partial I_{t+1}})\}, \tag{4.6}$$

[25] Our work also draws inspiration from the literature on credit rationing and capital market imperfections (e.g. Harrison *et al.* 2004). Recently, Janda (2011) modeled credit guarantees and interest rate subsidies in a framework of credit rationing.

where λ_t is the Lagrange multiplier and $\Psi_t = \frac{1+\lambda_{t+1}}{1+\lambda_t}$ is the marginal cost of capital and also represents the financial constraints. As Poncet *et al.* (2010) note, firms do not face financial constraints if the shadow cost of investment $\lambda_{t+1} = \lambda_t = 0$ for all time periods. If $\Psi_t > 1$, then firms invest today; if, on the other hand, $\Psi_t < 1$, a firm invests tomorrow.

From this theoretical derivation, we get an empirical model by proxying Ψ_t with cash flow (assets available for investment):

$$\Psi_t = a_0 + a_1 \frac{CashFlow}{K} \tag{4.7}$$

The marginal product of capital can be proxied as:

$$MPK_t = \frac{\partial \pi_t}{\partial K_t} = \theta_i (\frac{Sales}{K})_i \simeq b + \theta_i + \bar{\theta} (\frac{Sales}{K})_i, \tag{4.8}$$

and

$$\theta_i = \frac{\alpha_k}{\mu}, \tag{4.9}$$

where b is a constant, α_k is the share of capital in the Cobb-Douglas function, μ is a markup, θ_i can be captured using fixed effects, and $\bar{\theta}$ can be assumed to be the industry average.

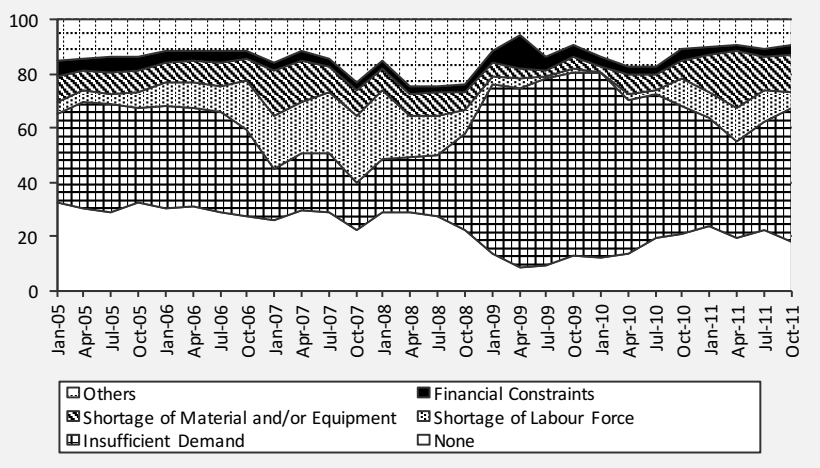
$$\frac{\partial C(I_t, K_t)}{\partial I_t} = \frac{1}{\alpha_1} [(\frac{I}{K})_t - \alpha_2 (\frac{I}{K})_{t-1} - \alpha_i + \alpha_t], \tag{4.10}$$

where α_1, α_2 are constants, α_i is the firm-specific level of investment (fixed effect), and α_t is a time effect.

To get the empirical equation we linearize the Euler equation and use first-order Taylor approximation around the means.

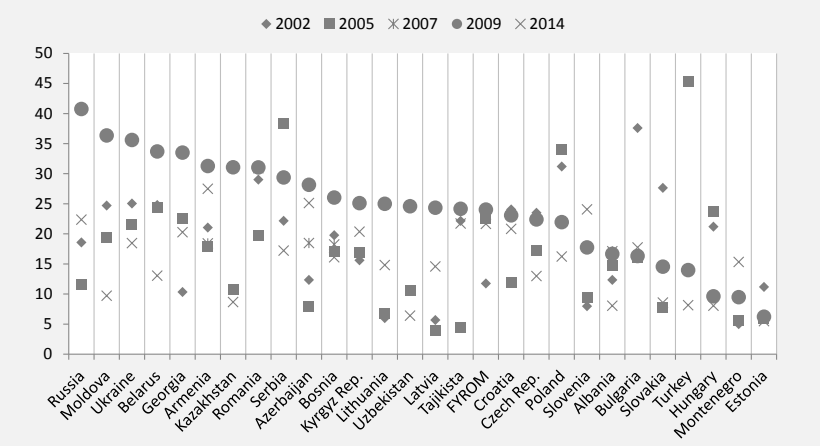
4.B Appendix B: Additional Figures

Figure 4.B1: Barriers to growth in industry



Source: Czech Statistical Office, authors' calculations.

Figure 4.B2: BEEPS: Finance as a major or severe obstacle



Notes: The figure depicts the share of companies that assess finance as a major or severe obstacle for their business growth. Finance as an obstacle varied in 2009 significantly across countries: from 6% in Estonia to 41% in Russia. In the Czech Republic, 24% of firms noted in late 2008 and early 2009 that finance is a major or severe barrier to their growth. Even though this share was very stable over the 2000s, we observe a temporary increase in the 2009 round in the majority of countries.
Source: BEEPS, authors' calculations.

Table 4.B1: Robustness check: turnover, all companies

Dependent variable: Investment rate	(1)	(2)	(3)
Investment rate$_{(t-1)}$	0.100	0.16	0.10
	(0.70)	(0.69)	(0.70)
Squared investment rate$_{(t-1)}$	-0.00097	-0.00086	-0.00097
	(0.0020)	(0.0020)	(0.0020)
Turnover$_{(t-1)}$	6.92***	7.13***	6.93***
	(1.01)	(0.94)	(1.01)
Cash flow$_{(t-1)}$	0.058***	0.063***	0.058***
	(0.012)	(0.011)	(0.012)
External debt$_{(t-1)}$	0.0080***	0.0083***	0.0080***
	(0.0022)	(0.0023)	(0.0022)
At some point bankrupt		-0.43	
		(0.33)	
(Cash flow)$_{(t-1)}$×(At some point bankrupt)		-0.100*	
		(0.052)	
Next year bankrupt			-0.78
			(0.55)
(Cash flow)$_{(t-1)}$×(Next year bankrupt)			0.060
			(0.063)
Constant	1.16**	1.00**	1.16**
	(0.55)	(0.50)	(0.55)
Number of instruments	37	39	39
AB test for AR(2) in first diffs p-value	0.26	0.38	0.26
Sargan test p-value	0.12	0.11	0.12
Hansen test p-value	0.35	0.29	0.35
Observations	295303	295303	295303
Sample	2006–2011	2006–2011	2006–2011

Notes: Heteroskedasticity and autocorrelation consistent standard errors in parentheses. All specifications include year and industry fixed effects. All variables are normalized by the respective firm's capital stock (fixed assets).
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4.B2: Robustness check: turnover, subsamples

Dependent variable: Investment rate	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Investment rate$_{(t-1)}$	-0.51	-0.48	0.96**	0.95*	-0.013	0.0070	0.32	2.28
	(0.66)	(0.65)	(0.49)	(0.49)	(0.47)	(0.39)	(0.62)	(2.73)
Squared investment rate$_{(t-1)}$	0.0011	0.00071	-0.0035*	-0.0035*	-0.00072	-0.0015	-0.0011	-0.0060
	(0.0018)	(0.0017)	(0.0019)	(0.0019)	(0.0020)	(0.0016)	(0.0015)	(0.0068)
Turnover$_{(t-1)}$	5.85***	5.83***	7.63***	7.63***	7.01***	6.70***	5.84***	7.42***
	(1.34)	(1.27)	(1.06)	(1.06)	(1.05)	(1.03)	(1.43)	(2.23)
Cash flow$_{(t-1)}$	0.073***	0.068***	0.055***	0.055***	0.060***	0.049***	0.060***	0.066**
	(0.016)	(0.016)	(0.013)	(0.013)	(0.013)	(0.012)	(0.017)	(0.028)
External debt$_{(t-1)}$	0.0066*	0.0062*	0.010***	0.010***	0.0077***	0.0063***	0.011***	0.015**
	(0.0035)	(0.0033)	(0.0025)	(0.0025)	(0.0026)	(0.0022)	(0.0042)	(0.0058)
At some point bankrupt	0.19		-1.29***		-0.86*		-0.17	
	(0.47)		(0.39)		(0.51)		(0.40)	
(Cash flow)$_{(t-1)}$×(At some point bankrupt)	-0.15**		-0.0027		-0.032		-0.037	
	(0.077)		(0.036)		(0.055)		(0.035)	
Next year bankrupt		-0.60		-0.70*		-0.56		-1.60
		(0.83)		(0.37)		(0.65)		(2.35)
(Cash flow)$_{(t-1)}$×(Next year bankrupt)		0.16***		-0.036		0.082		-0.0061
		(0.051)		(0.029)		(0.056)		(0.072)
Constant	1.30**	1.38***	0.39	0.39	1.25**	1.63***	0.99**	-0.26
	(0.53)	(0.50)	(0.33)	(0.33)	(0.51)	(0.50)	(0.40)	(1.76)
Number of instruments	36	36	36	36	39	39	39	39
AB test for AR(2) in first diffs p-value	0.50	0.16	0.34	0.33	0.39	0.051	0.49	0.59
Sargan test p-value	0.99	0.99	0.14	0.14	0.89	0.93	0.12	0.98
Hansen test p-value	0.47	0.42	0.58	0.58	0.12	0.34	0.89	1.00
Observations	120773	120773	174530	174530	170478	170478	124825	166903
Sample	2006–2008	2006–2008	2009–2011	2009–2011	1–19 empl.	1–19 empl.	20+ empl.	20+ empl.

Notes: Heteroskedasticity and autocorrelation consistent standard errors in parentheses. All specifications include year and industry fixed effects. All variables are normalized by the respective firm's capital stock (fixed assets).

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4.B3: Robustness check: instrumenting with lags 2–3, all companies

Dependent variable: Investment rate	(1)	(2)	(3)
Investment rate$_{(t-1)}$	-0.37	0.073	-0.37
	(0.91)	(0.60)	(0.91)
Squared investment rate$_{(t-1)}$	0.00030	-0.00061	0.00031
	(0.0024)	(0.0019)	(0.0024)
Change in sales$_{(t)}$	0.020***	0.021***	0.020***
	(0.0040)	(0.0035)	(0.0040)
Cash flow$_{(t-1)}$	0.095***	0.11***	0.095***
	(0.019)	(0.013)	(0.019)
External debt$_{(t-1)}$	0.024***	0.026***	0.024***
	(0.0040)	(0.0023)	(0.0040)
At some point bankrupt		-0.13	
		(0.34)	
(Cash flow)$_{(t-1)}$×(At some point bankrupt)		-0.12**	
		(0.055)	
Next year bankrupt			-0.44
			(0.41)
(Cash flow)$_{(t-1)}$×(Next year bankrupt)			0.056
			(0.068)
Constant	1.56*	1.13**	1.57*
	(0.84)	(0.47)	(0.84)
Number of instruments	33	35	35
AB test for AR(2) in first diffs p-value	0.38	0.52	0.38
Sargan test p-value	0.98	0.97	0.98
Hansen test p-value	0.90	0.87	0.90
Observations	305249	305249	305249
Sample	2006–2011	2006–2011	2006–2011

Notes: Heteroskedasticity and autocorrelation consistent standard errors in parentheses. All specifications include year and industry fixed effects. All variables are normalized by the respective firm's capital stock (fixed assets).
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4.B4: Robustness check: instrumenting with lags 2–3, subsamples

Dependent variable: Investment rate	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Investment rate$_{(t-1)}$	-0.80	-1.56	1.24***	1.23***	-0.15	-0.14	0.30	0.59
	(0.77)	(1.34)	(0.46)	(0.46)	(0.45)	(0.47)	(0.50)	(0.72)
Squared investment rate$_{(t-1)}$	0.0020	0.0036	-0.0043**	-0.0043**	-0.00069	-0.0012	-0.00058	-0.0014
	(0.0022)	(0.0031)	(0.0017)	(0.0017)	(0.0017)	(0.0019)	(0.0014)	(0.0018)
Change in sales$_{(t)}$	0.023***	0.021***	0.020***	0.020***	0.016***	0.015***	0.035***	0.028***
	(0.0044)	(0.0050)	(0.0041)	(0.0041)	(0.0034)	(0.0036)	(0.0074)	(0.0054)
Cash flow$_{(t-1)}$	0.11***	0.094***	0.10***	0.10***	0.096***	0.086***	0.11***	0.097***
	(0.017)	(0.023)	(0.014)	(0.014)	(0.013)	(0.016)	(0.019)	(0.017)
External debt$_{(t-1)}$	0.021***	0.018***	0.029***	0.029***	0.023***	0.022***	0.026***	0.029***
	(0.0028)	(0.0052)	(0.0026)	(0.0026)	(0.0020)	(0.0029)	(0.0034)	(0.0036)
At some point bankrupt	0.57		-1.36***		-0.43		0.33	
	(0.56)		(0.43)		(0.50)		(0.46)	
(Cash flow)$_{(t-1)}$×(At some point bankrupt)	-0.15**		-0.047		-0.16***		-0.015	
	(0.066)		(0.032)		(0.046)		(0.027)	
Next year bankrupt		0.25		-0.44		-0.26		-1.18
		(1.45)		(0.38)		(0.78)		(1.01)
(Cash flow)$_{(t-1)}$×(Next year bankrupt)		0.16***		-0.062***		0.090		-0.069*
		(0.055)		(0.023)		(0.060)		(0.036)
Constant	1.44**	2.09*	0.23	0.23	1.78***	1.99***	0.64**	0.54
	(0.57)	(1.10)	(0.37)	(0.37)	(0.47)	(0.55)	(0.32)	(0.47)
Number of instruments	32	32	32	32	35	35	35	35
AB test for AR(2) in first diffs p-value	0.73	0.37	0.47	0.46	0.038	0.040	0.33	0.29
Sargan test p-value	0.93	0.94	0.99	0.99	0.97	0.99	0.98	1.00
Hansen test p-value	0.50	0.66	0.84	0.84	0.42	0.56	0.41	0.90
Observations	124379	124379	180870	180870	172045	172045	133204	175493
Sample	2006–2008	2006–2008	2009–2011	2009–2011	1–19 empl.	1–19 empl.	20+ empl.	20+ empl.

Notes: Heteroskedasticity and autocorrelation consistent standard errors in parentheses. All specifications include year and industry fixed effects. All variables are normalized by the respective firm's capital stock (fixed assets).

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4.B5: Robustness check: OLS & FE, all companies

Dependent variable: Investment rate	Firm & year FE	Sector & year FE	OLS without FE
Investment rate$_{(t-1)}$	-0.18***	-0.0049**	-0.0035
	(0.011)	(0.0023)	(0.0023)
Squared investment rate$_{(t-1)}$	0.000077*	0.000014	0.000011
	(0.000041)	(0.0000094)	(0.0000094)
Change in sales$_{(t)}$	0.020***	0.021***	0.021***
	(0.0034)	(0.0030)	(0.0030)
Cash flow$_{(t-1)}$	0.10***	0.090***	0.090***
	(0.011)	(0.0086)	(0.0086)
External debt$_{(t-1)}$	0.029***	0.018***	0.018***
	(0.0021)	(0.0013)	(0.0013)
At some point bankrupt		0.060	0.086
		(0.30)	(0.30)
(Cash flow)$_{(t-1)}$×(At some point bankrupt)	-0.22*	-0.098*	-0.098*
	(0.12)	(0.057)	(0.057)
Constant	0.17**	0.59***	0.81***
	(0.072)	(0.12)	(0.029)
Observations	305249	305249	305249
Sample	2006–2011	2006–2011	2006–2011

Notes: Robust standard errors in parentheses. Variance is clustered at the firm level in the second and the third specification. All variables are normalized by the respective firm's capital stock (fixed assets).
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4.B6: Robustness check: FE, subsamples

Dependent variable: Investment rate	(1)	(2)	(3)	(4)	(5)	(6)
Investment rate$_{(t-1)}$	-0.0033	-0.0034	-0.0066***	-0.0066***	-0.0068***	-0.0024
	(0.0047)	(0.0047)	(0.0020)	(0.0020)	(0.0022)	(0.0050)
Squared investment rate$_{(t-1)}$	0.000015	0.000016	0.000014***	0.000014***	0.000012**	0.000015
	(0.000021)	(0.000021)	(0.0000053)	(0.0000053)	(0.0000054)	(0.000020)
Change in sales$_{(t)}$	0.023***	0.023***	0.019***	0.019***	0.017***	0.031***
	(0.0042)	(0.0042)	(0.0042)	(0.0042)	(0.0032)	(0.0071)
Cash flow$_{(t-1)}$	0.10***	0.099***	0.081***	0.081***	0.092***	0.085***
	(0.013)	(0.013)	(0.012)	(0.012)	(0.0099)	(0.017)
External debt$_{(t-1)}$	0.016***	0.017***	0.019***	0.019***	0.019***	0.014***
	(0.0018)	(0.0019)	(0.0018)	(0.0018)	(0.0015)	(0.0024)
At some point bankrupt	0.61		-0.73**		-0.34	0.48
	(0.43)		(0.34)		(0.39)	(0.46)
(Cash flow)$_{(t-1)}$×(At some point bankrupt)	-0.15*		-0.026		-0.11*	-0.031
	(0.082)		(0.031)		(0.068)	(0.025)
Next year bankrupt		-0.013		-0.98***		
		(0.68)		(0.17)		
(Cash flow)$_{(t-1)}$×(Next year bankrupt)		0.12***		-0.058***		
		(0.042)		(0.017)		
Constant	0.67***	0.68***	0.35***	0.35***	0.82***	0.75***
	(0.15)	(0.15)	(0.13)	(0.13)	(0.17)	(0.16)
Observations	124379	124379	180870	180870	172045	133204
Sample	2006–2008	2006–2008	2009–2011	2009–2011	1–19 empl.	20+ empl.

Notes: Robust standard errors in parentheses. Variance is clustered at the firm level. All specifications include year and industry fixed effects. All variables are normalized by the respective firm's capital stock (fixed assets).

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Response to Comments from the Opponents

March 28, 2017

Empirical Essays in Institutional Microeconomics

by Jiří Schwarz

I thank the reviewers for constructive comments, questions, and suggestions on the pre-defense version of my dissertation. They helped me to improve the thesis significantly. Their comments are typeset in italics; my response is in roman type.

I have renamed the thesis, switched the position of Chapters 3 and 4, and written a new Introductory chapter.

Response to Comments from Niclas Berggren

Chapter 1

1. *I am sorry to say that I am not very pleased with the introductory chapter*

   The introductory chapter has been rewritten to be more in line with the comments of all three referees. Also, I have changed the name of the dissertation to better suit its content.

   The new introductory chapter now provides an overview of the topic of institutional quality and its impact on real economy through entrepreneurship: First, I explain how it is possible that we observe quality of institutions change over time and differ across countries. Then I introduce some important papers dealing with the impact of institutional quality on economic growth, and mention also the role of informal institutions and their potential interplay with formal institutions. After that I turn my attention to the core mechanism behind the impact of institutions on real economy – the entrepreneur – and explain the hypothesis of Chapter 2 in this context. I also provide an overview of recent literature dealing with the impact of institutional quality on international trade and price differences.

   Turning my attention to the topic of productive vs. unproductive entrepreneurship, I explain why strategic patenting, the topic of Chapter 3, is an example of unproductive entrepreneurial activity. And not only that – it is also a good example of an unintended consequence of a government policy with completely different official goal (boosting innovation). In this sense I explain that the 2008 financial crisis led to a considerable broadening of the spectrum of monetary and macroprudential policy tools available to central banks, which already started to use them even with very limited empirical evidence of their potential side-effects. One example of such side-effect may be the impact of these policies on financially constrained firms – the topic of Chapter 4. At the end of the introductory chapter I provide my view of how the field may move forward and what should, in my opinion, receive more attention.

Chapter 2

1. *One problem with the chapter is that it cites the literature up until 2010, which has to do with the fact that the published version is from 2012. However, the thesis is submitted now, in 2016, and I therefore consider it reasonable to ask the PhD candidate to describe the development of the literature from 2010 up until today, and the place of his contribution in it, as an addendum to the actual chapter. I would suggest this is done in the introductory chapter 1.*

   I've added an overview of the literature dealing (also implicitly) with the impact of institutions on prices and trade in the introductory chapter.

2. *Why is price dispersion an interesting outcome to look at? Is it associated with economic efficiency or welfare? This could be explained better, so as to provide a motivation of the chapter.*

   I added a reference to welfare implications to the Introduction on p. 14:

   "Many authors estimate the size of the border effect and explain the role of various factors influencing cross-border price dispersion (Bergin & Glick, 2007; Parsley & Wei, 2007; Wolszczak-Derlacz, 2008). The underlying idea in their studies is that arbitrage is a process which should automatically equalize the prices in different places once we remove the influence of these factors. However, arbitrage is an entrepreneurial activity and as such should be influenced by institutional quality. The reason is that low-quality institutions can impose prohibitive costs to arbitrage in the same way as large distances between cities or high tariffs. And contrary to, e.g. distance or language differences, the institutional quality is improvable making it a potentially interesting subject to economic policy. However, the role of institutions is completely neglected by existing literature on the border effect. The main hypothesis of this paper is that institutional quality significantly influences the extent of price dispersion. As Engel & Rogers (2001) explain, price dispersion – a measure of deviations from the LOP – causes a deadweight loss to the economy. But this loss cannot be eliminated by simply fixing the exchange rates, because the underlying source of inefficiency is the price stickiness. They argue that only reduction of real barriers to trade implies welfare improvement."

3. *There are many institutional measures – it would have been good to see a discussion of which alternatives there are (maybe the ICRG or one of the two economic freedom indices) and what their respective strengths and weaknesses are. One important aspect is that many of them, including the one used by the author, are subjective. What does this imply for the reliability of the measure used?*

   I added a paragraph mentioning other alternatives on p. 21:

   "There is a number of other sources of institutional quality indicators also focusing on economic institutions: the International Country Risk Guide (ICRG), The Heritage Foundation's Index of Economic Freedom, the Fraser Institute's Economic Freedom of the World, the World Bank's Country Policy and Institutional Assessment (CPIA), etc. However, none of them provide any clear advantage over the WGI data. ICRG data are subject to payment and are collected by a small number of experts, which makes it prone to misinterpretation error. The same is true for CPIA, where the World Bank's staff assigns a rating to each country based on some input data. Both economic freedom indexes are based on a number of various data sources which is then translated into country score. But in order to use them as a proxy for institutional quality, an assumption must be made

that better institutions equal to more economic freedom, and, therefore, less regulation. This would unnecessarily incorporate an ideological aspect into the analysis.

On the other hand, the WGI data are free and come from 31 different sources of four kinds: commercial business information providers, surveys of firms and households, non-governmental organizations, and public sector data providers. Altogether, more than 400 variables are used to compute the indicators. This should lead to greater precision of data compared to any individual data source."

And in the related footnote:

"The WGI data are widely used in academic literature – the methodological paper by Kaufmann *et al.* (2010) has been cited more than 2700 times until March 2017 according to Google Scholar."

4. *The notion of entrepreneurship used is Kirznerian, stressing arbitrage in the presence of profit opportunities. However, the author treats the Baumol definition, which seems Schumpeterian, as essentially similar, but many in the entrepreneurship literature have noted the fundamental differences between them.*

   Yes, the entrepreneurial activity I describe in the paper is more Kirznerian. I didn't want to get into unnecessary details over this issue in the article but I can discuss the differences in the dissertation.

   I added a paragraph addressing this issue on p. 18:

   "Note, that the Kirznerian and the Schumpeterian views of entrepreneurship focus on different aspects. Whereas Kirzner stresses the arbitrage-based equilibrating behavior of entrepreneurs, Schumpeter emphasizes their ability to create new markets and disrupt the existing equilibria (Sundqvist *et al.*, 2012). In reality, both types of entrepreneurial activity coexist side by side. However, given how globalized the today's world is, there is no reason to believe that a Schumpeterian "disruptive" entrepreneur would aim only on one market and increase cross-border price dispersion if he or she didn't have to face institutional obstacles. The same reasoning regarding the effect of institutional quality on deviations from the LOP should, therefore, apply to this type of entrepreneur, too."

5. *I think the claim that this paper is the first to introduce institutions as explanatory factors of price convergence is too bold. For example, the literature on integration and price convergence tends to have an institutional component (. . .). There I think a more careful literature review could have been undertaken, with an ensuing slight modification of the claims about the contribution of the paper. The contribution is rather, in my view, the provision of a theory of the mechanism from institutions to price convergence (Kirznerian entrepreneurship).*

   Thank you for pointing that out. I added a paragraph explain the difference between my paper and the integration/currency union effect literature on p. 19:

   "Literature analyzing how currency unions and market integration influence international trade and price dispersion also implicitly estimates the impact of institutional changes. However, the effect doesn't seem to be particularly robust: Some authors find a sizable effect of currency unions and integration (Rose, 2000; Allington *et al.*, 2005; Goldberg & Verboven, 2005; Cavallo *et al.*, 2014; Glick & Rose, 2016), whereas others don't (Engel & Rogers, 2004; Wolszczak-Derlacz, 2010; Havránek, 2010). Even if we put the issue of robustness of the findings aside, interpreting the results from the point of view of institutional quality would require the assumption that currency and market integration leads

to higher-quality institutions which make arbitrage more feasible. But such assumption is never explicitly stated nor tested in this stream of literature. As a consequence, the available results don't allow us to directly address the link between institutional quality and deviations from PPP or LOP."

6. *This is because the data that exist on entrepreneurship, and which have been used in the studies he nevertheless cites, cover other aspects of entrepreneurship (if they cover entrepreneurship at all): namely, starting new companies (as in the Global Entrepreneurship Monitor) or obtaining patents or the like. None of these datasets cover arbitrage, which may be wholly unrelated, or even (as suggested above) negatively related, to price convergence. Therefore, I find it somewhat questionable to relate to this literature in a way that suggests that it supports the hypothesis of this paper.*

   I believe that these aspects should be correlated with what I study. For example, in order to start importing/exporting goods or services, a company often has to be set up first.

   I added a footnote explaining this reasoning on p. 19:

   "Institutions positively influencing venture capital investments or the number of produced patents do not have to necessarily increase the scope of arbitrage, as these activities are probably often pursued by different entities aiming at different goals. But in order to start importing or exporting goods, a company usually has to be set up first. If institutional quality influences establishment birth rate, it should also influence the costs of arbitrage and, consequently, price dispersion."

7. *P. 6: How are "institutions" and "low-quality institutions" defined and how do costs that affect arbitrage arise? What are those costs, and can they be measured? Relatedly, on p. 11 the terms "institutional quality" and "better institutions" are used. What is meant, exactly? Importantly, to avoid a tautology, it seems to me central to define quality/goodness in a way that is unrelated to arbitrage: it does not add new knowledge to claim that "better institutions give more arbitrage (and price convergence)", where "better" is defined as "giving more arbitrage (and price convergence)".*

   In this paper I understand institutions as the regulatory/policy framework of the country. As I explain on p. 28, "[b]ased on the theory presented in Section 2.3, the regulatory quality measure should best represent the analyzed quality of economic institutions. According to Kaufmann *et al.* (2010, p. 4), it captures 'perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development'." Therefore "better" means higher ability of the government to do so. Institutional quality is not defined using arbitrage, but rather constitutes one of the costs of arbitrage. In this sense, and I want to thank doc. Benáček for this idea, we can perceive institutional quality as institutional distance – similarly to geographical distance.

   To emphasize what "better institutions" mean, I added a sentence on p. 28:

   "The higher value of institutional measure indicates better institutional quality, which means that the ability of the government to implement sound policies and regulations that permit and promote private sector development is perceived to be higher compared to other governments. A better quality of institutions is expected to be correlated with lower price dispersion because good regulations lower the expected costs of entrepreneurial activity, making the costs of arbitrage smaller."

8. *I am surprised to see, in footnote 1 on p. 12, that cars are excluded from the analysis.*

... Generally, it would have been interesting to see a variation of cities and goods to see how sensitive the results are to the selection of these.

Cars were excluded because of the risk of their high heterogeneity among cities. In EIU City Data, cars are defined only by their engine displacement such as "Low-priced car (900-1,299 cc)", "Family car (1800-2499 cc)", etc. Sensitivity analysis regarding the selection of product categories is already provided in Table 2.A6. I added a row with marginal effects of regulatory quality on price dispersion for cross-border observations and an indicator if the marginal effects differ with respect to the "all" category. I also ran the regression including both the sum of institutions and their difference (see below) a number of times on random draws from the whole sample consisting of 30–50% of the original city pairs. The coefficients vary slightly in terms of their size, but they are always of the same sign and statistically significant. I would say that the major result – i.e. the negative impact of regulatory quality score sum on price dispersion and the positive impact of regulatory quality score difference on price dispersion for cross-border observations – is robust to selection of goods and cities.

9. *I find it to be a shortcoming that there is no precise theoretical discussion of how the six institutional indicators are supposed to be related to (net gains to) arbitrage. ...*

   As I mention above, I believe that in order to perform arbitrage, a number of steps have to be taken first by the entrepreneur. The costs of these steps are influenced by institutional (regulatory) quality. With the exception of government effectiveness and political stability measures, which are not significantly different, all other measures are significantly different from each other. As they were rescaled to [0-1] for Table 2.A5, their coefficients are directly comparable. Table 2.A5 reveals that the influence of the regulatory quality measure on price dispersion is the strongest. Also, using this measure in the baseline specification explains the largest part of variation in price dispersion.

   A number of papers use rule of law as the base proxy for institutional quality. However, I believe that such measure is more suitable for analyzing activities which are more complicated than arbitrage. Such as investment rates, vertical and horizontal integration, patenting, etc. Proposing a way of computing the latent quality of legal, political and economic institutions for panel data applications, Kunčič (2014) also uses regulatory quality from the WGI as one of sources of his economic institutions variables (together with one measure from the Freedom House's Freedom of the press index, Investment profile from ICRG, and a couple of items from the Heritage and the Fraser Institute's economic freedom datasets).

10. *I am somewhat puzzled by the criterion used for dividing goods into traded and nontraded: it is said to rely on "common sense". It is unclear what that is. There are more precise criteria in the literature. ... Why wasn't such a criterion used, where there could be a sensitivity analysis with regard to the division?*

    Due to the nature of the used approach, where I explain price dispersion measure and not the prices of individual items, it would be impossible to take into account their degree of tradability. But Crucini *et al.* (2005), looking at the degree of tradability of individual goods and their inputs, find that with decreasing tradability price dispersion among cross-border cities increases. Therefore, I believe that all I would get, if I could incorporate such information into my analysis, would be increasing price dispersion, and therefore increasing border effect, as tradability decreases.

    In order to check whether regulatory quality influences price dispersion of various types of goods with arguably various degree of tradability differently, I added a row with marginal

effect of regulatory quality on price dispersion for cross-border observations to Table 2.A6. The results suggest that the effect of institutional quality on price dispersion of non-traded items is not different from tradables. Comparing the marginal effect's 95% confidence interval of the all items category (the average) with the other categories of goods, non-tradables, personal items and alcohol do not have a significantly different marginal effect of regulatory quality on price dispersion. The effect of institutions on price dispersion by perishable and non-perishable food, clothing, and household items is significantly lower, and by recreation items higher. Also, lower Adjusted R^2 compared to the effect for all items in Column (9) shows that other factors play a larger role in the case of non-tradables.

11. *Is the band on no-arbitrage, as shown in Figures 2.1 and 2.2, always symmetrical, and what is the relevance of (a)symmetry?*

    I think that it is by definition symmetrical in my framework – it shows that the price in City A has to be higher by X compared to City B, or vice versa, for the arbitrage to be profitable. An asymmetrical band would mean that the costs of arbitrage from City A to City B would differ from the costs of arbitrage from City B to City A. It is possible that such a think can happen, but I believe that modeling it would complicate the analysis without providing any substantial insights into the effect of institutional quality on cross-border price dispersion.

12. *I wonder if there is an element of tautology in the theoretical idea that arbitrage takes place outside the no-arbitrage bound, i.e., when it is profitable. Is this idea disprovable (in principle)? If not, how would the author describe its usefulness?*

    Many of the often cited papers on border effect look at prices of individual goods. I argue on p. 14 that such an approach is incorrect because it is not consistent with the theory behind the LOP. Inside the no-arbitrage band the prices follow random walk process and their movement doesn't have to be influenced by arbitrage costs. To correctly estimate the size of border effect and the influence of its individual sources, we need to use price dispersion – a measure of the no-arbitrage band – as the dependent variable.

13. *To the extent that institutions provide an explanation for the degree of price convergence, what about the distinct differences in the degree of convergence between different categories of goods (Figures 2.5 and 2.6), which are all produced under the same institutions? Can institutions affect arbitrage profitability differently for different categories of goods?*

    In theory institutions can, of course, affect arbitrage profitability differently. But as Table 2.A6 suggests, the impact of institutional quality on arbitrage is very similar for all product categories in case of city pairs from different countries (see the marginal effects and their comparison).

14. *What is the role of other factors influencing price dispersion and, especially, might they interact with institutions? There is surprisingly little on this important topic in the paper. What is the risk for reverse causality: that price dispersion causes institutional change: and might not some third factor cause both a certain type of institutions and price dispersion? I think a discussion of this should have been included.*

    The pool of potential sources of the border effect is, indeed, large, as I show in the literature review part of the paper. But I didn't want to replicate the existing literature as I didn't think they should interact with institutional quality. Also, my approach was to present institutional quality as one of the costs of arbitrage, similar to distance, tariffs, language differences etc. In one of the robustness checks (Table 2.A7 and discussion on p. 33) I

include also a number of potential third factors, which were also sometimes present in the literature as factors influencing price dispersion. But the role of institutional quality stays significant which also, in my opinion, shows that the results are not driven by endogeneity.

Regarding the possibility of reverse causality: I ran the baseline regression with lags of regulatory quality sum and difference and the results hold. Also, if we believed that high price dispersion can cause worse regulatory quality, it would mean that entrepreneurs, unable to reap profits from productive activities (arbitrage), turn to unproductive activities, such as rent seeking. And, as a side effect, further cause institutional quality deterioration. Even so, it would take years for this process to reach some observable effects. Therefore, I believe that the specification I use doesn't suffer from this potential development.

15. *Might it be interesting to look at levels as well as at changes, e.g., in institutions and price dispersion? What insights might be gained by looking at the latter, as a complementary exercise?*

    Using first differences is generally a way to get rid of unobserved heterogeneity in panel data. I believe I do a similar thing by including city fixed effects in specification (9) and (10) in Table 2.2. The result is robust to this specification. Moreover, using fixed effects leaves more information available than taking differences. In terms of interpretation potential, I don't see how using first differences can be useful for the topic of the paper. I tried to run the regression in differences but didn't get significant results.

16. *The variable "border" does not seem to be defined in Table 2.A4.*

    Thank you, I added it.

17. *I find it rather strange to use, as the main measure of institutional quality, the sum of two countries' values. Wouldn't the distribution be expected to matter?*

    Thank you for a nice idea. I included both both the sum and the difference in one specification as a robustness check, see p. 32:

    "Moreover, including both the sum and the difference of regulatory quality measure simultaneously reveals (see Column 1 in Table 2.A7) that the lowest price dispersion is among cities which not only have the best regulatory quality, but also, at the same time, achieved similar quality levels. In other words, not only level, but also distribution matters. In a hypothetical situation of two cities with regulatory quality of 0.5, the impact on price dispersion would be $(0.5 + 0.5) \times (0.014 - 0.045) + |0.5 - 0.5| \times 0.053 = -0.031$, whereas for one city with regulatory quality 1 and the other with 0, the impact on price dispersion would be 0.022. Even though the average institutional quality is the same, the larger "institutional distance" causes significantly higher price dispersion."

18. *It would have been interesting to see regression results for a specification without the institutional measure.*

    I added it as a robustness check (p. 33):

    "Column 3 in Table 2.A7 reports the result of specification without any institutional measures. Interestingly, the border dummy coefficient doesn't increase, but the explanatory power of the model decreases sizably."

19. *Should not an EU dummy be part of the regressions, as trade conditions are different (and homogeneous) within the EU compared to outside it?*

    It is true that trade conditions do differ but from the institutional quality point of view, these should be captured by the regulatory quality variable. Also, specification using

city fixed effects captures also the EU effect and the regulatory quality coefficient doesn't change. I added a robustness check with city×year interaction dummies which should capture all city-related fixed effects, and also their development over time. Including the effect of EU. The robustness check on p. 33 (Table 2.A7, column 2) shows that the effect of institutional quality on price dispersion gets even stronger when including the above mentioned set of interaction dummies.

Chapter 3

1. *The authors should clarify why we should care about strategic patenting in a better motivation of the study.*

   I have rewritten the introduction of this chapter to show more clearly why strategic patenting is a socially harmful behavior.

2. *On p. 70 it should be explained how strategic patents are "a rent-seeking tool". Rent-seeking is the use of resources that could have been used for productive purposes to attain political favors. In what sense is a patent a tool to this end?*

   In my opinion, rent-seeking describes unproductive use of resources with the goal of extracting rent. But not only through politics – another frequently used channel is litigation. And strategic patents are acquired as a tool for extracting rent through litigation. The term rent-seeking is widely used in this context in the literature. E.g. Lemley & Shapiro (2005, p. 88) write: "Furthermore, the prospect of the prize of $600 in royalties to the patent holder will encourage rent-seeking behavior by patent applicants." See, also, Merges (2009) for a discussion of patent-based rent-seeking. This is one of the reasons I mention litigation statistics as one of the sources of my hypotheses.

   I explain it better in the rewritten introduction.

3. *Is the contribution to study the prevalence of strategic patenting over a longer time period than before and to study how it differs across industries? This should be made clearer – as well as why these two features of the study are important and interesting, forming a distinct contribution to the literature.*

   Again, the contribution should now be more clear. In the introduction, I also added a paragraph summing it up:

   "Our contribution to the existing literature consists of two components: We introduce a novel approach to identification of strategic patenting based on two complementary methods, a patent-level and a firm-level one, which allows the study of strategic patenting in the panel settings. And second, using this approach we show that the incidence of strategic patenting has not increased since 1980."

4. *It seems to me that extending the time period would be especially interesting if the variation in strategic patenting over time is related to economic and political factors that explain its variation – this would provide very useful knowledge Likewise, if one finds it in use in certain industries more than in others, could this be related to explanatory variables? If not, how is this knowledge useful?*

   A number of papers/books argue that patents fail to bolster innovation. I wanted to find out if this claim can be empirically tested and whether there are some time trends and differences across industries observable. The recent anecdotal evidence on patent litigation cases creates the impression that strategic patenting is on the rise. The result of our paper is that the data are not in line with this impression – the evidence doesn't show increased

strategic patenting in the last decades. It may be, of course, possible to try to find sources of the variation. But that would be, I believe, a topic for another paper.

5. *The authors should motivate their choice of four industries and 22 companies to study. Why these and not others? Why not a larger selection? Is it ascertained that the companies are typical companies for each industry? It seems to be acknowledged, on p. 75, that they are not. But if so, can the results be generalized? And if they cannot, how does that influence the value of the study from a policy perspective? It would be good to see a sensitivity analysis when varying the included samples (maybe a jack-knife exercise could be undertaken as well).*

   In order to do a firm-level analysis, the companies have to be always arbitrarily hand-picked. As we explain on p. 75, we needed companies with large enough patent portfolios to be able to statistically analyze it and track its development over time. The industries were chosen because they were expected to be highly innovative but, at the same time, to follow different approaches to patenting. This is the reason for limiting our sample to companies with market value of at least USD 2 billion and more than 10 years of history.

   I also added a paragraph commenting on the limited sample in Conclusion on p. 76:

   "A clear limitation of our study is the restriction of our sample to only 22 large companies, which was needed for the firm-level approach to strategic patenting identification. It is possible, that smaller companies with short history choose their patenting strategy differently. On the other hand, if we set aside non-practicing entities (also known as patent trolls), to use patents strategically, a company must be ready to exert considerable resources related to patent litigation. Not many practicing smaller companies would be able to do that on a sizable scale."

   One sensitivity analysis is described in section 3.7, where the patent sample was limited to only some technological fields. The results seem to be robust. I also tried to run the baseline regression on a number of randomly chosen subsamples (e.g. dropping random 20% of observations) of patents and the results do not change.

6. *The two hypotheses on p. 71 should be motivated: Is there any particular reason, aside from a pattern in the data, to formulate them? Is there a theoretical basis for them –a priori (preferably) or a posteriori? Moreover, the empirical findings, that go against the hypotheses, should also be given a theoretical explanation, in my view.*

   I tried to motivate the hypotheses better in the rewritten introduction. Even though there are some papers which address individual changes in patent policies (usually following some court decision), the effects of such changes are often so complicated that it is not clear if they work at all. I mention couple of them at the end of the results section (p. 72). Existing theoretical papers explain why companies may be expected to acquire patents for strategic use, but I don't recall any clear theoretical predictions regarding the development of strategic patenting over time or differences across industries. That is why I base my hypotheses on litigation and patent citation counts. Because in the end, I want to find out if the observed development in patent litigation is due to increased strategic patenting of large technology companies. If it is, then it reduces social welfare. If not, then we should try to find its source elsewhere (e.g. patent trolls?).

   I also tried to explain my findings in the conclusion (p. 75):

   "To sum up, our findings mean that the observed increase in patent litigation over the last decades had to be driven by factors other than strategic patenting of large technology companies. Part of the growth in patent cases may be attributed to patent trolls and other

non-practicing entities. However, the vast majority of court decisions, even in the fields we study, seem to be related to practicing entities (PricewaterhouseCoopers, 2016, p. 12). How to reconcile growing incidence of phenomena connected with strategic patenting, such as patent aggregation, creation of patent thickets, and more litigation, with a decrease in strategic patenting?

One possibility is, that these phenomena are predominantly caused by other market entities – smaller companies or NPEs. In other words, the sector of large technology companies may not be behind the socially harmful unproductive activities; or at least not more, than in the 1980s. The policy recommendation would be to target those parts of the market, which are responsible. The second possible interpretation of our result is that large technology companies use strategically patents which are not different from innovation-protecting patents in terms of their social value. In such a case, the welfare implications and policy recommendations would be unclear. Strengthening patent protection may in fact encourage the unwanted use of patents, and vice versa."

7. *On p. 71 the authors write: "We therefore reject both hypotheses and conclude that we do not observe a rising tendency of large technology companies to engage in socially harmful strategic patenting." I lack a wider discussion, especially the policy implications, of this finding.*

   I tried to indicate the policy implications of my findings (see my reaction to your previous comment). But I do not think that my results allow me to formulate anything stronger. Anything more would be pure speculation from my side.

8. *Regarding the literature review: . . . & It is not acknowledged that the paper was also presented at the Research Institute of Industrial Economics (IFN) in Stockholm (which happened on 29 January, 2014).*

   Thank you, I acknowledged the presentation at IFN and used the provided references in Introduction and at the end of the Results section.

9. *It is unclear to me if the authors control for/exclude self-citations. If not, this should probably be done (at least as a robustness check).*

   We did a robustness check without self-citations but the results were practically unchanged. I see we forgot to mention it anywhere.

   I added a footnote mentioning it on p. 72:

   "Excluding self-citations doesn't have any impact on our findings, even though they constitute 14.8% of all citations."

10. *Has there been some change in patent legislation or regulatory practice in the U.S. during the studied time period that could have affected the results?*

    Yes, there have been some changes.

    I added a discussion of policy changes on p. 72:

    "Utilization of strategic patenting may be influenced by changes in patent protection in the U.S. Gallini (2002) points out a couple of important court decisions affecting the strength of patent protection and discusses, whether these changes encouraged more innovation, disclosure, and technology transfers. She mentions extension of patentability to genetically engineered bacteria (in 1980), software (1981), or business methods and financial service products (1998). Following the 1998 decision in *State Street Bank and Trust v. Signature Financial Group*, other business methods started to receive patents, such as the Amazon's

one-click Internet ordering process (Gallini, 2002, p. 134). Another landmark Gallini mentions is the establishment of the Court of Appeals of the Federal Circuit in 1982. And finally, the Hatch-Waxman Act of 1984 and the adoption of a 20-year patent term in compliance with the Trade-Related Aspects of Intellectual Property (TRIPs) agreement provided longer patent protection and, consequently, increased the expected return to patenting.

According to Gallini, opposite effect on protection strength could have had the American Inventors Protection Act passed by Congress in 1999, which requires all patent applications to be published 18 months from the filing date. Potentially protection-weakening was also the 2000 Court of Appeals decision in *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co., Ltd.*. Mezzanotti (2017) analyzes the 2006 Supreme Court decision in *eBay v. MercExchange* which ended the practice of granting a permanent injunction[1] automatically after a patent infringement. The intention was to reduce abusive patent lawsuits and Mezzanotti shows that it led to an increase in quality and quantity of patenting. But it would be very complicated to link any of these policy changes to the obtained development of strategic patenting given the delay between patent application and its subsequent grant, which may be several years. Moreover, the relationship between stronger patent protection and more innovation itself has been questioned by a number of authors (see, e.g., Bessen & Meurer, 2008; Lerner, 2009; Mokyr, 2009)."

Chapter 4

1. *I miss a theoretical section in this paper, explaining in detail how the authors regard the "link between investment, bankruptcy, and financial constraints" (p. 41).*

   I have extended the discussion in Section 4.3.1 to explain why we chose to focus on these aspects.

2. *What is the link of this chapter to institutions, entrepreneurship and growth?*

   The link to the common theme of the thesis has been made clearer in the rewritten introductory chapter.

3. *It is not clear to me what the authors think the contribution of their study is. ...*

   Regarding the contribution, I write on p. 91:

   "Our contribution to the existing literature consists mainly of two components: By gathering information on bankruptcies, we are able to show that companies which go bankrupt face different credit constraints than healthy companies. And second, the 2008 crisis was a purely exogenous event for the Czech Republic. This allows us to show how credit constraints and the impact of bankruptcy events changed with the onset of the crisis, i.e. with credit contraction, without facing potential problems of model endogeneity."

   In the meantime, I have revised the paper included in this chapter according to comments of two anonymous referees from the Eastern European Economics journal. As I believe that the changes led to improvement of the paper, I replaced the text of the chapter with the new revised version of the paper. The major difference is that I switched turnover for change in sales as the proxy for Tobin's q in the baseline specification. Turnover is now included as a robustness check. The results changed slightly – there is now no difference in financial constraints of healthy companies for the individual subsamples, but they differ for companies going bankrupt. The results also seem to be much more robust now.

[1] An order forcing firm to stop any operation related to the violated patent.

4. *On presentation: Figure 4.1 should be explained in a note: What do the boxes and bars mean, exactly? And Figure 4.4 is hard to read as Financial constraints and Insufficient demand are hard to separate visually.*

   I explained Figure 4.1 (4.2 in the revised version) in the note and changed the colors in Figure 4.4 (now 4.B1).

5. *Figure 4.2: Since the study seems to be motivated by contrasting the Czech experience with that of others (who supposedly are different), it would be nice to see some comparative data for other countries – and to see some reference to empirical evidence of the claim that low stock market capitalization is generally related to a larger degree of bank-loan financing. Lastly, visual inspection of the figure seems to suggest that there was no (aggregate) credit crunch in Czechia, at least not in the sense that the share of loans as a financing source decreased. Why not comment on this?*

   Stocks cannot be meaningfully compared with flows on the aggregate level. Therefore, I added a new figure (4.1 in the revised version) showing changes in credit flows and changes in investment. It shows that a drop in credit flows to the non-financial sector usually precedes a drop in investment, which was true also for the 2008 crisis, and vice versa.

   Generally, non-financial companies have two sources of financing: internal and external. The usual sources of external financing are: equity, bank loans, trade credit, and corporate bonds. The role of corporate bonds was negligible in Czechia during the observed period, trade credit is not meant for investment financing. Low stock market capitalization shows that the role of equity is low, as well. That leaves bank credit as the most important source of external finance for investment. Other then own money, there is simply no other source of financing to be used. See, for example, Beck *et al.* (2008), for an international comparison of sources of financing.

6. *Figure 4.3: There seems to be an assumption that the evolution of credit followed an optimal path before the financial crisis and that the downturn thereafter was highly problematic. On what are there suppositions based? Can this be ascertained "a priori", before an analysis of consequences for outcome variables?*

   We do not deal with the issue of optimality in the paper. I do not even think that anything like an optimal amount of credit can be defined. The observed decline in lending indicates a possible change in credit supply that could have affected different types of firms differently. Anecdotal evidence in 2009 suggested that some firms were hit particularly hard by credit crunch. This constituted an interesting starting point to find out if the observed drop in lending was supply or demand driven.

7. *Similarly, there seems to be an assumption that the increase in the bankruptcy rate, as shown in Figure 4.6, was suboptimal.*

   As above, we do not analyze optimality. We wanted to show that an increase in bankruptcy rate coincided with the 2008 crisis and, therefore, could have been linked to the drop in available credit. Regarding the bankruptcy rate: E.g. in 2007, 57 out of 84,066 companies go bankrupt, which is 0.07 percent.

8. *I'm confused by the text on p. 43 – more precisely by how the sentence marked in italics (by me) is derived from what is written before it and how it squares with the last sentence of the quote: . . . Is the idea that a firm that goes bankrupt is financially constrained by definition and that if other firms have similar (or more restrained) bank-loan patterns*

they are also financially constrained? But if bankrupt firms are financially constrained by definition, why carry out the empirical analysis; and how, after it has been carried out, can one retain the classification of their being financially constrained when they seemed to have large bank loans?

I tried to explain it better in the rewritten results section. Following the literature on financial constraints identification from financial data, financial constraints are identified by the investment–cash flow sensitivity. Moreover, the revised results show that companies which go bankrupt are in fact often not financially constrained.

9. *It is not clear to me if the authors, on p. 49, reject or support the notion that investment-cash flow sensitivity is a useful indicator of financial constraints or not. They write as if they do; but then the quote from Kaplan and Zingales, which the authors claim to support, introduces doubt if they in fact do. Their position should be made clear and it should be motivated against the background of the arguments in the literature (not least the critical ones by Kaplan and Zingales (1997, 2000) and by Chen and Chen (2012).*

   We support the notion that investment–cash flow sensitivity is a useful indicator. Based on the discussion in the literature, we argue that there is no clear consensus if the strength of the sensitivity indicates also the strength of financial constraints. Therefore, we do not base our interpretation of the results on the size of the estimated coefficient.

   I have rewritten the part dealing with the Kaplan/Zingales critique on p. 97:

   "Regarding the investment–cash flow sensitivity, Kaplan & Zingales (1997) are skeptical about its ability to capture financial constraints, while Fazzari *et al.* (2000) counter-argue that these sensitivities matter. Agca & Mozumdar (2008) empirically showed a significant decline in investment–cash flow sensitivity over time, corresponding with reduction in capital market imperfections. But Chen & Chen (2011) document that the investment–cash flow sensitivity completely disappeared in recent years for U.S. manufacturing firms, even during the 2007–2009 credit crunch. They argue that if we believe that financial constraints have not disappeared, investment–cash flow sensitivity cannot be a good measure.

   As the dispute over the usability of investment–cash flow sensitivity as a measure of financial constraints still seems to be far from settled, we take the conservative approach of Kaplan & Zingales (1997) and refrain from interpreting the magnitude of the sensitivity as an indicator of the degree of financial constraints. Therefore, we only focus on whether the impact of cash flow on investment is statistically significant and positive."

10. *The authors use average Q, but there are studies using marginal Q, which might be considered "more correct" as a basis for economic decisions. Would this be possible with Czech data?*

    Generally, average Q is used as a proxy for marginal Q, which is theoretically more correct, but empirically unavailable (even though it can be obviously estimated, as the paper you refer to shows). In the Czech case, we do not even have data for average Q, nor to estimate marginal Q (market valuations of firms are available only for a very limited sample of publicly traded companies) and have to use a kind of sales accelerator model to proxy for average Q by using change in sales (or turnover as a robustness check). It is a usual approach in the literature.

    I added references to both papers to footnote on p. 99:

    "The ratio of the market value of existing capital to its replacement cost. Usually, we can only observe average Q (even this can be difficult, especially for non-listed companies).

Marginal Q, on the other hand, is the ratio of the market value of an additional unit of capital to its replacement cost. It is possible to estimate marginal Q (Gugler *et al.*, 2004), but most empirical work use average Q as the proxy for marginal Q. Berglund (2011) points out that the proposed methods of estimating marginal Q are likely to produce biased estimates."

11. *Mizen and Vermeulen (2005) remark, at the end of section 2.1: "We think that one of the more important reasons to be cautious in interpreting cash flow sensitivity as indicating financing constraints is that cash flow might forecast future profitability or sales growth." What is the authors' take on this?*

    I tried to run a regression explaining sales growth with lagged cash flow and when clustering the variance on the firm level, which should be the correct approach to calculating standard errors for my data, there is no statistically significant effect. D'Espallier & Guariglia (2015), analyzing Belgian small- and medium-sized enterprises, find that investment–cash flow sensitivities do not simply reflect investment opportunities, but signal the existence of financial constraints. They conclude that the investment opportunities bias may have been overstated in previous literature.

12. *On p. 57, in the second row in section 4.6, do you not mean "dependent variable"?*

    Yes, thank you. The formulation was not very clear. What we wanted to say is:

    "Our lagged dependent variable, the investment rate, is not strictly exogenous, meaning it is correlated with past and possibly current realizations of the error."

13. *Is the conclusion at the bottom row of p. 57 not surprisingly strong? Do the results really imply that financial constraints exist and are binding, especially in light of the earlier critique of this interpretation? What are possible other interpretations? And it they exist, do I understand the authors correctly, on p. 58, that their view is that there is no way of telling whether the financial constraints are big or small? Is the estimate then "nonsense"? If so, (a) how can it be concluded, on p. 61, "that financial constraints became more widespread and severe in the post-crisis period"?; and (b) how useful is this exercise then?*

    We base the conclusion on statistical significance of the investment–cash flow sensitivity. That doesn't mean that the estimate is nonsense. But as I also mention above, there is no clear consensus if the strength of the sensitivity indicates also the strength of financial constraints (monotonicity assumption).

    The revised conclusions are reformulated and are not that strong any more. I also added a paragraph relating our results to some survey results (p. 111):

    "Even though present, financial constraints are probably not very severe in the Czech Republic. This would be in line with the quarterly survey in the non-financial corporations' sector published by the Czech National Bank since March 2011. The results covering the first quarter of 2011 show that problems with obtaining external financing restricted investment decisions of less than 2% of respondents. This was far less than the influence of insufficient expected demand (28.2%)."

14. *I worry about the robustness of the statistical significance of the cash flow estimate in Table 4.2. It is only significant at the 10% level, and one wonders how a robustness analysis, e.g., with regard to the model specification, would affect the significance level. Table 4.3 goes some way towards this, but it basically retains the same model (and also displays weak significance for cash flow). Hence, it would be comforting to see more specifications and*

also see if other variables from the literature can be added to ensure there is no omitted variable bias.

The revised results are more robust. I also provide three robustness checks in Section 4.6 (p. 109):

"In order to ensure the robustness of our results, we introduce three different robustness checks. In the first one, we use turnover, instead of change of sales, as an alternative proxy for the Tobin's *q*. ... The second robustness check addresses the issue of estimation stability. System GMM estimator is known to be rather sensitive to the choice of the instruments' lag structure. In Tables 4.B1 and 4.B2 we present results obtained by using only lags 2–3 to instrument for the endogenous variables. ... In the third robustness check we drop the system GMM estimator altogether and estimate our baseline Equation 4.2 using three different approaches (see Table 4.B5). First, we use the fixed effects estimator with individual firms as the panel variable. Second, we copy our system GMM approach and run an OLS estimator with sector fixed effects with variance clustered on the firm level. Both specifications also include year fixed effects. And third, we estimate the model using OLS without any fixed effects, only with variance clustered on the firm level to allow for within-cluster correlation."

15. *With regard to the conclusions, are there any clear policy recommendations from this study (and if so, do they differ from previously commonly proposed policy recommendations with regard to credit in connection with financial crises etc)? This seems especially important to formulate, since the contribution is primarily about Czech empirics.*

Policy recommendations are difficult due to the indirect identification of financial constraints through the investment–cash flow sensitivity.

But I added a paragraph discussing the usability of the results as part of the conclusions on p. 111:

"Due to the nature of available data, our identification of financially constrained companies is only indirect. But if combined, for example, with survey data or data on firms' credit, it would be possible to identify a more direct link between credit and investment. Such research would then have potential policy implications. Good identification of financially constrained companies and sectors can help, for instance, in times of economic crisis to support the argument for well-targeted policy intervention (loan provision, guarantees) on the credit market. Our current results indicate that there was no need for such policies in the aftermath of the 2008 crisis in the Czech Republic. One reason is probably the fact that Czech banks hold excess liquidity and stayed profitable even after 2008. Therefore, they didn't have to substantially alter their lending behavior.

The finding that companies which are going to declare bankruptcy in the future were not financially constrained before the 2008 crisis, that is during the boom period, should be a warning not only for banks, but also for the regulator. Such procyclical behavior is actually the reason why central banks recently started to pursue financial stability as another important goal of monetary and newly emerging macroprudential policy (see, e.g., Frait *et al.*, 2015). As the risks seem to be negligible when nearing the peak of the boom, microprudential approach is generally not able to correctly asses riskiness of individual loans. Policies forcing the banks to create sufficient buffers during the good times may be able to limit the procyclical behavior and also mitigate the potential problems during the bust period. Information regarding the existence of financial constraints of companies nearing bankruptcy can be used as one of the inputs for evaluating how successful central banks are in their effort."

Response to Comments from Christian Bjørnskov

Chapter 1

The introductory chapter has been rewritten to be more in line with the comments of all three referees. Also, I have changed the name of the dissertation to better suit its content.

The new introductory chapter now provides an overview of the topic of institutional quality and its impact on real economy through entrepreneurship: First, I explain how it is possible that we observe quality of institutions change over time and differ across countries. Then I introduce some important papers dealing with the impact of institutional quality on economic growth, and mention also the role of informal institutions and their potential interplay with formal institutions. After that I turn my attention to the core mechanism behind the impact of institutions on real economy – the entrepreneur – and explain the hypothesis of Chapter 2 in this context. I also provide an overview of recent literature dealing with the impact of institutional quality on international trade and price differences.

Turning my attention to the topic of productive vs. unproductive entrepreneurship, I explain why strategic patenting, the topic of Chapter 3, is an example of unproductive entrepreneurial activity. And not only that – it is also a good example of an unintended consequence of a government policy with completely different official goal (boosting innovation). In this sense I explain that the 2008 financial crisis led to a considerable broadening of the spectrum of monetary and macroprudential policy tools available to central banks, which already started to use them even with very limited empirical evidence of their potential side-effects. One example of such side-effect may be the impact of these policies on financially constrained firms – the topic of Chapter 4. At the end of the introductory chapter I provide my view of how the field may move forward and what should, in my opinion, receive more attention.

Chapter 3

1. *Connection to the overall theme of the thesis.*

   Patents are important institutions which, as I argue, can give rise to both productive and unproductive activities. In the chapter I study the development of unproductive use of patents over time and differences across industries. I have rewritten the introduction of this chapter and also explain the link to the overall theme of the thesis in the introductory chapter.

2. *There is no explicit, concise research question.*

   Up to now, the topic of strategic patenting has been either analyzed in a case study settings (mostly in law journals) with the emphasis on litigation, or theoretically. I am not aware of articles trying to empirically address the development of this phenomenon over time or across industries. To do so, we also propose two complementary methods to study strategic patenting in the panel settings.

   The motivation, contribution, and research question is hopefully explained better in the rewritten intro section of this chapter.

3. *Association between the number of citations and the number of patents.*

   I added a plot and informed about a test on p. 56:

   "Figure 3.A6 doesn't show any relationship between the number of patents a company produced over the observed period and the average number of citations per year, nor is there any statistically significant linear relationship."

4. *Almost-not-cited software patents.*

   Actually, the proportion of almost-not-cited software patents in the period 1995-1999 was lower than in other industries. Their proportion jumped up for patents applied for after 1999, but not only for software patents, but across all industries. It may be possible that hardware and semiconductor companies were also influenced by the IT bubble, but why would it be the case for aerospace industry? I believe that the observed increase in almost-not-cited patents at the end of the 1990s is some general trend which I, unfortunately, cannot explain. I didn't find any other study that would address it.

5. *Patents as a rent-seeking tool.*

   As I also explain above to Niclas: In my opinion, rent-seeking describes unproductive use of resources with the goal of extracting rent. But not only through politics – another frequently used channel is litigation. And strategic patents are acquired as a tool for extracting rent through litigation. The term rent-seeking is widely used in this context in the literature. E.g. Lemley & Shapiro (2005, p. 88) write: "Furthermore, the prospect of the prize of $600 in royalties to the patent holder will encourage rent-seeking behavior by patent applicants." See, also, Merges (2009) for a discussion of patent-based rent-seeking. This is one of the reasons I mention litigation statistics as one of the sources of my hypotheses.

   I explain it better in the rewritten introduction.

6. *Identifying assumption for DEA.*

   I have rewritten the part explaining identifying assumption for DEA on p. 63:

   "Comparing estimates of relative efficiency among companies or industries over time would enable us to address the issue of strategic patenting from a different perspective. In order to interpret the obtained efficiency estimates as measures of strategic patenting, we assume that the companies in our sample are able to undertake R&D with comparable efficiency. That doesn't necessarily mean that they are equally innovative. But it means that they all have access to the best available technologies, researchers, engineers, knowledge, or know-how.

   We are convinced that our sample of high-tech companies meets such an assumption: almost all of them have their headquarters or research departments in the Silicon Valley area, almost all of them rank on the Forbes' World's biggest public companies list, they are often named among the best companies to work for in the U.S., etc. Therefore, if such a company produces less socially valuable patents with the same inputs, it does so as a conscious choice of the management and not because it is forced to."

   And in the related footnote:

   "In the sense as, for example, a Chinese company may face limitations regarding the supply of best-skilled labor."

Chapter 4

In the meantime, I have revised the paper included in this chapter according to comments of two anonymous referees from the Eastern European Economics journal. As I believe that the changes led to improvement of the paper, I replaced the text of the chapter with the new revised version of the paper. The major difference is that I switched turnover for change in sales as the proxy for Tobin's q in the baseline specification. Turnover is now included as a robustness check. The results changed slightly – there is now no difference in financial constraints of healthy

companies for the individual subsamples, but they differ for companies going bankrupt. The results also seem to be much more robust now.

1. *I would have preferred a theoretical section in order to develop clear, testable implications for the following section.*

   I have extended the discussion in Section 4.3.1 to explain why we chose to focus on these aspects.

2. *Are financial constraints a cause of bankruptcy, or are the higher financial constraints merely reflecting other underlying problems such that the estimates suffer from simultaneity bias?*

   Our goal was not to find out if financial constraints cause bankruptcy; we wanted to know whether companies, which in the end go bankrupt, had to face higher financial constraints. In the estimation we link investment rate with bankruptcy. And as we describe on p. 100, future bankruptcy should be able to capture unobserved variables that can be related to bankruptcy and determine investment rates, thereby limiting a potential omitted variable bias. We also discuss the issue of potential reverse causality:

   "To reduce potential omitted variable bias and to get more information on the relation between investment, bankruptcy, and cash flow, we also include information on future firm bankruptcy as an explanatory variable. While there may be a potential problem with reverse causality (e.g. lower investment leading to bankruptcy), including information on future firm bankruptcy can have the power to capture unobserved variables that can be related to bankruptcy and determine investment rates.

   At the same time, we believe that the reverse causality problem can arise for a dummy capturing whether a firm goes bankrupt sometime during our observed period, but not for a dummy capturing whether the firm goes bankrupt in the next period. The reason is that the insolvency proceedings in the Czech Republic take on average more than 600 days. Due to the length of the bankruptcy process, it is, therefore, highly unlikely that this year's investment rate would affect next year's bankruptcy. Moreover, we show that the investment rate does not significantly differ among healthy companies, companies going bankrupt in the future, and companies going bankrupt during the following year (see Table 4.1). Also, including one of the bankruptcy dummies in the regression doesn't influence the stability of other coefficients."

3. *The question of GMM estimates stability.*

   I added a couple of robustness checks (different proxy for Tobin's q, a simpler lag structure, fixed effects, OLS), see discussion on pp. 109–110. Our results seem to be very robust and stable. I also improved the description of the estimator we use (p. 105):

   "All specifications are estimated by a two-step system GMM estimator with collapsed instruments and robust standard errors corrected using the Windmeijer correction. Assuming that lagged investment rate and lagged squared investment rate are endogenous, we instrument for them using their $t-2$ to $t-5$ lags. The results of Arellano-Bond test for second-order correlation, and Sargan and Hansen tests reported in Tables 4.2 and 4.3 signal that the models are specified correctly. Even though in most specifications the autoregressive term turns insignificant, both lagged investment rate coefficients are significant in some specifications when estimated using a fixed-effects model. Ignoring the autoregressive nature of investment rate would therefore lead to biased results."

4. *Interpretation of interaction terms.*

   Thank you for pointing out the problematic interpretation of interaction terms. I calculated marginal effects of cash flow on investment rate to make sure I interpret the results correctly. Please see the rewritten Results section.

Response to Comments from Vladimír Benáček

Chapter 1

The introductory chapter has been rewritten to be more in line with the comments of all three referees. Also, I have changed the name of the dissertation to better suit its content.

The new introductory chapter now provides an overview of the topic of institutional quality and its impact on real economy through entrepreneurship: First, I explain how it is possible that we observe quality of institutions change over time and differ across countries. Then I introduce some important papers dealing with the impact of institutional quality on economic growth, and mention also the role of informal institutions and their potential interplay with formal institutions. After that I turn my attention to the core mechanism behind the impact of institutions on real economy – the entrepreneur – and explain the hypothesis of Chapter 2 in this context. I also provide an overview of recent literature dealing with the impact of institutional quality on international trade and price differences.

Turning my attention to the topic of productive vs. unproductive entrepreneurship, I explain why strategic patenting, the topic of Chapter 3, is an example of unproductive entrepreneurial activity. And not only that – it is also a good example of an unintended consequence of a government policy with completely different official goal (boosting innovation). In this sense I explain that the 2008 financial crisis led to a considerable broadening of the spectrum of monetary and macroprudential policy tools available to central banks, which already started to use them even with very limited empirical evidence of their potential side-effects. One example of such side-effect may be the impact of these policies on financially constrained firms – the topic of Chapter 4. At the end of the introductory chapter I provide my view of how the field may move forward and what should, in my opinion, receive more attention.

Chapter 2

1. *The weak point of this study is that we do not have pure tradables (that were included in the analysis) and non-tradables (that were excluded). There is a continuum of goods between both extremes that are the amalgams of various degrees in-between. This transitory nature of products could be more explicitly treated in the paper.*

   Due to the nature of the used approach, where I explain price dispersion measure and not the prices of individual items, it would be impossible to take into account their degree of tradability. But Crucini *et al.* (2005), looking at the degree of tradability of individual goods and their inputs, find that with decreasing tradability price dispersion among cross-border cities increases. Therefore, I believe that all I would get, if I could incorporate such information into my analysis, would be increasing price dispersion, and therefore increasing border effect, as tradability decreases.

   In order to check whether regulatory quality influences price dispersion of various types of goods with arguably various degree of tradability differently, I added a row with marginal effect of regulatory quality on price dispersion for cross-border observations to Table 2.A6. The results suggest that the effect of institutional quality on price dispersion of non-traded

items is not different from tradables. Comparing the marginal effect's 95% confidence interval of the all items category (the average) with the other categories of goods, non-tradables, personal items and alcohol do not have a significantly different marginal effect of regulatory quality on price dispersion. The effect of institutions on price dispersion by perishable and non-perishable food, clothing, and household items is significantly lower, and by recreation items higher. Also, lower Adjusted R^2 compared to the effect for all items in Column (9) shows that other factors play a larger role in the case of non-tradables.

2. *There is another snag that would deserve attention in the ch. 2: that of the product heterogeneity. We could argue that there is no such homogenous thing like e.g. "white bread 1 kg". The quality of breads can differ widely – and so do their prices. ... Indeed, the differences in quality as an omitted variable could strike a bias to the estimations. These are also a sort of an institutional barrier to arbitrage.*

   The data should be of comparable quality by definition of the data source. Some items, were homogeneity was highly questionable (such as cars), were excluded from the analysis. As I also explain on p. 12, the reliability of the data were tested by comparing their characteristics with the official CPI indices.

   I added a more thorough discussion of this problem on p. 20:

   "Filer & Hanousek (2000) point out that transition economies, which form a part of the data set, report more upward-biased inflation compared to developed countries. Among the sources of the bias is imperfectly estimated impact of quality improvements, new goods, or substitution in favor of lower-priced goods and outlets. The use of individual retail prices of comparable items, instead of a price index or inflation rate, should help, at least partly, to avoid such bias."

   And in the related footnote:

   "Section 2.7 provides a robustness check with city×year interaction dummies which should capture all city-related fixed effects, including a different level of goods quality or prices, and their development over time."

   The new robustness check is described on p. 33:

   "To make sure the results are not driven by upward-biased prices in transition countries (Filer & Hanousek, 2000), Column 2 in Table 2.A7 shows the result of estimating Equation 2.5 with city, year, and city×year interaction dummies. These should capture all city-related fixed effects, including a different level of goods quality or prices, and their development over time. The effect of regulatory quality on price dispersion is even stronger in this specification, even though the additional effect of being from two different countries loses significance. If goods in one city share a similar level of quality, such finding confirms the expectation that potential quality differences do not qualitatively change the results of the analysis."

3. *Could the author explain the real meaning how the US-CND border could have a similar effect on the deviation in prices (e.g. between Vancouver and Seattle) as 75000 miles of distance (i.e. 3-fold of the circumference of the Earth) if there would be no borders on the Earth?*

   Engel & Rogers (1996, p. 1120) explain that their "coefficient on the border in the regression is 11.9×10^{-3}, and on the log of distance it is 10.6×10^{-4}. Thus, crossing the border adds 11.9×10^{-3} to the average standard deviation of prices between pairs of cities. In order to generate that much volatility by distance, the cities would have to

be 75,000 miles apart", because the distance equivalent of such volatility is calculated as $exp[(11.9 \times 10^{-3})/(10.6 \times 10^{-4})]$.

I add a footnote on p. 16 explaining the source of this counterintuitive result:

"Engel & Rogers (1996) was the first paper estimating the importance of national borders on price deviations between two cities. The only explanatory variables they use are distance, existence of border, and city fixed effects. Therefore, their border variable captures all the various aspects that the other studies specify explicitly, such as institutional, cultural, or language barriers, tariffs, tradability of goods and their inputs, etc. What the result indicates is that these non-physical aspects are of much higher importance for cross-border trade than mere geographical distance."

4. *Specification of the model for estimation: the exchange rate system and the degree of (monetary) inflation are two institutions that would deserve consideration. On top of it they are interconnected but not to the same degree for all tradables – there are different coefficients of pass-thru. How could this be included into the model? ERDI (exchange rate deviation index) is a measure how price levels of two countries differ from the law of one price (or the purchasing power parity). How could the model in 2.5 absorb the price differences due to changing ERDIs?*

   As I describe on p. 16, nominal exchange rate volatility has been found to be strongly linked to short-run deviations from the purchasing power parity (Engel & Rogers, 2001). It is, therefore, true that exchange rate ought to have some influence. On the other hand, Cavallo *et al.* (2014) find that prices of the same goods exhibit large deviations from the law of one price, even when there is no nominal exchange rate volatility – when the exchange rates are pegged. They argue that only currency unions decrease price deviations. But Engel & Rogers (2004) or Wolszczak-Derlacz (2010) do not find that the euro introduction had significantly lowered price dispersion.

   ERDI, if I understand it correctly, would be an alternative way of defining my dependent variable – the price dispersion – only on a macro level. Including it into the model would mean including a (more or less perfect) explanation of the price dispersion which would leave almost nothing to analyze. It is true that not all products exhibit the same price dispersion and therefore face the same border effect, as I show in Figures 2.5 and 2.6, as well as in Table 2.A6.

5. *Since SD a MSE are two crucial but alternative dependent variables, I would welcome some test of the degree of their interdependency (e.g. by a regression). & It would be helpful if the Table 2.A4 contained the scale of data for institutional variables and a comment, which value shows the "no regulation".*

   I added scale information for institutional variables to Table 2.A4. They always range from -2.5 to 2.5, with higher values corresponding to better governance outcomes. There is no value for "no regulation", as the measure captures the quality of regulation. It is not simply an economic freedom type of index.

   The correlation coefficient for SD and MSE is 0.8. Regressing MSE on SD (without a constant) reveals that one measure can explain 84.7% of variation of the other measure. On pp. 26–27 I explain that their difference is mostly caused by price-level convergence of post-socialist economies.

6. *Distance between cities in km is not only a proxy for transportation transaction costs but also a proxy for a cultural and institutional distance. How the author solved the potential co-integration between distance and institutional variables?*

It is true that geographical distance is correlated with "institutional distance". The correlation coefficient between the sum of regulatory quality of two cities and their geographical distance is -0.47, and between the difference in regulatory quality and the distance 0.53. But even when including all three among explanatory variables, calculating their variance inflation factors (VIFs) reveals that we can reject that we suffer from multicollinearity: VIFs do not exceed 2.5, which is usually perceived as a very safe value.

7. *I only had a question why both "year" and "year squared" were used in col. (3) in parallel, instead of using the dummies.*

   Some papers reported a time trend in price dispersion. In order to test if the time trend is still statistically significant even after explaining part of the dispersion with institutional quality, I replaced in one specification year dummies with a time variable. The coefficients show that a common time trend is still significant and forms a parabola opened down with a peak in 2004.

8. *I would welcome if the author explained more why the fixed effects were selected for the estimation and how the random effects (or any alternative estimators) were rejected.*

   In almost all specifications I use year fixed effects in order to filter out the common time trend potentially influencing price dispersion in all city pairs in the sample. In columns (9) and (10) of Table 2.2 I present results of specification with city fixed effects included which should capture all city-related heterogeneity in the sample which could, in theory, bias the results. But the regulatory quality coefficient stays robust to this specification change. The choice of year/city fixed effects was, therefore, made for practical, and not statistical reasons.

9. *Nevertheless, the robustness checks (Table 2A6) bring some discrepancies where the previous negative signs of the "regulatory quality" variable turn suddenly positive in the majority of cases. Apparently, individual product categories behave differently and the data set reveals some heterogeneity in responses.*

   Results of specifications reported in Table 2.A6 include not only the regulatory quality variable, but also an interaction term between regulatory quality and border. Let's say that we are interested in the perishable food category (column 1): For city pairs which have a national border between them, the effect of regulatory quality on price dispersion is the sum of 0.022 (regulatory quality coefficient) and -0.068 (the interaction term coefficient). That is, the overall impact of institutional quality on price dispersion for cross-border cities is still negative: -0.046. To make interpretation of the results easier, I added a row with marginal effect of regulatory quality on price dispersion for cross-border observations to Table 2.A6. The effect of regulatory quality on price dispersion is still negative and statistically significant for all cross-border observations.

   The effect of institutional quality for city pairs which lie within one country is much less clear and is not that stable: Better institutional quality is correlated with more price dispersion between two cities within one country for some product categories, with less price dispersion for clothing, and not correlated at all in the case of recreation and non-traded goods. I do not have a convincing explanation of this result.

Chapter 3

1. *In the very beginning of the paper I had difficulties with some phrases of the patent business:*

I have rewritten the introduction of this chapter and tried to explain all the important terms.

2. *Another problem of mine concerned the specific interpretation of the basic working term of the thesis: the social value of a patent. My interpretation based on the opportunity costs of a patent and the patent externalities as a public good, did not fit to the interpretation offered by the author. Thus I could not develop an intuitive understanding e.g. how the patent forward citations could become a workable proxy for social values or how the patent maintenance fee could act as a reliable indicator of patent private value. Why the patent trading data was not used for assessing its social value instead?*

   Reliable patent trading data are, unfortunately, unavailable and therefore couldn't be used in this context. In one of the previous version of the paper we tried to use available information on patent trades, but the quality of the data was too low to be useful. Social value of a patent is a similar concept to value of academic work – the more useful articles or books get cited more often. Another parallel can be found with private and social costs of an externality. Social value of a patent is the potential benefit for the society (because it protects a useful innovation), whereas private value is the potential benefit for the patent holder (and doesn't have to protect a valuable innovation, but can be used to threaten a competitor or extract rent through licensing fees and royalties).

Chapter 4

In the meantime, I have revised the paper included in this chapter according to comments of two anonymous referees from the Eastern European Economics journal. As I believe that the changes led to improvement of the paper, I replaced the text of the chapter with the new revised version of the paper. The major difference is that I switched turnover for change in sales as the proxy for Tobin's q in the baseline specification. Turnover is now included as a robustness check. The results changed slightly – there is now no difference in financial constraints of healthy companies for the individual subsamples, but they differ for companies going bankrupt. The results also seem to be much more robust now.

1. *As an effect, a significant number of enterprises had to be excluded (see also p. 54). However, could it not lead to a selection bias, once highly problematic firms (and thus relevant to the bankruptcy estimation) were set aside?*

   We did not necessarily exclude whole companies from the sample, only individual yearly observations which were due to some reason problematic. It is true that these were probably of the smaller companies which are more prone to produce accounting/reporting errors.

   I checked the data and include information regarding the dropped observations in footnote on p. 102:

   "Observations of companies that will go bankrupt at some point in the future constitute 1.93% of our final dataset after data management (including observations older than 2006 which are used as instruments). Companies that will go bankrupt the following year constitute 0.14%. Due to above described data management we drop 44,030 observations older or equal than 2011. Observations of companies going bankrupt at some point constitute 5.81%, and companies going bankrupt the following year constitute 0.4%. This means we lose slightly above-proportional amount of observations related to companies going bankrupt, probably due to higher error rate in their financial statements data. But

the unreliability of the data which have been dropped make it impossible to seriously estimate the scope and the direction of the potential selection bias."

2. *The author distinguishes between three financial constraints: access to loans, access to stock market flotation and access to own cash flow balances. I would welcome if at least in the presented surveys pointing to constraints to entrepreneurship there was given more attention to the institutional constraints, e.g. to "bureaucracy and regulation".*

   The rewritten introductory chapter provides a thorough discussion of the impact of institutions on entrepreneurship and firms.

3. *The switchover from investment rate equation 4.1 to 4.2 could be explained in more detail (e.g. in a footnote or in an appendix). The reason (and economic meaning) for the quadratic term in the second parameter could be thus clarified.*

   The reason for including the squared investment rate is that we expect a non-linear effect of past investment on current investment.

   I have slightly rewritten the part explain the model on p. 99:

   "However, as noted above, we focus on a post-transition country where large information asymmetry is still assumed. Also, Tobin's q would be available only for a very limited sample of publicly listed companies. Therefore, our baseline equation follows a large body of literature (Behr *et al.*, 2013; Carbó-Valverde *et al.*, 2009; Hobdari *et al.*, 2009; Cinquegrana *et al.*, 2012) and makes use of the available balance-sheet data, especially sales growth, to instrument for Tobin's q. Such a specification resembles the traditional sales accelerator model linking investment to the development in a firm's output or sales (see, e.g., Fazzari *et al.*, 1988):"

   And in the related footnote:

   "We add lagged investment rate and squared investment rate to control for its autoregressive nature – past investments influence today's investments. The squared term is there to capture potential non-linear relationship. We also use turnover instead of sales growth in one of the robustness checks."

4. *The last subparagraph of section 4.4 on p. 52 mentioning the inclusion of the information on future firm bankruptcy could be more specific and avoid thus the reader's uncertainty what was actually meant by that. Also the problem of potential endogeneity in the empirical testing could be more discussed.*

   I tried to explain it better on p. 100:

   "To reduce potential omitted variable bias and to get more information on the relation between investment, bankruptcy, and cash flow, we also include information on future firm bankruptcy as an explanatory variable. While there may be a potential problem with reverse causality (e.g. lower investment leading to bankruptcy), including information on future firm bankruptcy can have the power to capture unobserved variables that can be related to bankruptcy and determine investment rates.

   At the same time, we believe that the reverse causality problem can arise for a dummy capturing whether a firm goes bankrupt sometime during our observed period, but not for a dummy capturing whether the firm goes bankrupt in the next period. The reason is that the insolvency proceedings in the Czech Republic take on average more than 600 days. Due to the length of the bankruptcy process, it is, therefore, highly unlikely that this year's investment rate would affect next year's bankruptcy. Moreover, we show that

the investment rate does not significantly differ among healthy companies, companies going bankrupt in the future, and companies going bankrupt during the following year (see Table 4.1). Also, including one of the bankruptcy dummies in the regression doesn't influence the stability of other coefficients."

5. *Instrumental variables (AB/BB) technique is selected for the estimation of all enterprises (see Table 4.2). However, the next tests are done by FE regressions working with various decompositions of data. Unfortunately fixed effect estimators are often stricken by a bias due to endogeneity. The differences in results in Table 4.3 would then deserve more careful treatment. Are the results in tables 4.2 and 4.3 compatible?*

   All specification use the same estimation method. See on p. 105:

   "All specifications are estimated by a two-step system GMM estimator with collapsed instruments and robust standard errors corrected using the Windmeijer correction. Assuming that lagged investment rate and lagged squared investment rate are endogenous, we instrument for them using their $t-2$ to $t-5$ lags. The results of Arellano-Bond test for second-order correlation, and Sargan and Hansen tests reported in Tables 4.2 and 4.3 signal that the models are specified correctly. Even though in most specifications the autoregressive term turns insignificant, both lagged investment rate coefficients are significant in some specifications when estimated using a fixed-effects model. Ignoring the autoregressive nature of investment rate would therefore lead to biased results."

6. *I would definitely welcome if the author discussed in more detail on the results of Table 4.3 in individual columns, particularly the columns 1 and 2, whose estimated coefficients do not offer a strong statistical significance of the regression and of the whole model as such. Does it mean that your model was not correctly specified for the times of boom?*

   If we wanted to explain investment, we could say that the model was not correctly specified. But our intent was to check if there is investment–cash flow sensitivity present. I have rewritten most of the results interpretation section. Everything is hopefully much more clear now.

References

Agca, S. & A. Mozumdar (2008): "The Impact of Capital Market Imperfections on Investment-Cash Flow Sensitivity." *Journal of Banking & Finance* **32(2)**: pp. 207–216.

Allington, N. F. B., P. A. Kattuman, & F. A. Waldmann (2005): "One Market, One Money, One Price?" *International Journal of Central Banking* **1(3)**: pp. 73–115.

Beck, T., A. Demirguckunt, & V. Maksimovic (2008): "Financing patterns around the world: Are small firms different?" *Journal of Financial Economics* **89(3)**: pp. 467–487.

Behr, P., L. Norden, & F. Noth (2013): "Financial constraints of private firms and bank lending behavior." *Journal of Banking & Finance* **37(9)**: pp. 3472–3485.

Bergin, P. R. & R. Glick (2007): "Global price dispersion: Are prices converging or diverging?" *Journal of International Money and Finance* **26(5)**: pp. 703–729.

Berglund, T. (2011): "The elusive marginal q." *Applied Financial Economics* **21(20)**: pp. 1489–1493.

Bessen, J. & M. J. Meurer (2008): "Do Patents Perform like Property?" *Academy of Management Perspectives* **22(3)**: pp. 8–20.

Carbó-Valverde, S., F. Rodríguez-Fernández, & G. F. Udell (2009): "Bank Market Power and SME Financing Constraints." *Review of Finance* **13(2)**: pp. 309–340.

Cavallo, A., B. Neiman, & R. Rigobon (2014): "Currency Unions, Product Introductions, and the Real Exchange Rate." *The Quarterly Journal of Economics* **129(2)**: pp. 529–595.

Chen, H. & S. Chen (2011): "Investment-Cash Flow Sensitivity Cannot Be a Good Measure of Financial Constraints: Evidence from the Time Series." *Journal of Financial Economics* **103(2)**: pp. 393–410.

Cinquegrana, G., C. Donati, & D. Sarno (2012): "Financial constraints and relationship lending in the growth of Italian SMEs." *MPRA Paper 39825*, University Library of Munich, Germany.

Crucini, M. J., C. I. Telmer, & M. Zachariadis (2005): "Understanding European Real Exchange Rates." *American Economic Review* **95(3)**: pp. 724–738.

D'Espallier, B. & A. Guariglia (2015): "Does the investment opportunities bias affect the investment–cash flow sensitivities of unlisted SMEs?" *The European Journal of Finance* **21(1)**: pp. 1–25.

Engel, C. & J. H. Rogers (1996): "How Wide Is the Border?" *American Economic Review* **86(5)**: pp. 1112–1125.

Engel, C. & J. H. Rogers (2001): "Deviations from purchasing power parity: causes and welfare costs." *Journal of International Economics* **55(1)**: pp. 29–57.

Engel, C. & J. H. Rogers (2004): "European product market integration after the euro." *Economic Policy* **19(39)**: pp. 347–384.

Fazzari, S. M., R. G. Hubbard, & B. C. Petersen (1988): "Financing Constraints and Corporate Investment." *Brookings Papers on Economic Activity* **19(1)**: pp. 141–206.

Fazzari, S. M., R. G. Hubbard, & B. C. Petersen (2000): "Financing Constraints and Corporate Investment: Response to Kaplan and Zingales." *NBER Working Papers 5462*, National Bureau of Economic Research, Inc.

Filer, R. K. & J. Hanousek (2000): "Output Changes and Inflationary Bias in Transition." *Economic Systems* **24(3)**: pp. 285–294.

Frait, J., S. Malovaná, & V. Tomšík (2015): "The interaction of monetary and macroprudential policies in the pursuit of the central bank's primary objectives." In Czech National Bank (editor), "Financial Stability Report 2014/2015," pp. 110–120.

Gallini, N. T. (2002): "The Economics of Patents: Lessons from Recent U.S. Patent Reform." *The Journal of Economic Perspectives* **16(2)**: pp. 131–154.

Glick, R. & A. K. Rose (2016): "Currency unions and trade: A post-EMU reassessment." *European Economic Review* **87**: pp. 78–91.

Goldberg, P. K. & F. Verboven (2005): "Market integration and convergence to the Law of One Price: evidence from the European car market." *Journal of International Economics* **65(1)**: pp. 49–73.

Gugler, K., D. C. Mueller, & B. B. Yurtoglu (2004): "Marginal q, Tobin's q, Cash Flow, and Investment." *Southern Economic Journal* **70(3)**: pp. 512–531.

Havránek, T. (2010): "Rose effect and the euro: is the magic gone?" *Review of World Economics* **146(2)**: pp. 241–261.

Hobdari, B., D. C. Jones, & N. Mygind (2009): "Capital investment and determinants of financial constraints in Estonia." *Economic Systems* **33(4)**: pp. 344–359.

Kaplan, S. N. & L. Zingales (1997): "Do Investment-Cash Flow Sensitivities Provide Useful Measures of Financing Constraints." *The Quarterly Journal of Economics* **112(1)**: pp. 169–215.

Kaufmann, D., A. Kraay, & M. Mastruzzi (2010): "The Worldwide Governance Indicators: Methodology and Analytical Issues." *Policy Research Working Paper 5430*, World Bank, Washington, DC.

Kunčič, A. (2014): "Institutional quality dataset." *Journal of Institutional Economics* **10(1)**: pp. 135–161.

Lemley, M. A. & C. Shapiro (2005): "Probabilistic Patents." *The Journal of Economic Perspectives* **19(2)**: pp. 75–98.

Lerner, J. (2009): "The Empirical Impact of Intellectual Property Rights on Innovation: Puzzles and Clues." *American Economic Review* **99(2)**: pp. 343–348.

Merges, R. P. (2009): "The Trouble with Trolls: Innovation, Rent-Seeking, and Patent Law Reform." *Berkeley Technology Law Journal* **24**: p. 1583.

Mezzanotti, F. (2017): "Roadblock to Innovation: The Role of Patent Litigation in Corporate R&D." *Mimeo*. `http://www.kellogg.northwestern.edu/faculty/mezzanotti/documents/innovation.pdf`. Accessed: 2017-03-15.

Mokyr, J. (2009): "Intellectual Property Rights, the Industrial Revolution, and the Beginnings of Modern Economic Growth." *American Economic Review* **99(2)**: pp. 349–355.

Parsley, D. C. & S.-J. Wei (2007): "A Prism into the PPP Puzzles: The Micro-Foundations of Big Mac Real Exchange Rates." *The Economic Journal* **117(523)**: pp. 1336–1356.

PricewaterhouseCoopers (2016): "2016 Patent Litigation Study: Are we at an inflection points?" `https://www.pwc.com/us/en/forensic-services/publications/assets/2016-pwc-patent-litigation-study.pdf`. Accessed: 2017-03-16.

Rose, A. K. (2000): "One money, one market: the effect of common currencies on trade." *Economic Policy* **15(30)**: pp. 7–46.

Sundqvist, S., K. Kyläheiko, O. Kuivalainen, & J. W. Cadogan (2012): "Kirznerian and Schumpeterian entrepreneurial-oriented behavior in turbulent export markets." *International Marketing Review* **29(2)**: pp. 203–219.

Wolszczak-Derlacz, J. (2008): "Price convergence in the EU—an aggregate and disaggregate approach." *International Economics and Economic Policy* **5(1)**: pp. 25–47.

Wolszczak-Derlacz, J. (2010): "Does One Currency Mean One Price?" *Eastern European Economics* **48(2)**: pp. 87–114.