Three Essays in Applied Econometrics

Moritz Meyer

Thesis submitted for assessment with a view to obtaining the degree of Doctor of Economics of the European University Institute

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European University Institute
Department of Economics

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Abstract

Institutions, circumstances and interactions between agents shape economic outcomes on the individual and aggregate level. In this thesis I explore three different set ups which combine a theoretical model and an empirical framework to better understand how the wider environment influences behavior and outcomes in markets. The following three papers focus on applications in the areas of economic growth, labor markets and health economics.

The global network position of an economy has a profound impact on economic growth. A new measure of economic integration is implemented to characterize economic globalization. Descriptive statistics suggest that this new methodology offers superior possibilities to capture global trends which reflect patterns of interactions between firms and countries. Findings from a modified empirical growth model suggest that a more central global network position fosters economic growth. Robustness checks and alternative estimation strategies address issues of endogeneity and reversed causality in a dynamic panel framework.

Social networks and in particular the interaction between applicants, workers and firms influence labor market outcomes. The behavior of firms, workers and applicants during the recruitment process is modeled in a bayesian signaling model which under certain conditions predicts a higher match quality between an applicant and a firm if employee referrals were used. Here, the theoretical model pays special attention to potential incentive problems due to nepotism and favoritism. Empirical results suggest a higher starting wage and a longer duration of the position as well as a different earnings path for workers who learnt about their job through a social network.

Individual behavior in terms of consumption depends on the health status. The theoretical concept of state dependent utility functions illustrates that changes in circumstances impact individual behavior such that the health status influences the relative composition of the consumption basket over different categories of goods and services. Results from the empirical framework support this concept and show robust findings for changes in consumption in non durable and semi durable goods which can be linked to the individual health status measured in terms of functional problems to activities of daily living.

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Acknowledgments

Outcomes in economics reflect the result of an ongoing process of repeated interactions with multiple players – I believe that this thesis is an excellent example for such a complex process with many ups and downs. I would like to thank my supervisors Jerome Adda, Russell Cooper and Andrea Mattozzi for the time they invested into this project. Furthermore, I very much appreciated and benefited from all the feedback I received from Uta Schoenberg and Andrea Weber who acted as external supervisors in my thesis committee. The repeated interaction including discussions, meetings and presentations heavily influenced the thesis as it is today. Their guidance, patience and motivation were key to finish my doctoral thesis.

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Three Essays in Applied Econometrics

The world of social sciences in general and economics in particular is dominated by powerful theoretical models which describe behavior on the individual, firm and aggregate level. These insights allow for a better understanding of observed outcomes and provide a framework to design policy interventions. At the same time statistics and mathematics introduce additional tools to evaluate substantial amount of information to identify correlations and causalities which characterize the relationships between events.

This thesis explores methods from multiple areas of social sciences and brings three different theoretical frameworks to the data. In this spirit, I hope to contribute to a more profound knowledge base which allows researchers in social sciences to combine theoretical findings with actual observations on individual, firm and aggregate behavior.

The first paper on economic integration and economic growth introduces a novel approach to characterize globalization. Furthermore the empirical framework identifies a link between these two processes which shape our world today. This joint paper with Georg Duernecker and Fernando Vega Redondo first proposes a new way to measure globalization. Using social network theory we define each country's position in a global trade network in terms of all direct and indirect trade links. Second, the theoretical model illustrates how this network position translates into higher economic activity. On a macro level we postulate that a more central network position of an economy has a positive impact on the growth rate of the economy. Third, the empirical model uses advanced methods to establish a causal link between economic integration and economic growth. Here, we use a dynamic panel framework and a limited information maximum likelihood approach to reduce potential problems from omitted variables and reversed causality. A wide set of robustness tests including an instrumental variable approach and a bayesian modeling exercise highlight the validity of findings in our paper. Our results suggest that a more central position in a global trade network offers better opportunities to grow faster.

The second paper on social networks and labor markets provides theoretical and empirical evidence that employee referrals can be used to achieve a higher match quality when hiring a new worker. The theoretical framework exploits a bayesian signaling game to model the behavior of a worker inside the firm to either recommend an applicant to an employer or not. Depending on the incentive structure firms establish preconditions for different equilibria where some of them induce a higher match quality in the hiring process. I pay special attention to further compliance issues where workers face a trade off between contradicting goals which has the potential to change their signals. More specifically, results from the theoretical model show how nepotism and favoritism alter the decision of the worker which implies that the firm is no longer able to achieve a higher match quality through a social network channel. The empirical model uses data on

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individual labor market outcomes. Findings suggest that the starting wage but also the duration of the job and earnings profiles differ between workers who learnt about the position through a social network and those who did not. In summary theoretical and empirical results from this paper illustrate that match quality between applicants and firms is higher for employee referrals.

The third paper on the health status of individuals and their consumption behavior provides an empirical counterpart to the theoretical concept of state dependent utility functions. In contrast to previous papers which depend on survey information and experimental design I use panel data to show how a change in the health status has a profound impact on the consumption behavior of individuals. The empirical model explores variation in the individual health status measured in terms of functional problems to perform activities of daily living to explain the relative composition of the consumption basket with respect to non durable and semi durable goods. Results illustrate that the health status has an impact on consumption behavior which can be separated out from changes in age.

In summary, the following three papers relate to different areas in social sciences. My empirical applications to economic growth, labor markets and health economics illustrate how economic theory and empirical methods can be used to improve our understanding of individual, firm and aggregate behavior. Lastly, these findings allow for policy interventions which have the potential to achieve better economic outcomes and increase social welfare.

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1 | Being Close to Grow Faster

Globalization features one of the major global trends which shapes economic outcomes in developing and developed countries. Standard results from the empirical growth literature suggest that participation in worldwide trade is an important determinant of economic growth. In contrast to previous findings this paper argues that not only the level of openness matters but the degree of integration of an economy into the global trade network is even more important for the growth performance of an economy. The new measure of integration captures the network position of an economy and takes into consideration higher order links between economies in the global trade network. First, the theoretical framework builds on social network theory to characterize alternative measures of economic integration which describe patterns of globalization. Second, this paper uses a unique data set constructed from the UN Comtrade database and exploits a wide set of bilateral import and export flows to characterize the country's participation in worldwide trade. Third, the empirical identification strategy takes into account the dynamic panel structure of the data to disentangle the impact of economic integration on economic growth. Results build on the first difference and system generalized method of moments and the limited information maximum likelihood method which address problems of endogeneity and lagged dependent variables in the dynamic panel framework. The empirical analysis highlights the importance of integration to fully understand the economic growth performance in a between and within country perspective. Controlling for the standard set of independent variables in the empirical growth literature and using different robustness checks findings suggest a significantly positive effect of integration on economic growth. [1]

Keywords: economic globalization, dynamic panel estimation, social network theory

JEL Classification: C330, F430, O400, O430

[1]This paper is joint work with Georg Duernecker (University of Mannheim) and Fernando Vega- Redondo (European University Institute). We are grateful to Jérôme Adda, Russell Cooper, Helmut Luethkepohl, David Levine, Temel Taskin, Guntur Sugiyarto, Bernard Hoekman, Benno Ferrarin and three anonymous referees from the World Bank for advice. We would like to thank participants to the Third Year Forum at the European University Institute (Florence), the ERD research seminar at the Asian Development Bank (Manila) and the presentation at the Centre for the Study of African Economies (Oxford) for useful comments. This paper benefited from in depth discussions during the "Networks for Prosperity Initiative" organized by the United Nations Industrial Development Organization (Vienna). Contact address: Moritz Meyer, European University Institute, Economics Department, Via della Piazzuola 43, 50133 Florence, Italy, E-mail: moritz.meyer@eui.eu. All remaining errors are our own responsibility. A previous version of this paper was circulated under the title "Being close to grow faster: A network based empirical analysis of economic globalization" as EUI working paper ECO 2012/05.

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Executive Summary

Globalization features one of the major global trends which shapes economic outcomes in developing and developed countries. During the past fifty years, political change and economic transformation have enhanced international trade between countries. Furthermore, new transportation and information technologies contributed to an increased exchange of goods and services.

Even though globalization is well documented from a narrative perspective, the measurement of this process remains a key challenge among academic researchers and policy makers. The multitude of different concepts and measures which have been applied so far can be categorized into three separate classes: First, the trade intensity is probably the most prominent one. It measures the amount of aggregate trade volumes of an economy relative to its total production. More specifically, it is expressed as the ratio of the sum of imports and exports to the gross domestic product for a given year. The second class of measures evaluates a country's outward orientation in terms of the level of tariffs and also accounts for possible non-tariff trade barriers as well as political and economic factors which potentially affect a country's foreign exposure. The third class considers a wide range of different economic, political and social characteristics of an economy and factor all of the selected dimensions into a weighted composite index. Essentially, all of the three classes of globalization measures were heavily criticized on various grounds and a number of severe deficiencies were explicitly pointed out which suggests the limited usefulness of the conventional indicators.

This paper proposes a novel approach to quantify a country's outward orientation and makes use of social network theory to evaluate the degree of integration of an economy into the global trade network. The methodology allows for a potential role of second- and higher-order relationships between countries for the connectedness of a given country. As a consequence, the new measure of economic integration accounts for the increasing importance of global value chains which gained in importance especially for countries in Europe, North America, South East Asia and East Asia. The construction of the index of economic integration builds on the well-established concept of centrality. Here, economic integration takes into consideration the relative network position of each country with respect to all other economies in a global trade network. Consequently, the new measure of economic integration does not only relate to direct trading links between countries but also incorporates indirect trading links. Findings from the empirical analysis show that these higher- order links are of key importance. Here, the computations make use of a wide set of bilateral import and export flows from the United Nations Comtrade database and exploit a set of 143 countries over the period from 1962 to 2008 to characterize the country's network position in a global trade network.

Descriptive statistics show that economic openness and economic integration describe two different dimensions of economic globalization. The correlation between these two measures is surprisingly low. For example, using the traditional concept of trade intensity many African economies are characterized as relatively open towards international trade. On the contrary, the measure of economic integration takes into consideration the relative position of each country in the global trade network, such that for example the Central African Republic shows up rather to the bottom of the ranking. China might be another noteworthy example which highlights the drawbacks of traditional measures of globalization. In terms of trade restrictions and the black market premium on the official exchange rate the economy is

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characterized as closed which contradicts a widely shared perception that China is one of the drivers behind economic integration, especially on the Asian continent. The measure of economic integration emphasizes the significant changes the Chinese economy has made over the last years and reflects the participation into international trade which we observe today. Based on this observation, results in this paper suggest that conventional indicators of openness, which are mostly based upon aggregate trade statistics or trade policies, are only a very rudimentary description of a country's outward orientation.

Summary statistics illustrate the validity of the new measure of economic integration on the country level. The time series profiles for different countries do not only reflect changes within a country but also changes in response to broader developments in the global trade network. For example, the profile for Argentina suggests that the degree of economic integration decreased as a consequence from the sovereign default to the beginning of the 2000s. On the contrary, the measure for China illustrates how the end of the Cultural Revolution and the increasing participation into the world economy at the beginning of the 1980s increases the measure of economic integration substantially. Furthermore, the measure of economic integration does not only capture changes which affect the country of interest but also takes into consideration broader trends in the global trade network which affect the country through indirect trade links. For instance, the formation of the North Atlantic Free Trade Area between Mexico, Canada and the United States has increased the degree of economic integration for Mexico in two distinct ways: first, the reduction in transaction costs for bilateral trade has provided better access to economic opportunities in Canada and the United States; second, Mexico has benefited from the very central network position of the United States in the world economy. Accordingly the improved relative network position of Mexico in the global trade network did not only attract foreign investment to exploit market opportunities in the country itself, but also relates to the improved access of Mexico to the United States and further (indirect) market opportunities around the world. This mechanism of direct and indirect effects in a global trade network motivates the link between economic integration and economic growth.

The theoretical framework defines an environment where firms benefit from further integration which enhances cooperation and boosts economic activity. On the firm level a more central network position enhances the flow of information and builds trust between partners. As a consequence cooperation deepens, joint projects evolve and firms benefit from further knowledge and technology transfer. In addition, firms realize higher returns to investment since access to markets and opportunities increase. Thus on the micro level economic integration supports the growth of firms whereas on the macro level it fosters economic growth on the country level.

Standard results from the empirical growth literature suggest that participation in worldwide trade is an important determinant of economic growth. With the aforementioned measure of economic integration at hand, this paper then turns to a long-standing discussion in the empirical literature on economic growth which concerns the effect of a country's outward orientation on economic growth. The existing literature on this matter has produced a vast number of possible explanations to understand economic growth in a cross country and within country perspective. Most of these results have been highly disputed, mainly because of difficulties in measuring globalization and various econometric shortcomings.

The empirical identification strategy takes into account the dynamic panel structure of the data to disentangle the impact of economic integration on economic

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growth. Here, the empirical specification aims at the identification of a causal link between a set of variables and economic activity on the country level. More specifically, empirical findings in this paper illustrate that the new measure of economic integration of a country into the global trade network is particularly important to understand the growth performance of an economy. This note contributes to this literature by introducing a newly developed measure of economic integration into an empirical growth framework and, at the same time, it improves on previous econometric methods. More concretely, findings from the empirical analysis build on a dynamic panel framework and exploit within country variation to establish a causal relationship.

Dynamic panels have been established as an advanced method in the empirical growth literature to foster explanations for the observed disparities in the economic growth performance across and within countries. In comparison to traditional cross sections, dynamic panels allow for country fixed effects to control for unobserved, but country fixed heterogeneity, and allow for lagged variables in the dynamic panel framework. Furthermore, the empirical identification strategy makes use of internal instruments to deal with the issue of endogeneity which plagues most of the regression analysis in the empirical growth literature. Identification comes from within country variation.

Empirical findings suggest that the new measure of economic integration is an important factor for explaining growth differences, and that it displays a statistically significant and robustly positive effect on economic growth. Controlling for the standard set of independent variables in the empirical growth literature and using different robustness checks, findings suggest a significantly positive effect of integration on economic growth. Robustness checks include a bayesian model averaging exercise which underlines the relative importance of the measure of economic integration to explain economic growth. The previous literature has elaborated on a wide set of possible candidates which influence economic growth. Often it is difficult to establish a causal relationship and at the end of the day it is not clear which variables are the most prominent ones to include into an empirical growth model. In these terms results from the bayesian model averaging approach suggest that in contrast to trade intensity, economic integration shows up to be economically and statistically significant independent of the composition of the set of independent variables. The calculated inclusion probability refers to the relative importance of the measure of economic integration of being included into an empirical growth model and supports the validity of the theoretical and empirical relevance of economic integration to explain economic growth on the country level. In summary, the positive relationship between integration and economic growth emphasizes the importance of a country's position in a global trade network.

From a policy perspective these findings emphasize the link between a country's position in a global trade network and its economic growth performance. A more central network position allows for higher returns to investment due to enhanced cooperation and further knowledge transfers on the firm level. Then, direct and indirect trading links and a more central position in the global trade network boost economic growth on the country level. As a consequence, initiatives to foster trust and cooperation between partners describe a promising path towards higher economic growth and prosperity. Here multilateral trade agreements on the country level reduce information and transportation costs and allow for market access and further growth opportunities through direct and indirect trading links.

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1.1 Introduction and Motivation

Globalization features one of the major global trends, which shapes economic outcomes in developing and developed countries. During the past fifty years, political change and advancements in technologies enhanced international trade openness and economic integration between countries (Bordo et al., 2003). It is well-know that this time period is also characterized by a steady rise in world production measured in terms of GDP and has witnessed a significant increase in international trade in goods and services. Descriptive statistics in the appendix to this paper suggest that to the end of the sample period, ranging from 1962 to 2008, exports between countries grew even faster than economic output [2]. In this context, standard results from the empirical growth literature suggest that participation in worldwide trade is an important determinant of economic growth (Durlauf et al., 2005). Here, most empirical papers analyze the impact of globalization on economic growth by including a measure of trade intensity, which captures the level of imports and exports relative to overall production in an economy (Rodriguez and Rodrik, 2001), into the empirical growth model. On the contrary, this paper argues that not only the level of economic openness matters, but instead the relative position of a country in the global trade network is even more important to understand the growth performance of an economy. Here, the new measure of economic integration captures the network position of an economy and takes into consideration higher-order links between countries in the global trade network. Furthermore, results from the empirical analysis highlight the importance of economic integration to fully understand the growth performance of a country in a global trade network. Using a limited information maximum likelihood estimator in a dynamic panel framework to mitigate problems of endogeneity in the empirical growth model, findings suggest a significantly positive effect of integration on economic growth. From a policy perspective these findings illustrate that further economic integration, and not just openness, have a strong positive impact on economic growth.

This paper presents a new methodology to establish a causal link between economic integration and economic growth. First, the theoretical framework explores social network theory to define a measure of economic integration. This approach builds on the well-established concept of centrality and provides a measure of economic integration to describe patterns of economic globalization. Second, this paper makes use of the UN Comtrade database and exploits a wide set of bilateral import and export flows to determine a country's network position in a global trade network. This information is used to compute the country and time specific measure of economic integration for 125 countries between 1962 and 2008. Third, the empirical identification strategy takes into account the dynamic panel structure of the data and previous concerns on endogeneity to disentangle the impact of economic integration on economic growth.

Social network theory defines a theoretical environment, which links the relative position of agents in a network to economic outcomes. Here, centrality in a network is gained by accessing many central agents, which in turn promotes economic activity [3]. This paper presents a new measure of economic integration, which explores trade links in a global trade network to characterize the network position of each country. More specifically, the measure captures the

[2] Figures 1.8 and 1.9 illustrate the increase in world production and show changes in global trade between 1962 and 2008.

[3] Among others, Kali and Reyes (2007) construct a global measure of centrality to characterize the network position of different agents in a network.

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idea of weighted links, which are constructed from the fraction of bilateral trade that can be observed for different trading partners in the global trade network. To account for size effects, we scale the fraction of bilateral trade by the total trade volume of the country and normalize this volume by the size of the economy (GDP). This novel approach allows us to determine the network structure of the world economy to later disentangle the impact of globalization on economic growth. Based on the theoretical framework in Duernecker and Vega-Redondo (2013), we expect a positive relationship between the measure of economic integration and the economic performance of an economy. Here, the theoretical model illustrates how a trading link between two countries can be interpreted as embodying a project that generates additional value to the economy, because it provides access to further markets and makes existing innovations more profitable.

The implementation of this new measure of economic integration explores the UN Comtrade database; then, descriptive statistics highlight major differences of our measure of integration compared to the standard measure of economic openness previously used in the empirical growth literature. Figure 1.9 depicts the two distinct time trends of openness and integration over the last decades [4]. The visual analysis suggests that the process of globalization is characterized by an increase in the level of openness, but also in the measure of economic integration. Furthermore, the figure illustrates that changes in the level of openness and integration are not highly correlated. Consequently, openness and integration describe different dimensions of economic globalization and offer additional explanations for the observed disparities in growth performance within countries [5].

Dynamic panels have been established as a new standard in the empirical growth literature to foster explanations for observed disparities in the economic growth performance within countries (Caselli et al., 1996; Bond et al., 2001). In comparison to traditional cross sections, dynamic panels allow for country fixed effects to control for unobserved heterogeneity. Results in this paper build on the first difference and system generalized method of moments and the limited information maximum likelihood method. First difference and system GMM address the issue of unobserved country fixed effects and allow for lagged variables in the dynamic panel framework. Furthermore, the empirical identification strategy makes use of internal instruments to deal with the issue of endogeneity which plagues most of the regression analysis in the empirical growth literature. The limited information maximum likelihood estimation procedure is a generalization of the two step estimator and allows for better properties in finite samples, with a large set of internal instruments which suffer from weak identification. Controlling for the standard set of independent variables in the empirical growth literature and using different robustness checks, results highlight a significantly positive effect of integration on economic growth.

The remainder of this paper is organized as follows. Section II introduces the empirical literature on the characterization of globalization and highlights some of the challenges in the previous empirical growth literature. In section III, we present the theoretical framework, which establishes a relationship between the position of an economy in the global trade network and its economic activity. Section IV first develops our measure of economic integration which builds on

[4]Openness is defined as imports plus exports over GDP. The concept on how to measure economic integration is explained later. The degree of integration decreases in the measure.

[5]Comment Edmund Phelps (Lindau, 2011): Large gains from openness. But in no way openness can explain globalization over the last years. Economic integration fosters competition and leads to higher productivity and diffusion of knowledge.

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insights from social network theory and then describes the data set taken from the UN Comtrade data. In this context, we also discuss basic properties of our measure of economic integration in a descriptive manner. Section V presents the identification strategy to estimate coefficients in the empirical growth model. In section VI, we estimate a dynamic panel model using a limited information maximum likelihood method approach and discuss results from alternative specifications including an instrumental variable approach. Finally, section VII draws some policy implications and concludes.

1.2 Literature Review: Trade and Growth

A long-standing theme in the empirical literature on economic growth concerns the identification of growth determinants. Inspired by early work of Baumol (1986) and Barro (1991) numerous studies were designed to establish that a given variable does or does not help explain cross country growth differences. One variable that has attracted particular interest, and whose effect on growth is still an unresolved puzzle is a country's openness to international trade. Much of the early work like Dollar (1992), Ben-David (1993), Sachs and Warner (1995), Edwards (1998) and Frankel and Romer (1999), but also more recent studies such as Dollar and Kraay (2003), Alcalá and Ciccone (2004), Romalis (2007) and Feyrer (2009) advocate that greater openness for a country leads to faster economic growth and higher levels of GDP per capita for a country. For instance Dollar (1992) finds that growth is negatively related to two measures of how closed economies are to trade; an indicator based on real exchange rate distortion and an indicator of real exchange rate variability. Also, Ben-David (1993) suggests that trade liberalization leads to lower income inequality among the liberalizing countries.

In their highly influential study Sachs and Warner (1995) construct a dummy variable of openness that classifies a country as open if none of the five following criteria holds: (i) the country has average tariff rates over 40 percent, and (ii) non-tariff barriers cover 40 percent or more of imports, (iii) the country operates under a socialist economic system, (vi) there is a state monopoly of the country's major exports, and (v) the black-market premium on its official exchange rate exceeds 20 percent [6]. Using data on 79 countries over the period 1970 to 1989, the authors find that their openness index has a strongly positive and significant effect on growth. Edwards (1998) relates aggregate productivity growth on a range of pre-existing measures of trade openness, and finds that most measures are positively correlated with productivity growth.

In an attempt to improve empirical identification Frankel and Romer (1999) address the concern that traditional measures of trade openness are a potential source of endogeneity, since reverse causality running from growth to trade is likely to occur and leading to inconsistent estimates of the effect of openness on growth. To properly instrument for trade openness, Frankel and Romer (1999) (and later Irwin and Tervio (2002)) employ a gravity model to isolate geographical components of openness that are assumed independent of economic growth, including population, land area, borders, and distances. Here, gravity models use geographical characteristics of countries to predict the level of bilateral trade. In a first step, bilateral trade is regressed on a set of importer and exporter dummies and on a vector of trade impediments: distance, contiguity (control for trade costs), common language, colonial links, dummies for common membership of a regional trade agreements, a currency union and WTO membership.

[6] China experienced a significant increase in economic trade over the last 30 years. Nevertheless this classification puts China into the category of non open economies.

Then predicted values are hopefully exogenous. Using this instrument, the authors find a positive effect running from trade to growth. Due to the time invariant nature of geography one of the drawbacks behind this approach is that identification comes from between country variation. Thus, the empirical framework cannot be used to characterize the within country perspective which offers additional possibilities to control for the unobserved country fixed effect. Feyrer (2009) builds on this criticism and uses information on improvements in air transportation technology to construct a time-varying geographic instrument for openness to trade. The heterogeneity across time makes this instrument suitable in a panel environment. Using data on 62 countries over the period 1950 to 1995 he finds that the actual trade volume – instrumented by the predicted trade volume – has a positive and significant effect on growth.

By the late 1990s, a consensus – which became known as the *Washington Consensus* – seemed to have emerged that a greater openness to international trade leads in fact to faster growth and higher standards of living for a country. However, a thorough reinvestigation of existing evidence undertaken by Rodriguez and Rodrik (2001) turned the consensus firmly on its head. These authors argue that results are not reliable because of difficulties in measuring openness, the collinearity of trade policies with other macro policies, the correlation of openness measures with other determinants of economic performance and various econometric difficulties in general. This criticism was, by and large, found to be justified by the profession. Rodriguez and Rodrik (2001) argue that the indicator employed by Dollar (1992) seems to be more a measure of economic instability rather than of trade openness. Also they find that the regression results reported by Dollar (1992) are not very robust to alternative specifications of the growth equation and when using a newer version of the Penn World Tables for the same countries and the same time period the openness indicator is not significant and enters with the "wrong" sign. Also the results of Sachs and Warner (1995) are found to be less robust than claimed. Rodriguez and Rodrik (2001), confirm earlier criticism raised by Harrison (1996) and Harrison and Hanson (1999) that most of explanatory power of the Sachs and Warner index comes from the two non-trade components of their measure: the existence of a state monopoly of the country's major exports, and the black-market premium on its official exchange rate. Interestingly, the trade-related measures turn out to be insignificant when they are used separately, which casts doubts on whether the index constructed by Sachs and Warner is in fact a proper measure of a country's outward orientation.

Wacziarg and Welch (2003) correct the original Sachs and Warner index to account for the criticism raised, and update the index to the 1990s. They show that the positive effect of trade on growth vanishes when the longer time horizon is considered in a cross-sectional setup. Rodriguez and Rodrik (2001) and Brock and Durlauf (2001) criticize the instrumental variable approach by Frankel and Romer (1999) on the grounds that the instrument may not be valid as geographical variables are likely to be a determinant of economic performance through other channels than just trade, such as health, institutions or climate. Rodrik et al. (2004) argue that previous studies have not properly controlled for the potential interaction between institutions, trade integration and geography. They find that more favorable geography affects income levels through the quality of institutions and not through trade integration. Therefore, once institutions are controlled for, trade openness has no direct effect on incomes, while geography has at best weak direct effects. These results put in question the validity of any geography-based instruments used in studies along the lines of Frankel and Romer (1999).

For a critical review of the recent work on openness and growth see Rodriguez (2007). Winters (2004), Estevadeordal and Taylor (2008) and Singh (2010) provide a comprehensive survey of the

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literature on trade and growth together with a thorough summary of the entire debate.

Composite measures of globalization

The large range of indicators that have been used by the literature to measure a country's outward orientation can be divided into two broad categories: (i) indicators of the aggregate trade intensity (for example, the ratio of exports plus imports to GDP or the fraction of primary products in total exports) and (ii) indicators of trade policy and trade restrictiveness (for example, the Sachs and Warner index, average tariffs or Leamer's intervention index) [7] [8]. In this context an important point raised by Rodriguez and Rodrik (2001) is whether the existing indicators are actually well suited to measure the particular dimensions of integration which are considered most relevant to economic performance. Arguably economic integration has multiple facets. According to Kacowicz (1999), Li and Reuveny (2003) and Arribas et al. (2009) a country becoming more integrated into the "world economy" typically experiences an intensification of cross-border interaction, information exchanges, technology diffusion, and convergence in cultural, social and political activity. Consequently, any indicator of openness which is solely based upon aggregate trade statistics is likely to offer only an incomplete characterization of a country's outward orientation.

A new generation of indicators has emerged recently contemplating different dimensions of openness and aiming to offer a broader perspective on the phenomenon of integration [9]. For instance, Dreher (2006) develops a composite measures of globalization covering what is argued to be the most important dimensions of integration: (i) economic integration, (ii) social integration and (iii) political integration. He uses information on 23 variables for 123 countries over the period 1970 to 2000 to construct three subindexes which are in turn aggregated into one single index of globalization. Using panel data techniques he finds that globalization has a positive and significant effect on economic growth. When entering the sub- indices separately, he finds that the indicator for economic integration is most robustly related to economic growth, whereas political integration has no effect. Other examples for composite globalization measures include Andersen and Herbertsson (2003); Lockwood and Redoano (2005); Heshmati (2006) and Martens and Zywietz (2006) [10].

Network based measures of economic integration

Another recent and promising approach to measure integration emphasizes the importance of the architecture of (trade) connections each country has with the rest of the world. Advocates of this view, such as Kali and Reyes (2007), Arribas et al. (2009) and Fagiolo et al. (2010), argue that standard indicators of openness are able to recover first-order trade relationships (for example, import and exports between any two countries) but miss all second- and higher-order relationships

[7] Here, the World Trade Organization uses the term "market access" to summarize tariff and non-tariff measures, agreed by members for the entry of specific goods into their markets.

[8] Durlauf et al. (2005) provide a tabular listing of the extensive set of indicators.

[9] In this context the terms openness, integration and globalization are often used synonymously.

[10] The "AT Kearney and Foreign Policy Magazine Globalization Index" (A.T. Kearney and Foreign Policy, 2007) and the "DHL Global Connectedness Index" (Ghemawat and Altman, 2012) describe alternative examples on how to aggregate information from different dimensions of globalization into one measure to characterize the level of integration for each country in the world economy.

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across countries [11]. These higher order connections are potentially important determinants of economic integration and performance, since the process of integration also advances because of the effect of indirect links (OECD, 2005). Therefore Arribas et al. (2009) stress that any measure of international integration in the age of globalization must take into account the complexity of connections among countries.

Network-based measures of international economic integration typically employ a social network approach which depicts the web of (trade) relations as a network in which countries play the role of nodes and a link indicates the existence of an import and export relationship between any two countries. This approach has been used recently, for instance by Garlaschelli and Loffredo (2005) and Fagiolo et al. (2010) to study the properties of the world trade web and its evolution over time. More specifically, Fagiolo et al. (2010) employ a weighted network analysis on data for 159 countries over the period 1981 to 2000, and find that according to their measure the world trade web is remarkably stable over time and international goods market integration has not significantly increased over the last 20 years. Arribas et al. (2009) employ a network analysis to develop indicators for openness, connectedness and integration for 59 countries over the period 1967 to 2004. Kali and Reyes (2007) use trade data for 192 countries, for the years 1992 and 1998 and compute network-based measures of each country's participation and influence in the global trade network. Also, they run a cross-country growth regression and find that a country's position in the network, measured in terms of degree centrality, has important implications for economic growth. Kali et al. (2007) analyze the relationship between the structure of trade and economic growth. Using data on 120 countries over the period 1980 to 2003 they construct a Herfindahl- Hirschman concentration index which measures, for each country, the dispersion of trade flows among all of its trading partners. They find that the number of trading partners is positively correlated with economic growth, where trade dispersion is found to be negatively correlated with growth.

1.3 A Centrality-based Measure of Globalization

This section outlines the theoretical approach undertaken in Duernecker and Vega-Redondo (2013) to study the link between economic integration and economic activity. As explained below, this approach motivates the new measure of economic integration introduced in this paper.

The model proposed by Duernecker and Vega-Redondo (2013) involves a fixed set of agents, $N = \{1, 2, ..., n\}$, who are uniformly distributed in some space. For simplicity, let us identify this space with a one-dimensional ring and denote by $d(i.j)$ the geographical distance between any two nodes, i and j. Let $t \geq 0$ be the continuous variable indexing time. At each t, agents are connected by a network $g(t)$ specifying the pair of agents $\{i, j\}$ who are connected by a link.

[11] Models on market potential of an economy measure the potential of some site r as a weighted sum of the purchasing power of all other sites s, with the weights being a declining function of geographic distance (Fujita et al., 2001). Mayer and Zignago (2005) suggest that there is a strong positive relationship between their measure of market potential and the level of GDP per capita. In consequence, larger and/or more centrally located countries are characterized by a higher income per capita than countries which either serve a small market or have few or smaller neighbors. One criticism against the market potential framework is that this concept only explores direct links in the global trade network. This measure does not allow for any higher-order links and is not able to capture the full architecture of international trade. Namely, what happens if there is a global trade network with three countries where country r trades with s1 and s2. If there is no link between r and s2, but trade between r and s1 and s1 and s2, the measure of market potential neglects any effect of s2 on r which goes through s1.

Over time, agents establish and destroy the economic links to each other, thus giving rise to the dynamics of the overall social network. To fix ideas, link creation is viewed as the result of "innovation," while link destruction is interpreted as the outcome of "obsolescence". We formulate each of them first, and then turn to motivating them.

Innovation: At each t, every agent $i \in N$ obtains an "idea" for an economically valuable project at rate $\eta > 0$. But to carry out the corresponding project, agent i needs the collaboration of some other agent in the network. *Ex ante*, the probability that any *specific* agent j be the one required for the project is assumed proportional to $d(i,j)^{-\alpha}$. Thus the probability that any two agents enjoy some new linking or collaboration opportunity decays with their bilateral geodistance at the rate α. Consider any pair of agents $\{i,j\}$ who enjoy such a linking opportunity. We assume that the link will indeed materialize if, and only if, the following two conditions are jointly satisfied:

(i) They are not already linked.

(ii) They are either direct neighbors or/and their social distance is not larger than some parameter μ.

Volatility: At each t, every link $\{i,j\}$ in $g(t)$ becomes "obsolete" and vanishes at the rate $\alpha > 0$.

Our formulation for innovation displays several key features. First, it posits that the underlying space plays an important role in shaping economic opportunities. That is, *ceteris paribus*, opportunities are more likely to arise close-by than far-away. This, for example, could be a reflection of the fact that the more distant agents are the less of a common background they have (language, expectations, norms), which makes it more difficult for them to collaborate fruitfully [12]. The rate at which such space-induced decay occurs is given by α. This parameter captures the importance of geography, and can be associated to technological and cultural factors such as the effectiveness of communication technologies or the cross-cultural convergence of habits and social norms, which we take as exogenous to the model. For conciseness, we shall refer to α as the degree of *social cohesion*.

A second feature of the process of link formation is that no pair of players may undertake more than one project at a time. Admittedly, this is an extreme assumption but represents a simple way of capturing the idea that profitable opportunities must be exhausted if an agent revisits the same partner repeatedly. As explained, it is the key force leading agents to turn "global" in order to sustain a large number of valuable links and projects.

And thirdly, our formulation of innovation separates the arrival of non-redundant opportunities from the actual materialization of those opportunities. For the latter to occur (for example, a link to be formed), it is required that the two agents involved must be sufficiently close, either physically or/and socially. A natural motivating idea here is that, once the possibility for a new project has arisen between some agents i and j, they must be able to either

(a) learn about each other and their complementary skills, [13]

[12] It is sometimes argued that diversity breeds innovation. If we associate diversity to increasing geographical density, such a relationship will indeed be a feature of our model, but an *endogenous* one. That is, agents who collaborate globally (and thus do so with diverse agents) are more innovative, because they are better at escaping the saturation of *fresh* (i.e. not yet exploited) opportunities existing in the geographical vicinity.

[13] The survey by Rauch (2001) discusses the role of global social networks as a key channel though which business practices, technical know-how, and market opportunities spread and get to be known across distant geographic locations.

or/and

(b) monitor and trust the partner's behavior in their ongoing collaboration [14].

The assumption is that, in order for this to happen, the agents must be immediate geographic neighbors (in which case information in every respect should flow readily) or the number of intermediaries in the social structure cannot be too high, for instance no larger than μ. To fix ideas, we shall think of this parameter as a reflection of the quality of *institutions*. The motivation is that, in some contexts, it could capture the readiness of agents to abide by a cooperative norm of behavior, for example by relaying valuable information or providing third-party monitoring.

Our formulation of volatility is particularly simple [15]. It postulates that all projects eventually become obsolete and vanish, and this process occurs at a constant rate λ. This rate is to be compared with that at which ideas arrive to the system, η, which is a measure of the potential (or innovativeness) of the economy. Naturally, in our continuous-time dynamic system, only the ratio η/λ matters, so we chose to normalize $\lambda = 1$ without loss of generality. In summary, the overall dynamic process is a struggle between link creation and link destruction. If the network connectivity is high, so will be as well the rate at which links are destroyed. Thus, in the long run, a dense network can be sustained only if such a fast pace of link destruction can be offset with a comparably high rate of link creation.

Naturally, the aforementioned considerations not only apply to the network as a whole but also to each individual agent: any of them who succeeds in maintaining many links must be capable of creating many links as well. And since such link-creation ability in turn depends on being sufficiently close (in the social network) to others, the following prediction ensues. Agents who are socially closer to the rest of the population should also display more links. To be more precise, define by $F_i(d)$ the fraction of agents that are at less than social distance d from any given agent i. Clearly, the function $F_i : \mathbb{R} \to [0, 1]$ can be regarded as a cumulative distribution function. Consider now any other agent j with her corresponding function F_j. Then, if both agents are in a fully symmetric situation in every other respect, a sufficient condition for the rate of link creation of agent i to be higher than that of j for *any value of* μ is that F_j first-order stochastically dominates F_i, such that

$$F_j(d) \leq F_i(d) \quad \forall d \geq 0.$$

But this is such a strong requirement that one can hardly expect it to be relevant for empirical analysis [16]. We shall thus rely on a natural proxy for it based on the average magnitudes given by the aforementioned distributions. We shall then say that some agent i is better integrated than some other agent j, if and only if

[14] The importance of the social network as a basis for monitoring and deterrence of opportunistic behavior was stressed in the classical work of Coleman (1988), while a more recent account of this phenomenon can be found in Karlan et al. (2009), both at a theoretical and empirical level. This line of research highlights that the social network can operate as "social collateral", thus rendering opportunistic behavior unprofitable. Another interesting illustration of this phenomenon is discussed in the celebrated study of Southern Italy by Banfield (1958), who coined the term *amoral familism*. In essence, this describes a situation where the deviation from a cooperative norm is the concern of third parties only when it involves closely related individuals. In our context, this would amount to a low value of μ.

[15] Other more elaborate formulations could be contemplated without affecting the gist of our results. For example, it could be postulated that the rate of destruction of any particular link increases in the number of links the two agents currently have, or on their social distance. This would not affect the essential gist of our analysis.

[16] In particular, it yields only a very partial ordering across different situations, and hence it is unsuited to construct a useful measure of globalization.

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$$\int d\,\mathrm{d}F_i < \int d\,\mathrm{d}F_j.$$

In this paper, our objective is to test empirically the prediction that more integrated "agents" perform better, in the sense of growing faster. This is the most basic prediction that follows from the model studied in Duernecker and Vega-Redondo (2013), and seems the natural place to start in assessing its validity [17]. And, as is common in the theory of growth, this paper explores country aggregate data to conduct the analysis. In a first step, we provide an operational counterpart of the binary-network model that can be applied when the intensity interaction is measured by continuous variables such as trade or investment. This is the objective of the next section, where we propose a measure of globalization that can be applied to "nodes" conceived as consisting of many individual agents, whose inter flows are real rather than binary.

1.4 Globalization and the World Economy

The theoretical framework illustrates that our approach to describe economic integration differs significantly from previous attempts to characterize economic globalization. Here, the traditional measure of openness is based on the ratio between imports and exports to aggregate output of an economy. Contrary, the measure of economic integration accounts for the network structure and patterns of direct and indirect bilateral trade relationships between countries. In the following, we first discuss the construction of our measure of economic integration and then focus on its properties and discuss descriptive statistics from a balanced panel which contains 125 countries and covers the time period from 1962 to 2008 [18].

1.4.1 Construction of the Measure of Integration

Let N be the set of countries and denote by x_{ij} the interaction flow from any given country i to some other country j. In this paper, we focus on bilateral trade flows, so x_{ij} stands for the exports from i to j while x_{ij} corresponds to the imports from j to i. In general, these flows could reflect other forms of interaction such as investment flows (foreign direct investment), financial transfers, or global migration flows. The starting point for the calculations of our measures of integration is the matrix $X_t = (x_{ij,t})_{i,j=1}^{125}$, where $x_{ij,t}$ stands for the flow of exports from country i to country j in year t. Notice that $x_{ii,t} = 0$ for all countries $i = 1, ..., 125$ and time periods $t = 1962, ..., 2005$. Using the matrix X of bilateral trade flows, we normalize its entries to account for inter-country asymmetries that would otherwise distort the respective magnitudes. This normalization is geared to capture the following two important features of these flows:

(i) the true openness of each country, as measured by the magnitude of its trade flows *relative* to both its own country size and relative to the size of the rest of the world;

[17] The model also predicts, that, if geographical cohesion is not too strong, the transitions to globalization are abrupt, large, and robust. It identifies as well a novel (network-based) source of equilibrium multiplicity that – in contrast with the classical theory of growth – implies that globalized economies are not only richer but also grow faster as environmental conditions improve. Finally, another related implication is that, as geographical cohesion falls (an apparent feature of the modern world economy), the wedge between rich and poor countries would widen, as long as the later do not become globalized.

[18] The list of countries in the sample can be found in the appendix. Consider that the empirical analysis builds on a restricted sample of 85 countries. We eliminate possible problems of sample selection by considering only countries which report bilateral trade data without any breaks between the years 1962 and 2008.

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(ii) the relative weight of each partner in the overall trade flows of every given country.

To account for (i), denote by $Y_{i,t}$ the GDP of country i in time period t measured in current USD and by $\beta_{i,t} = \frac{Y_{i,t}}{\sum_{k=1}^{125} Y_k}$ the share of country i's GDP in the world GDP [19]. Then, we follow Arribas et al. (2009) and identify the *openness* of a country i with the weighting factor $\theta_{i,t}$, which for a given country i in year t is computed as $\theta_{i,t} = \frac{\sum_{k=1}^{125} x_{ik,t}}{(1-\beta_{i,t})Y_{i,t}}$, where $Y_{i,t}$ is the GDP of country i in period t. This normalizes the aggregate exports of the country by its own size (as captured by its GDP) and the size of the "rest of the world" with which trade is conducted [20].

To account for (ii), the matrix of normalized export flows Z_t, where $z_{ij,t} = \frac{x_{ij,t}}{\sum_{k=1}^{125} x_{ik,t}}$, is obtained by normalizing the export flows from i to j by the total exports of country i. As a result, the elements of each row in Z sum up to 1. The row-stochastic matrix A for the year t is straightforwardly obtained by combining Z_t and $\theta_{i,t}$ for all $i = 1, ..., 125$. Then, the matrix of interaction between any country i and j, such that $A = (a_{ij})_{i,j=1}^{n}$ is defined as follows:

- $\forall i = 1, 2, ...n, a_{ii} = \theta_i$
- $\forall i = 1, 2, ..., n, i \neq j, a_{ij} = (1 - \theta_i) z_{ij}$

Provided $0 \leq \theta_i \leq 1$, the matrix A defined as above is a row-stochastic matric and $\sum_{i,j=1}^{n} a_{ij} = 1$. This allows us to view this matrix as the adjency matrix of a *weighted directed network* where the aggregate level of interaction flowing from each node is normalized to unity. Equivalently, we can also regard the entries of the matrix A as the transition probabilities of a markov chain where each of the n agents is associated to a distinct state.

The standard measure and the number of steps It is natural to define the proximity of two agents/nodes, i and j, as the expected number of steps it takes i to reach j, or viceversa. In the appendix to this paper, we explain in detail how such distance measure can be easily computed from the above mentioned matrix A. To understand it conceptually, let us interpret any given a_{ij} in this matrix as the fraction of links of a typical individual in country i that connects to agents in country j. Then, this entry may be identified with the *probability* that there is an indirect connection to country j mediated through some randomly selected individual of country i. It is in this sense that we argue that our (continuum) notion of distance represents a natural counterpart of the geodesic distance defined in our theoretical model for a (discrete) binary network. More specifically, if $\overrightarrow{\varphi}_{ji}$ denotes the expected number of steps for the associated stochastic process to make the transition from i to j we define the distance $\varphi_{ji}\,(= \varphi_{ji})$ between i and j as follows:

$$\varphi_{ji} \equiv \tfrac{1}{2}\left(\overrightarrow{\varphi}_{ij} + \overrightarrow{\varphi}_{ji}\right)$$

.

Next, we construct a measure of any given country i by computing a weighted average of the different φ_{ji} for every other $j \neq i$, where the weight associated to each country j is equal to its share β_j in world GDP (see above for the definition). This weighting scheme reflects the idea

[19] We obtain the data for GDP from the World Bank National Accounts Data Base. The series we use is labeled "NY.GDP.MKT.PCD".

[20] This normalization requires, that if either the size of the country or the rest of the world increases, exports should increase in the same proportion if the country is to be judged as equally open to globalization.

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that any access obtained to a particular country has to be evaluated in terms of the "value", for example GDP, generated in that country. Thus, the standard measure integration ϕ_i of each country $i = 1, 2, ..., n$ is given by

$$\phi_i \equiv \sum_{j \neq i} \beta_j \varphi_{ij}$$

.

Here, the degree of integration decreases in the measure of economic integration: the more steps are necessary to reach country i from any other country in the global trade network using either direct or indirect links, the less integrated the economy is. Later we postulate that using the growth rate of GDP per capita between period t and period t+1 as dependent variable, the measure of integration in period t is expected to have a negative coefficient.

1.4.2 UN Comtrade data

This subsection briefly describes how the measure of integration we have proposed in the previous section is operationalized. To construct our measure of economic integration we use data on bilateral export flows for 125 countries over the period 1962 to 2008, taken from the United Nations Commodity Trade Statistics database (UN Comtrade) [21]. For each year, $t = 1962, ..., 2008$, we observe the total value of exports, measured in current USD, for a given country pair ij, where i and j respectively denote the country of origin and the country of destination. Here, table 1.1 shows an illustrative example, summarizing the bilateral export flows among the three countries Germany, China and the USA in the year 2000.

Table 1.1: Export flows between three countries in the year 2000, in current USD.

		Destination		
		China	Germany	USA
Origin	China	-	9,277,789,992	52,156,428,118
	Germany	8,472,113,000	-	55,389,893,000
	USA	16,249,167,650	29,219,631,160	-

Notes: Export flows between China, Germany and the United States of America for the year 2000. Measured in current USD.
Source: UN Comtrade data.

The exports of the 125 countries which we use here, cover, on average 95.7% of the total amount of yearly world export flows over the time period from 1962 until 2008. The minimum and the maximum coverage is obtained in the years 1974 and 1989 with 94.2% and 97.3% respectively. Likewise, the GDP coverage ratio of our sample in terms of world GDP is also high – on average 97.8% – and very stable over time with minimum and maximum values of, respectively, 96.9% (1964) and 98.9% (2005). The high and stable coverage ratio for export flows indicates that the data at hand allows for an accurate description of the global trade network. This is particularly reassuring to know given that the quality of our measure is tightly linked to how close our

[21] The UN Comtrade database summarizes detailed information on bilateral trade flows between all countries in the world and covers different categories of manufactured and non-manufactured goods and services.

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representation of the trade network comes to the actual one [22]. If, for instance, we missed out a large and highly connected country then our global trade network would exhibit large gaps with respect to the actual one as many of the actual trade flows would not be captured. Obviously, this would induce a substantial bias into the integration measures for not only all the direct but also the indirect trading partners of the missing country.

For some countries in some years the data on export flows are not reported. This is due to the fact that UN Comtrade collects data from national statistical agencies and occasionally – for instance in the case of the former Soviet Union – this data was not released. To mitigate the missing data problem we choose to rely on import data – also provided by UN Comtrade – and use the observed import flows from j to i to impute the missing export flow from i to j. On average, 6.35% of the yearly export flows are imputed.

An important issue concerns the treatment of the former Soviet Union, former Yugoslavia, former Czechoslovakia and Germany. For the first three, we observe the trade flows for the entire federation until 1992, 1992 and 1993 respectively, and for each of the member countries thereafter. We choose to continue treating each of the three federations as a single economic system, also after their dissolution. Technically, we disregard all trade flows among the members of a federation, and consider only exports to non-members. Likewise, we observe trade flows for East and West Germany separately until 1990, and for unified Germany thereafter. Here, we use the same approach as before and consider a hypothetical unified Germany which disregards all export flows between East and West Germany.

1.4.3 Patterns within and across countries

The measure of economic integration characterizes the process of globalization and describes a world which is becoming more integrated over time. In other words, economic trade and global value chains incorporate – compared to previous periods – more countries which are connected through a dense network of bilateral trade links. To illustrate the validity of our measure of integration, we now focus on a set of countries observed between 1962 and 2008. Based on the full sample of 125 countries, this subsection summarizes some key properties of our measure of economic integration (see figure 1.10). The descriptive analysis confirms that the underlying network approach to economic integration is a valid attempt to characterize the process of globalization and adds further insights compared to the traditional openness measure used in the literature [23].

USA and Mexico Over the sample period between 1962 and 2008 both countries show a trend towards more integration. Comparing the level of integration, the USA is far more integrated into the global trade network than Mexico. For Mexico we find that around 1994 and 1995 the decrease in integration – which is equivalent to an increase in the measure – coincides with the Tequilla crisis which describe a a breakdown in financial markets and economic activity (Calomiris, 1999; Mishkin, 2009). Contrary, the enlargement of the North American Free Tared

[22] Alternative measures (foreign direct investment and global migration flows) only focus on specific product classes. Furthermore, these calculations would be complicated by the fact in the case of foreign investment but also migration there is no universal (harmonized) definition valid for all countries. As a consequence data availability and data quality decreases substantially and difficulties arise when describing a global trade network.

[23] The appendix provides further examples, which elaborate on the time series profile for economic integration in most Asian and African economies.

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Area which started in 1995 had an immediate and positive impact on the level of integration for both countries, the USA and Mexico.

Ireland and Spain With respect to different enlargement steps of the European Union (European Community), we next pay special attention to Ireland and Spain. Ireland joint the common market in 1973 which coincides with an increase in the level of integration in the subsequent years. Our measure of integration confirms the picture of Ireland as a so-called "celtic tiger": compared to the global average, and relative to many other countries in the world economy and the rest of Europe, Ireland experienced a significant increase of integration after they had joint the European Community. This positive time trend is widely seen as a driver for high growth rates of the Irish economy. After Spain started a political and economic transformation from a dictatorship to a liberal market economy in the late 1970s, economic integration with the rest of the world increased. The entry to the European Community in 1986 was followed by a steady increase in integration because Spain now had the opportunity to intensify its trade links with the rest of Europe and achieve better access to further economies worldwide.

China The biggest economy in East Asia is widely seen as an example on how economic globalization can transform an economy. Until the political changes to the end of the 1970s, which followed the death of Mao Zedong in 1976, China mainly focused on internal development. In response to political and economic reforms announced by Deng Xiaoping, the economy shifted towards more integration and China is now one of the biggest trading partners in the world. In parallel to increased openness, the economy became far more integrated into the world economy. Bilateral trade flows towards the United States of America and the European Union increased significantly and China moved from isolation to become a global player these days. To the end of the sample period, integration of the Chinese economy also benefited from close economic cooperation among countries in East and South East Asia and the deepening of value chains in the region. In comparison, India followed a different growth strategy and never achieved a similar level of integration into the global trade network like China (see further discussion in the appendix).

Burundi and the Democratic Republic of Congo Two countries in Africa, Burundi and the Democratic Republic of Congo, illustrate that not all countries benefited from economic integration. Both countries were involved into internal conflicts and according to their time trend for integration, their participation in international trade did not change much over time. Interestingly, over the same time period the level of openness increased, which demonstrates the distinct character of both measures; for example, the Democratic Republic of Congo increased the exploitation of raw materials and exported these goods to a small set of trading partners. As a consequence, openness increased but at the same time the degree of integration remained relatively constant.

Argentina Lastly, we focus on the case of Argentina. To the beginning of the 20th century, the second biggest economy in Latin America was among the most globalized countries worldwide. Nevertheless, the time trend of economic integration for the last 40 years suggests that Argentina was below the global average of economic integration. Furthermore, the data shows a very volatile time trend which might be due to changes in the political and economic environment.

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For example the financial crisis in Asia in the year 1997 and the following contagion to Latin America including a sovereign default in 2001, reduced the level of integration significantly. This can possibly be linked to a worsening access to international markets and as a consequence a breakdown of bilateral trade [24].

Distribution of the measure of integration Globalization describes a global trend where a large set of countries participate. Nevertheless, the extent to which countries participate in global trade varies dramatically across time and space. In this context we now focus on the distribution of our measure of integration. In particular, we are interested in differences across economies and the question in how far these differences are persistent over time. Figure 1.12 displays the time trend for mean and standard deviation of our measure of integration. Comparing the year 1962 to the year 2008 we find that the standard deviation increased substantially over time. This time trend suggests an increasing gap between well globalized economies and less globalized ones.

A key question in this context remains: Is it the same set of countries which were left behind in 1965 and in 2005? Here figures 1.13 and 1.14 create further insights. The horizontal axis shows the level of integration in the year 1965 and the vertical axis displays the corresponding measure of integration in the year 2005. Some countries (below the 45 degree line) are better integrated into the global trade network today than in the past; others (above the 45 degree line) are less integrated today compared to previous times. In addition, we also plot the level of integration in the year 1965 against the change in integration between 1965 and 2008. Again this figure illustrates that except for some countries like South Korea and China, the ordering in terms of their level of economic integration remains surprisingly stable over time. It is mostly the set of countries which were already well integrated in the year 1965 which then experienced higher growth rates in this measure between 1965 and 2005.

A detailed comparison of different percentiles of the distribution of economic integration relative to the median illustrates that there are two broad categories of countries (see figure 1.12). First, those which were not globalized at the beginning and did not change their relative position over time. And second, those economies which were among the front runners in terms of globalization and today interact even more than in the past. Accordingly it is not only the distance between the very top (10th percentile) and the very bottom (90th percentile) which has increased over time - in fact it is that the gap between the 10th percentile also increased in terms of integration relative to the median (50th percentile). Furthermore, the ratio between the median and the 90th percentile did not change much. This suggests that aside from few exceptions the set of countries which was highly integrated in the past, tends to dominate the process of globalization even over time. In other words, the "front runners" (10th percentile) experienced much more integration over time than the "left behinds" which includes a wide set of countries.

Figure 1.11 summarizes most of the previous discussion. The figure on the top shows the two kernel density distributions for the measure of integration which characterize the world economy in 1965 and 2005; to the bottom, the standard measure of openness. First, the large standard deviation for integration and openness suggests that countries experience different levels of economic globalization. Second, we compare two different distributions, one describing the world

[24] In response to the sovereign default in Argentina 2001, the country did not have access to international capital markets any longer. National poverty rates increased to up to 50 percent. To rebuild the economy, the government focused very much on internal market development (see India) and imposed high tariffs on imports and exports.

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in "old times" (1965) and the other distribution, which explores data from "new times" (2005). Here, we observe that there are significant shifts towards more integration today compared to the past. Both distributions moved towards higher levels of integration (and openness) which reflects the idea of economic globalization. Third, the trend towards more economic integration is not equally distributed among countries. The figures and especially their changes over time suggest that only some countries in the lower (upper) part of the distribution of integration (openness) have experienced additional integration (openness). In other words, non globalizers in the past still lag behind in the present and have hardly changed their degree of integration relative to their initial position in 1965. At the same time highly globalized economies in the past increased their degree of integration even more and participated in the process of globalization such that they are now even more globalized than they were in the past. This time trend increases (persistent) disparities among countries, which is in line with previous findings in figure 1.14. The corresponding distribution on openness makes use of the level of openness. Again we observe a trend towards more globalization in the world economy. From an empirical point of view the aforementioned heterogeneity with respect to the level of integration across and within countries allows for identification of the impact of integration (and openness) on the economic growth performance of a country.

Further summary statistics on the properties of the measure of integration and openness are summarized in table 1.2 in the appendix to this research paper. Here, summary statistics are calculated for the restricted sample which is later used in the empirical analysis and take into consideration the across and within country dimension of the panel data.

1.4.4 Comparison between openness and integration

The introduction to this paper has shown that many empirical growth studies measure globalization by the ratio of imports and exports over total GDP. To our understanding this measure characterizes the openness of an economy towards trade but does not necessarily reflect the integration into the global trade network. In this context, figure 1.15 suggests the correlation between openness and integration to be low. the figure on the top uses data taken from the year 2005 describes each country by its combination of the level of openness and its degree of integration. Using the previously established measure of economic integration, table 1.3 suggests that the correlation between openness and integration is close to 0.08 [25]. This preliminary result illustrates that openness and integration capture two distinct dimensions of globalization such that both measures could be included into the empirical model jointly (no problems of multicollinearity).

The differences between openness and integration also becomes clear from table 1.4. In addition to the absolute level of openness, integration and the Sachs and Warner measure for the years 1970, 1990 and 2005 we include their ranking which relates to their relative position within in the corresponding distribution. The table illustrates that these three alternative measures capture largely different dimensions of globalization. For example, the United States of America is characterized by a rather low level of openness. In line with common wisdom, our measure of integration highlights the very important role the United States of America takes in terms of globalization. Furthermore, the above mentioned indicator proposed by Sachs and Warner

[25] The rank correlation between openness and integration draws a similar picture in terms of the relationship between openness and integration.

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(1995) summarizes the trade policy of an economy to determine a country's openness to trade. Using their methodology countries which experience a high level of openness and integration (for example China) are actually categorized as being closed towards economic trade.

1.4.5 Integration and economic growth

The main focus of this paper is to establish a link between the degree of economic integration into the global trade network and the economic activity of a country. Accordingly, figure 1.16 shows the relationship between the measure of integration to the beginning of the sample period in the year 1965 and the growth of GDP between 1965 and 2005. The unconditional correlation suggests a slightly negative relationship between the level of economic integration in period t and the growth of the economy between t and t+1. Given the nature of the measure of economic integration this implies that a more central network position has a positive impact on the growth of the economy in the subsequent time period. Furthermore, this figure shows an unconditional correlation and does not take into account additional control variables. In the empirical part of this paper we include a large set of independent variables to control for (observed) differences in terms of state and control variables.

1.4.6 Modified measure of integration

In addition to the previously discussed standard measure of economic integration (for the empirical analysis and descriptive statistics the paper refers to this measure as integ (standard)), we construct two more measures which follow a similar methodology (see appendix). First, we only consider indirect links which are assumed to be strictly exogenous to the trade policy of country i. In contrast to the standard measure, we do not calculate the number of steps to reach country i, but only country i-1. Then, we instrument the last step between i and i-1 by the geographic distance between the two countries. By construction, the modified measure shows a lower mean than the standard measure (6.30 vs 8.29) since the last step, namely going from country i to i-1, will always increase the number of steps at least by one. Later, the empirical analysis refers to this measure of integration as integ (instrument). Second, we construct the standard measure based on a modified network matrix. Instead of using aggregate trade between countries, we now exploit bilateral trade in manufacturing and investment goods [26]. Accordingly, this measure called integ (investment) does not account for trade in agricultural goods and resources but rather manufacturing and investment goods. From an analytical perspective it is not clear if the modified measure displays a different number of steps. If trade was distributed equally over all product classes, then the network matrix would not change. Based on the observation that some countries specialized in trade in certain product classes (comparative advantage) the network matrix will most probably change such that the sample mean increases from 8.29 for the standard measure of integration to 9.82 for the investment measure of integration. Later on, both measures allow for robustness checks in the empirical analysis.

[26] For the modified measure of integration we make use of bilateral trade in the following categories: chemicals and related products (SITC 5), manufactured goods classified chiefly by material (SITC 6), machinery and transport equipment (SITC 7) and miscellaneous manufactured articles (SITC 8).

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1.5 Empirical Growth Model

The empirical model establishes a framework to estimate the dynamic panel model in the next section. Here, the estimation strategy pays special attention to key identification problems discussed in the previous literature. For instance, in a framework where the lagged dependent variable is among the independent variables, both the OLS estimator and the within group estimator turn out to be inconsistent. Furthermore, the standard empirical growth model suffers from inconsistent estimates due to contemporaneous feedback effects (reversed causality), unobserved and time invariant country fixed effects and measurement error. In an intermediate step, we then focus on the first difference GMM and system GMM estimator which allow for consistent estimates in a dynamic panel model. Finally, we suggest the LIML estimator as our preferred estimation strategy to characterize the link between a country's degree of economic integration into the global trade network and its economic growth rate.

The section is structured as follows: First, the dynamic panel model to establish a link between integration and economic growth is introduced. Second, we focus on previous estimation strategies from the empirical growth literature. Third, the set of independent variables is explained. Fourth, we present the empirical identification strategy used in this paper.

1.5.1 Dynamic growth regression

The theoretical model establishes a link between a country's degree of economic integration into the global trade network and its economic activity. To make this case empirically, we use the growth rate of GDP per capita as dependent variable. In addition to our measure of economic integration $C_{i,t-1}$, the set of independent variables includes additional control variables $X_{i,t-1}$ which are typically used in the empirical growth literature to understand differences in growth performance within and across countries [27]. More specifically, let $y_{i,t}$ be the natural logarithm of GDP per capita in country i and time t. If $X_{i,t-1}$ describes the set of independent variables other than the variable for integration $C_{i,t-1}$, the dynamic panel model can be written such that

$$y_{i,t} - y_{i,t-1} = \tilde{\alpha} \cdot y_{i,t-1} + X_{i,t-1} \cdot \beta + \gamma \cdot C_{i,t-1} + \rho_t + \eta_i + \epsilon_{i,t}. \tag{1.1}$$

Here, the implicit error term $u_{i,t}$ can be decomposed into different components: First, the unobserved country fixed effect η_i and second, the individual and time characteristic error term $\epsilon_{i,t}$. To account for global trends, the empirical model takes into consideration periodic specific shocks ρ_t which are common across all countries.

Furthermore, the empirical model shown in equation 1.1 takes into consideration the dynamic properties of the empirical growth model, with current realizations of the dependent variable influenced by past ones. Some independent variables might be predetermined but not strictly exogenous. As a consequence, regressors are independent of current disturbances, but they may be influenced by past ones (or even like in the case of endogeneity, the assumption on contemporaneous non correlation does not hold). The lagged dependent variable is one example. This argues against cross section regressions, which must essentially assume country fixed effects away, and in favor of a panel set up, where the first difference and the system GMM allow for arbitrarily distributed fixed effects. For the estimation step, we split the sample period from

[27] Notation used in this paper heavily borrows from Caselli et al. (1996).

1965 to 2005 into eight time intervals of length five years and make use of different dynamic panel estimation strategies [28].

$$y_{i,t} = \alpha \cdot y_{i,t-1} + \beta \cdot X_{i,t-1} + \gamma \cdot C_{i,t-1} + \rho_t + \eta_i + \epsilon_{i,t}. \tag{1.2}$$

Here, results from the empirical growth model contribute to the discussion on the so called beta-convergence, which focuses on the relationship between the growth rate of GDP today and the level of GDP in the previous period. The literature on neoclassical growth models argues that diminishing returns to capital induce conditional convergence, such that the coefficient of initial GDP is negative. Consequently, a country with lower GDP will grow faster which induces a process of catching up with respect to richer economies. Conditional convergence cannot be rejected if the transformed coefficient α is significantly smaller than one [29].

1.5.2 Empirical growth literature

The early literature on empirical growth models builds on the idea of bringing the theoretical growth models (Romer, 1986; Lucas, 1988) to the data and then identify growth determinants by analyzing differences in standards of living across countries (Barro, 1991; Quah, 1993). For example, Mankiw et al. (1992) use the standard Solow model as a starting point and later enrich the empirical framework by possible explanations for endogenous economic growth (Solow, 1956; Cass, 1965). Accordingly, information on human capital [30], social capital and institutions [31] are included into the set of independent variables. Furthermore – as we have already seen from the discussion in section II – researches tend to control for globalization using basic measures of economic openness [32].

For the early generation of growth models, the empirical identification strategy is mainly based on cross section analysis and often suffers from severe problems of contemporaneous feedback effects, measurement error and omitted variables bias. For example, the correlation between the unobserved country fixed effect and the set of independent variables induces inconsistent estimates which ruins most of the OLS estimates. To alleviate these identification problems, Frankel and Romer (1999) employ an instrumental variables approach and proxy the level of economic openness by some standard ingredients from gravity models, such as population, country size and the distance between trading partners [33]. Alternatively, Acemoglu et al. (2001) use settler mortality to instrument for the quality of institutions in a country.

Dynamic panel models allow for superior identification strategies to account for shortcomings of the cross section analysis (Islam, 1998; Rodriguez and Rodrik, 2001). Using a first difference

[28] Both, the difference and the system GMM estimator build on the assumption of no serial autocorrelation in the error term such that $E[\epsilon_{i,s} \cdot \epsilon_{j,t}] = 0$ for all i,j and s,t. The use of five year intervals reduces possible problems of serial autocorrelation in the transitory component of the disturbance term. See Arellano Bond test in the results section.

[29] This is equivalent to: If $\tilde{\alpha}$ is significantly smaller than zero, the predictions from the literature on conditional convergence cannot be rejected.

[30] Barro and Lee (2001), Easterly (2001) and Barro and Lee (2010) make use of the Barro Lee database which contains different measures of primary and secondary education. Cohen and Soto (2007) employ information on educational outcomes provided by the UNESCO.

[31] see King and Levine (1993), Mauro (1995) and Rodrik et al. (2004).

[32] see Dollar (1992) and Hall and Jones (1999).

[33] Feyrer (2009) introduces a new instrument which varies over countries and time. This approach allows for a panel data approach to alleviate problems of endogeneity.

GMM estimator Caselli et al. (1996) conclude that previous findings underestimate the rate of conditional convergence [34]. The key advantage underlying the first difference GMM is the use of a panel structure of the data such that identification does not come from between country variation but makes use of within country variation. Furthermore, using first differences and then employing internal instruments offers a new route to eliminate problems of unobserved and time invariant country fixed effects such as geography, climate and most political and social institutions which only change slowly (so called deep determinants of economic growth). Later, Bond et al. (2001) introduce the system GMM estimator (Blundell and Bond, 1998) to alleviate the problem of weak instruments arising for the first difference GMM approach. In this context it looks questionable if the key identifying assumption of mean stationarity is satisfied and the resulting moment condition can be used for the identification of parameters in the empirical growth model. Accordingly, Moral-Benito (2010b) expresses his concerns about the validity of the system GMM estimator and proposes the LIML approach to estimate the dynamic growth regressions [35].

Within years, a large number of empirical studies identified a wide range of variables which contribute to a better understanding of economic growth [36]. Nevertheless, these findings do not offer any insights which of the variables are the most important determinants to understand differences in terms of economic growth across and within countries. Sala-i Martin et al. (2004) was among the first to employ "bayesian averaging of classical estimates" methods to discriminate among the large number of independent variables in the empirical growth literature. The underlying idea is to reduce problems of model uncertainty which relate to the number of variables included and to identify the most appropriate set of independent variables (Moral-Benito, 2010a; Ciccone and Jarocinski, 2010). Sala-i Martin et al. (2004) conclude that out of 67 variables, only 18 achieve a sufficient posterior inclusion probability which characterizes the probability that an independent variable should be added to an empirical growth model.

1.5.3 Independent variables

The empirical model, characterized in equation 1.2, includes a standard set of independent variables (Barro, 1991) [37]. We distinguish between two categories of variables (Caselli et al., 1996). First, state variables which characterize institutions in an economy and are measured at the beginning of the reference period (secondary education and life expectancy). Second, control variables, which result from the optimizing behavior of different agents in the economy (government policy or firm behavior). These variables are measured as averages over the reference period (investment and government share over GDP, price level of investment, level of integration

[34] Holtz-Eakin et al. (1988) introduces the idea of GMM estimation into the empirical growth literature. Arellano and Bond (1991) and Arellano and Bover (1995) provide excellent examples and further extensions on the first difference and system GMM. Among others, Levine et al. (2000) investigates the causal relationship between financial institutions and economic growth using a GMM approach.

[35] In fact, the limited information maximum likelihood estimator is a more general form of the two stage least squares procedure and was introduced into the literature in 1949. Due to computational problems this estimation method is rarely used (Anderson, 2005; Lai et al., 2008; Anderson et al., 2010).

[36] Durlauf et al. (2005) provide an excellent survey on findings from previous growth regressions and discuss their ability or inability to address the validity and predictions of both the exogenous and endogenous growth theory. Also Durlauf and Johnson (1995), Barro (1998) and Durlauf and Quah (1999).

[37] The selection of variables is to some degree random; nevertheless previous papers using the bayesian model averaging approach suggest that all our independent variables have a high posterior inclusion probability (Sala-i Martin et al., 2004)

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and openness) [38]. Using lagged independent variables reduces potential problems related to reversed causality, since values of the independent variables relate to time periods when the dependent variable was not yet realized. Nevertheless, problems of reversed causality and endogeneity remain if forward looking agents in the economy take decisions based on the expected realization of the dependent variable in the future [39] .

lagged GDP per capita. The set of independent variables includes the level of GDP per capita measured at the beginning of the time period of interest. By conditioning on the level of GDP per capita, we are able to interpret changes in the dependent variable as economic growth. Furthermore, the estimated coefficient on lagged GDP per capita allows for further insights regarding the discussion on convergence in the empirical growth literature.

secondary education. The theoretical literature on endogenous economic growth concludes that human capital accumulation enables countries to generate further economic growth even if the economy has already reached its steady state. For example, Mankiw et al. (1992) estimate an empirical model using the secondary enrollment rate – adjusted for the proportion of the population that is of secondary school age – to measure human capital. We include average years of secondary school attainment for adults as independent variable to control for differences in human capital (Barro and Lee, 2001, 2010).

life expectancy. The previous growth literature reasons that life expectancy captures additional information on human capital coming from the health status of the population. Similar to human capital accumulation, an increased level of life expectancy allows for a better growth performance of an economy (Sachs and Warner, 1995).

investment share. The neoclassical growth model emphasizes the importance of physical capital accumulation in an economy. Following the standard Solow growth model, the ratio of investment to output characterizes the saving rate in an economy and is expected to have a positive impact on economic growth (De Long and Summers, 1991).

price level of investment. To account for distortions of market prices in the economy, we include the price level of investment into the set of independent variables (Agarwala, 1983; Singh, 1992). Given that domestic but also foreign investment can be seen as important drivers for economic growth and heavily depend on investment conditions in an economy, we make use of the price level of investment defined as purchasing power parity of investment goods over the exchange rate in current prices with US dollar equal to one.

government share. The ratio of government expenditure, transfers and further government activity to overall GDP in an economy characterizes how much the government is involved into the economy. Given that government expenditure per se does not generate economic growth but contributes to some crowding out of private investment in an economy, the estimated coefficient is expected to be negative.

openness. The traditional concept of economic openness of an economy captures the trade volume and accounts for the exchange of goods and services with other countries. Economic

[38] Further information on descriptive statistics and data sources are summarized in the appendix.

[39] For example, when including education, we need to consider that people take into consideration the expected future level of GDP per capita when investing into their education (Bobba and Coviello, 2007).

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theory predicts that specialization allows for higher economic growth through the so called comparative advantage. Rodriguez (2007) includes the ratio of exports and imports to output in current international dollars as a measure for economic openness (Hall and Jones, 1999).

integration. The previous section focused on our new measure of integration which characterizes the position of a country in the global network (Kali and Reyes, 2007).Here, a higher level of integration allows for better access to international markets and thus increases the return to investment which translates into a higher growth rate of the economy. As discussed earlier, the empirical growth model in the following section explores alternative specifications of our measure of integration to test for robustness of empirical findings.

Results from the empirical analysis build on a set of 85 countries observed from 1965 to 2005. To reduce problems of attrition (possibly due to extreme political or economic changes), we only consider countries where data on dependent and independent variables is available for the entire sample period.

1.5.4 Identification strategy

Contemporaneous feedback effects (reverse causality), measurement error and unobserved country fixed effects can be seen as different sources for endogeneity and result in inconsistent estimated coefficients in the empirical growth model. For instance, making use of economic activity as dependent variable and using institutions in a country as independent variables, right hand side variables usually suffer from reverse causality. As a consequence, the exogeneity assumption does not hold any longer and most researchers using cross sections are only able to capture partial correlations instead of causality [40]. Furthermore, most variables are measured with a considerable measurement error. Since developing countries represent a large fraction of our sample, results heavily depend on the quality of data provided by their national statistics authorities. The upcoming discussion illustrates how alternative estimation strategies can be used to reduce the impact of above mentioned problems on estimation results.

The empirical identification strategy in this paper takes multiple steps to reduce problems from endogeneity. First, our measure of integration builds on direct and indirect links in the global trade network. In a theoretical framework, countries are only able to impact direct links (for instance using trade policies) which introduces serious problems of reversed causality. By taking into consideration higher order links our measure of integration establishes a methodology to mitigate potential problems of endogeneity. In addition to the standard measure of integration, the modified measure of integration only accounts for indirect links. As we have seen in the previous section, the high correlation between the standard and the modified measure suggests that our standard measure varies mostly due to indirect links. Second, most independent variables are calculated as average over a five year period preceding the year when we measure GDP per capita. Accordingly values for state and control variables are determined before the growth rate is measured. Also, this approach reduces measurement error in the set of independent variables. Third, identification in the empirical growth model builds on within country variation. Either by

[40] Using the notation introduced in this section, the condition on strict exogeneity can be stated as follows: $E[\epsilon_{i,t}|y_{i,t-1}, X_{i,t-1}, C_{i,t-1}, \rho_t, \eta_i] = 0$ with t=1 ... T and i=1 ... N. Coefficients in the empirical model can only be identified correctly, if the condition on exogeneity is satisfied for all independent variables.

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introducing a country dummy or by taking first differences we eliminate problems of unobserved country fixed effects which are possibly correlated with independent variables. The use of panel data with country fixed effects permits to control for all factors that are constant over time and which potentially affect the growth rate of income per capita. This approach reduces problems of endogeneity considerably. Fourth, we introduce additional moment conditions and make use of internal instruments to get around the finite sample bias in the within group estimator. Here, first difference and system GMM but also the LIML approach make use of internal instruments which eliminate endogeneity due to contemporaneous feedback effects.

OLS and within group estimator Under the assumption that unobserved country fixed effects η_i are correlated with independent variables in the model the traditional OLS estimator leads to inconsistent estimated coefficients [41]. Hsiao (2003) shows that due to $E[\eta_i \cdot y_{i,t-1}] > 0$, we expect an upward bias for the estimated parameter α.

Adding year and country dummies into the set of independent variables, identification of coefficients in the empirical model comes from within country variation. The finite sample bias with only eight time periods and 85 countries, raises problems of inconsistent estimates for the within group estimator. Nickell (1981) and Beggs and Nerlove (1988) illustrate that in response to the short time dimension the within group estimator induces inconsistent parameter estimates, with a downward bias for the estimated parameter α [42].

First difference and system GMM estimator Following the shortcomings of the OLS and the within group estimator we next focus on the first difference GMM and system GMM estimator which both allow for consistent estimates in a dynamic panel framework. The assumption that explanatory variables are predetermined implies a set of moment conditions that can be used in the context of GMM to generate consistent estimates of parameters of interest.

The first difference GMM estimator proposes some alternative route to eliminate the problem of endogeneity in a dynamic panel framework (Arellano and Bond, 1991). Under the assumption that moment condition 1.3 is valid, the estimation procedure first eliminates the unobserved country fixed effect by taking first differences (with $\Delta u_{i,t} = \Delta(\eta_i + \epsilon_{i,t}) = \Delta\epsilon_{i,t}$). Second, we instrument the difference of the independent variable with lagged levels of predetermined regressors or endogenous variables as instruments for subsequent first differences [43].

$$E[Z_{i,s} \cdot \Delta u_{i,t}] = E[Z_{i,s} \cdot \Delta\epsilon_{i,t}] = 0 \qquad \text{with} \quad s \leq \text{t-2}, \quad \text{t=3 ... T} \tag{1.3}$$

In addition to moment condition 1.3, first difference and system GMM both require the serial autocorrelation in the error term to be zero [44], such that

[41] An excellent discussion regarding the upward and downward bias in the OLS and within group estimator can be found in Caselli et al. (1996) and Bond (2002).

[42] The crucial problem behind the within group estimator is the idea of demeaning the data by subtracting the country specific mean $\bar{z}_i$ from each observation $z_{i,t}$ which yields $\tilde{z_{i,t}}$. Thereafter, we make use of the OLS estimator and regress $\tilde{y_{i,t}}$ on $y_{i,\tilde{t-1}}$ conditioning on the within deviation of additional independent variables and using the error term $\tilde{\epsilon_{i,t}}$. Following the model specification discussed in the previous section, $y_{i,\tilde{t-1}}$ and the transformed error term $\tilde{\epsilon_{i,t}}$ are negatively correlated, since $corr(y_{i,t-1}, -\epsilon_{i,t-1}) < 0$ and $corr(-y_{i,t}, \epsilon_{i,t}) < 0$.

[43] Assuming that error terms are serially uncorrelated and considering the dynamic nature of our model, $y_{i,t-2}$ is correlated with $y_{i,t-1} - y_{i,t-2}$ but not with $\epsilon_{i,t} - y_{i,t-1}$.

[44] Serial autocorrelation would suggest that lags of the dependent variable (or any other variable used as instruments that are not strictly exogenous) suffer from endogeneity and provide invalid instruments. For example, if AR(1) in levels occurs, $y_{i,t-1}$ is correlated with $\epsilon_{i,t-1}$ which implies a correlation between first differenced error

$$E[\epsilon_{i,t} \cdot \epsilon_{j,s}] = 0 \qquad \text{for each} \quad \text{i,j,t} \quad \text{and} \quad \text{s.} \tag{1.4}$$

The system GMM estimator makes use of additional moment conditions which improves efficiency relative to the first difference GMM approach (Blundell and Bond, 1998). Previous simulation exercises have shown that first difference GMM suffers from weak identification because past levels convey little information about future changes [45]. Thus, system GMM uses – in addition to the difference equation – level equations to obtain a system of two equations. For the equation in levels the lagged first differences of the explanatory variables are used as instruments. Instead of transforming the regressors to expunge the fixed effects, it differences the instruments to make them exogenous to the fixed effects. Consequently, the system GMM estimator converges more quickly than the first difference GMM estimator when explanatory variables are highly autocorrelated (Bond et al., 2001).

$$E[\Delta Z_{i,t-1} \cdot u_{i,t}] = E[\Delta Z_{i,t-1} \cdot (\eta_i + \epsilon_{i,t})] = 0 \quad \text{with} \quad \text{t=3 ... T} \tag{1.5}$$

Moment condition 1.5 requires that changes in the instrumenting variables are orthogonal to the unobserved country fixed effects such that $E[\Delta Z_{i,t} \cdot \eta_i] = 0$ for all i and t. This identifying assumption requires that throughout the study period faster growing countries are not systematically closer or further away from their steady states than slower growing ones. Hence $\Delta Z_{i,t}$ is a valid instrument for the variables in levels if deviations from the long run means are not systematically related to the unobserved country fixed effects. In reality we observe that initial conditions are not distributed according to the steady state distribution of the data generating process. For instance, many poor countries in Asia and Africa only achieved independence in the 1960s; over the sample period these former colonies show a different growth path which was strongly influenced by their colonial heritage such as ethnic conflicts and lack of institutions. This example illustrates that the country fixed effect (colonial status) did not only influence the initial level of GDP per capita but also the subsequent growth over the observation period.

Limited information maximum likelihood The previous discussion highlights a set of problems which complicate identification in a dynamic panel framework and suggests that previous attempts to mitigate these failures have not been fully convincing. More specifically, the large set of (potentially weak) instruments for the first difference GMM estimator and the condition on mean stationarity for the system GMM estimator question identification in most empirical models (Davidson and MacKinnon, 1993). Here, the LIML estimator outperforms the first difference GMM estimator in a finite sample with many (potentially weak) instruments (Godfrey and Wickens, 1982; Anderson, 2005; Lai et al., 2008; Anderson et al., 2010). The LIML estimation procedure builds on some earlier papers by Anderson and Rubin (1949, 1950), who introduced the LIML as a generalized instrumental variables estimation procedure (Bekker, 1994; Hahn and Hausman, 2002; Cameron and Trivedi, 2005).

$$E[\Delta\epsilon_{i,t-1} \cdot u_{i,t}] = E[\Delta\epsilon_{i,t-1} \cdot (\eta_i + \epsilon_{i,t})] = 0 \quad \text{with} \quad \text{t=3 ... T} \tag{1.6}$$

terms.

[45] Most variables in the empirical growth literature demonstrate a rather persistent time series behavior. Variables are close to a random walk and first differences are close to being innovations which will not identify any parameters of interest. Thus, it looks questionable if past levels are good instruments for subsequent differences in the model.

The LIML estimator identifies estimated coefficients by jointly estimating the first and the second stage by maximum likelihood. Here, homoscedasticity with respect to the error term in the first stage and joint normality is assumed [46]. In addition to the standard set of GMM instruments, the LIML estimator takes into consideration further moment conditions on the serial correlation of the error terms in condition 1.6. Accordingly the assumption on serial non correlation is crucial and requires the use of five year time intervals (see above). Comparing the LIML to the 2SLS estimator (either standard or GMM), under the assumption of homoscedastic errors both the feasible likelihood based estimator in a panel data context and the first difference GMM estimator yield asymptotically equivalent results.

1.6 Results in a Comparative Perspective

The previous discussion focused on different estimation strategies used in the empirical growth literature. Problems arise due to contemporaneous feedback effects, measurement error, unobserved country fixed effects and the dynamic panel model structure of the data. For the first difference and the system GMM estimator, the large number of internal instruments induces problems of over-fitting of the instrumented variables. First, we estimate a standard growth model including our measure of economic integration. In line with descriptive statistics and the theoretical framework, we find that integration into the global trade network contributes statistically and economically significantly to the growth performance of an economy. The section includes a detailed discussion of the most relevant test statistics to discriminate among the different estimation strategies. Second, we present additional results on alternative measures of economic integration. Instead of exploiting the number of steps needed to arrive from each country in the global trade network to country j, we construct and instrument which characterizes country j by an indirect measure of integration which only accounts for higher order links in the global trade network and counts the number of steps to arrive to country j - 1 (instrumental variable approach). Furthermore, a second robustness test only explores bilateral trade in manufacturing and investment goods.

1.6.1 Integration and economic growth: Number of steps

The empirical framework extends the standard empirical growth model by our measure of integration which accounts for the network position of an economy. Here, table 1.6 reports the main results from the empirical growth model including a measure of economic integration. The estimated coefficient on our measure of economic integration is negative and statistically significant. Given the nature of this measure of integration, these findings suggest a positive impact of economic integration on economic growth – which is independent of the estimation strategy. In comparison to the standard empirical growth model in table 1.5 (this model specification replicates standard growth models without any measure of integration), we observe that some coefficients change in sign, size and significance, which allows for additional insights on possible channels. It is worthwhile mentioning that especially the estimated coefficient on the investment share changes substantially. This supports the idea that investment can be seen as one of the channels which explain how an increased degree of integration affects economic

[46] Simulation studies suggest that a violation of the assumption of joint normality does not have a large impact on the estimation results (Anderson et al., 1982).

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growth.

The summary of our results follows the so-called bounding strategy which relates our results from the GMM and the LIML estimation procedure to earlier findings from simple OLS and within group estimators. In line with the previous discussion on the validity of different estimation strategies, we claim that the LIML estimator is most accurate. Estimated coefficients and test statistics in table 1.6 suggest that independent of the estimation strategy, the set of independent variables is able to capture differences in the growth performance. For the OLS and the within group estimator the adjusted R–squared and the p value on the F–statistic do not reject the validity of variables included into the set of independent variables [47]. For the first difference and the system GMM estimation, the p value on the Chi squared statistic is zero which supports the explanatory power of the set of independent variables. Given the huge differences of our estimation strategies it is not surprising that size and significance but also the sign of estimated coefficients differ substantially.

Estimation results from all specifications suggest the estimated coefficient on the level of lagged GDP per capita is highly significant and smaller than one. Accordingly, we cannot reject the idea of conditional convergence which suggests that poor countries catch up relative to rich countries. Remember from the discussion in section V, that the OLS and the within group estimator (specification OLS2, OLS3 and FEWG2, FEWG3) are inconsistent in a dynamic panel framework [48]. Nevertheless, the estimation results define an upper (0.916) and a lower bound (0.740) of the estimated coefficient on lagged GDP per capita [49].

Our estimation results in table 1.6 confirm the importance of human and physical capital for a successful economic growth performance of a country. Using the first difference and the system GMM estimator (specifications diffGMM2s2erc, diffGMM2s3erc and sysGMM2s2, sysGMM2s3) both the estimated coefficient on secondary education and the estimated coefficient on life expectancy are positive. For the OLS and the within group estimator, the estimated coefficient on the investment share is positive which suggests that additional investment increases ceteris paribus GDP per capita in an economy. Results change for the first difference and the system GMM estimator and the estimated coefficient turns slightly negative (not significant). Furthermore, the estimation results illustrate that an increase in the government share over GDP has a strikingly negative influence on the dependent variable — given the set of independent variables in the empirical model. As outlined in the description of the empirical model, the price of investment captures distortions in the economy and contributes negatively to economic growth.

Next, we discuss estimation results from the limited information maximum likelihood estimator (specifications LIML2 and LIML3) which are asymptotically equivalent to the first difference estimator. Given the shortcomings related to different estimation strategies which we have explored in the previous section, this estimation strategy does not suffer as much from the finite sample bias and the large number of weak instruments as for example the first difference GMM estimator. Furthermore, results do not rely on the assumption of mean stationarity (see system GMM estimator and upcoming discussion later in this section). The second specification

[47] The empirical model includes time dummies for the OLS estimation and additional country dummies for the within group estimation. Estimated coefficients are not reported in the tables in the appendix.

[48] OLS: upwards biased. Within: downwards biased. As a consequence further estimated coefficients in the set of independent variables are underestimated (OLS) or overestimated (within), if variables are positively correlated.

[49] Reported coefficients relate to specification 2 which includes a measure of integration into the set of independent variables, but does not account for openness (see table 1.6).

(specification LIML2) reports results adding our measure of economic integration into the set of independent variables. Estimated coefficients change substantially compared to our previous analysis using the difference and the system GMM estimator. Results even show that only the coefficients on lagged GDP per capita, government share and integration remain significantly different from zero. These findings are in line with Moral-Benito (2010a) and are also driven by the fact that identification in the empirical model only comes from within country variation [50]. Including a measure of openness (specification LIML3) does not have a huge impact on previous findings. We even find that in a model with both, a measure of integration and a measure of openness, the estimated coefficient on integration remains statistically significant from zero and impacts the growth performance of an economy [51]. This strengthens the idea that our network based approach to economic growth adds further wisdom on how globalization matters for economic growth. Additionally, these results suggest that openness and integration capture two different dimensions of globalization, which both seem to matter in terms of economic growth.

First difference GMM estimator The first difference GMM estimator allows for a large set of internal instruments for subsequent first differences: one instrument for each time period, variable and lag distance. The large set of instruments looks particularly appealing if weak instruments for the equation in first differences induce a downward bias of the estimated coefficient on lagged GDP per capita towards the within group estimator [52]. In the case of over-identification, we could reduce the number of instruments using two different strategies. Either, we restrict the number of lags considered as instruments or we collapse instruments by creating one instrument for each variable and lag distance (neglecting time) [53]. Our results make use of first difference GMM estimator with collapsed instruments. Here, specification tests check for endogeneity of different lags of the independent variables (Hansen J test statistics). To prevent problems from endogenous independent variables, we do not use the first lag to instrument first differences, but only start with the second lag in levels [54]. Furthermore, the covariance matrix is calculated using a two-step estimation procedure which accounts for robustness to panel specific heteroscedasticity and increases asymptotic efficiency compared to a one-step procedure [55].

Estimation results from the first difference GMM model confirm all the shortcomings we have discussed in the previous section. The estimated coefficient on lagged GDP is biased downwards

[50] Most variables in the empirical growth literature only change slowly, because it takes time until institutions reveal some impact on the structure of the economy. Nevertheless, standard results suggest that in a cross country analysis they are important determinants of economic growth.

[51] For the system GMM estimation and the LIML estimator, the estimated coefficient on openness becomes insignificant.

[52] In general, the literature recommends the number of instruments to be smaller than the number of clusters (countries).

[53] Roodman (2009) reports that collapsed instruments induce losses in efficiency but allow for additional information coming through a larger set of instruments.

[54] (a) exogenous (no correlation with contemporaneous or past error term). (b) predetermined (possibly correlated with past, but not the contemporaneous error term): $E[X_{i,t} \cdot \epsilon_{i,s}] \neq 0$ for s < t and $E[X_{i,t} \cdot \epsilon_{i,s}] = 0$ for $s \geq t$ such that $Y_{i,t-1}$ is a valid instrument. (c) endogenous (potentially correlated with past and contemporaneous error term): $E[X_{i,t} \cdot \epsilon_{i,s}] \neq 0$ for $s \leq t$ and $E[X_{i,t} \cdot \epsilon_{i,s}] = 0$ for $s > t$ such that $Y_{i,t-2}$ is a valid instrument. Same reasoning for model in first differences.

[55] Standard errors reported are calculated based on the Windmeijer correction (Windmeijer, 2005). Arellano and Bond (1991) and Blundell and Bond (1998) demonstrate that ordinary standard errors calculated in a two-step approach tend to be severely downward biased.

(0.658) even below the estimated coefficient from the within group model (0.740) which is possibly due to weak internal instruments. Furthermore, the Hansen J statistic (p value: 0.618) suggests that validity of instruments as a group cannot be rejected for standard confidence levels [56] [57]. The Arellano Bond test statistic relates to assumption 1.4 on serial autocorrelation and explores the null hypothesis of "no serial autocorrelation". The test for AR(2) in first differenced residuals tests the key identifying assumption that there is no second order serial correlation in first differenced residuals which is equivalent to the assumption of no AR(1) serial autocorrelation in the level error terms [58]. Test statistics from the Arellano Bond test reveal the existence of first order serial correlation in first differenced residuals (p value 0.001). At the same time, we reject second order serial autocorrelation in first differenced residuals (p value 0.393) such that assumption 1.4 holds.

System GMM estimator The first difference GMM estimator builds on the assumption that lagged levels are valid internal instruments for first differences. In addition, system GMM makes use of lagged first differences to include them as further instruments into the empirical model [59]. Compared to the first difference GMM estimator, estimated coefficients change in size and significance. We observe that some estimates move closer to the results we have already obtained from the OLS and the within group estimator. It turns out that the estimated coefficient on lagged GDP per capita (0.776) is now part of the interval characterized by the OLS (0.916) and within group estimator (0.740). These findings support our previous conclusion that the first difference GMM approach suffers from weak identification.

To address the validity of additional instruments used in the system GMM model, we first report the Hansen J test and second focus on results from the difference Hansen J test [60]. Compared to the first difference GMM estimation, the p value from the Hansen J statistic (0.596) decreases but stays above any conventional level of confidence. At the same time, the difference Hansen J statistic (p value 0.178) is not overly supportive for the validity of additional instruments used for the system GMM estimation. We split the sample according to initial GDP per capita. Results show that estimated coefficients change slightly for each sample whereas significance and sign remain constant across sub samples. Both test procedures in combination with theoretical reasoning bring us to the conclusion that the additional moment conditions for the system GMM approach are not valid. Here, the key identifying assumption behind the

[56] For an over-identified model, the Sargan over-identification test has the null hypotheses of "the instruments as a group appear exogenous", which implies that the moment conditions hold. Since the Sargan statistic is not robust to heteroscedasticity, we make use of the Hansen J statistics, which is the minimized value of the two-step GMM criterion function and is robust.

[57] Sargan (1958) finds that for an increased number of instruments, the Hansen J test statistic becomes weak and the p value is always close to one. In fact, most of the empirical growth models report p values close to one and do not reject the null of validity of instruments.

[58] AR(1) test in first differences: $E[\Delta\epsilon_{i,t} \cdot \Delta\epsilon_{i,t-1}] = E[(\epsilon_{i,t} - \epsilon_{i,t-1}) \cdot (\epsilon_{i,t-1} - \epsilon_{i,t-2})]$ which both share the $\epsilon_{i,t-1}$ such that we reject the null H0 of no autocorrelation. Next we move to AR(2) test in first differences: $E[\Delta\epsilon_{i,t} \cdot \Delta\epsilon_{i,t-2}] = E[(\epsilon_{i,t} - \epsilon_{i,t-1}) \cdot (\epsilon_{i,t-2} - \epsilon_{i,t-3})]$ where we do not reject the null of "no autocorrelation", such that AR(1) in levels is not autocorrelated.

[59] Roodman (2009) concludes that in case of a random walk variable, past changes may indeed be more predictive of current levels than past levels are of current changes.

[60] The incremental Sargan test (or difference Hansen J test) for over-identification restriction is based on the difference in the Sargan (Hansen) J test statistic between the system and difference specification and tests whether subsets of instruments are valid; e.g. those used for system GMM in addition to difference GMM (Blundell and Bond, 1998).

system GMM is violated, such that the system GMM specification cannot be used in the context of our empirical growth model.

Limited information maximum likelihood The previous discussion illustrates that OLS and within group estimator are inconsistent, and the difference GMM estimator suffers from weak identification. Furthermore, the system GMM estimator makes use of additional moment conditions which are not valid in the context of our research design. In line with Moral-Benito (2010b), we focus on estimation results from the LIML approach which is asymptotically equivalent to the first difference GMM estimator. The estimation strategy eliminates unobserved country fixed effects by first differences and includes time dummies into the empirical model. Results are based on the Broyden-Fletcher-Goldfarb-Shanno optimization method. Taking into consideration the validity of the additional moment condition on the structure of the error term (see equation 1.6), the LIML estimation strategy arrives to the strongest possible identification in a dynamic panel framework with a large set of potentially weak internal instruments.

1.6.2 Robustness tests using a modified measure of integration

Validity of previous results from the empirical growth model heavily depends on robustness to alternative specifications of our measure of integration. This section presents results from an instrumental variable approach. Based on the conjecture that direct links might be subject to contemporaneous feedback effects and introduce problems of endogeneity and inconsistent estimates, we estimate an alternative specification where only variation in higher order links is used as an instrument. Later, empirical findings explore an alternative measure of economic integration which does not account for bilateral trade on the aggregate level but focuses on trade in manufacturing and investment goods. This specification is much closer to the theoretical model discussed in section III. Results from both specifications support previous findings and suggest that economic integration has a positive impact on economic growth.

Instrumental variable approach using only indirect links Most variables in the empirical growth literature are plagued by endogeneity issues. As mentioned earlier, contemporaneous feedback effects induce inconsistent estimated coefficients, because independent variables such as institutions and government policies do not only foster economic growth but also the other way round. In the context of our measure of economic integration it is possible that higher economic growth favors the network position of an economy, for instance through increased bargaining power in bilateral or multilateral trade negotiations such as the World Trade Organization, the World Bank or the European Union. Our instrumental variable approach makes use of a modified measure of integration which exploits only higher order links. The modified measure for country j is constructed as the standard measure minus all direct links between country j and all its direct trading partners. Instead the last step is proxied by the geographic distance between the two countries (the appendix to this research paper includes a detailed discussion of the algorithm used to calculate the modified measure of integration). Assuming that a country j is only able to impact the formation of direct links between itself and any country i but not indirect links between any set of countries i and k, this modified measure allows for superior properties in terms of the exogeneity assumption.

Validity of the instrumental variable approach requires that the instrument is uncorrelated with the error term of the second stage. Any effect of the instrument Z on the dependent variable

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Y has to be channeled through the endogenous variable X. Apart from Z > X > Y there is no room for a direct channel from Z > Y as any effect that is generated by the change in Z is already captured by the resulting change in X. The modified measure Z is likely to not directly affect the growth rate Y as it is only a sub part of the standard measure X, but obviously a very important one (as the high correlation between Z and X indicates). In other words, the validity of the instrument is satisfied, as links between any two countries i and k are likely to be independent of the growth rate of country j.

Strength of the instrument depends on the correlation between the standard measure and the modified measure of integration. Descriptive statistics suggest that the correlation between the two different measures is 0.992. More specifically, the strength of the instrument builds on the idea that changes in higher order links influence the network position of country j in the global trade network. To illustrate this concept, we focus on the example of the North American Free Trade Area (NAFTA) which was established in 1995 and connects Mexico, the United States of America and Canada. If higher order links are important to describe the network position of Mexico, we should observe that subsequent to the formation of the NAFTA area, Mexico and the United States move much more in parallel in terms of the level of integration than before. This reflects the conceptional framework, that Mexico does not only benefit from direct trading links to other countries in the global trade network but also benefits from indirect trading links which connect the United States of America to the rest of the world. Figure 1.10 in the appendix to this paper show the time series profile for the two countries and confirms the previous thought experiment.

Altogether, we interpret the modified measure of integration as a valid and strong instrument to be used in the instrumental variables approach. Test statistics from the first stage suggest that the instrument is strong in a sense that the F–statistic (1149 and the p value is 0.000) and R–squared (0.9873) are high [61]. Using the instrumented level of integration as an independent variable in the second stage, empirical findings do not change significantly compared to previous findings and we still identify a positive impact of integration on economic growth (see table 1.7). Relative to the standard approach, discussed in the previous section (see table 1.6), most coefficients do not change in size, sign and significance. Most importantly, the estimated coefficient on the instrumented level of integration remains significantly negative and supports previous findings.

Bilateral trade in investment goods The theoretical model in Duernecker and Vega-Redondo (2013) postulates that integration has a positive impact on economic activity, mainly because links between countries can be interpreted as productive projects which generate further economic possibilities. So far we have proxied bilateral links by trade flows in goods and services. Since bilateral trade differs in terms of returns, we next distinguish between different categories of bilateral trade. The UN Comtrade data does not only provide information on bilateral trade between two countries on the aggregate level but also disaggregated for specific classes of products and services (Standard International Trade Classification codes, Revision 3). Our

[61] In the first stage, we regress the level of integration on the modified measure of integration and the set of independent variables which is also used in the second stage. Furthermore, we include time and country dummies. The p value on the instrument is 0.000 and the coefficient 0.893. Hereafter we calculate the predicted values and then introduce them into the second stage of the model to proxy for the standard measure of integration. Results for the second stage regression can be found in table 1.7.

modified measure of integration now only exploits trade in manufacturing and investment goods. Here, the algorithm we used to generate the measure of integration for each country and time period, is the same like the algorithm for the standard measure of integration. Descriptive statistics in tables 1.3 and 1.2 show the correlation between the standard measure and the investment measure is high (0.911).

Empirical findings in table 1.8 allow for a detailed discussion on how the investment measure of integration performs in an empirical growth model. Compared to results from the previous specifications in tables 1.6 and 1.7, some coefficients change slightly in size, sign and significance. For instance, the estimated coefficient on life expectancy is now positive and significant, whereas the estimated coefficients on investment share and government share remain insignificant. However, their size and sign is more in line with previous findings from the empirical literature. The estimated coefficient on the investment measure of integration remains negative and confirms previous findings: A higher level of economic integration has a positive impact on economic activity in an economy.

1.7 Conclusion and Policy Implications

This paper proposes a new route to incorporate a measure of economic integration into the empirical growth literature. In addition to previous attempts to explain the growth performance of countries using a wide set of independent variables, we introduce a new measure of integration which incoprorates the network structure of the global trade network. Using a unique data set of bilateral trade flows constructed from the UN Comtrade database, descriptive statistics suggest that this measure of economic integration captures a different dimension of globalization compared to the traditional measure of trade openness. The empirical analysis employs different estimation approaches to account for the particular needs of the dynamic panel structure. Our estimation strategy addresses problems of unobserved country fixed effects and allows for lagged variables in the dynamic panel framework. Furthermore, the estimation approach makes use of internal instruments to deal with the issue of contemporaneous feedback effects, which plagues most of the regression analysis in the empirical growth literature. Based on the limited information maximum likelihood estimation procedure, we find that our measure of integration of an economy is economically and statistically significant. A central network position has a positive impact on the growth performance of an economy which is distinct from the impact of economic openness. These findings are robust to alternative estimation strategies (first difference and system GMM, limited maximum likelihood approach) and variations in the underlying data. Estimation results suggest that parts of the positive effect of investment on economic growth go through the integration channel. Furthermore, our results confirm the concept of conditional convergence and suggest that countries with a lower level of GDP per capita today have higher growth rates and catch up with respect to high income countries.

From a policy perspective, our findings contribute to a better understanding of channels that explain how economic globalization is linked to economic growth. Here, we suggest that economic policy needs to distinguish between two different perspectives of globalization: first, the increased trade over GDP ratio which is discussed intensively in the previous literature; second, the network perspective of globalization which focuses on the network position of an economy in the global trade network. Whereas a positive estimated coefficient on openness suggests more exchange of goods and services per se boosts economic growth, a positive coefficient on economic

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integration underlines the importance of the network structure of global trade. In this context, we link our estimation results to the discussion on previous empirical findings on tariffs and trade agreements. We claim that bilateral agreements increase the level of openness but not necessarily the degree of integration. In this sense multilateral trade agreements like the World Trade Organization and the Doha Round and regional integration like the European Union and the Association of South-East Asian Nations offer further possibilities to enhance economic growth. From a development perspective we conclude that developing countries benefit from multilateral trade agreements since they provide access to additional markets and attract further investment.

Future research needs to elaborate on alternative data sets to construct our measure of integration. As discussed in the data section of this paper, our computations of the network based measure of integration build on bilateral trade flows between two countries i and j. Furthermore, we exploit a second approach which accounts for the composition of overall trade and differentiates between trade in manufacturing and investment goods from trade in natural resources. Since our theoretical framework predicts that especially foreign direct investment contributes to a better growth performance, we suggest that future research should elaborate on bilateral foreign direct investment flows. This variable offers additional possibilities to identify the relationship between the degree of integration of an economy into the world economy and its economic activity. Furthermore, future research could explore the relationship between economic integration, structural policies and economic growth. Growth patterns for South Korea, Mexico and Brazil suggest that governments can influence the process of international integration using a wide set of structural policies. This observation raises the question on which structural policies allow countries to leverage growth opportunities from economic integration? From a theoretical perspective, economic growth is a function of capital, labor but also economic integration and structural policies. Structural policies such as industrial policy affect national development through specialization and diversification. Thus, the effectiveness of such policies interacts with the extent of economic integration.

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Measure of Integration (Standard and Investment)

In the benchmark case, the measure of integration of country i is computed as the weighted average of the expected number of steps necessary to reach country i from any country j. The starting point for the computation is an $(n \times n)$-matrix A which is row stochastic as the one constructed in section III. We want to think of it as the adjacency matrix of a weighted directed network over n nodes. Each entry a_{ij} is the probability (weight) with which node i connects to node j in the network. Then the directed distance φ_{ij} from i to j is identified as the expected number of steps required to reach country j from country i when, at every node $k = 1, 2, ..., n$, each possible link $\overrightarrow{kl}$ is chosen with probability a_{kl}. To fix ideas think of a particle lying at i which can move to one of its neighbors j with probability a_{ij} (staying at i with probability a_{ii}).

To compute such expected magnitude it is useful to consider the $(n-1) \times (n-1)$ matrix A_{-j} obtained from A by deleting the jth row and the jth column such that the resulting matrix is no longer row stochastic. Here the probability that a path that started at i is at $k \neq j$ after r steps is simply $[(A_{-j})^r]_{ik}$, where $(A_{-j})^r$ is the rth fold composition of A_j with itself and $[\cdot]_{ik}$ stands for the ik-entry of the matrix $[\cdot]$. Thus the probability that it visits node j for the first time in step $r+1$ is simply $\gamma_{ij}(r+1) = \sum_{k \neq j} [(A_{-j})^r]_{ik} \; a_{kj}$. The expected number of steps to reach country i from any country j, $\varphi_{i,j}$ can be obtained using the following calculations.

$$\begin{aligned} \varphi_{i,j} &= \sum_{r=1}^{\infty} r \; \gamma_{ij}(r) = \sum_{r=0}^{\infty} (r+1) \; \sum_{k \neq j} [(A_{-j})^r]_{ik} \; a_{kj} \\ &= \sum_{k \neq j} \sum_{r=1}^{\infty} r \left[(A_{-j})^{r-1} \right]_{ik} \; a_{kj} = \left[\Big(\sum_{r=1}^{\infty} r \; (A_{-j})^{r-1} \Big)_{ik} \right]_{\substack{k=1,2,...,n \\ k \neq j}} \Big(a_{kj} \Big)_{\substack{k=1,2,...,n \\ k \neq j}}. \end{aligned}$$

Using a standard formula from linear algebra with $\sum_{r=1}^{\infty} r \; (A_{-j})^{r-1} = (I - A_{-j})^{-2}$, the (column) vector $\varphi_{i,j}$ can be written as column vector

$$\Big(\varphi_{ij} \Big)_{\substack{i=1,2,...,n \\ i \neq j}} = (I - A_{-j})^{-2} \; \Big(a_{ij} \Big)_{\substack{i=1,2,...,n \\ i \neq j}}.$$

Finally, note that, because A is a row-stochastic matrix, such that $a_{ij} = 1 - \sum_{k \neq j} a_{ik}$ and in consequence $\Big(a_{ij} \Big)_{\substack{i=1,2,...,n \\ i \neq j}} = (I - A_{-j}) \; e$ where e is the column vector $(1, 1, ..., 1)^{\top}$. Hence $\varphi_{i,j}$ can be computed from the following expression

$$\Big(\varphi_{ij} \Big)_{\substack{i=1,2,...,n \\ i \neq j}} = (I - A_{-j})^{-2} \, (I - A_{-j}) \; e = (I - A_{-j})^{-1} \; e.$$

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Indirect Measure of Integration (Instrument)

As mentioned earlier it is possible that the benchmark measure of integration is endogenous to the country's economic performance. A potential endogeneity results from a direct impact of a country's GDP on the country's trade flows with its immediate trading partners. In consequence all direct links of a country could be affected. This section discusses a proposal on how to modify the computation with the aim of making the measure of integration immune against endogeneity. The main underlying idea is to compute an *indirect* measure of integration which uses only the higher order trade connections of a country and disregards the potentially endogenous direct (first order) connections. As before in the benchmark case the key ingredient is the row stochastic matrix A. The computation of this indirect measure involves the following sequence of steps.

1. Pick a country $j \neq i$ and determine $\varphi_{m,j,-i}$, that is the expected number of steps required to reach node j from node $m \neq i$, conditional on **not** utilizing any of the links that involve node i. This concept implies that any path that connects j to m is not allowed to go through i. The connections from and to i are disregarded since these are the ones that may be endogenous to country i's GDP. The computation of $\varphi_{m,j,-i}$ largely follows the steps taken to compute the measure $\varphi_{m,j}$ in the benchmark case.

$$\varphi_{m,j,-i} = \sum_{k \neq i,j} \sum_{r=1}^{\infty} r \left[\left(A_{-i,-j} \right)^{r-1} \right]_{m,k} a_{k,j} \tag{1.7}$$

$A_{-i,-j}$ is a $(n-2) \times (n-2)$ matrix that is obtained from A by deleting the ith and the jth column, and additionally eliminating the ith and the jth row. $[\cdot]_{m,k}$ indicates the elements of the mth row and the kth column of the array $[\cdot]$. Rearranging equation (1.7) yields the following expression:

$$\varphi_{m,j,-i} = \left[\left(\sum_{r=1}^{\infty} r \left(A_{-i,-j} \right)^{r-1} \right)_{m,k} \right]_{k=1,2,...,n;k \neq i,j} \left(a_{k,j} \right)_{k=1,2,...,n;k \neq i,j} \tag{1.8}$$

where $\left(a_{k,j} \right)_{k=1,2,...,n;k \neq i,j}$ is an $(n-2) \times 1$ vector that is obtained from the jth column of matrix A by deleting the ith and the jth element. By using $\sum_{r=1}^{\infty} r \left(A_{-i,-j} \right)^{r-1} = \left(I - A_{-i,-j} \right)^{-2}$ and substituting it into (1.8), we obtain

$$\varphi_{m,j,-i} = \left[\left(I - A_{-i,-j} \right)^{-2}_{m,k} \right]_{k=1,2,...,n;k \neq i,j} \left(a_{k,j} \right)_{k=1,2,...,n;k \neq i,j} \tag{1.9}$$

2. In the next step, $\varphi_{m,j,-i}$ is computed for all combinations of (m,j), where $m = 1, 2, ..., n$ and $j = 1, 2, ..., n$, with $m, j \neq i$. This results in the $(n-1) \times (n-1)$ dimensional matrix $\left(\varphi_{m,j,-i} \right)^{n,n}_{m=1,j=1,m,j \neq i}$. An element of which gives us the expected number of steps from any country j to each of country i's potential trading partners $m = 1, 2, ..., n, m \neq i$. The key difference to the related matrix in the benchmark case, i.e. $\varphi_{m,j}$, is that here all connections from and to country i are disregarded.

3. With $\varphi_{\cdot,\cdot,-i}$ at hand, we have the information about how well country i's (potential) trading partners are integrated into the world wide trade network. To establish how integrated country i itself is, we need to have an indicator which measures the proximity of country

i to each of its (potential) trading partners. Notice that it is the direct links from i to all other countries which is critical when it comes to the issue of endogeneity. Therefore it is essential that an indicator is used which is disconnected as much as possible from country i's contemporaneous growth performance. Here we suggest to use the geographical distance measured in kilometers between countries. This choice has several merits: (a) it is strictly exogenous to country i's current and past GDP, (b) it has been shown that the geographical distance between two countries is a good proxy for the intensity of their bilateral trade relations, and (c) the data is accurate.

4. Let $geo_{i,m} = geo_{m,i}$ denote the geographical distance, in kilometers, between countries i and m. We use the inverse of which as a measure of proximity, i.e. $\omega_{i,m} = \frac{1}{geo_{i,m}}$. The higher is the distance between i and m the lower will be the implied weight $\omega_{i,m}$. The weights are re scaled in the following way

$$\tilde{\omega}_{i,m} = \frac{\omega_{i,m}}{\sum_{m \neq i} \omega_{i,m}} \qquad \text{such that} \quad \sum_{m \neq i} \tilde{\omega}_{i,m} = 1. \tag{1.10}$$

5. Using the weights $\tilde{\omega}_{i,m}$ together with the average path length from country j to each country $m \neq i$, $\varphi_{j,m,-i}$, we compute the expected number of steps from country j to country i as follows

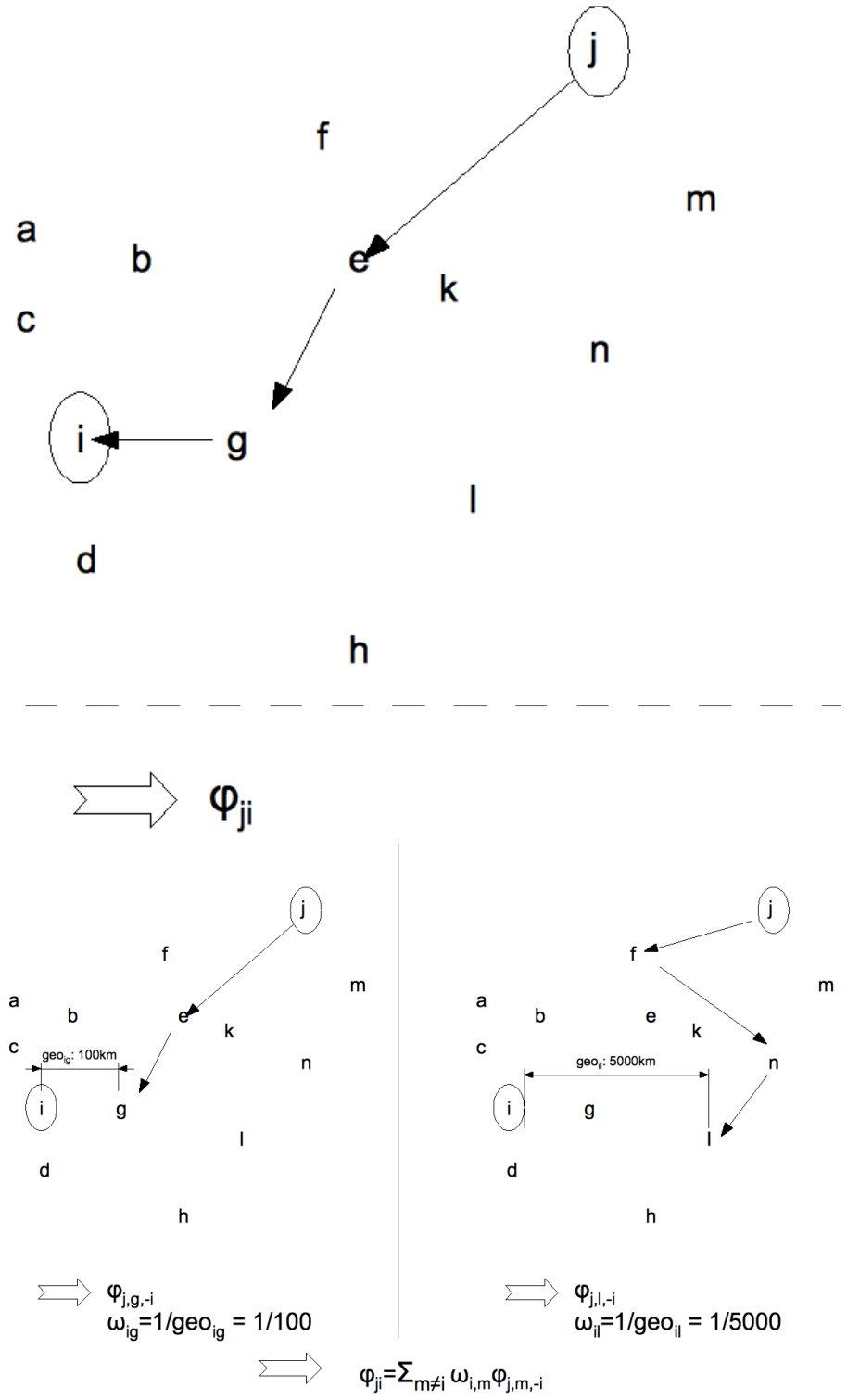
$$\tilde{\varphi}_{j,i} = \sum_{m \neq i} \tilde{\omega}_{i,m} \varphi_{j,m,-i}. \tag{1.11}$$

6. Lastly, after repeating the previous step for all $j = 1, 2, ..., n$ we can construct the *indirect* measure of integration of country i as

$$\sum_{j} \beta_j \tilde{\varphi}_{j,i} \qquad \text{where} \quad \tilde{\varphi}_{i,i} = 0. \tag{1.12}$$

To illustrate the difference between the benchmark indicator and the indirect integration measure, figure 1.1 depicts how the expected number of steps between j and i, $\varphi_{j,i}$, are computed in the benchmark case and in the modified version.

Figure 1.1: Two different measures of economic integration.



Notes: Measure of integration in the benchmark case (top) and using only higher order links (bottom). The empirical analysis explores both measures of integration for the empirical analysis and refers to the former as "integ (standard)" and to the later as "integ (instrument)". In addition a third measure of integration, called integ (investment)" is used which does not build on aggregate trade flows but refers to trade in investment goods.

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List of Countries

Afghanistan (4), Albania (8), **Algeria** (12), Angola (24), **Argentina** (32), **Australia** (36), **Austria** (40), Bahamas (44), Bahrain (48), Barbados (52), **Belgium** (56), Bermuda (60), **Bolivia** (68), **Brazil** (76), Bulgaria (100), Myanmar (104), **Burundi** (108), **Cameroon** (120), **Canada** (124), **Central African Rep.** (140), **Sri Lanka** (144), Chad (148), **Chile** (152), **China** (156), **Colombia** (170), **Congo** (178), **Dem. Rep. of the Congo** (180), **Costa Rica** (188), Cuba (192), Czechoslovakia (200), **Benin** (204), **Denmark** (208), **Dominican Rep.** (214), **Ecuador** (218), **El Salvador** (222), Ethiopia (231), **Fiji** (242), **Finland** (246), **France** (251), Djibouti (262), **Gabon** (266), **Gambia** (270), Germany (276), **Ghana** (288), Gibraltar (292), **Greece** (300), **Guatemala** (320), Guinea (324), Guyana (328), **Haiti** (332), **Honduras** (340), **Hong Kong** (344), Hungary (348), Iceland (352), **Indonesia** (360), **Iran** (364), Iraq (368), **Ireland** (372), **Israel** (376), **Italy** (381), **Cote d'Ivoire** (384), **Jamaica** (388), **Japan** (392), **Jordan** (400), **Kenya** (404), **Rep. of Korea** (410), Kuwait (414), Lao People's Dem. Rep. (418), Lebanon (422), Liberia (430), Madagascar (450), **Malaysia** (458), **Mali** (466), Malta (470), **Mauritania** (478), **Mauritius** (480), **Mexico** (484), **Morocco** (504), **Mozambique** (508), Oman (512), **Nepal** (524), **Netherlands** (528), New Caledonia (540), **New Zealand** (554), **Nicaragua** (558), **Niger** (562), Nigeria (566), **Norway** (579), **Pakistan** (586), **Papua New Guinea** (598), **Paraguay** (600), **Peru** (604), **Philippines** (608), Poland (616), **Portugal** (620), Qatar (634), **Romania** (642), Saudi Arabia (682), **Senegal** (686), **Sierra Leone** (694), **India** (699), **Singapore** (702), Somalia (706), **South Africa** (710), **Spain** (724), Sudan (736), Suriname (740), **Sweden** (752), **Switzerland** (757), **Syria** (760), **Thailand** (764), **Togo** (768), **Trinidad and Tobago** (780), **Tunisia** (788), **Turkey** (792), **Uganda** (800), Fmr USSR (810), **Egypt** (818), **United Kingdom** (826), **United States of America** (842), Burkina Faso (854), **Uruguay** (858), **Venezuela** (862), Yemen (887), Fmr Yugoslavia (890) [62]

Germany (until 1989)
Former Democratic Republic of Germany (278), Former Federal Republic of Germany (280)
Former Czechoslovakia (since 1993)
Czech Rep. (203), Slovakia (703)
Former Soviet Union (since 1992)
Azerbaijan (31), Armenia (51), Belarus (112), Estonia (233), Georgia (268), Kazakhstan (398), Kyrgyzstan (417), Latvia (428), Lithuania (440), Rep. of Moldova (498), Russian Federation (643), Tajikistan (762), Turkmenistan (795), Ukraine (804), Uzbekistan (860)
Former Yugoslavia (since 1992)
Bosnia Herzegovina (70), Croatia (191), Slovenia (705), Serbia and Montenegro (891)

[62] Country codes in brackets. Countries in bold are part of the empirical analysis.

List of Variables

lnyt: Logarithm of GDP per capita in 2005 constant prices. Real GDP per capita (Laspeyres) is obtained by adding up consumption, investment, government and exports, and subtracting imports in any given year. The given year components are obtained by extrapolating the 2005 values in international dollars from the aggregation using national growth rates. It is a fixed base index where the reference year is 2005. *Source: Penn World Table 6.3 (rgdpl).* The variable **lnyt_l** refers to the lagged logarithm of GDP per capita.

sed: Stock of years of secondary education in the total population. Level x years proceeding the year of measurement. *Source: Barro and Lee (2010) Education Data (yr_sch_sec).*

lnlex: Logarithm of the life expectancy at birth. Level x years proceeding the year of measurement. *Source: World Development Indicators 2005 (SPDYNLE00IN).*

ish: Investment share of real GDP per capita (rgdpl). Constant price GDP per capita and expenditure shares in 2005 constant prices. Average over x years time interval proceeding the years of measurement. *Source: Penn World Table 6.3 (ki).*

gsh: Government share of real GDP per capita (rgdpl). Constant price GDP per capita and expenditure shares in 2005 constant prices. Average over x years time interval proceeding the years of measurement. *Source: Penn World Table 6.3 (kg).*

ipr: Purchasing power parity numbers for investment goods. Price level of investment. Current price national accounts at PPPs in current prices. Average over x years time interval proceeding the years of measurement. *Source: Penn World Table 6.3 (pi).*

openk: Openness in constant prices. Constant price GDP per capita and expenditure shares in constant 2005 prices. Exports plus imports divided by real GDP per capita (Laspeyres, see above) is the total trade as a percentage of real GDP. The export and the import figures are in national currencies from the World Bank and United Nations data archives. This is the constant price equivalent of the openc variable and measures the total trade as a percentage of GDP. Average over x years time interval proceeding the years of measurement. *Source: Penn World Table 6.3 (openk).*

integ: Measure of integration calculated from bilateral trade data (see section III and IV). Average over x years time interval proceeding the years of measurement. *Source: UN Comtrade data.* The empirical framework uses three different measures of integration [integ (standard), integ (investment) and integ (instrument)] which differ in construction and underlying data.

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Robustness Tests and Specification Issues

GDP per worker (productivity): Traditionally GDP per capita is used as the dependent variable in the empirical growth literature. Alternatively GDP per worker reflects the productive assets in an economy. Using GDP per worker as dependent variable, some coefficients change slightly. Sign and significance for the measure of integration remain unchanged.

investment share and domestic investment: The Penn World Tables only provide information on the investment share in an economy (definition see above). Alternatively data taken from the World Bank offers further information on the level of domestic investment. Since we believe that international investment flows are an important channel for economic growth in an economy we stick to the former definition.

government share and consumption: The idea to include government activity into the empirical model reflects the assumption that government activity distorts prices in an economy and introduces inefficiencies. Government consumption itself only reflects the part of GDP that is spent through the government. Alternatively the government share includes consumption expenditure and services but also investment, transfers and redistribution which are paid by the government.

measure of political institutions: Following the previous empirical growth literature we introduce an additional variable which proxies for the political stability in an economy. The standard variable taken from the Polity IV database characterizes the level of democracy and autocratic systems. Our coefficient of interest, the estimated coefficient on integration, does not change in sign, size or significance.

seven and eight time periods: Following the criticism by Baghwati who reasons that results heavily depend on the time period analyzed, we reduce the number of time intervals considered. As expected estimation results change slightly but not significantly.

79 and 85 countries: Following the criticism by Baghwati who claims that results heavily depend on the set of countries analyzed we reduce the number of countries considered. As expected estimation results change slightly but not significantly.

Penn World Tables data 6.0 Penn World Tables data 6.1 Penn World Tables data 6.3 Penn World Tables data 7.0 and World Bank data: Ciccone raises concerns that results might depend on the data repository where the data is drawn from. In fact some estimated coefficients change slightly with respect to size but not with respect to significance. Consider that the sample period might change as well due to a different length of the time series. Corrected for the new sample period changes are still minor. Using the Penn World Table 7.0 we observe changes in the estimated coefficient on investment share (now 0.20 but still insignificant) and the estimated coefficient on integration which changes to -0.12 (and is still highly significant).

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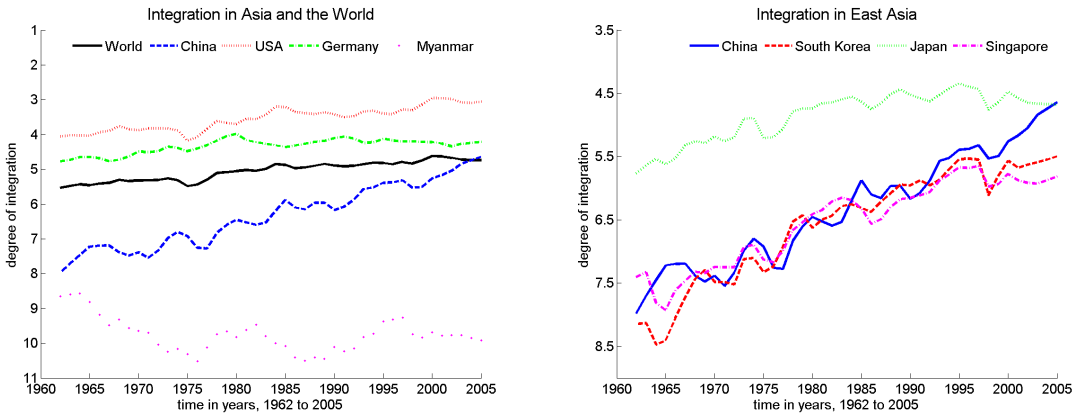
Economic Integration in Asia

Economic globalization benefited largely from a move towards more integration in East Asia and South East Asia. This section provides some descriptive statistics for a set of countries in this region and discusses time series profiles. We do not only focus on Japan which is characterized by a high degree of economic integration over the entire sample period but also discuss previous developments for South Korea and in particular China which experienced a substantial move towards more integration over the last 50 years. Furthermore we pay special attention to countries in South Asia (India, Pakistan, Sri Lanka and Nepal) and South East Asia (Indonesia, Malaysia, Thailand and Philippines). Findings illustrate the consequences from the Asian financial crisis in 1997 on economic integration.

Figure 1.2: Measure of integration for different countries in Asia 1



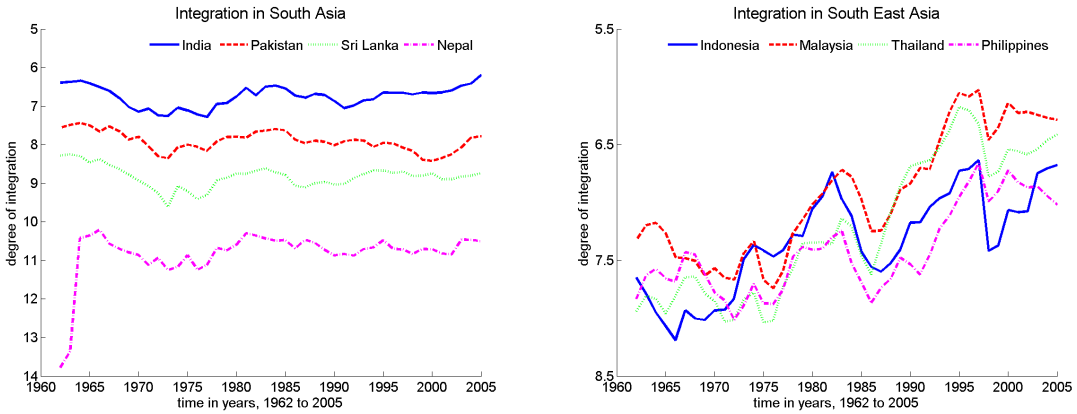
Notes: Time series profiles for different countries in Asia and East Asia using our measure of integration (standard). Source: UN Comtrade data 1962-2008. World Bank data. Penn World Tables data. Own calculations.

Japan is a highly industrialized economy which is well connected to international markets. Its economic success builds on a well established network position which enables the country to participate in the global value chain by importing natural resources and exporting high value products to trading partners all over the world. Economic integration for **South Korea** shows a similar pattern like Japan even if the economy started the process of economic integration some time later. The graphs suggest that South Korea experienced a significant slowdown during the Asian financial crisis when the degree of integration decreased again.

Our measure of the degree of integration highlights how **China** moved towards more globalization over the sample period from 1965 to 2005 (see discussion in section IV). Relative to the world average China closed a significant gap and today the country is characterized by more integration than the average of all other countries. Compared to mainland China **Hong Kong** benefited much earlier from special investment conditions and a different business environment which explains its distinct pattern of economic globalization and the high degree of economic integration. In a similar way economic integration in **Singapore** builds on its special geographic position and increased business opportunities due to an extremely market oriented government policy.

Compared to the previous examples **India and Sri Lanka** show a very different pattern of economic integration. In line with political ideology and implemented through the national planning commission India focused on domestic economic development. Our data illustrates the

Figure 1.3: Measure of integration for different countries in Asia 2



Notes: Time series profiles for different countries in South Asia and South East Asia using our measure of integration (standard).
Source: UN Comtrade data 1962-2008. World Bank data. Penn World Tables data. Own calculations.

strong links between India and the former Soviet Union. As a consequence the collapse of the Soviet Union to the beginning of the 1990s reduced Indian trade activities even further. An extreme example for a low degree of economic integration is **Nepal** which is geographically and economically isolated. Accordingly the country mainly trades through India or Bangladesh which both report low levels of economic integration as well.

To the end of the 1990s the Asian financial crisis affected economic development and international trade patterns for many economies in South East Asia and East Asia (and later on also in Latin America). **Indonesia, Thailand and Malaysia** experienced a substantial reduction in international capital flows and in consequence international trade decreased dramatically. In this context it is interesting to observe that the degree of economic integration in the **Philippines** decreased even further when the rest of the continent recovered slowly from the Asian financial crisis.

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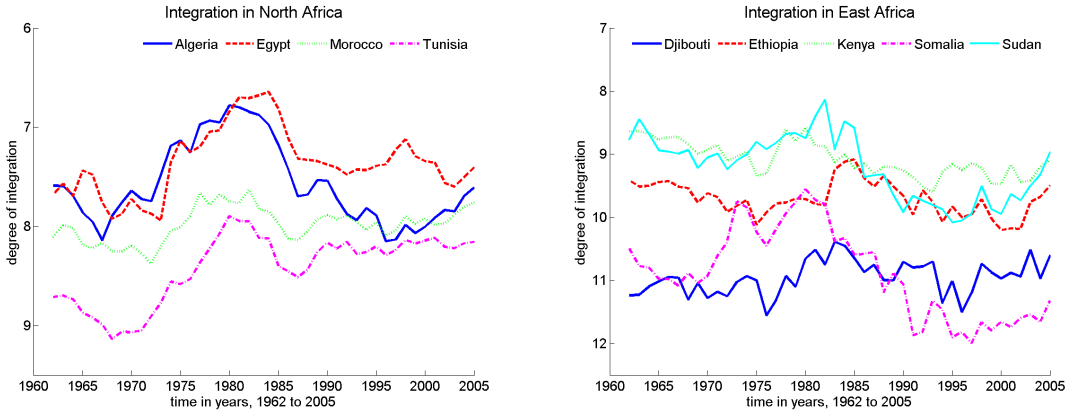
Economic Integration in Africa

Countries differ substantially in terms of their level and trend of economic integration. Previous descriptive statistics have shown that economic integration for African countries is rather low compared to the rest of the world. A closer look at a set of countries in different regions of Africa offers additional insights and illustrates the validity and strength of our measure of economic integration. In the following discussion we suggest that differences across countries can be linked to the historical heritage and the geographical situation which shape (economic) development outcomes.

Figure 1.4: Measure of integration for different countries in North Africa and East Africa



Notes: Time series profiles for different countries in North Africa and East Africa using our measure of integration (standard).
Source: UN Comtrade data 1962-2008. World Bank data. Penn World Tables data. Own calculations.

A widespread result from different empirical studies highlights the importance of the colonial background to understand the growth performance of an economy. In particular the global trade network preserves the influence of a past colonial structure of the world economy. For instance the francophone countries in the Mediterranean area (Maghreb) are still closely connected to France and benefit from special agreements with the European Union. The European Union has signed a wide set of bilateral agreements with Morocco, Algeria, Tunisia, Libya and Egypt which are summarized under the the so called European Neighborhood Policy. Furthermore the Barcelona process in 2010 started a discussion on the future formation of a Euro Mediterranean free trade area. In addition to its geographic closeness this explains why countries in **North Africa** experience a relatively high level of economic integration compared to many other countries in Africa. The strong co movement of countries in the sample highlights the close trade links between the countries in North Africa themselves.

East Africa has been a place with profound political challenges over the last years. Here Ethiopia is one example for sustainable economic and politic development. Nevertheless, this trend slowed down significantly when Ethiopia started a long lasting war with Eritrea which reduced further investment and had a negative impact on economic integration. At the same time the collapse of the Soviet Union which was a strong economic and political partner to Ethiopia destroyed existing trade links and contributed to the negative time trend in economic integration. Somalia has been trapped in a bloody civil war for many years which also impacted the level of economic integration negatively.

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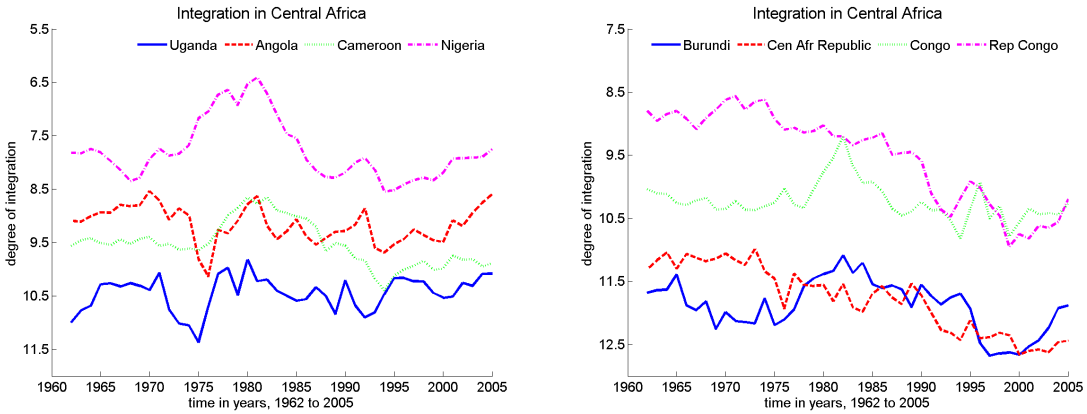
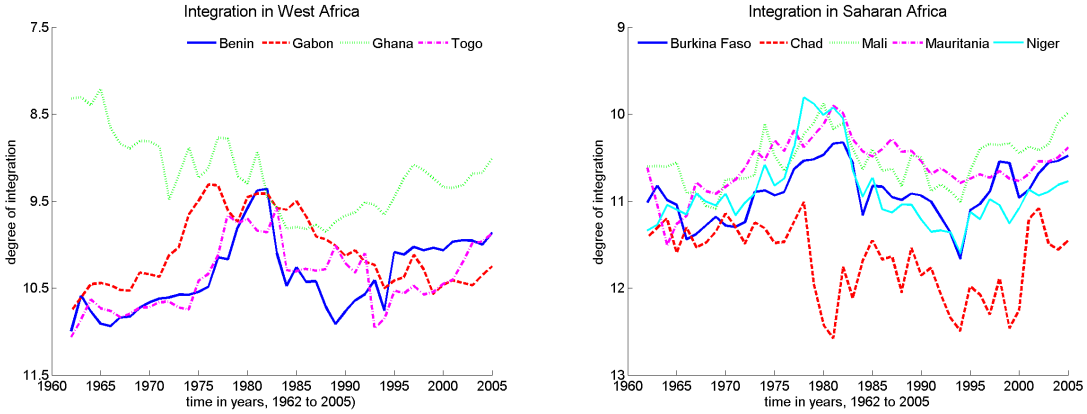
Figure 1.5: Measure of integration for different countries in Central Africa



Notes: Time series profiles for different countries in Central Africa using our measure of integration (standard).
Source: UN Comtrade data 1962-2008. World Bank data. Penn World Tables data. Own calculations.

With respect to the level and time trend of economic integration, countries in **Central Africa** show a significantly lower degree of integration than any other region in the sample. Most of the countries did not achieve further economic integration over time but remained isolated. In other words these economies do not participate in the global trade network. This pattern is mainly due to geographic isolation, lack of (transport) infrastructure and political instability. One interesting example in this group of countries is Nigeria. During the 1970s the country benefited economically from the increased exploitation of oil reserves. However in the subsequent time period from 1980 until 1994 political conflicts had a negative impact on economic integration which is well captured by the corresponding figure. Uganda is another example where our measure of economic integration varies due to civil war during 1971 and 1977.

Figure 1.6: Measure of integration for different countries in West Africa and Saharan Africa



Notes: Time series profiles for different countries in West Africa and Saharan Africa using our measure of integration (standard).
Source: UN Comtrade data 1962-2008. World Bank data. Penn World Tables data. Own calculations.

Many countries in **West Africa** are former French colonies. Following their independence in the 1960s they slowly integrated into the global trade network. Often trade mainly built on the exploitation of natural resources which often caused political instability. Another explanation for the differences between openness and integration (openness is rather high and volatile for African

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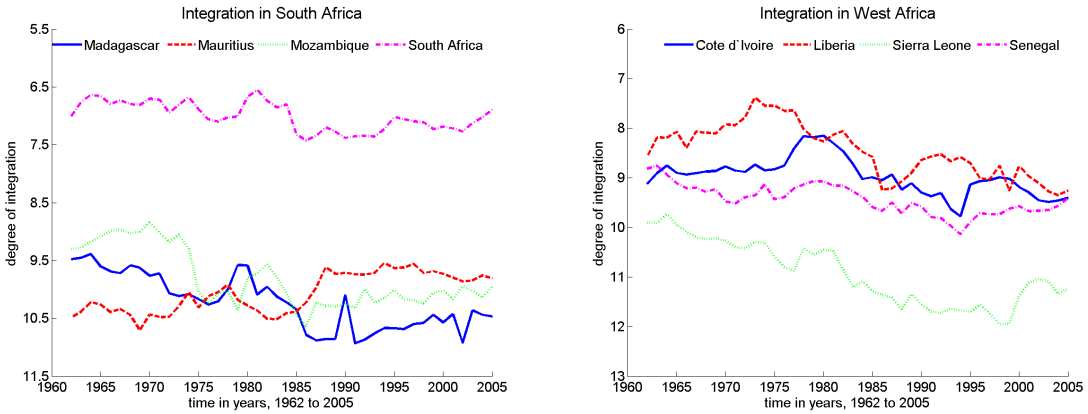
countries) comes from the composition of international trade. As mentioned earlier trade mainly relies on exchange of natural resources which according to our theoretical framework should not really translate into further economic growth. It is interesting to compare the standard measure of integration to the alternative measure of integration which exploits only trade in manufacturing and investment goods.

Figure 1.7: Measure of integration for different countries in South Africa and West Africa



Notes: Time series profiles for different countries in South Africa and West Africa using our measure of integration (standard).
Source: UN Comtrade data 1962-2008. World Bank data. Penn World Tables data. Own calculations.

The examples of Mauritius and Madagascar highlight the importance of geographic characteristics to better understand the observed level of economic integration. Both countries are sea locked which in general provides better access to international trading routes but also hinders economic interaction with neighboring countries. Both countries benefit from their possibilities to attract tourism. South Africa differs systematically from the rest of Africa in terms of ethnic and political conditions.

Descriptive Statistics and Estimation Results

Table 1.2: Summary Statistics: Dependent and independent variables.

Variable		Mean	(Std. Dev.)	Min.	Max.	N
lnyt	overall	8.614	1.087	5.744	10.730	N = 680
	between		1.055	6.681	10.309	n = 85
	within		0.284	7.508	9.955	T = 8
lnyt_l	overall	8.526	1.059	5.744	10.641	N = 680
	between		1.021	6.652	10.244	n = 85
	within		0.298	7.305	9.713	T = 8
sed	overall	1.582	1.208	0.023	5.261	N = 680
	between		1.061	0.063	4.839	n = 85
	within		0.586	-0.216	3.734	T = 8
lnlex	overall	4.122	0.190	3.537	4.395	N = 680
	between		0.175	3.665	4.337	n = 85
	within		0.076	3.881	4.340	T = 8
ish	overall	0.205	0.105	-0.008	0.576	N = 680
	between		0.098	0.035	0.474	n = 85
	within		0.041	0.057	0.396	T = 8
gsh	overall	0.166	0.076	0.042	0.616	N = 680
	between		0.069	0.044	0.521	n = 85
	within		0.033	0.015	0.383	T = 8
ipr	overall	77.236	56.713	18.276	646.164	N = 680
	between		46.132	28.075	266.908	n = 85
	within		33.319	-71.344	456.491	T = 8
integ (standard)	overall	8.070	1.917	2.950	12.665	N = 680
	between		1.889	3.475	11.892	n = 85
	within		0.381	6.697	9.440	T = 8
integ (instrument)	overall	6.081	2.032	-0.592	9.847	N = 680
	between		2.001	0.146	9.387	n = 85
	within		0.411	4.371	7.700	T = 8
integ (investment)	overall	9.928	1.861	4.546	15.256	N = 680
	between		1.721	5.711	13.538	n = 85
	within		0.730	7.964	11.759	T = 8
openk	overall	0.623	0.465	0.024	3.742	N = 680
	between		0.417	0.143	3.120	n = 85
	within		0.208	-0.217	2.622	T = 8

Notes: Summary statistics on variables included into the empirical framework.
Source: UN Comtrade data 1962-2008. World Bank data. Penn World Tables data. Own calculations.

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Table 1.3: Correlations between dependent and independent variables.

	lnyt	lnyt_l	sed	lnlex	ish	gsh	ipr	integ (standard)	integ (instrument)	integ (investment)	openk
lnyt	1.000										
lnyt_l	0.990	1.000									
sed	0.771	0.776	1.000								
lnlex	0.838	0.828	0.752	1.000							
ish	0.648	0.618	0.449	0.650	1.000						
gsh	-0.278	-0.261	-0.143	-0.149	-0.195	1.000					
ipr	-0.075	-0.059	-0.029	-0.122	-0.291	0.096	1.000				
integ (standard)	-0.773	-0.746	-0.632	-0.717	-0.623	0.213	0.072	1.000			
integ (instrument)	-0.759	-0.733	-0.637	-0.693	-0.599	0.215	0.076	0.992	1.000		
integ (investment)	-0.685	-0.657	-0.477	-0.584	-0.581	0.161	0.042	0.911	0.900	1.000	
openk	0.072	0.057	0.048	0.062	0.186	-0.084	0.021	0.077	0.107	0.133	1.000

Notes: Table of correlations for all variables included into the empirical framework.

Source: UN Comtrade data 1962-2008. World Bank data. Penn World Tables data. Own calculations.

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Table 1.4: Ranking of alternative measures of globalization.

	year 1970					year 1990					year 2005			
country	openk (1)	rank (2)	integ(3)	rank (4)	SW (5)	openk	rank	integ	rank	SW	openk	rank	integ	rank
Afghanistan	12.21	102	9.78	84		26.13	97	10.85	99		96.47	34	9.49	81
Albania	43.05	57	10.88	103		27.50	95	10.75	97		70.07	61	9.51	82
Algeria	91.42	19	7.64	36	0	73.97	32	7.54	39	0	71.88	59	7.61	45
Argentina	14.05	96	7.31	27	0	22.75	104	8.33	51	0	44.26	97	7.54	43
Australia	20.97	91	6.54	14	1	28.85	92	6.34	19	1	42.08	101	6.10	17
Austria	40.68	62	6.62	16	1	65.43	38	6.14	16	1	102.09	26	6.13	18
Bahrain	175.29	3	9.53	79		164.15	5	9.16	64		175.96	5	8.99	69
Belgium	86.08	23	5.50	9	1	124.59	10	5.09	9	1	169.57	6	5.15	11
Benin	58.48	41	10.67	97	0	36.19	80	10.77	98	1	50.12	92	9.86	85
Bolivia	45.58	54	9.84	85	1	47.38	59	10.44	92	1	67.64	64	10.14	93
Brazil	10.44	106	6.98	22	0	13.39	109	6.95	31	0	26.65	109	6.40	25
Bulgaria	76.06	29	8.26	53		74.85	30	8.71	54		136.63	13	7.89	50
Burkina Faso	37.64	70	11.28	107	0	59.15	49	10.94	101	0	33.95	105	10.48	99
Burundi	28.90	82	11.99	108	0	34.74	83	11.55	105	0	45.09	95	11.88	108
Cameroon	27.57	84	9.39	73	0	30.56	90	9.56	75	0	41.78	102	9.88	87
Canada	39.22	66	5.45	8	1	49.94	56	5.08	8	1	71.92	58	4.71	7
Central African Republic	45.64	52	11.06	105	0	44.93	67	11.72	107	0	33.50	106	12.44	109
Chad	45.62	53	11.14	106	0	45.54	64	11.85	108	0	80.96	45	11.45	107
Chile	26.29	85	8.02	48	0	47.41	58	8.08	47	1	74.14	55	7.40	40
China Version 1	11.38	104	7.38	29	0	25.36	100	6.17	18	0	67.25	65	4.64	5
Colombia	22.49	90	8.09	49	0	26.01	98	8.26	50	1	43.84	99	7.68	46
Congo DemRep	39.39	63	8.62	56	0	92.21	20	9.59	77	0	79.77	46	10.20	94
Congo Rep	100.91	10	10.35	91	0	102.76	17	10.24	90	0	136.54	14	10.28	96
Costa Rica	42.96	59	9.23	71	0	61.66	44	9.11	62	1	102.65	25	8.35	58
Cote d'Ivoire	78.23	28	8.77	59	0	63.45	41	9.30	70	0	98.09	32	9.40	79
Cuba	32.79	78	8.62	55		31.41	89	8.94	58		36.36	104	9.19	74
Denmark	35.83	73	6.52	13	1	61.94	43	6.54	20	1	92.84	36	6.60	28
Dominican Republic	63.57	38	9.19	70	0	60.50	48	8.80	55	0	65.53	68	8.20	54
Ecuador	35.31	74	9.10	68	1	41.55	73	9.25	67	0	62.66	73	8.52	62
Egypt	80.05	25	7.73	38	0	62.33	42	7.37	36	0	64.16	71	7.41	41
El Salvador	34.13	75	9.51	77	0	33.80	84	9.51	73	1	71.72	60	8.61	64
Fiji	92.18	17	10.40	93		134.06	8	10.48	94		127.58	18	10.50	101
Finland	33.73	76	6.92	20	1	41.92	72	6.74	25	1	78.07	48	6.70	30
France	19.72	93	5.05	4	1	32.71	85	4.47	3	1	52.98	88	4.56	3
Gabon	96.61	12	10.35	90	0	87.69	23	10.13	86	0	98.30	31	10.25	95
Gambia	52.98	45	12.01	109	0	72.29	34	11.54	104	1	111.47	21	11.08	105
Germany	25.27	87	4.49	2	1	40.66	74	4.11	2	1	76.75	49	4.21	2
Ghana	174.79	4	8.81	60	0	58.88	50	9.67	79	1	97.74	33	9.01	70
Greece	15.60	94	7.13	23	1	36.71	78	6.94	30	1	54.71	86	6.83	34
Guatemala	68.09	35	9.19	69	0	45.65	63	9.14	63	1	66.05	66	8.33	56
Guyana	114.66	8	10.10	87	0	124.41	11	11.40	103	1	210.27	4	10.93	103
Haiti	14.16	95	10.64	96	0	24.15	103	10.15	87	0	51.29	90	9.95	88
Honduras	164.03	5	9.53	78	0	113.68	15	9.66	78	0	136.49	15	8.46	59
Hong Kong	102.70	9	6.87	18	1	189.56	2	5.88	12	1	384.87	2	5.41	13
Hungary	25.07	88	6.89	19	0	36.52	79	7.59	40	0	133.54	16	6.75	32
Iceland	63.76	37	9.66	82		60.63	47	9.49	72		75.98	51	9.22	75
India	11.91	103	7.15	24	0	17.05	106	6.86	29	0	44.31	96	6.19	20
Indonesia	46.53	51	7.93	45	0	46.59	60	7.17	32	1	62.92	72	6.67	29

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Table 1.4: Ranking of alternative measures of globalization (table from previous page continued).

	year 1970					year 1990					year 2005			
country	openk (1)	rank (2)	integ(3)	rank (4)	SW (5)	openk	rank	integ	rank	SW	openk	rank	integ	rank
Iran	86.18	22	7.32	28	0	75.76	29	7.35	35	0	60.72	76	7.33	39
Iraq	89.54	20	8.65	57	0	186.86	4	7.79	41	0	157.59	8	8.10	52
Ireland	43.04	58	7.45	32	1	77.94	28	6.84	27	1	151.44	9	6.28	22
Israel	47.01	50	7.59	35	0	60.81	45	7.17	33	1	87.74	40	6.88	35
Italy	27.90	83	5.21	6	1	42.58	71	4.78	6	1	52.18	89	4.85	8
Jamaica	70.34	33	8.71	58	1	107.22	16	9.19	66	1	101.95	27	9.06	72
Japan	10.77	105	5.18	5	1	16.86	107	4.53	4	1	27.28	107	4.68	6
Jordan	36.19	72	9.41	74	1	128.56	9	8.85	56	1	146.11	11	8.47	60
Kenya	72.08	31	8.93	63	0	43.02	70	9.26	68	0	64.62	69	9.09	73
Korea Rep	12.87	99	7.48	33	1	32.56	86	5.96	13	1	82.81	43	5.49	14
Kuwait	91.53	18	8.20	52		79.11	26	8.62	52		94.19	35	8.10	51
Laos	12.74	101	10.74	99		35.26	82	12.03	109		58.03	80	10.96	104
Lebanon	70.71	32	8.15	50		123.74	12	9.07	61		64.20	70	8.60	63
Liberia	146.14	6	7.92	44		64.38	40	8.64	53		86.82	41	9.26	76
Madagascar	134.82	7	9.77	83	0	57.23	51	10.10	85	0	73.78	56	10.47	98
Malaysia	79.16	27	7.57	34	1	139.83	7	6.84	26	1	212.10	3	6.28	23
Mali	36.95	71	10.75	100	0	45.73	62	10.50	95	0	57.94	81	9.98	90
Malta	323.90	1	9.62	81		188.07	3	9.17	65		160.56	7	8.96	67
Mauritania	74.12	30	10.84	101	0	96.42	18	10.55	96	0	117.27	20	10.38	97
Mauritius	96.40	13	10.44	95	1	158.66	6	9.71	81	1	125.71	19	9.81	84
Mexico	12.77	100	6.94	21	0	22.34	105	6.10	15	1	61.55	75	5.21	12
Morocco	38.62	68	8.19	51	0	44.93	68	7.88	44	1	69.42	63	7.76	48
Mozambique	42.08	60	8.84	61		49.77	57	10.24	91	0	74.85	52	9.96	89
Nepal	13.25	98	10.86	102	0	31.53	88	10.87	100	0	45.29	94	10.49	100
Netherlands	52.79	46	5.30	7	1	78.34	27	4.99	7	1	131.67	17	4.92	9
New Zealand	30.25	80	7.85	43	0	43.46	69	7.92	45	1	58.15	79	7.57	44
Nicaragua	33.73	77	9.59	80	0	40.44	75	10.45	93	0	87.83	39	9.39	78
Niger	39.39	64	10.92	104	0	73.84	33	11.22	102	0	50.50	91	10.77	102
Nigeria	51.40	47	7.93	46	0	56.44	53	8.19	49	0	54.35	87	7.76	47
Norway	54.97	44	6.61	15	1	65.63	37	6.73	24	1	72.80	57	6.83	33
Oman	95.77	14	10.30	89		87.33	24	9.26	69		98.67	30	8.87	66
Pakistan	38.90	67	7.79	40	0	32.09	87	8.01	46	0	38.61	103	7.78	49
Papua New Guinea	70.10	34	9.44	75		70.70	36	9.70	80	0	138.47	12	10.07	91
Paraguay	44.44	56	10.44	94	0	95.40	19	9.53	74	1	106.80	24	9.55	83
Peru	29.98	81	8.30	54	0	24.54	102	9.03	60	0	44.21	98	8.33	55
Philippines	47.38	48	7.78	39	0	74.32	31	7.53	38	1	111.18	22	7.02	37
Poland	20.14	92	7.26	26	0	27.72	93	7.33	34	0	74.51	53	6.31	24
Portugal	30.32	79	7.41	30	1	44.99	66	6.73	23	1	65.60	67	6.50	27
Qatar	92.46	16	9.91	86		90.11	22	9.48	71		101.71	28	8.51	61
Romania	2.43	109	7.70	37		25.83	99	7.81	42		76.54	50	7.13	38
Saudi Arabia	83.65	24	8.02	47		79.73	25	6.64	21		85.30	42	6.72	31
Senegal	65.77	36	9.48	76	0	65.35	39	9.58	76	0	69.60	62	9.41	80
Sierra Leone	57.22	43	10.27	88	0	45.13	65	11.55	106	0	55.08	85	11.24	106
Singapore	276.13	2	7.24	25	1	339.37	1	6.15	17	1	446.06	1	5.81	15
South Africa	62.99	39	6.70	17	0	38.40	76	7.38	37	0	56.09	84	6.90	36
Spain	13.99	97	6.44	12	1	27.62	94	5.48	10	1	56.69	82	5.11	10
Sri Lanka	98.37	11	8.93	62	0	54.80	54	9.03	59	0	74.50	54	8.74	65
Sudan	62.80	40	9.05	66		29.33	91	9.92	84		45.43	93	8.96	68

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Table 1.4: Ranking of alternative measures of globalization (table from previous page continued).

	year 1970					year 1990					year 2005			
country	openk (1)	rank (2)	integ(3)	rank (4)	SW (5)	openk	rank	integ	rank	SW	openk	rank	integ	rank
Sweden	39.24	65	5.99	11	1	53.30	55	6.02	14	1	89.73	38	6.15	19
Switzerland	37.72	69	5.94	10	1	60.65	46	5.65	11	1	91.12	37	5.83	16
Syria	79.18	26	8.97	65	0	71.30	35	8.94	57	0	80.97	44	8.34	57
Thailand	57.23	42	7.85	42	1	90.50	21	6.69	22	1	149.50	10	6.41	26
Togo	47.24	49	10.72	98	0	56.68	52	10.22	89	0	79.03	47	9.87	86
Trinidad &Tobago	88.92	21	8.95	64	0	119.73	13	9.80	83	0	107.98	23	9.04	71
Tunisia	93.72	15	9.07	67	0	117.41	14	8.16	48	1	99.74	29	8.16	53
Turkey	10.27	107	7.83	41	0	24.63	101	6.86	28	1	62.20	74	6.19	21
Uganda	41.89	61	10.39	92		27.08	96	10.20	88		42.76	100	10.08	92
United Kingdom	25.51	86	4.94	3	1	36.97	77	4.58	5	1	56.60	83	4.57	4
United States	10.22	108	3.87	1	1	16.47	108	3.43	1	1	26.93	108	3.05	1
Uruguay	24.02	89	9.35	72	0	36.16	81	9.75	82	0	59.52	78	9.27	77
Venezuela	44.48	55	7.42	31	0	46.47	61	7.86	43	1	60.13	77	7.49	42

Notes: Rows are labeled as follows. First, the measure of openness (openk) in levels (1) and ranks (2). The standard measure of openness is defined as exports plus imports divided by GDP. Export and the import figures are in constant 2005 prices from the World Bank and United Nations data archives. Second, the degree of integration (integ - standard) in levels (3) and ranks (4). In both cases, the ranking for openness and integration depends on the relative position in terms of openness and integration. Third, the Sachs and Warner measure (5) which characterizes the country's trade policy and is coded zero is the country is closed and one if the country is open.
Source: UN Comtrade data 1962-2008. World Bank data. Penn World Tables data. Sachs and Warner data. Own calculations.

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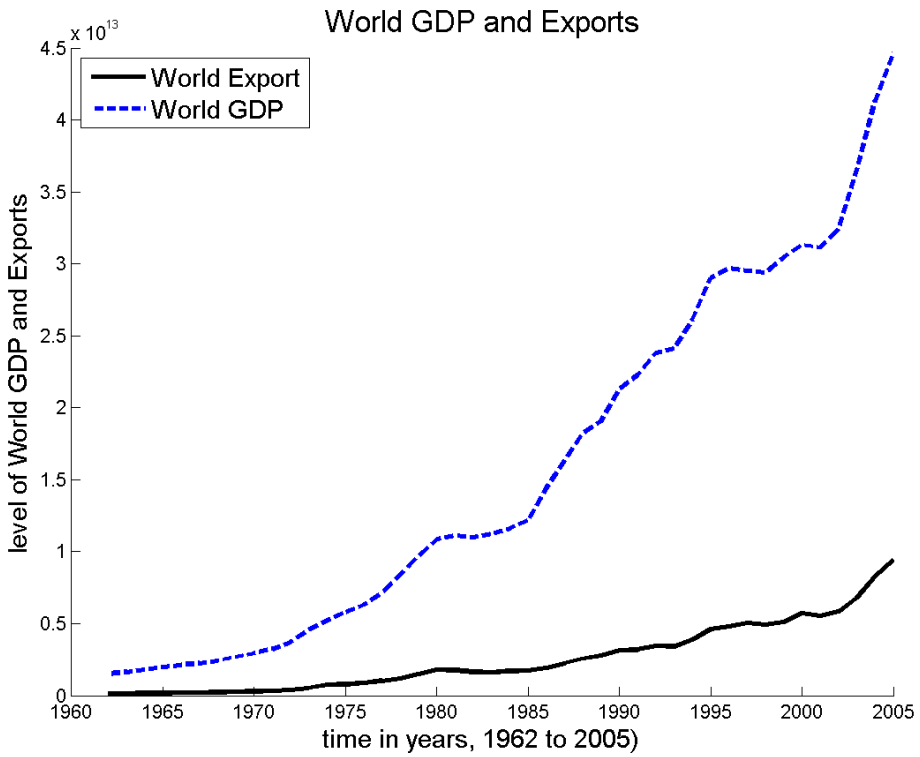
Figure 1.8: World GDP and global exports.



Notes: Global output increased significantly between 1960 and 2005; at the same time political and technological change benefited exports.
Source: UN Comtrade data 1962-2008. World Bank data. Own calculations.

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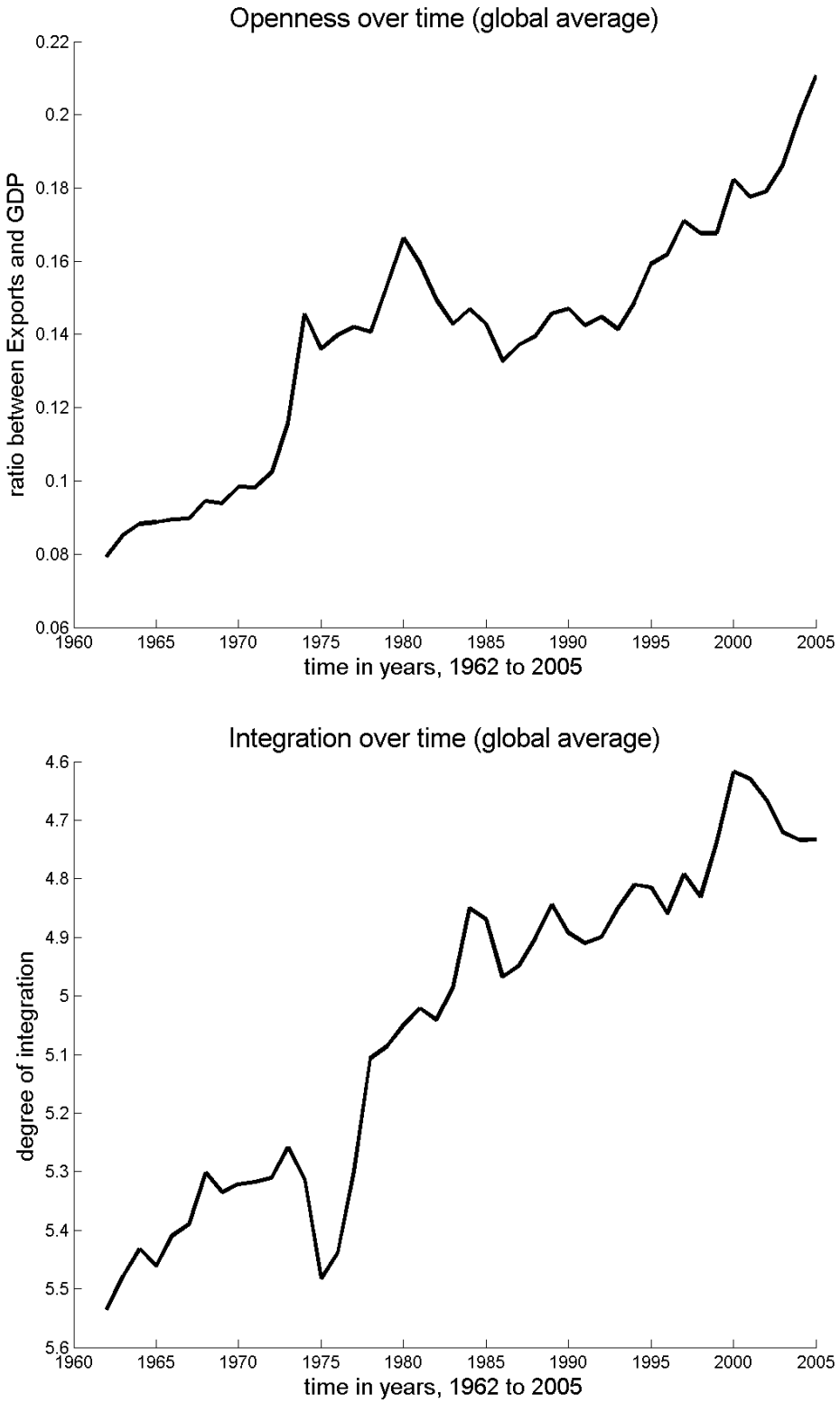
Figure 1.9: Economic globalization between 1962 and 2005.



Notes: Global average for the standard measure of openness (top) and our measure of economic integration (bottom). The measure of economic integration captures the distance to other countries in the global network. Accordingly, a high level implies that a country is less integrated. Both, openness and integration show a positive time trend and reflect the process of globalization.
Source: UN Comtrade data 1962-2008. World Bank data. Own calculations.

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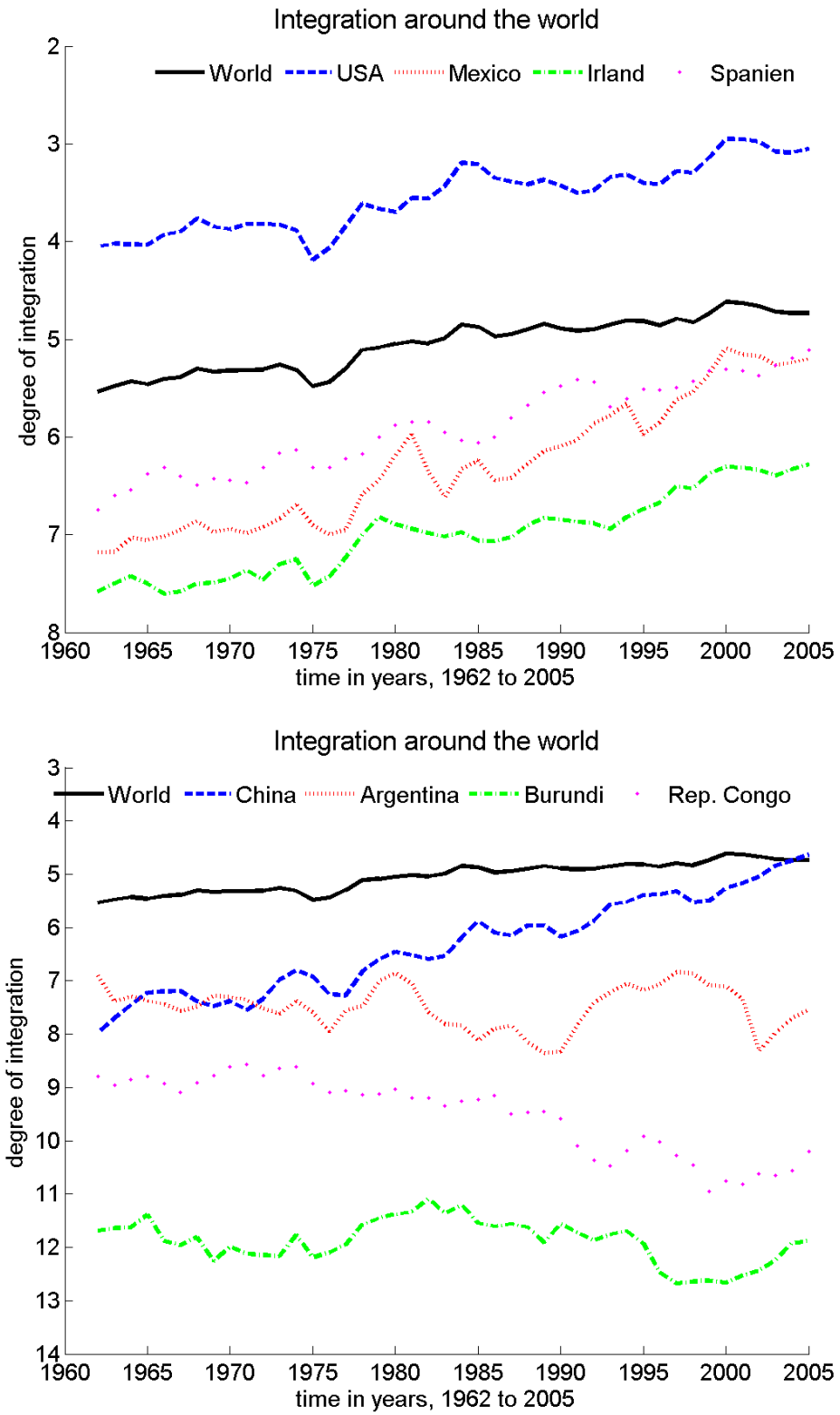
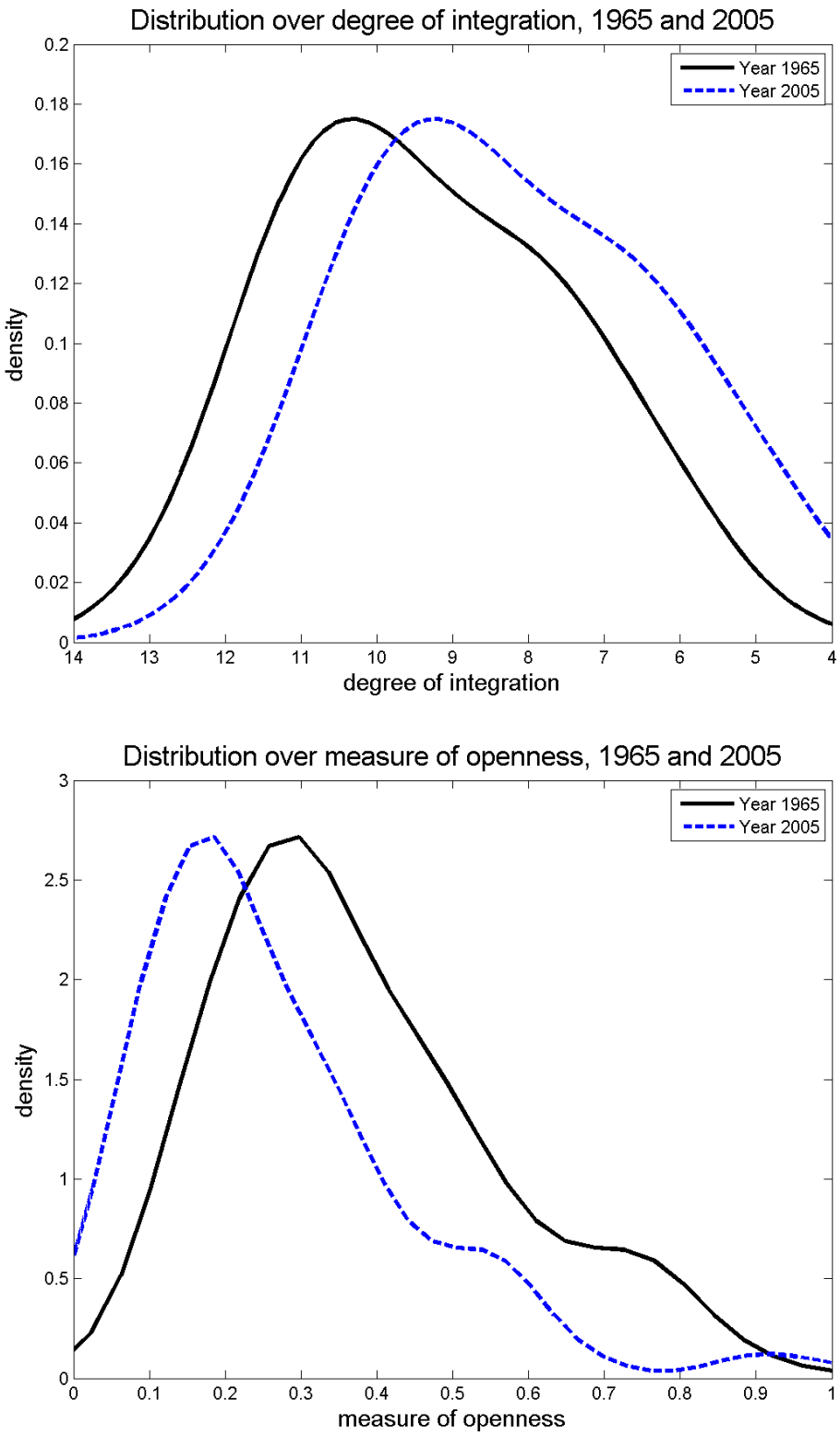
Figure 1.10: Measure of economic integration in a global perspective.



Notes: Country examples for USA, Mexico, Ireland and Spain (top); China, Argentina, Burundi and Republic of Congo (bottom). The time series profile illustrates the process of globalization and shows that participation into the global trade networks differs significantly across time and countries.
Source: UN Comtrade data 1962-2008. World Bank data. Own calculations.

Figure 1.11: Kernel density distribution for integration and openness.



Notes: Kernel distribution over the level of integration (top) and the level of openness (bottom) for two different time periods, 1965 and 2005.

Source: UN Comtrade data 1962-2008. World Bank data. Own calculations.

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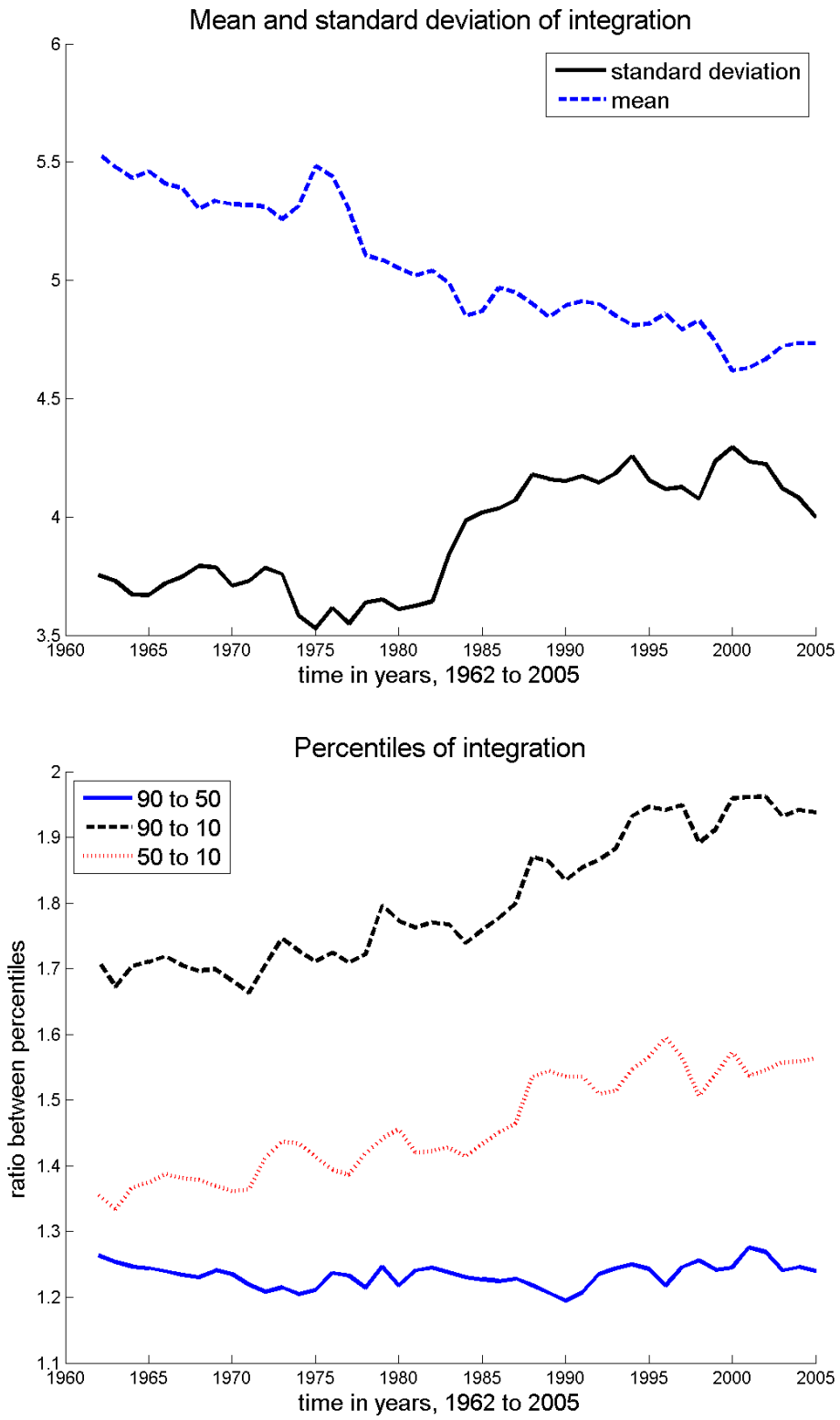
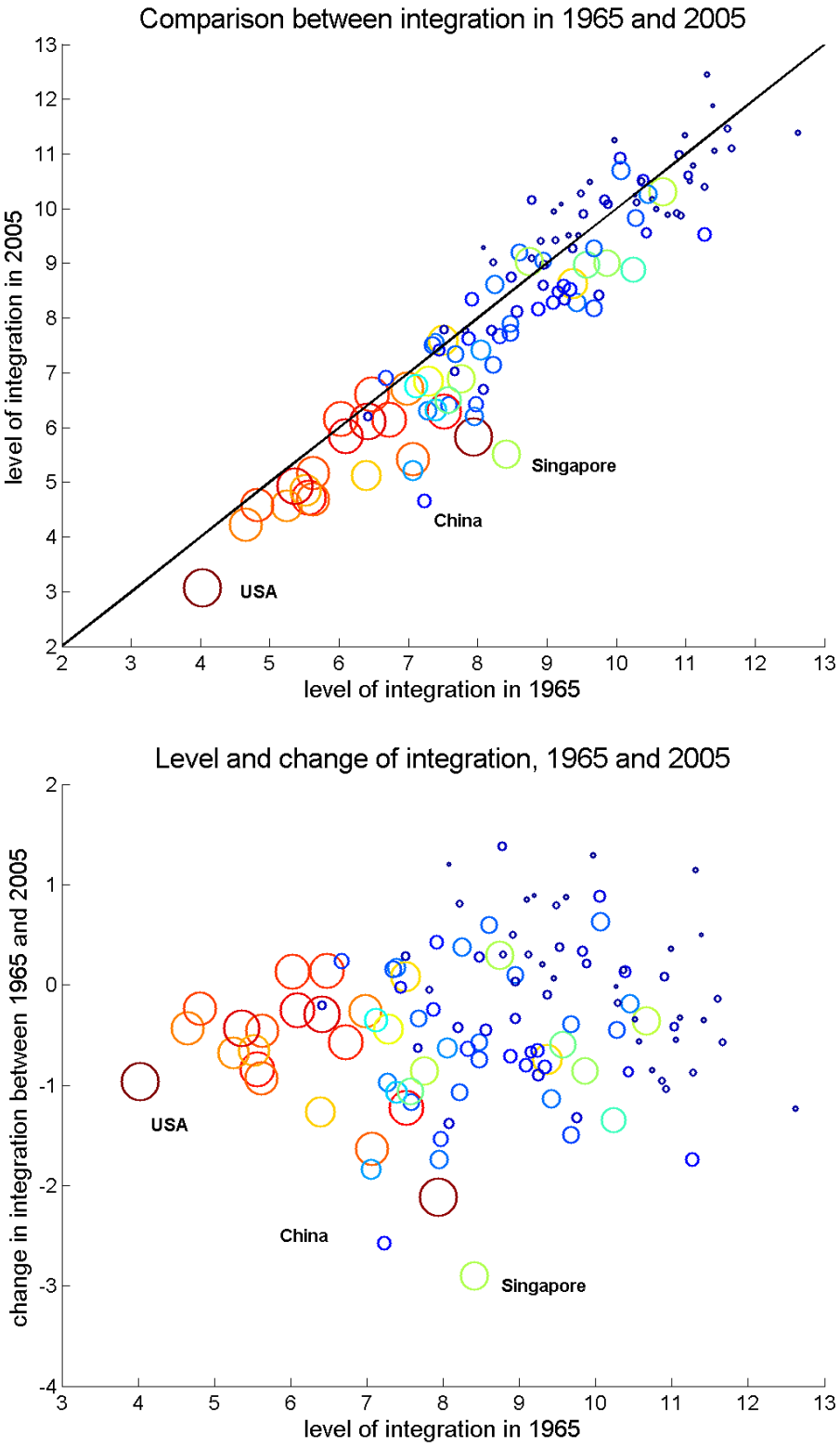
Figure 1.12: The distribution of economic integration.



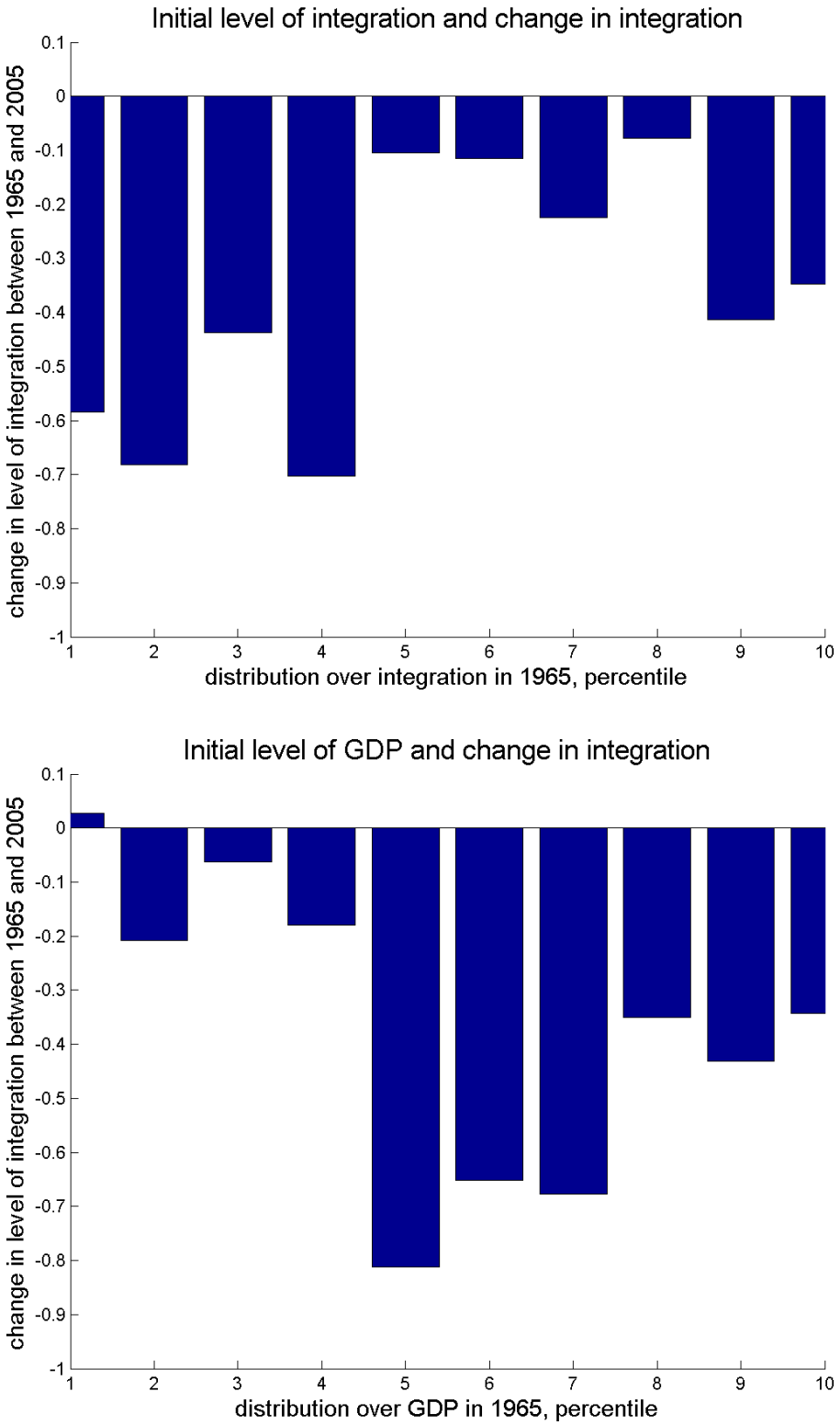
Notes: Mean and standard deviation of our measure of economic integration (top). Different percentiles taken from the distribution of integration (bottom). Differences persist and the world seems to become more unequal over time. Source: UN Comtrade data 1962-2008. World Bank data. Own calculations.

Figure 1.13: Economic integration in the years 1965 and 2005.



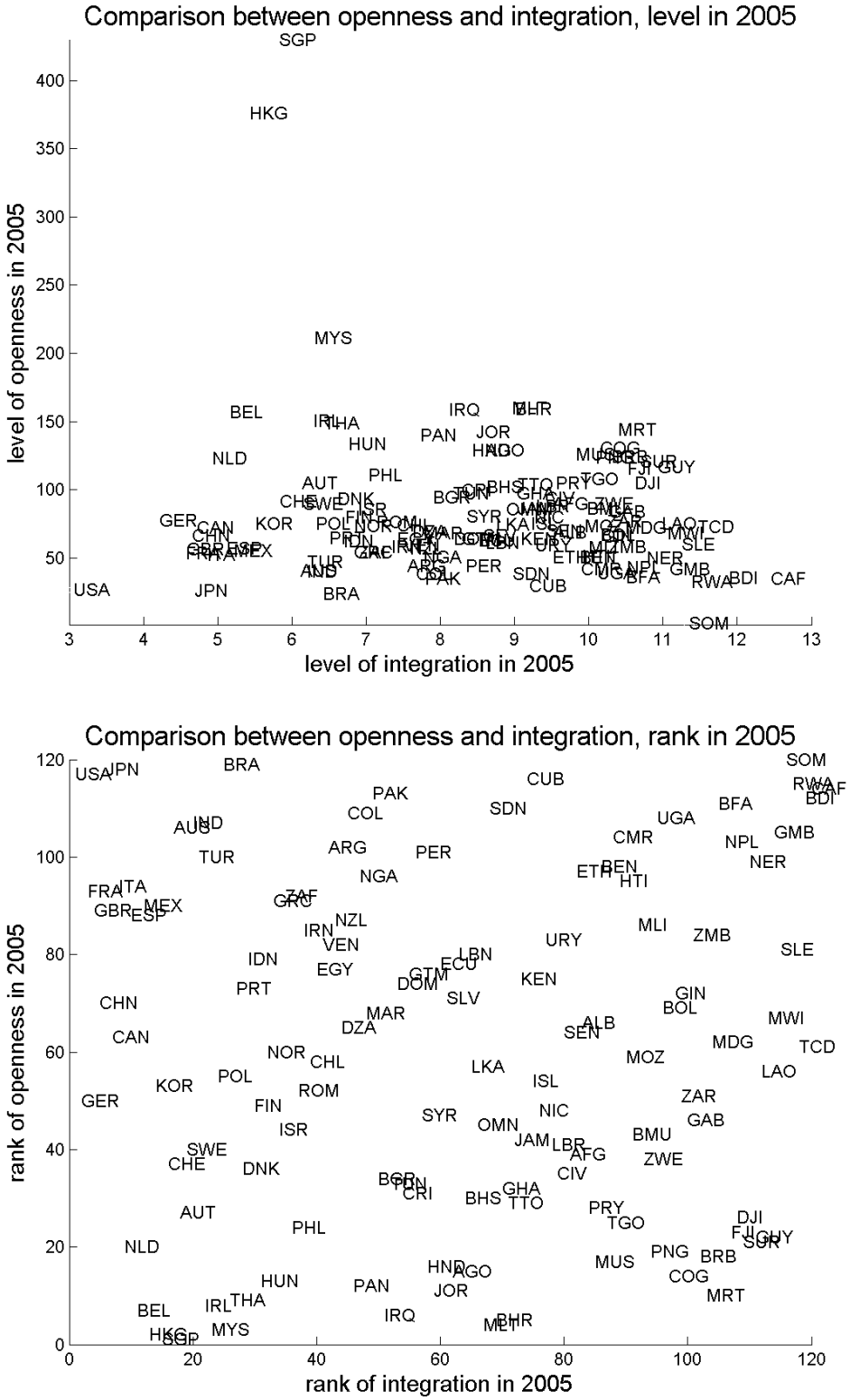
Notes: Comparison between the level of integration for two different time periods, years 1965 and 2005 (top). Countries below (above) the 45 degree line became more (less) integrated for the year 2005 than they were in the year 1965. The growth rate of integration between 1965 and 2005 relative to the initial level in the year 1965 (bottom). The size of circles is relative to per capita GDP in the United States of America.
Source: UN Comtrade data 1962-2008. World Bank data. Own calculations.

Figure 1.14: Integration in the initial time period influences outcomes in the future.



Notes: Growth incidence curve for the average growth rate of integration by percentile. Categories reflect the percentile of the distribution of the level of integration (top) and the level of GDP (bottom) in the initial time period in 1965. The figure suggests that the gap between the front runners and those left behind has increased dramatically.
Source: UN Comtrade data 1962-2008. World Bank data. Own calculations.

Figure 1.15: Openness and integration. Comparison in level and rank.



Notes: Correlation between openness and integration in the year 2005. The first figure explores the level of openness and integration (top) and the second figure the rank in these two measures (bottom). The two measures of openness and integration describe two completely different dimensions of globalization; no linear or non linear relationship exists. Source: UN Comtrade data 1962-2008. World Bank data. Own calculations.

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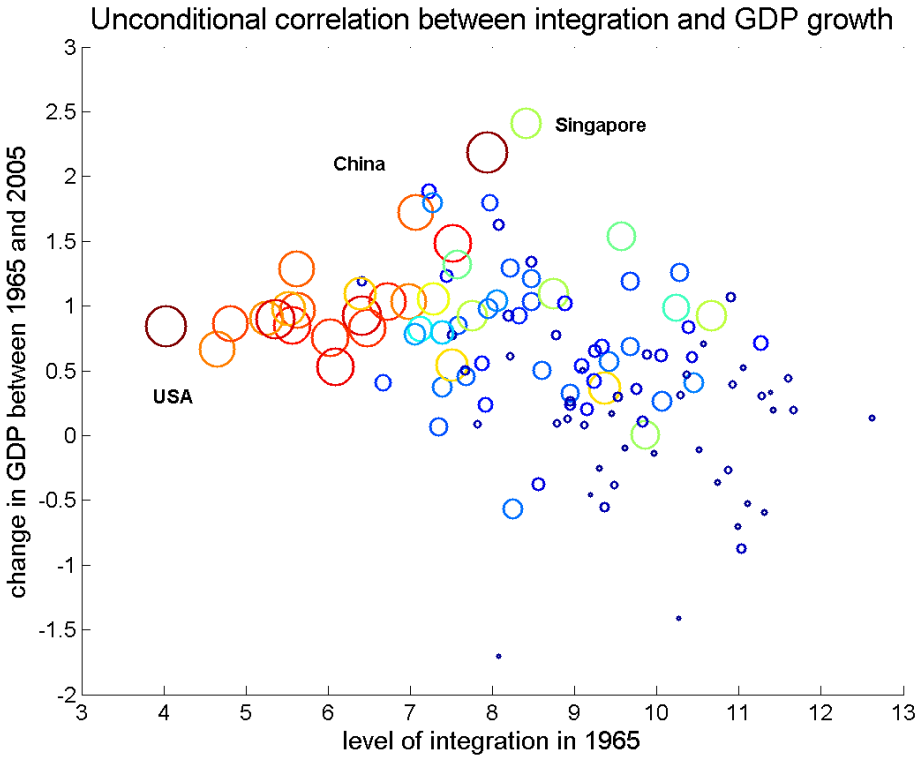
Figure 1.16: Economic integration and GDP growth between 1965 and 2005.



Notes: Unconditional correlation between the level of integration in the year 1965 and the change in GDP per capita between 1965 and 2005. The comparison between the two variables suggests that countries which were more integrated to the beginning of the sample in 1965 also grew faster for the subsequent time period between 1965 and 2005.
Source: UN Comtrade data 1962-2008. World Bank data. Own calculations.

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Table 1.5: Different specifications of the empirical growth model (baseline model).

	OLS0	OLS1	FEWG0	FEWG1	diffGMM2s0erc	diffGMM2s1erc	sysGMM2s0	sysGMM2s1	LIML0	LIML1
	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.
lnyt_1	0.928***	0.927***	0.848***	0.835***	0.771***	0.678***	0.891***	0.867***	0.966***	0.934***
	(0.013)	(0.013)	(0.041)	(0.045)	(0.097)	(0.108)	(0.044)	(0.043)	(0.030)	(0.0029)
sed	0.017**	0.018**	0.016	0.013	0.107	0.130*	0.025	0.049	0.009	0.030
	(0.007)	(0.007)	(0.018)	(0.018)	(0.077)	(0.073)	(0.037)	(0.033)	(0.027)	(0.028)
lnlex	0.349***	0.369***	0.099	0.192	0.128	0.245	0.497***	0.456**	–0.006	–0.009
	(0.061)	(0.062)	(0.174)	(0.178)	(0.535)	(0.433)	(0.189)	(0.191)	(0.154)	(0.159)
ish	0.388***	0.330***	0.475**	0.351**	0.336	0.440	0.470*	0.466*	0.607***	0.582***
	(0.102)	(0.100)	(0.181)	(0.149)	(0.425)	(0.316)	(0.274)	(0.254)	(0.166)	(0.173)
gsh	–0.301***	–0.283***	–0.222	–0.213	–0.911**	–0.769	–1.007***	–0.971***	–0.548***	–0.392**
	(0.083)	(0.079)	(0.217)	(0.227)	(0.452)	(0.498)	(0.284)	(0.353)	(0.195)	(0.196)
ipr	0.000	–0.000	–0.000	–0.000	0.001	0.000	0.001	0.000	–0.001	–0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
openk		0.032**		0.101*		0.221		0.064		0.052
		(0.013)		(0.054)		(0.163)		(0.068)		(0.034)
Constant	–0.807***	–0.900***	0.807	0.478			–1.087	–0.782		
	(0.217)	(0.224)	(0.870)	(0.876)			(0.741)	(0.765)		()
N	680	680	680	680	595	595	680	680	680	680
Clusters	85	85	85	85	85	85	85	85	85	85
vcetype	Robust	Robust	Robust	Robust	Corrected	Corrected	Corrected	Corrected	Robust	Robust
esttype					difference	difference	system	system	liml	liml
R squared (adj)	0.985	0.985	0.987	0.987						
ll	416.732	420.472	505.745	513.571						
chi2					1390.636	1628.884	178.627	113.613		
chi2p					0.000	0.000	0.000	0.000		
j					42.000	48.000	49.000	56.000		
hansenp					0.598	0.620	0.469	0.476		
hansenp					0.598	0.620	0.469	0.476		
ar1p					0.001	0.010	0.000	0.000		
ar2p					0.175	0.314	0.148	0.216		

Notes: Dependent variable in this model is the log of per capita GDP. diffGMM2s and sysGMM2s are the two step difference GMM (system GMM) estimation results. Robust standard error are reported in (). For the two step estimates standard errors are Windmeijer corrected. * significant at 0.10 level, ** 0.05 level, and *** 0.01 level. Values reported for the Hansen J test are p values for the null hypothesis of instrument validity. Diff Hansen reports the p- value for validity of additional moment restrictions required by system GMM. Values reported for AR(1) and AR(2) are p- values for first and second order auto correlated disturbances in first equations. For LIML estimation the number of parameters includes all variance and covariance parameters. To derive results we used the Broyden - Fletcher - Goldfarb - Shanno optimization method. Time dummies are included in the model, but not shown in the result tables. Five year panel, between 1975 and 2005. Source: UN Comtrade data 1962-2008. World Bank data. Penn World Tables data. Own calculations.

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Table 1.6: Different specifications of the empirical growth model (measure of integration).

	OLS2	OLS3	FEWG2	FEWG3	diffGMM2s2erc	diffGMM2s3erc	sysGMM2s2	sysGMM2s3	LIML2	LIML3
	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.
lnyt_1	0.916***	0.913***	0.740***	0.742***	0.658***	0.676***	0.776***	0.782***	0.822***	0.795***
	(0.013)	(0.013)	(0.041)	(0.039)	(0.111)	(0.082)	(0.064)	(0.056)	(0.000)	(0.000)
sed	0.010	0.010	0.014	0.013	0.148**	0.143**	0.047	0.057**	0.024	0.008
	(0.007)	(0.007)	(0.018)	(0.018)	(0.064)	(0.060)	(0.033)	(0.029)	(0.310)	(0.742)
lnlex	0.291***	0.308***	0.047	0.089	0.136	0.211	0.197	0.299*	–0.110	–0.138
	(0.067)	(0.066)	(0.166)	(0.159)	(0.336)	(0.290)	(0.198)	(0.176)	(0.443)	(0.347)
ish	0.319***	0.222**	0.061	0.040	0.171	0.168	–0.219	–0.055	0.174	0.045
	(0.101)	(0.100)	(0.167)	(0.160)	(0.374)	(0.360)	(0.308)	(0.303)	(0.311)	(0.790)
gsh	–0.282***	–0.252***	–0.240	–0.235	–0.822	–0.809	–0.721**	–0.690**	–0.431***	–0.149***
	(0.083)	(0.076)	(0.210)	(0.216)	(0.509)	(0.496)	(0.297)	(0.288)	(0.015)	(0.007)
ipr	–0.000	–0.000	–0.000**	–0.000**	–0.000	–0.000	0.000	–0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.049)	(0.012)
integ (standard)	–0.022***	–0.026***	–0.143***	–0.132***	–0.152*	–0.132*	–0.122***	–0.093**	–0.143***	–0.181***
	(0.006)	(0.006)	(0.036)	(0.039)	(0.090)	(0.075)	(0.039)	(0.037)	(0.000)	(0.000)
openk		0.047***		0.042		0.040		0.063		0.000
		(0.015)		(0.057)		(0.107)		(0.054)		(0.093)
Constant	–0.258	–0.292	3.200***	2.885***			2.238*	1.435		
	(0.295)	(0.291)	(0.760)	(0.714)			(1.287)	(1.243)		
N	680	680	680	680	595	595	680	680	680	680
Clusters	85	85	85	85	85	85	85	85	85	85
vcetype	Robust	Robust	Robust	Robust	Corrected	Corrected	Corrected	Corrected	Robust	Robust
esttype					difference	difference	system	system	liml	liml
R squared (adj)	0.986	0.986	0.988	0.988						
ll	428.641	436.622	533.832	535.102						
chi2					1161.055	1741.250	124.584	152.475		
chi2p					0.000	0.000	0.000	0.000		
j					48.000	54.000	56.000	63.000		
hansenp					0.618	0.762	0.536	0.646		
hansenp					0.618	0.762	0.536	0.646		
ar1p					0.000	0.000	0.000	0.000		
ar2p					0.393	0.376	0.208	0.243		

Notes: Dependent variable in this model is the log of per capita GDP. diffGMM2s and sysGMM2s are the two step difference GMM (system GMM) estimation results. Robust standard error are reported in (). For the two step estimates standard errors are Windmeijer corrected. * significant at 0.10 level, ** 0.05 level, and *** 0.01 level. Values reported for the Hansen J test are p values for the null hypothesis of instrument validity. Diff Hansen reports the p- value for validity of additional moment restrictions required by system GMM. Values reported for AR(1) and AR(2) are p- values for first and second order auto correlated disturbances in first equations. For LIML estimation the number of parameters includes all variance and covariance parameters. To derive results we used the Broyden - Fletcher - Goldfarb - Shanno optimization method. Time dummies are included in the model, but not shown in the result tables. Five year panel, between 1975 and 2005. Source: UN Comtrade data 1962-2008. World Bank data. Penn World Tables data. Own calculations.

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Table 1.7: Different specifications of the empirical growth model (instrument of integration).

	OLS2	OLS3	FEWG2	FEWG3	diffGMM2s2erc	diffGMM2s3erc	sysGMM2s2	sysGMM2s3	LIML2	LIML3
	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.
lnyt_1	0.916***	0.913***	0.736***	0.739***	0.624***	0.664***	0.765***	0.777***	0.831***	0.804***
	(0.013)	(0.013)	(0.040)	(0.039)	(0.108)	(0.081)	(0.065)	(0.055)	(0.037)	(0.035)
sed	0.010	0.011	0.014	0.013	0.170**	0.155**	0.056	0.062**	0.023	0.0008
	(0.007)	(0.007)	(0.019)	(0.019)	(0.069)	(0.064)	(0.034)	(0.029)	(0.024)	(0.024)
lnlex	0.292***	0.309***	0.045	0.089	0.137	0.206	0.195	0.317*	– 0.132	–0.182
	(0.067)	(0.066)	(0.166)	(0.161)	(0.365)	(0.289)	(0.210)	(0.179)	(0.144)	(0.146)
ish	0.320***	0.223**	0.047	0.028	0.162	0.152	–0.255	–0.076	0.134	0.035
	(0.100)	(0.100)	(0.176)	(0.169)	(0.365)	(0.338)	(0.299)	(0.302)	(0.173)	(0.167)
gsh	–0.282***	–0.252***	–0.241	–0.236	–0.699	–0.782	–0.734**	–0.681**	–0.436**	–0.454**
	(0.083)	(0.077)	(0.217)	(0.222)	(0.512)	(0.496)	(0.323)	(0.287)	(0.180)	(0.176)
ipr	–0.000	–0.000	–0.000**	–0.000**	–0.000	–0.000	0.000	–0.000	– 0.000*	–0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IV integ (instrument)	–0.022***	–0.026***	–0.147***	–0.136***	–0.181**	–0.135**	–0.122***	–0.090**	–0.129***	–0.172***
	(0.006)	(0.006)	(0.041)	(0.045)	(0.084)	(0.063)	(0.039)	(0.035)	(0.032)	(0.031)
openk		0.047***		0.043		0.058		0.076		–0.017
		(0.015)		(0.057)		(0.109)		(0.054)		(0.033)
Constant	–0.265	–0.298	3.278***	2.945***			2.333*	1.347		
	(0.294)	(0.290)	(0.802)	(0.797)			(1.332)	(1.212)		
N	680	680	680	680	595	595	680	680	680	680
Clusters	85	85	85	85	85	85	85	85	85	85
vcetype	Robust	Robust	Robust	Robust	Corrected	Corrected	Corrected	Corrected	Robust	Robust
esttype					difference	difference	system	system	liml	liml
R squared (adj)	0.986	0.986	0.988	0.988						
ll	428.304	436.254	533.018	534.354						
chi2					977.587	1499.615	121.922	154.864		
chi2p					0.000	0.000	0.000	0.000		
j					48.000	54.000	56.000	63.000		
hansenp					0.649	0.804	0.529	0.620		
hansenp					0.649	0.804	0.529	0.620		
ar1p					0.000	0.000	0.000	0.000		
ar2p					0.400	0.366	0.184	0.221		

Notes: Dependent variable in this model is the log of per capita GDP. diffGMM2s and sysGMM2s are the two step difference GMM (system GMM) estimation results. Robust standard error are reported in (). For the two step estimates standard errors are Windmeijer corrected. * significant at 0.10 level, ** 0.05 level, and *** 0.01 level. Values reported for the Hansen J test are p values for the null hypothesis of instrument validity. Diff Hansen reports the p- value for validity of additional moment restrictions required by system GMM. Values reported for AR(1) and AR(2) are p- values for first and second order auto correlated disturbances in first equations. For LIML estimation the number of parameters includes all variance and covariance parameters. To derive results we used the Broyden - Fletcher - Goldfarb - Shanno optimization method. Time dummies are included in the model, but not shown in the result tables. Five year panel, between 1975 and 2005.
Source: UN Comtrade data 1962-2008. World Bank data. Penn World Tables data. Own calculations.

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Table 1.8: Different specifications of the empirical growth model (integration in investment goods).

	OLS2	OLS3	FEWG2	FEWG3	diffGMM2s2erc	diffGMM2s3erc	sysGMM2s2	sysGMM2s3	LIML2	LIML3
	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.
lnyt_1	0.915***	0.912***	0.742***	0.742***	0.721***	0.707***	0.818***	0.799***	0.805***	0.763***
	(0.014)	(0.014)	(0.043)	(0.043)	(0.111)	(0.085)	(0.046)	(0.041)	(0.000)	(0.000)
sed	0.011	0.012	0.007	0.006	0.129*	0.122**	0.022	0.047	0.022	0.026
	(0.007)	(0.007)	(0.019)	(0.019)	(0.068)	(0.060)	(0.034)	(0.029)	(0.359)	(0.297)
lnlex	0.300***	0.319***	0.200	0.241	0.518*	0.457*	0.366**	0.382**	0.224**	0.315**
	(0.066)	(0.065)	(0.171)	(0.168)	(0.266)	(0.244)	(0.170)	(0.160)	(0.126)	(0.040)
ish	0.326***	0.235**	0.137	0.096	0.438	0.363	–0.081	–0.014	0.270***	0.206
	(0.101)	(0.101)	(0.157)	(0.142)	(0.310)	(0.283)	(0.261)	(0.242)	(0.093)	(0.203)
gsh	–0.296***	–0.271***	–0.194	–0.192	–0.840*	–0.790*	–0.766***	–0.701**	–0.264***	–0.179
	(0.084)	(0.078)	(0.208)	(0.215)	(0.496)	(0.443)	(0.274)	(0.288)	(0.123)	(0.294)
ipr	–0.000	–0.000	–0.001**	–0.001**	–0.000	–0.000	–0.000	–0.000	–0.000	–0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.016)	(0.002)
integ (investment)	–0.022***	–0.026***	–0.124***	–0.116***	–0.118**	–0.103**	–0.102***	–0.089***	–0.140***	–0.179***
	(0.006)	(0.006)	(0.025)	(0.026)	(0.052)	(0.042)	(0.025)	(0.024)	(0.000)	(0.000)
openk		0.044***		0.051		0.100		0.070		0.031
		(0.015)		(0.055)		(0.113)		(0.055)		(0.351)
Constant	–0.261	–0.298	2.573***	2.290***			1.169	1.020		
	(0.292)	(0.287)	(0.782)	(0.722)			(0.848)	(0.845)		
N	680	680	680	680	595	595	680	680	680	680
Clusters	85	85	85	85	85	85	85	85	85	85
vcetype	Robust	Robust	Robust	Robust	Corrected	Corrected	Corrected	Corrected	Robust	Robust
esttype					difference	difference	system	system	liml	liml
R squared (adj)	0.986	0.986	0.988	0.988						
ll	427.355	434.548	538.977	541.046						
chi2					1339.029	2262.981	123.035	182.130		
chi2p					0.000	0.000	0.000	0.000		
j					48.000	54.000	56.000	63.000		
hansenp					0.590	0.782	0.561	0.804		
hansenp					0.590	0.782	0.561	0.804		
ar1p					0.000	0.000	0.000	0.000		
ar2p					0.366	0.373	0.224	0.262		

Notes: Dependent variable in this model is the log of per capita GDP. diffGMM2s and sysGMM2s are the two step difference GMM (system GMM) estimation results. Robust standard error are reported in (). For the two step estimates standard errors are Windmeijer corrected. * significant at 0.10 level, ** 0.05 level, and *** 0.01 level. Values reported for the Hansen J test are p values for the null hypothesis of instrument validity. Diff Hansen reports the p- value for validity of additional moment restrictions required by system GMM. Values reported for AR(1) and AR(2) are p- values for first and second order auto correlated disturbances in first equations. For LIML estimation the number of parameters includes all variance and covariance parameters. To derive results we used the Broyden - Fletcher - Goldfarb - Shanno optimization method. Time dummies are included in the model, but not shown in the result tables. Five year panel, between 1975 and 2005.
Source: UN Comtrade data 1962-2008. World Bank data. Penn World Tables data. Own calculations.

2 | My Friends, My Network, My Job

Social networks have a profound impact on individual labor market outcomes. This paper establishes a theoretical framework where firms, workers, and applicants are linked through a social network of friendships and family links, which can be used by firms to reduce information asymmetries and increase match quality during the recruitment process. Here, the bayesian signaling game focuses on the decision of the worker, who is employed inside the firm and has links with the applicant outside the firm; the model proposes a set of equilibria where firms are able to generate matches with increased match quality through a social network. The theoretical framework pays special attention to potential incentive problems that arise due to nepotism and favoritism. The empirical model brings these predictions to the data and focuses on labor market outcomes at the individual level. The analysis exploits the panel dimension of the German Socio Economic Panel and highlights differences in labor market outcomes that can be linked to the existence of the aforementioned social networks. Empirical results focus on three key issues: First, findings allow for further insight on the determinants of the event *I found my last job using either friends or relatives*. Second, the paper evaluates the relationship between the use of a social networks and the starting wage of applicants. Third, results shed light on the question of how far long term labor market outcomes such as the duration of the job and the earnings profile differ by the entry channel into a job. Findings illustrate fluctuations in the use of social networks over the business cycle which highlight the decision making process of the worker who acts an an intermediary between the firm and the applicant. More specifically, the higher level of the unemployment rate reduces the probability to find a job through a social network. Additionally, results from the empirical model suggest that social networks improve match quality, resulting in longer employment spells and higher starting wages. [1]

Keywords: labor markets, bayesian signaling games, social networks, duration analysis

JEL Classification: C140, D010, D850, J310, J620

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2.1 Introduction

For most applicants social networks are an important source for job offers [2]. At the same time firms benefit from reduced information asymmetries and increased match probability when recruiting a new worker. The literature on social networks and labor markets suggests that between 30 and 70 percent of workers found their job using a social network. For instance, Klein and Harkness, J. (2005) make use of the 2001 wave of the International Social Survey Program and find that on average 42 percent of all individuals who have ever worked, reported that they learnt about their job using a social network - differences exist across countries, but also between occupations and the type of employment [3].

The theoretical literature describes different models where firms exploit social networks, which connect current workers and potential applicants to fill open vacancies inside a firm. Montgomery (1991) employ a framework in which employee referrals guarantee a better flow of information and thus improve match quality between firms and applicants. As a consequence, both applicants and employers welcome the use of social networks to reduce uncertainty about the match quality between applicant and firm and to increase the number of potential applicants. The theoretical framework in this paper builds on the idea that firms share the benefits from the improved match quality by paying a bonus to intermediating workers and a "network" premium to applicants. For instance, there is evidence that firms in the private sector often pay a bonus to workers if the applicant stays in the firm for at least six months. Here, examples 2.7 and 2.7 from the World Bank and the European Bank for Reconstruction and Development illustrate that firms benefit from their worker's knowledge on whom exactly the firm needs. The theoretical framework highlights the role of workers inside the firm and focuses on their behavior as intermediaries between applicants and firms. Based on a bayesian signaling game, the theoretical model describes an environment where the unobserved match quality between firms and applicants determines the type of a worker (Spence, 1973). In the benchmark model, firms set incentives and disincentives to influence the worker's decision to send a signal to the firm and recommend an applicant. The extension elaborates on possible distortions and inefficiencies in the referral process that might arise if social distance changes the optimization problem of the worker. Altogether, the theoretical framework suggests that firms can use benefits and indirect punishments to generate a (semi) separating equilibrium in the bayesian signaling game; workers inside the firm inform outside applicants about job offers in a strategic way such that the resulting match quality between firms and applicants is higher than average. Furthermore, theoretical findings in this paper illustrate that nepotism and favoritism influence this decision and, under certain conditions, challenge the existence of the equilibrium outcome. In summary, the following predictions from the theoretical model are later used as predictions for the empirical analysis. First, workers inside the firm incorporate a scheme of incentives and disincentives into their decision to recommend an applicant. In consequence, an increase in the regional unemployment rate has a negative impact on the probability of finding a job though a social network. Second, applicants who enter the firm through a social network, receive a wage which differs from the rest of the applicants. Here, a positive wage premium suggests an increased match quality between applicants and firms. Third,

[2] The term "social network" is used synonymously to "informal search channel" and "network of friends". In the following a social network connects individuals such as friends and relatives.

[3] Ioannides and Loury (2004) provide a general overview of previous findings in the theoretical and empirical literature on the role of social networks in labor markets, also Pellizzari (2010).

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the increased match quality translates into a longer duration of the job. And fourth, workers who entered a job through a social network channel have a lower wage growth because the referral has already reduced information asymmetries between firms and workers to the beginning of the match.

A set of empirical papers suggests that labor market outcomes depend on the recruitment channel. For many empirical applications, findings illustrate that the use of social networks, which connect workers to applicants, translates into a positive premium on the starting wage and increases the duration of employment. Furthermore, firms benefit from employee referrals because applicants who found their job through a social network identify better with the firm, which translates into increased productivity. The empirical framework in this paper exploits data from the German Socio Economic Panel (GSOEP) and makes use of information at the individual level to investigate the impact of social networks on individual labor market outcomes. Based on the answer to the question "How did you find out about this job", summary statistics in table 2.1 describe eight different channels into employment. Due to the design of the survey question, this analysis only considers successful matches, in the sense that the employee and the employer agreed on a work contract. Summary statistics for the observation period between 1991 and 2009 illustrate that around 30 percent of individuals report that they used their social network to find a job. Recall that the importance of one of the channels does not only depend on the employees' preferences but also on how employers behave in labor markets.

The empirical framework builds on predictions from the theoretical model; results highlight the importance of social networks on labor market outcomes. First, selection into different recruitment channels is non random. The empirical analysis identifies determinants which influence the decision to make use of a social network when searching for a job. Firm characteristics like firm size and the sector of industry are key. Findings suggest that, in line with the theoretical model, regional labor market conditions have an impact on the use of social networks as a channel to find a job: during times of high unemployment, the probability that individuals make use of a social network and find a job successfully decreases significantly. This reflects predictions from the theoretical model, which suggest that the worker's decision to engage in an employee referral depends on the punishment in the event that a high match quality between applicant and firm does not materialize. Here, an increased unemployment rate increases the potential punishment. Second, the empirical analysis focuses on the link between the use of social networks as entry channel into a job and its impact on the starting wage. Results highlight the importance of firm characteristics and non-cognitive skills when explaining the starting wage an individual receives in a new job. Using a fixed effects model to control for unobserved individual specific characteristics, data suggests that there is a positive "network premium" for individuals who entered a job through a social network – which suggests an increased match quality due to social networks. Third, the panel dimension of the data set elaborates on long term labor market outcomes of individuals by focusing on the relationship between the use of social networks and the duration of the job. Empirical results from the duration analysis (using both parametric and semi parametric models) suggest that jobs that were established through a social network last longer. From a theoretical perspective, this can be attributed to a higher match quality, which reduces the probability of an adverse productivity shock, which would otherwise destroy the job. Fourth, the wage profile for the first three years differs systematically between individuals, depending on their entry channel into employment. Taking into consideration that more information about match quality between applicant and firm is revealed at the beginning of the job, findings from

the empirical analysis support a flatter wage profile.

From a policy perspective the theoretical model and the empirical framework highlight the importance of social networks as an instrument that can reduce information asymmetries in the labor market. Results suggest that firms can set incentive schemes such that workers inside the firm only recommend applicants with an expected high match quality. Furthermore, favoritism and nepotism distort the decisions of workers, which introduces inefficiencies into the employee referrals. At the same time the theoretical paper highlights further inefficiencies that could arise if firms – in response to nepotism and favoritism – impose a ban on close friends and relatives being employed in a firm.

The remainder of this paper is organized as follows. Section II introduces the theoretical and empirical literature on social networks and labor markets. In section III, the theoretical framework illustrates the role of social networks in an environment where firms employ workers that are connected to external applicants through a social network. Section IV presents the estimation strategy. Section V describes the dataset taken from the GSOEP data. In section VI, I estimate different empirical models and discuss results from different specifications. Finally, section VII draws some policy implications and concludes.

2.2 Literature Review: Social Networks and Labor Markets

Social networks influence a wide range of economic outcomes through multiple channels. The first papers to investigate the importance of social networks and to better understand their implications on individual behavior from a modeling perspective, were written in the late 1960s (Rees, 1966; Boorman, 1975; Granovetter, 1974). Later, a seminal paper by Montgomery (1991) provided a theoretical framework that described how social networks increase the probability of a job offer and generate higher earnings due to reduced information asymmetries Mortensen and Vishwanath (1994). This mechanism, which increases both match quality and match probability, results in an environment where firms make use of their high ability workers to gain access to further high ability workers. The theoretical literature emphasizes the important role of employee referrals as screening device for applicants, which can reduce uncertainty about prospective worker's' productivity more cheaply than formal application procedures (Calvó-Armengol and Jackson, 2007; Kono, 2006). Furthermore, social networks in labor markets enhance the flow of additional information about character traits that are difficult to identify during an interview but which have a significant impact on the future productivity of the job. For instance, the recruiting firm has only limited possibilities to learn more about non-cognitive skills.

Most papers in the literature on social networks take the network structure as given and focus on the direct effects of social networks on economic outcomes. This assumption of exogenous social networks abstracts from the question how individuals behave when social networks are formed (Jackson and Watts, 2002; Granovetter, 2005; Marmaros and Sacerdote, 2006). From a theoretical perspective, the identification of a causal relationship between social networks and economic outcomes is confounded by the classical problem of selection on unobserved characteristics. In response, the literature on social network formation addresses the endogeneity of social networks and provides a theoretical framework on how individuals form social networks. Bramoullé and Saint-Paul (2010) describe a theoretical model of endogenous network formation that focuses on the influence of social networks on labor market transitions. In line with previous research on economic homophily (McPherson et al., 2001; Valat, 2010), their model incorporates the idea

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that the probability of formation of a new link is greater between two employed individuals than between an employed and an unemployed individual. Their findings suggest that this generates a negative duration dependence in exit rates from unemployment. Long term unemployed workers have fewer connections with employed workers than the short term unemployed, which reduces their exit rates compared to the latter. Thus, unemployment exhibits duration dependence since the probability of obtaining a job decreases in the length of time that an agent has been unemployed. At the same time, higher connectivity among unemployed individuals reduces duration dependence since unemployed friends become helpful once they find a new job.

In addition, this research investigates the impact of social network structure on economic outcomes. Calvó-Armengol (2006) introduce elements of strategic network formation and focus on the emerging structure of bilateral contacts, which determine the architecture of social networks. Their research offers explanations of how network structure impacts labor market outcomes such as wages and the duration dependence of unemployment. More specifically, the theoretical model relates network geometry to communication processes and takes up the issue of strategic network formation in the case when unemployed individuals can use social networks to communicate job offers. Their findings suggest that differences in the network structure have an impact on the aggregate unemployment rate. At the individual level Calvó-Armengol and Jackson (2004) find that an agent's employment status and his wages over time depend on his relative position in the social network (Kolm et al., 2003). The wages and employment statuses of agents who are connected to each other are positively correlated across time (Calvó-Armengol, 2004). This result could be seen as an explanation for the persistent inequality in wages between whites and blacks.

The empirical literature clearly highlights the impact of social networks on economic outcomes at the individual and at the aggregate level (Bramoullé and Fortin, 2010). For instance, previous empirical studies illustrate the impact of social networks on school decisions and performance (Sacerdote, 2001; Zimmerman, 2003; Lalive and Cattaneo, 2009; Calvó-Armengol et al., 2009) and migration decisions (Beaman, 2012). Furthermore, there are empirical papers on the role of social networks as an instrument for risk sharing (Philippines, Fafchamps and Lund (2003)) and the role of social learning in the diffusion of a new agricultural technology (Ghana, Conley and Udry (2010)). Most closely related to this paper, there have been a steadily growing number of empirical papers that focus on social networks and labor market outcomes.

The early literature mainly focuses on the existence of social networks and provides estimates on the importance of friends and relatives in finding employment. Granovetter (1973, 1974) conduct a survey of different cities in Massachusetts and conclude that around 50 percent of jobs were obtained through employee referrals. In the same spirit, Beaman and Magruder (2012) find that more than 40 percent of employees have, at some point, helped their friends or relatives to find a job with their current employer. Social networks do not only shape labor market outcomes in developed countries, but also in the developing world (Wahba and Zenou, 2005). Nakanishi (1991) implement a study on Manila slums and claim that contacts and referrals are often seen as a prerequisite for obtaining a new job. Using survey information from Mumbai, Munshi and Rosenzweig (2006) emphasize the high prevalence of referral based entry into low and unskilled jobs. Their results suggest that 70 percent of blue collar workers made use of a social network when finding a job, whereas the share for white collar workers is significantly lower (around 44 percent).

Further research focuses on the link between social networks and labor market outcomes (Fontaine, 2008; Loury, 2006). Here, Laschever (2009) exploits a natural experiment (the World

World I draft), which allows him to test for the existence of network effects on the labor market without having the standard problem of endogenous network formation. Findings from the empirical model decompose the outcome effect into endogenous and contextual effects, avoiding the standard reflection problem highlighted by Manski (1993). With respect to the wage dynamics of individuals who gained their job through a social network there is no agreement in the empirical literature. Bayer et al. (2008) suggest that jobs found through a social network have lower wages. His explanation builds on the idea that employee referrals often induce a higher job losing rate and lower bargaining power such that wages are lower. Munshi (2003) focuses on Mexican migrants and emphasizes the importance of community ties. Empirical findings suggest that employee referrals display a lower turnover rate and stay longer in the firm. This result supports a theoretical framework in which firms benefit from reduced information asymmetries. Furthermore, Bandiera et al. (2009, 2010) exploit a field experiment in the agricultural sector and show that firms benefit from increased productivity if co-workers are friends. Here, results suggest that social networks and peer-effects change productivity, which provides evidence for the positive contribution of social networks as recruitment channel. Additionally, the findings illustrate the direct impact of financial incentives on the decisions of workers to recommend applicants with higher ability. Most recently and closely related to findings from this research paper, Dustmann et al. (2011a) formulate a theoretical model for referral-based job search networks and test their predictions using employer-employee linked data from Germany. Their results illustrate that reduced informational deficiencies lead to productivity gains which in the end support higher wages and reduce incentives to leave the firm.

Social networks have important consequences for labor markets and can influence both welfare, and the efficiency of outcomes. The literature on nepotism and favoritism in the context of employee referrals in labor markets suggests that firms might disregard superior candidates when using social networks to recruit their applicants. For example, Dhillon et al. (2012) highlight the idea that employee referrals result in lower quality matches if friends and relatives support job search (Pistaferri, 1999; Bramoullé and Goyal, 2009). Using data from Italy, Ponzo and Scoppa (2010) show that individuals using a social network tend to be of a lower quality. Workers therefore earn a negative wage premium when using social networks. Fafchamps and Moradi (2009) exploits data from Ghana and finds evidence of referee opportunism. As a consequence, workers with lower chances of promotion behave more opportunistically, leading to more instances of nepotism and favoritism. The bayesian signaling game in this paper accounts for social distance between the worker and the applicant and discusses changes in the decision of the worker due to nepotism and favoritism. As a consequence, incentive problems arise, which influences the efficiency of the referral process. Under certain circumstances, the firm is no longer able to make use of social networks to recruit people and does not benefit from increased match quality. From a welfare perspective the social bonus only materializes if there is a match through the informal search channel.

2.3 Firms and Workers in a Social Network

The theoretical model introduces social networks into a search and matching environment where firms can access their worker's social network to search for applicants. In this set-up the social

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network connects workers inside the firm to applicants outside the firm [4]. The model builds on the idea that labor markets are governed by search frictions, information asymmetries and incomplete information. Social networks increase the match quality and match probability between firms and applicants. The existing empirical and theoretical literature suggests that social networks generate a higher match quality because workers inside the firm have ties with people outside the firm who share similar characteristics [5]; accordingly employee referrals contain additional information about unobserved characteristics that can possibly not be extracted from a curriculum vitae or a job interview. Firms have the possibility to set incentives (monetary and non-monetary) to influence the match quality of employee referrals. In addition, firms can access a larger pool of applicants if they make use of their workers' contacts when filling an open vacancy. Even though this mechanism can also be contributed to social networks, the increased match probability will not be the focus of the upcoming discussion.

The theoretical framework focuses on the following questions: First, how should firms make use of social networks to influence the quality of applicants? Second, how should workers who have a job inside the firm and a social network outside the firm make employee referrals to applicants? How do workers' characteristics like risk (loss) aversion and time discount rate impact the decision to make employee referrals? Third, what is the efficient equilibrium outcome - and, if the first best solution cannot be achieved, where do inefficiencies come from and are there any policies to reduce these inefficiencies?

2.3.1 Structure of the game

The theoretical model builds on the literature on signaling games [6]. The solution to this signaling game makes use of a perfect bayesian equilibrium (Mas-Colell et al., 1995; Vega-Redondo, 2003).

First, nature determines the match quality between an applicant and the firm (the applicant is connected to the worker through a social network). The match quality is drawn from a distribution $\mathcal{T}$, which is public knowledge to applicants, workers and firms. Since I focus on the decision of the worker, I later interpret the match quality as the type of the worker (t_1). Second, the informed player's strategy set (that of the worker) consists of signals contingent on information. The worker observes his type $t_1 \epsilon \mathcal{T}$ and chooses some signal m_1 with $m_1 \epsilon \mathcal{M}$. I interpret this as a binary choice for the worker, who either recommends an applicant ($m_1 = 1$) or does not ($m_1 = 0$) [7]. Alternatively, I could think about m_1^* as an underlying latent variable that is mapped into a binary choice m_1. Third, the uninformed player's strategy set (that of the firm) consists of actions contingent on signals. The firm observes the signal chosen by the worker (m_1), but not his type (t_1). In the last step, the firm then chooses his preferred action a_2 with $a_2 \epsilon \mathcal{A}$, that is, it either recruits an applicant or does not. I assume that firms do not influence the composition of the aggregate pool of applicants. Even though high quality people are sorted through the social network channel, this does not change the distribution over match quality. In the next period, production takes place. If there was a successful match between

[4] For the purpose of my paper, the structure and formation of social networks are irrelevant. Here the term social network refers to the link that connects the worker to the applicant.

[5] McPherson et al. (2001) uses the term homopholy to describe an environment where people with similar characteristics become friends.

[6] Spence (1973) was among the first to introduce signaling games in the economic literature.

[7] Recommendation coincides with the action to inform the applicant about the job. In practical terms, this would be the worker's decision to forward a job offer he has received from inside the firm to an applicant outside the firm.

an applicant and a firm, the applicant works in the firm and produces some output. The level of output depends on the match quality between applicant and firm. The output of a worker i in firm f is given by $y_i^f = a_i \cdot t_i^f$, where t_i^f characterizes the match quality between the firm and the applicant. Match quality $\mathcal{T}$ is normally distributed and the expected match quality between some specific applicant i and all possible firms is 1. Using only two types t_H and t_L, and assigning a probability p to the high type, the probability of each type t_H and t_L is 0.5. During the job interview and the entire selection process, the match quality remains unobserved and will only becomes apparent over time [8]. The informal search channel reduces the uncertainty about the match quality between the applicant and the firm. The worker who is already in the firm knows both the firm and the applicant. His recommendation behavior contains information on the expected match quality, which is unobserved to the firm. Under the assumption that the bonus and the punishment are set correctly, the distribution over match quality differs between applicants who apply through the formal and informal channels. Depending on the performance of the applicant (as reflected by the match quality), the worker who made the referral receives a bonus $b \epsilon \Re$ or loses his or her reputation $d \epsilon \Re$ in the firm.

The theoretical framework assumes that the firm cannot pay wages conditional on the actual performance (match quality) of the new worker, but that when paying wages the firm may differentiate between the formal and informal recruitment channel. The financial risk that the applicant does not perform as expected stays mostly with the firm; in other words, the worker and the applicant receive a wage that is not directly conditional on the match quality of the new applicant. In addition to the fixed wage, the worker receives a bonus from the firm that depends on the match quality between the applicant and the firm. For simplicity, this bonus is discrete and not continuous. In the following I will assume that the bonus is paid if the match quality between the applicant and the firm is above average [9]. As a consequence, workers only make referrals to friends with a high expected match quality, since their behavior has long lasting implications for their reputation inside the firm. In extreme cases, one could imagine workers not being promoted, or suffering other non-monetary consequences due to making bad referrals.

2.3.2 Workers send signal based on type

At the beginning of each period, each worker receives two different signals (which are private information) about match quality and social distance, which characterize their friend this period. The following properties describe the information set of the worker:

1. The match quality between the applicant and the firm follows a normal distribution with mean $\mu = t_i^f$ and standard deviation σ. In the context of the signaling game, the parameter t_i^f describes the type of the worker. This influences the worker's decision and is unknown to the firm.

2. The social distance between the worker and the applicant is characterized by a stochastic variable δ_{ij}, which is drawn from a distribution $\mathcal{S}$. The theoretical model builds on the idea that social distance between the worker and the applicant allows for an additional bonus

[8] Sengul (2010) makes a similar assumption for the theoretical model. Her results from the empirical model suggest that, depending on the level of qualification, it takes up to two years until the match quality between an applicant and a firm is fully revealed.

[9] In fact, many firms reward an employee referral if the match quality is above average and the applicant remains inside the firm for a certain period. For simplicity, the theoretical model focuses on the first condition.

for the worker. As a consequence, a worker with close friends bases his or her signal not only on the match quality between the firm and the applicant, but also on the potential benefits coming from the friendship (leading to nepotism and favoritism). Here, a share q of workers draws a realization of δ_{ij}, which is below an exogenously determined threshold. Later, the theoretical model refers to this group of people as close friends or relatives. In other words, share q of type t_L mimics t_H because they receive an additional benefit from close friendship with the applicant. Here, the theoretical framework assumes equal distribution of $\mathcal{S}$ across both groups, t_H and t_L.

3. Both players, the worker and the firm, know the general distribution over match quality between applicants and firms, with t_i^f being normally distributed with mean $\mu = 1$ and standard deviation $\sigma = 1$.

4. Lastly, the incentive scheme written by the firm, which includes information about the bonus b and the punishment d, is known to the worker before he engages into an employee referral.

Workers maximize utility over their action m_1, namely, recommending a friend of type t_1 or not . The worker offers access to his social network to the firm if the gain from a referral exceeds the possible loss in reputation from a bad match. The decision depends on the bonus and the punishment, the general and the applicant specific distributions over match quality between applicant and firm, and the social distance between the worker and the applicant.

$$max_{m_1} u(m_1, a_2, t_1) \quad \text{with} \quad u(m_1, a_2, t_1) = (1 - F_t(1)) \cdot m_1 \cdot b - F_t(1) \cdot m_1 \cdot d^{\gamma} \tag{2.1}$$

The optimization problem combines a benefit $(1 - F_t(1)) \cdot b$ and a cost $(F_t(1) \cdot m \cdot d^{\gamma}$ such that a signal is costly and depends on the type of worker. The cost function is characterized by the following properties: first $c_{m_1} > 0$, such that a positive signal is costly on the margin; and second $c_{m_1,t_1} < 0$, such that a positive signal is less costly on the margin for higher type applicants. This interpretation incorporates the idea that, in the case of a low type, the probability of being punished is higher and the positive signal becomes more costly. Furthermore, the parameter γ is larger than one, such that utility decreases in a non-linear way, and the reward gives less utility than the possible punishment. This reflects the idea that individuals are afraid of bad choices and the associated punishments [10]. More specifically, the parameter γ is determined by the following behavioral traits of the worker, such that

1. γ increases in the risk aversion of the worker; if the risk of unemployment is increasing and the worker expects difficulties in finding a new job, the firm can lower the punishment and still receive a truthful signal about the match quality of the applicant.

2. γ decreases in the time discount rate of the worker; if retirement is close or the firm will stop operating in the near future, the firm needs to increase the level of punishment significantly to sustain the incentive for the worker to send a truthful signal about the match quality of the applicant.

[10] See literature on loss and risk aversion.

Using the total differential and applying it to the utility function of the worker, I find [11]:

$$\frac{db}{dm}|_{u=\bar{u}} > 0 \quad \text{and} \quad \frac{d\frac{db}{dm}}{dt}|_{u=\bar{u}} < 0 \tag{2.2}$$

These results suggest that the indifference curves in the (bonus, message) space are upward sloping for both types of workers. For the high type, the indifference curves are flatter than those of the low type. In other words, the low type requires higher compensation, relative to the high type, to send a positive signal (that is, to recommend his friend to the firm). Both conditions together imply that the single crossing condition holds [12]. As a consequence, the bayesian signaling game in the following section will arrive at a unique equilibrium which, ceteris paribus, depends on the ratio between the bonus and the punishment.

2.3.3 Firms take actions and produce

In the second step, the firm decides whether it wants to recruit the applicant proposed by the worker (given that the employee referral in the first step was successful). The firm knows the general distribution over match quality between the firm and applicants (which is public information). The firm can then set incentives such that workers only nominate certain types of applicants. Using a bonus and a punishment scheme, the firm restricts the match quality domain from which applicants from the informal search channel can be drawn. Firms maximize utility over their action a_2, that is, whether they recruit an applicant or not. Output for a position with profile a_i^f (worker i in firm f) is defined as $y_i^f = a_i^f \cdot t_i^f$. This way, output depends on the match quality between the worker and the firm. Given a fixed wage $\omega_i^f = a_i^f$, which reflects the profile of the position and is paid each period from the firm to the worker (there is no risk sharing between worker and firm), I define the firm's profit in expectation as expected output minus costs, such that [13]

$$E[\Pi_i] = E[y_i] - \omega_i = E[a_i \cdot t_i] - a_i \tag{2.3}$$

where $E[a_i \cdot t_i]$ is the expected output from the vacancy, which depends on the qualification (profile) of the applicant (which is deterministic) and match quality (which is stochastic). Under the assumption that the match quality t_i between an applicant and the firm is normally distributed with population mean $E_f[t_i] = 1$ and ex ante unobserved to the firm, the firm makes zero profits in expectation.

The bonus is financed using the (positive) surplus, which comes from the higher expected match quality that arises when the applicant applies through the social network channel. This model abstracts from additional gains, for instance, due to increased match probability. The surplus can either be paid to the applicant (in the form of a higher wage) or to the worker (in the form of a bonus). Depending on the bargaining power of the firm, part of the surplus from increased match quality stays inside the firm.

$$SP(t_i) = \max\ [0, y_i - \omega_i] = \max\ [0, t_i a_i - a_i] = a_i \cdot \max\ [0, t_i - 1] \tag{2.4}$$

[11] $\frac{db}{dm}|_{u=\bar{u}} = -\frac{dU}{dm} \cdot (\frac{dU}{db})^{-1} = -\frac{-F_t(1)d^2}{1-F_t(1)} = d^2 \cdot \frac{F_t(1)}{1-F_t(1)}$

[12] In the literature on game theory this conditions is often called the Spence - Mirrlees single crossing property, which is essential for the solution of any signaling game.

[13] In the following, the indices for worker i and firm f are removed so as not to confuse the reader.

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This definition of the surplus restricts the possible range for the bonus to be paid from the firm to the worker. Let $\mu(t|m)\epsilon[0,1]$ be the belief of the firm that a worker with signal m is of type t. Then $SP(T_{max}) = t_H - 1$ and $SP(T_{min}) = 0$ [14]. The bonus b(m) can be defined such that

$$b(m) = \mu(T_{max}|m) \cdot SP(T_{max}) + (1 - \mu(T_{max}|m)) \cdot SP(T_{min}) \tag{2.5}$$

The firm's optimization problem with choice over a_2 can be written as follows:

$$max_{a_2} u(m_1, a_2, t_1) \quad \text{with} \quad u(m_1, a_2, t_1) = -(b(m_1) - \eta_i \cdot a_i \cdot \max \ [0, t_i - 1])^2 \tag{2.6}$$

where η characterizes the bargaining power of the worker relative to the firm.

2.3.4 Equilibrium strategy

In equilibrium, optimality on the firm level requires that the bonus for each type of worker corresponds to the expected match quality and the associated surplus generated in the match between the applicant and the firm. It is the firm's choice of punishment (the cost) which determines the perfect bayesian equilibrium in the signaling game. The results suggest that three different equilibria are possible: first, a pooling equilibrium with high costs, where no type of worker sends a signal; second, a pooling equilibrium with no (low) costs, where firms are also unable to identify worker type; and third, a semi-separating equilibrium with intermediate cost, in which workers send signals that are positively correlated with their type. In the following I characterize conditions for each equilibrium and illustrate optimality based on worker and firm behavior and beliefs.

A perfect bayesian equilibrium in a signaling game requires a strategy profile $(m_1^*(t_1), a_2^*(m_1))$ for player 1 (the worker) and player 2 (the firm) together with beliefs $\mu(t_1|m_1)$ for player 2 such that the following conditions hold:

1. Optimality of workers and their decision to either recommend or not recommend an applicant m_1; the worker's strategy is optimal given his type and the firm's strategy.

$$m_1^*(t_1) \quad \text{maximizes} \quad u_1(m_1, a_2^*(m_1), t_1) \quad \text{for all} \quad t_1 \epsilon \mathcal{T} \tag{2.7}$$

2. Optimality of firms and their decision to recruit or not recruit an applicant a_2; the firm's strategy is optimal given his beliefs and the worker's strategy.

$$a_2^*(m_1) \quad \text{maximizes} \quad \sum_{t_1' \epsilon T} u_2(m_1, a_2, t_1) \cdot \mu(t_1|m_1) \quad \text{for all} \quad m_1 \epsilon \mathcal{M} \tag{2.8}$$

3. Optimality of beliefs; the firm's beliefs about type and signal are compatible with bayes rule. If any type of worker plays m_1 with positive probability then

$$\mu(t_1|m_1) = \frac{p(t_1) \cdot prob(m_1^*(t_1) = m_1)}{\sum_{t_1' \epsilon T} p(t_1') \cdot prob(m_1^*(t_1') = m_1)} \quad \text{for all} \quad t_1 \epsilon \mathcal{T} \tag{2.9}$$

otherwise, $\mu(t_1|m_1) = xxx$ for out of equilibrium beliefs [15].

[14] One way to include search and recruitment costs would be to specify the surplus as follows: $SP(T_{min}) > 0$ and $SP(T_{max}) = (t_{max} - 1) \cdot a_i$.

[15] Refinement of equilibrium concept makes use of the intuitive criterion to eliminate out of equilibrium beliefs

Pooling equilibrium with no (low) cost

In a pooling equilibrium with low cost all types of player 1 use identical signals; no information is transmitted in player 1's signal. The equilibrium strategies for a low cost scenario are $m_1^*(t_1 = t_L) = 0$ and $m_1^*(t_1 = t_H) = 0$. Beliefs can then be defined as follows:

$$\begin{aligned} \mu(T_{high}|m = 1) &= 1.999 \\ \mu(T_{low}|m = 1) &= 1.999 \\ \mu(T_{high}|m = 0) &= p \\ \mu(T_{low}|m = 0) &= 1 - p \end{aligned} \tag{2.10}$$

A pooling equilibrium of the signaling game is that t_L and t_H send identical signals. If the firm observes signal $m = 0$, the firm believes that the worker is of type t_H with probability p and that the worker is of type t_L with probability $1 - p$. Optimality for firms requires that the bonus equals the expected match quality for each type. The firm pays bonus $b(m) = (t_H - 1) \cdot p + (t_L - 1) \cdot (1 - p) = 0$ for both signals, which reflects the expected match quality of the applicant. Any deviation implies that the firm makes negative profits. Beliefs are consistent with the equilibrium strategy profile and bayes rule for $m = 0$. If $m = 1$ has been observed, bayes rule does not apply because $m = 1$ should not occur in equilibrium – hence, any belief is fine. Optimality for workers requires that, independent of type, no worker will recommend their friends in a low cost scenario. The low type worker will not deviate, if

$$\begin{aligned} (1 - F_t(1))|_{t=t_L} \cdot 0 - F_t(1)|_{t=t_L} \cdot d^\gamma < 0 \quad & \text{for m} = 1 \\ 0 \quad & \text{for m} = 0 \end{aligned} \tag{2.11}$$

The high type worker will not deviate, if

$$\begin{aligned} (1 - F_t(1))|_{t=t_H} \cdot 0 - F_t(1)|_{t=t_H} \cdot d^\gamma < 0 \quad & \text{for m} = 1 \\ 0 \quad & \text{for m} = 0 \end{aligned} \tag{2.12}$$

From the previous equations I find that both types do not deviate and a pooling equilibrium with no (low) cost evolves, if and only if

$$d^\gamma = 0. \tag{2.13}$$

Separating equilibrium with intermediate cost

In a separating equilibrium, different types of player 1 use different signals. Player 2 perfectly learns player 1's type in equilibrium, where equilibrium strategies are $m_1^*(t_1 = t_L) = 0$ and $m_1^*(t_1 = t_H) = 1$ such that only high types send a signal. Beliefs can be defined as follows

(Kreps, Cao). For simplicity, I then eliminate out of equilibrium beliefs and set the corresponding probabilities to zero.

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$$\begin{aligned} \mu(T_{high}|m=1) &= 1 \\ \mu(T_{low}|m=1) &= 0 \\ \mu(T_{high}|m=0) &= 0 \\ \mu(T_{low}|m=0) &= 1 \end{aligned} \tag{2.14}$$

A separating equilibrium of the signaling game with two types, $t_L < 1$ and $t_H > 1$, arises when only the high type sends a signal ($m = 1$). The firm believes the worker to be a high type if it receives a signal. Optimality for the firm requires the bonus to be equal to the expected match quality for each corresponding type, such that the firm is maximizing expected profits. Firm optimality yields $b(m = 1) = t_H - 1$ and $b(m = 0) = 0$. Under these conditions, beliefs are consistent with the equilibrium strategy profile. The optimal strategy for a worker of low type t_L is sending no signal ($m = 0$) if

$$\begin{aligned} (1 - F_t(1))|_{t=t_L} \cdot (t_H - 1) - F_t(1)|_{t=t_L} \cdot d^\gamma < 0 \quad & \text{for m} = 1 \\ 0 \quad & \text{for m} = 0 \end{aligned} \tag{2.15}$$

The optimal strategy for worker of high type t_H is sending a signal ($m = 1$) if

$$\begin{aligned} (1 - F_t(1))|_{t=t_H} \cdot (t_H - 1) - F_t(1)|_{t=t_H} \cdot d^\gamma > 0 \quad & \text{for m} = 1 \\ 0 \quad & \text{for m} = 0 \end{aligned} \tag{2.16}$$

If $t_L < 1$ and $t_H > 1$ then $F_t(1)|_{t=t_L} > F_t(1)|_{t=t_H}$ such that there is always an interval for d such that a separating equilibrium in the signaling game exists. Then separating equilibrium is possible if cost is such that

$$d^\gamma > (t_H - 1) \cdot \frac{1 - F_t(1)}{F_t(1)}|_{t=t_L} \quad \text{and} \quad d^\gamma < (t_H - 1) \cdot \frac{1 - F_t(1)}{F_t(1)}|_{t=t_H} \tag{2.17}$$

If the cost of punishment falls below the lower bound then the semi-separating equilibrium collapses and only a pooling equilibrium with no (low) cost remains; if the cost of punishment rises above the upper bound, the model arrives at a second pooling equilibrium with high cost (see below) where signal extraction becomes impossible. Furthermore, previous results suggest that the existence of a separating equilibrium in a bayesian signaling game depends on the risk (loss) aversion γ of the worker. These findings demonstrate that, in the case of an increased level of risk aversion of the worker (for example due to an increase in the unemployment rate, which acts as an indirect increase in the punishment), the semi-separating equilibrium collapses and only the pooling equilibrium remains, in which employee referrals do not generate a higher match quality.

Semi-separating equilibrium with intermediate cost

In a semi-separating equilibrium, some signals are chosen by several types of player 1, and other signals are chosen only by a single type. As a consequence, signal extraction is limited, since

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$m = 1$ is sent from two types of workers. Still, the firm can learn from the signal because only one type of workers sends the signal $m = 0$. Using the previously established theoretical framework, there are two types, $t_L < 1$ and $t_H > 1$. Additionally, the parameter q describes the share of workers who have close friends; the share of good friends and close relatives is the same for both types of workers. Let parameter p characterize the share of t_H (using a normal distribution with mean 1, p is 0.5), and let q be the share of t_L that mimics t_H due to social closeness. As long as q is not too high, the firm has a chance to generate high quality matches through the social network and does better than through just drawing from the general distribution. In other words, this condition for a semi-separating equilibrium requires that there are not too many low types that mimic high types and in consequence, not all workers make their referral based only on their social distance with the applicant.

The equilibrium strategies for workers in the bayesian signaling game can be characterized as follows: for low types, the share q sends a positive signal such that $m_1^*(t_1 = t_L) = q > 0$ and for high types all workers send a positive signal such that $m_1^*(t_1 = t_H) = 1$; in summary all high types and some low types send a signal $m = 1$. The firm's belief that the worker is of high type is zero if he does not send any signal and $\frac{p}{p+q(1-p)}$ if he sends a signal. Then, for any prior, beliefs must be defined as follows:

$$\begin{aligned} \mu(T_{high}|m=1) &= \frac{p}{p+q(1-p)} \\ \mu(T_{low}|m=1) &= \frac{q(1-p)}{p+q(1-p)} \\ \mu(T_{high}|m=0) &= 0 \\ \mu(T_{low}|m=0) &= 1 \end{aligned} \tag{2.18}$$

Beliefs are consistent with the equilibrium strategy profile. In a semi-separating equilibrium with two types, firm optimality requires the bonus to reflect the expected match quality for each corresponding type of worker such that $b(m=1) = (t_H - 1) \cdot \frac{p}{p+q(1-p)} + (t_L - 1) \cdot \frac{q(1-p)}{p+q(1-p)}$ and $b(m=0) = 0$. Here the bonus accounts for the share of low types that mimic a high type with $q > 0$. The incentive constraint for the worker suggests that no signal $m = 0$ (for t_L) and signal $m = 1$ (for t_H and a share q of low types) describes the optimal strategy if the bonus is positive. The low type worker will not deviate as long as

$$\begin{aligned} (1 - F_t(1))|_{t=t_L} \cdot [(t_H - 1) \cdot \frac{p}{p+q(1-p)} + (t_L - 1) \cdot \frac{q(1-p)}{p+q(1-p)}] - F_t(1)|_{t=t_L} \cdot d^\gamma < 0 \quad \text{for m} = 1 \\ 0 \quad \text{for m} = 0 \end{aligned} \tag{2.19}$$

The high type worker will not deviate from sending a signal $m = 1$ if

$$\begin{aligned} (1 - F_t(1))|_{t=t_H} \cdot [(t_H - 1) \cdot \frac{p}{p+q(1-p)} + (t_L - 1) \cdot \frac{q(1-p)}{p+q(1-p)}] - F_t(1)|_{t=t_H} \cdot d^\gamma > 0 \quad \text{for m} = 1 \\ 0 \quad \text{for m} = 0 \end{aligned} \tag{2.20}$$

The first constraint on t_L is binding and the second on t_H is strict such that

$$[(t_H - 1) \cdot \frac{p}{p+q(1-p)} + (t_L - 1) \cdot \frac{q(1-p)}{p+q(1-p)}] \cdot \frac{1 - F_t(1)}{F_t(1)}|_{t=t_L} = d^\gamma \tag{2.21}$$

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$$d^{\gamma} = [(t_H - 1) \cdot p + (t_L - 1) \cdot (1 - p)] \cdot \frac{1 - F_t(1)}{F_t(1)}|_{t=t_H} = 0 \quad \text{and} \quad d^{\gamma} < (t_H - 1) \cdot \frac{1 - F_t(1)}{F_t(1)}|_{t=t_L} \tag{2.22}$$

The lower bound is zero and the upper bound is positive. Recall that q is only defined between 0 and 1. If q is high and approaches one in the limit, then the semi-separating equilibrium collapses and the solution to the signaling game is defined by a pooling equilibrium (lower bound). If q is low and close to zero, then a pure separating equilibrium evolves (upper bound) – see the previous section. In between, the semi-separating equilibrium discussed in this section holds.

Pooling equilibrium with high cost

In a pooling equilibrium with high cost all types of workers t_L and t_H send identical signals; no information is transmitted in the signal sent by the worker to the firm. The equilibrium strategies for workers are then $m_1^*(t_1 = t_L) = 0$ and $m_1^*(t_1 = t_H) = 0$. Beliefs can be defined as follows:

$$\begin{aligned} \mu(T_{high}|m = 1) &= 1.999 \\ \mu(T_{low}|m = 1) &= 1.999 \\ \mu(T_{high}|m = 0) &= p \\ \mu(T_{low}|m = 0) &= 1 - p \end{aligned} \tag{2.23}$$

The firm believes that the worker is t_H with probability p if it observes no signal, and that the worker is t_L with probability $1 - p$ if it observes no signal. Optimality for firms requires that $b(m) = 0$, such that the bonus equals the expected match quality for each corresponding type. Any deviation implies that the firm makes negative profits. Beliefs are consistent with the equilibrium strategy profile for $m = 0$. If $m = 1$ has been observed, bayes rule does not apply because $m = 1$ should not occur in equilibrium – hence, any belief is fine. Optimality for workers requires that, independent of type, no worker will make any recommendation. If there is no bonus, only risk remains and workers receive negative expected utility for sending $m = 1$. The low type worker will not deviate if the following set of conditions holds

$$\begin{aligned} (1 - F_t(1))|_{t=t_L} \cdot 0 - F_t(1)|_{t=t_L} \cdot d^{\gamma} < 0 \quad & \text{for m} = 1 \\ 0 \quad & \text{for m} = 0 \end{aligned} \tag{2.24}$$

High type worker will not deviate, that is

$$\begin{aligned} (1 - F_t(1))|_{t=t_H} \cdot 0 - F_t(1)|_{t=t_H} \cdot d^{\gamma} < 0 \quad & \text{for m} = 1 \\ 0 \quad & \text{for m} = 0 \end{aligned} \tag{2.25}$$

Neither type will deviate since sending a signal is too expensive if the bonus is 0 and the cost > 0, if

$$d^{\gamma} > (t_H - 1) \cdot \frac{1 - F_t(1)}{F_t(1)}|_{t=t_H} \tag{2.26}$$

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2.3.5 Discussion on inefficiencies and a ban on close friends

The theoretical model describes an environment where the worker's decision is influenced by two different determinants: first, match quality between the applicant and the firm; and second, social distance between worker and applicant. In response, the worker can only send one binary signal to the firm, which summarizes his or her evaluation of the applicant. Four different combinations of match quality and social distance are possible [16]:

1. low social distance and low match quality
2. low social distance and high match quality
3. high social distance and low match quality
4. high social distance and high match quality

In the optimal case, when the referral decision of the worker is only influenced by match quality, a positive signal could be observed for combinations (2) and (4). Here, match quality would be high and social distance would not influence the behavior of the worker. If social distance impacts the decision of the worker, such that $q > 0$ (where q is defined as the share of workers for which social distance is low), inefficiencies in the search and matching process arise. Since workers do not only support applicants with high match quality, a positive signal is sent for three different types of applicants: (1), (2) and (4). Using p to measure the share of high quality matches in the economy, the probability $\mu(T_{low}, S_{low}|m = 1)$ describes a situation where firms receive a positive signal from the worker but the match quality between applicant and firm is low.

$$\mu(T_{low}, S_{low}|m = 1) = q(1 - p) > 0 \tag{2.27}$$

In the resulting semi-separating equilibrium, the firm also receives a positive signal for applicants who show low match quality but benefit from the close relationship between applicant and worker – often referred to as the case of nepotism and favoritism. Clearly, the low correlation between signal and type introduces inefficiencies into the referral process [17]. These inefficiencies increase in q, such that the semi-separating equilibrium in the signaling game collapses and only two pooling equilibria remain, in which no signal extraction about the match quality of the applicant is possible.

Under these circumstances, firms often introduce a policy in which anyone who has received a referral through close friends or relatives is banned from the application process. Example 2.7 in the appendix describes how the European Bank for Reconstruction and Development eliminates applications that could otherwise induce problems of nepotism and favoritism. Again, this scenario generates inefficiencies since only referrals for combination (4) would be possible.

$$\mu(T_{high}, S_{low}|m = 1) = qp < p \tag{2.28}$$

[16] For simplicity, the following discussion assumes a binary measure on match quality and social distance. High match quality refers to a quasi-perfect fit between applicant and firm. Low social distance describes a close relationship between applicant and worker – this could be either a direct friendship or a close family relationship.

[17] Here, the firm is only interested in the match quality and ignores any positive gains from having a low social distance between the applicant and the worker.

As a consequence, the firm misses all those applicants who are characterized by a low social distance between worker and applicant but also show a high match quality (combination 2).

2.3.6 Results from the theoretical model

The theoretical framework identifies conditions under which firms are able to influence their workers' decisions to recommend an applicant or not. Previous findings suggest that firms can manipulate the bonus and punishment such that only applicants with high match quality apply through the informal search channel. This mechanism works particularly well in an environment where only the expected match quality between firm and applicant governs the worker's signal. In reality, the decision of the worker is also influenced by the social distance between applicant and worker (which is private information for the worker, and unobserved for the firm) such that inefficiencies in the referral decision arise. As long as there is a sufficiently large positive correlation between match quality and the signal a worker sends, firms can generate a higher match quality by recruiting through a social network.

In the empirical part of this paper, I will test the following predictions, which support the findings from the theoretical model. The empirical framework builds on data from the German Socio Economic Panel (GSOEP).

First, the theoretical model suggests that firms can exploit a scheme of benefits and punishments to encourage, or to discourage workers from recommending applicants. In the previous section, I discussed the possibility that the optimal punishment changes if the risk of unemployment increases. More specifically, the perceived level of risk aversion influences the decision made by the worker (Kahneman and Tversky, 1979; Kahneman, 2003). Here, the risk aversion can be interpreted as a function of preferences, such as the time discount rate, and indicators that describe the environment of the worker, such as the regional unemployment rate. From an empirical perspective, I test to what extent the business cycle, and more precisely, the level of the regional unemployment rate, has an impact on the probability that applicants make use of a social network to find a new job. Based on the previous discussion, I would expect that an increase in the unemployment rate would have a negative impact on the supply of social network jobs, which would reduce the probability of finding a job through friends and relatives.

Second, findings from the theoretical model show that, under certain conditions a semi-separating equilibrium in a bayesian signaling game exists, such that firms achieve a higher match quality if they make use of employee referrals. As a consequence, firms generate a surplus, which is later shared between the three players in the bayesian signaling game (the firm, the worker and the applicant). There is narrative evidence, for instance from the World Bank (see example 2.7), that firms include employee referral programs into their recruitment strategy to motivate applications with higher match quality. From an empirical perspective a positive "network premium" on the starting wage would support the idea that firms generate a higher match quality going through a social network. I will later use detailed information on the starting wage of individuals to better understand to what extent a positive wage premium is paid to the applicant if he found their job through a social network. The non-existence of this premium would suggest that employee referrals do not generate higher quality matches, possibly due to distortions related to nepotism and favoritism.

Third, a higher match quality impacts long term labor market outcomes, which characterize the relationship between a firm and an applicant. The increased match quality reduces the

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probability that the job is destroyed in response to an adverse productivity shock (Pissarides, 2000). As consequence, I expect the duration of the job to be longer for individuals who got into their job through a social network. Here, the empirical framework uses detailed information on the duration of a job and analyzes to what extent there are systematic differences between groups.

Fourth, results from the theoretical model illustrate that social networks enable firms to achieve a higher match quality even at the beginning of the employment spell . This implies that uncertainty about the productivity of the applicant inside the firm is lower which would, in turn, justify a higher starting wage. In the long term, the firm gains less additional knowledge about the applicant during the employment spell (Schönberg, 2007; Sengul, 2010). Compared to a worker hired through the formal channel, the wage profile of a recommended worker should be flatter, as the firm generates less additional information regarding the productivity of the worker during the time of employment.

2.4 Empirical Model: Methodology

The empirical part brings the predictions from the theoretical model to the data. First, a probit model focuses on the determinants of the event *I found my last job using either friends or relatives*. The estimated coefficient on the regional unemployment rate describes to what extent the worker inside the firm responds to changes in the (implicit) punishment scheme. Second, the starting wage is regressed on a set of independent variables, including a dummy variable that indicates whether an individual found his job through a social network. Findings from the theoretical model suggest a positive "network premium" due to improved match quality. Third, empirical results exploit the GSOEP data to learn more about the long term effects of social networks on labor market outcomes. Taking into consideration the improved match quality in the semi-separating equilibrium of the bayesian signaling game, the duration of the employment spell is expected to be longer. Fourth, I expect the wage profile over time to be flatter since the social network channel reduces uncertainty about the applicant's productivity right from the beginning of the job.

2.4.1 Entry channel to find a new job: determinants

Descriptive statistics in table 2.1 suggest that, between 1991 and 2009, around 30 percent of the sample observations found their job through friends or relatives. Data from the GSOEP illustrate that social networks are a much more important resource for finding a new job than, for instance, the employment office or private recruitment agencies, which account for around 13 percent of the sample observations [18]. A probit model is estimated to identify the underlying determinants of individual labor market behavior. Here, the dependent variable relates to the entry channel into a job and takes the value $N = 1$ if the individual reported that he found his job through a

[18] In addition to the job search channel, the GSOEP collects further information on the reason for leaving the last job. Summary statistics in table 2.2 show that patterns differ slightly between the two different groups of workers. First, applicants who found a job through a social network leave the job more often through resignation than applicants from the reference group do. Second, applicants who entered the job through a social network report a lower (unconditional) probability of dismissal. Third, summary statistics do not suggest that social networks are only used to fill temporary positions. On the contrary, the share of workers who left their job due to the end of a temporary contract is even lower for applicants who made use of friends or relatives to find their job.

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social network and $N = 0$ otherwise. The set of independent variables includes individual and firm characteristics but also information on the wider macroeconomic environment.

Later, the interpretation of estimation results focuses on two potential determinants of the entry channel into employment. First, the estimated coefficient on the unemployment rate identifies cyclical patterns in the use of social networks that can be linked to business cycle fluctuations. Second, results pay special attention to non-cognitive skills, which might have additional explanatory power over the decision an individual takes with respect to the entry channel. Here, the set of non-cognitive skills captures heterogeneity in terms of behavioral characteristics, such as openness and negativity, or positive reciprocity, which impact the formation of social networks; as a consequence, these measures also influence the probability that individuals have access to a network of friends and relatives to find a job.

The empirical model is characterized by equation 2.29, where N is the dependent variable that characterizes the entry channel into employment; X includes all independent variables to better explain heterogeneity in the data. For the probit model, the error term ϵ_i is normally distributed.

$$Prob(N_{it} = 1|X_{it}) \quad = \quad X_{it} \cdot \beta + \epsilon_{it} \tag{2.29}$$

Empirical findings build on three alternative specifications, which differ in terms of the set of independent variables and the estimation strategy. The first and second models exploit cross sectional variation to identify estimated coefficients; in contrast, the third model uses a fixed effects model and exploits within individual variation. This approach makes it possible to reduce potential problems of endogeneity with respect to the formation of social networks.

2.4.2 Starting wage: applicants benefit from increased match quality

The starting wage depends on the productivity of the applicant. Findings from the theoretical framework illustrate that the starting wage differs systematically across recruitment channels and increases in the match quality between the applicant and the firm. Accordingly, it is possible that applicants who used a social network to find a job, experience a "network premium" that reflects the surplus from increased match quality. To test for this hypothesis in an empirical framework, the standard mincer wage regression in equation 2.30 includes a dummy variable N which takes the value 1 if individuals used a social network to find their job and 0 otherwise.

The dependent variable for this specification refers to the starting wage an individual reported for the year when he started their job. The calculation of the starting wage (see summary statistics in table 2.8) builds on the net monthly income and takes into consideration the actual number of hours worked, including possible overtime [19] [20] [21]. Then the starting wage ω_{it} is regressed on N_{it} and further control variables X_{it}.

[19] The wage is calculated using the following questions from the GSOEP: First, *How high was your net income (which means wages or salary after deduction of taxes and social security) from employment last month? If you received extra income such as vacation pay or back pay, please do not include this. Please do include overtime pay.* Second, *And how many hours per week do your actual working-hours consist of including possible over-time?* Calculations are based on a multiplier of 4.33 to arrive at hourly earnings. Third, the wage is deflated to the year 2005 using the *Consumer Price Index* provided by destatis Germany.

[20] Given the high correlation (0.943) between the gross (mean 12.01, median 10.62) and the net (mean 7.39, median 7.04) monthly income, results do not differ in this measure. Accounting for potential subtractions due to taxes and higher reliability, I use net income.

[21] Additionally, I clean the data using a Z score of 4 to reduce the impact from extraordinary individuals who

$$\omega_{it} = \gamma \cdot N_{it} + X_{it} \cdot \beta + \epsilon_{it} \tag{2.30}$$

The estimation strategy takes into account previous concerns about the existence of unobserved heterogeneity, which could result in inconsistent estimated coefficients for the simple OLS model. For instance, non-cognitive skills influence the decision about the entry channel into employment but also impact the productivity in a firm, and thus the starting wage [22]. In response, a second model is estimated, which controls for heterogeneity in non-cognitive skills. The third specification explores a fixed effects model to establish a link between the use of social networks and the starting wage [23]. Here, empirical identification builds on within-individual variation to eliminate potential problems due to selection into networks.

2.4.3 Duration of a job: a matter of the entry channel

The duration of a job depends on the match quality between the worker and the firm. As discussed in the theoretical framework, match quality differs across recruitment channels, which might also impact the duration of an employment spell. As a first step, figures 2.3 and 2.4 summarize the main characteristics of the duration data extracted from the GSOEP data [24]. The first set of histograms refers to the starting month and the ending month of a job; the second set of histograms builds on information on the starting year and the ending year. Calculations exclude all individuals who either left their job in December 2009 or continued their job after December 2009, and also individuals who are right censored, in the sense that the ending month of their job is unknown. Later, results from the empirical analysis adjust for right censoring in the data.

Monthly data in figure 2.3 suggests that the number of individuals who start and finish a job varies over time and shows fluctuations over the year; many individuals start their job either in January, April or September. Before the summer break and especially towards the end of the year, the number of new hires (including job transitions within a firm) is relatively low. The share of individuals that leave their job is highest in December. Around one fifth of individuals leave their job in December, which includes individuals who leave the workforce completely. Furthermore, monthly data illustrates that, towards the beginning of the summer break when many firms adjust production capacities, the number of individuals who leave their job is higher than at any other time in the year.

Yearly data in figure 2.4 describes a strong co-movement of hirings and firings with the business cycle. As expected, the number of hirings is positively correlated with the annual growth rate of GDP; the number of individuals who leave their job is negatively correlated with the annual growth rate of GDP. The time series information shows that, towards the end of the

earn either very little or very much. Robustness checks illustrate that estimation results do not depend on the specification of the Z score and estimation results are robust to associated changes in the sample used in the empirical analysis.

[22] In this context, previous empirical papers suggest that a higher level of non-cognitive skills has an impact on wages. Among others, (Caliendo et al., 2009, 2010; Lindqvist and Vestman, 2011) highlight the importance of non-cognitive skills in understanding the starting wages that individuals receive.

[23] Using data from 15 different member countries of the European Union Pellizzari (2010) show that a fixed effects model often reverses the effect of social networks on wages because it allows for identification, even if unobserved individual fixed effects exist.

[24] Appendix 2.7 discusses the algorithm used to determine the duration of an employment spell.

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sample, in the year 2009, the German economy experienced an annual growth rate of -4.9 percent. This breakdown in industrial production was mainly triggered by the financial crisis; due to a wide set of active labor market policies the consequences for the labor market were minor [25].

Summary statistics suggest that the median duration of a job is 25 months (using only uncensored observations). The mean is higher (37.09 months), which reflects the skewness of the distribution. After 80 months (6.7 years) 10 percent of the jobs are still ongoing, which can be explained by the high share of civil servants (around 5 percent) and employees in the public sector (around 25 percent). For the Kaplan Meier survivor function in figure 2.5 the vertical axis shows the proportion of jobs that are still in progress after a stated time (number of months). Not all jobs had finished by the end of the sample period (around 41 percent of the sample are subject to right censoring) [26]. Furthermore, the stepwise nature of the Kaplan Meier survivor function illustrates the issue of discrete and continuous time. Using monthly information on the employment status in a continuous framework, I implicitly assume the hazard rate to be constant over the time interval (of one month). For the empirical analysis, the ratio between the width of each interval relative to the average spell length allows for a continuous time analysis.

The hazard curve in figure 2.5 illustrates that the hazard rate is first increasing and then decreasing monotonically, with a higher rate at the beginning of the sample. Here, the hazard rate captures the instantaneous probability of leaving a state in time $t+1$ conditional on survival to time t. The increase in the monthly hazard towards the beginning of the sample reflects the high number of fixed term contracts in Germany (6, 12 or 24 months). The large proportion of workers with fixed term contracts is due to the high incidence of publicly subsidized jobs, which include job creation measures and wage subsidies (which are limited in terms of time) [27]. After 36 months the hazard rate decreases monotonically. The Exponential model does not allow for changes in the hazard over time and seems unsatisfactory for approximating the shape of the hazard curve. On the other hand, the Weibull and the Log-logistic model offer promising approaches for learning more about the determinants of the duration of a job. In addition, the semi-parametric Cox model, which does not impose any assumptions on the functional form of the hazard function looks like a possible candidate.

Empirical model for the duration analysis The duration model focuses on the conditional hazard rate $\lambda(t|X)$ [28]. Here the hazard rate is a function of the length of the job t and a set of observable characteristics X, with a particular focus on the entry channel into the job. By assumption, all independent variables are time invariant over the observation period. For most

[25] The German government initiated an intensive labor market program to respond to the negative impact of the financial crisis on labor markets, which included a very broad program on short term contracts (Burda and Hunt, 2011; Möller, 2010).

[26] Using flow sampling, the sample is only subject to right censoring but not to left censoring. When an observation is right censored, this implies that the information on the duration is incomplete because the subject did not have an event during the observation period. A key identifying assumption is that, conditional on the set of independent variables, parameters of the distribution of censoring time are not informative about parameters of the distribution of the duration of the job.

[27] IAB data suggests that between 1997 and 2003 the share of fixed term contracts for newly employed workers was 33 percent for West Germany and significantly higher for East Germany. Until 2009 the proportion of fixed term employees increased further in both West and East Germany. 43 percent of the establishments with fixed term workers reported that the duration of their fixed term working contracts ranged between six and 12 months (Boockmann and Hagen, 2008). Across all sectors, 47 percent of the contracts of recently hired persons were fixed term (Eurofond, 2007).

[28] For a more detailed discussion on duration models see Kiefer (1988).

independent variables, this requirement holds true (for example education, gender and migrant status), whereas for other variables (for example experience) this is a rather strong statement. Nevertheless, the example of experience, which increases linearly in the duration of the job, illustrates that identification does not generally fail if variables are time variant.

The empirical model estimates the probability that a job that has been in progress for t months will end in month $t+1$. The class of proportional hazard models describes an approach where all individuals have a hazard of the same shape, and observable characteristics only shift the baseline hazard. The empirical analysis then exploits two parametric procedures (the Weibull and the Log-logistic model) and a semi-parametric estimation procedure (the Cox model) to identify parameters that characterize the shape of the baseline hazard. In general, the hazard rate $\lambda(t|X)$ is characterized such that

$$\lambda(t|X) = \lambda_0 \cdot \Phi(X, \beta) \tag{2.31}$$

where $\Phi(X, \beta)$ takes different functional forms Cameron and Trivedi (2005). The two parametric models in equations 2.32 and 2.33 differ in the underlying duration dependence and, consequently, also in the shape of the conditional hazard function. For the Weibull model, the hazard function increases (or decreases) monotononically over time. The Exponential model assumes a constant hazard rate over time and can be interpreted as a special case of the Weibull model. Here, the Exponential model builds on the idea that the hazard is constant over time, such that the underlying process is memoryless and exit time does not depend on how long the individual has been in the initial status. The Log-logistic model is an accelerated lifetime model, where the hazard function is non-monotonic over time and allows for more flexibility.

$$\lambda(t|X) = \Phi(X \cdot \beta) \cdot \alpha \cdot t^{\alpha-1} = \exp(\gamma \cdot N_i + X \cdot \beta) \cdot \alpha \cdot t^{\alpha-1} \tag{2.32}$$

$$\lambda(t|X) = \frac{\exp(\gamma \cdot N_i + X \cdot \beta) \cdot \alpha \cdot t^{\alpha-1}}{1 + \exp(\gamma \cdot N_i + X \cdot \beta) \cdot t^{\alpha}} \tag{2.33}$$

Both the Weibull model and the Cox model fall into the category of proportional hazard models, such that the explanatory variable scales the baseline hazard multiplicatively. For instance, an estimated coefficient larger than 0 increases the baseline hazard, which translates into a shorter time span until an event occurs [29]. The Log-logistic model is an accelerated lifetime model where regressors rescale the time axis. Consequently, an estimated coefficient larger than 0 leads to an increase in the duration.

2.4.4 Wage profile: focus on long term labor market outcomes

Lastly, the wage profile of individuals is used to evaluate the impact of social networks on long term labor market outcomes. Given the data design and the limitations discussed above (right censoring and panel attrition, but also many job durations that are shorter than 12 months), I observe a subset of individuals for the subsequent years $t+j$. Here, t indices the time an

[29] For a categorical 0 and 1 scalar variable the impact of a discrete change from 0 to 1 is given by exp(beta) - 1. For example, a hazard ratio 0.2 can be interpreted as follows: belonging to x = 1 instead of x = 0 decreases the hazard by nearly 80 per cent over the (monthly) baseline hazard.

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individual gets into a job and j captures the duration of the job in years [30]. As a dependent variable, the linear regression model uses earnings in period $t+j$. The set of independent variables includes the starting wage ω_{it} and a dummy variable N describing whether an individual entered a job through the social network channel.

$$\omega_{i,t+j} = \alpha \cdot \omega_{it} + \gamma \cdot N_{it} + X_{ijt} \cdot \beta + \epsilon_{it} \tag{2.34}$$

Figure 2.7 and table 2.9 capture some descriptive statistics of the dependent variable in equation 2.34. The ratio between hourly wages in year $t+j$ relative to the starting wage in year t characterizes the wage profile at the aggregate level. Here, all monetary units are deflated to the year 2005, such that a ratio larger than 1 suggests a wage growth which is, on average, positive. Figures 2.7 in the appendix to this paper illustrate that wages increase over time. Furthermore, summary statistics in table 2.9 do not identify a clear pattern in terms of differences between individuals who used a social network compared to those who did not. In the following section I discuss findings from the empirical model that explores cross sectional information, and also a fixed-effects model to learn more about the long-term effects of social networks on the wage profile.

2.5 Data: German Socio Economic Panel

The empirical analysis makes use of the German Socio Economic Panel Survey (GSOEP) provided by the German Institute of Economic Research [31]. The GSOEP is a wide ranging and representative longitudinal data set of private households in the Federal Republic of Germany since 1984 and Eastern Germany since 1990. It is a household based study which re-interviews each adult household member annually. Additional samples have been taken of East Germans and immigrants. Until 2011, there have been about 12 000 households with more than 20 000 adult persons sampled. The aim of the survey is to collect yearly representative micro data to measure stability and change in living conditions. It largely follows a micro level approach, and includes sociological and political science variables. Some of the many topics surveyed include household composition, occupational biographies, employment characteristics, health and satisfaction indicators. However, as with all panels, the GSOEP is subject to attrition, which could bias the results. The main source of attrition is refusal; special measures have been taken to reduce attrition, such as re-contacting respondents each year until all members of the household have refused for two consecutive years.

In contrast to previous attempts to establish a link between the use of social networks and labor market outcomes, the empirical analysis does not make use of administrative data. This

[30] An alternative way to characterize the career path of individuals is to analyze the positions individuals work in when being employed. In this context, the Ganzeboom scale (position, department size, responsibility) offers information on the prestige of a position. The occupational status is measured by the International Socio-Economic Index of Occupational Status (ISEI) (Ganzeboom et al., 1992; Ganzeboom and Treiman, 2003), which summarizes the power, income and required educational achievement associated with various positions in the occupational structure. The ISEI scale is a continuous scale of occupations derived from the International Standard Classification of Occupations and data on the education and income of about 74,000 full-time employed men in sixteen countries.

[31] For a detailed discussion of the data set, see Frick and Haisken-DeNew (2005); Wagner (2007); von Rosenbladt and Siegel (2006); Krupp (2008).

comes with the cost of knowing less details about the firm and the type of working contract [32]. The GSOEP data offsets this drawback by providing detailed information on the entry channel and by collecting a wide set of individual and household specific information. Furthermore, the panel character of the data allows for additional insights regarding long-term labor market outcomes.

2.5.1 Set of independent variables

Based on the the theoretical model and the preliminary discussion on methodology, the empirical analysis exploits a wide range of individual specific information to control for heterogeneity across individuals that has the potential to explain differences in labor market behavior. This information can be grouped into three broad categories as follows: first, individual and household specific information; second, firm and job specific information and third, macro-level information.

Individual specific information. The set of independent variables includes individual specific information like gender, age, education and migration background (see table 2.4). Additionally, the empirical model accounts for previous labor market experience and a set of non-cognitive skills (see table 2.7).

Gender. The variable *female* takes the value one if the individual is female. Overall, 49.8 percent of the sample observations relate to women in the labor market.

Age and **Age (sq).** The average age in the sample – measured at the beginning of the job – is 35.6 years. The squared term is scaled by dividing it by 100.

Education. The educational status of an individual is recoded according to the international ISCED scale (UNESCO, 1997), such that the following categories can be established: general education (baseline, 1), middle education (2), vocational, abitur [33], and higher than abitur (3) and higher education (4). Categorical information is used to account for non-linearities in the return to education.

Migrant. The variable *migrant background* takes the value one if the individual has a direct or indirect migrant background. For the sample from the GSOEP data, 16.5 percent of the observations report a migrant background.

Experience and **Experience (sq).** The measure of labor market experience summarizes the total duration of all previous jobs in part-time and full-time employment (the average is 11.8 years). The squared term is scaled by dividing it by 100.

Non- cognitive skills. Data from the GSOEP provides information on a set of cognitive and non-cognitive measures. Based on answers to a wide set of questions relating to non-cognitive skills, I introduce seven different measures on neuroticism, extraversion, openness, agreeableness, conscientiousness, positive reciprocity, and negative reciprocity [34].

[32] For example the IAB data provides further information on firm characteristics and allows for a more detailed information on wages (see for example Dustmann et al. (2011b)).

[33] The category "abitur" refers to individuals who successfully finished secondary education; this degree enables them to attend university.

[34] The index builds on the (unweighted) average over different variables. As robustness checks I also constructed these measures based on principal component analysis and did not arrive to different results.

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Since the information was only collected for two years (2005 and 2009), I extrapolate these measure to previous years by correcting the initial measure for age effects [35].

Firm and job specific information. Both entry into the labor market and labor market outcomes are the result of a bargaining situation between applicants and firms. Consequently, the set of independent variables incorporates information on the sector of employment and also on the company size. To account for job specific characteristics, the set of independent variables includes information on the type of contract and a dummy variable for whether the individual is employed in the public sector (see table 2.5).

Sector, industry. The categorical variable *sector of employment* is generated using the 2 digit NACE scale, giving us four categories: agriculture, mining and other (baseline, 1), energy, manufacturing and construction (2), trade and transport (3), and bank, insurance and service (4).

Company size. The categorical variable *size of company*distinguishes between small, medium, large and extra large companies based on the number of employees [36]: small with less than 5 employees (baseline, 1), between 5 and 19 employees (2), medium size 20 to 199 (3), large companies with 200 to 1999 employees (4) and extra large companies with more than 2000 employees (5).

Employment status. The categorical variable *employment status* defines three different categories of employment: 77.9 percent of the observations report to be in full-time employment (baseline, 1), 20 percent work in regular part-time employment (2) and the rest are in marginal part-time employment (3).

Public sector. The variable *public sector* takes the value one if the individual is working in the public sector (24 percent of the observations).

Civil servant. The variable *public service* takes the value one if the individual is employed as a civil servant. Civil servants make only a small part of the workforce (for this sample 4.4 percent) and do not use social networks since their training and assignment into jobs is more centralized (e.g. teachers).

White and blue collar workers. The variable *white collar* takes the value one if the position can be categorized as a white collar job (63.5 percent of observations).

Unemployment rate and labor market tightness. Data on regional labor market characteristics such as the unemployment rate and labor market tightness are collected from the national statistics office [37]. The average employment rate over time and space is 11.9, although there are significant variations, with a minimum of 3.7 and a maximum of 22.1 percent.

[35] The construction of this index accounts for age effects by first regressing it on age and age squared and then isolating the residual.

[36] Later, I will introduce further restrictions to exclude self employed individuals from the sample.

[37] Information on the unemployment rate and labor market tightness is gathered from administrative data provided by the Statistisches Bundesamt and the OECD.

Macro information. To control for differences across regions, dummies for 15 German federal states are introduced [38]. These dummies are supposed to capture any regional factors affecting labor market outcomes, such as regional differences in institutions and labor market structure. I also include year dummies to control for economic conditions across time (business cycle fluctuations). To account for shifts in the demand and supply of labor over the year, the empirical model allows for dummies for each month. All macro information from external data sources is matched to the GSOEP data on year and state (see table 2.6).

State. Schleswig-Holstein (baseline, 1), Hamburg (2), Niedersachsen (3), Bremen (4), Nordrhein-Westfalen (5), Hessen (6), Rheinland-Pfalz, Saarland (7), Baden-Wuerttemberg (8), Bayern (9), Berlin (11), Brandenburg (12), Mecklenburg-Vorpommern (13), Sachsen (14), Sachsen-Anhalt (15) and Thueringen (16).

Year start. Dummy for each year between 1991 and 2010 (baseline: year 1991).

Month start. Dummy for each month January until December (baseline: month January).

2.5.2 Restrictions on the data

For the empirical analysis of individual labor market behavior the sample from the GSOEP is restricted to women and men aged from 20 till 60 years. In an attempt to reduce heterogeneity in terms of working contracts I require individuals to work at least 15 hours a week. Furthermore, only individuals who are working as employees are included; I do not take into consideration individuals who are self employed. This restricts the sample to workers in full-time employment, regular part-time employment or marginal part-time employment. Furthermore, I only consider individuals that provided an answer to the question *How did you find your last position?*. Recall that for our sample from the GSOEP, I only observe successful matches between employees and employers. To reduce problems from differences in the survey design and also from differences in the sample, I only start in the year 1991 [39]. Most importantly in this context: In 1990 the German reunification took place and the survey was adapted to include a significantly larger population. The first time period I observe is January 1991 and the last time period is December 2009. The restricted sample used for the empirical analysis does not, by construction, suffer from any problems of attrition. As discussed earlier, data on non-cognitive skills is collected in the year 2005 and 2009 and later extrapolated into past and future time periods. By definition, this extrapolation only works within individuals, and any individual not observed in the year 2009 is automatically not included in the sample. Obviously, this strategy has an impact on the estimation results such that results in this paper speak for the restricted sample from the GSOEP data but not necessarily for the German labor market in general.

2.6 Results from the empirical model

The empirical analysis explores data from the GSOEP and lends support to previous findings from the theoretical model. Results suggest that the event *using a social network to search for a*

[38] Due to confidentiality issues, the regional data put individuals from Rheinland Pfalz and Saarland into one and the same category. This also reflects the fact that the two labor markets are highly integrated. For a similar reason, East and West Berlin form one category.

[39] Major updates of the GSOEP took place in 1991 (East) and 1998 (migrants).

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job is not random across individuals and is also influenced by the regional unemployment rate. Furthermore, findings from the empirical model show that individuals who made use of a social network benefit from a higher starting wage and a longer duration of employment, which can be contributed to the increased match quality between applicant and firm. The wage profile is flatter, which illustrates differences in how firms learn about the match quality between applicant and firm. Altogether, the empirical analysis highlights the importance of social networks in labor markets and provides evidence that match quality is higher for jobs that were established through an employee referral.

2.6.1 Determinants of individual search behavior

Results in table 2.10 suggest that individual characteristics, firm characteristics and the wider macro environment influence the decision of individuals to make use of a social network when searching for a job. First, specifications 1 to 3 focus on marginal effects from the probit model discussed in the previous section. Neglected heterogeneity and endogeneity have the potential to induce considerable specification problems. Second, estimated marginal effects in specifications 4 and 5 build on the fixed effects model, which accounts for unobserved but time-invariant characteristics. As a consequence, identification comes from variations within individuals who started more than one job during the sample period. Altogether, test statistics for the probit model such as the pseudo R-squared and the F-statistic support the validity of the set of independent variables. Identification for the fixed-effects model is much weaker since I require changes within individuals and do not focus on overall heterogeneity between observations. Results from the probit and fixed-effects model do not contradict each other in terms of sign of estimated coefficient; nevertheless, differences in terms of size highlight the relevance of unobserved and time-invariant characteristics.

Empirical findings in table 2.10 illustrate that a higher level of the regional unemployment rate has a statistically and economically negative impact on the probability that individuals report having found their job through a social network (see hypothesis 1) [40]. Two alternative explanations can be seen as divers behind these results: First – and in line with hypothesis 1 from the theoretical model – workers change their behavior in the referral process during times of increased economic instability and become more selective in terms of employee referrals. Here, the increase in the regional unemployment rate changes the implicit punishment in the bayesian signaling game and makes workers inside the firm more cautious which, in the end, reduces the probability that a job is found through a social network. Second, social networks generate less job offers during times of high unemployment rates. Due to network effects this mechanism reduces job offers through the social network channel even more than alternative recruitment channels (Galeotti and Merlino, 2010). Altogether, the negative estimated coefficient on the regional unemployment rate suggests that social networks are less valuable during times of economic instability.

In addition, results from the probit model (specifications 1 to 3) confirm previous findings from the social science literature. For instance, females make use of a social network when searching for a job with a lower probability. Also, the educational degree of an individual influences the channel used to get into a job. Individuals who report educational attainment,

[40] I also use labor market tightness to alternatively characterize regional labor market conditions and confirm previous findings.

summarized in the category "middle educational degrees", have a lower probability of using a social network compared to the baseline category "only general educational". For individuals with higher educational degrees there is, on average, a lower probability of using a social network to get into a job. Furthermore, migrants experience an increased probability of using friends and relatives to find a job compared to non-migrants [41]. Estimated coefficients from specification 3 suggest that, in addition to the above mentioned set of independent variables, non-cognitive skills such as openness and positive or negative reciprocity do not necessarily influence the probability of having found a job through a social network.

Firm characteristics are crucial to understanding individual search behavior in labor markets. Individuals working in larger firms experience a lower probability of having found their job using a social network. This pattern might be driven by the fact that bigger firms often make use of more formal recruitment strategies and include human resources units that can more easily assess the match quality between an applicant and a firm. This reduces the need to go through a social network to benefit from higher match quality and increased matching probability. Furthermore, empirical results highlight differences across sectors and industries. The overall profile of the position matters significantly when it comes to the use of social networks. First, marginally employed workers report a higher probability of having found their job through a social network than full-time employees. Second, white collar workers, compared to blue collar workers, are characterized by a lower probability of having used a social network channel to enter a job. Third, public sector workers, and in particular public servants, are less likely to have used a social network to find a job.

The comparison between specifications 4 and 5 in table 2.10 illustrates the importance of region and time dummies when explaining the usage of social network (not reported in the results tables). First, the significance of state dummies highlights the relevance of regional labor market characteristics, which refer to the structure of the regional economy and reflect differences in terms of labor market institutions. Second, the significance of estimated coefficients on the starting year and the state is informative when discussing how regional labor market characteristics influence the usage of social networks. Given that the estimated coefficient on the regional unemployment rate becomes insignificant when using the extended set of region and time dummies (specification 5), the empirical analysis suggests that the unemployment rate influences the dependent variable through time and region effects. Third, control variables for different starting months capture the idea that people starting their jobs at different times of year have very different characteristics, and that employers are looking for different types of employees at different times of the year. Here, results show that supply and demand side differences in the labor market influence the decision to make use of social networks when searching for a job.

2.6.2 An enriched mincerian wage regression

The empirical literature on labor markets has frequently made use of wage regressions to identify the effects of individual specific characteristics on the wage. Findings from the theoretical model suggest that social networks allow for a higher match quality between applicants and firms. In reference to hypothesis 2 from the theoretical model, results in this section illustrate that individuals who made use of a social network when finding a job experienced a positive “network

[41] Dustmann et al. (2011b) use data from the IAB employment data and find that ethnic networks play an important role for search in the labor market (Goel and Lang, 2010; Munshi, 2003; Beaman, 2012).

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premium" of around 5 percent.

Results from the empirical model in table 2.11 can be summarized as follows. First, estimated coefficients replicate standard results from the literature on mincerian wage regressions (Mincer, 1974; Heckman et al., 2003). For instance, data from the GSOEP confirms a positive impact of age and experience (seniority) with a negative second derivative. Education increases the starting wage in an economically and statistically significant way. Furthermore, females receive a strikingly negative wage premium. Also, individuals with a migrant background receive a lower starting wage on average. Second, the set of independent variables includes binary information on the use of social networks when finding a new job. The estimated coefficient supports the idea of a positive "network premium" for male, non-migrant, blue collar workers. Depending on the specification, the positive effect on the starting wage is between 3 and 5 percent for the OLS and the fixed effects model respectively. For females and white collar workers who make use of social networks to get into a job, this effect decreases and might even turn negative. Third, test statistics from the empirical model and estimated coefficients in the results table illustrate the importance of firm specific characteristics. The sector and, in particular, the firm size have a strong impact on the starting wage of individuals. These findings reflect the well known fact that large firms pay higher wages (Gerlach and Huebler, 1998; Pull, 2003). Fourth, estimated coefficients highlight the relevance of additional information on the starting date (starting month and year) and region (state) of a job. Here, time variables extract variation in wages due to business cycles. Furthermore, region dummies control for the observed differences at the state level, and in particular, differences between states in East and West Germany.

Specification 3 in table 2.11 suggests that non-cognitive skills are important to include into the set of independent variables when explaining the starting wage of individuals. In reference to results from the probit model in the previous section, which identifies determinants of the event *I have found my job through a social network*, it is possible that non-cognitive skills increase the use of social networks and also increase the starting wage of individuals. In other words, the endogeneity of the decision to use a social network while searching for a new job induces inconsistent estimates in the standard OLS model in specifications 1 and 2. To test to what extent non-cognitive skills impact the starting wage, I introduce a set of independent variables that summarize information on individual character traits. Here, previous research has shown that openness, positive and negative reciprocity have an impact on the formation of social networks and influence the starting wage [42]. Test statistics and the significance of some coefficients illustrate the importance of these measures. Nevertheless, the inclusion of additional information on non-cognitive skills into the set of independent variables does not alter previous findings on the "network premium", which is still around 3 percent for the OLS model.

The fixed-effects model in specifications 4 and 5 gives us a second opportunity to control for time invariant unobserved characteristics. Empirical results in table 2.11 exploit the fact that the GSOEP data often reports more than one job per individual. Thus, findings from the fixed-effects model account for any unobserved but individual specific heterogeneity. Estimated coefficients change relative to the previous specifications 1, 2 and 3, which refer to an OLS model (especially in size but not necessarily in sign); these findings higlight potential problems due to correlation with unobserved and time-invariant characteristics that induce estimated coefficients in the OLS model to be inconsistent. The "network premium" for individuals who made use of a social

[42] See, for example, Caliendo et al. (2010) for a detailed discussion.

network is around 5 percent for males, whereas females experience a negative premium. The fixed-effects model does not identify significant differences for migrants and white collar workers, which might also be due to insufficient within individual variation in these variables. Altogether, the comparison between the standard OLS approach in specifications 1 to 3 and the fixed-effects model in specifications 4 and 5 illustrates the importance of unobserved and individual specific heterogeneity in explaining the starting wage of individuals. In this respect, the empirical analysis highlights the drawbacks of previous empirical models, which rely on cross-sectional data and do not control for non-cognitive skills or for time invariant and unobserved characteristics.

2.6.3 Job duration, match quality and the social network

The theoretical framework illustrates that increased match quality through a social network channel also translates into a longer duration of employment (see hypothesis 3). Empirical findings from the duration model suggest that workers who found their job through a social network experience a lower hazard rate, such that the job continues for a longer length of time.

As discussed in the previous section, the duration model uses the number of months until an individual reports changing job as dependent variable [43]. Next, regression results in table 2.12 explore parametric and semi-parametric estimation procedures, which differ in terms of the specification of the hazard function. For instance, the Weibull model (specification 2) is defined by equation 2.32, where alpha smaller than one (the estimated parameter alpha is 0.986 and statistically not significant from 1) implies a slightly decreasing hazard rate; as a consequence, the probability of leaving the job decreases over time. The Log-logistic model (specification 3), characterized in equation 2.33, allows for more flexibility in the sense that increases and decreases in the hazard rate are possible. Within the framework of the Log-logistic model, alpha smaller than one (the estimated parameter alpha is 0.708 and statistically significant from 1 at the 1 percent confidence level) suggests that the hazard is decreasing monotononically over time. Test statistics show a slightly better log-likelihood statistic for the Log-logistic model, which offers superior possibilities for matching the underlying data generating process. In contrast to the parametric Weibull and the Log-logistic model, the Cox proportional hazard model in specification 1 offers a semi-parametric approach and allows for an unrestricted baseline hazard in the duration of employment.

Empirical results reported in table 2.12 show that individuals who got into their job using a social network of friends and relatives experience a longer duration of employment. This effect is statistically and economically significant, independent of the specification of the underlying hazard function. Ceteris paribus, a male, non migrant, blue collar worker experiences a decrease in the monthly hazard rate of around 20 percent if he made use of a social network to get into a job. The effect is even bigger for females and results suggest that the duration of a job started through a social network is around 30 percent longer, compared to the control group. This effect does not exist for migrants who make use of a social network. Empirical findings also suggest that this increased duration of employment does not hold for white collar workers who entered their job through a social network. In summary, these findings illustrate that, for some groups in the labor market, social networks allow for a better match quality between applicants and firms

[43] The GSOEP data does not specify this transition – in fact, there are three types of changes possible: first, a new position within the same firm; second, a new position in a different firm; third, an individual leaves the labor market and enters into unemployment or retirement.

such that a job is associated with a lower probability of destruction.

The wider set of independent variables in table 2.12 controls for additional characteristics that have an impact on the hazard rate. Relative to the baseline hazard, older workers and individuals with a higher level of education experience a longer duration of employment (Boockmann and Steffes, 2005). Furthermore, the profile of the position matters for the duration of the job. Relative to full-time employees, part-time employees and in particular marginally employed workers experience a shorter duration of employment. White collar workers, and especially public servants, tend to benefit from a lower hazard rate which, ceteris paribus, implies that they are employed for longer in the same job. Company characteristics also influence the duration of a job. Estimated coefficients highlight differences across sectors that are not statistically different from zero. On the contrary, a lower hazard rate for larger firms suggests that job continue for a longer time span. Furthermore, results illustrate that non-cognitive skills matter in a statistically and economically significant way.

2.6.4 A long term perspective on wages

Social networks influence the level of the starting wage and the duration of a job; in addition, hypothesis 4 from the theoretical model suggests that social networks also have an impact on the wage process over time. Firms that recruit through a social network are able to reduce uncertainty about match quality from the very beginning of the employment relationship; thus, there is less additional information that the firm can reveal during the subsequent months and years. As a consequence, the long term wage profile should be flatter for applicants who enter the firm through a social network.

Findings in table 2.13 only focus on within individual variation to identify coefficients of interest. Here, each specification (FE year 1 to FE year 3) explores the long-term perspective on wages for the first, second and third years in which individuals report being employed in the same job [44]. Among other things, results suggest that age, education and firm size are associated with differences in the wage profile. Furthermore, public servants and also females, seem to have a lower wage growth over time.

Results from the fixed-effects model in specifications 1 to 3 provide suggestive evidence that the wage profile is flatter if an individual made use of a social network to get into a job (see table 2.13). Although the estimated coefficient is not statistically significant – identification is difficult due to the restricted sample size – the effect tends to be economically important. The estimated coefficient is increasing in size and suggests that after three years male, non migrant, blue collar workers report wages to be around 6 percent lower compared to someone who did not make use of a social network to enter their job. Altogether, results from this analysis show that the entry channel for a job has an impact on the subsequent wage profile.

2.7 Conclusion

In this paper I use a bayesian signaling game to model employee referrals through social networks. Results from the theoretical framework suggest that, under certain conditions, the match quality between applicant and firm is higher if the applicant was recruited through a social network.

[44] Due to the decreasing number of observations, I limit the number of years to three. Otherwise, identification of estimated coefficients comes from only a few observations.

Findings from the empirical analysis highlight the impact of social networks on individual labor market outcomes. Data from the German Socio Economic Panel (GSOEP) illustrate that the decision to make use of social networks to find a job is based on observed characteristics. Furthermore, the starting wage, the wage profile and the duration of the job vary systematically depending on the entry channel into a job.

The theoretical framework focuses on the behavior of workers who are employed inside a firm and are connected to friends or relatives outside the firm. Here, results from the bayesian signaling game show that firms can influence the worker's decision to recommend, or not to recommend a friend of given match quality. Using an incentive scheme that introduces a bonus and a punishment allows the firm to alter the behavior of its workers; under certain circumstances, the separating equilibrium enables the firm to exploit the social network channel and attract only applicants with an expected high match quality between applicant and firm. Furthermore, findings from the theoretical model suggest that nepotism and favoritism change the behavior of workers. As a consequence, inefficiencies in the referral process arise whenever the worker's decision is influenced by his social distance from the applicant. The semi-separating equilibrium collapses whenever the share of low quality matches that benefit from the employee referral due to nepotism and favoritism increases too much, such that, the correlation between type and signal decreases. Moreover, the equilibrium conditions in the bayesian signaling game suggest that behavioral traits and the time discount rate, and also regional labor market characteristics have an impact on the referral process in a social network; for instance, an increase in the regional unemployment rate manipulates the value of the punishment, such that the worker engages in less employee referrals.

The empirical framework exploits data from the GSOEP and supports previous findings from the theoretical model. First, results focus on the individual decision to make use of a social network as a search channel for a new job. Based on the fact that around 30 percent of the sample observations report that they have found their last job through friends and relatives, the empirical analysis identifies individual and firm specific characteristics as important determinants of this decision. Furthermore, findings highlight the role of the regional unemployment rate, which has an economically and statistically significant impact on the probability of finding a job through a social network. During times of high unemployment, social networks offer less job opportunities – a result which supports the idea that workers are more reluctant to engage in employee referrals. Second, the empirical analysis illustrates that there is a positive "network premium", such that applicants who went through a social network receive a higher starting wage. This reflects the idea of increased match quality between applicants and firms. Furthermore, these findings illustrate that, in the case of Germany, the semi-separating equilibrium in the bayesian signaling game does not collapse due to nepotism and favoritism; thus, firms are able to generate a higher match quality through the social network channel. Third, the panel dimension of the data allows for additional insights regarding the long-term labor market outcomes of employee referrals. Exploiting information on the duration of the job, the empirical analysis suggests that individuals who used a social network to find a job are employed for a longer time than individuals who used alternative recruitment channels. This result illustrates the positive impact of the increased match quality, such that the probability that an adverse productivity shock destroys the job decreases. Fourth, the wage profile differs for the two groups of workers. In line with the hypothesis that there are less information asymmetries between the referred applicant and the firm at the beginning of the job, the wage profile is flatter; less additional

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information about the worker's productivity is revealed over time.

The predictions from the theoretical model and findings from the empirical framework offer additional areas for future research. For instance, the stability of equilibria in a bayesian signaling game deserves further attention since the social distance between players often changes their associated payoff functions. On the one hand, an international comparison would focus on the question of how far differences in nepotism and favoritism can be linked to a positive or negative "network premium" in the starting wage that individuals receive [45]. On the other hand, a richer data set on the career development of workers and applicants – including additional information on their relationships – would enable researchers to better understand the behavior of players in a social network.

[45]The World Value Survey summarizes information on individual beliefs regarding the importance of friends and relatives for economic outcomes. Moreover, data from the European Union Statistics on Income and Living Conditions (EU SILC) project allows for an international comparison of starting wages at the individual level.

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Example 1: World Bank

Many firms in the private sector but also international organizations like the World Bank Group make use of social networks to attract applications from potential employees. This information taken from the World Bank i.refer information sheet offers further insights on why employers use social networks when looking for new employees.

> *Staff Referral Program [i.refer]: Get involved in finding the right people to join in pursuing the Bank's mission ... People who share your talent and commitment to improving the lives of the poor. Refer an eligible candidate to the World Bank, and if they are subsequently hired you could earn as much as USD 1000.*
>
> *What is a Referral Program for? Many organization in both the public and private sectors have benefited from formal referral programs. These have proven effective in attracting non- active candidates who are a good fit for the organizations and the job. The i-refer program enables the World Bank Group to acknowledge the staff's contribution when they tap into their extensive professional networks and their referral is hired. It also highlights the World Bank Group's on- going recruitment needs for diversity, high- priority vacancies and hard-to-find skills.*

Example 2: European Bank for Reconstruction and Development

During the application process to the European Bank for Reconstruction and Development, the applicant needs to answer the following questions. Here, the first question suggests that firms want to identify links between current workers inside the firm and applicants outside the firm. The second question illustrates that many firms (and especially international organizations) imposed a policy which restricts applications from close relatives. One reason might be the need to prevent nepotism and favoritism in the application process.

> *Where did you hear about this vacancy? (please select)*
> *If you were referred to this position by an employee of this company then please enter their company email, otherwise just leave this item blank.*
>
> *Screening Question: Answer Yes and No. Are you a close relative of an EBRD employee or close relative of the spouse or domestic partner of a Bank employee? (The "close relatives" of an employee comprise the employee's spouse, domestic partner, children, grand-children, brothers, sisters, parents, grand-parents, uncles, aunts, nephews, nieces and first cousins, as well as the employee's sons-in-law, daughters-in-law, brothers and sisters-in law and parents-in-law, and any stepson, stepdaughter, stepbrother and stepsister, and stepparent of the employee.)*

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Algorithm to Calculate Duration of Job from GSOEP Data

1. **Definition START MONTH and START YEAR:** Extract information on month when an individual started a new job. If there are two different starting months for a given year, I take the later one. The corresponding START YEAR is given by the year when I observe the START MONTH.

2. **Definition END MONTH and END YEAR:** Extract information on month and the year when an individual finishes a job. If there are two different ending month for a given year, I take the earlier one. The corresponding END YEAR is given by the year when I observe the END MONTH.

3. **Calendar information for each individual and month:** If I observe that individual arrives to an absorbing state (0: registered unemployment; retirement; school and university; military and community service; household activity) in period t - conditional on not being in an absorbing state in period $t-1$ (1: full time employment; part time employment; job training; maternity leave) – I set the END MONTH to $t-1$. For any individual December 2009 defines a natural end to any position. I will later redefine these duration spells and introduce censoring. Taking into consideration the sample restrictions and the fact that the panel is balanced, censoring only occurs for the end of the sample, namely anyone who is employed in December 2009 is also defined to be censored.

4. **Generation START JOB and END JOB:** Information on START MONTH and START YEAR is used to define the START JOB in terms of month. Similar approach for END JOB.

5. **Generation ranking START and END job:** For each individual I generate an information on the number of the START and END I observe in the data.

6. **Measure of DURATION (JOBb):** To determine the duration of a job I exploit all information on job starts and ends. (a) For each individual, fix the first START JOB and then calculate the distance to any possible END JOB. The smallest distance defines the first duration for that individual. (b) Continue accordingly for any possible START JOB.

7. **Measure of DURATION (JOBc):** The previous algorithm builds on the assumption that all individuals report any start and end of a job. Problems arise, if an individual starts a new job, but does not report on the previous job ending. Accordingly, I next calculate an alternative measure which evaluates any smallest distance between START JOB and the subsequent START JOB. (a) For each individual, fix the first START JOB and then calculate the distance to any possible subsequent START JOB. The smallest distance defines the first duration for that individual. (b) Continue accordingly for any possible START JOB.

8. **Measure DURATION (JOBd):** For any START JOB, I now have two information. One duration (JOBb) which incorporates the next possible end and a second duration (JOBc) which relies on the subsequent start of the next job. For each start I take the minimum and then set this information to missing if the first measure (JOBb) is larger than the second measure (JOBc) - given the second is well defined. This restriction is

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needed since if this condition holds, I know exactly that JOBb builds on wrong information, without knowing the exact end.

9. **Generation CENSOR variable:** There are two possible cases when an observation is censored (right). First, if the individual leaves the panel (and the previous job did not end) and second, if the panel itself ends. In both cases, I generate a variable which characterizes a spell by its censoring status.

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Descriptive Statistics and Estimation Results

Table 2.1: Recruitment channels in the GSOEP data.

	Channel	Frequency	Percent
1	Employment Office (Arbeitsamt)	767	11.21
2	Private Recruitment Agency	103	1.51
3	Advertisement Newspaper	927	13.55
4	Advertisement Internet	251	3.67
5	Returned To Former Employee	525	7.67
6	Other, E.G. Does Not Apply	2032	29.69
7	**Through Friends And Relatives**	2033	29.71
8	own chance	205	3.00
	Total number of observations	*6843*	

Notes: The table provides summary statistics to the question *How did you find out about this job?* Only if individuals found a new position successfully over the last survey period.
Source: GSOEP data. Own calculations.

Table 2.2: Reason for leaving the previous job. By entry channel.

	reason for leaving	**network 0**	**network 1**
1	Place Of Work Closed	12.88	15.01
2	Own Resignation	26.05	33.62
3	**Dismissal**	27.96	24.96
4	Mutual Agreement	8.76	7.65
5	**Temporary Contract Expired**	22.30	15.73
6	Reached Retirement Age,Pension	2.06	3.03
	Total number of observations	1359	693

Notes: The table provides summary statistics to the question *How was this job terminated?* Only if individuals left their last position during the last survey period.
Source: GSOEP data. Own calculations.

Table 2.3: Summary Statistics on Variables SOCIAL NETWORKS and DURATION.

Variable	**Mean**	**(Std. Dev.)**	**Min.**	**Max.**	**N**
starting month of job	5.845	(3.456)	1	12	6843
entry channel for job	5.180	(2.057)	1	8	6843
social network	0.297	(0.457)	0	1	6843
reason leaving job	2.999	(1.39)	1	6	2052
starting year of job	2000.764	(5.22)	1991	2009	6843
ending month of job	9.122	(3.754)	1	12	6843
ending year of job	2004.638	(4.997)	1991	2009	6843
duration of job	50.767	(46.104)	2	228	6843
number of jobs	1.990	(1.058)	1	5	6760
duration of job censored	0.407	(0.491)	0	1	6843

Notes: Descriptive information on the duration of a job calculated from the restricted sample.
Source: GSOEP data. Own calculations.

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Table 2.4: Summary Statistics on Variables PERSONAL.

Variable	Mean	(Std. Dev.)	Min.	Max.	N
female	0.498	(0.5)	0	1	6843
migrant background	0.165	(0.372)	0	1	6843
age	35.631	(9.810)	20	60	6843
experience in labor market	11.783	(9.666)	0	45	6843
education	2.649	(0.957)	1	4	6840

Notes: Descriptive information on individual characteristics calculated from the restricted sample.
Source: GSOEP data. Own calculations.

Table 2.5: Summary Statistics on Variables FIRM.

Variable	Mean	(Std. Dev.)	Min.	Max.	N
sector of employment	3.037	(0.952)	1	4	6843
size of company	3.171	(1.235)	1	5	6843
contracted work hours (week)	35.598	(7.713)	15	77	6843
employment status	1.243	(0.476)	1	3	6843
public sector	0.240	(0.427)	0	1	6843
public servant	0.044	(0.204)	0	1	6843
white collar	0.635	(0.482)	0	1	6843

Notes: Descriptive information on firm characteristics calculated from the restricted sample.
Source: GSOEP data. Own calculations.

Table 2.6: Summary Statistics on Variables MACRO.

Variable	Mean	(Std. Dev.)	Min.	Max.	N
state of residence	8.782	(4.162)	1	16	6843
starting month of job	5.845	(3.456)	1	12	6843
starting year of job	2000.764	(5.22)	1991	2009	6843
unemployment rate	11.887	(4.858)	3.7	22.1	6843

Notes: Descriptive information on macro characteristics calculated from the restricted sample.
Source: GSOEP data. Own calculations.

Table 2.7: Summary Statistics on Variables NONCOG.

Variable	Mean	(Std. Dev.)	Min.	Max.	N
openness	0.002	(0.191)	-0.597	0.42	6843
conscientiousness	0.006	(0.142)	-0.810	0.215	6843
extraversion	0.005	(0.186)	-0.658	0.372	6843
agreeableness	0.001	(0.157)	-0.685	0.27	6843
neuroticism	-0.003	(0.2)	-0.509	0.518	6843
positive reciprocity	0.002	(0.146)	-0.824	0.198	6843
negative reciprocity	-0.002	(0.238)	-0.394	0.655	6843

Notes: Descriptive information on individual characteristics and in particular non cognitive skills calculated from the restricted sample.
Source: GSOEP data. Own calculations.

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Table 2.8: Starting wage from GSOEP data. By entry channel.

network 0				**network 1**			
Obs	4810	Percentil 10	3.97	Obs	2033	Percentil 10	3.70
Mean	7.39	Percentil 25	5.08	Mean	6.53	Percentil 25	4.66
Std. Dev.	3.55	Median	6.67	Std. Dev.	2.88	Median	5.99
Skewness	1.86	Percentil 75	8.78	Skewness	1.96	Percentil 75	7.75
		Percentil 90	11.67			Percentil 90	9.96

Notes: Net hourly earnings, deflated to 2005. The table provides summary statistics to the question *How high was your net income (which means wages or salary after deduction of taxes and social security) from employment last month? If you received extra income such as vacation pay or back pay, please do not include this. Please do include overtime pay.* (2) Consumer Price Index from destatis Germany. (3) *And how many hours per week do your actual working-hours consist of including possible over-time?* Calculations are based on a multiplier of 4.33 to arrive to monthly earnings.
Source: GSOEP data. Own calculations.

Table 2.9: Earnings profile over years. By entry channel.

Variable	**Mean**	**(Std. Dev.)**	**Min.**	**Max.**	**N**
earnings index after 1 year	1.056	(0.373)	0.079	15.945	5879
earnings index after 2 years	1.079	(0.346)	0.161	5.378	3878
earnings index after 3 years	1.111	(0.374)	0.220	6.631	2917
earnings index after 4 years	1.13	(0.388)	0.105	7.093	2257
earnings index after 5 years	1.15	(0.466)	0.105	10.926	1807
earnings index after 6 years	1.164	(0.401)	0.211	5.201	1480
earnings index after 7 years	1.194	(0.498)	0.18	8.558	1210
earnings index after 8 years	1.209	(0.445)	0.101	5.465	961
network 0					
earnings index after 1 year	1.052	(0.318)	0.079	7.506	4121
earnings index after 2 years	1.073	(0.332)	0.217	5.195	2698
earnings index after 3 years	1.105	(0.347)	0.220	5.524	2016
earnings index after 4 years	1.130	(0.395)	0.105	7.093	1572
earnings index after 5 years	1.147	(0.507)	0.105	10.926	1250
earnings index after 6 years	1.159	(0.382)	0.211	4.813	1029
earnings index after 7 years	1.198	(0.514)	0.180	8.558	846
earnings index after 8 years	1.212	(0.439)	0.101	4.408	662
network 1					
earnings index after 1 year	1.065	(0.476)	0.176	15.945	1758
earnings index after 2 years	1.094	(0.376)	0.161	5.378	1180
earnings index after 3 years	1.125	(0.428)	0.348	6.631	901
earnings index after 4 years	1.130	(0.371)	0.354	4.362	685
earnings index after 5 years	1.156	(0.358)	0.526	3.674	557
earnings index after 6 years	1.174	(0.441)	0.494	5.201	451
earnings index after 7 years	1.186	(0.46)	0.257	6.113	364
earnings index after 8 years	1.202	(0.459)	0.257	5.465	299

Notes: The average earnings index (after X years) summarizes the ratio between average earnings in year X relative to the average starting wage in year 0. The lower part of the table presents the average earnings index conditional on the entry channel into a job: first, all individuals who did not make use of the social network channel to enter a job; and second all individuals who made use of a social network.
Source: GSOEP data. Own calculations.

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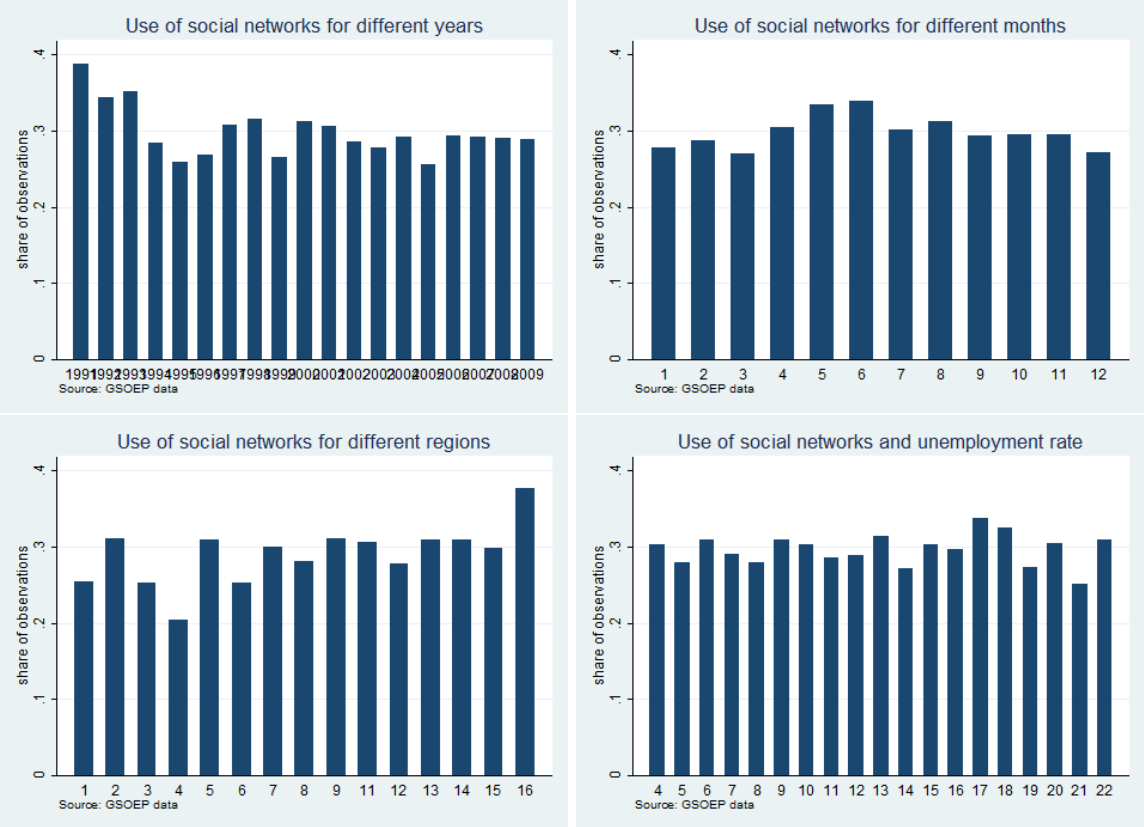
Figure 2.1: The use of social networks over time and space.



Abbreviations: States are coded as follows: Schleswig-Holstein (1), Hamburg (2), Niedersachsen (3), Bremen (4), Nordrhein-Westfalen (5), Hessen (6), Rheinland-Pfalz, Saarland (7), Baden-Wuerttemberg (8), Bayern (9), Berlin (11), Brandenburg (12), Mecklenburg-Vorpommern (13), Sachsen (14), Sachsen-Anhalt (15) and Thueringen (16).
Notes: Figures show the share of successful job matches which were initiated through a social network. The horizontal axis differs by figure and exploits variation in time (year and month), states and unemployment rate.
Source: GSOEP data. Own calculations.

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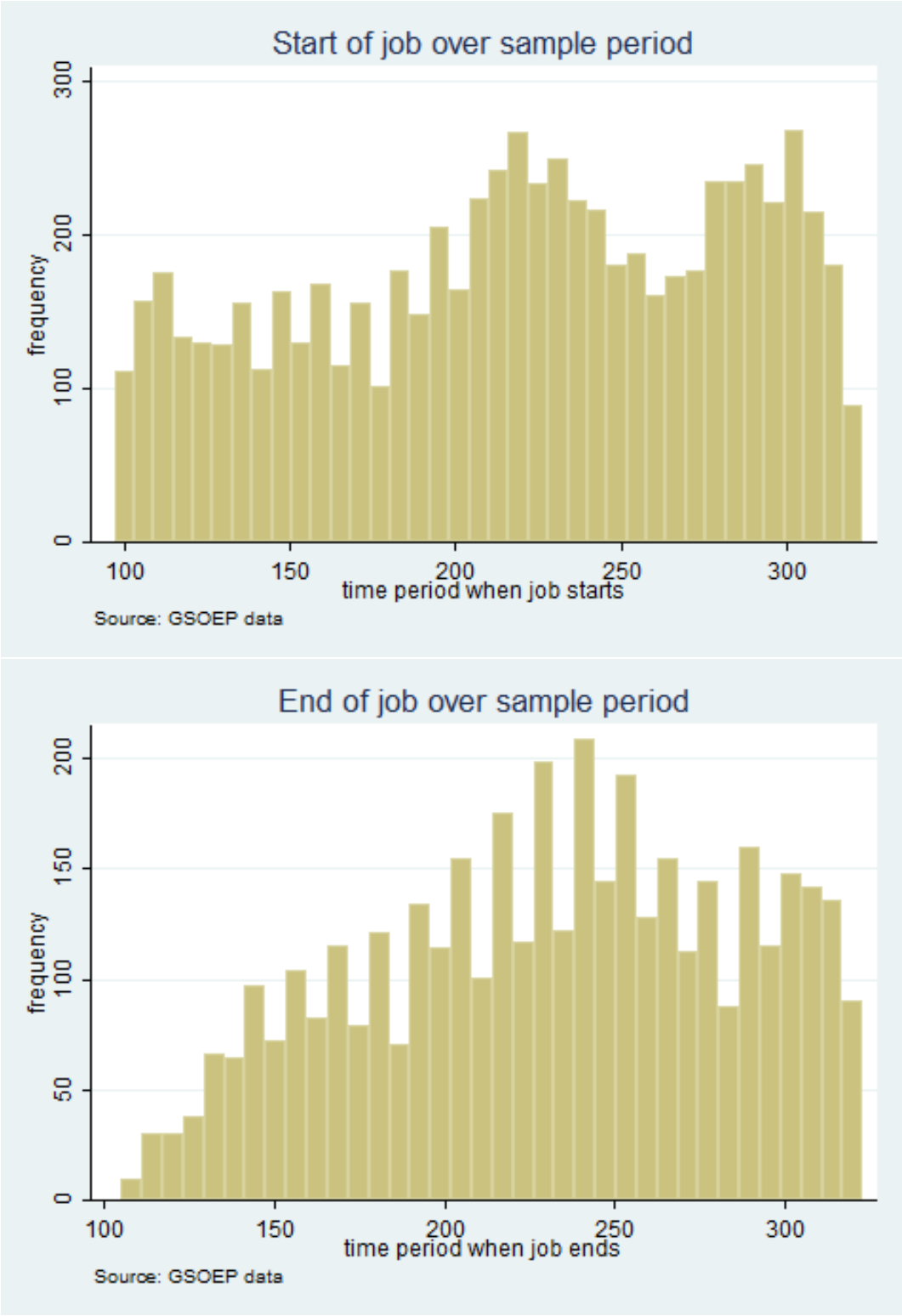
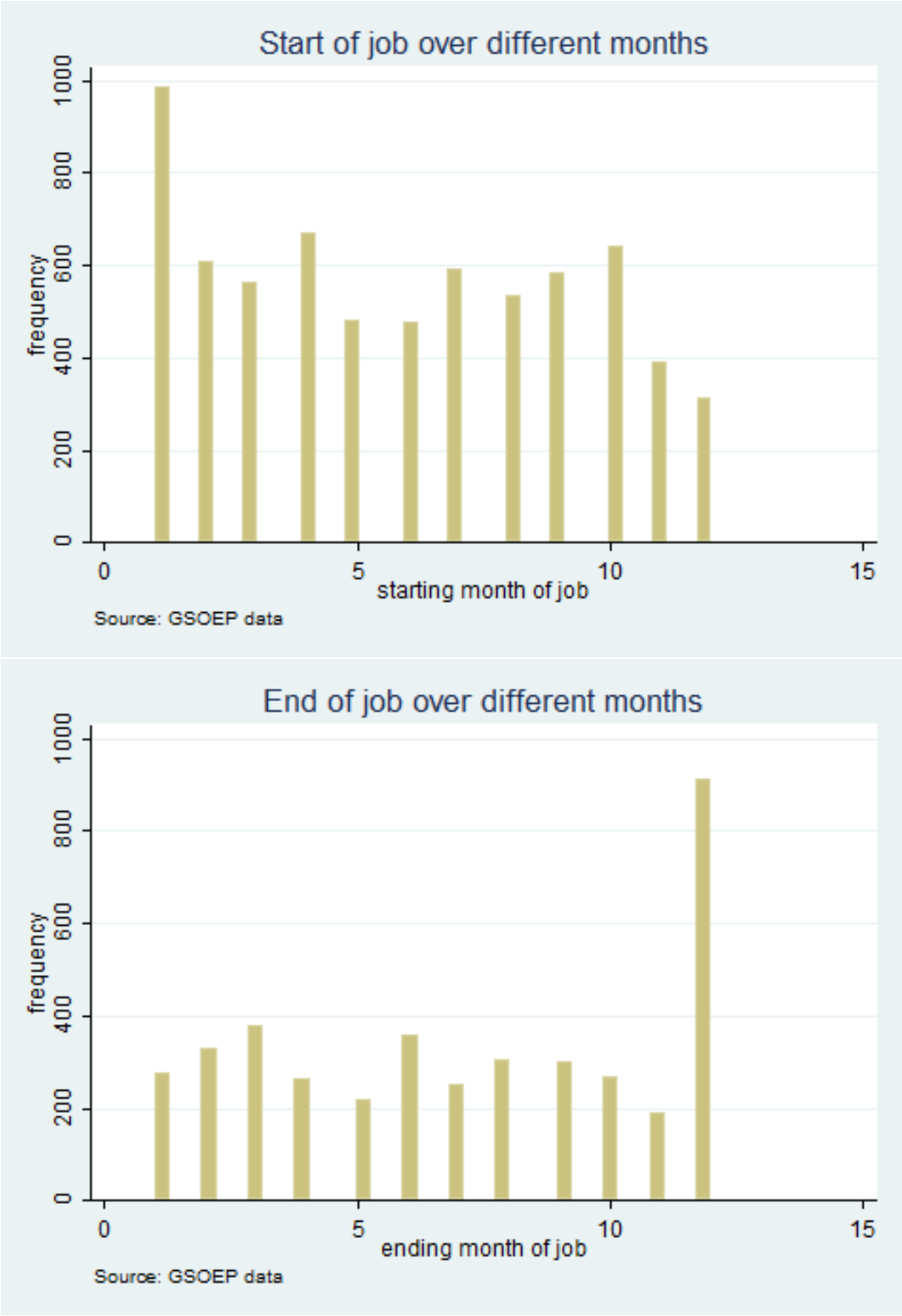
Figure 2.2: Number of jobs started (ended) each period.



Notes: The first time period of observation is January 1991 whereas the last month of observation is December 2009. Information on the ending month excludes individuals which are right censored.
Source: GSOEP data. Own calculations.

Figure 2.3: Number of jobs which started (ended) each month.



Notes: The first time period of observation is January 1991 whereas the last month of observation is December 2009. Information on the ending month excludes individuals which are right censored.
Source: GSOEP data. Own calculations.

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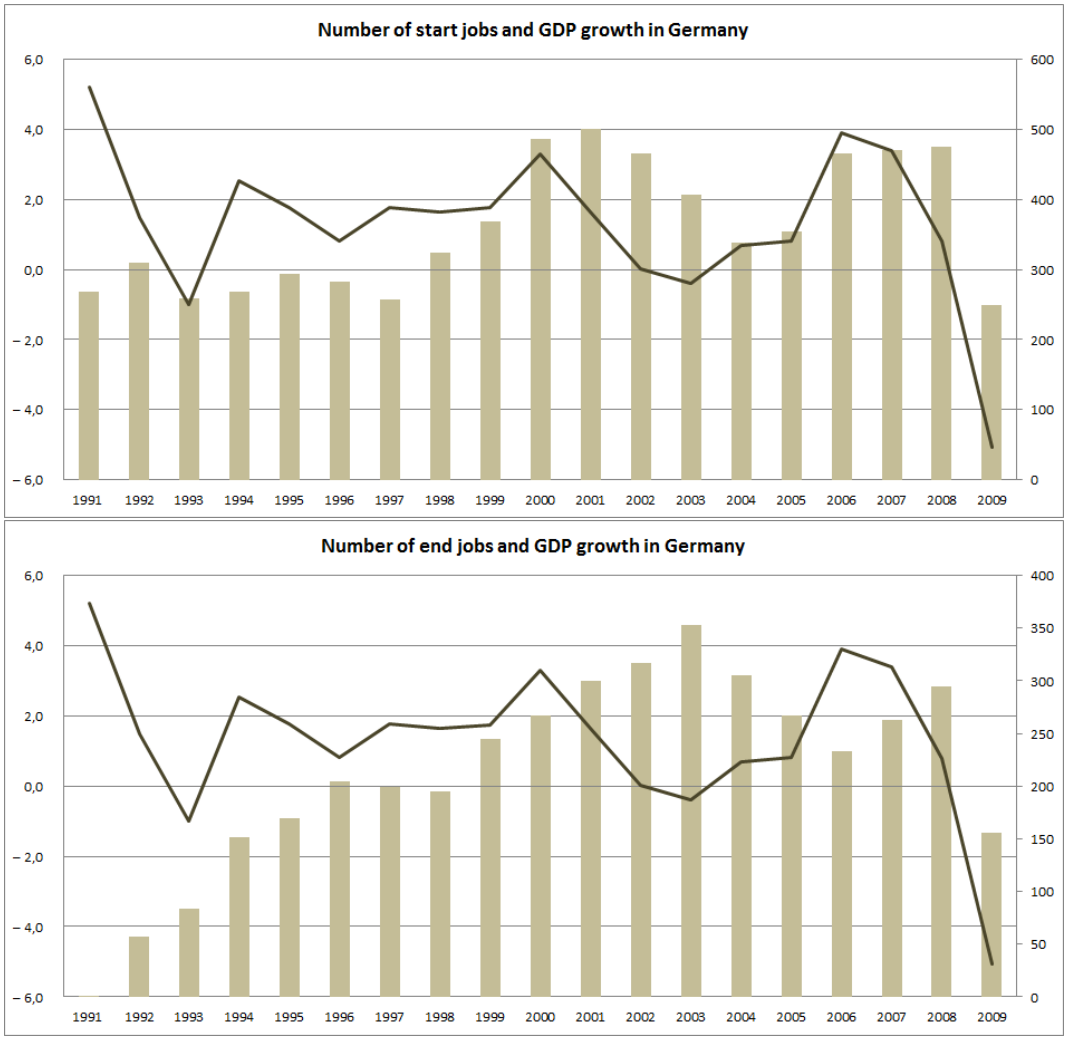
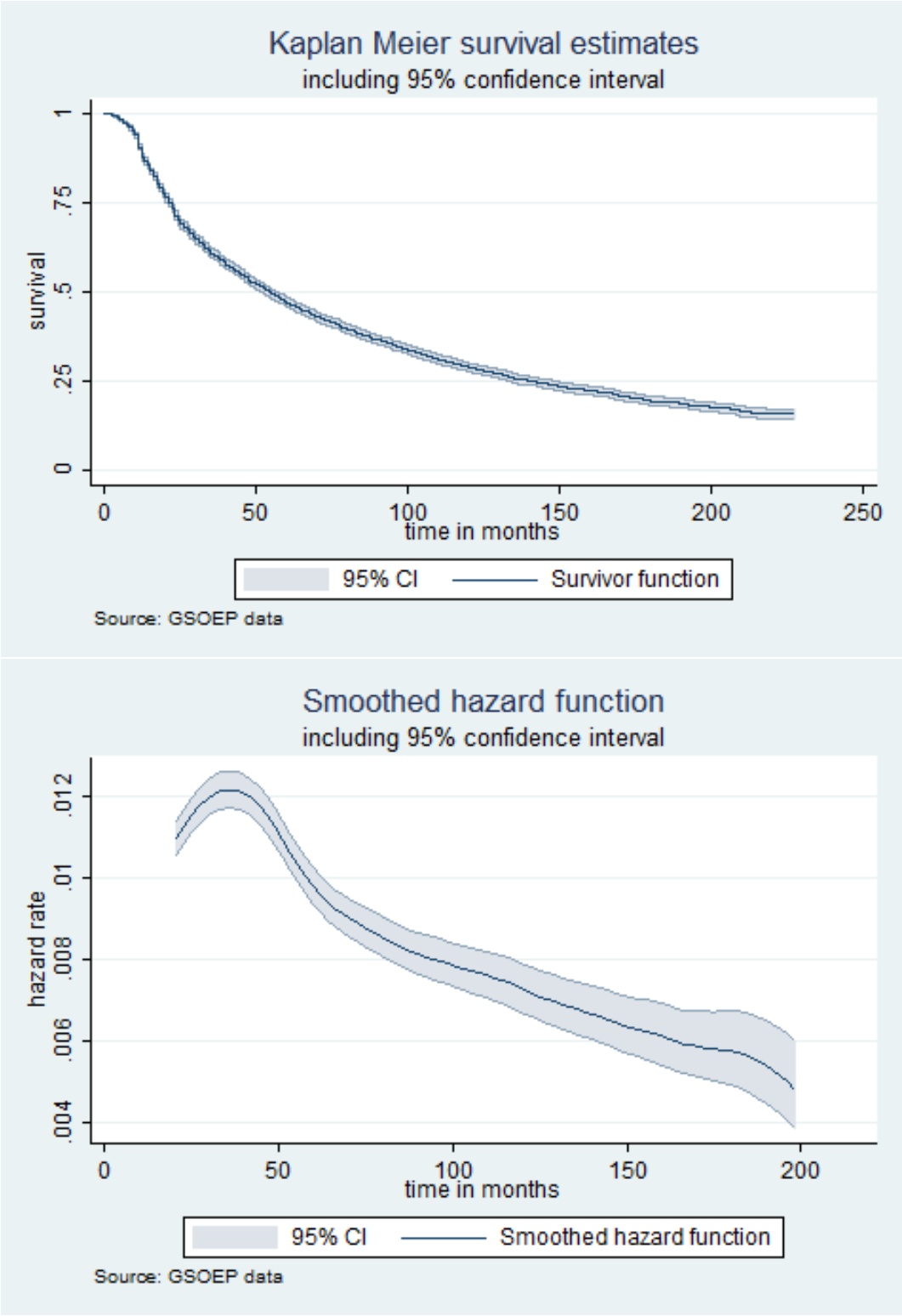
Figure 2.4: Number of jobs which started (ended) each year.



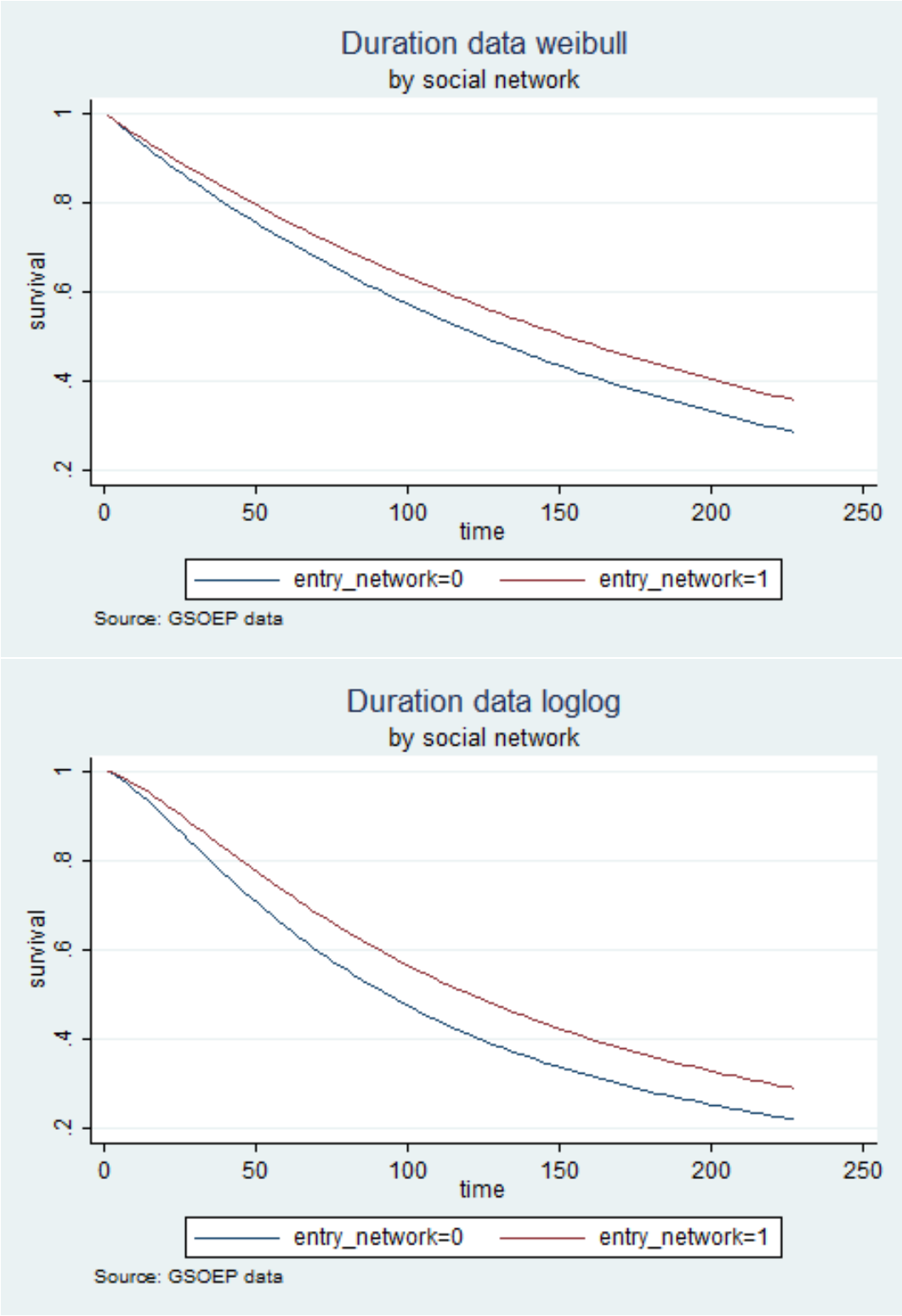
Notes: The first figure shows the number of jobs started (right scale, GSOEP). The second figure focuses on the number of jobs ended (right scale, GSOEP data). For each figure the left scale measures annual GDP growth rate for Germany (left scale, OECD). The first time period of observation is January 1991 whereas the last month of observation is December 2009. Information on the ending month excludes individuals which are right censored.
Source: GSOEP data and OECD data. Own calculations.

Figure 2.5: Survivor and hazard function for the duration of job.



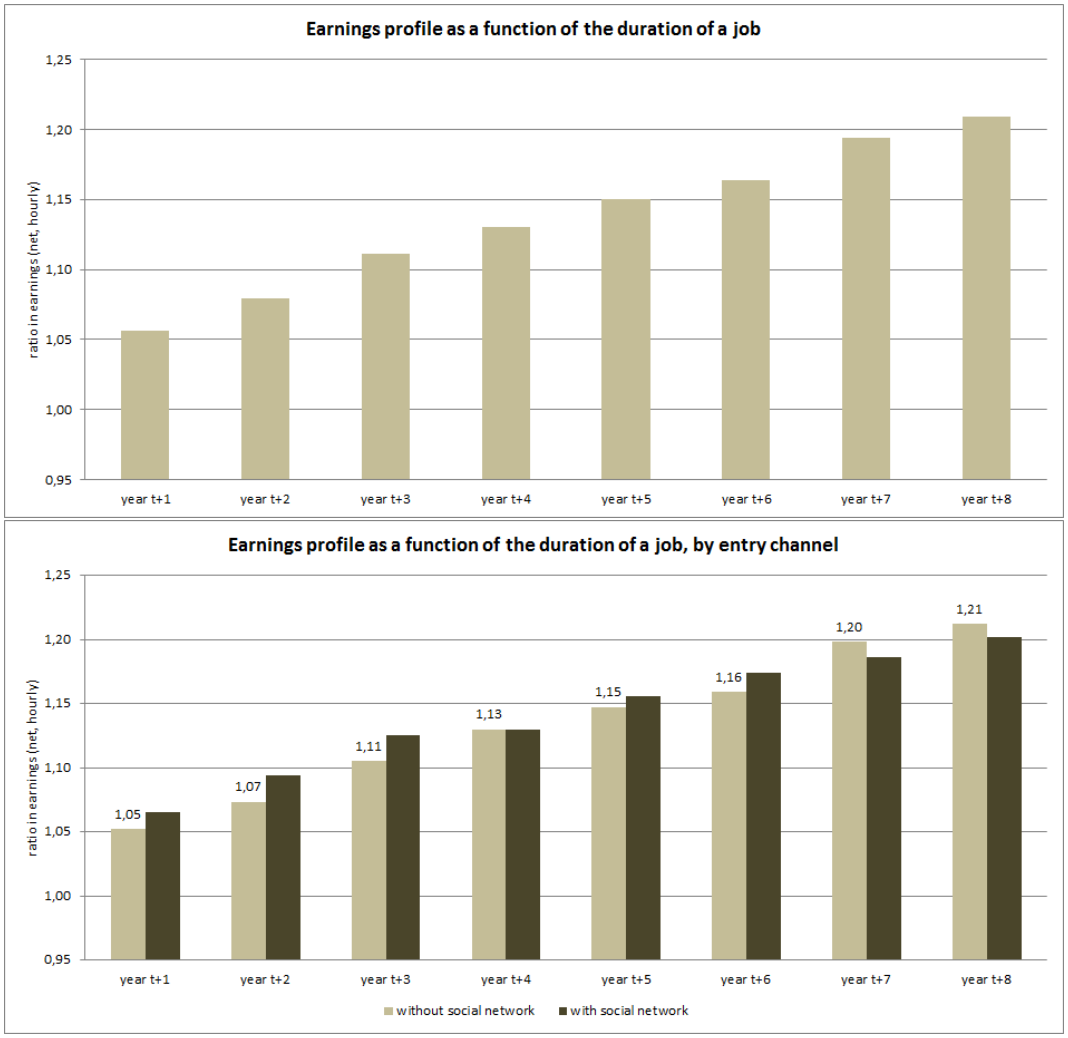
Notes: The figures show the survivor function (Kaplan Meier) and the hazard function calculated from the duration data.
Source: GSOEP data. Own calculations.

Figure 2.6: Survivor and hazard function for the duration of job.



Notes: The figure show hazard functions using a Weibull distribution (top) and the Log-logistic model (bottom). Both figures differentiate by the entry channel into a job, namely if an individual made use of a social network channel or not.
Source: GSOEP data. Own calculations.

Figure 2.7: Earnings profile over time in years.



Notes: The figure on the top summarizes the ratio between average earnings in year x relative to the starting wage in year t. The second figure on the bottom distinguishes between individuals who made use (did not make use) of a social network to get into a job.
Source: GSOEP data. Own calculations.

Table 2.10: Results from the entry channel model.

	Probit Coeff./SE.	Probit Macro Coeff./SE.	Probit NonCog Coeff./SE.	FE Coeff./SE.	FE Macro Coeff./SE.
female	–0.021	–0.022*	–0.024*		
	(0.013)	(0.013)	(0.014)		
age	–0.007	–0.007	–0.006	0.013	0.008
	(0.006)	(0.007)	(0.007)	(0.020)	(0.021)
age (sq)	0.007	0.007	0.006	–0.022	–0.023
	(0.008)	(0.009)	(0.009)	(0.027)	(0.027)
experience	0.002	0.001	0.001	0.004	0.003
	(0.003)	(0.003)	(0.003)	(0.010)	(0.011)
experience (sq)	–0.006	–0.007	–0.006	0.004	0.006
	(0.008)	(0.008)	(0.008)	(0.033)	(0.033)
middle education	–0.031	–0.036	–0.038*		
	(0.022)	(0.022)	(0.022)		
vocational, abitur	–0.056**	–0.056**	–0.059***		
	(0.023)	(0.023)	(0.023)		
higher education	–0.029	–0.034	–0.039		
	(0.025)	(0.025)	(0.025)		
migrant background	0.027*	0.038**	0.037**		
	(0.016)	(0.016)	(0.017)		
energy, manufacturing, construction	0.022	0.020	0.020	0.076	0.056
	(0.031)	(0.031)	(0.031)	(0.065)	(0.066)
trade, transport	0.062*	0.060*	0.061*	0.081	0.064
	(0.033)	(0.034)	(0.034)	(0.068)	(0.069)
bank, insurance, service	0.035	0.032	0.032	–0.014	–0.037
	(0.032)	(0.032)	(0.032)	(0.064)	(0.066)
5 to 19 employees	–0.032	–0.028	–0.029	–0.029	–0.039
	(0.020)	(0.020)	(0.020)	(0.043)	(0.044)
20 to 199 employees	–0.063***	–0.060***	–0.060***	–0.059	–0.067
	(0.019)	(0.019)	(0.019)	(0.043)	(0.043)
200 to 1999 employees	–0.105***	–0.104***	–0.103***	–0.083*	–0.097**
	(0.019)	(0.019)	(0.019)	(0.049)	(0.049)
more than 2000 employees	–0.136***	–0.129***	–0.129***	–0.125**	–0.135**
	(0.019)	(0.019)	(0.019)	(0.052)	(0.053)
part time employment	0.018	0.023	0.024	–0.023	–0.019
	(0.016)	(0.016)	(0.016)	(0.036)	(0.036)
marginal employment	0.067*	0.073*	0.076*	0.183*	0.198**
	(0.040)	(0.042)	(0.042)	(0.093)	(0.095)
white collar	–0.096***	–0.097***	–0.098***	–0.037	–0.028
	(0.015)	(0.015)	(0.015)	(0.039)	(0.040)
public sector	–0.047***	–0.052***	–0.053***	0.045	0.056
	(0.016)	(0.016)	(0.016)	(0.037)	(0.038)
public servant	–0.161***	–0.156***	–0.154***	–0.129	–0.150
	(0.026)	(0.026)	(0.026)	(0.120)	(0.122)
unemployment rate	–0.001	–0.008	–0.008	–0.012***	–0.005
	(0.001)	(0.005)	(0.005)	(0.004)	(0.010)
N	6840	6840	6840	6840	6840
ll				1126.775	1216.048
chi2	313.828	384.839	392.942		
p	0.000	0.000	0.000	0.000	0.000

Notes: Dependent variable in this model is 1 if job is found through a social network and 0 otherwise. In addition to the set of independent variables listed above, models 2, 3 and 5 include information on the starting month, starting year and the region of residence. Model 3 includes time invariant information on non cognitive skills. Models 1 to 3 make use of a probit model with robust standard errors. Models 4 and 5 build on a fixed effects model. Level of significance: * 0.10 ** 0.05 *** 0.01. Source: GSOEP data. Own calculations.

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Table 2.11: Results from the entry wage model.

	OLS Coeff./SE.	OLS Macro Coeff./SE.	OLS NonCog Coeff./SE.	FE Coeff./SE.	FE Macro Coeff./SE.
network	0.023	0.032**	0.032**	0.049*	0.052*
	(0.015)	(0.015)	(0.015)	(0.028)	(0.028)
INT network X female	–0.041**	–0.048**	–0.047**	–0.082**	–0.091***
	(0.020)	(0.019)	(0.019)	(0.035)	(0.035)
INT network X migrant	0.016	0.009	0.007	–0.016	–0.016
	(0.023)	(0.023)	(0.023)	(0.044)	(0.044)
INT network X white collar	–0.053***	–0.049**	–0.050***	0.019	0.028
	(0.020)	(0.019)	(0.019)	(0.036)	(0.035)
female	–0.182***	–0.171***	–0.160***		
	(0.012)	(0.012)	(0.012)		
age	0.030***	0.025***	0.026***	0.057***	0.051***
	(0.005)	(0.005)	(0.005)	(0.013)	(0.013)
age (sq)	–0.040***	–0.036***	–0.037***	–0.084***	–0.077***
	(0.007)	(0.007)	(0.007)	(0.018)	(0.018)
experience	0.011***	0.013***	0.012***	0.013*	0.017**
	(0.002)	(0.002)	(0.002)	(0.007)	(0.007)
experience (sq)	–0.018***	–0.017***	–0.016**	0.017	0.011
	(0.007)	(0.006)	(0.006)	(0.022)	(0.022)
middle education	0.055***	0.075***	0.073***		
	(0.017)	(0.017)	(0.017)		
vocational, abitur	0.124***	0.133***	0.128***		
	(0.019)	(0.018)	(0.018)		
higher education	0.238***	0.266***	0.259***		
	(0.020)	(0.019)	(0.019)		
migrant background	0.002	–0.034**	–0.029**		
	(0.014)	(0.014)	(0.014)		
energy, manufacturing, construction	0.157***	0.154***	0.149***	0.089**	0.103**
	(0.024)	(0.022)	(0.023)	(0.043)	(0.043)
trade, transport	0.021	0.013	0.010	–0.014	–0.001
	(0.025)	(0.023)	(0.024)	(0.045)	(0.045)
bank, insurance, service	0.092***	0.080***	0.076***	0.000	0.017
	(0.024)	(0.023)	(0.023)	(0.043)	(0.043)
5 to 19 employees	0.069***	0.064***	0.061***	0.041	0.052*
	(0.018)	(0.017)	(0.017)	(0.028)	(0.029)
20 to 199 employees	0.108***	0.101***	0.100***	0.061**	0.066**
	(0.017)	(0.017)	(0.017)	(0.028)	(0.028)
200 to 1999 employees	0.192***	0.185***	0.183***	0.121***	0.129***
	(0.019)	(0.018)	(0.018)	(0.032)	(0.032)
more than 2000 employees	0.271***	0.247***	0.243***	0.156***	0.161***
	(0.019)	(0.018)	(0.018)	(0.035)	(0.035)
part time employment	–0.036***	–0.045***	–0.042***	–0.057**	–0.048**
	(0.013)	(0.013)	(0.012)	(0.024)	(0.024)
marginal employment	–0.443***	–0.457***	–0.454***	–0.329***	–0.341***
	(0.053)	(0.052)	(0.052)	(0.062)	(0.062)
white collar	0.206***	0.184***	0.184***	0.012	0.003
	(0.014)	(0.014)	(0.014)	(0.029)	(0.029)
public sector	–0.034***	–0.014	–0.014	–0.017	–0.024
	(0.012)	(0.012)	(0.012)	(0.025)	(0.025)
public servant	0.225***	0.207***	0.203***	0.193**	0.202**
	(0.025)	(0.025)	(0.025)	(0.079)	(0.080)
unemployment rate	–0.022***	0.010**	0.011***	–0.005*	–0.002
	(0.001)	(0.004)	(0.004)	(0.003)	(0.007)
N	6840	6840	6840	6840	6840
r2	0.398	0.442	0.445	0.130	0.180
F	160.029	72.772	66.598	11.307	5.388
p	0.000	0.000	0.000	0.000	0.000

Notes: Dependent variable in this model is the log of the starting wage. In addition to the set of independent variables listed above, models 2, 3 and 5 include information on the starting month, starting year and the region of residence. Model 3 includes time invariant information on non cognitive skills. Models 1 to 3 make use of an OLS model with robust standard errors. Models 4 and 5 build on a fixed effects model. Level of significance: * 0.10 ** 0.05 *** 0.01. Source: GSOEP data. Own calculations.

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Table 2.12: Results from the duration model.

	Cox model Coeff./SE.	Weibull model Coeff./SE.	LogLog model Coeff./SE.
network	–0.187***	–0.186***	0.255***
	(0.060)	(0.064)	(0.067)
INT network X female	–0.123*	–0.119	0.090
	(0.072)	(0.077)	(0.082)
INT network X migrant	0.208**	0.200**	–0.257***
	(0.090)	(0.095)	(0.100)
INT network X white collar	0.179**	0.171**	–0.209**
	(0.074)	(0.078)	(0.084)
female	0.301***	0.327***	–0.324***
	(0.045)	(0.047)	(0.051)
age	–0.117***	–0.130***	0.117***
	(0.017)	(0.018)	(0.018)
age (sq)	0.167***	0.184***	–0.167***
	(0.022)	(0.024)	(0.024)
experience	–0.031***	–0.038***	0.038***
	(0.008)	(0.008)	(0.008)
experience (sq)	0.055**	0.073***	–0.065***
	(0.022)	(0.023)	(0.024)
middle education	–0.126**	–0.135**	0.138**
	(0.062)	(0.066)	(0.068)
vocational, abitur	–0.033	–0.033	0.109
	(0.069)	(0.072)	(0.074)
higher education	–0.071	–0.074	0.097
	(0.073)	(0.076)	(0.078)
migrant background	–0.052	–0.052	0.078
	(0.056)	(0.058)	(0.061)
energy, manufacturing, construction	–0.081	–0.085	0.103
	(0.078)	(0.083)	(0.096)
trade, transport	–0.021	–0.015	0.009
	(0.079)	(0.085)	(0.099)
bank, insurance, service	–0.025	–0.030	0.022
	(0.080)	(0.085)	(0.097)
5 to 19 employees	0.023	0.036	–0.007
	(0.058)	(0.062)	(0.065)
20 to 199 employees	–0.104*	–0.114*	0.105*
	(0.056)	(0.060)	(0.064)
200 to 1999 employees	–0.215***	–0.230***	0.207***
	(0.061)	(0.065)	(0.070)
more than 2000 employees	–0.275***	–0.275***	0.300***
	(0.065)	(0.069)	(0.073)
part time employment	0.072	0.074	–0.079
	(0.046)	(0.049)	(0.051)
marginal employment	0.439***	0.478***	–0.425***
	(0.103)	(0.103)	(0.117)
white collar	–0.347***	–0.352***	0.407***
	(0.049)	(0.052)	(0.055)
public sector	–0.061	–0.065	0.029
	(0.047)	(0.050)	(0.053)
public servant	–0.155	–0.128	0.192*
	(0.101)	(0.107)	(0.107)
unemployment rate	0.015	0.013	–0.010
	(0.015)	(0.016)	(0.016)
weibull parameter		0.986	
gamma parameter			0.708 ***
N	6840	6840	6840
ll	–31848.587	–7731.415	–7548.253
p	0.000	0.000	0.000

Notes: Dependent variable in this model is the duration of the job in month. In addition to the set of independent variables listed above, models 1 to 3 include information on the starting month, starting year and the region of residence. Also, models 1 to 3 include time invariant information on non cognitive skills. Model 1 makes use of a semi parametric Cox duration model. Model 2 and 3 build on a parametric specifications of the hazard function with a Weibull hazard function and a Log-logistic hazard function respectively. For the duration data, I observe 5227 different individuals with altogether 4059 failures. Level of significance: * 0.10 ** 0.05 *** 0.01. Source: GSOEP data. Own calculations.

Table 2.13: Results from the long term wage model.

	FE year 1 Coeff./SE.	FE year 2 Coeff./SE.	FE year 3 Coeff./SE.
net earnings LOG Year 0	0.640***	0.480***	0.403***
	(0.034)	(0.052)	(0.079)
network	0.009	–0.018	–0.064
	(0.023)	(0.045)	(0.049)
INT network X female	0.009	–0.032	0.203**
	(0.031)	(0.059)	(0.079)
INT network X migrant	–0.029	0.083	0.171*
	(0.042)	(0.082)	(0.101)
INT network X white collar	0.004	0.060	–0.023
	(0.031)	(0.056)	(0.074)
age	0.016	0.037	0.047*
	(0.011)	(0.023)	(0.026)
age (sq)	–0.023	–0.045	–0.088**
	(0.015)	(0.029)	(0.035)
experience	0.002	–0.002	–0.006
	(0.006)	(0.014)	(0.012)
experience (sq)	0.012	0.023	0.086**
	(0.016)	(0.032)	(0.037)
energy, manufacturing, construction	0.011	0.086	–0.064
	(0.034)	(0.060)	(0.111)
trade, transport	–0.019	0.107*	–0.194
	(0.035)	(0.064)	(0.138)
bank, insurance, service	0.011	0.072	–0.084
	(0.032)	(0.062)	(0.118)
5 to 19 employees	0.024	0.054	–0.102
	(0.025)	(0.048)	(0.077)
20 to 199 employees	0.010	0.115**	–0.032
	(0.026)	(0.045)	(0.081)
200 to 1999 employees	0.064**	0.159***	0.022
	(0.031)	(0.051)	(0.094)
more than 2000 employees	0.006	0.054	–0.145
	(0.032)	(0.057)	(0.099)
part time employment	–0.017	–0.017	–0.178*
	(0.025)	(0.049)	(0.099)
marginal employment	–0.030	–0.042	
	(0.079)	(0.149)	
white collar	0.033	–0.007	0.027
	(0.029)	(0.057)	(0.070)
public sector	–0.009	0.051	0.020
	(0.022)	(0.035)	(0.054)
public servant	–0.221***	–0.368***	0.094
	(0.069)	(0.089)	(0.227)
unemployment rate	–0.007	–0.012	–0.000
	(0.006)	(0.010)	(0.011)
N	5677	3844	2892
r2	0.506	0.403	0.485
ll	5.881.616	4.880.780	4.730.377
p	0.000	0.000	0.000

Notes: Dependent variable in this model is the log of wage n years after job started. The table focuses on the earnings profile for the first three years after the job has started. All model specifications include information on the starting month, starting year and the region of residence. Models 1 to 3 build on a fixed effects model. Level of significance: * 0.10 ** 0.05 *** 0.01. Source: GSOEP data. Own calculations.

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3 | Health Status and Consumption Behavior

How do individuals adjust their consumption behavior in response to a deterioration of their health status? In the light of demographic transition, when the number of individuals who reach a critical age where the probability of functional limitations increases dramatically, understanding how the individual health status influences consumption behavior deserves additional attention. While the theoretical framework is well established and builds on the concept of state dependent utility functions, previous empirical studies either focused on experimental designs and hypothetical questions or did not distinguish between the effects from aging and those effects from changes in the individual health status. This research paper uses empirical data, provided by the Health and Retirement Study and the related Consumption and Activities Mail Survey, to explore the consequences of functional problems in activities of daily living on consumption behavior of individuals above the age of 65; furthermore, the analysis is restricted to consumption of non durable and semi durable goods and dis aggregates overall consumption into nine global consumption categories. First, the empirical analysis explores a system of seemingly unrelated regressions to estimate the impact of the health status on the relative composition of the consumption basket with respect to different categories of goods and services. Second, a fixed effects model is specified to focus on changes which occur within individuals and contribute to explanations how individual consumption behavior changes over time. Regression results show expected signs and significant coefficients for the impact of changes in the individual health on consumption behavior. Controlling for a powerful set of variables, findings from the empirical analysis separate out a change in consumption that can be solely associated to changes in the health status. [1]

Keywords: consumption behavior, health status, state dependent utility functions

JEL Classification: I100, C330

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3.1 Introduction

Over the last century, medical progress and socioeconomic transformation have benefited people all over the world to live longer and die later. At the same time, many countries in the Western hemisphere now experience a rise in the share of older people which is strongly related to the post World War II baby boom. Clinical studies suggest that the probability of severe health conditions increases substantially as individuals become older. In particular, the frequency of functional problems related to activities of daily living rises dramatically. For instance, Johnson et al. (2006) focus on the relationship between the process of aging and the occurrence of severe health problems. Using data for the United States of America, they find that 59 percent of adults aged 70 and older experience a major new medical condition over about a ten year period or are married to someone who does. Under these circumstances, understanding the dynamics of aging health and determining the consequences for economic outcomes deserves special attention with respect to academic research and policy making.

Previous research in social sciences shows that the health status affects individual behavior through a wide range of alternative channels. First, in a static environment the health status and functional problems influence preferences as well as the possibility set. In the context of this research paper, the link between the health status and consumption behavior arises if functional problems in activities of daily living have an impact on the structure of preferences and alter the composition of individual consumption through changes in the utility function. Here, the framework of state dependent utility functions (Zeckhauser, 1970, 1973) illustrates that the marginal utility of consumption declines with worsening health as many consumption goods – such as traveling – are complements to good health. On the other hand, the marginal utility of consumption increases with deteriorating health as other consumption goods – such as prepared meals or assistance with self care – are substitutes to good health (Evans and Viscusi, 1990; Finkelstein et al., 2013). Second, data from the United States of America emphasizes the importance of cost sharing requirements and suggests that under certain circumstances changes in the health status trigger financial restrictions to become binding. For instance, French and Jones (2004) and Nardi et al. (2010) describe an environment where health shocks affect out of pocket medical expenses, which in turn have a large impact on further economic decisions including the labor market exit decision. Estimating a dynamic programming model with uncertain medical expenses, they find that both medical expense shocks and uncertainty surrounding future expenses have a substantial effect on individual consumption and saving decisions. Third, in a dynamic setting shifts in risk attitudes and adjustments in time preferences translate into a different decision making which implies a change in revealed preferences. In summary, theoretical models and empirical findings show that the health status is one candidate to explain the observed heterogeneity in individual market behavior. For example, the static analysis of data taken from the Health and Retirement Study and the Study of Assets and Health Dynamics Among the Oldest illustrates that the health status of individuals can be taken as a determinant for the portfolio choice of households (Rosen and Wu, 2004; Berkowitz and Qiu, 2006; Edwards, 2008; Coile and Milligan, 2009).

This research paper uses the theoretical framework of state dependent utility functions and exploits data from the Health and Retirement Study and the Consumption and Activities Mail Survey to better understand how changes in the health status influence individual consumption behavior. More specifically, the empirical analysis pays special attention to consequences from

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functional problems in activities of daily living on the allocation of consumption expenditure to nine different categories of consumption goods. The underlying research question can be phrased as follows: *How do individuals adjust their consumption behavior in response to a change in the health status?* First, the previous literature offers a wide set of different interpretations of consumption behavior. For example, Domeij and Johannesson (2006) discuss adjustments in the ratio between consumption and savings which occur in response to a health shock. In contrast, the theoretical and empirical model in this paper focuses on the impact of the individual health status on the demand for nine different categories of non durable and semi durable consumption goods. Second, the individual health status is characterized in terms of functional problems in activities of daily living. This way, the empirical model exploits variations in the health status related to self reported problems to perform basic activities of daily living, limited mobility and agility which are widely interpreted as the underlying reason for changes in individual behavior. Third, the empirical framework relates to a subgroup of individuals older than 65 years. To identify only the impact of the health status on consumption behavior and to abstract from potential volatility in the labor income stream and adjustments within the household, the empirical model is restricted to elderly after the age of 65 years who are either singles or widows. For these individuals the income stream mainly consists of social benefits and gains from investment and housing. Results for the empirical model illustrate the impact of health on the relative composition of individual consumption with respect to non durable and semi durable goods. Among other things, the empirical framework separates out a change in consumption behavior that can be solely associated to changes in the health status and is independent of aging.

Findings from this paper contribute in at least two dimensions to the latest literature on the link between health and consumption. First, by analyzing the relationship between the individual health status and consumption behavior, this paper adds to ongoing empirical research to validate the theoretical concept of state dependent utility functions. In contrast to previous research, the empirical analysis makes use of panel information from the Health and Retirement Study and the Consumption and Activities Mail Survey. Hence, results do not refer to an experimental research design chosen by Evans and Viscusi (1990, 1991) where the identification of the impact of changes in the health status on consumption behavior relates to hypothetical situations; empirical findings in this paper are based on actual behavior reported in the data when individuals change their consumption behavior in response to changes in the health status [2]. Second, this paper focuses on the impact of changes in the health status on the relative composition of the consumption basket. Here, the empirical model explores micro data and determines the influence of changes in the health status on a wide set of different consumption categories of non durable and semi durable goods. In reference to Finkelstein et al. (2013), these findings test the validity of their key assumption which requires that the relative composition of aggregate consumption in the sick state is predetermined. They assume that consumption would not be predetermined if optimizing individuals are able to reallocate consumption in response to their state dependent preferences and change the composition of their consumption basket.

The remainder of this paper is organized as follows. Section II and III introduce the theoretical and the empirical framework and present the concept of state dependent utility functions which

[2] Sloan et al. (1998) conclude that a validation of the concept of state dependent utility functions based on actual market behavior instead of hypothetical questions would be an important extension with respect to previous research in this area.

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supports the empirical model explored in this paper. I discuss possible links between a health shock and its impact on consumption behavior and provide a short discussion about the individual labor market exit decision. Section IV describes the data taken from the Health and Retirement Study and the Consumption and Activities Mail Survey and the construction of consumption categories and the health measure used in this research paper. Section V presents the main empirical results. I estimate a seemingly unrelated regression model and discuss findings from a fixed effects model. Finally, section VI draws some policy implications and concludes.

3.2 Theoretical Framework

This research paper focuses on the link between the health status and consumption behavior. Here, raw data taken from the Health and Retirement Study (HRS) and the Consumption Activities and Mail Survey (CAMS) allow for some preliminary assessment which illustrates the relationship between these two variables [3]. Figures on page 164 and following summarize some basic patterns which describe the unconditional link between the health status and the composition of individual consumption. Each figure shows average budget shares with respect to nine different consumption categories (see table 3.1) conditional on the number of functional problems in activities of daily living (ADL) self reported by the individuals (see table 3.2). Furthermore, the descriptive analysis distinguishes between different types of problems in ADLs: first, an aggregate measure on ADLs summarizes all information provided by the individual into one index; second, the proxy for the individual health status builds on functional problems related to instrumental ADLs which show up more often and do not necessarily require an adjustment in consumption behavior; and third, three separate measures on problems in ADLs related to basic activities, mobility and agility are used to learn more about specific limitations in daily living. Altogether, these figures show striking differences in terms of consumption behavior across observations which differ in terms of health status. For some consumption categories there is an increase and for others a decrease in the budget share dependent on the the number of health problems reported. For instance, the budget share related to transportation services decreases in the number of health problems (aggregate ADL on page 164). On the contrary, the budget share for health related consumption items increases in the number of functional problems. In summary, these figures use unconditional correlations to illustrate the relationship between the health status measured in terms of ADLs and different consumption categories related to non durable and semi durable goods; later, the empirical analysis takes into consideration further information on individual characteristics, which account for additional heterogeneity across and within individuals, to isolate a causal link between the health status and consumption behavior.

3.2.1 Three different mechanisms at play

Before moving to the empirical framework to further analyze variations in consumption behavior across observations, the theoretical framework discusses potential mechanisms which explain observed patterns from the descriptive analysis above. The following discussion highlights three alternative channels which provide possible explanations for the observed link between the health status and consumption behavior. Here, the relative composition of the consumption basket with respect to nine different categories of goods adjusts, if in response to a change in the health

[3] Section IV further discusses data and restrictions used for the empirical analysis.

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status

1. *cost sharing requirements force individuals to spend more on health (everything else equal).* The introduction to this research paper has shown that additional expenditure due to cost sharing requirements can be high enough to hit the individual's budget constraint. Under these circumstances the relative composition of the budget to non durable and semi durable goods changes if only health expenditure increase and the absolute expenditure to all other goods remains constant. A simple fixed effects model explores within individual variation to see in how far changes in the health status require individuals to increase the absolute level of health related expenditure.

2. *the available budget to non durable and semi durable goods is affected.* The deterioration of the health status can have an impact on overall expenditure if precautionary savings increase or the individual time discount rate changes. Here, a special situation occurs if bad health induces individuals to leave the labor market. Under certain conditions, the loss of labor market income is not compensated by payments from the social welfare system and the overall budget to non durable and semi durable goods needs to adjust in response to a change in the labor market status (which was initially induced by a change in the health status). A fixed effects model makes use of the overall budget as dependent variable to determine the influence of changes in the health status and adjustments in the labor market status. Furthermore, the estimation strategy for the empirical model in section V includes a measure on the size of the overall budget into the set of independent variables.

3. *preferences change and the consumption possibility set of individuals alters.* The concept of state dependent utility functions establishes a theoretical foundation to better understand how changes in the health status induce adjustments in consumption behavior through variations in the marginal utility of consumption with respect to different consumption categories. Later, the main body of this research paper uses a seemingly unrelated regression model and a fixed effects model to illustrate that the above mentioned channel contributes significantly to the explanation of how observed patterns of individual consumption behavior relate to changes in the health status.

3.2.2 Relevance of cost sharing requirements

For most countries, and even under the existence of relatively generous social security system, additional medical expenditure affects individual consumption behavior through cost sharing requirements. In their paper, describing the US health care system, Butrica et al. (2009) mention as examples for cost sharing the exclusion of certain services such as dental care, routine vision care and most long term health care services. Most importantly, these cost sharing requirements also refer to medical services and goods which mitigate the consequences of functional problems in ADLs.

Implications of cost sharing requirements on the individual consumption budget are far from clear. Research based on the Medicare Current Beneficiary Survey finds that older adults on average devote about one fifth of their incomes to health care (Gross et al., 1999). Also, Hwang et al. (2001) report that adults between the age of 45 and 64 with three or more chronic conditions averaged 1,055 US Dollar in annual out of pocket payments for health care services in 1996, compared with only 356 US Dollar for those with no chronic conditions. Butrica et al. (2009)

find that with respect to the elderly a large fraction of the additional expenditure is actually covered by government sponsored programs such as Medicare and Medicaid [4]. Smith (1999) reports that out of pocket spending on health appear to be rather small since many of the elderly have Medicare or Medicaid insurance plans which reimburse most of the uncovered expenses. On the contrary, Edwards (2008), using data from the Assets and Health Dynamics Among the Oldest survey, reports that households estimate that there is a 30 percent probability that medical expenditure will eat up existing savings within five years. Furthermore, descriptive analysis shows that certain subsets of the population devote a relatively large share of income to health care (Crystal et al., 2000; Goldman and Zissimopoulos, 2003).

The empirical model in equation 3.1 makes use of the logarithm of total health expenditure hc_{it} as dependent variable for a fixed effects model to better understand determinants of how much individuals spend to health related consumption items. More specifically, the estimated coefficient on the health status H_{it} provides preliminary evidence on the impact of cost sharing requirements with respect to functional problems in ADLs. To control for heterogeneity within individuals, the set of independent variables also includes additional information on the labor market status and the age of individuals. Furthermore, the empirical model includes yearly dummies to capture year specific effects and region dummies to control for differences across regions. The set of independent variables also incorporates interaction terms for years and regions.

$$\log hc_{it} = \alpha_i + \gamma_{1i} \cdot H_{it} + \gamma_{2i} \cdot age_{it} + \gamma_{3i} \cdot L_{it} + \gamma_{3i} \cdot H_{it} \cdot L_{it} + MACRO_{it} \cdot \beta + \epsilon_{it} \qquad (3.1)$$

Results in table 3.7 suggest that changes in the health status, which are measured in terms of different indices of ADLs, do not have a systematic and significant impact on the level of health expenditure. Among the five different empirical specifications only the specification "ADL mobility", which uses an index on functional problems related to mobility, shows a significant estimated coefficient. An increase of the health measure by one unit, which corresponds to inability to perform none of the four different activities summarized in the index, is associated to an increase of total health expenditure by 29 percent (significant on the 10 percent level). On the contrary the estimated effect for the specification "ADL agility" is particularly small and insignificant. As we will see in the following discussion in section IV, functional problems with respect to mobility and agility show up relatively early in the life cycle and force individuals to adjustments in their (consumption) behavior. Furthermore, upcoming results suggest that additional adjustments in response to functional limitations with respect to basic ADLs are no longer necessary if individuals have already changed their behavior earlier due to ADLs in mobility and agility. In summary, results in this subsection illustrate that cost sharing requirements do not systematically force individuals to spend more on health related goods and services which in turn reduces the relative budget shares on non durable and semi durable consumption goods.

3.2.3 Adjustments in the available budget

Changes in the health status have the potential to affect the size of the overall budget, defined as aggregate expenditure on non durable and semi durable consumption goods. Three different

[4] In general, there are two major social security schemes which support the poor and elderly to cover their health expenditure: first, Medicaid provides government funded health care for the poor and second, Medicare offers a federal health care scheme for the old.

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channels are discussed on the background of the existing literature and later tested using data from the HRS. First, the direct effect of the health status on the overall consumption level. Second, the indirect effect of the health status going through the labor market decision of individuals. Third, potential changes in the overall budget which can be associated solely to the labor market exit decision of individuals.

First, the direct link between the health status and the overall budget. Descriptive statistics in table 3.6 illustrate that 95 percent of the sample observations used in the empirical analysis have access to government sponsored insurance programs such as Medicare and Medicaid. As a consequence, these individuals do not need to bare additional health costs since Medicare covers large parts of health expenditure associated to a change in the health status. At the same time results from the previous analysis suggest that the absolute level of expenditure on health related goods and services increases slightly if individuals experience a deterioration of their health status. Even though this relationship is non systematic in a statistical manner, it is possible that some individuals adjust their overall budget due to cost sharing requirements.

Second, indirect effects such that a change in the health status influences the overall budget through the labor market behavior of individuals. Previous research has shown that a change in the health status does not only have a direct impact on the budget but it is reasonable to assume that severe health conditions are one of the most important determinants of labor market behavior among older workers (Anderson and Burkhauser, 1985; Currie and Madrian, 1999). Many empirical studies have demonstrated that a deterioration of the health status triggers an (early) departure from the labor market (Bound et al., 1999; Dwyer and Mitchell, 1999; Kerkhofs et al., 1999; Campolieti, 2002) which possibly reduces the available budget to non durable and semi durable goods. Descriptive statistics in table 3.6 illustrate that around one sixth of individuals in the sample above the age of 65 years are still in the labor market. This finding is in line with statistics taken from the U.S. Bureau of Labor Statistics which provides annualized numbers for the civilian non institutionalized population and labor force from the Current Population Survey. For those aged 65 and older, the rate increased from 13.7 percent in 1975 to 16.8 percent in 2008. This upward trend among the working near elderly and elderly is likely to continue because of workers" needs for more earning years to accumulate assets in defined contribution (401(k)-type) plans – especially after the 2008 downturn in the stock market and economy (Copeland, 2008). A second reason behind working after the age of 65 years is that employers often provide employees with a health insurance. If the individual leaves the labor market this cost – which is especially high in the case of a bad health status – has to be covered by the individual itself. To abstract from these insurance related problems, this empirical analysis only includes individuals above the age of 65. Hence, all individuals are fully eligible to normal retirement benefits, even if previous changes in the US legislation have now increased the retirement age to 67. In summary, for individuals who are still in the labor market after the age of 65 years, a change in the health status might induce individuals to leave the labor market which is associated to a drop in labor market income and a reduction of aggregate consumption expenditure.

Third, the so called consumption retirement consumption puzzle which summarizes theoretical and empirical findings on how individuals adjust their consumption patterns when leaving the labor market. For instance, Battistin et al. (2009) reports that the level of aggregate consumption reduces substantially when people retire from the labor market. From a theoretical perspective, these empirical findings contradict predictions from the standard life cycle model where individuals

smooth their consumption over retirement through borrowing and saving activities (Hamermesh, 1984; Mariger, 1987; Banks et al., 1998; Bernheim et al., 2001; Hurst, 2008). Fisher et al. (2008) find much less evidence of a decline in total expenditure. Using data from the Consumer Expenditure Survey, they observe that most of the decline in total expenditure is predominantly accounted for by expenditure on food at home and away from home (Miniaci et al., 2003). At the same time, Aguiar and Hurst (2005) show that expenditure on food consumption drops significantly but utility from consumption remains constant. Their explanation builds on the idea that home production increases quality of food bought in the market (Brzozowski and Lu, 2006) and additional time for shopping allows for better offers and lower consumption expenditure. Altogether, the previous literature offers additional explanations on how to reconcile the observed reduction in expenditure with the concept of consumption smoothing which in turn explains changes in consumption behavior due to an exit from the labor market.

In line with the ongoing discussion on the link between the health status, labor market participation and consumption behavior, the empirical specification in equation 3.2 is used to learn more about the determinants of the level of the individual budget to non durable and semi durable goods. Findings relate to three different questions raised in the previous section. First, how do changes in the health status affect the level of the overall budget? Second, is there an change in the overall budget if individuals leave the labor market? Third, do individuals who leave the labor market due to a change in the health status experience an additional reduction in their budget? To answer these question, the empirical model in equation 3.2 uses the level of the overall budget c_{it} of individual i in time t as dependent variable. The set of independent variables includes information on the health status H_{it}, the labor market status L_{it}, and an interaction term between health and labor market status $H_{it}xL_{it}$. Additionally, the set of independent variables incorporates further control variables which capture the age of individuals and differences in terms of region and time (summarized in the vector MACRO). For the fixed effects model, the empirical specification include a time invariant fixed effect α_i.

$$\log c_{it} = \alpha_i + \gamma_{1i} \cdot H_{it} + \gamma_{2i} \cdot age_{it} + \gamma_{3i} \cdot L_{it} + \gamma_{3i} \cdot H_{it} \cdot L_{it} + MACRO_{it} \cdot \beta + \epsilon_{it} \tag{3.2}$$

Results from the fixed effects model are presented in table 3.8 in the appendix to this research paper. Here, the calculated values on the correlation between individual fixed effects and independent variables in the model confirm the use of the fixed effects panel model. Findings from the empirical model can be summarized as follows: First, there is no statistically significant impact of a change in the health status on the level of the overall budget. As expected, estimated effects vary across health measures but altogether they do not suggest any systematic variation in the overall budget due to changes in the health status. Second, estimated coefficients illustrate that observations who are still in the labor market have a higher overall budget which exceeds the budget on non durable and semi durable goods of retired observations by something like five percent. Nonetheless, the associated coefficient is insignificant and results reject the concept of the consumption retirement puzzle. Third, the effect which refers to the interaction between labor market status and health status turns out to be insignificant as well. This result shows that individuals who experience a worsening in their health status and leave the labor market at the same time, do not increase or reduce their overall budget on non durable or semi durable goods in a systematic manner. In terms of the initial research question raised in this paper, findings suggest that changes in the health status do not impact the overall budget neither directly though

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the health status nor indirectly through the labor market exit decision.

3.2.4 Changes in preferences and consumption possibility set

Preliminary findings in table 3.8 illustrate that individuals do not adjust the size of their overall budget to non durable and semi durable goods in response to a change in the health status in a statistically significant way. Furthermore, previous results in table 3.7 suggest that additional expenditure due to cost sharing requirements in the case of health problems do not systematically rise such that changes ion the relative composition of the consumption basket come by construction. Under these circumstances, the observed consumption patterns could be linked to heterogeneity in the health status via shifts in preferences and adjustments in the consumption possibility set. These findings would support the theoretical concept of state dependent utility functions.

From a theoretical perspective, Zeckhauser (1970, 1973) were among the first to introduce the idea of state dependent utility functions into the literature in economics. Here, the concept of state dependent utility functions refers to models where the status or environment of an individual changes the shape of the utility function. For example, the definition of the utility function includes parameters which reflect the individual health status (e.g. good and bad health status) such that changes in these parameters influence the optimal allocation of aggregate expenditure on non durable and semi durable consumption categories through the marginal utility of consumption with respect to different consumption categories.

The empirical literature defines different approaches to test for the existence of state dependent utility functions using mainly behavioral studies. Evans and Viscusi (1990) design a willingness to pay survey and estimate the impact of job injuries on utility and marginal utility of income. The survey asks individuals about the amount of money they would require to compensate them for hypothetical exposure to specific health risks and examine how these self reported compensating differentials vary with the level of income (risk dollar trade off). Results from the study suggest that the marginal utility of a given level of income was greater when being healthy than being injured. More specifically, findings from the willingness to pay survey illustrate that the marginal utility of income falls to 0.77 in the flexible utility function model and 0.92 in the log utility model where good health has a marginal utility of one. Evans and Viscusi (1991) consider minor health effects and estimate the overall structure of utility functions for adverse health effects using survey data on risk dollar trade offs. Findings show that minor health effects do not alter the structure of the utility function. Consumers treat injuries as tantamount to a drop in income, implying that the health shock does not change the structure of the utility function in a fundamental way. Sloan et al. (1998) use both risk risk and risk dollar approaches to assess intangible health losses associated with multiple sclerosis and find that the marginal utility of income is lower in the state with multiple sclerosis than without. In summary, these studies highlight the existence of state dependent utility functions which account for the individual health status; nonetheless doubts remain regarding the validity of previous results since the methodology of hypothetical survey questions is not as informative as actual market behavior.

Finkelstein et al. (2013) use data from the Health and Retirement Survey and estimate how the marginal utility of aggregate consumption varies with health. The empirical analysis builds on information on permanent income, health and different measures of subjective well being using the later as utility proxies. Findings from the empirical model show robust evidence that

the marginal utility of aggregate consumption declines as health deteriorates. More specifically, results suggest that a one standard deviation increase in the number of chronic health problems (arthritis, cancer, diabetes, heart problems, high blood pressure, lung, stroke) is associated with an eleven percent decline in the marginal utility of consumption. Furthermore, Finkelstein et al. (2013) find that a one standard deviation increase in the number of household diseases is associated with a statistically insignificant 1.3 percent increase in total consumption and a 1.5 percent increase in consumption on non durable goods. Similar to my findings from the previous section, there does not seem to be any evidence of systematic changes in total consumption or income following an adverse health event. Regarding the strength of their findings, one of the key assumptions behind the econometric analysis requires that in the sample of elderly individuals out of the labor force and with health insurance the composition of the consumption basket is predetermined and does not change in response to health shocks. Later, this research paper illustrates that this assumption does not necessarily hold if functional problems in ADLs are used as a health measure.

3.3 State Dependent Utility Functions and the Health Status

The empirical framework identifies the impact of the health status on consumption behavior using data from the Health and Retirement Study. Here, the concept of state dependent utility functions defines a theoretical framework which allows for the characterization of optimal quantities $q \epsilon \mathbb{R}_+^L$ as a function of total expenditure $x > 0$, a vector of non negative prices $p \gg 0$ and individual characteristics z such as the health status.

3.3.1 Consumer optimization problem

The theoretical model builds on the assumption that each individual has well defined preferences over all consumer goods available. Furthermore, individuals are price takers and prices are given exogenously. Then individual utility $u(q, z)$ can be expressed as a function of quantities q and individual characteristics z. As usual individuals maximize utility subject to a budget constraint; here, total expenditure can be written as $x(z) = p^T \times q$, where p^T is the transposed price vector and expenditure depend on the health status. Using insights from duality theory, the utility maximization problem is transformed into a cost minimization problem such that

$$\min_{q \geq 0} \quad x(z) \geq p \cdot q \qquad s.t. \quad v(q, z) = u.$$

Here the solution for good j characterizes the Hicksian demand function for each good in the system. Furthermore, the following transformations explore the fact that in the optimum Hicksian demand equals Marshallian demand, such that $h_j(u, p, z) = g_j(x(z), p, z) = q_j$ where the function h describes the Hicksian demand function and g the Marshallian demand function for good j. Then in the optimum the cost (or expenditure) function can be derived by plugging in the optimal quantities into the cost function, such that

$$c(u, p, z) = \sum_{j=1}^{M} p_j \cdot h_j(u, p, z) = x(z).$$

Applying Shepard's Lemma, demand for good j is a function of utility level u, prices p and characteristics z

$$\frac{\partial c(u,p,z)}{\partial p_j} = q_j(u,p,z).$$

Using a positive monotone transformation of the cost function first, the general cost function $\log c(u,p,z)$ equals $\log x(z)$. Then Shepard's Lemma can be used to characterize the budget share for good j, namely $w_j(x(z),p,z,u)$, as a function of total expenditure x (z), prices p, individual characteristics z and the minimum utility level u, such that

$$\frac{\partial \log c(u,p,z)}{\partial \log p_j} = \frac{q_j(u,p,z)\cdot p_j}{c(u,p,z)} = \frac{q_j(x(z),p,z)\cdot p_j}{c(u,p,z)} = w_j(x(z),p,z,u).$$

3.3.2 Demand system

The solution to a simple consumer optimization problem defines an empirical model used in the following section. Suppose there are M goods in a demand system [5]. Then the previous discussion shows that demand for good j, expressed in budget shares w_{ijt}, is defined as a function of total expenditure x_{it}, the own price effect p_{jt}, some cross price effects $p_{j't}$ and individual characteristics z_{it}. Including an error term ϵ_{ijt} into the econometric model, the system of M different goods can be written as follows. Here demand from different individuals $i = 1...N$ for each good $j = 1...M$ in time period t is given such that

$$w_{ijt} = \alpha_j + \beta_j \cdot f(x_{it}(z_{it})) + \gamma_{j1} \cdot g(p_{1t}) + ... + \gamma_{jM} \cdot g(p_{1M}) + \delta_j \cdot h(z_{it}) + \epsilon_{ijt} \tag{3.3}$$

This general expression for the budget share does not explicitly characterize the functions f, g and h. Later, different empirical models are used to allow for a nonlinear impact of individual characteristics on the budget shares. Furthermore, the specification of the empirical model takes into consideration that for each individual i budget shares w_{ijt} add up to one and the estimator accounts for the structure of the error terms ϵ_{ijt} which might be correlated for different goods j but within the same individual i.

3.4 Data from the Health and Retirement Study

Data for this research paper come from the Health and Retirement Study (HRS) provided by the Survey Research Center at the University of Michigan for the National Institute of Aging [6] (Burkhauser and Gertler, 1995; National Institutes of Health, 2007). Starting in 1992, the HRS provides a large, nationally representative sample of older Americans . The data set is organized as a longitudinal survey on Americans ages 53 and older which re interviews participants biannually.

Part of the HRS is the Consumption and Activities Mail Survey (CAMS) (Hurd and Rohwedder, 2009). It provides a supplemental mail survey on household expenditures to a subset of respondents in the years 2001, 2003, 2005, 2007 and 2009. The questionnaire includes information on (A) activities, (B) consumption and (C) demographics. Data collected from households and

[5] The literature on demand systems, specification and estimation goes back to Deaton and Muellbauer (1980) who introduced the "Almost Ideal Demand System (QUAIDS)" (Banks et al., 1997; Barten, 1964).

[6] Health and Retirement Study, [RAND Health and Retirement Study 2010] public use data set. Produced and distributed by the University of Michigan with funding from the National Institute on Aging (grant number NIA U01AG009740). Ann Arbor, Michigan (2010).

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individuals includes expenditure on 32 different groups of goods and services designed to capture all household spendings over the last 12 months [7]. The structure of the CAMS is close to the Consumer Expenditure Survey and collects data on 26 non durable and semi durable consumption items and 6 durable consumption items. The survey was sent and finally returned from 3866 households in 2001, 3254 households in 2003, 3880 households in 2005, 3738 households in 2007 and 3588 households in 2009 [8].

In combination with the CAMS, the panel data of the HRS allows for assessing a variety of important practical and theoretical issues, including how the health status of individuals affects consumption behavior on the individual level. With respect to this research paper, the empirical framework focuses on detailed information on the health status, consumption behavior and a variety of economic and demographic variables. In particular, the empirical model exploits information on different functional limitations to activities of daily living (ADLs) that have the potential to change the individual demand for goods and services. Here, the empirical analysis accounts for additional restrictions which limits the analysis to individuals above the age of 65 who live in a one person household and are non institutionalized (see discussion on restrictions below). The appendix of this research paper presents summary statistics and additional figures which characterize the data taken from the HRS and the CAMS.

3.4.1 Individual Consumption Behavior

The dependent variable in the empirical model refers to the individual consumption behavior observed from the CAMS data. Here, the empirical framework only explores consumption with respect to non durable and semi durable goods. Thus an observation period which corresponds to one year guarantees that expenditure equals consumption. Regarding the reliability of recall data, Browning et al. (2003) argue that respondents do a remarkable good job of reporting their household's expenditures on non durable consumption items such as food at home.

For the following empirical analysis consumption is separated into nine global categories. More specifically, each consumption category summarizes information on goods which are substitutes, whereas the global consumption categories are complements relative to each other. Table 3.1 characterizes the different global categories and summarizes the consumption items included into the analysis. Grouping consumption expenditure into categories reduces problems from non respondents and individuals who reported zero spending. Furthermore, this methodology reduces potential measurement errors which arise from respondents putting expenditure into wrong categories [9].

The empirical model focuses on the relative composition of the consumption basket. Thus budget shares provide information on the relative importance of different consumption categories and do not only reflect the fact that an individual consumes a specific level of category A and category B. Under the above mentioned assumption that the level of the overall budget does

[7] Depending on the categories individuals could choose to fill in information for the last week or the last month. The empirical part explores harmonized data which refers to a time period of one year.

[8] The response rates for all waves were between 70 and 80 percent. Numbers reported correspond to all households which returned the survey including valid information on consumption expenditures.

[9] To eliminate outliers which are not representative for the sample, consumption data is cleaned using the following algorithm. First, a so called Z score is constructed for all financial variables using the sample mean and standard deviation of log values. Second, the empirical analysis drops all observations with values for z such that $|z| > 4$. This way any observation that lies outside four standard deviations of the mean on either the log of total expenditures or any of the nine global consumption categories is eliminated from the data.

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not change in response to changes in the health status and further health expenditure do not influence the available budget for non health related consumption categories, this approach allows for further insights regarding preferences and consumption possibilities of individuals. Here, the focus on non durable and semi durable goods guarantees that expenditure generates an instantaneous utility during the period when the expenditure is reported.

Table 3.3 reports average consumption expenditure for nine different global categories over time using the restricted sample of individuals above the age of 65 years. Average expenditure for the years 2001, 2003, 2005, 2007 and 2009 is measured in nominal US Dollar and includes individuals which report zero consumption for some of the categories. The time series behavior of consumption offers two basic insights. First, between the years 2001 and 2003 data shows big changes in nominal expenditure. This pattern reflects adjustments in the survey design from the first to the second wave of the CAMS. Starting with the second wave, the introduction of additional consumption items gave interviewers the possibility to collect further information about actual consumption expenditure. To correct for this data problem, the empirical analysis focuses on global categories that summarize expenditure from smaller subcategories. Second, total consumption expenditure for the year 2005 are lower compared to previous cross sections. It is reasonable to assume that the decline in the stock markets between 2000 and 2003 has induced a reduction in consumption expenditure. Due to the fact that the empirical analysis does not explore absolute consumption shares but rather the relative composition of the consumption basket, results do not suffer from these (systematic) changes in absolute levels over time. Additionally, table 3.4 characterizes consumption in the the pooled cross section of individuals. In reference to the methodology applied in the empirical model, the table presents absolute and relative shares for each global consumption category with respect to total expenditure. Again, descriptive statistics suggest huge variations in relative shares across individuals. Later, this heterogeneity will be linked to the health status of individuals to better understand the relationship between health and consumption.

3.4.2 Individual Health Status

In addition to consumption data, the HRS collects information on the individual health status. More specifically, table 3.2 summarizes all measures used in the study to characterize the health status with respect to different dimensions of functional problems and diseases. The table distinguishes between three broad categories of measures. First, functional limitations describe the physical ability to perform a set of activities of daily living (ADLs) and instrumental activities of daily living (iADLs) [10]. According to Katz et al. (1963) and Dor et al. (2006) the wide set of ADLs can be sorted into three main categories: functional problems that limit (i) basic activities, (ii) mobility, and (iii) agility. On the contrary, limitations to iADLs focus more on tasks like for instance the ability of using a map or managing money (Lawton and Brody, 1969). Second, epidemiological problems (Smith, 1999) focus on the nature of various medical conditions which might trigger functional impairments in the long run. The HRS collects data on seven different diseases which are reported for all periods in the panel (hypertension, diabetes, cancer, heart disease, chronic lung disease, stroke and arthritis). Third, the self rated health status (Mossey and Shapiro, 1982) illustrates how individuals rank their relative position on a scale from 1 to

[10]The phrasing of questions related to ADLs is as follows: *Does your health in any way limit your daily activities compared to most people at your age?*

5 (poor, fair, good, very good, excellent) and the self reported survival probabilities provides information on expected mortality. Table 3.5 offers an overview over individual health conditions in the sample. Summary statistics illustrate substantial variations in the number of functional problems to different ADLs but also a large heterogeneity for other health measures discussed earlier.

The set of measures on the individual health measure differs with respect to objectiveness of measurement, adjustment behavior and long term consequences. In essence these differences have an impact on the choice of the preferred measure for the health status used in the empirical analysis. First, some measures allow for more subjective influence (self reported health status) whereas other measures can be considered to be more objective (cancer, heart disease, chronic lung disease) (Dwyer and Mitchell, 1999). Second, the need in how far functional limitations or diseases require an immediate and measurable adjustment on (consumption) behavior differs substantially. For instance, some functional problems require immediate adjustments (problems in ADLs related to basic activities and mobility) whereas other diseases only have a delayed impact on consumption behavior (hypertension and diabetes). Third, only some changes in the individual health status have a long lasting and permanent impact such that adjustments in individual (consumption) behavior become inevitable since individuals have a rather low probability to recover from disabilities related to basic activities, mobility and agility.

The empirical analysis sheds light on the question how permanent changes in the health status affect consumption behavior through shifts in preferences and the consumption possibility set. Here, functional problems in ADLs are more informative than for example information on severe diseases; in most cases, functional limitations require an immediate and permanent change in consumption behavior. Potential problems arise due to limited information in the data regarding the true health status of an individual but also with respect to individual expectations. Even if an individual did not report a change in the health status, expectations about future limitations in ADLs affect their behavior today. Using an inter temporal framework, the risk of a worsening health status but also a change in the actual or perceived time horizon are widely interpreted as explanations for a negative growth in individual wealth. In contrast to Oswald and Powdthavee (2008) who show that individuals partly adapt to disability and conclude that the onset of disabilities reduces happiness more in the short run than in the long run (habituation effects), the empirical framework in this paper does not analyze in how individuals adapt to a new health status.

The preferred health measure used in the empirical model in section V explores observed heterogeneity between observations related to different measures on ADLs (sub indices on ADLs related to basic activities, mobility and agility). More specifically, the analysis exploits variations in a composite index based on limitations to ADLs and iADLs to characterize the link between the individual health status and consumption behavior. Here, the construction of the index follows a principal component analysis and summarizes all answers to questions in one specific area into one measure ranging from 0 to 1. Summary statistics are available from table 3.5 where 0 indicates no functional limitations [11].

Figure 3.6 highlights the relationship between the health status and the age of individuals using four different indices based on functional problems in ADLs. Averages are calculated in terms of age and separated for males and females. The main differences between the four

[11] The appendix summarizes further details on the construction of the composite health measure used as proxy for the individual health status.

measures can be summarized as follows. First, differences in terms of level; difficulties in ADLs associated to agility and mobility are observed much more frequently than functional problems related to basic activities and instrumental ADLs. Second, differences in the timing; for basic activities and mobility there is a steady decrease in the ability to perform tasks associated on these health measures. For mobility descriptive statistics suggest a jump as soon as individuals have reached a certain age. In other words, problems associated to mobility arise for a large number of individuals following the age of 75 to 80. Third, differences between genders; for most data points females report a worse state than males. This observation is in line with previous findings in other studies claiming that females have a more negative evaluation of their health status. Obviously descriptive statistics for later cohorts might suffer from a sample selection problem because only individuals in good health reach the corresponding age bracket.

One criticism brought up against the use of health indices relates to the concern that information is too much aggregated. As a consequence it becomes unclear which changes in the individual health status induce a change in the aggregate measure. The analysis in figure 3.7 suggests that the occurrence of health problems follows a global pattern. In the beginning individuals report problems associated to mobility and agility. Later problems in ADLs linked to basic activities arise. This observation favors the use of three separate health indices for mobility, agility and basic activities in the empirical analysis against only exploiting an aggregate measure on all functional problems. Furthermore, the systematic patterns in the order of health problems has an impact on the expected adjustment behavior of individuals. If problems related to mobility and agility happen first and require adjustments in consumption behavior, the effect due to problems in basic activities will be smaller since individuals have already taken necessary steps at an earlier stage of their life. In reference to these concerns, the empirical model uses five different hierarchical indices which increase in severity of ADLs and iADLs as health measure included into the set of independent variables.

3.4.3 Additional Control Variables

The empirical model takes into consideration further differences across and within individuals. Here, the set of independent variables for the empirical model includes additional information on three different categories of variables: first, socio demographic characteristics which vary over time; second, socio demographic characteristics which are time invariant; and third, macro variables. Table 3.6 in the appendix to this research paper provides summary statistics on these variables.

Socio demographic characteristics which vary over time (SOCVAR). Previous research has shown that individuals adjust their consumption expenditures over the life cycle. To identify changes in the budget shares which can be associated to aging, information on the age of individuals is included into the set of independent variables. Also information on the individual labor market status is added to the empirical model to identify substitutes and complements of consumption categories with respect to being in the labor market (for example transportation and food away). Descriptive statistics illustrate that for the sample of individuals above the age of 65 years, the share of individuals who is still in the labor market is around 17 percent [12].

[12] This observation is in line with Finkelstein et al. (2013) who find that 20 percent of individuals above the age of 65 years are still in the labor market.

Furthermore, the presence of children has an impact on consumption behavior. A dummy on children is introduced into the model since it might capture heterogeneity in budget shares with respect to consumption expenditure on leisure activities. For example, grandparents spend their holidays with their grandchildren which reduces expenditure on expensive hotels. The dummy on home ownership is supposed to extract variation in consumption behavior which relates to the costs of housing. In line with the vast literature on linear and quadratic demand systems, the set of independent variables incorporates an information on the overall size of the budget (linear and quadratic). Hence, results from the empirical analysis allow for the identification of normal and inferior goods.

Socio demographic characteristics which are fixed over time (SOCFIX). The empirical model includes a dummy variable on the gender of the individual of interest which takes value one for females. The information on education is used to capture systematic differences in the social status which might impact consumption patterns as well. To account for non linearities in the educational level, the set of independent variables includes three dummies for different educational degrees: schoollow (less than high-school and general education); a reference group which characterizes individuals with high-school degree or some college; and schoolhigh for college and above. Furthermore, the empirical model includes a dummy variable on the migration status which takes the value one for individuals being born outside the US. Also, the set of independent variables accounts for the race of individuals such that a binary variable takes the value one if the individual is white or of Caucasian origin, and zero otherwise.

Macro variables (MACRO). This research paper is not directed towards analyzing the impact of changes in prices on the relative demand for different goods. Nevertheless, the empirical model accounts for changes in consumption behavior which might be triggered by changes in prices. Here, the set of independent variables does not include detailed information on prices but instead controls for time and region effects. Yearly dummies absorb changes in demand which come through the overall change in the price level in the economy [13]. Region dummies control for different price levels across regions [14]. Interaction terms between region and time are used to control for different price movements across regions. This wide range of control variables on the macro level allows for different price trends for each of the nine consumption categories in the model.

3.4.4 Restrictions to the sample from the HRS

The empirical analysis requires some crucial restrictions to the sample of observations. First, the sample from the HRS is limited to individuals above the age of 65 years; otherwise identification of the impact of health shocks on consumption behavior is complicated due to additional volatility in the labor income stream which also influences individual consumption behavior. To prevent the sample from being a negative selection of individuals which has already left the labor market for distinct reasons, the age of 65 serves as a lower bound for sample observations in the empirical analysis. Under these restrictions, all remaining individuals have full access to pension schemes and are eligible to government sponsored programs such as Medicare and Medicaid which mitigate

[13] The set of independent variables includes yearly dummies for the years 2001, 2003, 2005, 2007 and 2009.

[14] Regional dummies for ten different census regions in the United States: New England, Mid Atlantic, EN Central, WN Central, S Atlantic, ES Central, WS Central, Mountain, Pacific and other.

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the income effect of changes in the health status. Second, restrictions on the composition of households are necessary to allow for the identification of determinants of individual consumption behavior. In general, data on consumption behavior is collected on the household level and not for each household member separately. Thus, the sample for the empirical analysis is limited to households with only one household member. This step guarantees that changes in consumption behavior which follow a health shock are not eliminated by reallocation of resources and time within the household [15]. For one member households, information on consumption obtained from the CAMS data is identical to individual consumption. Third, the empirical model excludes all individuals living in a nursing home.

The static environment in this research paper neglects any inter temporal aspect of consumption behavior. First, this analysis does not elaborate on the inter temporal allocation of consumption and savings but instead focuses on the allocation of individual consumption expenditure to non durable and semi durable goods. The literature has shown that a worsening health status also has an impact on the level of savings and thereby an indirect impact on the optimal path of consumption. Individuals expect future increases in health expenditure and accumulate additional precautionary savings to insure against uncertainty in future health expenditure. Second, the assumption that consumption to non durable and semi durable goods generates instantaneous utility neglects the idea that some categories of expenditure can also be seen as an investment into the future which generates additional utility in subsequent periods. Third, the static model does not take into consideration potential adjustment processes related to a change in the health status (Chetty and Szeidl, 2007).

3.5 Estimation Strategy and Results

In line with the theoretical framework presented in section III and the data from the Health and Retirement Study and the Consumption and Activities Mail Survey discussed in section IV, the empirical framework explores different estimation strategies to establish a causal link between the health status and the individual consumption behavior. The empirical analysis identifies substitutes and complements with bad health defined in terms of functional problems related to activities of daily living. First, the analysis focuses on a static environment and presents results on how the health status of individuals affects their consumption behavior. For this purpose data from a pooled cross section is used and a seemingly unrelated regression (SUR) model is estimated. Here the empirical model does not distinguish between variation within and between individuals. Second, the panel dimension of the HRS allows for empirical identification of the impact of changes in the individual health status on consumption behavior. Results stem from a fixed effects panel model which focuses on observed differences within individuals over time.

3.5.1 Empirical model

Section III has shown how the individual utility maximization problem can be transformed into an empirical model with M goods in a demand system (see equation 3.3.2). Here, demand for good j, expressed in budget shares w_{ijt}, serves as dependent variable for the regression model.

[15] Imagine a household with two individuals. If one individual suffers a health shock the impact on consumption behavior might not be observable on the aggregate level because the other member of the household offers the services out of the market.

Adding an error term ϵ_{ijt}, demand from individuals $i = 1...N$ for each good $j = 1...M$ in time period t is given, such that

$$\begin{aligned} w_{ijt} = \quad & \alpha_j + \beta_{1j} \cdot H_{it} + \beta_{2j} \cdot age_{it} + \beta_{3j} \cdot budget_{it} + \beta_{4j} \cdot budgetsq_{it} \\ & + SOCVAR_{it} \cdot \gamma_{1j} + SOCFIX_i \cdot \gamma_{2j} + MACRO_{it} \cdot \gamma_{3j} + \epsilon_{ijt}. \end{aligned} \tag{3.4}$$

The set of independent variables includes a health measure which reflects the individual ability to perform a wide range of ADLs. As discussed in the previous section, the health measure differs across specifications and allows for a better understanding in how far different functional problems in ADLs induce individuals to adjust their consumption behavior. Further control variables are supposed to isolate systematic heterogeneity across and within individuals. First, socio demographic variables which are varying over time ($SOCVAR_{it}$). As mentioned earlier, age and the labor market status have a decisive impact on the composition of the individual consumption basket. To isolate the effect coming from the individual budget, the size of the overall budget on non durable and semi durable goods and a quadratic term in this variable are added to the empirical model. This way empirical results show if consumption categories are either normal or inferior goods. Furthermore, the specification in equation 3.4 controls for home ownership and a dummy variable if children are available. Both variables have the potential to explain observed differences across individuals with respect to their consumption behavior. Second, socio demographic variables which are constant over time ($SOCFIX_i$); for instance, information on gender, education, migration background and race which possibly have an impact on the consumption behavior of individuals. Third, differences on the macro level which account for differences across time and regions control for observed heterogeneity in the data ($MACRO_{it}$).

Any estimation strategy needs to take into consideration some particular characteristics of the data at hand. First, budget shares for each individual add up to one. As a consequence, the matrix of independent variables in the system of equations becomes singular and non invertible. Since the Mth good is a linear combination of the $M-1$ goods in the individual consumption basket, the estimation step will only account for $M-1$ goods for each individual in time [16]. Using the adding up constraint remaining parameters for the missing good can be calculated. Second, the estimator allows for the possibility that error terms within individuals and time but across different goods might be correlated due to unobserved heterogeneity.

3.5.2 Seemingly unrelated regression model in pooled cross section

The empirical model introduced in equation 3.4 establishes a link between the individual health status and the relative composition of the consumption basket. Given the structure of the data introduced above, the SUR model is used to estimate the empirical model from the pooled cross section (Zellner, 1962). For the SUR model, the relationship between w_{111} and w_{121} is indirect and it comes through correlation in the error terms across different equations. Thus the term seemingly unrelated regression is deceptive, as clearly the equations are related if the errors ϵ_{ijt} in different equations are correlated on the individual level. Test statistics for the SUR model

[16] Berndt and Savin (1975) show that estimation results do not depend on the choice of which good is eliminated from the estimation.

are obtained from the Breusch-Pagan test and clearly show that the null hypothesis – H0: error terms are uncorrelated within individuals – can be rejected.

Estimation of the empirical model identifies coefficients for a system of equations where the number of goods M is fixed and reasonable small and the number of individuals N goes to infinity. The estimation procedure applies the feasible GLS estimator as it is generally more efficient than OLS for a system of stacked equations (Cameron and Trivedi, 2005). Furthermore, the empirical model is estimated correcting for clusters on the individual level and applying analytic weights provided by the HRS. Table 3.10 summarizes estimated coefficients from the SUR model. In comparison to a far simpler specification in table 3.9 which only includes the health measure and some control variables for differences across time and region, the comparison between estimated coefficients and test statistics in the two models suggests that the set of independent variables from the empirical model 3.4 has substantial explanatory power to capture heterogeneity across and within individuals.

Results from the empirical model highlight the economic and statistical importance of the health status to explain observed differences across and within individuals which refer to the relative composition of the consumption basket. The following discussion focuses on the estimated coefficient on the health measure and draws some general conclusion from results in table 3.10. First, an increase in the variable "health measure" which reflects a negative deterioration of the health status, increases the relative demand for some goods like housing services and food at home while at the same time it decreases the relative budget spent on transportation and recreation. Second, size, sign and significance of estimated coefficients depend on the health measure used for the estimated specification. The previous discussion has illustrated that problems in ADLs related to mobility arise earlier than problems in ADLs related to basic activities. As a consequence the adjustment behavior differs systematically between different health measures. An alternative explanation could be that the impact of the health status on consumption behavior is heavily influenced by cost sharing requirements which differ across functional problems in ADLs. Third, results suggest that problems in ADLs related to basic activities force individuals to broader adjustments in terms of their consumption behavior than for example problems in ADLs related to agility. This reflects the idea that changes in preferences and in particular in the consumption possibility set depend on the health measure used for the corresponding empirical specification. In summary, the significance of some of the estimated coefficients on the health measure illustrates that the composition of the consumption basket is systematically related to the individual health status. Clearly these preliminary findings support the theoretical concept of state dependent utility functions.

Furthermore, findings from the SUR model identify a wider set of variables which can be seen as determinants for the observed differences in consumption behavior across and within individuals. In line with the previous discussion in section II the estimated coefficient on the budget (linear and squared) suggests that some categories in the set of non durable and semi durable consumption goods are inferior goods (food and transportation) whereas others are normal goods (housing and recreation). Also results in table 3.10 illustrate that the age of individuals influences consumption patterns. In particular, the estimated coefficient on age shows that both age and health have an independent influence on the relative composition of the consumption basket. For instance, aging reduces the relative demand for food at home whereas an adverse change in the health status increases expenditure on these items. The opposite pattern can be observed for expenditure related to transfers to friends and relatives. In addition to these

findings, further information on gender of the individual, migration background, race, education, the labor market status, ownership of a house and a binary information on children captures observable heterogeneity in the data. Depending on the specification and the consumption categories results suggest systematic differences which can be linked to the above mentioned characteristics. For example, individuals who are still in the labor market spend a higher share on transportation and home owners allocate a higher fraction of their expenditure to housekeeping and gardening services.

The key identifying assumption when applying the SUR model in equation 3.4 requires that error terms are uncorrelated with any independent variable in the model [17]. If this assumption is violated and there are unobserved factors correlated with any of the independent variables, the estimates from the SUR model become inconsistent. Regarding the research questions in this paper, it is possible that unobserved characteristics vary systematically by individual and impact the estimated coefficients of the true relationship between health and consumption; more specifically, unobserved and individual fixed characteristics include behavioral traits on how individuals react to functional limitations, but also how they evaluate their individual health status. One way to correct for this miss specification is to estimate a fixed effects model to control for unobserved heterogeneity. The estimates obtained from the fixed effects model are not subject to bias arising from time invariant and unobserved characteristics which differ across but not within individuals. In the following subsection, the fixed effects estimator only exploits variation within individuals and neglects differences across individuals.

3.5.3 Fixed effects model and within individual variation

The previous discussion has shown that individual fixed effects are potentially correlated with independent variables. In response, the empirical model in equation 3.5 takes into consideration an individual fixed effect δ_{ij} which accounts for unobserved heterogeneity. Then the estimated coefficients provide information on how changes in the health status induce changes in individual budget shares w_{ijt}.

$$\begin{aligned} w_{ijt} = \quad & \alpha_j + \beta_{1j} \cdot H_{it} + \beta_{2j} \cdot age_{it} + \beta_{3j} \cdot budget_{it} + \beta_{4j} \cdot budgetsq_{it} \\ & + SOCVAR_{it} \cdot \gamma_{1j} + MACRO_{it} \cdot \gamma_{2j} + \delta_{ij} + \epsilon_{ijt} \end{aligned} \tag{3.5}$$

Similar to the SUR model analysis, the empirical model includes a wide set of control variables. Identification in the fixed effects model comes from time varying individual specific information. Accordingly, the empirical model considers all socio demographic information on time varying characteristics and further controls for region and time effects. Even though individuals are observed for up to five waves, which translates into a maximum observation window of ten years, panel statistics illustrate that the data set from the HRS is far from being balanced [18]. Average group size is around two which draws attention to potential problems associated to the so called mortality bias (Shorrocks, 1975). Here, it is possible that those individuals who left the sample earlier were different in terms of characteristics which would introduce an additional bias

[17] Using the notation introduced in this section, the condition on strict exogeneity can be expressed as follows: $E[\epsilon_{i,j,t}|X_{i,j,t}] = 0$ with t=1 ... T, j=1 ... J and i=1 ... N.

[18] Using five different specifications (aggregate ADL, instrumental ADL, ADL basic, ADL mobility and ADL agility) the average number of observations is around two for each of the fixed effects models (2.1, 2.2, 2.5, 2.2 and 2.2).

into results from the empirical model [19]. Test statistics suggest that the correlation between unobserved, individual specific heterogeneity and independent variables in the model is sufficiently high such that only estimated coefficients from the fixed effects model are consistent (see reported correlation between error terms and independent variables).

The key difference between the SUR model and the fixed effects model is that identification in the fixed effects model is based solely on variation within individuals. Consequently, some estimated coefficients in the fixed effects model (see tables 3.11 to 3.19) change in size and significance relative to previous results. For some consumption categories, like for example "transportation" and "health", estimation results still show statistically and economically significant changes in individual consumption behavior which can be linked to changes in the health status. In contrast to findings in table 3.10 some estimated coefficients on the health status turn insignificant in the fixed effects model which can be attributed to the limited variation within individuals (for example "housing", "food home" and "food away"). In this context, differences between the two empirical specifications suggest that identification of estimated coefficients in the pooled cross section is mainly driven by differences across individuals and not by variation within individuals.

Tables 3.11 to 3.19 in the appendix to this research paper present the main results from the fixed effects model using budget shares as dependent variable. Here, estimated coefficients support the theoretical concept of state dependent utility functions and demonstrate that changes in the health measure which is defined in terms of functional problems in ADLs require adjustments in the individual consumption behavior. Findings regarding the key variable of interest can be summarized as follows. First, for most consumption categories the five different specifications, which vary in the health measure included into the set of independent variables (ADL, iADL, ADL basic, ADL mobility and ADL agility), show similar signs. For instance, a deterioration in the health status induces a lower relative share for five consumption categories (homefix, food away, transportation, recreation, transfers) whereas the relative budget share for three consumption categories increases (food home, health and cloth). As mentioned earlier some of the effects are not significant. Second, the size of estimated coefficients on the health status differs in the categories of ADLs. For example, the change in the consumption share to "food away" is particularly large if individuals experience functional problems related to instrumental ADLs. Also, the relative share related to "transportation" reduces for all health measures except for ADLs in agility which reflects the fact that functional problems in this category do not limit mobility of individuals. Results in table 3.17 illustrate that increases in the relative share dedicated to health expenditure depends on the category of functional problems individuals report. Here, the economically and statistically significant effect to instrumental ADLs and ADLs in mobility suggest that cost sharing requirements play an important role. Third, empirical findings for some specifications illustrate that both the estimated coefficient on the health status but also the coefficient on age are statistically significant. For instance, the fixed effects models for "transportation" and "health" show estimation results which suggest significance of health and age in one and the same model. Accordingly, the empirical analysis in this paper suggests that health and age describe two independent sources for adjustments in consumption behavior over the life cycle.

Findings in tables 3.11 to 3.19 illustrate that within individual variation with respect to the

[19] The theoretical framework behind this empirical problem would be that health capital, financial capital and human capital are highly correlated on the individual level. To correct for this problem, see Attanasio and Hoynes (2000); Attanasio and Emmerson (2003).

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wider set of independent variables has some explanatory power when it comes to the analysis of individual consumption behavior. For instance, the estimated coefficients on the budget in the five different specifications "housing", "food at home", "transportation", "recreation" and "clothing" clearly identify inferior and normal goods. Also, the labor force status (positive for transfers) and the dummy on children show expected signs (negative for recreation). Similar to the health status, identification of estimated coefficients on the wider set of independent variables yields much weaker results – mainly, because the pooled cross section shows much more heterogeneity in consumption across individuals than within individuals.

In summary, results from the fixed effects model show that individuals adjust the relative composition of their consumption basket in response to a change in the health status. This conclusion adds to previous research by Finkelstein et al. (2013) where the empirical model builds on the assumption that relative basket shares do not change in the state of the individual. In addition, findings show an effect of the health status on consumption behavior which is independent of aging and only comes from within individual variation in the health status. Then changes in the health status are an independent source of changes in individual consumption behavior which can be separated out from the effect of aging. From a policy perspective this suggests that medical progress has an impact on how individuals change their (consumption) behavior and it is not only demographic transition itself which shifts consumption patterns in the economy.

3.6 Conclusion and Policy Implications

The link between individual characteristics and their impact on consumption behavior over the life cycle is still largely unexplained. This paper focuses on the health status to explain parts of the puzzle how individuals adjust their consumption behavior over time. Here, the concept of state dependent utility functions defines a well established theoretical framework to include the health status into an utility maximization problem. The empirical analysis makes use of data from the Health and Retirement Study in combination with the Consumption and Activity Mail Survey from the United States of America to estimate different empirical models on how individuals adjust the relative composition of their consumption basket in response to changes in the ability to perform a wide set of different activities of daily living.

The empirical framework categorizes expenditure on non durable and semi durable goods in terms of nine distinct consumption categories. Furthermore, the measure on the individual health status summarizes detailed information on functional problem with respect to different activities of daily living. Estimation results from the empirical model suggest that the relative composition of the consumption basket is responsive to changes in the health status. Size, sign and significance depend on the health measure and the consumption category employed in the empirical analysis. First, the seemingly unrelated regression model provides preliminary evidence about a systematic relationship between consumption behavior and the individual health status. Second, a fixed effects model illustrates that a change in the health status influences consumption behavior even if variation only comes from within individuals. Most importantly, findings from the empirical analysis identify an effect that goes from changes in the health status to changes in consumption behavior which can be separated out from the effect of aging. Here, shifts in preferences and adjustments in the consumption possibility set offer potential explanations for the observed patterns in the data.

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In the context of policy design it would be interesting to learn more about the welfare implications of these changes in consumption behavior. The theoretical literature illustrates that adjustments – due to changes in the individual health status – are costly in terms of individual utility. One explanation could be that cost sharing requirements in the case of functional limitations force individuals to cut down expenditure on other goods. To fully understand the impact of changes in the health status and to isolate those mechanisms, future research should focus on the question how different insurance programs mitigate the impact of changes in the health status on consumption behavior and thereby also change individual utility. This knowledge would contribute to improvements of social policy and enables targeted interventions for those members of society who need financial support the most. Taking in mind that demographic transition tends to further increase the number of people who experience changes in the health status, these results allow for a better understanding on how medical progress and demographic transition change economic welfare of many societies worldwide.

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Comments on Data from the Health and Retirement Study

In contrast to the raw data from the HRS, this research paper explores data from the RAND HRS which provides additional variables that were recoded and cleaned. In terms of the different health measures, this version of the micro data offers the following improvements. First, corrections due to problems in skip patterns; depending on the respondents' answers to some questions subsequent questions about ADLs were skipped or omitted during the interview. Later these answers were imputed based on the following logic: respondents who could run or jog for one mile without difficulties were not asked if they could walk several blocks or one block. Second, transformation of answers into binary variables; for the analysis of dichotomous indicators of any functional problem in terms of ADLs, respondents answering *yes*, *can't do* and *don't do* to the neutrally worded questions were classified as having difficulties (Freedman et al., 2003).

Indices on the Health Status. The empirical analysis explores different health measures based on limitations to ADLs and iADLs. To construct these indices I summarize all answers to questions in one specific area into one measure ranging from 0 to 1 where 0 indicates no functional limitations. On grounds of previous research by Spector et al. (1987); Katz et al. (1970) and Coile (2004), four different hierarchical indices with different categories that increase in severity of ADLs and iADLs are constructed: `RADLBASICINDEX`, `RADLMOBILINDEX`, `RADLAGILINDEX` and `RIADLINDEX`. Spector and Fleishman (1998) argue that combining ADL and iADL items in one scale increases the range and sensitivity of these items to measure functional impairments. They conclude that a one parameter model was most appropriate meaning that overall levels of functional impairment could be measured simply by identifying the total number of items where respondents report difficulties. Using the principal components analysis as an alternative aggregation method, I reduce the complexity of the multivariate data into a uni variate measure.

Principal Component Analysis. Descriptive statistics suggest that the wide set of health measures in terms of ADLs is highly correlated, possibly because they capture the same event. Hence, the principal components analysis reduces the number of observed variables into a smaller number of principal components (artificial variables) that accounts for most of the variance in the observed variables. The first principal component accounts for as much of the variability in the data as possible.

Construct Validity. The use of these indices and the results derived from the subsequent empirical analysis depends on the construct validity of the five health measures `RADLINDEX`, `RADLBASICINDEX`, `RADLMOBILINDEX`, `RADLAGILINDEX` and `RIADLINDEX` (Fonda and Herzog, 2004). Wallace and Herzog (1995) find that individuals with health conditions such as diabetes, cancer, heart problems and stroke reported a higher score for the aggregate ADL measure. Stump et al. (1997) relates basic ADLs and advanced ADLs to other aspects of health status measures and social demographics. Here, most of the health conditions were associated with worse functioning. Rodgers and Miller (1997) examines the extent to which ADL measures are correlated with several criteria such as age, health status, the number of health conditions, and the number of doctor visits. All correlations show the expected direction and are statistically significant.

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Descriptive Statistics and Estimation Results

Table 3.1: Consumption Categories in the Consumption and Activities Mail Survey.

Global Category	Code	Category
Fixed Home Expenses	01.	Mortgage Payments
	02.	Rent
	03.	Electricity
	04.	Water
	05.	Heat
	06.	Telephone, cable
	07.	Homeowner's or renter's insurance
	08.	Property Taxes
Housekeeping and Maintenance	11.	Housekeeping supplies
	12.	Housekeeping services
	13.	Gardening supplies
	14.	Gardening services
	1114.	*Housekeeping and gardening*
	15.	Home maintenance supplies, furniture
	16.	Home maintenance services
	1516.	*Home repairs and maintenance*
	91.	Refrigerator
	92.	Washer and dryer
	93.	Dishwasher
	94.	Television
	95.	Computer
Food at Home	21.	Food and beverages at home
Food Away	31.	Food and beverages going out
Clothing	41.	Clothing and apparel
Transportation	51.	Vehicle finance charges
	52.	Vehicle insurance
	53.	Gasoline
	54.	Vehicle maintenance
	81.	Auto purchase and lease
Health out of Pocket	61.	Medications
	62.	Health care services
	63.	Medical supplies
	64.	Health insurance
Recreation	71.	Tickets to movies, events
	72.	Sports equipment
	73.	Hobbies
	74.	Trips and vacations
	75.	Personal care products
	7273.	*Hobbies and Sports*
Transfers	101.	Cash or gifts to family and friends
	102.	Contributions to organizations

Notes: This table illustrates how different consumption categories on non durable and semi durable goods are summarized into nine different global categories.
Source: HRS and CAMS data.

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Table 3.2: Health Status in the Health and Retirement Survey.

Global Category	Code	Difficulty
ADL Basic	bath	bathing and showering
	bed	getting in or out of bed
	dress	dressing
	eat	eating
	toilt	using the toilet
	walkr	walking across room
ADL Agility	arms	reaching and extending arms above shoulder level
	dime	picking up a dime
	stoop	stooping/ kneeling/ crouching
	chair	getting up from chair after sitting for long periods
	sit	sitting for about 2 hours
	lift	lifting or carrying weights over 10 pounds
	push	pushing or pulling a large objects
ADL Mobility	clims	climbing several flights of stairs
	clim1	climbing one flight of stairs
	walks	walking several blocks
	walk1	walking one block
instrumental ADL	map	using a map
	meals	preparing hot meals
	meds	taking medications
	money	managing money
	phone	using telephone
	shop	shopping for groceries
Severe Conditions	hibp	hypertension
	diab	diabetes
	cancr	cancer
	heart	heart disease
	lung	chronic lung disease
	strok	stroke
	arthr	arthritis
Self Reported Health	shlt	self report of health
Survival Probabilities	liv75	probability to live until 75 and older
	liv10	probability to live until 80 up to 100

Abbreviations: ADL – activities of daily living.
Notes: In combination with the description in section IV this table summarizes the wide set of health measures in the data. Later, the empirical analysis focuses on functional problems related to activities of daily living (ADL).
Source: HRS data.

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Table 3.3: Consumption Behavior for Five Waves of CAMS data.

	year 2001	**year 2003**	**year 2005**	**year 2007**	**year 2009**
Fixed Home Expenses	6352.73	8739.79	7990.52	9232.00	9869.56
Housekeeping and Maintenance	2292.81	2599.95	2163.26	2694.36	2363.47
Food at Home	2253.15	2486.79	2356.36	2580.93	2682.65
Food Away	943.33	982.03	819.13	1044.73	1047.54
Clothing	701.29	675.09	440.04	496.78	435.61
Transportation	2259.85	1891.31	2170.66	2391.78	2453.05
Health out of Pocket	1684.29	3456.84	3106.03	2788.78	3296.06
Recreation	1262.69	1350.16	1211.15	1589.56	1524.80
Transfers	3222.44	2571.93	2140.28	2791.62	2812.87
observations	827	718	799	852	855

Notes: Data is calculated based on the restricted sample of individuals older than 65 years. All values are absolute values in nominal US Dollars.
Source: CAMS data. Own calculations.

Table 3.4: Consumption Basket in Absolute and Relative Shares.

Consumption Category	**Mean**	**(Std. Dev.)**	**Mean**	**(Std. Dev.)**
	absolute shares		relative shares	
Fixed Home Expenses	8500.173	(10292.5)	0.367	(0.202)
Housekeeping and Maintenance	2417.775	(6977.3)	0.08	(0.11)
Food at Home	2481.538	(2693.538)	0.129	(0.112)
Food Away	970.612	(2332.039)	0.038	(0.057)
Clothing	541.159	(1320.195)	0.025	(0.049)
Transportation	2250.995	(3111.795)	0.099	(0.102)
Health out of Pocket	2874.621	(5084.806)	0.124	(0.125)
Recreation	1395.487	(2733.993)	0.054	(0.071)
Transfers	2713.107	(9301.355)	0.085	(0.125)

Notes: Data is calculated from the pooled cross sections with 4051 observations.
Source: CAMS data. Own calculations.

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Table 3.5: Health Problems and Functional Conditions in the Data.

Variable	Mean	(Std. Dev.)	N
ADL index	0.229	(0.239)	2898
ADL basic index	0.068	(0.168)	4043
ADL mobil index	0.304	(0.35)	3306
ADL agility index	0.311	(0.3)	3400
Instrumental ADL index	0.048	(0.127)	3070
bath: difficulty-bathing, shower	0.077	(0.267)	4046
bed: difficulty-get in or out bed	0.051	(0.221)	4050
dress: difficulty-dressing	0.094	(0.292)	4050
eat: difficulty-eating	0.026	(0.16)	4051
toilt: difficulty-using the toilet	0.07	(0.256)	4051
walkr: difficulty-walk across room	0.07	(0.255)	4050
arms: difficulty-reach or extend arms up	0.183	(0.387)	4030
dime: difficulty-pick up a dime	0.09	(0.286)	4045
stoop: difficulty-stoop/kneel/crch	0.523	(0.5)	3949
chair: difficulty-get up fr chair	0.433	(0.495)	4050
sit: difficulty-sit for 2 hours	0.188	(0.391)	4011
lift: difficulty-lift or carry 10lbs	0.286	(0.452)	3812
push: difficulty-push or pull lg obj	0.313	(0.464)	3580
clims: difficulty-clmb sev flt str	0.524	(0.499)	3429
clim1: difficulty-clmb one flt stair	0.206	(0.404)	3833
walks: difficulty-walk sev blocks	0.368	(0.482)	3925
walk1: difficulty-walk one block	0.172	(0.377)	4005
map: difficulty-use a map	0.131	(0.338)	3298
meals: difficulty-prepare hot meal	0.051	(0.221)	3934
meds: difficulty-take medications	0.023	(0.15)	3934
money: difficulty-managing money	0.044	(0.205)	4008
phone: difficulty-use telephone	0.027	(0.162)	4046
shop: difficulty-shop for grocery	0.093	(0.29)	3982
hibp: reports high bloodpreasure	0.653	(0.641)	4046
diab: reports diabetes	0.173	(0.449)	4046
cancr: reports cancer	0.197	(0.439)	4048
heart: reports heart prob	0.344	(0.61)	4049
lung: reports lung disease	0.162	(0.495)	4050
strok: reports stroke	0.092	(0.37)	4050
arthr: reports arthritis	0.766	(0.575)	4050
shlt: self-report of health	2.857	(1.075)	4046
liv75: probability to live 75+	63.131	(29.718)	209
liv10: probability to live 80-100	45.203	(32.289)	3481

Notes: Data is calculated based on the restricted sample of individuals older than 65 years.
Source: HRS and CAMS data. Own calculations.

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Table 3.6: Individual Characteristics in the Data.

Variable	**Mean**	**(Std. Dev.)**	**N**
age	76.382	(7.446)	4051
labor market status (DUM)	0.169	(0.375)	4051
home owner (DUM)	0.686	(0.464)	4051
children (DUM)	0.841	(0.365)	3974
female (DUM)	0.77	(0.421)	4051
migrant background (DUM)	0.061	(0.24)	4051
white (DUM)	0.915	(0.279)	4049
schoollow	0.236	(0.425)	4051
schoolhigh	0.141	(0.348)	4051
years of education	12.255	(2.829)	4042
hispanic (DUM)	0.034	(0.182)	4051
years worked (self – report)	31.255	(17.5)	4051
veteran status	0.154	(0.361)	4046
out of pocket medical expenses, last 2 yrs	3239.744	(11813.901)	4051
covered by government plan	0.96	(0.197)	4047
government plan – medicare	0.952	(0.214)	4048
government plan – medicaid	0.091	(0.287)	4038
government plan – champus	0.04	(0.196)	4049
life insurance	0.569	(0.495)	4026
insurance with employer	0.299	(0.458)	4051
long term care insurance	0.124	(0.329)	4007
other insurance	0.315	(0.464)	4016
total of all assets	292143.845	(540059.767)	4051
total non – housing assets	191847.972	(476552.067)	4051
non – housing financial wealth	114313.326	(358446.616)	4051
income total household	56101.728	(1252754.067)	4051

Notes: Data is calculated based on the restricted sample of individuals older than 65 years.
Source: HRS and CAMS data. Own calculations.

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Figure 3.1: Consumption Behavior and Health Status: Aggregate ADL.

Notes: Figures differs in the consumption category and report average budget shares (vertical axis) for individuals who report a given number of health problems with respect to activities of daily living (horizontal axis).
Source: HRS and CAMS data. Unbalanced panel from 2000 to 2009. Own calculations.

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Figure 3.2: Consumption Behavior and Health Status: Instrumental ADL.

Notes: Figures differs in the consumption category and report average budget shares (vertical axis) for individuals who report a given number of health problems with respect to instrumental ADLs (horizontal axis).
Source: HRS and CAMS data. Unbalanced panel from 2000 to 2009. Own calculations.

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Figure 3.3: Consumption Behavior and Health Status: ADL Related to Basic Activities.

Notes: Figures differs in the consumption category and report average budget shares (vertical axis) for individuals who report a given number of health problems with respect to basic ADLs (horizontal axis).
Source: HRS and CAMS data. Unbalanced panel from 2000 to 2009. Own calculations.

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Figure 3.4: Consumption Behavior and Health Status: ADL Related to Mobility.

Notes: Figures differs in the consumption category and report average budget shares (vertical axis) for individuals who report a given number of health problems with respect to mobile ADLs (horizontal axis).
Source: HRS and CAMS data. Unbalanced panel from 2000 to 2009. Own calculations.

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Figure 3.5: Consumption Behavior and Health Status: ADL Related to Agility.

Notes: Figures differs in the consumption category and report average budget shares (vertical axis) for individuals who report a given number of health problems with respect to agile ADLs (horizontal axis).
Source: HRS and CAMS data. Unbalanced panel from 2000 to 2009. Own calculations.

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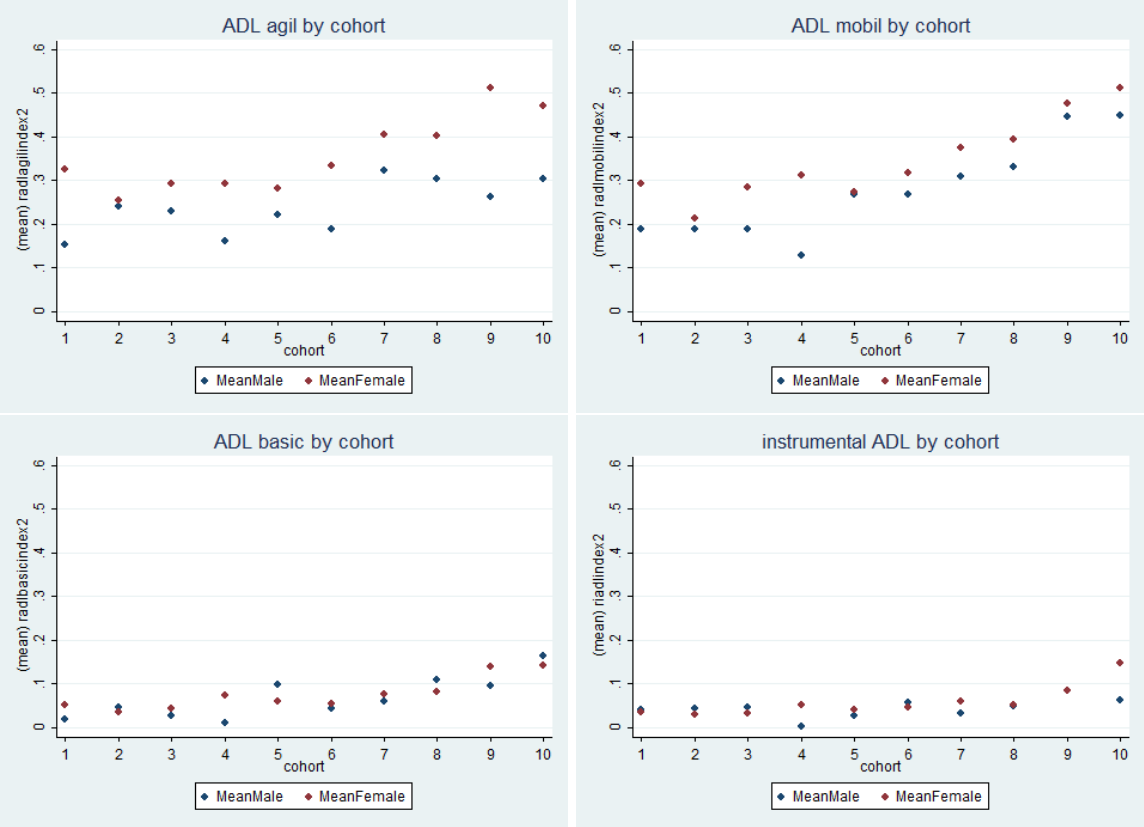
Figure 3.6: Life Cycle Profile of Health Problems Related to ADLs. By Cohort and Gender.



Notes: Cohorts are calculated on the basis of three year intervals. Here, category "1" refers to the youngest cohort (born between 1939 and 1941) and "10" characterizes the oldest cohort (born between 1912 and 1914) available in the sample. Results focus on timing of functional problems in activities of daily living and illustrate differences between males and females.
Source: HRS data. Unbalanced panel. Own calculations.

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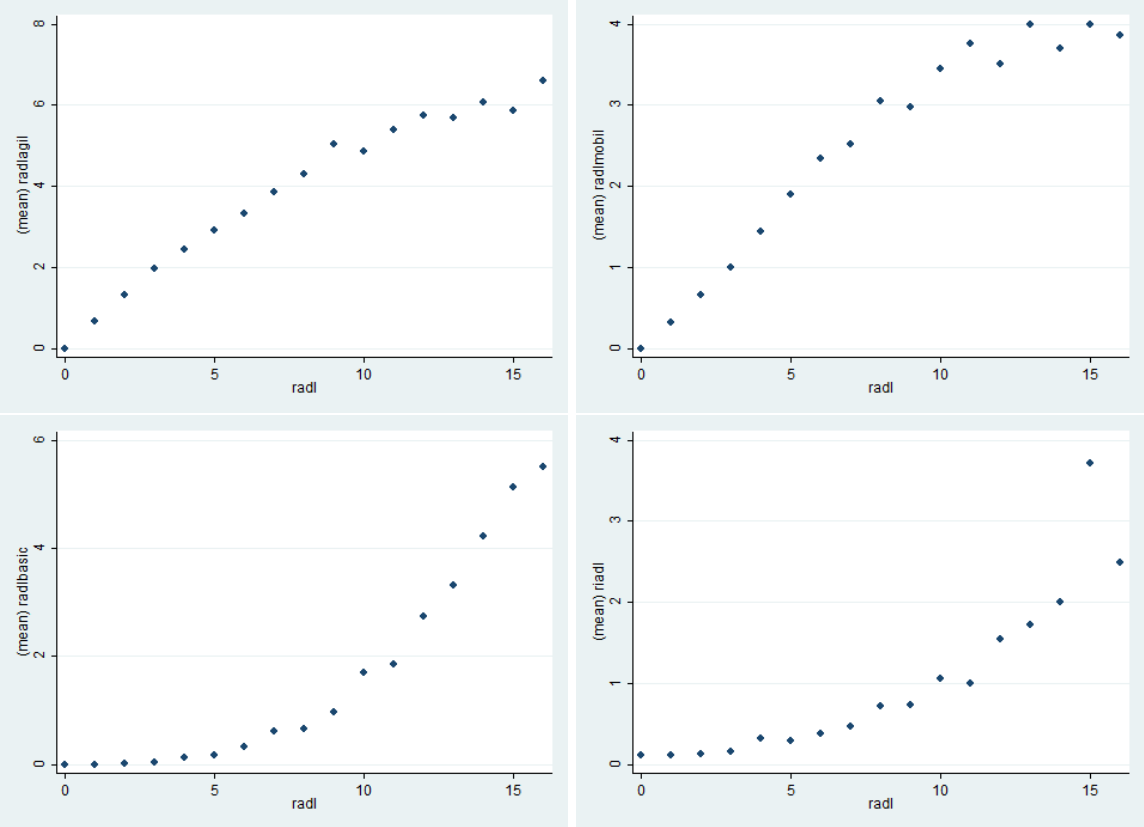
Figure 3.7: Order of Health Problems Related to ADLs.



Notes: The horizontal axis shows the overall number of problems in ADLs. The vertical axis shows an sub indices on agility, basic, mobility and instrumental ADLs. Results highlight the timing of functional problems in activities of daily living and emphasize a shared pattern across individuals. First problems related to agility and mobility arise and only later individuals report problems related to basic activities.
Source: HRS data. Unbalanced panel. Own calculations.

Table 3.7: Fixed Effects Model with Health Expenditure as Dependent Variable.

log(health expenditure)	ADL	ADL instru	ADL basic	ADL mobility	ADL agility
	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.
healthmeasure	0.126	0.321	–0.282	0.294*	–0.003
	(0.260)	(0.512)	(0.233)	(0.161)	(0.125)
age	0.093***	0.119***	0.121***	0.113***	0.089***
	(0.032)	(0.037)	(0.025)	(0.028)	(0.028)
laborstatus	0.078	0.091	0.048	0.026	0.116
	(0.111)	(0.094)	(0.086)	(0.105)	(0.108)
health X labor	0.149	–0.146	0.104	0.235	–0.004
	(0.343)	(1.121)	(0.360)	(0.231)	(0.279)
cons	–0.206	–1.621	–2.026	–1.937	0.562
	(2.474)	(2.835)	(2.002)	(2.218)	(2.142)
r2	0.1413	0.1177	0.1180	0.1424	0.1277
corr	–0.5726	–0.6657	–0.6809	–0.6715	–0.5512
N	2669	2845	3688	3035	3115
Cluster	1296.0000	1330.0000	1543.0000	1400.0000	1417.0000
avg	2.0594	2.1391	2.3901	2.1679	2.1983

Notes: The empirical model includes yearly dummies to capture year specific effects and region dummies to control for differences across regions. Interaction terms for year and regions are included as well. Furthermore, the estimation strategy accounts for clustering on the household level, estimate robust standard errors and include analytic weights provided by the HRS. Level of significance: * 0.10 ** 0.05 *** 0.01.
Source: HRS and CAMS data. Own calculations.

Table 3.8: Fixed Effects Model with Overall Budget as Dependent Variable.

log(budget)	ADL	ADL instru	ADL basic	ADL mobility	ADL agility
	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.
healthmeasure	0.036	–0.023	–0.171	0.051	0.007
	(0.153)	(0.318)	(0.161)	(0.089)	(0.076)
age	0.021	0.024	0.030*	0.028	0.020
	(0.014)	(0.027)	(0.016)	(0.017)	(0.016)
laborstatus	0.056	0.023	0.040	0.063	0.065
	(0.056)	(0.054)	(0.049)	(0.051)	(0.062)
health X labor	–0.064	0.876*	0.047	0.005	–0.206
	(0.208)	(0.494)	(0.200)	(0.129)	(0.176)
cons	7.862***	8.447***	7.459***	7.214***	8.280***
	(1.161)	(2.052)	(1.236)	(1.376)	(1.229)
r2	0.0346	0.0343	0.0294	0.0342	0.0315
corr	–0.5097	–0.4889	–0.5251	–0.5447	–0.4751
N	2898	3070	4043	3306	3400
Cluster	1380.0000	1409.0000	1639.0000	1491.0000	1513.0000
avg	2.1000	2.1789	2.4667	2.2173	2.2472

Notes: The empirical model includes yearly dummies to capture year specific effects and region dummies to control for differences across regions. Interaction terms for year and regions are included as well. Furthermore, the estimation strategy accounts for clustering on the household level, estimate robust standard errors and include analytic weights provided by the HRS. Level of significance: * 0.10 ** 0.05 *** 0.01.
Source: HRS and CAMS data. Own calculations.

Table 3.9: Unconditional correlations from a SUR model.

	ADL Coeff./SE.	ADL instru Coeff./SE.	ADL basic Coeff./SE.	ADL mobility Coeff./SE.	ADL agility Coeff./SE.
sharehomefix					
healthmeasure	0.061***	0.001	0.025	0.045***	0.039***
	(0.015)	(0.027)	(0.019)	(0.010)	(0.011)
sharehousing					
healthmeasure	–0.004	0.006	0.019*	–0.009	–0.001
	(0.009)	(0.016)	(0.010)	(0.006)	(0.006)
sharefoodhome					
healthmeasure	0.035***	0.062***	0.067***	0.033***	0.019***
	(0.008)	(0.015)	(0.010)	(0.005)	(0.006)
sharefoodaway					
healthmeasure	–0.017***	–0.020**	–0.016***	–0.014***	–0.013***
	(0.004)	(0.008)	(0.005)	(0.003)	(0.003)
sharetransp					
healthmeasure	–0.068***	–0.104***	–0.084***	–0.048***	–0.041***
	(0.008)	(0.014)	(0.009)	(0.005)	(0.006)
sharehealth					
healthmeasure	0.075***	0.129***	0.075***	0.052***	0.050***
	(0.009)	(0.017)	(0.011)	(0.006)	(0.007)
sharerecrea					
healthmeasure	–0.058***	–0.036***	–0.045***	–0.038***	–0.039***
	(0.006)	(0.010)	(0.007)	(0.004)	(0.004)
sharetransf					
healthmeasure	–0.031***	–0.039**	–0.044***	–0.025***	–0.019***
	(0.009)	(0.018)	(0.012)	(0.006)	(0.007)
r2	0.0322	0.0277	0.0273	0.0350	0.0294
N	2898	3070	4043	3306	3400

Abbreviations: DUM = dummy variable.

Notes: The empirical model includes yearly dummies to capture year specific effects and region dummies to control for differences across regions. Interaction terms for year and regions are included as well. Furthermore, the estimation strategy accounts for clustering on the household level, estimate robust standard errors and include analytic weights provided by the HRS. Level of significance: * 0.10 ** 0.05 *** 0.01.

Source: HRS and CAMS data. Own calculations.

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Table 3.10: Seemingly unrelated regression model for health status and constantumption behavior.

	ADL Coeff./SE.	ADL instru Coeff./SE.	ADL basic Coeff./SE.	ADL mobility Coeff./SE.	ADL agility Coeff./SE.
sharehomefix					
healthmeasure	0.030*	–0.059**	–0.015	0.020**	0.014
	(0.016)	(0.027)	(0.019)	(0.010)	(0.012)
budget (linear term)	–0.006***	–0.005***	–0.006***	–0.005***	–0.005***
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
budget (quadratic term)	0.000**	0.000**	0.000***	0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
female (DUM)	–0.011	–0.008	–0.011	–0.004	–0.014
	(0.009)	(0.008)	(0.008)	(0.008)	(0.009)
migrant background (DUM)	0.052***	0.032**	0.041***	0.044***	0.050***
	(0.015)	(0.015)	(0.013)	(0.014)	(0.014)
white (DUM)	–0.043***	–0.056***	–0.053***	–0.058***	–0.043***
	(0.014)	(0.013)	(0.011)	(0.013)	(0.013)
schoollow	–0.020	–0.025**	–0.019*	–0.015	–0.017
	(0.012)	(0.011)	(0.010)	(0.011)	(0.011)
schoolhigh	0.021	0.000	0.007	0.011	0.010
	(0.018)	(0.016)	(0.015)	(0.016)	(0.016)
age	–0.001*	–0.001*	–0.000	–0.001**	–0.000
	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)
labor force (DUM)	0.025**	0.028***	0.025**	0.023**	0.026**
	(0.012)	(0.010)	(0.010)	(0.011)	(0.011)
home owner (DUM)	–0.064***	–0.063***	–0.069***	–0.067***	–0.070***
	(0.011)	(0.010)	(0.009)	(0.010)	(0.010)
children (DUM)	0.005	0.009	0.007	0.002	0.008
	(0.011)	(0.010)	(0.009)	(0.010)	(0.010)
sharehousing					
healthmeasure	0.012	0.036**	0.037***	0.004	0.011
	(0.009)	(0.016)	(0.010)	(0.006)	(0.007)
budget (linear term)	0.003***	0.003**	0.003***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
budget (quadratic term)	–0.000***	–0.000**	–0.000***	–0.000***	–0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
female (DUM)	0.022***	0.020***	0.021***	0.021***	0.023***
	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)
migrant background (DUM)	–0.003	–0.003	–0.003	–0.004	–0.006
	(0.009)	(0.009)	(0.007)	(0.008)	(0.008)
white (DUM)	–0.007	–0.001	–0.005	–0.004	–0.006
	(0.008)	(0.007)	(0.006)	(0.007)	(0.007)
schoollow	0.022***	0.011	0.012**	0.018***	0.015**
	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
schoolhigh	–0.010	–0.008	–0.010	–0.011	–0.010
	(0.010)	(0.009)	(0.008)	(0.009)	(0.009)
age	0.001**	0.000	0.000	0.001**	0.001*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
labor force (DUM)	–0.013*	–0.013**	–0.012**	–0.013**	–0.012**
	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
home owner (DUM)	0.052***	0.054***	0.052***	0.052***	0.052***
	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)
children (DUM)	–0.009	–0.009	–0.008*	–0.009*	–0.010*
	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)
sharefoodhome					
healthmeasure	0.023***	0.040***	0.055***	0.022***	0.010
	(0.009)	(0.015)	(0.011)	(0.006)	(0.007)
budget (linear term)	–0.004***	–0.005***	–0.005***	–0.005***	–0.005***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
budget (quadratic term)	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

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Table 3.10: Results from the SUR model (table from previous page continued).

	ADL	ADL instru	ADL basic	ADL mobility	ADL agility
	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.
female (DUM)	–0.003	–0.004	–0.000	–0.001	–0.003
	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)
migrant background (DUM)	0.011	0.012	0.009	0.017**	0.005
	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)
white (DUM)	0.018**	0.023***	0.015**	0.014*	0.018**
	(0.007)	(0.007)	(0.006)	(0.007)	(0.007)
schoollow	0.003	0.004	0.006	0.006	0.002
	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
schoolhigh	0.010	0.017*	0.018**	0.011	0.018**
	(0.009)	(0.009)	(0.008)	(0.009)	(0.009)
age	–0.001***	–0.001***	–0.001***	–0.001***	–0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
labor force (DUM)	0.006	0.002	0.002	0.007	0.003
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
home owner (DUM)	0.003	0.001	0.001	0.002	0.003
	(0.006)	(0.005)	(0.005)	(0.005)	(0.006)
children (DUM)	–0.006	–0.004	–0.006	–0.007	–0.005
	(0.006)	(0.005)	(0.005)	(0.005)	(0.006)
sharefoodaway					
healthmeasure	–0.009*	–0.013*	–0.010*	–0.009***	–0.006*
	(0.005)	(0.008)	(0.005)	(0.003)	(0.003)
budget (linear term)	–0.000	0.000	0.000	–0.000	0.000
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
budget (quadratic term)	0.000*	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
female (DUM)	–0.016***	–0.015***	–0.017***	–0.018***	–0.016***
	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)
migrant background (DUM)	–0.000	0.003	0.004	0.002	0.002
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
white (DUM)	0.014***	0.014***	0.012***	0.014***	0.013***
	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)
schoollow	–0.008**	–0.003	–0.002	–0.006*	–0.005
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
schoolhigh	–0.004	–0.004	–0.007	–0.003	–0.006
	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)
age	0.000	0.000	0.000	0.000	–0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
labor force (DUM)	0.007**	0.006*	0.005*	0.007**	0.006*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
home owner (DUM)	–0.004	–0.007**	–0.003	–0.004	–0.004
	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)
children (DUM)	–0.012***	–0.010***	–0.011***	–0.009***	–0.013***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
sharetransp					
healthmeasure	–0.026***	–0.081***	–0.045***	–0.026***	–0.009
	(0.008)	(0.014)	(0.009)	(0.005)	(0.006)
budget (linear term)	–0.004***	–0.004***	–0.003***	–0.004***	–0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
budget (quadratic term)	0.000***	0.000***	0.000**	0.000***	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
female (DUM)	–0.039***	–0.033***	–0.036***	–0.038***	–0.038***
	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)
migrant background (DUM)	–0.031***	–0.018**	–0.026***	–0.027***	–0.029***
	(0.008)	(0.008)	(0.006)	(0.007)	(0.007)
white (DUM)	–0.003	–0.011	–0.010*	–0.003	–0.010
	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
schoollow	–0.021***	–0.015**	–0.017***	–0.021***	–0.019***
	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)
schoolhigh	0.021**	0.016**	0.013*	0.019**	0.017**

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Table 3.10: Results from the SUR model (table from previous page continued).

	ADL	ADL instru	ADL basic	ADL mobility	ADL agility
	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.
	(0.009)	(0.008)	(0.007)	(0.008)	(0.008)
age	–0.002***	–0.002***	–0.002***	–0.002***	–0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
labor force (DUM)	0.038***	0.030***	0.036***	0.035***	0.039***
	(0.006)	(0.005)	(0.005)	(0.005)	(0.006)
home owner (DUM)	0.042***	0.035***	0.038***	0.038***	0.040***
	(0.006)	(0.005)	(0.004)	(0.005)	(0.005)
children (DUM)	0.020***	0.010*	0.016***	0.022***	0.018***
	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)
sharehealth					
healthmeasure	0.054***	0.107***	0.057***	0.037***	0.033***
	(0.010)	(0.017)	(0.012)	(0.006)	(0.007)
budget (linear term)	0.001	0.001	–0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
budget (quadratic term)	–0.000	–0.000	–0.000	–0.000	–0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
female (DUM)	0.007	0.013**	0.011**	0.010**	0.010*
	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)
migrant background (DUM)	–0.032***	–0.028***	–0.031***	–0.028***	–0.033***
	(0.009)	(0.010)	(0.008)	(0.009)	(0.009)
white (DUM)	0.027***	0.035***	0.040***	0.037***	0.029***
	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)
schoollow	0.005	0.009	0.004	0.002	0.007
	(0.007)	(0.007)	(0.006)	(0.007)	(0.007)
schoolhigh	–0.002	–0.002	0.006	–0.002	0.004
	(0.011)	(0.010)	(0.009)	(0.010)	(0.010)
age	0.002***	0.002***	0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
labor force (DUM)	–0.006	–0.010	–0.008	–0.008	–0.006
	(0.007)	(0.007)	(0.006)	(0.007)	(0.007)
home owner (DUM)	–0.004	–0.008	–0.004	–0.006	–0.002
	(0.007)	(0.006)	(0.005)	(0.006)	(0.006)
children (DUM)	–0.007	–0.012**	–0.001	–0.009	–0.005
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
sharerecrea					
healthmeasure	–0.051***	–0.017	–0.036***	–0.029***	–0.035***
	(0.006)	(0.010)	(0.007)	(0.004)	(0.004)
budget (linear term)	0.002***	0.003***	0.003***	0.002***	0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
budget (quadratic term)	–0.000**	–0.000***	–0.000***	–0.000**	–0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
female (DUM)	0.007**	0.006*	0.005*	0.004	0.009***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
migrant background (DUM)	0.006	–0.004	0.008*	0.004	0.007
	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)
white (DUM)	0.001	–0.002	–0.001	0.004	–0.002
	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)
schoollow	0.001	0.006	0.003	0.000	0.002
	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)
schoolhigh	–0.008	–0.008	–0.007	–0.002	–0.010
	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)
age	–0.000	–0.000*	–0.001***	–0.000*	–0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
labor force (DUM)	–0.012***	–0.010**	–0.009**	–0.009**	–0.013***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
home owner (DUM)	–0.002	–0.002	–0.000	0.000	–0.003
	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)
children (DUM)	–0.001	0.002	–0.001	0.002	–0.003
	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)

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Table 3.10: Results from the SUR model (table from previous page continued).

	ADL Coeff./SE.	ADL instru Coeff./SE.	ADL basic Coeff./SE.	ADL mobility Coeff./SE.	ADL agility Coeff./SE.
sharetransf					
healthmeasure	–0.037***	–0.012	–0.043***	–0.021***	–0.021***
	(0.010)	(0.018)	(0.012)	(0.006)	(0.007)
budget (linear term)	0.008***	0.007***	0.007***	0.008***	0.007***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
budget (quadratic term)	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
female (DUM)	0.018***	0.008	0.014***	0.013***	0.016***
	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)
migrant background (DUM)	–0.012	–0.006	–0.009	–0.015*	–0.005
	(0.009)	(0.010)	(0.008)	(0.009)	(0.009)
white (DUM)	0.002	0.006	0.007	0.001	0.009
	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)
schoollow	0.013*	0.008	0.010	0.012*	0.008
	(0.008)	(0.007)	(0.006)	(0.007)	(0.007)
schoolhigh	–0.021*	–0.005	–0.012	–0.017*	–0.016
	(0.011)	(0.010)	(0.009)	(0.010)	(0.010)
age	0.002***	0.002***	0.002***	0.002***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
labor force (DUM)	–0.039***	–0.029***	–0.035***	–0.036***	–0.036***
	(0.007)	(0.007)	(0.006)	(0.007)	(0.007)
home owner (DUM)	–0.019***	–0.005	–0.010*	–0.013**	–0.012*
	(0.007)	(0.006)	(0.005)	(0.006)	(0.006)
children (DUM)	0.015**	0.019***	0.008	0.012*	0.014**
	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
r2	0.0927	0.0839	0.0917	0.0953	0.0916
N	2853	3019	3975	3253	3345

Abbreviations: DUM = dummy variable.
Notes: The empirical model includes yearly dummies to capture year specific effects and region dummies to control for differences across regions. Interaction terms for year and regions are included as well. Furthermore, the estimation strategy accounts for clustering on the household level, estimate robust standard errors and include analytic weights provided by the HRS. Level of significance: * 0.10 ** 0.05 *** 0.01.
Source: HRS and CAMS data. Own calculations.

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Table 3.11: Fixed-effects model, dependent variable: Fixed Home Expenses.

share	ADL	ADL instru	ADL basic	ADL mobility	ADL agility
	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.
healthmeasure	–0.058	–0.059	–0.047	–0.020	–0.031
	(0.038)	(0.053)	(0.040)	(0.022)	(0.022)
age	0.005	0.009	0.007	0.006	0.006
	(0.007)	(0.007)	(0.006)	(0.007)	(0.007)
budget (linear term)	0.001	0.000	–0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
budget (quadratic term)	–0.000	–0.000	–0.000	–0.000	–0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
labor force (DUM)	0.010	–0.005	0.006	0.009	0.002
	(0.018)	(0.017)	(0.015)	(0.017)	(0.017)
home owner (DUM)	–0.009	–0.010	–0.026	–0.001	–0.021
	(0.024)	(0.023)	(0.020)	(0.022)	(0.022)
children (DUM)	–0.001	0.048	0.004	0.010	0.003
	(0.043)	(0.079)	(0.047)	(0.049)	(0.040)
r2	0.0430	0.0420	0.0362	0.0456	0.0304
corr	–0.5313	–0.6092	–0.4828	–0.6298	–0.4319
N	2842	3012	3966	3242	3336

Abbreviations: DUM = dummy variable.
Notes: Level of significance: * 0.10 ** 0.05 *** 0.01.
Source: HRS and CAMS data. Own calculations.

Table 3.12: Fixed-effects model, dependent variable: Housekeeping and Maintenance.

share	ADL	ADL instru	ADL basic	ADL mobility	ADL agility
	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.
healthmeasure	–0.002	0.031	0.048**	–0.016	0.004
	(0.027)	(0.030)	(0.020)	(0.014)	(0.016)
age	–0.001	–0.003	–0.000	0.000	–0.002
	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
budget (linear term)	0.002***	0.003***	0.003***	0.003***	0.002***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
budget (quadratic term)	–0.000***	–0.000***	–0.000***	–0.000***	–0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
labor force (DUM)	–0.015	–0.019**	–0.012	–0.014	–0.012
	(0.010)	(0.010)	(0.009)	(0.010)	(0.010)
home owner (DUM)	0.027**	0.025*	0.024***	0.024**	0.022*
	(0.013)	(0.013)	(0.009)	(0.011)	(0.011)
children (DUM)	0.035	0.027	0.035		
	(0.071)	(0.065)	(0.056)	(0.071)	(0.059)
r2	0.1010	0.0954	0.0816	0.0928	0.0923
corr	–0.5710	–0.4682	–0.5244	–0.5911	–0.5413
N	2842	3012	3966	3242	3336

Abbreviations: DUM = dummy variable.
Notes: Level of significance: * 0.10 ** 0.05 *** 0.01.
Source: HRS and CAMS data. Own calculations.

Table 3.13: Fixed-effects model, dependent variable: Food at Home.

share	ADL	ADL instru	ADL basic	ADL mobility	ADL agility
	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.
healthmeasure	0.010	0.008	0.040	0.007	0.006
	(0.023)	(0.032)	(0.027)	(0.013)	(0.013)
age	–0.000	–0.000	–0.002	–0.001	0.000
	(0.004)	(0.005)	(0.003)	(0.003)	(0.003)
budget (linear term)	–0.001***	–0.001***	–0.001***	–0.001***	–0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
budget (quadratic term)	0.000***	0.000***	0.000***	0.000***	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
labor force (DUM)	0.006	0.020**	0.005	0.007	0.006
	(0.011)	(0.009)	(0.009)	(0.010)	(0.010)
home owner (DUM)	0.024**	0.018	0.013	0.021*	0.019
	(0.012)	(0.011)	(0.011)	(0.011)	(0.013)
children (DUM)	–0.018	–0.012	–0.014	–0.021	–0.017
	(0.040)	(0.043)	(0.037)	(0.039)	(0.036)
r2	0.0673	0.0568	0.0401	0.0594	0.0518
corr	–0.6170	–0.1955	–0.3995	–0.5443	–0.4872
N	2842	3012	3966	3242	3336

Abbreviations: DUM = dummy variable.
Notes: Level of significance: * 0.10 ** 0.05 *** 0.01.
Source: HRS and CAMS data. Own calculations.

Table 3.14: Fixed-effects model, dependent variable: Food away.

share	ADL	ADL instru	ADL basic	ADL mobility	ADL agility
	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.
healthmeasure	0.007	–0.034**	–0.002	0.004	0.002
	(0.014)	(0.015)	(0.008)	(0.009)	(0.006)
age	0.003	0.003	0.001	0.002	0.002
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
budget (linear term)	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
budget (quadratic term)	–0.000	–0.000*	–0.000	–0.000	–0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
labor force (DUM)	–0.004	0.003	0.000	–0.002	–0.002
	(0.007)	(0.005)	(0.005)	(0.006)	(0.006)
home owner (DUM)	–0.004	–0.001	–0.002	–0.005	–0.002
	(0.008)	(0.008)	(0.006)	(0.007)	(0.007)
children (DUM)	0.010	–0.002	0.000	0.007	0.004
	(0.017)	(0.020)	(0.013)	(0.018)	(0.013)
r2	0.0335	0.0500	0.0333	0.0415	0.0233
corr	–0.6370	–0.6834	–0.4882	–0.6143	–0.5257
N	2842	3012	3966	3242	3336

Abbreviations: DUM = dummy variable.
Notes: Level of significance: * 0.10 ** 0.05 *** 0.01.
Source: HRS and CAMS data. Own calculations.

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Table 3.15: Fixed-effects model, dependent variable: Transportation.

share	ADL	ADL instru	ADL basic	ADL mobility	ADL agility
	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.
healthmeasure	–0.014	–0.076***	–0.052**	–0.024**	0.000
	(0.018)	(0.023)	(0.020)	(0.011)	(0.009)
age	–0.001	–0.002	–0.003**	–0.003*	–0.002
	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
budget (linear term)	–0.001***	–0.001***	–0.001***	–0.001***	–0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
budget (quadratic term)	0.000**	0.000**	0.000*	0.000	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
labor force (DUM)	–0.004	–0.014	–0.004	–0.006	–0.002
	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)
home owner (DUM)	0.000	0.014	0.011	0.004	0.002
	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
children (DUM)	0.018	0.018	–0.001	0.006	0.009
	(0.013)	(0.013)	(0.013)	(0.014)	(0.012)
r2	0.0731	0.0925	0.0801	0.0725	0.0678
corr	–0.5594	–0.3799	–0.4905	–0.5514	–0.5538
N	2842	3012	3966	3242	3336

Abbreviations: DUM = dummy variable.
Notes: Level of significance: * 0.10 ** 0.05 *** 0.01.
Source: HRS and CAMS data. Own calculations.

Table 3.16: Fixed-effects model, dependent variable: Recreation.

share	ADL	ADL instru	ADL basic	ADL mobility	ADL agility
	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.
healthmeasure	–0.028	0.020	–0.006	–0.014	–0.009
	(0.021)	(0.033)	(0.017)	(0.011)	(0.010)
age	–0.004*	–0.004	–0.003*	–0.004**	–0.003
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
budget (linear term)	–0.001**	–0.001***	–0.001***	–0.001**	–0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
budget (quadratic term)	0.000	0.000**	0.000*	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
labor force (DUM)	–0.002	0.003	–0.001	–0.001	–0.004
	(0.010)	(0.009)	(0.007)	(0.008)	(0.009)
home owner (DUM)	–0.000	0.004	0.003	–0.002	0.001
	(0.007)	(0.007)	(0.005)	(0.006)	(0.006)
children (DUM)	–0.039**	–0.035**	–0.031**	–0.031**	–0.036**
	(0.015)	(0.016)	(0.015)	(0.015)	(0.016)
r2	0.0451	0.0498	0.0355	0.0437	0.0374
corr	–0.5976	–0.6139	–0.5129	–0.6875	–0.4920
N	2842	3012	3966	3242	3336

Abbreviations: DUM = dummy variable.
Notes: Level of significance: * 0.10 ** 0.05 *** 0.01.
Source: HRS and CAMS data. Own calculations.

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Table 3.17: Fixed-effects model, dependent variable: Health out of Pocket.

share	ADL	ADL instru	ADL basic	ADL mobility	ADL agility
	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.
healthmeasure	0.064**	0.141**	0.016	0.057***	0.021
	(0.032)	(0.063)	(0.026)	(0.021)	(0.014)
age	0.007**	0.004	0.006**	0.008**	0.004
	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)
budget (linear term)	–0.000	0.000	0.000	–0.000	–0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
budget (quadratic term)	0.000	–0.000	–0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
labor force (DUM)	–0.005	–0.006	–0.007	–0.008	–0.002
	(0.011)	(0.011)	(0.010)	(0.010)	(0.011)
home owner (DUM)	–0.020	–0.034*	–0.030*	–0.035*	–0.020
	(0.017)	(0.019)	(0.017)	(0.020)	(0.015)
children (DUM)	0.039***	0.042*	0.036***	0.037**	0.034***
	(0.015)	(0.023)	(0.014)	(0.015)	(0.013)
r2	0.0954	0.1038	0.0880	0.1101	0.0802
corr	–0.4621	–0.3135	–0.4257	–0.6260	–0.2853
N	2842	3012	3966	3242	3336

Abbreviations: DUM = dummy variable.
Notes: Level of significance: * 0.10 ** 0.05 *** 0.01.
Source: HRS and CAMS data. Own calculations.

Table 3.18: Fixed-effects model, dependent variable: Transfers.

share	ADL	ADL instru	ADL basic	ADL mobility	ADL agility
	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.
healthmeasure	–0.018	–0.004	–0.009	–0.017	–0.012
	(0.027)	(0.032)	(0.020)	(0.012)	(0.017)
age	–0.006**	–0.006*	–0.004*	–0.005**	–0.005*
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
budget (linear term)	0.000	–0.000	0.000	0.000	0.001
	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
budget (quadratic term)	–0.000	0.000	0.000	0.000	–0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
labor force (DUM)	0.015**	0.016**	0.014**	0.015**	0.014**
	(0.007)	(0.007)	(0.006)	(0.006)	(0.007)
home owner (DUM)	–0.016	–0.011	0.013	–0.003	0.002
	(0.012)	(0.014)	(0.012)	(0.012)	(0.012)
children (DUM)	0.010	0.004	0.007	0.011	0.004
	(0.016)	(0.023)	(0.015)	(0.016)	(0.015)
r2	0.0469	0.0917	0.0711	0.0485	0.0582
corr	–0.7471	–0.6398	–0.5537	–0.6808	–0.5513
N	2842	3012	3966	3242	3336

Abbreviations: DUM = dummy variable.
Notes: Level of significance: * 0.10 ** 0.05 *** 0.01.
Source: HRS and CAMS data. Own calculations.

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Table 3.19: Fixed-effects model, dependent variable: Clothing.

share	ADL	ADL instru	ADL basic	ADL mobility	ADL agility
	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.	Coeff./SE.
healthmeasure	0.041**	–0.028	0.010	0.022**	0.018***
	(0.017)	(0.042)	(0.017)	(0.010)	(0.007)
age	–0.003	–0.001	–0.001	–0.003	–0.001
	(0.006)	(0.006)	(0.005)	(0.005)	(0.006)
budget (linear term)	–0.001***	–0.000***	–0.000***	–0.000***	–0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
budget (quadratic term)	0.000***	0.000**	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
labor force (DUM)	–0.000	0.001	–0.000	0.000	–0.001
	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)
home owner (DUM)	–0.002	–0.004	–0.005	–0.003	–0.002
	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
children (DUM)	–0.044**	–0.093	–0.036**	–0.047**	–0.036**
	(0.018)	(0.071)	(0.017)	(0.018)	(0.017)
r2	0.0871	0.0647	0.0579	0.0788	0.0668
corr	–0.6100	–0.6662	–0.5402	–0.6277	–0.4955
N	2842	3012	3966	3242	3336

Abbreviations: DUM = dummy variable.

Notes: Level of significance: * 0.10 ** 0.05 *** 0.01.

Source: HRS and CAMS data. Own calculations.

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