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Global value chains, national innovation systems and economic development

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Abstract

The purpose of the paper is to examine the hypothesis that increased participation in global value chains (GVCs), such as assembly of imported parts for exports, leads to higher economic growth. The focus is particularly on the extent to which this holds for low-income countries, and the role that capability-building, i.e., the development of the national innovation system, plays for the possibility to benefit from GVCs. The analysis is based on evidence from 125 countries over the period 1997-2013. To analyse the issue a comprehensive framework that allows for the inclusion of a range of relevant factors, including GVC participation (measured by the foreign value added embodied in a country's exports), is applied. The results suggest that countries that increase GVC participation do not grow faster than other countries, when other relevant factors are controlled for. Small countries, and countries with low capabilities, appear to be particularly disadvantaged.

Keywords: Global value chains, capability, national innovation system, economic development, economic growth.

JEL codes: F43, O10, O30, O40, O57.

1. Introduction

What explains the extent to which countries manage to exploit the worldwide pool of technological knowledge to their advantage? This has been a hotly contested issue in economic and development research for a long time. The so-called Washington Consensus, advocated by the World Bank and other international organizations, predicted that this would be easy as long as the country shied away from tampering with markets and practiced openness to trade and foreign investment. However, empirical research has found the evidence on this proposition to be rather mixed (Görg and Greenaway 2004, Fagerberg, Srholec and Verspagen 2010, Keller 2010).

It was pointed out by several contributors to the debate that one explanation might be that successful exploitation of foreign knowledge crucially depends on the development of national "technological capability" (Kim 1997, Lall 1992) or "absorptive capacity" (Cohen and Levinthal 1990, Criscuolo and Narula 2008) within the framework of a "national innovation system" (Lundvall 1992, Nelson 1993). The emergence of the innovation-system approach has from the early 1990s onward led to a host of new research emphasizing the role of national capability-building in economic development (Fagerberg and Srholec 2008, Lundvall et al 2009). However, since national innovation systems are increasingly dependent on foreign sources of knowledge, it is also important to assess if, how and in what forms openness to various channels for transfer of foreign knowledge matters for economic development.

One important strand of research on economic development has focused on how and to what extent foreign direct investment (FDI) by multinational firms contribute to economic growth in countries at different levels of development (Narula and Dunning 2010). An important insight from this literature is that spillovers to host country firms require that those firms have a sufficient absorptive capacity and linkages with the foreign affiliates (Castellani and Zanfei 2006, Narula 2014, Rojec and Knell 2017). Econometric studies at the country level also indicate that a positive impact of FDI is conditional on national capabilities and human resources (Borensztein, De Gregorio and Lee 1998, Xu 2000, Filippetti, Frenz and Ietto-Gillies 2016).

A new stream of literature that emerged during the 1990s pointed out that the combination of the ICT revolution and innovations in transport technology had led to the development of new ways to produce and distribute goods and services globally (Sturgeon 2002) in the form of global value chains (GVCs) coordinated and led by multinational companies, so-called "lead firms" (Gereffi and Korzeniewicz 1994, Gereffi et al. 2005). It was argued that this might provide enterprises in developing countries with opportunities to upgrade technologically and in terms of functions through participating in such networks (Ernst and Kim 2002, Gereffi and Fernandez-Stark 2011, Gereffi 2014). Following this line of argument, international organizations, such as the World Bank, have recommended developing countries to increase their participation in GVCs in order to spur economic growth.[1]

Much of the empirical research on GVCs has taken the form of case studies at the level of enterprises, geographical clusters or specific segments of vertically organised business activities.[2] These studies have brought to light many examples of local firms in countries at different levels of development that have been able to upgrade products and processes in an interaction with lead firms in high income countries. However, moving from case studies to analyses of entire countries or the global economy as a whole is a challenging step that was for a long time hampered by lack of data on participation in GVCs at the national and global level. More recently, international agencies such as OECD and UNCTAD, as well as networks of researchers, have created data sets that in a better way than before account for trade in intermediate products (Timmer et al. 2015 and Eora 2016). These data may be used to illustrate the proliferation of GVCs (Koopman et al 2010, 2014, Timmer et al. 2014 and Foster-McGregor et al 2015).

The purpose of this paper is to examine the hypothesis that increased participation in GVCs, such as assembly of imported parts for exports, leads to higher economic growth. The focus

[1] See for example the following programmatic statement on the World Bank's website: "Participation in global value chains (GVCs), the international fragmentation of production, can lead to increased job creation and economic growth. The World Bank Group is helping developing countries catch the GVCs wave and realize the benefits GVCs can deliver". (http://www.worldbank.org/en/topic/global-value-chains, accessed on 11 April, 2018.

[2] For a combination of macroeconomic and sectoral analysis in a specific region see Del Prete, Giovannetti and Marvasi (2017).

is particularly on the extent to which this holds for low-income countries, an issue that has received relatively little attention so far, often due to data limitations (Kummritz and Quast 2016). Therefore, the present paper has placed emphasis on including as many low-income countries as possible, to some extent at the expense of richer data and availability of time series. To explore this issue, we apply a framework that allows for the inclusion of a range of relevant factors, including not only GVC participation[3], but also other factors that may influence transfer and exploitation of knowledge and the development of the national innovation system.

In section 2 we discuss how different forms of capability building and foreign sources of knowledge, including participation in GVCs, interact with the process of economic development. Based on the conclusions reached there the subsequent section 3 delves more deeply into the measurement of the various factors, including capabilities, participation in GVCs and other channels for foreign knowledge transfer, and explores the relationship with economic development. Section 4 of the paper considers, using regression analysis, the extent to which increased participation in GVCs, measured by foreign value added in a country's exports, is associated with higher economic growth. The final section sums up the lessons from the study.

In general, the results presented in this paper suggest that countries that increase their participation in GVCs, e.g., through assembly of imported parts for exports, do not grow faster than other countries, when other relevant factors are controlled for. Countries with low capabilities, i.e, weakly developed innovation systems, appear to be particularly disadvantaged. The same holds for small economies. However, it should be noted that due to the nature of the available data, the results should not be interpreted as proving causal relationships.

[3] GVC participation is in this paper is measured as foreign (imported) value added embodied in a country's exports, which is the only measure that is available for a broad sample of countries. A typical example of such GVC participation is assembly of imported parts for exports. See section 3 of this paper for an extended discussion.

2. The roles of knowledge, capabilities and GVCs in economic development

Today it is generally acknowledged that a very important source of differences in levels of economic development concerns differences in the command of knowledge (for an overview see Fagerberg and Srholec 2009). Moreover, it is increasingly recognized that much economically useful knowledge is difficult and costly to identify, access, acquire and exploit and that, for most if not all nations, foreign knowledge-bases are much larger than domestic ones. Hence the ability to tap into these foreign knowledge-bases becomes of utmost importance for the economic development of a nation.

Several different channels for such knowledge transfer may be identified. Much knowledge, scientific knowledge for example, is in principle free, but that does not mean that it is easy to access and exploit. Above all it requires a high quality national education system, and a public and private R&D system that makes it possible to link up with advanced global research networks (Wagner and Leydesdorff 2005). Some advanced knowledge is proprietary and enterprises and governments can obtain access by paying for it, for instance, by licensing. Still, successfully exploiting the knowledge continues to be demanding and requires domestic engineering and design capabilities to succeed. FDI is another potential channel of knowledge transfer that may generate positive spillovers to domestic firms. Several studies of such spillovers demonstrate, however, that the benefits are conditional on developing sufficient indigenous capabilities on the receiving end (Bell and Marin 2004, Castellani and Zanfei 2006, Criscuolo and Narula 2008, Narula 2014). Participation in international trade, for example importing capital goods (Gomulka 1971), may also contribute to knowledge transfer. Finally, knowledge may be embodied in people, i.e., skilled workers and experts moving across national borders (Saxenian 2006). Sending students to obtain training abroad may be seen as one way to strengthen the domestic knowledge base. Common for these different channels of knowledge flows is that the effective use and diffusion of the knowledge absorbed will depend upon the strength of the national innovation system, e.g., its technological infrastructure, the skills of its labour force and firm-level capabilities (Fagerberg, Srholec and Verspagen 2010).

Participation in GVCs is a particular form of openness to trade in which knowledge transfer takes place in a more organized and interactive manner than in other forms of trade under the supervision of so-called "lead firms" governing the activities of the chain. Studies by GVC scholars have analysed how specific major multinational firms have organised production chains and how they have influenced formally independent firms operating as their preferred suppliers (Gereffi and Fernandez-Stark 2011). Gereffi, Humphrey and Sturgeon (2005) proposed five different modes of governance in global value chains: i) Hierarchy; ii) Captive; iii) Relational; iv) Modular; and v) Market. According to the authors, the further down we go on this list, the less dominating the lead firm. The dominance of the lead firm may be rooted in market control for a final product – such as when Walmart procures blue jeans from formally independent suppliers in Mexico (Gereffi 1999). Alternatively dominance may be rooted in technological capabilities – such as when Apple procures electronic components from formally independent producers in China (Linden et al 2009).

Often case studies of participation in GVCs have revealed long term relationships and illustrated that the dominant firm under certain circumstances and to a certain degree will contribute to upgrading in the supplier firms (Gereffi 1999).[4] Walmart needs good quality products adapted to market needs and Apple needs high quality components that are designed so that they fit into final products, including new product generations. However, the literature has also demonstrated that there are limits for the willingness of dominant firms to share knowledge and build capabilities among suppliers. A crucial issue is branding and market access. Walmart does not want the Mexican suppliers to become independent producers of a competing brand and Apple will only share technological knowledge that is not at the core of the business. Actually, we would expect the dominant firm to take all kinds of precautions to avoid that the supplier becomes a competitor (Humphrey and Schmitz 2000).

Moreover, it is important to take into account that not all transactions in organized markets take place in GVCs dominated by multinationals and distributed worldwide. In fact, much of

[4] Humphrey and Schmitz (2002) make a distinction between four forms of industrial upgrading: New process, New product, New function and New sector. While lead firms may have an interest in stimulating the development of new processes and products among suppliers they also might use their position in captive and relational forms of governance to block suppliers' attempts to move into new functions (building strong internal R&D capability or establishing own brand).

the trade in intermediate goods takes place between enterprises located in high-income countries and within supranational regions (Europe, Asia and Africa) rather than between continents and sometimes regional trade agreements explain this kind of trade (Sturgeon 2001). For example, the process of European integration was accompanied by a dramatic increase in this kind of trade. Such trade may of course involve long-term relationships between unequal partners, but it may also involve interaction between equal partners, and with suppliers in a quite strong position. Thus, the impact of GVC participation on the economy may differ a lot across different contexts.

While firms in high- and middle-income countries with a strong industrial base and knowledge infrastructure may be in a position to benefit from participation in GVCs,[5] it is not obvious that this holds to the same extent for firms located in low-income countries with a weak national innovation system. According to the literature on GVCs, the potential for upgrading will differ depending on the governance mode in the value chain, e.g., how dominating the lead firm is. Arguably, enterprises from countries with weak innovation systems may be expected to be predominantly operating in modes dominated by foreign multinational oligopolies (Gereffi and Fernandez-Stark 2011, Gereffi and Lee 2012). Therefore, it cannot be excluded that a major part of the economic value created goes to other parts of the value chain with more leverage (Linden et al 2009, Ali-Yrkkö, Rouvinen, Seppälä and Ylä-Anttila 2011). Nor is it obvious that the local economy in which the enterprise is located benefits.

For example, a potential downside for the national economy might be that an enterprise joining a GVC, although advanced by local standards, decouples from interacting with domestic firms and thus undermines the potential for building dynamic national or regional clusters (Schmitz 1995 and 1999, Ponte and Ewert 2009). Activities that become offshored to developing countries tend to be low-value added and thus low-commitment, which means that they are footloose and not embedded in the local economy (Castellani and Zanfei 2006, Narula and Dunning 2010, Giroud and Mirza 2015). Furthermore, if the enterprise remains

[5] For example, enterprises in countries such as Korea, Singapore and China have entered into international interactions as suppliers to multinationals in electronics and used the experience to move from being dependent suppliers to developing their own brands, ending up as important multinational enterprises (Lee 2013).

locked into narrow functions, the implications for the national economy may not be as favourable as policy makers would have wished, at least not in the longer run. Development effects ultimately depend on the value-added intensity of activities undertaken locally. Several studies indicate that strong local capabilities are required for deriving substantial benefits from joining GVC (Giuliani, Pietrobelli and Rabellotti 2005, Fu, Pietrobelli and Soete 2011).

It is clear from the discussion that knowledge, including access to foreign sources of knowledge, is essential for economic development. However, it is also evident that there are several different channels for acquiring knowledge, that countries exploit these to a different extent and that the ability to do so depends on domestic capability-building. Therefore, to get a better grasp on the role of GVC participation in economic development, a broad framework including not only GVCs and other channels for knowledge transfer, but also domestic capability-building and other relevant factors, will be required.

3. A preview of the data

This section is concerned with the empirical operationalisation of the factors discussed above, as well as their relationships with economic development given by GDP per capita. All of the variables are measured in two points in time: initial and final periods, which refer to data from the nearest available year to 1997 and 2013, and whenever appropriate used in logs to limit the influence of outliers.[6] Although the selected indicators have broad coverage, in some cases there were missing values that had to be dealt with (further details on definitions and sources can be found in Appendix A1).[7]

[6] If necessary unity was added to avoid logs of zero. Unity was also added to variables with values very close to zero to avoid generating outliers with high negative values. The index of the quality of a country's bureaucracy is not used in logs, as countries are ranked on a fixed five-points scale.

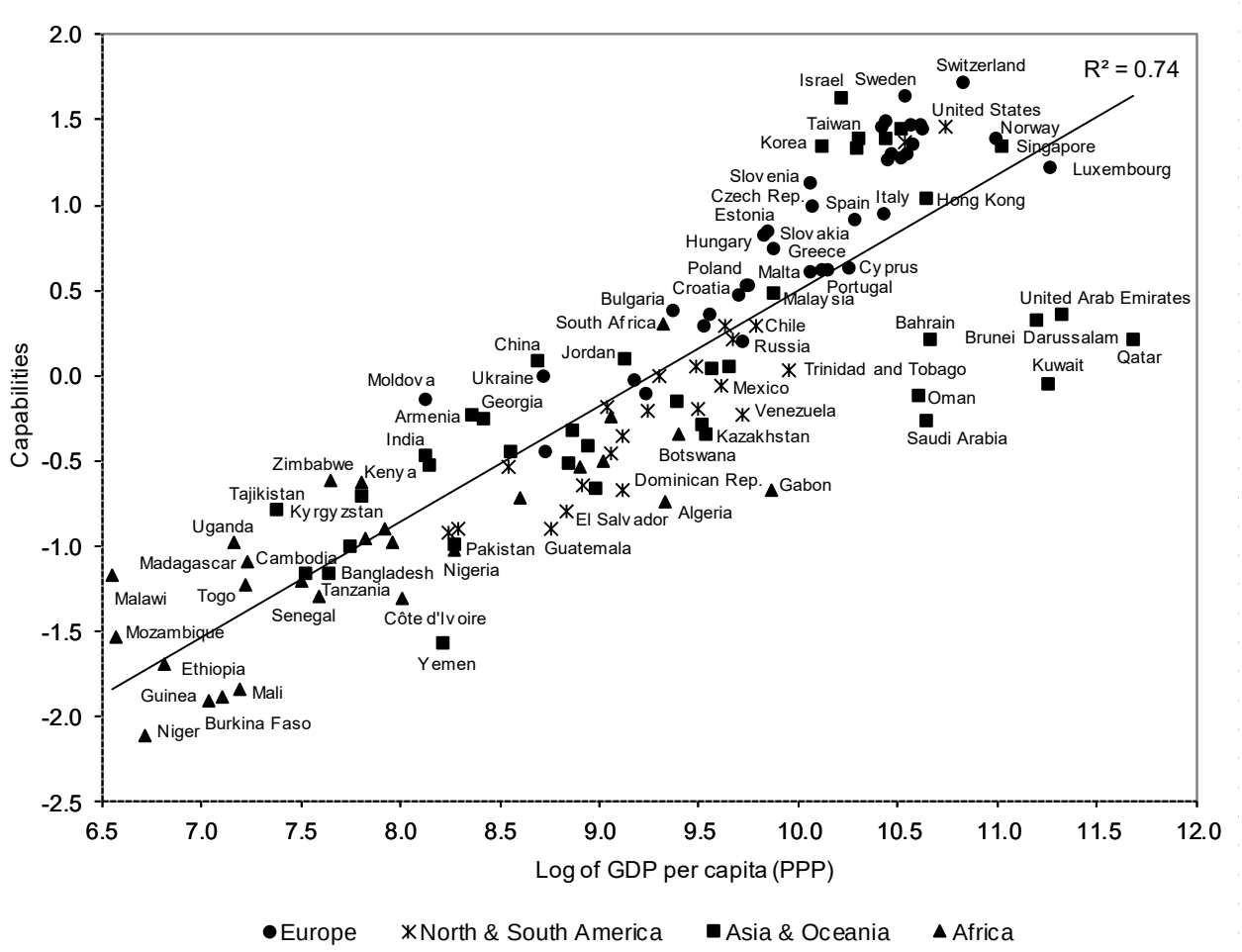
[7] Missing data were imputed (in particular about 16 % and 17 % of the sample for R&D expenditures and trademark applications, respectively) using the impute procedure in Stata 11.2 (for more information see Stata 2005, pp. 217-221). The procedure, which is regression-based, uses information from other variables in the data set to fill in missing values.

As concerns capabilities, we take into account nine different indicators that together give a broad view on where a country stands with respect to the development of its national innovation system.[8] The first four indicators reflect what Kim (1997) called "innovation capabilities", i.e., the quality of a country's science base (as measured by publications), R&D investments, patents and trademarks. The two next indicators on the list, namely ISO certification and internet users, are broader in character and may be seen as examples of what Kim (1997) labelled "production capabilities". Finally, the set of indicators contains two measures referring to the educational level of the labour force and an index reflecting the quality of a country's bureaucracy, both of which may be regarded as examples of what Abramovitz (1986) called "social capabilities".

For the purpose of the analysis the nine selected capability indicators are weighed together into a composite measure using factor analysis (for detailed results see Appendix A2). As shown by the factor loadings the various capability indicators are closely correlated, giving strong empirical support to the use of a composite measure. Figure 1 plots the resulting capability measure against GDP per capita. The regression line between the two variables is also reported. As might be expected GDP per capita is an increasing function of a country's capability-level. Poor countries generally have low capabilities. Furthermore, resource-rich countries tend in some cases to have far higher GDP per capita than their capability levels would indicate.

[8] The capability-indicators taken into account below strongly resemble those included in the "innovation system" measure proposed by Fagerberg and Srholec (2008) based on a similar methodology as the one applied here. However, their study also contained a rich set of indicators on governance and institutions, which factored out in separate dimensions.

Figure 1: GDP per capita and Capabilities, average 1997 and 2013



At the centre of our interest is to explore how participation in GVCs relates to economic development. Following Koopman et al (2010 and 2014), a country's gross exports can be split up into a part capturing domestically produced value added and a part capturing imported value added that is incorporated into the country's exports. The latter has become commonly used as an indicator for the extent of downstream GVC participation, such as assembly of foreign-produced parts for exports. In this study this indicator is called GVC imports. The same indicator has also been dubbed "backward-linkage indicator" (Kummritz and Quast 2016) or simply "foreign value added in exports" (Koopman et al 2014, Timmer et al 2014 and Foster-McGregor, et al 2015).[9]

[9] For caveats of using input-output tables for measuring the participation in GVCs see Nomaler and Verspagen (2014).

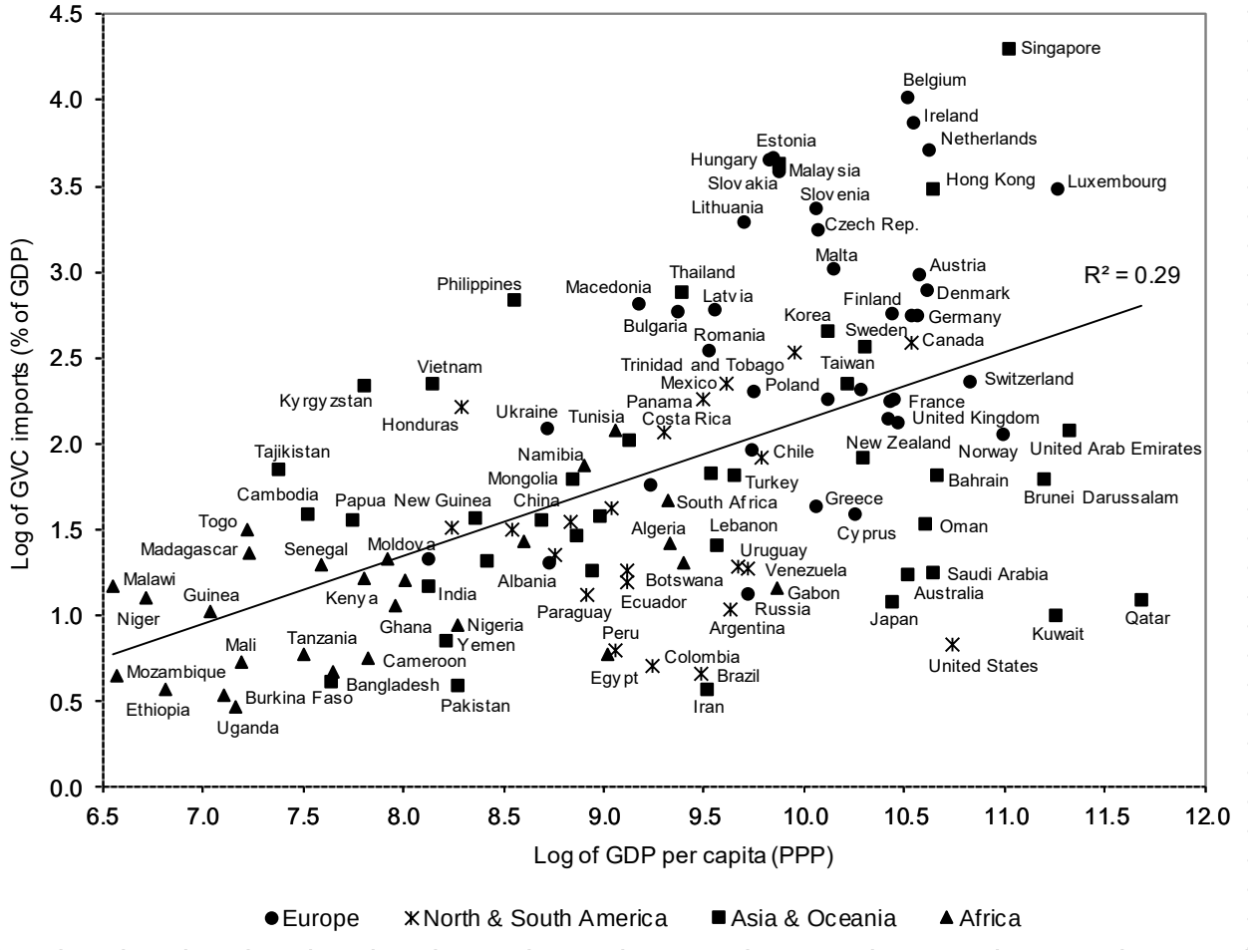
Until recently trade statistics were only available in terms of gross exports and imports, hence reflecting sales, not value added, and thus becoming increasingly biased due to the spread of GVCs. Nevertheless, international organizations, including UNCTAD and OECD, have put great effort to trace how intermediate products move between countries using detailed data on international transactions recorded in input-output tables, resulting in the Eora multi-region input-output table (MRIO) database (Eora 2016). More specifically, the GVC imports indicator used in this study is derived from the Trade In Value Added (TiVA) database (UNCTAD/Eora 2016), which is based on the MRIO dataset and provides evidence from 189 countries, including many developing nations.[10] For more detailed explanation of the database and calculation of the GVC imports indicator see UNCTAD (2013, pp. 26-29).

A country's exports does not consist of final goods only, but also of inputs for further processing and exports by other countries. Koopman et al (2011 and 2014) refer to this indicator of upstream GVC participation as "indirect value-added exports". It has been also interpreted as "forward-linkage indicator" (Kummritz and Quast 2016) or "the extent of GVC participation for relatively upstream sectors" (Foster-McGregor et al. (2015). However, this indicator is not included in the TiVA database (UNCTAD/Eora 2016) that we are using. Moreover, for developing countries this indicator primarily reflects their traditional roles as exporters of commodities, that has been extensively analysed elsewhere (see, e.g., Morris, Kaplinsky and Kaplan 2012, Fitter and Kaplinsky 2001 and Narula 2018), and which, although interesting, is not the central focus of this paper.

Figure 2 plots the extent of GVC imports against GDP per capita. The figure reveals that this form of participation in GVCs is not as closely correlated with economic development as capabilities are (Figure 1). In fact, there is a lot of variation across countries at similar levels of development, and the degree of variation appears to increase as countries get richer.

[10] Other database with multi-country input-output tables that can be used to compute GVC imports is the World Input–Output Database (WIOD) (Timmer et al. 2015), which, however, provides evidence only on 43 predominantly advanced countries.

Figure 2: GDP per capita and GVC imports, average 1997 and 2013



Moreover, as pointed out earlier, there are other channels for knowledge transfer that countries may exploit and that need to be taken into account. The variables for which reliable data are available and hence could be taken into account in the study are i) capital goods imports; FDI (inward); and iii) outbound mobility of tertiary students (to North America and Western Europe). We use imports of capital goods - rather than total imports - because the use of foreign capital goods is often cited as an important channel for knowledge transfer (see, e.g., Gomulka 1971). Another reason is that using total imports would lead to double-counting since GVC imports is a sizeable part of total imports. Unfortunately, there were no data for migration of highly skilled personnel that could be exploited in the analysis. Another potentially relevant indicator used in other studies is payments for import of proprietary knowledge (e.g. licenses etc.) but this could not be taken into account separately in the present case since it is also already included in GVC imports.

4. Does it matter?

Arguably, the level of economic development may be seen as the result of a process in which not just one but several channels for knowledge transfer interact with other national and international factors. Moreover, knowledge-based growth is not only about exploiting foreign knowledge, because domestic knowledge creation and the national innovation system matter too. Finally, economic development may also be influenced by factors that have little to do with knowledge such as abundance of natural resources. To take all these factors into account this section turns to multivariate regression analysis.

The purpose of the analysis that follows is to test whether increased GVC participation measured by the indicator of GVC imports is associated with higher economic growth, when the possible influence of other relevant factors is accounted for (so-called "conditioning factors"). However, it should be noted that the cross-sectional nature of the data does not allow for testing of causality or the impact of possible country-specific factors, and that the results should therefore be interpreted with caution.

To analyse this issue, we employ a so-called conditional growth regression (Cornwall 1976, Barro 1991):

(1) $y = a_0 + a_1Y + a_2O + a_2o + a_3C + a_4c + a_5F$,

where the dependent variable is growth of GDP per capita. *Y* refers to the initial level of GDP per capita. O/*o* represent the initial level/growth of various channels for transfer of foreign knowledge. As mentioned above, in addition to GVC imports we also include capital goods imports, inward FDI and tertiary students abroad. *C/c* is the initial level/growth of relevant capabilities (as described in the previous section) and F represents other exogenous factors controlled for to reduce the possible omitted variable bias. The control variables taken into

account here reflect differences in country size,[11] industrial structure, disease ecology and nature. All variables are in logs, as already noted above, thus growth refers to log difference (a log approximation of the growth rate). The sample includes 125 countries between 1997 and 2013 (descriptive statistics on the variables that enter the regression analysis is provided in Appendix A3 and the list of countries is in Appendix A4).

The inclusion of the initial level of GDP per capita among the explanatory factors reflects the classical "catch-up" or "latecomer" hypothesis advanced by economic historians such as Gerschenkron (1962) and Abramovitz (1986), i.e., that low-income countries far from the technology frontier have a larger scope to benefit from international knowledge spillovers than countries close to the frontier. Thus, the estimated impact of this variable should be expected to be negative, indicating slower growth for countries close to the frontier.

The results are reported in Table 1. OLS robust to outliers is used in the estimates based on the procedure suggested by Li (1985). Beta coefficients are reported, i.e. the variables enter the analysis standardized with mean of zero and standard deviation of one, thus the estimated coefficients refer to the impact of change by one standard deviation. The first column in Table 1 reports estimates of the model without controls, while in the second column the control variables are added. However, since the estimates for some of the variables were not statistically significant, a backward search for the best model was conducted, using a 20% significance level as criterion for exclusion/re-inclusion in the model, the results of which are reported in the third column.

[11] Size, represented by population, is pertinent to control for, as firms in large countries naturally engage more with domestic customers, suppliers and investors than do firms in smaller economies.

Table 1: Explaining growth of GDP per capita: Regression results, iteratively re-weighted least squares, 1997-2013

	(1)	(2)	(3)
GDP per capita	-1.03***	-1.12***	-1.00***
	(8.34)	(5.40)	(8.52)
Capabilities	0.87***	0.61***	0.62***
	(6.15)	(3.38)	(4.14)
Δ capabilities	0.41***	0.29***	0.27***
	(5.50)	(3.48)	(3.47)
GVC imports	-0.15	-0.17	-0.15
	(1.37)	(1.57)	(1.48)
Δ GVC imports	-0.23***	-0.22***	-0.20***
	(3.41)	(3.15)	(3.43)
Capital goods imports	0.19**	0.30***	0.28***
	(2.02)	(2.72)	(3.01)
Δ capital goods imports	0.05	0.07	..
	(0.63)	(0.88)	
FDI inward	0.02	0.03	..
	(0.24)	(0.34)	
Δ FDI inward	-0.05	-0.04	..
	(0.63)	(0.45)	
Outbound mobility of tertiary students	-0.06	0.05	..
	(0.71)	(0.51)	
Δ outbound mobility of tertiary students	0.21***	0.23***	0.23***
	(3.13)	(3.38)	(3.49)
Control variables:			
Size (population)	..	0.16	0.15*
		(1.65)	(1.94)
Agriculture	..	-0.12	..
		(0.79)	
Natural resources rents	..	-0.02	..
		(0.22)	
Tropics	..	0.03	..
		(0.33)	
Malaria	..	-0.27***	-0.24***
		(2.82)	(2.95)
F-test	12.96***	9.92***	18.01***
R^2	0.44	0.47	0.45
Number of observations	125	125	125

Note: The dependent variable is log difference of GDP per capita (PPP, constant 2011 international USD) divided by the number of years (a log approximation of the annual growth rate). Absolute value of robust t-statistics in parentheses. *, **, *** denote significance at the 10, 5 and 1 per cent levels. Beta coefficients reported.

The results suggest that capabilities, whether measured by the initial level or subsequent growth, have a strong, positive relationship with growth of GDP per capita, and the estimated relation is quite robust with respect to changes in specification. However, only two of the eight variables for channels of knowledge transfer included in the test can be shown to be positively correlated with economic growth, namely capital goods imports (initial level) and sending tertiary students abroad (growth). The estimates indicate that countries that increase GVC imports tend to grow more slowly than other countries, when a number of other relevant factors are controlled for. Nevertheless, as already noted, these results do not provide information on the direction of causality.

It is possible, however, that this estimate, which is for all countries in the sample, masks quite different relationships for subgroups of countries with common characteristics, such as development level and size. The relatively small sample does not allow for extensive testing of this possibility. Nevertheless, to throw some light on this issue we report in Table 2 a test for the parameter stability across groups of countries by adding to the model dummy variables for membership in the various groups and allowing for their interactions with the increase of GVC imports. All other variables remain the same (third column of Table 1). The dimensions taken into account are income level (as defined by the World Bank), development level (as defined by the IMF), initial capability level (as derived from the factor analysis), geography (continents) and country size (population).[12] The base category is low-income countries in the World Bank classification, developing countries in the IMF case, low-capability countries according to the factor score, African countries in the version with continents and small countries when it comes to size. Along all five dimensions, there are

[12] Countries are assigned to income level groups according to their classification in 1997 by the World Bank (2015) and to development level groups following the classification used by the IMF (1997). Based on the capabilities index in the initial period, as derived from the factor analysis (Table 1), countries are assigned to three groups as follows: i) Low capabilities with the index more than one standard deviation below the mean (15 countries); ii) Medium capabilities with the index within the range of one standard deviation below and above the mean (85 countries); and iii) High capabilities with the index more than one standard deviation above the mean (25 countries). The results are qualitatively similar, if the Medium capabilities group is split into Medium-low (58 counties) and Medium-high (27 countries) depending on whether the index is below or above the mean, respectively. Countries are assigned to a continent, where resides most of the population. Size groups are defined in terms of the initial population reported by the World Bank (2016) as follows: i) Small size with less than 5 mil (40 countries); ii) Medium size with 5 to 20 mil. (45 countries); and iii) Large size with more than 20 mil. (40 countries).

indications of parameter variability, although often not statistically significant at conventional levels. The strongest support for parameter variation is for large and medium-sized economies, countries that are classified as advanced by the IMF and countries with high capabilities. For these country groups the estimated relationship between increased GVC imports and economic growth (i.e., the sum of the estimated coefficient for the base category and the interaction dummy) is close to zero.

The interpretation of these findings is plain. For advanced countries with well-developed capabilities it does not matter much whether they participate in GVCs a little more or a little less. Hence, it appears that when they participate in GVCs, they tend to have sufficient leverage to get their fair share of the economic benefits. This does not hold for countries without such capabilities, however, and not for very small countries either. A possible explanation, then, consistent with the literature on GVCs, would be that firms in these countries have little leverage when it comes to decisions on how to share the economic benefits from the value added created in the GVCs.

Table 2: Testing for differences in the impact of increased GVC imports across country groups

	(1) Income level (World Bank)	(2) Development level (IMF)	(3) Capabilities level (Factor analysis)	(4) Geography (Continents)	(5) Size (Population)
Δ GVC imports	-0.31*** (3.55)	-0.28*** (3.77)	-0.32** (2.02)	-0.35*** (3.20)	-0.42*** (3.81)
Δ GVC imports x Medium income	0.12 (0.89)	..	..	..	..
Δ GVC imports x High income	0.18 (1.34)	..	..	..	..
Δ GVC imports x Transition	..	-0.04 (0.24)	..	..	..
Δ GVC imports x Advanced	..	0.30** (2.02)	..	..	..
Δ GVC imports x Medium capabilities	..	..	0.05 (0.32)	..	..
Δ GVC imports x High capabilities	..	..	0.34* (1.72)	..	..
Δ GVC imports x Asia and Oceania	..	..	..	0.22 (1.49)	..
Δ GVC imports x America	..	..	..	0.23 (1.14)	..
Δ GVC imports x Europe	..	..	..	0.27 (1.60)	..
Δ GVC imports x Medium size	..	..	..	..	0.28* (1.87)
Δ GVC imports x Large size	..	..	..	..	0.33** (2.25)

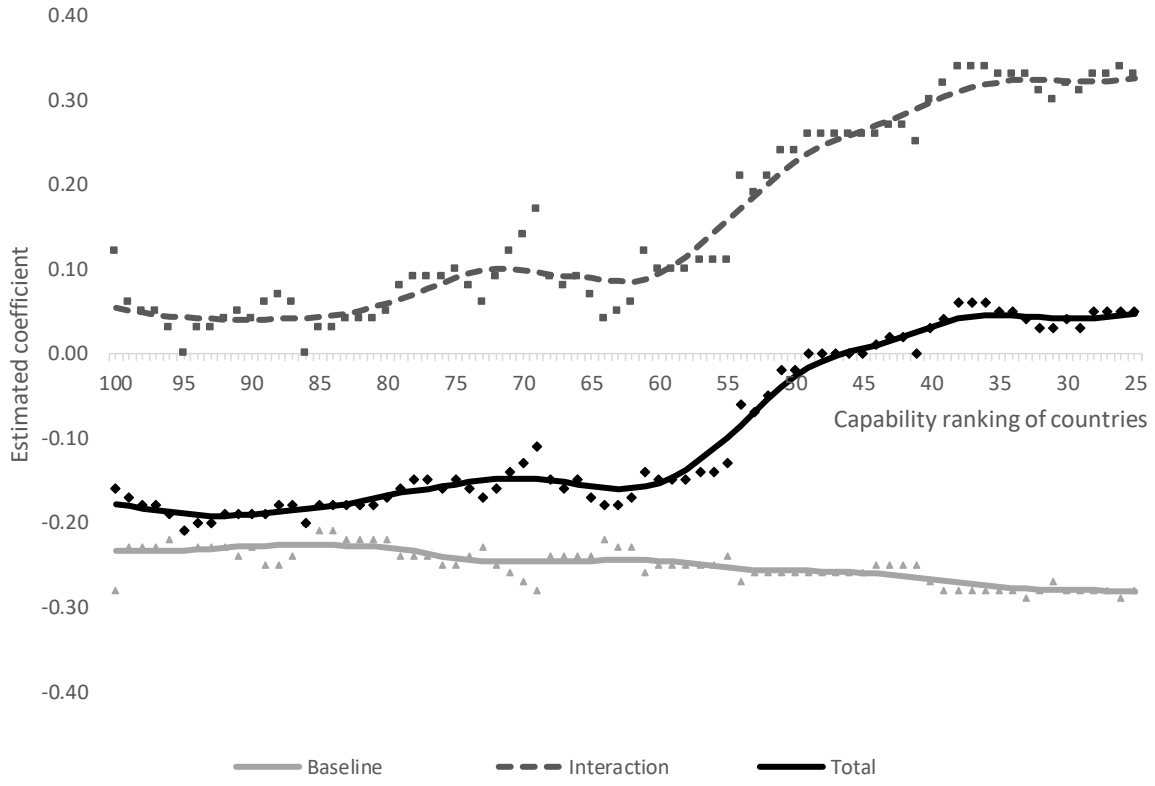
Note: The dependent variable is log difference of GDP per capita (PPP, constant 2011 international USD) divided by the number of years (a log approximation of the annual growth rate). All other variables remain the same as in the third column of Table 1, i.e. in the preferred model, except that the group dummies are added to the regression. Absolute value of robust t-statistics in parentheses. *, **, *** denote significance at the 10, 5 and 1 per cent levels. Beta coefficient of Δ GVC imports reported.

Thus, the results suggest that countries with less-well developed capabilities actually lose from taking more active part in GVCs, but that this does not hold for countries higher up on the capability ladder. An interesting question, then, is at what level of capabilities does GVC

participation starts to make more sense economically.[13] Figure 3 provides a take on this issue. The figure shows (from left to right) how the estimate of an interaction term between the increase of GVC imports and a country-dummy (when countries are ranked by the initial capability level) changes as the number of countries covered by the dummy becomes gradually smaller (i.e., increasingly limited to high capability countries). For example, 75 on the horizontal axis indicates that a dummy for the top 75 countries in terms of capabilities is used in the estimate, etc. The results show that the sample divides in two parts at a medium level of capabilities. For the more capable countries, starting from a level close to the poorest member countries of the European Union (Bulgaria and Romania, for example) or the more advanced countries in Latin-America (such as Argentina, Chile or Uruguay), the relationship between increased GVC imports and economic growth (the sum of the baseline and the interaction term) edges up slightly above zero. However, for less capable countries the relationship remains clearly negative.

[13] We wish to thank one of the editors of this journal for proposing this question.

Figure 3: The impact of increased GVC imports at different capability levels - an explorative analysis



Note: The baseline is the estimated beta coefficient of Δ GVC imports. Interaction is the estimated coefficient of an interaction term between Δ GVC imports and a dummy variable for countries with capabilities exceeding a certain threshold level. Total is the sum of the baseline coefficient and the interaction term. All other variables remain the same as in the third column of Table 1. Smoothed values (the lines) are derived from kernel-weighted local polynomial smoothing (using Epanechnikov kernel function).

As pointed out above, cross-sectional data is not well suited for analyses of the direction of causality. For example, while - as pointed out earlier - the usual assumption is that participation in GVCs affects economic growth, an effect in the opposite direction may not be ruled out. While interesting, this is not an issue that can be explored with the available data. Such problems may also be relevant for some of the other indicators. We tested the robustness of the results with regards to removing the growth of capital goods imports and outbound mobility of tertiary students from the preferred model (Table 1, third column), however, the main conclusions, including with respect to parameter stability, did not change.

[14] Furthermore, multi-collinearity may be a problem in small, cross sectional data sets. A particular concern might be the correlation between GDP per capita and capabilities (see Figure 1 and Appendix A5 for details). Nevertheless, both variables come out with statistically highly significant coefficients and results of the variance inflation factors (VIFs) test confirm that there is not a serious collinearity problem.[15]

5. Concluding remarks

In the 1980s international organizations such as the IMF and World Bank forged the so-called Washington Consensus which emphasized openness to trade and FDI and a hands-off approach with respect to markets as essential ingredients for development. The consensus soon started to crack however, as research indicated that the empirical support for the underlying assumptions was far from robust (Rodrik 1994, Chang 2002, Fagerberg and Godinho 2004).

From the 1990s onwards, a sizeable literature has emerged on the increasing role played by GVCs, coordinated by multinational companies, in the world economy, and the possibilities that participation in such chains may entail for firms in developing countries. As pointed out in the introduction to this paper, the very same international organizations that were behind the now defunct Washington Consensus now actively promote participation in such chains as a way forward for development. The question arises if this is just old wine in a new bottle, or if it represents a decisive new turn in the process of global economic development with significant new opportunities for low-income countries to escape the poverty trap. This paper has attempted to throw new light on the issue, using a framework that also takes into account other factors that may be of importance for growth and development, and data for a broad sample including many low-income countries. Having an extensive country coverage is

[14] Results of these additional tests are available on request.
[15] In the preferred specification (Table 2, third column), mean VIF = 2.91 for the whole model and maximum VIF = 7.18 for the most correlated single variable. For more details on the VIF test see estat vif command in Stata (2017, pp. 2276-2280).

essential for producing reliable evidence on the matter, but the cross-sectional nature of the available data means that the analysis presented in this paper is explorative.

It is certainly true, as shown by e.g., Kummritz and Quast (2016) that participation in GVCs has increased steadily over the last decades.[16] However, as pointed out in section 2, positive effects for all participating countries cannot be taken for granted, because it cannot be excluded that most of the benefits go to the multinationals that coordinate the chains, and that spillovers in the context of developing countries, being pecuniary or technological in nature, are small and possibly less than they would have been had the human and other resources been devoted to something else. The results of this paper suggest that in general countries gain little if at all in terms of economic growth from increasing their participation in GVCs measured by foreign value added in exports. Moreover, the analysis suggests that countries with less-well developed capabilities – about half of the sample analysed here – that increase this form of participation in GVCs perform worse economically than other countries with similar characteristics. The same applies for very small countries. Unfortunately, there are not many other studies that the results presented here can be compared to. But it is noteworthy that Kummritz (2015), using different methods and a smaller sample of countries, also finds that low-income countries do not benefit economically from participating in GVCs.[17]

Nevertheless, the results presented here confirm, in line with other research (Fagerberg and Srholec 2008, 2017), that there is a strong link between developing technological and social capability and economic development. Furthermore, the results suggest that building the innovation system is not only important for economic development more generally, but also for the possibility to benefit from GVC participation. So placing emphasis on improving such factors, i.e., developing the national innovation system, appears to be a fruitful direction for policy. How to do that is a challenging issue that we cannot address in the necessary detail in the present paper. As emphasized in the literature on national innovation systems, specific

[16] Whether this also should be expected to hold in the future is another matter, that we cannot pursue here. See IRC Trade Task Force (2016) for an interesting take on this issue.

[17] Tajoli and Felice (2018) present estimates of a knowledge production function with patenting as dependent variable and R&D spillovers transmitted through GVC participation among the independent variables. Patenting is well known to be a problematic indicator in a developing country context (Fagerberg, Srholec and Verspagen 2010). Nevertheless, they conclude that GVC participation plays a positive role for knowledge transmission, and that this holds also for developing countries. However, their sample include very few developing countries, and not s single low-income country (as classified by the World Bank) or country from Africa.

policy recommendations need to be based upon deep insight in the unique characteristics of the national innovation system (Lundvall et al 2009). Moreover, the different dimensions included in the capability measure employed here might warrant separate attention, as they may be of different importance in countries at different levels of development (Cirera and Maloney 2017).

Several issues raised in this paper merit more research. Better data and longer time series may allow for more elaborate tests, particularly with respect to causality, than those employed in this paper. The time period taken into account here is relatively short and includes a major global economic crisis. It cannot be excluded that this has influenced the results. There may also be long lags in cause-effect relationships that would be easier to detect if longer time series had been available. Moreover, as also suggested in other recent research (Narula 2018, Pietrobelli and Staritz 2018), the questions concerning the role of - and interaction between - building the innovation system and different forms of openness in the process of economic development certainly deserve more attention. Finally, the GVC measure used here is derived from national accounting and does as such not discriminate between different types of governance of the value chains, which remains a challenge for future research (Altenburg 2006, Kaplinsky and Morris 2015).

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Appendix A1: Definitions and sources of the variables

Indicator & definition	*Scaling*	*Source*	*Estimated observa-tions*
GDP per capita: Gross domestic product converted to constant 2011 international dollars using purchasing power parity rates.	USD per capita	World Bank (2016)	0
Scientific and engineering articles: Counts of citable documents recorded in SCImago Journal & Country Rank (based on information contained in the Scopus database).	per mil. people	SCImago (2016)	0
USPTO patent applications: Counts of applications for utility patens filed in the United States Patent and Trademark Office (USPTO) classified by country of residence of the first named inventor.	per mil. people	USPTO (2016)	0
R&D expenditures: Intramural expenditure on research and experimental development (R&D) performed on the national territory.	% of GDP	UNESCO (2016), OECD (2016), Castellacci and Natera, (2011) and national sources	39
Trademark applications: Counts of applications for registration of trademarks filed by residents directly and via the Madrid system.	per mil. people	WIPO (2016)	43
ISO 9001 certifications: Counts of ISO 9001 management system standard certifications.	per mil. people	ISO (2014)	0
Internet users: Internet users are individuals who have used the Internet (from any location) in the last 12 months.	per 100 people	World Bank (2016)	0
Mean years of schooling: Average number of years of education received by people ages 25 and older, converted from education attainment levels using official durations of each level.	years	UNDP (2016)	0
Adult literacy: People aged 15 and over who can read , understand and write a short, simple statement on their everyday life.	% of adult population	UNDP (2016) and World Bank (2016)	2
Bureaucracy quality: An assessment of the institutional strength and quality of the bureaucracy, which represents a shock absorber that tends to limit revisions of policy when governments change.	index	PRS Group (2014)	10
GVC imports: Imported inputs (produced in other countries) accounted in the gross exports of a country derived from input-output tables.	% of GDP	UNCTAD/Eora (2016)	0
Capital goods imports: Imports of capital goods (BEC, rev. 3 categories 41, 51 and 52) derived from trade in goods statistics.	% of GDP	UN (2016)	7
FDI inward: The value of capital and reserves (including retained profits) attributable	% of GDP	UNCTAD (2016)	0

to foreign parent enterprises with lasting management interest, plus the net indebtedness of foreign affiliates to the parent enterprises.			
Outbound mobility of tertiary students: Gross outbound tertiary enrolment ratio given by the number of tertiary students from a given country studying in North America and Western Europe expressed as the percentage of the population of tertiary age in that country.	Gross enrolment in %	UNCTAD (2016)	8
Size (population): All residents regardless of legal status or citizenship (except for refugees not permanently settled in the country of asylum) who are generally considered part of the population of their country of origin.	people	World Bank (2016)	0
Agriculture: Agriculture corresponds to ISIC divisions 1-5 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production.	% of GDP	World Bank (2016)	0
Natural resources rents: The sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents.	% of GDP	World Bank (2016)	0
Tropics: Proportion of land area in Koeppen-Geiger tropics.	share	Gallup et al. (1999)	0
Malaria ecology: Stability of malaria transmission given by biologic characteristics of vector mosquitoes.	index	Kiszewski et al. (2004)	0

Appendix A2: Capabilities: Results of the factor analysis

	Factor loadings
Scientific and engineering articles (per capita)	0.94
USPTO patent applications (per capita)	0.87
R&D expenditures (% of GDP)	0.79
Trademark applications (per capita)	0.76
ISO 9001 certifications (per capita)	0.91
Internet users (per capita)	0.70
Years of schooling (years)	0.80
Adult literacy (% of adult population)	0.68
Bureaucracy quality (index)	0.76

Note: The extraction method is principal factors; based on pooled data in 125 countries in 1997 and 2013, hence 250 observations in total; only one factor with eigenvalue > 1.00 was detected; 0.65 proportion of eigenvalues accounted for by the first factor using the trace of the correlation matrix as the divisor.

Appendix A3: Descriptive statistics

	Mean	St. dev.	Min	Max
Δ GDP per capita	0.024	0.020	-0.036	0.097
GDP per capita	9.071	1.243	6.195	11.609
Capabilities	-0.286	0.950	-2.222	1.520
Δ capabilities	0.036	0.014	0.009	0.081
GVC imports	1.657	0.872	0.284	3.967
Δ GVC imports	0.024	0.023	-0.039	0.089
Capital goods imports	1.955	0.457	0.701	3.280
Δ capital goods imports	0.003	0.025	-0.072	0.076
FDI inward	2.665	0.834	0.486	5.128
Δ FDI inward	0.061	0.054	-0.069	0.272
Outbound mobility of tertiary students	0.542	0.594	0.019	3.294
Δ outbound mobility of tertiary students	0.010	0.018	-0.020	0.088
Size (population)	16.217	1.559	12.510	20.930
Agriculture	2.318	0.975	0.086	4.073
Natural resources rents	1.506	1.129	0.000	3.807
Tropics	1.566	2.020	0.000	4.615
Malaria	0.684	1.016	0.000	3.483

Note: All variables are in logs, Δ refers to log difference divided by the number of years (a log approximation of the annual growth rate).

Appendix A4: List of countries (alphabetically)

Albania	Cyprus	Iran	Morocco	Slovenia
Algeria	Czech Rep.	Ireland	Mozambique	South Africa
Argentina	Cote d'Ivoire	Israel	Namibia	Spain
Armenia	Denmark	Italy	Netherlands	Sri Lanka
Australia	Dominican Rep.	Jamaica	New Zealand	Sweden
Austria	Ecuador	Japan	Nicaragua	Switzerland
Azerbaijan	Egypt	Jordan	Niger	Taiwan
Bahrain	El Salvador	Kazakhstan	Nigeria	Tajikistan
Bangladesh	Estonia	Kenya	Norway	Tanzania
Belarus	Ethiopia	Korea	Oman	Thailand
Belgium	Finland	Kuwait	Pakistan	Togo
Bolivia	France	Kyrgyzstan	Panama	Trinidad and Tobago
Botswana	Gabon	Latvia	Papua New Guinea	Tunisia
Brazil	Georgia	Lebanon	Paraguay	Turkey
Brunei Darussalam	Germany	Lithuania	Peru	Uganda
Bulgaria	Ghana	Luxembourg	Philippines	Ukraine
Burkina Faso	Greece	Macedonia	Poland	United Arab Emirates
Cambodia	Guatemala	Madagascar	Portugal	United Kingdom
Cameroon	Guinea	Malawi	Qatar	United States
Canada	Honduras	Malaysia	Romania	Uruguay
Chile	Hong Kong	Mali	Russia	Venezuela
China	Hungary	Malta	Saudi Arabia	Vietnam
Colombia	Iceland	Mexico	Senegal	Yemen
Costa Rica	India	Moldova	Singapore	Zambia
Croatia	Indonesia	Mongolia	Slovakia	Zimbabwe

Appendix A5: Correlation table

	Δ GDP per capita	GDP per capita	Capabilities	Δ capabilities	GVC imports	Δ GVC imports	Capital goods imports	Δ capital goods imports	FDI inward	Δ FDI inward	Outbound mobility of tertiary students	Δ outbound mobility of tertiary students	Size (population)	Agriculture	Natural resources rents	Tropics	Malaria
Δ GDP per capita	1.00																
GDP per capita	-0.37	1.00															
Capabilities	-0.16	0.83	1.00														
Δ capabilities	0.34	0.05	-0.15	1.00													
GVC imports	0.06	0.50	0.63	0.08	1.00												
Δ GVC imports	-0.13	0.06	0.14	0.00	-0.02	1.00											
Capital goods imports	-0.02	0.28	0.26	0.00	0.63	0.00	1.00										
Δ capital goods imports	0.08	-0.36	-0.28	-0.03	-0.27	0.30	-0.42	1.00									
FDI inward	0.05	0.16	0.16	-0.09	0.39	-0.04	0.47	-0.20	1.00								
Δ FDI inward	-0.02	0.04	0.10	0.16	0.10	0.25	0.06	0.09	-0.47	1.00							
Outbound mobility of tertiary students	-0.28	0.64	0.56	0.03	0.43	0.13	0.41	-0.45	0.22	0.22	1.00						
Δ outbound mobility of tertiary students	0.36	0.03	0.04	0.40	0.19	0.11	0.10	0.08	-0.04	0.24	0.02	1.00					
Size (population)	0.18	-0.25	-0.11	0.06	-0.25	-0.08	-0.59	0.21	-0.24	-0.25	-0.52	-0.17	1.00				
Agriculture	0.36	-0.92	-0.79	0.04	-0.49	-0.08	-0.30	0.31	-0.23	-0.03	-0.60	0.03	0.22	1.00			
Natural resources rents	-0.06	-0.27	-0.57	0.05	-0.42	-0.34	-0.11	0.09	-0.03	-0.28	-0.31	-0.07	0.01	0.30	1.00		
Tropics	-0.01	-0.42	-0.48	-0.11	-0.26	-0.15	0.00	-0.09	0.02	-0.16	-0.29	-0.21	0.14	0.38	0.32	1.00	
Malaria	-0.13	-0.59	-0.61	-0.26	-0.37	-0.05	-0.05	0.16	0.05	-0.14	-0.28	-0.22	0.08	0.46	0.39	0.59	1.00