Global value chains, national innovation systems and economic development

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Abstract

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such as GVC participation, but also technological and social capabilities, is developed. The analysis is based on evidence from 125 countries, including many developing nations, over the period 1997-2013. It is shown that economic growth reflects the strength of the national innovation system and that GVC participation is not the potent driver of economic growth that tends to be assumed.

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 (Fagerberg, Srholec and Verspagen 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) 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 matters for economic development.

Another approach, which also emerged during the 1990s, attacks the issue of openness head on by focusing on participation in so-called "global value chains" (GVC) as a way to promote economic development (Gereffi and Korzeniewicz 1994, Gereffi et al. 2005). It is argued 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), taking the form of global production networks (or value chains) coordinated and led by multinational companies (so-called "lead firms"), and that this may 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).

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.[1] These studies have brought to light many examples of local firms in less developed countries 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 GVC 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 (Eora 2016 and UNCTAD 2013). These data may be used to illustrate the proliferation of GVC.

In this paper we argue that arriving at conclusive evidence on the matter requires a comprehensive framework that allows for the inclusion of a range of relevant factors, including not only different forms of "openness" but also differences in in "technological" and "absorptive" capacity, e.g., the development of the national innovation system, and other relevant factors. In section 2 we discuss how different forms of capability building and

openness to foreign sources of knowledge, including participation in GVCs, interact in 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 forms of openness, and explores the relationship with economic development. It is shown that although several of these variables are correlated with economic development, there is also a lot of diversity in how countries at roughly similar levels of development link up with the global economy. Section 4 of the paper considers, using regression analysis, the extent to which high participation in GVC trade matters for a country's economic performance. The final section is concerned with the lessons from the study and the implications for policy.

2. The roles of knowledge, openness and GVC in economic development

The role of "openness" in long term development has attracted attention for years. A sizeable empirical literature has emerged but has failed to develop robust knowledge on the matter (Fagerberg, Srholec and Verspagen 2010). This may of course have to do with weaknesses in data or methods, for example data on developing countries' participation in GVCs has only recently become available. However, it may also have to do with theoretical shortcomings, notably the lack of a sufficiently comprehensive theoretical framework that allows for the inclusion of both different forms of openness and other relevant factors.

Traditionally, economists saw economic development as resulting from increases in the factors of production, i.e., capital, labour and natural resources that a country possesses. However, when scholars started to research the reasons behind the large differences in levels of economic development globally, they soon realized that very little of the observed differences could be explained in this way (Abramovitz 1956, Solow 1956). Today it is generally acknowledged among economists 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 mechanisms 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. Foreign direct investments (FDI) is another potential channel of knowledge transfer that may generate positive spillovers to other domestic firms. Studies of such spillovers demonstrate that the main beneficiaries are enterprises with in house capabilities and regions with a reasonably strong knowledge base (Bell and Marin 2004, Fagerberg, Srholec and Verspagen 2010). Participation in international trade, for example

importing capital goods (Gomulka 1971), may contribute to knowledge transfer. Finally, knowledge may also be embodied in people, i.e., skilled workers and experts moving across national borders (Saxenian 2006). Sending students to study abroad may be seen as one way to strengthen the domestic knowledge base. Common for these different channels of knowledge flow 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.

Participation in GVCs is a particular form of openness to trade in which knowledge transfer takes place in a more or less organized manner under the supervision of so-called "lead firms" governing the activities of the chain (Gereffi, Humphrey, and Sturgeon 2005).[2] 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). The dominance of the main 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 the case studies 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).[3] For example 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 about 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 precaution 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 the trade in intermediate goods takes place between enterprises located in high income countries and within supranational regions (Europe, Asia and Africa) rather 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,[4] it is not obvious that this holds to the same extent for firms located in low income countries with a weak national innovation system. Arguably, enterprises from such countries may be expected to be weak players in GVC dominated by multinational oligopolies. Hence, it cannot be excluded that a major part of the economic value created goes to other parts of the value chain with more leverage. 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.[5] Furthermore, if the enterprise, while upgrading products and processes, remains 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. Several studies indicate that strong local capabilities are required for deriving substantial benefits from joining GVCs (Giuliani, Pietrobelli and Rabellotti 2005, Fu, Pietrobelli and Soete 2011).

It is clear from the discussion that knowledge, including openness to foreign sources of knowledge, is essential for economic development. However, it is also evident that there are several different channels for acquiring knowledge, and that the ability to successfully exploit these depends on domestic capability-building. Therefore, to get a better grasp on the role that openness plays in economic development, a broad framework including not only various sources of openness but also domestic capability-building and other relevant factors is required.

3. A preview of the data

This section is concerned with the empirical operationalisation of the factors discussed above, i.e., capabilities and openness, 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.[7] Further details on definitions and sources can be found in Appendix A1.

As concerns capabilities, we take into account nine different indicators (see Table 1) 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 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".

Table 1: 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.

For the purpose of the analysis the nine selected capability indicators are weighed together into a composite measure using factor analysis (Table 1). 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. All poor countries generally have very low capability levels. Furthermore, resource-rich countries tend in some cases to have far higher GDP per capita than their capability levels would indicate.

Figure 1: GDP per capita and Capabilities, average 1997 and 2013
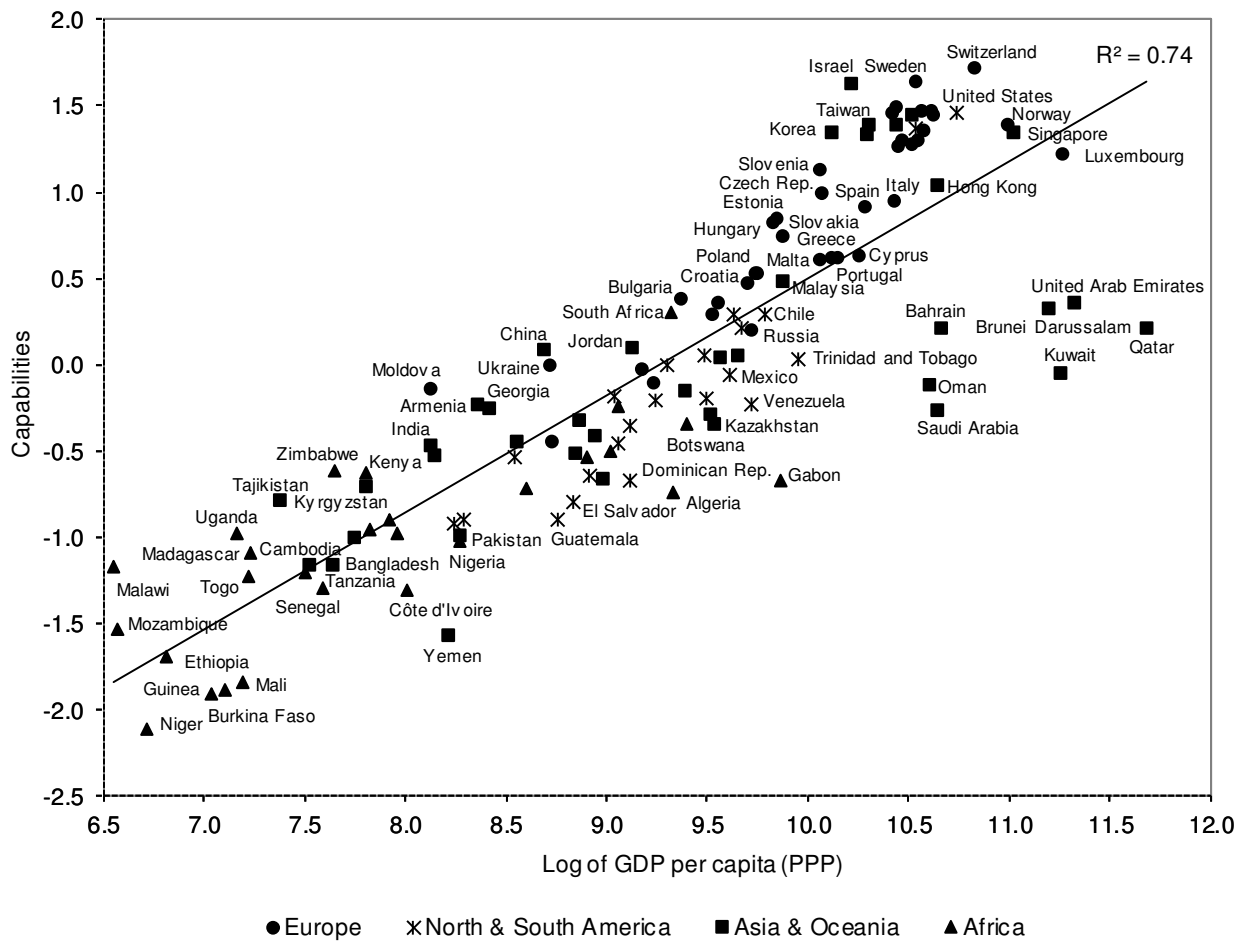
At the centre of our interest is to measure how participation in GVCs relates to economic growth. Until recently trade statistics were only available in terms of gross exports and imports, hence reflecting sales, not value added. UNCTAD jointly with OECD have put great effort to trace how intermediate products move between countries using detailed data on international transactions recorded in input-output tables, resulting in the UNCTAD-Eora GVC Database (Eora 2016). The data allows for the calculation of a measure of GVC participation – that we call GVC imports - reflecting the extent to which a country's exports contains inputs (or value added) produced in other countries (e.g., assembly of foreign-produced parts for exports). Another possible measure of GVC participation is the share of a

country's exports that consist of goods for further processing and export by other countries (GVC exports).[9] However, for developing countries this primarily reflects their traditional roles as exporters of raw materials, which, although interesting, is not central to the literature on GVC participation and economic development and thus the theme of this paper. This study therefore only uses GVC imports to measure GVC participation.[10]

Figure 2 plots GVC participation against GDP per capita. The figure reveals that participation in global value chains is positively correlated with economic development. But there is also a lot of variation across countries in this respect, and the degree of variation appears to increase as countries get richer. Hence, it is not obvious that there is one single model that all countries have to pass through - or converge towards - in the process of development.

Figure 2: GDP per capita and GVC participation, average 1997 and 2013
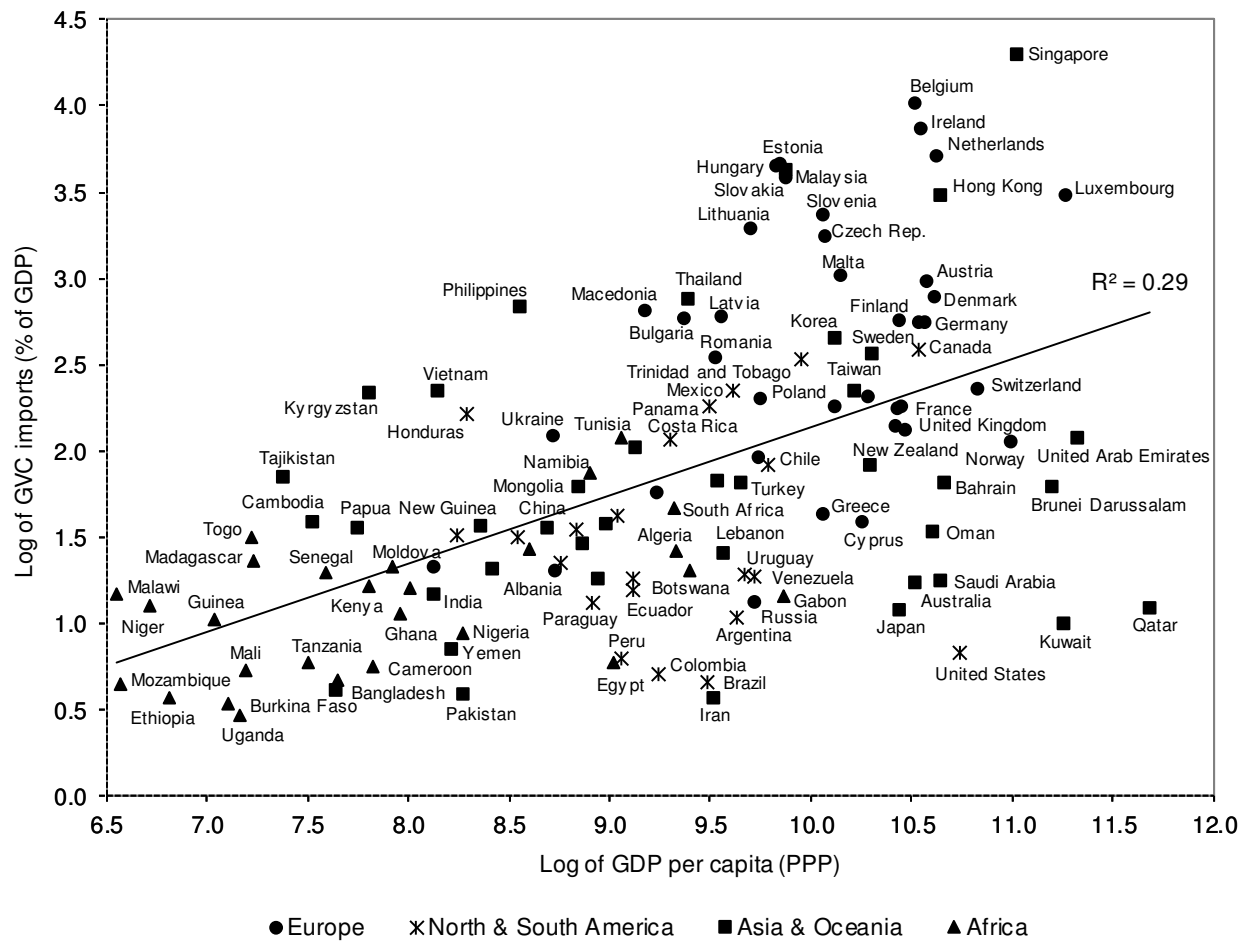
Moreover, as pointed out earlier, there are other channels of openness that countries may exploit and that need to be taken into account. Figures 3-4 contain some basic information on three openness-channels (in addition to GVC participation) emphasized in Section 2 that we have been able to find data for, namely capital goods imports[11]; foreign direct investments (FDI inward); and the ability to tap into advanced education systems abroad (outbound mobility of tertiary students). Unfortunately, there were no data for migration of highly skilled personnel that could be exploited in the analysis.[12]

Figure 3: Openness indicators, level in 1997
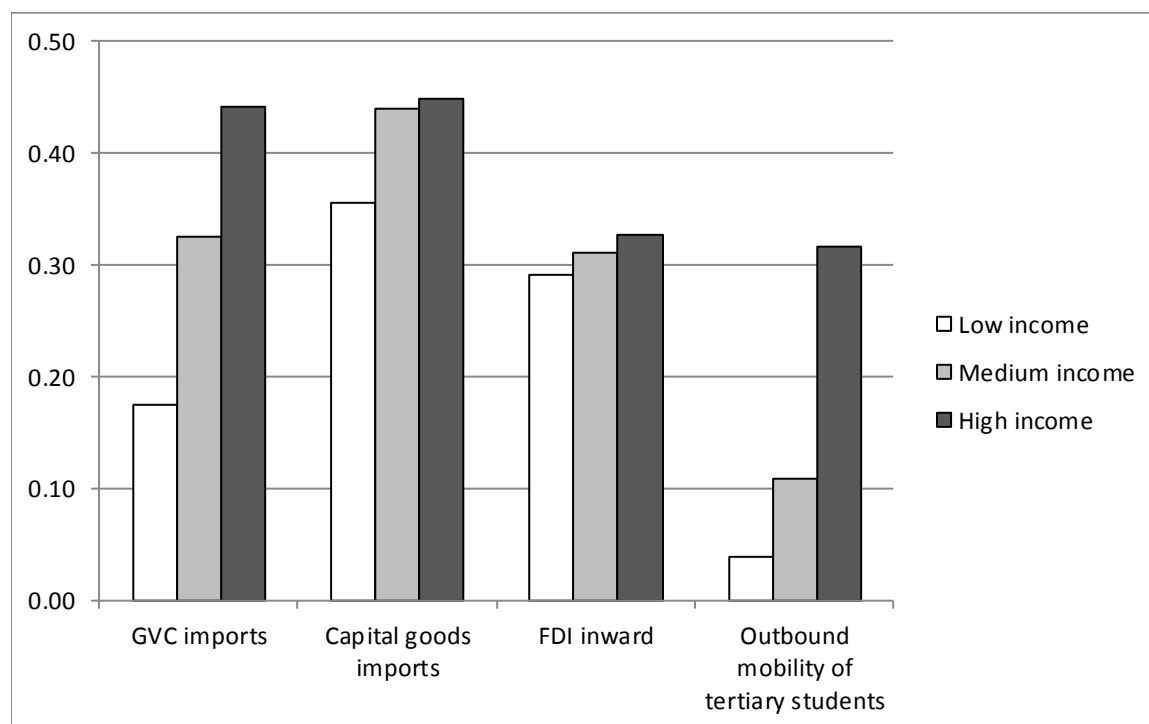
Note: Because of different measurement units, the indicators are rescaled to the range between 0 (minimum) and 1 (maximum). Countries are assigned to income groups according to their classification in 1997 by the World Bank (2015).

Figure 4: Openness indicators, growth between 1997 and 2013
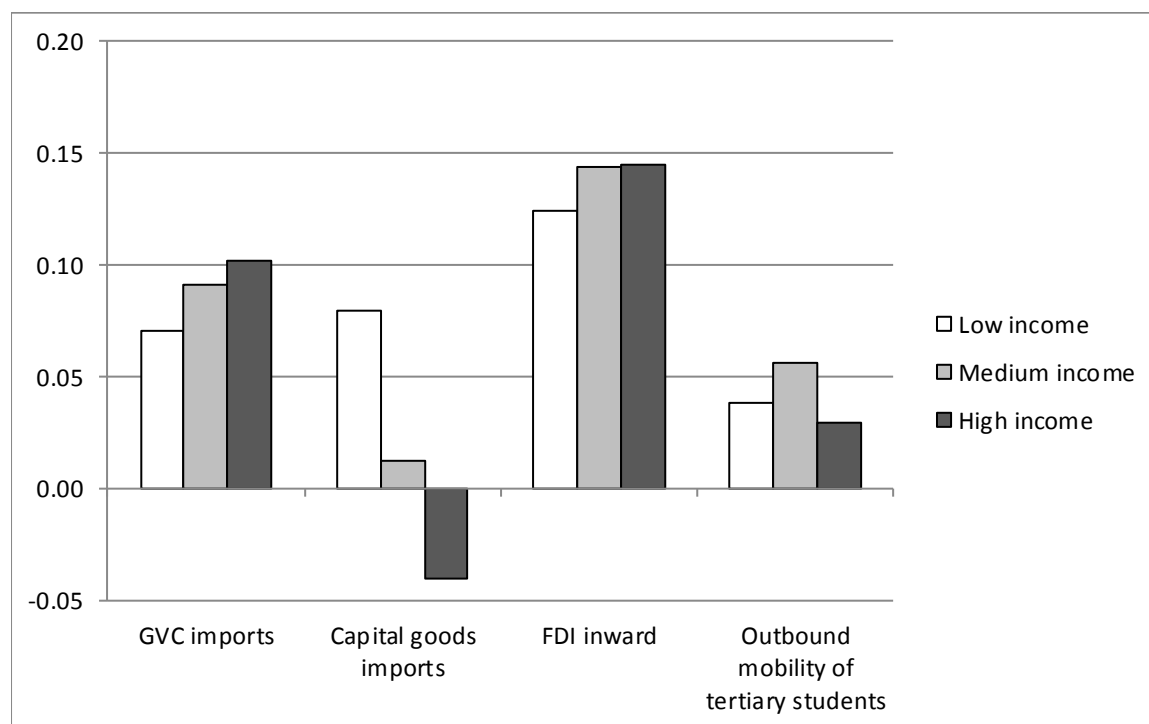
Note: Because of different measurement units, the indicators are rescaled to the range between 0 (minimum) and 1 (maximum). Countries are assigned to income groups according to their classification in 1997 by the World Bank (2015).

Figures 3-4 confirm that GVC participation is much higher in the rich part of the world than in poorer countries. Moreover, as Figure 4 shows, this pattern is reinforced over time. Sending students abroad is also much more common in rich countries. However, it is growing somewhat faster in countries on a low and in particular medium income-level. For capital goods imports and inward FDI, the differences across countries are much smaller, and there is a tendency towards reduced differences over time. Thus, the openness-indicators taken into account are characterized by quite different distributions and trends.

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 different forms of openness to foreign knowledge have an impact. Moreover, knowledge-based growth is not only about exploiting foreign knowledge, 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.

Above we looked at the relationship between levels of openness and levels of economic development. In this section we will look at a dynamic version of that relationship, hence the correlation between levels and changes in openness and changes in economic development.

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

(1) y = a$_0$ + a1Y$_{-1}$ + a$_2$O +a$_2$o + a$_3$C + a$_4$c +a$_5$F,

where *Y/y* is level/growth of GDP per capita. O/*o* is level/growth of openness (measured in various ways). As mentioned above, in addition to GVC imports we also include capital goods import, inward FDI and tertiary students abroad. *C/c* is level/growth of relevant national 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, industrial structure, disease ecology, and nature.[13] All variables are in logs, as already noted above, thus growth refers to log difference

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(a log approximation of the growth rate).The sample includes 125 countries between 1997 and 2013.[14]

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 from benefitting 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 2. OLS robust to outliers is used in the estimates based on the procedure suggested by Li (1985). The first column in Table 2 reports estimates of the model without controls, while in the second column 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.

Table 2: 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). Absolute value of robust t-statistics in parentheses. *, **, *** denote significance at the 10, 5 and 1 per cent levels. Beta values reported.

The results suggest that capabilities, whether measured by initial level or subsequent growth, have a strong, positive effect on growth of GDP per capita, and the estimated impact is quite robust with respect to changes in specification. However, only two of the eight forms of openness taken into account in the test can be shown to affect economic growth positively, namely capital goods imports (initial level) and sending tertiary students abroad (growth). The estimated impact of GVCs participation is significant and negatively signed, indicating that countries that engage more actively in GVCs tend to be worse off compared to other countries with similar characteristics.

Since the findings with respect to the impact of GVC participation on economic development may be contrary to common wisdom, Table 3 reports a test for the parameter stability across various groups of countries as customary defined. All other variables remain the same (third column of Table 2). The dimensions taken into account are income level (as defined by the World Bank), development level (as defined by the IMF), geography (continents) and country size.[15] The coefficient reported in the first row is for the base category, which is low-income countries in the World bank classification, developing countries in the IMF case, African countries in the version with continents and small countries when it comes to size. The results indicate that in all four cases increased GVC participation makes the countries in the base category worse off economically, and the negative estimate is in all cases strongly significant. Nevertheless, along all four dimensions there are some indications of parameter variability, although not always statistically significant at conventional levels. The strongest support for parameter variation is for advanced and large countries. However, the difference is not sufficiently large to make a convincing case for a positive effect of increased GVC participation for any country group. At best it becomes close to zero.[16]

Table 3: Testing for differences in the impact of increased GVC imports across country groups

	(1) World Bank	(2) IMF	(3) Continents	(4) Size
Δ GVC imports	-0.31*** (3.55)	-0.28*** (3.77)	-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 Transition	..	-0.04 (0.24)	..	..
Δ GVC imports Advanced	..	0.30** (2.02)	..	..
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). All other variables remain the same as in the third column of Table 2, i.e. in the best 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 values reported.

Reverse causation (a feedback from dependent to independent variables) cannot be excluded. But there are good empirical and theoretical grounds to assume that developing the national innovation system (improving capabilities) and increasing participation in GVCs drive growth rather than the other way around. Endogeneity may be more likely for the   other openness indicators taken into account in the model, for instance, economic growth may have a positive impact on the propensity to study abroad. We therefore 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 2, third column), however, the main conclusions, including with respect to parameter stability, did not change, which is reassuring.[17]

5. Conclusions

The importance of "openness" for economic development has been a hotly debated topic in applied international economics and development studies. In the 1980s international organizations such as IMF and the 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. In fact, a fair reading of the evidence suggests that during the last half century very few countries globally succeeded in making the transition from low to high income, and that the policy approach adopted in these countries differed fundamentally from the Washington Consensus (Rodrik 1994, Chang 2002, Fagerberg and Godinho 2004).

From the 1990s onwards a sizeable literature has emerged on the increasing role played by GVC, coordinated by multinational companies, in the world economy, and the possibilities that participation in such chains may entail for developing countries. 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 (World Bank 2017). The question arises if this is just the Washington Consensus in new tapping, 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 importance for development, and data for a broad sample including a fair number of developing countries. Arguably, having a broad framework and country coverage is essential for producing reliable evidence on the matter.

It is certainly true, as shown in this paper, that participation in GVC has increased steadily over the last decades.[18] 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 developing country, being pecuniary or technological in nature, are small and possibly less than they would have been had the human and other resources from the developing country been devoted to something else. Gereffi, a pioneer in research on GVC, may well be right when he argues: "Globalization's benefits will continue to be unevenly distributed, with its gains going to those with more education, skills, wealth, and power." (Gereffi and Fernandez-Stark 2011, p. 37).

The results presented in this paper suggest that for developing countries the increased participation in GVC is not the potent driver of growth that international organizations such as the World Bank tend to assume.[19] Thus it appears that the evidence behind policy recommendations urging low income countries to engage in GVC controlled by foreign multinationals may not stand up to scrutiny. This does not mean that the analysis undertaken here is lacking with respect to implications for policy. 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. So placing emphasis on improving such factors, i.e., developing the national innovation system, seems to be the right direction to go.

This being said there are several issues raised in this paper that merit more research. For example, the question raised in this paper concerning the role - and interaction - of different forms of openness in the process of economic development certainly deserves further scrutiny. Moreover, 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 (Gereffi et al 2005), this clearly requires more attention. Another intriguing question is that, although GVC participation may not be a super highway to prosperity for the entire developing world, it may still be the case that it works for a more limited set of countries with specific characteristics, if so which (and why)? Finally, the perhaps most challenging question of all is, who gains from this process both at the macro and the micro levels, and what is the appropriate research design for revealing the answer to that question?

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Appendix A1: Definitions and sources of the variables

Indicator & definition	Scaling	Source	Estimated observations
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	Eora (2016) and UNCTAD (2013)	0
Capital goods imports: Imports of capital goods (BEC, rev. 3 categories 41, 51 and 52) derived from trade in goods statistics.	% of GDP	United Nations (2017)	7

FDI inward: The value of capital and reserves (including retained profits) attributable to foreign parent enterprises with lasting management interest, plus the net indebtedness of foreign affiliates to the parent enterprises.	% of GDP	UNCTAD (2016)	0
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

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

[2] Gereffi's distinction between producer driven and user driven value chains has inspired a discourse on 'governance' among GVC-scholars. Gereffi, Humphrey and Sturgeon (2005) propose five different modes of governance: Hierarchy, Captive, Relational, Modular and Market. It is assumed that the further down we get on this list, the less is the element of dominance of the lead firm.

[3] 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).

[4] 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).

[5] The well-documented case of shoe-making in Sinos Valley, Brazil illustrates this problem (Schmitz 1995 and Schmitz 1999).

[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.

[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, the study by Fagerberg and Srholec also contained a rich set of indicators on governance and institutions, which in their study factored out in separate dimensions.

[9] GVC exports are not included in Eora (2016) but are available from Foster-McGregor et al. (2015).

[10] Although we consider GVC-imports to be the indicator that gets closest to the phenomenon studied in the literature on global value chains, the sources underlying the construction of the indicator contain no information on how the value chains are governed. For example, we are not aware of any method to separate, say, semi-hierarchical and hierarchical transactions from market transactions in the statistics.

[11] We use imports of capital goods - rather than total imports - partly because imports of capital goods is often cited as an important channel for knowledge transfer (see, e.g., Gomulka 1971) but also because using total imports would entail double-counting (since GVC imports is a sizeable part of total imports).

[12] Payments for import of proprietary knowledge through licenses etc could not be taken into account separately either since it is included in GVC imports.

[13] 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.

[14] The reader is referred to Appendix Table A1 for details on definitions and sources of the variables included in the analysis.

[15] Countries are assigned to income 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). Size groups are defined in terms of the initial population as follows: i) small with less than 5 mil (40 countries); ii) medium with 5 to 20 mil. (45 countries); and iii) large with more than 20 mil. (40 countries).

[16] The same test of parameter stability was also conducted for the initial level of GVC imports and similar conclusions were reached, albeit most of the differences did not turn out to be statistically significant at the conventional levels; the results are available upon request.

[17] Results of these additional tests are available on request.

[18] 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.

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[19] 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, also finds that low-income countries do not benefit economically from participating in GVC.