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Being close to grow faster: A network-based empirical analysis of economic globalization*

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Abstract

Globalization features one of the major global trends which shape 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 (trade intensity), 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 of this paper makes use of social network theory to characterize a measure of economic integration. We employ the well-established concept of centrality and construct alternative measures to describe patterns of economic globalization. Second, we make use of a unique data set constructed from the UN Comtrade database and exploit a wide set of bilateral import and export flows to characterize the country's participation in worldwide trade. Third, the identification strategy takes into account the dynamic panel structure of our data to disentangle the impact of economic integration on economic growth. Our results build on the difference and system generalized method of moments and the limited information maximum likelihood method. We take into consideration possible problems of endogeneity and lagged variables in the dynamic panel framework. The empirical analysis highlights the importance of openness and especially 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, we find a significantly positive effect of integration on economic growth.

Keywords: Economic Globalization, Growth Regressions, Dynamic Panel Estimation, Social Network Theory

JEL Classification: C330, F430, O400, O430

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Executive Summary

Globalization features one of the major global trends which shape economic outcomes in developing and developed countries. During the past fifty years, political change and new transportation and information technologies enhanced international trade openness and economic integration between 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 (trade intensity), but the degree of integration of an economy into the global network is even more important for the growth performance of an economy. Most empirical papers analyze the impact of economic openness on economic growth by including a measure of trade intensity into the empirical model. Trade intensity captures the level of imports and exports relative to overall production in an economy. Instead our methodology evaluates the degree of integration of an economy into the global network structure. 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 of this paper makes use of social network theory to characterize a measure of economic integration. We employ the well-established concept of centrality and construct alternative measures to describe patterns of economic globalization. Second, we make use of a unique data set constructed from the UN Comtrade database and exploit a wide set of bilateral import and export flows to characterize the country's network position in a global trade network. Third, the empirical identification strategy takes into account the dynamic panel structure of our data to disentangle the impact of economic integration on economic growth.

Dynamic panels have been established as a new standard 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. Our results build on the difference and system generalized method of moments and the limited information maximum likelihood method. We take into consideration possible problems 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.

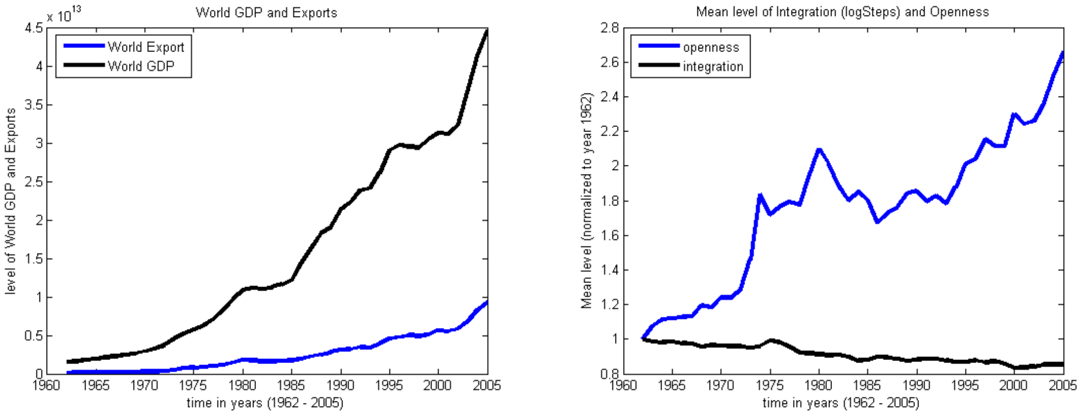
The empirical analysis highlights the importance of openness and especially economic integration to fully understand the growth performance in a between and within country perspective. Controlling for the standard set of independent variables in the empirical growth literature and using different robustness checks, we find a significantly positive effect of integration on economic growth. Our results suggest that economic integration offers a statistically and economically significant explanation to understand differences in the growth performance across and within countries. The positive correlation between integration and economic growth emphasizes the importance of a country's position in a global network. From a policy perspective these findings suggest that further economic integration, and not just openness, have a strong positive impact on economic growth.

1 Introduction and Motivation

Globalization features one of the major global trends which shape 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). Graph 1 (left) illustrates the rise in world production measured as GDP over a total of 125 countries. Over the same time period international trade in goods and services follows a similar upward rising path. To the end of the sample period ranging from 1962 to 2005 exports grow even faster than economic output.

Standard results from the empirical growth literature suggest that participation in worldwide trade is an important determinant of economic growth (Durlauf et al., 2005). In contrast to previous findings, this paper argues that not only the level of openness matters (trade intensity), but the degree of integration of an economy into the global network is even more important for the growth performance of an economy. Most empirical papers analyze the impact of economic openness on economic growth by including a measure of trade intensity into the empirical model. Trade intensity captures the level of imports and exports relative to overall production in an economy (Rodriguez and Rodrik, 2001). Instead our methodology evaluates the degree of integration of an economy into the global network structure. 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.

Figure 1: Globalization: Openness and Integration



This paper distinguishes between two different dimensions of economic globalization, which we refer to as openness and integration. In graph 1 (right) the two lines characterize the time trend of openness and economic integration over the last decades [1]. The graphical analysis suggests that globalization is characterized by an increase in the level of openness but also in the degree of economic integration. Furthermore, the graph illustrates that changes in the level of openness and integration are not highly correlated. Accordingly, we can imagine that openness and the degree of integration of an economy into the global trade network incorporate different dimensions of economic globalization and offer additional explanations for the observed disparities in growth performance across and within countries [2].

Our paper presents a new methodology to construct a measure of economic integration and later includes it into a dynamic panel framework. First, the theoretical framework of this paper makes use of social network theory to characterize a measure of economic integration. We employ the well-established concept of centrality and construct alternative measures to describe patterns of economic globalization. Second, we make use of a unique data set constructed from the UN Comtrade database and exploit a wide set of bilateral import and export flows to characterize the country's network position in a global trade network. This information is used to compute the country and time specific degree of economic integration for 125 countries between 1962 and 2005. Third, the empirical identification strategy takes into account the dynamic panel structure of our data to disentangle the impact of economic integration on economic growth.

[1] Openness is defined as imports plus exports over GDP. The concept to measure integration is explained later. Consider that the degree of integration decreases in the measure.

[2] Comment 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.

Social network theory defines measures of centrality to evaluate the relevance of different nodes in a network. Following this theoretical framework, centrality is gained by accessing many central nodes (Vega-Redondo, 2007) [3] which in turn promotes economic growth. First, 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 (Duernecker and Vega-Redondo, 2011). Second, a more diversified trade network ensures against risks if one trading partner collapses. Thus, a more integrated economy does not only have a smoother growth performance but integration might also have a positive impact on the mean of economic growth [4]. The calculations to arrive to our measure of economic integration capture the 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 (2011) we expect a positive relationship between our measure of centrality and the economic performance of an economy.

Dynamic panels have been established as a new standard in the empirical growth literature to foster explanations for the observed disparities in the economic growth performance across and 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, but country fixed heterogeneity. Our results build on the first difference and system generalized method of moments (GMM) and the limited information maximum likelihood method (LIML). First difference and system generalized method of moments procedures address the issue of correlated and unobserved country fixed effects and allows for lagged variables in the dynamic panel framework. Furthermore, the empirical identification strategies make 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.

The empirical analysis highlights the importance of openness and especially economic integration to fully understand the 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, we find a significantly positive effect of integration on economic growth. Our results suggest that economic integration offers a statistically and economically significant explanation to understand differences in the growth performance across and within countries. The positive correlation between integration and economic growth emphasizes the importance of a country's position in a global network. From a policy perspective these findings suggest that further economic integration, and not just openness, have a strong positive impact on economic growth.

The remainder of this paper is organized as follows. Section II introduces the empirical literature on globalization and economic growth and describes some of the challenges behind the previous literature. In section III, we present the theoretical framework which established a relationship between the degree of integration of an economy into the world economy and its economic activity. Section IV first develops our measure of economic integration which builds on insights from social network theory and then describes the unique data set taken from the UN Comtrade data and the construction of our new measure of integration used in this paper. In this context we also discuss basic properties of our measure in a descriptive manner. Section V presents the key challenges and details about the estimation strategy. In section VI we estimate a dynamic panel model using a LIML approach and discuss results from alternative specifications. Finally, section VII draws some policy implications and concludes.

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

[4] Comment Stiglitz (Lindau 2011): Does a higher degree of integration allow for a more stable growth path (less fluctuations and more diversification) or do we observe problems in case of crises because contagion spreads the "virus" across all countries in the network (business cycle synchronization)?

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. By using data on 95 developing countries over the period 1976 to 1985, 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. Ben-David (1993) finds 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 [5]. 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 strongly positively correlated with productivity growth. Frankel and Romer (1999) address the concern that traditional measures of trade openness are a potential source of endogeneity, as reverse causality running from growth to trade is likely to occur and leading to inconsistent estimates of the effect of openness on growth. 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. Then the predicted values are hopefully exogenous. 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. Using this instrument, the authors find a positive effect running from trade to growth [6].

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 the 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 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-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

[5] 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.

[6] Due to the time invariant nature of geography, identification comes from between country variation. Thus, the empirical framework cannot be used to characterize the within country perspective which exploits time variation for a given country and offers additional possibilities to control for the unobserved country fixed effect.

of a country's outward orientation.

Wacziarg and Welch (2003) correct the original Sachs-Warner index to account for the criticism raised, and they 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. 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 setup. 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. 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 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 succinctly 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-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. For instance, Dreher (2006) develops an overall index of globalization covering what is argued to be the most important dimensions of integration: economic integration, social integration and 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 [9]. 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 growth, whereas political integration has no effect. Other examples for composite globalization measures include Andersen and Herbertsson (2003); Heshmati (2006); Lockwood and Redoano (2005) and Martens and Zywietz (2006).

Network-based measures of international 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), Fagiolo et al. (2010) and Arribas et al. (2009), argue that standard indicators of openness are able to recover first-order trade relationships (e.g. import and exports between any two countries) but miss all

[7] World Trade Organization definition for "market access": 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] Notice that in this context the terms openness, integration and globalization are often used synonymously.

second- and higher-order relationships across countries [10]. These higher order connections are potentially important determinants of economic integration and performance, since, as the OECD (2005) emphasizes, the process of integration also advances because of the effect of indirect networks. 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. Measures of this sort typically employ a 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) relation 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. 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 by degree centrality) has important implications for economic growth. Kali and Reyes (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.

3 A Centrality-based Measure of Globalization

This section outlines the theoretical approach undertaken in Duernecker and Vega-Redondo (2011) to study globalization. As explained below, this approach motivates the different measures of economic integration which we construct in this paper.

The model proposed by Duernecker and Vega-Redondo (2011) involves a fixed set of agents, $N = \{1, 2, ..., n\}$, who are uniformly distributed in some (say, physical) 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 at t. 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. *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.

[10] Models on market potential 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 (The Spatial Economy, New Geography, Krugman). This measure does not allow for any kind of higher order links and is not able to capture the full architecture of international trade. Namely, what happens if country r trades with s1 and s2. If there is no link between r and s2, but trade between (1) r and s1 and (2) s1 and s2, the measure on market potential neglects s2 completely. "There is a strong positive relationship between market potential and income per capita (level effects). Larger and/or more centrally located countries are much richer than countries characterized by a small market and few or smaller neighbors" (Head and Mayer). The market potential framework only makes use of direct links.

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 [11]. 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 (i.e. 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, [12]

or/and

(b) monitor and trust the partner's behavior in their ongoing collaboration [13].

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, i.e. 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, e.g. by relaying valuable information or providing third-party monitoring.

Our formulation of volatility, on the other hand, is particularly simple [14]. 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 essence, 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.

[11] 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.

[12] See e.g. the survey by Rauch (2001) where he 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.

[13] 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.

[14] 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 involve currently have, or on their social distance. This would not affect the essential gist of our analysis.

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, i.e.

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

But this is such a strong requirement that one can hardly expect it to be relevant for empirical analysis [15]. 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 iff

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

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 (2011), and seems the natural place to start in assessing its validity [16]. And, as is common in the theory of growth, we shall use country aggregate data to conduct the analysis. So, as 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 (trade, investment, etc.). 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.

4 Globalization and the World Economy

The theoretical framework illustrates that our new measure of 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 output of an economy. Contrary, the measure of economic integration takes into consideration the network structure and patterns of bilateral trade relationships between countries. In the following, we first discuss the construction of our measure and then focus on its properties and discuss descriptive statistics generated from a balanced panel which contains 125 countries and covers the time period from 1962 to 2005 [17].

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

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

[16] The model also predicts, for example, 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.

[17] 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 1965 and 2005.

j while x_{ij} corresponds to the imports from j to i. But, in general, those flows could reflect other forms of interaction such as investment flows (FDI), financial transfers, or population movements. The matrix of all bilateral flows is denoted by $X \equiv (x_{ij})_{i,j=1}^{n}$.

Starting from the matrix X of trade flows, we now 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 the size of the rest of the world;

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

To account for (i), denote by y_i the GDP of country i and by β_i the fraction of country i's GDP in world economy, i.e. $\beta_i \equiv \frac{y_i}{\sum_{j=1}^{n} y_{ij}}$. Then, we follow Arribas et al. (2009) and identify the *openness* of a country i with the value $\theta_i \equiv \frac{\sum_{j\neq i} x_{ij}}{(1-\beta_i)y_i}$. This normalizes the aggregate exports of the country by its own size (as captured by its GDP) and the size of the of the "rest of the world" with which trade is conducted [18].

To account for (ii), on the other hand, we simply normalize the export flows of each country i by its aggregate volume, so that the induced magnitudes $z_{ij} \equiv \frac{x_{ij}}{\sum_{j\neq i} x_{ij}}$ satisfy $\sum_{j\neq i} = 1$. Then, we construct a matrix of interaction between any county i and j, such that $A = (a_{ij})_{i,j=1}^{n}$ 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, i.e. $\sum_{i,j=1}^{n} a_{ij} = 1$. 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, of course, 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 implementation of matrix A The starting point for our calculation 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 $i = 1, ..., 125$ and $t = 1962, ..., 2005$. 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 [19]. The weighting factor $\theta_{i,t}$ 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, measured in current USD, of country i in period t, and $\beta_{i,t} = \frac{Y_{i,t}}{\sum_{k=1}^{125} Y_k}$ is the share of country i's GDP in the world GDP. We obtain the data for GDP from the World Bank National Accounts Data Base [20]. The row-stochastic matrix A for the year t is straightforwardly obtained by combining Z_t and $\theta_{i,t}$ for all $i = 1, ..., 125$. Finally, the centrality indicator $\tilde{\mathcal{C}}$ is then obtained by applying simple matrix algebra as demonstrated in the previous section.

The logsteps measure based on the number of steps Building upon the latter interpretation, 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. 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:

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

In the appendix, we explain in detail how such distance measure can be easily computed from the matrix A. To understand it conceptually, let us interpret any given a_{ij} in this matrix as the fraction of links

[18] This normalization requires, for example, 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.

[19] Notice that I do not provide a detailed technical explanation of how the measure is computed at this point as this will be in the text. Rather, I refer to the individual steps which are outlined there.

[20] The series we use is labeled "NY.GDP.MKT.PCD"

of a typical individual in country i that connect to agents in country j. Then, that entry may be also 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.

Finally, to assess the degree of global integration of any given country i, we construct a measure of it 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 that any access obtained to a particular country has to be evaluated in terms of the "value" (i.e. GDP) generated in that country. Thus, the integration ϕ_i of each country $i = 1, 2, ..., n$ is given by

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

4.2 UN Comtrade data

In this section we briefly describe how the measures of integration we propose in the previous section are operationalized. To construct our measures of economic integration we use data on bilateral export flows for 125 countries over the period 1962 to 2005, taken from the United Nations Commodity Trade Statistics Database (UN Comtrade) [21]. For each year, $t = 1962, ..., 2005$, 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 is an illustrative example, depicting the bilateral export flows among the three countries Germany, China and the USA in the year 2000.

Table 1: Export flows in 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	-

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 2005. 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 final measure is tightly linked to how close our 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 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 [23].

For some countries in some years the data on export flows are not reported. This is due to the fact that the UN Comtrade collects the data from national statistical agencies and occasionally - for instance in the case of the former Soviet Union - these data was not released. To get around the missing data problem we choose to rely on import data - also provided by the UN Comtrade - and use the observed import

[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.

[22] Alternative measures (FDI, migration) only focus on specific product classes or make use of bilateral flows of foreign direct investment. As a consequence data availability decreases substantially and difficulties arise when characterizing a global trade network.

[23] In addition to our methodology based a constant world concept, we also constructed based on a changing world scenario. The correlation between the two measures is high (0.98) and results do not change in a meaningful way.

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.

4.3 Patterns within and across countries

Based on the full sample of 125 countries, this section summarizes some key properties of our preferred measure of integration, the logsteps measure. Using the logsteps measure, the global perspective suggests an increasing time trend for integration. In other words, economic trade includes – 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 2005. The descriptive analysis confirms that the underlying network based 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 [24].

Proposition 1: Let `logsteps` be the measure of integration of an economy into the world economy. The degree of integration decreases in the measure. Using the growth rate of GDP per capita in period t as dependent variable, the measure of integration is expected to have a negative coefficient.

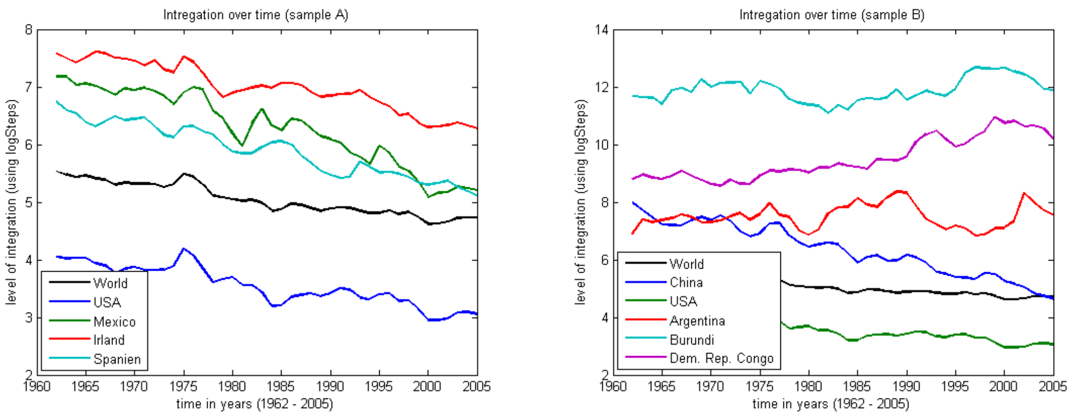
USA and Mexico Both countries show a trend towards more integration over the sample period from 1962 to 2005 (see graph 2). Comparing the level of integration for both countries the USA is far more integrated than Mexico. Consider that the USA seems to have a direct impact on the average which is due to the weighting we used to calculate the average level of integration of the world economy. For Mexico we find that around 1994 and 1995 the decrease in integration – which is equivalent to an increase in the logsteps measure – coincides with the Tequilla crisis (Calomiris, 1999; Mishkin, 2009). Contrary, the enlargement of the NAFTA (from 1995 onwards) had an immediate and positive impact on the level of integration for both, 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 average, and relative to many other countries in the world economy, Ireland experienced a significant increase of integration. This positive time trend is widely seen as a driver for economic growth 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 trade 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 a better access to further economies worldwide.

China This country in East Asia is widely seen as a front runner in terms of economic globalization. Until the political changes at the end of the 1970s, which followed the death of Mao Zedong in 1976, China mainly focused on internal development. Following political and economic reforms announced by Deng Xiaoping, the economy shifted towards more openness and China is now one of the biggest exporters in the world. In parallel to increased openness, the economy became far more integrated into the world economy as well. Bilateral trade flows towards the USA and the European Union increased significantly

[24] The appendix provides some more examples which discuss the time series profile for economic integration in most African and Asian economies.

Figure 2: Measure of integration for different countries



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. In comparison, India followed a different growth strategy and never achieved a similar level of integration into the global trade network like China did.

Burundi and the Democratic Republic of Congo A reversed pattern can be observed for Burundi and the Democratic Republic of Congo. 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. Accordingly, openness increased but at the same time the degree of integration stayed pretty much constant.

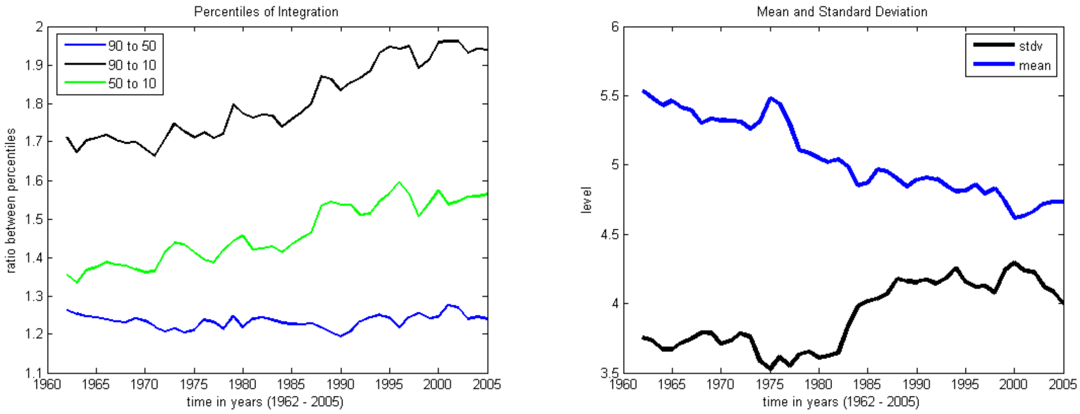
Argentina Lastly, we draw our attention to the case of Argentina. The second biggest economy in Latin America was one of the most globalized countries at the beginning of the 20th century. Nevertheless, the time trend suggests that Argentina was below average in terms of integration over the last 40 years. Furthermore, the data shows a very volatile time trend which might be contributed to changes in the political and economic environment. For example the financial crisis in Asia (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 breakdown of bilateral trade and as a consequence a worsening access to international markets [25].

Level of dispersion Globalization describes a trend where many different countries participate. Nevertheless, the extent to which countries participate in global trade varies dramatically. In this context we now focus on the dispersion in terms of the degree of integration. In particular, we are interested in differences across economies and the question in how far these differences are persistent over time. Graph 3 displays the time trend for different percentiles for the distribution of logsteps and the time trend for the standard deviation. Comparing the year 1962 to the year 2005 we find that the standard deviation increased over time. This time trend suggests an increasing gap between well globalized economies and non globalized ones. A detailed comparison of different percentiles relative to the median illustrates that there are two broad categories of countries. 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 just the distance between the very top (p10) and the very bottom (p90) increased over time - in fact it is that the p10 also increased in terms of integration relative to the median (p50). Contrary, the ratio between the p50 and p90 did not change much over time. Altogether this suggests that few countries were highly integrated in the past and tend to dominate the process of globalization even over time. In other

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

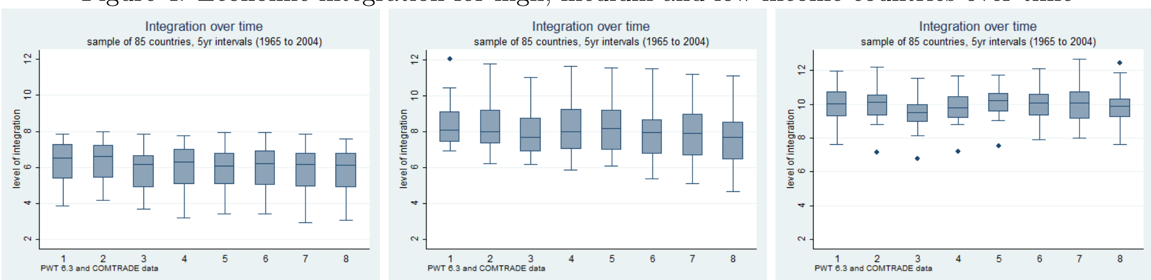
words, the “front runners” (p10) experienced much more integration over time than the “left behinds” which includes a wide set of countries.

Figure 3: Distribution over the measure of integration



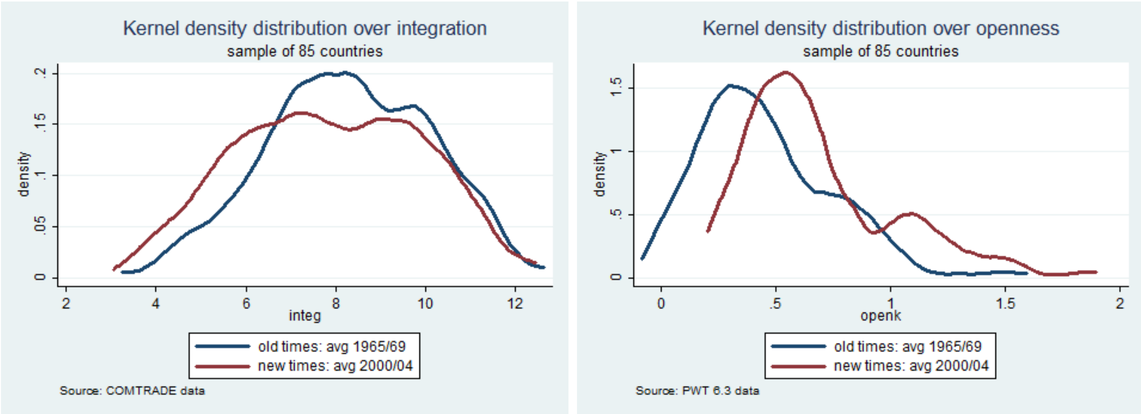
High, middle and low income countries Related to vast differences across countries, we next split the sample into three categories. Dependent on their initial level of GDP per capita to the beginning of the sample period in 1970, we define high, middle and low income countries. Graph 4 emphasizes what we have already observed to the beginning of the analysis. Using the logsteps measure, we find significant differences across categories in the level of integration. Compared to low and middle income countries, high income countries are well integrated into the world economy. Their level of integration differs significantly from the rest of the world. Furthermore, the differences in the time trend suggest that especially richer economies, which were already more globalized to the beginning of the sample period, benefited from economic integration. This interpretation is in line with the previous findings on the characteristics of the distribution on integration. In fact, the graphs suggest that only high income economies experienced a trend towards more globalization. Additionally, we observe that even within these categories there is still a considerable variation in terms of the level of integration.

Figure 4: Economic integration for high, medium and low income countries over time



Summary Graph 5 summarizes most of the previous findings. To the left, the two kernel density distributions for the measure of integration, using logsteps as our preferred measure. To the right, the standard measure of openness. First, the large standard deviation for integration and openness suggest that countries experience different levels of economic globalization. Second, we compare two different distributions, one describing the world in “old times” (average 1965 to 1969) and the other graph based on data from “new times” (average 2000 to 2004). We observe that there are shifts towards more integration today compared to the past. Both distributions moved towards higher levels of integration (and openness) and support the idea of economic globalization. Third, the trend towards more economic integration is not equally distributed among countries. The graphs and especially their changes over time suggest that only the lower (upper) part of the distribution for integration (openness) experienced additional integration (openness). In other words, non globalizers in in the past still lagged behind in the present and hardly changed their degree of integration. 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 in the past. Consider that this time trend increases (persistent) disparities among countries, which is in line with graph 3. The graph to the right pictures the distribution over the level of openness. Again we observe a trend towards more globalization in the world economy.

Figure 5: Kernel density estimates for logsteps and openness

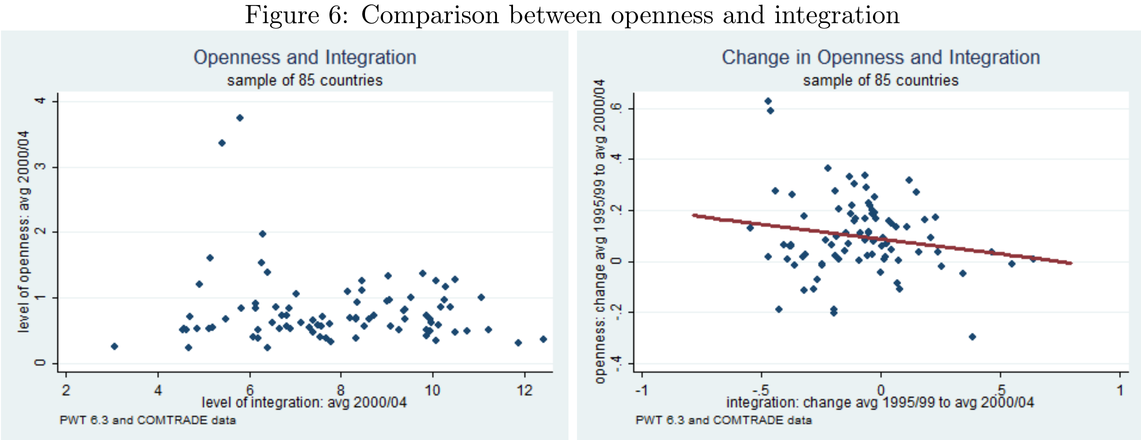


From an empirical point of view the heterogeneity with respect to the level of integration across and within countries allows for identification of the impact of integration (and openness) on the economic growth performance of a country. Further summary statistics on the properties of the measure of integration and openness are summarized in table 2. Summary statistics are calculated for the restricted sample which is used in the empirical analysis and take into consideration the across and within country dimension of the panel data.

4.4 Comparison between openness and integration

The introduction to this paper illustrated 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 and does not necessarily reflect the integration into the world economy. In this context, graph 6 suggests the correlation between openness and integration to be rather low. To the left, data taken from the year 2005 (by construction this measure is calculated as the average over the years 2000 to 2004) describe each country by its combination of the level of openness and its degree of integration [26]. Using the logsteps measure, the correlation between openness and correlation is close to 0.05 (see table 3 in the appendix). This finding suggests, that openness and integration capture different dimensions of globalization and could be included into the empirical model jointly. The graph to the right shows a negative relationship between the change in the logsteps measure and the change in openness. The change is calculated by comparing values in 2000 and 2005. Given the properties of the logsteps measure (see proposition 4.3), a country which experienced more openness over the last 5 years also became more integrated.

Figure 6: Comparison between openness and integration



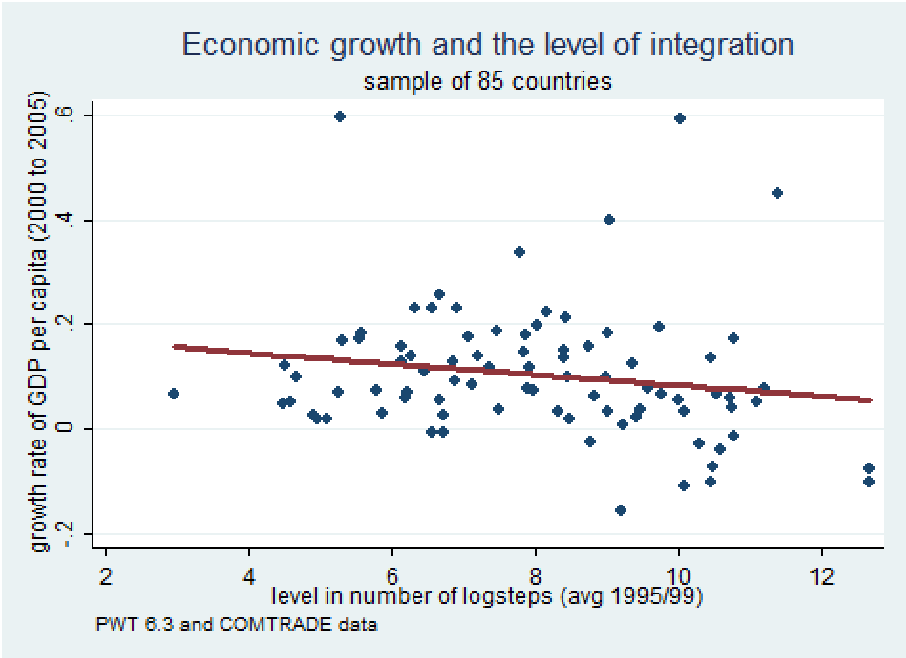
[26]Outliers are Hong Kong and Singapore which experience a high degree of openness.

The differences between openness and integration are also shown in table 4. In addition to the calculated measures for the years 1970, 1990 and 2005 we introduce a ranking which illustrates the largely different dimensions of openness and integration. For example, the United States are 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 take in terms of globalization. Furthermore we include the indicator variable proposed by (Sachs and Warner, 1995) which 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.

4.5 Integration and economic growth

The main focus of this paper is to establish a link between the degree of integration into the world economy and the economic activity of a country. Accordingly, we focus on graph 7 showing the relationship between the measure of integration to the beginning of the time period and the growth of GDP per capita. We plot the change in the level of integration between 2000 and 2005 against the growth of per capita GDP between time period 2000 and 2005.

Figure 7: Unconditional correlation between initial level of integration and economic growth



The graph 7 on the unconditional correlation suggests a slightly negative relationship between the change in economic integration between period t and t+1 (using the logsteps measure) and the growth of the economy in the same time period. Given the nature of the logsteps measure this implies that more economic integration has a positive impact on the growth of the economy. Consider that these graphs only show an unconditional correlation and do 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.

4.6 Modified measure on integration

In addition to the logsteps measure presented in the previous section, we constructed two more measures. First, we only consider indirect links which are assumed to be strictly exogenous to the trade policy of one country. In contrast to the standard measure, we do not calculate the number of steps to reach country j, but only country j-1. By construction, the modified logsteps measure shows a lower mean than the standard logsteps measure (6.30 vs 8.29) since the last step (namely going from country j to j-1) will always increase the number of steps at least by one. Second, we construct the standard logsteps measure based on a modified network matrix. Instead of using aggregate trade between countries, we now exploit bilateral trade in product classes 5 to 8 (manufacturing and investment goods). Accordingly this measure does not account for trade in agricultural goods and resources but more like investment goods. From an analytical perspective it is not clear if the measure on the number of steps will change. Imagine trade was distributed equally over all product classes, then the network matrix would not change. Since this assumption clearly does not hold, our modified logsteps measure will change. Based on the observation that some countries specialized in trade in certain product classes (comparative advantage) the network matrix will most probably change in the following way: For some countries (clusters) we will see systematic changes and most probably the mean will increase (9.82 vs 8.29). Both measures allow for robustness checks in the empirical analysis.

5 Empirical Model

The theoretical model establishes a link between a country's degree of economic integration into the world economy and its economic activity. To make this case empirically, we use the growth rate of GDP per capita as dependent variable. The set of independent variables not only includes a measure of integration $C_{i,t-1}$ but 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].

The following discussion establishes the theoretical foundations to estimate the dynamic panel model in the next section. First, we focus on previous findings from the empirical growth literature. Second, we discuss the main properties of the empirical model. Third, the set of independent variables is introduced. Fourth, we present the empirical identification strategy. Consider that 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 reversed causality. In an intermediate step, we 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 procedure to characterize the link between a country's degree of economic integration into the world economy and its economic activity.

5.1 Empirical growth literature

The early literature on empirical growth models starts with some simple cross section analysis, such as Barro (1991); Quah (1993). These empirical models build on the idea of bringing the theoretical growth models (Romer, 1986; Lucas, 1988; Barro and Sala-i Martin, 2003) to the data and then identify growth determinants by analyzing differences in standards of living across countries. 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 [28], social capital and institutions [29] 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 [30].

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 measurement error, reverse causality and endogeneity. 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 [31]. Alternatively, Acemoglu et al. (2001) use settler mortality to instrument for the quality of institutions in an economy.

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

[28] Barro and Lee (2001), Barro and Lee (2010) and Easterly (2001) 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.

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

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

[31] 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.

Within years, a large number of empirical studies identified a wide range of variables which contribute to a better understanding of economic growth [32]. Nevertheless, these empirical 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 model.

Given the shortcomings of the cross section analysis, dynamic panel models allow for superior identification strategies (Islam, 1998; Rodriguez and Rodrik, 2001). Caselli et al. (1996) employ a first difference GMM estimator and conclude that previous findings underestimate the rate of conditional convergence [33]. The key advantage underlying the first difference GMM is the use of a panel structure of the data such that results do not only come from between country variation but also make 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. Country fixed effects control for time invariant factors (so called deep determinants of economic growth) such as geography, climate and most political and social institutions which only change slowly. 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 (section VII) 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 model. Accordingly, Moral-Benito (2010b) expresses his concerns about the validity of the system GMM estimator and proposes the LIML approach to estimate empirical growth models [34].

5.2 Dynamic growth regressions

The empirical model exploits the dynamic panel structure of the data. 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 is

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

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.

The empirical model shown in equation 1 takes into consideration the dynamic properties of the empirical growth model, with current realizations of the dependent variable influenced by past ones. Furthermore, 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 difference and the system GMM allow for arbitrarily distributed fixed effects.

[32] 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).

[33] 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.

[34] 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).

In the empirical growth literature, the so called beta-convergence 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. In an intermediate step we transform the growth rate into two components: GDP per capita today and GDP per capita in the previous period using the second element as independent variable in the model, such that

$$y_{i,t} = \alpha \cdot y_{i,t-1} + \beta \cdot X_{i,t-1} + \gamma \cdot C_{i,t-1} + \rho_t + \eta_i + \epsilon_{i,t}. \tag{2}$$

In other words, conditioning on the level of GDP per capita in the previous period, what is the level of GDP per capita today? Conditional convergence cannot be rejected if the transformed coefficient $\alpha = \tilde{\alpha} + 1$ is significantly smaller than one [35]. For the estimation step, we split the sample period from 1965 to 2005 into eight time intervals of length five years and make use of different dynamic panel estimation strategies [36].

5.3 Independent variables

The empirical model, characterized in equation 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 and openness) [38]. Recall that using lagged independent variables reduces problems related to reversed causality, since values of the independent variables relate to time periods when the dependent variable was not realized yet. 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 convergence.

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 a 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).

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

[36] 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.

[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)

[38] Further information on descriptive statistics and data sources can be found 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).

investment share. The neoclassical growth model emphasizes the importance of physical capital accumulation in an economy. Following the standard Solow growth models, 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 in 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 theory predicts that specialization allows for higher economic growth through the so called comparative advantage. Rodriguez (2007) include the natural log of 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). We can imagine that a higher level of integration allows for a better access to international markets and thus increases the return to investment which translates into a higher growth rate of the economy.

5.4 Sample Restrictions

The 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. Consider that identification from our models comes from within country variation. Accordingly we increased the number of available time periods rather than the number of countries.

5.5 Identification strategy

The following discussion on some of the key challenges in the empirical growth literature demonstrates that reverse causality and the existence of unobserved country fixed effects, which are potentially correlated with independent variables in the empirical model, induces endogeneity. Making use of economic activity as dependent variable and using institutions in an economy as independent variables, right hand side variables are usually endogenous. Due to a large set of contemporaneous feedback mechanisms, 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 depend heavily on the reliability of data provided by their national statistics authorities. Consider that unobserved country fixed effect, contemporaneous feedback effects (reverse causality) and measurement error can be seen as source for inconsistent coefficient estimates.

Our identification strategy 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 (using trade policy) which introduces serious problems of reversed causality. By taking into consideration higher order links our measure of integration establishes a methodology to achieve exogeneity of our measure of integration. In addition to the standard measure

[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 strict exogeneity is satisfied for all independent variables.

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 logsteps measure suggests that our standard measure varies mostly due to indirect links. Second, all 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. Consider, that problems remain if expectations about economic growth in the future drive the development of institutions and policies today. Third, identification in the empirical model builds on within country variation. Either by 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 first difference model. First difference and system GMM but also the LIML approach make use of lagged levels to instrument for first differences.

OLS and within group estimator Under the assumption that unobserved country fixed effects η_i are correlated with independent variables in the model – and in particular with the lagged dependent variable $y_{i,t-1}$ – the traditional OLS estimator leads to an inconsistent estimator. 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. As a consequence, the standard OLS estimator is inconsistent because independent variables are correlated with the unobserved country fixed effect [41].

Introducing year and country dummies, identification of coefficients in the empirical model comes from within country variation. The finite sample bias with only eight time periods and 85 countries observed implies problems of inconsistency for the within group estimator. 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 $corr(-y_{i,t}, \epsilon_{i,t}) < 0$ (Beggs and Nerlove, 1988; Nickell, 1981). Due to the short time dimension of the panel data the within group estimator induces inconsistent parameter estimates, with a downward bias for the estimated parameter α.

First difference 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. We introduce an instrumental variable approach model where lagged levels are used as internal instruments for first differences. System GMM makes use of additional instruments which improves efficiency relative to the first difference GMM approach, given moment conditions hold.

The first difference GMM estimator (Arellano Bond) 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 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 dependent variable with lagged levels of predetermined regressors or endogenous variables as instruments for subsequent first differences [42].

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

In addition to moment condition 3, we need to make further assumptions on the structure of the error term. In here we require zero mean expectation for the individual and time specific error term, 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); Bond (2002).

[42] 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 $\epsilon_{i,t} - y_{i,t-1}$.

$E[\epsilon_{i,t}] = 0$. Additionally, first difference and system GMM both require the serial autocorrelation in the error term to be zero, such that

$$E[\epsilon_{i,t} \cdot \epsilon_{j,s}] = 0 \quad \text{for each} \quad \text{i,j,t} \quad \text{and} \quad \text{s}. \tag{4}$$

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 terms.

System GMM estimator The system GMM estimator (Blundell Bond) estimator makes use of additional moment conditions to reduce the bias in the first difference GMM estimator due to weak instruments. Blundell and Bond (1998) demonstrate in a simulation exercise that first difference GMM suffers from weak identification because past levels convey little information about future changes [43]. Consequently, the system GMM estimator converges more quickly than the first difference GMM estimator when the explanatory variables are highly autocorrelated (Bond et al., 2001). In addition to the difference equation, the system GMM uses 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 transforms – differences – the instruments to make them exogenous to the fixed effects.

$$E[\Delta Z_{i,t-1} \cdot u_{i,t}] = E[\Delta Z_{i,t-1} \cdot (\eta_i + \epsilon_{i,t})] = 0 \quad \text{with} \quad \text{t=3 ... T} \tag{5}$$

In this context it is crucial to reconsider the structure of the error component $u_{i,t}$. Moment condition 5 requires that changes in the instrumenting variables are uncorrelated with – orthogonal to – the unobserved country fixed effects such that $E[\Delta Z_{i,t} \cdot \eta_i] = 0$ for all i and t. Given $E[\Delta Z_{i,t} \cdot \eta_i]$ is time invariant, $\Delta Z_{i,t}$ is a valid instrument for the variables in levels. This identifying assumption requires that throughout the study period faster growing countries are not systematically closer or further from their steady states than slower growing ones, in the sense that deviations from the long run means are not systematically related to the unobserved country fixed effects (constant means of both the Y and X series through time for each country). In reality we observe that initial conditions are not distributed according to the steady state distribution of the process. This problem arises because many countries only were established in the 1960s following independence or a war which questions the idea of mean stationarity fundamentally.

Limited information maximum likelihood The previous discussion illustrates a set of problems which arise in a dynamic panel framework. For the OLS problems arise due to unobserved and country specific heterogeneity. Furthermore, estimation procedures suffer from the finite sample character of our data which fails the within group estimator, and the large set of (potentially weak) instruments which are used for the first difference GMM estimator (Davidson and MacKinnon, 1993). The system GMM estimator fails because the condition on mean stationarity does not hold.

Moral-Benito (2010b) proposes the limited information maximum likelihood estimator to identify parameters in the empirical growth literature. The LIML estimator outperforms the first difference GMM estimator in a finite sample with many (potentially weak) instruments (Anderson, 2005; Lai et al., 2008; Anderson et al., 2010; Godfrey and Wickens, 1982). Consider, that the LIML estimator belongs to the category of k class estimators and follows a similar concept like the standard IV estimation. In fact, the LIML estimation procedure builds on some earlier paper by Anderson and Rubin (1949, 1950), who introduced the LIML as a generalized IV estimation procedure (Bekker, 1994; Hahn and Hausman, 2002; Cameron and Trivedi, 2005). The LIML estimator identifies parameters by jointly estimating the first and the second stage by maximum likelihood. Here, homoscedasticity with respect to the error term in

[43] 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 first stage and joint normality are assumed [44]. 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 yield asymptotically equivalent results.

$$E[\Delta\epsilon_{i,t-1} \cdot u_{i,t}] = E[\Delta\epsilon_{i,t-1} \cdot (\eta_i + \epsilon_{i,t})] = 0 \quad \text{with} \quad \text{t=3 ... T} \tag{6}$$

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 6. Accordingly the assumption on serial non correlation is crucial and requires the use of five year time intervals (see above).

6 Results in a Comparative Perspective

The previous discussion focused on different estimation strategies used in the empirical growth literature. The main problems arise due to the dynamic panel model structure, reversed causality and unobserved country fixed effects, endogeneity in most of the independent variables and the fact that the set of (internal) instruments tends to be weak. For the first difference and the system GMM estimation, the large number of instruments induces problems of over-fitting of the instrumented variables [45]. Since a standard estimation procedure does not exist in the empirical growth literature, the summary of our results follows the so-called bounding strategy (Bond et al., 2001) and relates our results from the GMM and the LIML estimation procedure to earlier findings from simple OLS and within group estimators.

First, we estimate a standard growth model including our preferred measure of economic integration (logsteps). 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 economic 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 measures of economic integration for country j. Instead of exploiting the number of steps needed to arrive from each country i in the sample to country j (logsteps), we characterize country j by the modified measure of logsteps (instrumental variable approach) and an alternative logsteps measure which exploits only trade in investment goods.

6.1 Integration and economic growth: Number of steps

The empirical analysis takes into consideration the measure of integration into the world economy which builds on insights from network theory. Based on the theoretical framework discussed in the previous section, we enrich the standard growth model by our measure of integration which accounts for the network position of an economy. In line with the previous discussion on the validity of different estimation strategies, we believe that the LIML estimator is most reliable. Nevertheless, the following section reports alternative approaches and discusses test statistics with respect to possible shortcomings.

Table 6 reports the main results from the empirical growth model including a measure of economic integration. Using the logsteps variable as our preferred measure to characterize the degree of integration, the estimated coefficient on integration is negative and statistically significant. Given the nature of this measure of integration (see proposition 4.3), our results suggest a positive impact of economic integration on economic growth – which is independent of the estimation strategy. Compared to the standard growth model, we observe that some coefficients change in sign, size and significance which allows for additional insights on possible channels. In this context it is worthwhile mentioning that especially the estimated coefficient on the investment share changes substantially (see table 5 for comparison, this model specification replicates standard growth models without any measure of integration). This supports the idea that investment can be seen as one of the channels which explain how economic growth is effected by an increased degree of integration.

[44] 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).

[45] Sargan (1958) finds that for an increased number of instruments, the Hansen J test statistic becomes weak and the p value is 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.

Estimated coefficients and test statistics in table 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 empirical model [46]. 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 in the nature 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 models suggest the estimated coefficient on the level of lagged GDP per capita to be 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 VI, that the OLS and the within group estimator (specification OLS2, OLS3 and FEWG2, FEWG3) are inconsistent in a dynamic panel framework [47]. Nevertheless, the estimation results define an upper (0.916) and a lower bound (0.740) of the estimated coefficient on the lagged GDP per capita (Bond, 2002) [48].

Our estimation results in table 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 (specification 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. Consider that results change for the first difference and the system GMM estimator and the estimated coefficient turns slightly negative (not significant). Furthermore, the estimation results suggest 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 the estimation results from the limited information maximum likelihood estimator (specification LIML2 and LIML3) which are asymptotically equivalent to the first difference estimator. Given the shortcomings we have explored in the previous section, we believe that 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, we do not require the assumption on mean stationarity to hold (see system GMM estimator and upcoming discussion later in this section). The second specification (specification LIML2) reports results using logsteps as our measure of integration. Estimated coefficients change substantially compared to our previous analysis using the difference and the system GMM estimator. Results even suggest 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 [49]. Compared to our previous estimation steps, the estimated coefficient on integration does not change much and can be interpreted as follows: Using elasticities, an increase in integration by one percent increases GDP per capita in the next period by 0.143 percent.

Including a measure of openness (specification LIML3) does not have a huge impact on the previous results. We even find that in a model with both, a measure of integration and a measure of openness, integration remains statistically significant from zero and impacts the growth performance of an economy [50]. 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 indicate that openness and integration capture two different dimensions of globalization which both seem to be important in terms of economic growth.

[46] Consider that the empirical model includes time dummies for the OLS estimation and additionally country dummies for the within group estimation. Estimated coefficients are not reported in the tables in the appendix.

[47] 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.

[48] 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 6).

[49] 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.

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

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 towards the within group estimator (Blundell and Bond, 1998) [51]. In the case of over-identification, we could reduce the number of instruments using two alternative 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) [52]. Our results make use of first difference GMM estimator with collapsed instruments.

The specification tests check for endogeneity for 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 [53]. 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 [54].

Our 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 (0.658) even below the estimated coefficient from the within group model (0.740) which is possibly due to weak 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 [55]. The Arellano Bond test for serial autocorrelation (assumption 4) builds on 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 [56]. Test statistics from the Arellano Bond taken from the logsteps model 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 4 holds.

System GMM estimator The first difference GMM estimator builds on the assumption that lagged levels are valid instruments for first differences. In addition, system GMM makes use of lagged first differences to include them as further instruments into the empirical model [57]. Compared to the 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 give support to our prior that difference GMM 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 [58]. Compared to the first

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

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

[53] (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.

[54] 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.

[55] 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.

[56] 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.

[57] "Where Arellano Bond instruments differences with levels, Blundell Bond instruments levels with differences. For a random walk variable, past changes may indeed be more predictive of current levels than past levels are of current changes" (Roodman, 2009).

[58] 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).

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 strategy. We split the sample according to initial GDP per capita (results available from the authors on request). 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. We believe that the key identifying assumption behind the system GMM is violated – namely, it looks difficult to believe in mean stationarity of the dependent and the independent variables in a framework of economic growth – such that the system GMM specification cannot be used for an 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, we believe that 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 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 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.

6.2 Robustness tests using a modified measure of integration

Validity of our results from the previous section heavily depends on robustness to alternative. This section focuses on empirical findings which rely on alternative specifications of our measure of integration (see previous discussion in section IV). First we present a modified measure of integration which only takes into consideration indirect links. Based on the conjecture that direct links might be subject to feedback effects and introduce endogeneity and inconsistent estimates, we estimate an alternative specification where only variation in higher order links is used as an instrument. Second this section elaborates on empirical findings from a modified measure which does not take into consideration aggregate trade but only trade in manufacturing and investment goods. This specification is much closer to the theoretical model discussed in section III. Both specifications support our previous findings and suggest that economic integration has a positive impact on economic growth.

Instrumental variable approach using only indirect links Most of the independent variables in the empirical growth literature are plagued by endogeneity issues. As mentioned earlier, reversed causality induces inconsistent estimates, because institutions do not only foster economic growth but also the other way round. Our instrumental variable approach makes use of a modified measure of integration which exploits only indirect links. Assuming that a country j is only able to impact the formation of direct links between country j 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.

To guarantee the validity of the instrument, it must be uncorrelated with the error term of the second stage. Any effect of the instrument Z on the dependent variable 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 subpart 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 j and k are likely to be independent of the growth rate of country i.

The high correlation between the standard measure and the modified measure (0.992) suggests the instrument to be strong. The modified measure of integration for country j is constructed as the standard measure minus all direct links between country j and all its trading partners. The strength of the instrument builds on the idea that changes in higher order links have an impact on the network position of country i. To illustrate the implications, we focus on the example of the NAFTA area 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 i but also benefits from indirect trading links through the United States of America.

Summing up we interpret the modified measure on integration as a valid and strong instrument. 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 [59]. Using the instrumented level of integration as an independent variable in the second stage, our empirical findings do not change significantly compared to previous findings and we still identify a positive impact of integration on economic growth (see table 7). Most coefficients do not change in size, sign and significance compared to the standard approach discussed in the previous section. Especially, 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 (2011) postulates that integration has a positive impact on economic activity, mainly because links between two countries j and i can be interpreted as productive projects which generate further economic possibilities. In an empirical framework we proxy links by bilateral trade flows in goods and services between country j and i. Since we can imagine that bilateral trade differs in terms of quality, we next make a difference 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 modified measure of integration now only exploits trade in manufacturing and investment goods [60]. Consider that 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.

Results from the descriptive analysis in tables 3 and 2 show the correlation between the standard measure and the modified logsteps measure to be high (0.911). Furthermore, empirical findings in table 8 allow for a detailed discussion on how the modified measure of integration performs in an empirical growth model. Compared to results from the previous specifications in tables 6 and 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 our modified measure of integration remains negative and confirms previous findings: A higher level of economic integration has a positive impact on economic performance of an economy.

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.

[59] 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 7.

[60] 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).

The empirical analysis employs different estimation approaches to account for the particular needs of the dynamic panel structure. Our estimation strategy addresses problems of correlated and 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 endogeneity 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 favorable 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 (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. Following our results, 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 degree of integration of an economy into 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 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 (e.g. World Trade Organization and Doha Round) and regional integration (e.g European Union and 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. The positive impact on the economic growth performance of an economy increases in the centrality of the partner country, the new trade agreement refers to.

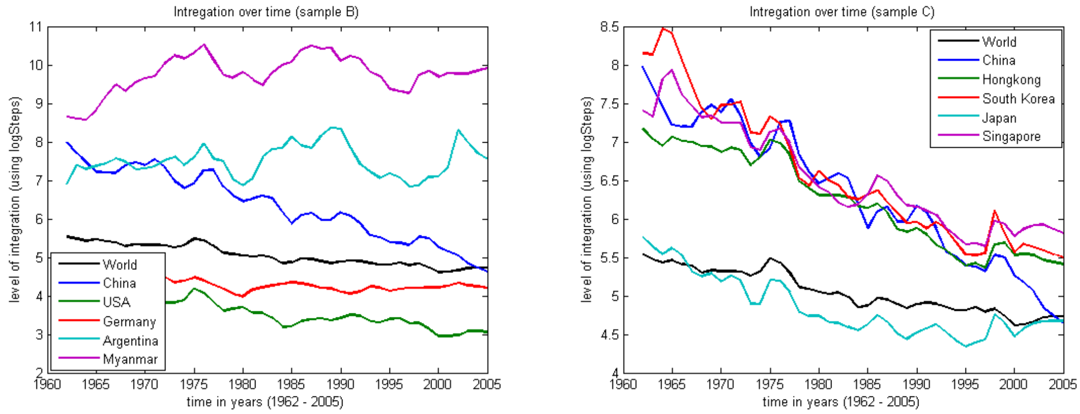
Future research needs to incorporate an alternative measure of bilateral trade flows. As discussed in the data section of this paper, our computations of the network based measure of integration build on bilateral trade flows between two countries i and j. Furthermore we exploit a second approach which accounts for the composition of overall trade and differentiates between trade in 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.

A Focus Asia

Economic globalization benefited largely from a move towards more integration in East and South East Asia. This section provides some descriptive statistics for a set of countries in this region and discusses historical trends. We do not only focus on Japan which is characterized by a high degree of economic integration over the entire sample period, but also 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 and Sri Lanka) and later on illustrate the consequences from the Asian financial crisis in 1997 on economic trade.

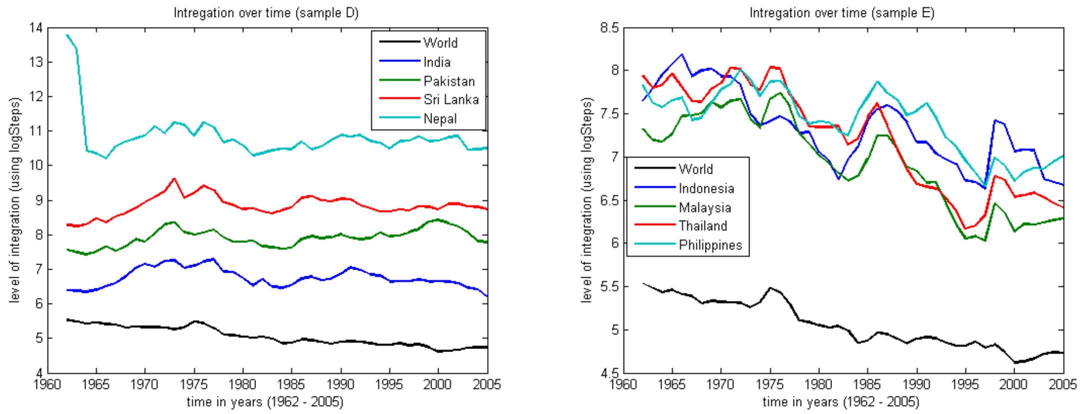
Japan is a highly industrialized economy which is well connected to international markets. Its economic success builds on a well established network position which enables the country to participate in the global value chain by importing natural resources and exporting high value products all over the 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 slowdown during the Asian financial crisis when the degree of integration decreased again.

Figure 8: Measure of integration for different countries in Asia 1



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 finally is characterized by more integration than the average of all countries. Consider that **Hong Kong** benefited from special investment conditions and a different business environment compared to the mainland 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 open minded government policy.

Figure 9: Measure of integration for different countries in Asia 2



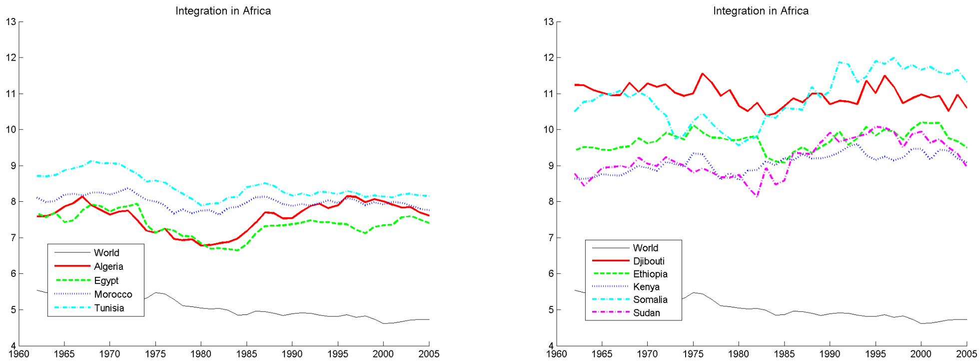
Compared to the previous examples, **India and Sri Lanka** show a very different pattern in terms of economic integration. In line with political ideology and implemented through the national planning commission, India focused on domestic development. Our data illustrates the strong links between India 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 especially in South East and East Asia. **Indonesia, Thailand and Malaysia** experienced a substantial reduction in international capital flows and at the same time consequence international trade decreased. 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.

B Focus 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 in Africa offers additional insights and illustrates the validity and strength of our measure on globalization. In the following discussion, we suggest that differences across countries can be linked to the historical heritage and the geographical situation which shapes their (economic) development.

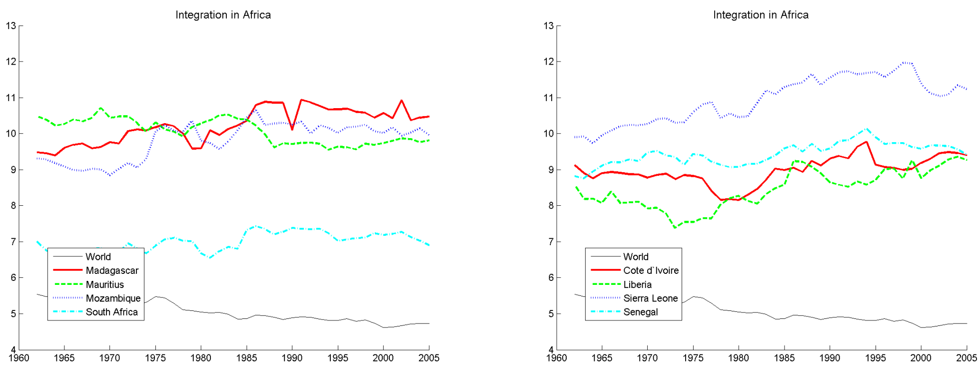
Figure 10: Measure of integration for different countries in North and East Africa



A widespread result from different empirical studies highlights the importance of the colonial background to understand the growth performance of an economy. In fact we can imagine that not just institutions in general, but 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 links to the European Union. For instance, the European Union has special 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. Consider that the strong co-movement of countries in the sample highlights the close trade links between the countries in North Africa.

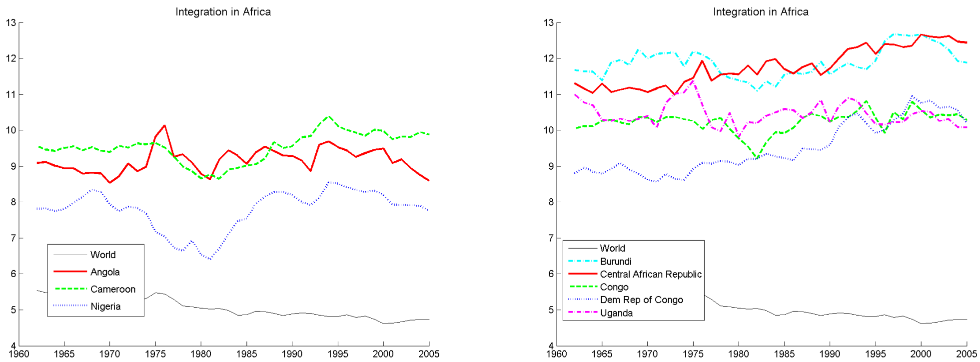
East Africa has been a place with profound political challenges over the last years. Ethiopia was long been an example for sustainable economic and politic development. This trend slowed down significantly when Ethiopia started a long lasting war with Eritrea which reduced further investment and had 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 time trend. Somalia has been trapped in a bloody civil war for many years which also impacted the level of economic integration negatively.

Figure 11: Measure of integration for different countries in West and South Africa



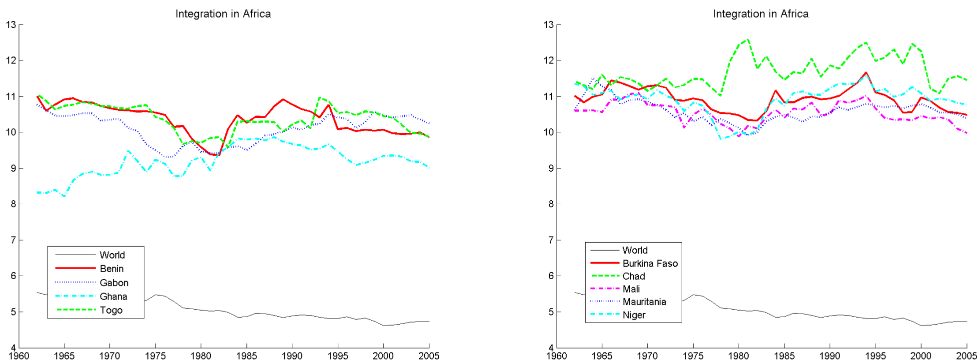
The example of Mauritius and Madagascar illustrates the importance of geographic characteristics to understand the observed level of economic integration. Both countries are sea locked which in general provides better access to international trading routes but also hinders economic interaction with neighboring 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.

Figure 12: Measure of integration for different countries in Central Africa



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 stayed isolated. In other words they 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 graphs. Uganda is another example where our measure of integration varies due to civil war during 1971 and 1977.

Figure 13: Measure of integration for different countries in West Africa



Many countries in **West Africa** were French colonies. Following their independence in the 1960s they slowly integrated into the global trade network. Consider that trade was mainly build 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 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 economic growth. In this context it looks interesting to compare the standard measure to the measure which exploits only trade in manufacturing and 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) [61]

Germany (until 1989)
Fmr Dem. Rep. of Germany (278), Fmr Fed. Rep. 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)

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

Computation of the measure of global integration

Our starting point is an $(n \times n)$-matrix A, which is row-stochastic, as the one constructed in section IV. We want to think of it as the adjacency matrix of a weighted directed network over n nodes. Thus each entry a_{ij} is the weight/probability with which node i connects to node j. Then, the directed distance φ_{ij} from i to j is identified as the expected number of steps required to reach j from 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 that can move to one of the neighbors of it, say 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. (This matrix, of course, is no longer a stochastic matrix.) Then, it can be easily seen that 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

$$\gamma_{ij}(r+1) = \sum_{k \neq j} [(A_{-j})^r]_{ik} \ a_{kj}.$$

Therefore, the expected number of steps φ_{ij} can be obtained as follows:

$$\begin{aligned} \varphi_{ij} &= \sum_{r=1}^{\infty} r \ \gamma_{ij}(r) = \sum_{r=0}^{\infty} (r+1) \sum_{k \neq j} [(A_{-j})^r]_{ik} \ a_{kj} \\ &= \sum_{k \neq j} \sum_{r=1}^{\infty} r \left[(A_{-j})^{r-1}\right]_{ik} \ a_{kj} = \left[\left(\sum_{r=1}^{\infty} r \ (A_{-j})^{r-1} \right)_{ik} \right]_{\substack{k=1,2,...,n \\ k \neq j}} \Big(a_{kj} \Big)_{\substack{k=1,2,...,n \\ k \neq j}} \end{aligned} \tag{7}$$

Using now a standard formula from linear algebra we have:

$$\sum_{r=1}^{\infty} r \ (A_{-j})^{r-1} = (I - A_{-j})^{-2}$$

so that, in an integrated matrix form, the (column) vector $\Big(\varphi_{ij} \Big)_{\substack{i=1,2,...,n \\ i \neq j}}$ can be written as follows

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

Finally, note that, because A is a row-stochastic matrix, it follows that

$$a_{ij} = 1 - \sum_{k \neq j} a_{ik}$$

and therefore

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

where e is the column vector $(1, 1, ..., 1)^{\top}$. Hence the vector $\Big(\varphi_{ij} \Big)_{\substack{i=1,2,...,n \\ i \neq j}}$ can be computed from the following simple expression:

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

Computation of the instrument

In the benchmark case, the measure of integration of country i, for a given point in time, is computed as the weighted average of the expected number of steps necessary to reach country i from any country j are given by the share of country j's GDP in world GDP. Here is a proposal how to modify the computation with the aim of making the measure of integration immune against endogeneity. The idea is to compute, for each country i, an indirect measure of integration, denoted[integi. The key ingredient here is, as before in the benchmark case, the row-stochastic matrix A. An element of which, say ai;j indicates the probability with which i connects to j.

List of variables

lnyt: Logarithm of constant price GDP per capita and expenditure shares 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 geary aggregation using national growth rates. It is a fixed base index where the reference year is 2005. Source: Penn World Table 6.3 (rgdpl).

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 per capita. 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 is 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 four and five). Average over x years time interval proceeding the years of measurement. Source: UN COMTRADE data.

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, one could imagine that 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 the same.

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.

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 introduced 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. Furthermore, we confirm previous results and find that the measure of openness turns insignificant as soon as we introduce the measure of political institutions.

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 86 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.

PWT 6.0 PWT 6.1 PWT 6.3 PWT 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).

Descriptive statistics and estimation results

Table 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
logsteps (cons)	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
logsteps (mod)	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
logsteps (p58)	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

Table 3: Correlations between dependent and independent variables

	lnyt	lnyt_l	sed	lnlex	ish	gsh	ipr	logsteps (cons)	logsteps (mod)	logsteps (p58)	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				
logsteps (cons)	-0.773	-0.746	-0.632	-0.717	-0.623	0.213	0.072	1.000			
logsteps (mod)	-0.759	-0.733	-0.637	-0.693	-0.599	0.215	0.076	0.992	1.000		
logsteps (p58)	-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

Table 4: ranking

year 2005	year 1970					year 1990								
country (*)	openk (2)	rank (3)	integ(4)	rank (5)	SW (6)	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

Table 4: ranking

year 2005	year 1970					year 1990								
country (*)	openk (2)	rank (3)	integ(4)	rank (5)	SW (6)	openk	rank	integ	rank	SW	openk	rank	integ	rank
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
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

Table 4: ranking

year 2005	year 1970					year 1990								
country (*)	openk (2)	rank (3)	integ(4)	rank (5)	SW (6)	openk	rank	integ	rank	SW	openk	rank	integ	rank
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
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

(3) openk (used for empirical analysis): measure of openness. Exports plus imports divided by GDP is the total trade over GDP. The export and the import figures are in CONSTANT 2005 prices from the World Bank and United Nations data archives. (5) logsteps: Degree of integration evaluates the network structure of an economy. Constant world. Aggregate trade.(2) (4) rankings for openk and logsteps: The ranking for the corresponding variables depends on the relative position in terms of openness and integration. (6) Sachs and Warner measure: Based on the country's trade policy a country is characterized in terms of two different categories. Being either open -1- or closed -0. Data is available until 1992.

Table 5: Different specifications of the empirical growth model baseline

	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_l	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.*

Table 6: Different specifications of the empirical growth model logsteps (cons)

	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_l	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	–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.*

Table 7: Different specifications of the empirical growth model logstepsIV

	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_l	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	–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.*

Table 8: Different specifications of the empirical growth model logstepsp5678

	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_l	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	–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.*

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