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Global Value Chains and Upgrading: What, When and How?

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Global Value Chains and Upgrading: What, When and How?[1]

Padmashree Gehl Sampath and Bertha Vallejo[2]

Abstract

This paper focuses on explaining how technological capabilities interact with trade and GVCs participation to foster upgrading. We analyse trade performance of 74 developing countries in 2000 and 2010 from a perspective of learning, to understand what variables account for technological diversification over time when countries trade, including through GVCs. We find that technological capabilities not only condition the initial determination of local firms in trade and GVCs, but they also determine the extent to which local firms in developing countries manage to leverage knowledge flows and move into activities of greater technological complexity from a dynamic perspective. Our results point to the critical role of national learning variables in countries' performance over time. While emerging economies have synergistic relationships between variables that explain technological capabilities and their trade and GVC performance, this is not the case for developing countries as whole in our sample.

Keywords: Trade, global value chains (GVCs), technological capabilities, learning, developing countries, least developed countries (LDCs), structural change, diversification, policy.

JEL Codes: F14, L14, L16, L23, O14, O19, O25, O31, O33, O43.

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1 Introduction

Global value chains (GVCs) have become the central mechanism for trade and investment in the world economy today. According to recent estimates, not only is production unprecedentedly fragmented, it is mostly conducted within GVCs that accounted for 85% of total global trade in 2016 (UNCTADStat, 2017). By segmenting production processes from conceptualisation and R&D to production, assembly and distribution, GVCs reorganise production and reduce the emphasis on *creating final products and processes* within any specified geographical space, making it possible for firms to engage in *particular activities* where they may have a niche expertise. A vertical fragmentation of production occurs in the value chain, whereby the lead firm (at the top of the chain) commands a variety of inputs from other suppliers all the way down the chain.

The re-organisation of production through GVCs changes the dynamics of innovation and capabilities building in a significant way, by introducing inter-firm linkages as a predominant channel of knowledge flows. It transforms international trade dynamics from one that operates predominantly at the level of countries, to one between firms, where each firm adds value in a sequential fashion or trades in inter-mediate products that operate as inputs to final products elsewhere globally (Flento & Ponte, 2017; Sturgeon & Ponte, 2014). A new actor - the lead firm - is of tantamount importance, upending the production processes as we knew them in the traditional sense, structuring new forms of inter-firm relationships along the chain that can enable firms from developing countries to not only gain access to international markets, but also learn through better access to technologies (Gereffi, 1999; Pietrobelli, 2008; Pietrobelli & Rabelloti, 2011).

These changes carry profound implications for all countries in general, and developing countries in particular, given the central role of technological change for industrial growth, catch-up and economic development (Johnson & Noguera, 2012; Suder, Liesch, Inomata, Mihailova, & Meng, 2015). The GVCs literature has focused on many aspects of this dynamic, looking at how fragmentation of production impacts upon industry organisation and employment, but the research has predominantly emphasised these results for developed countries (Foster-McGregor, Kaulich, & Stehrer, 2015; Gereffi, 1999). Such studies tend to assume that lead firms generally have positive impacts on other firms that participate in GVCs in terms of enabling them to upgrade and supply products and services to global markets (Gereffi, 1999; Sturgeon, van Biesebroeck, & Gereffi, 2008).[3]

Extending the analogy further, more recent GVC analyses have argued that GVCs could present a rare option for local firms and suppliers to not only access new markets, but also to access new technologies (Pietrobelli, 2008), identifying different kinds of upgrading possibilities that such chains offer (Humphrey & Schmitz, 2000). It has been proposed that GVCs may provide an ideal option for smaller firms in developing countries to gradually upgrade and climb up the industrial production ladder, instead of struggling to build capabilities to master entire production systems (Baldwin, 2012). It has also been suggested that GVCs can open up several venues for technology transfer, by enabling local firms to enter to certain production networks that open them up to new business practices, management methods and organisational skills, apart from enabling them to engage in technological upgrading (see Gereffi & Fernandez-Stark, 2010a, 2010b; Hernandez et al., 2014).

[3] For a critique of this, see Morrison, Pietrobelli, and Rabelloti (2008).

Despite the broader appeal of this argument, these effects cannot be generalised since much of the work on GVCs in developing countries takes the form of case studies of firms in different sectors.[4] Studies of this nature often shed light on how firms in developing countries have been able to use access to GVCs to upgrade their technological capabilities; but the inferences can differ based on the countries/ sectors in question. For example, studies of GVCs in East Asian countries find that local firms were able to leverage learning from GVC participation to extract sector and economy-wide effects (see for example, Estevadeordal, Blyde, Harris, & Volpe, 2013; Feenstra & Hamilton, 2006; Lee, 2013). These conclusions are somewhat at odds with many other case studies of GVCs in other developing countries that shed light on difficulties for upgrading Dolan et al, 1999; (see for example, Baffes, 2006; Gereffi, 1999; Gibbon & Ponte, 2005; Ponte, 2002). Additionally, some recent reviews on GVCs on technological change in least developed countries (LDCs) have voiced concern that the emphasis of GVC participation on static comparative advantages can lead to locking in LDC suppliers into low-value added activities in certain primary sectors (UNCTAD, 2013, 2016; UNECA, 2014).

Hence, it is not only that existing evidence does not provide the basis to draw uniform conclusions on what forms of inter-firm relationships matter most to leverage knowledge flows and learning, but it also does not shed light on the circumstances in which such beneficial effects might materialise (De Marchi, Giuliani, & Rabelloti, 2015). What is clearly missing in the GVCs approach is an understanding of the upgrading process itself (Bell & Albu, 1999) and how this is conditioned by the capacity of local firms/ actors to absorb knowledge within such chains. This paper tackles this as its central research question: how do pre-existing technological capabilities of countries shape the ways in which local firms participate in GVCs, and interact to benefit from knowledge and learning opportunities opened up by GVCs?

Given that GVCs are (a) mostly structured around products/ services for which there is a continuous, foreseeable demand, and (b) allow participation of firms based on their pre-existing capabilities, from a static perspective, it would be normal to assume that firms integrate into value chains from the perspective of their current comparative advantages. But technology tends to be highly localised in regions that have diversified production structures, and diffusion through international transactions is slower, and dependent on a number of in-country factors that dictate and shape local technological capabilities. In this paper, therefore, we argue that not only do technological capabilities condition the initial creation of the inter-firm relationships in the GVCs (thereby shaping the power relationships in chains that GVCs literature has focused on), they also determine the extent to which such inter-firm relationships leverage knowledge flows over time and help countries and firms to upgrade and move up the value chain, from a dynamic perspective. We propose that approaching these issues from the perspective of learning and technological capabilities building can provide a better assessment of the circumstances in the beneficial effects of GVCs for learning can materialise.

We argue that technological capabilities not only condition the initial creation of the inter-firm relationships in the GVCs (thereby shaping the power relationships in chains that GVCs literature has focused on), but they also determine the extent to which such inter-firm relationships leverage knowledge flows over time and help countries and firms to upgrade and

[4] Some key GVCs that have been explored previously include coffee in Columbia, Uganda and Ethiopia; horticulture/ cut flower sectors in Kenya, Tanzania, Ethiopia; garments in Bangladesh and Cambodia; and the electronics industry in East Asia. See for example Baffes (2006); Gereffi (1999); Gibbon and Ponte (2005); Ponte (2002).

move up the value chain, from a dynamic perspective. We propose that approaching these issues from the perspective of learning and technological capabilities building can provide a better assessment of the circumstances under which the beneficial effects of GVCs for learning can materialise.

We use trade data (trade in manufactured goods classified into technological export categories using the Lall classification) to look at how capabilities of developing countries dictate their ability to create value-added. We acknowledge that trade in intermediate products is not the same as GVCs participation; however, we use this approach to (a) understand the interaction between local learning variables, the development of technological capabilities to export in different sectors, and the ability of countries to benefit from integration into trade and GVCs,[5] and (b) to cover as many developing and least developed countries to derive broader results on how and under what circumstances trade and GVCs can lead to learning and upgrading.

The empirical analysis uses the variables on manufacturing value added, exports of countries in different technological sectors, and variables that proxy for learning over time. We derive these variables from theoretical underpinnings of innovation studies, which argue that (a) technological learning in countries is the result of the process of accumulating capabilities, both embodied in machinery and equipment and in people in the form of tacit know-how and skills and (b) such capabilities shape the ability of local firms to engage in collaborations of the kind that lead to upgrading (see among others, Lall, 1992, 2004). Section 2 of this paper discusses the relationship between GVCs, upgrading, technological capabilities and economic development, zooming in on the key variables important for this investigation. In our empirical analysis in Section 3, we construct a dataset of 78 developing countries for all these variables. But data inconsistencies in the developing countries affects the creation of an even panel over time, and in order to ensure that this does not adversely impact the results, we run the regressions for two years as two snapshots, namely, 2000 and 2010 to draw conclusions on how and which learning variables impact the technological export categories in which countries export over time. Our findings suggest a synergistic relationship between the opportunities for upgrading presented by GVCs and local technological capabilities. We find that in the case of those countries that use trade and GVCs participation to develop a diversified technological base, their increased ability to generate MVA and outperform is parallel shaped by a number of in-country institutional factors that help them to continuously learn and develop technological capabilities that benefit them. Section 4 discusses the results and Section 5 presents the broader implications of our findings.

2 Understanding GVCs and upgrading in the broader context of economic development

Economic development results from structural change in the economy that shifts labour from low productivity activities (such as traditional agriculture) towards activities that have higher productivity levels (Ros, 2000). This indispensable process, at the heart of economic catch-up, is not as simple as it sounds. 'Successful' structural change involves not only diversifying activities but adopting and adapting existing technologies and climbing the

[5] Since at least 85% of trade takes place through GVCs, we use this as the option rather than to construct the data from a different source.

technology ladder by continuously upgrading production structures in key sectors of manufacturing (Amsden, 2001; Gerschenkron, 1962).[6]

In classical economic literature, manufacturing is considered crucial to upgrading and learning because technological complexity varies from sector to sector. Not only are there are significant differences in production processes across low, medium, high technology sectors that have rather large implications for how firms learn and how such learning diffuses within the economy (Kaldor, 1981; Lall, 1992; Keith Pavitt, 1986; Prebish, 1950), but also, some forms of learning seem to be more important to build and sustain technological capabilities that sustain diversified production structures. Particularly, when learning takes place in technological domains of design and engineering activities (which are the backbone of medium technology sectors), it leads to synergies and spillovers in a broader spectrum of manufacturing activities in the local economy (Hobday, 1998; Nelson, 1993). Over time, these synergies lead to diversified activities in many sectors, helping to transform industrial production entirely mainly as a result of steeper learning curves that these sectors entail, along with rapidly falling costs and growing domestic markets. Studies on industrial catch-up have consistently highlighted how countries that succeed do so because they embark upon this process, which accounts for how they eventually close the gap with the technological frontier (Cimoli, Dosi, Nelson, & Stiglitz, 2006).[7]

Within this broader narrative, trade opportunities – especially those through GVCs - offer a critical learning and upgrading opportunity for local firms to engage in technological efforts and tap into the lack of demand for innovative products in the global economy. But the links between GVCs, learning and upgrading do not seem to be straight-forward.

2.1 GVCs and upgrading: what we know until now

When firms in developing countries integrate into existing trading patterns, there is ample leeway for them to upgrade horizontally into other sectors (that demand a similar level of technological intensity), or vertically into technological intensive sectors, or stay put in the same sector. The GVCs literature does consider the notion of upgrading at length, but it does so predominantly in the context of 'governance' of chains; namely, the kinds of relationships that develop in the value chain and how they impact on development. In the GVCs approach, governance is seen as a critical element in value chains that affects market access, determines fast track to the acquisition of production capabilities, dictates distribution of gains, and suggests various policy entry points to change GVC-related outcomes (Humphrey and Schmitz, 2001). In general, five key forms of GVC governance are identified – market, modular, captive, relational and hierarchical (see Gereffi, Humphrey, & Sturgeon, 2005). The literature identifies the different kinds of governance structures in GVCs, and the kinds of upgrading they facilitate.

Humphrey and Schmitz (2000, pp. 3-4) provide the most basic template that has been used extensively in GVC studies, classifying upgrading into: process upgrading, product upgrading and functional upgrading. While process upgrading involves minor changes, product upgrading (changing into the production of new products) or functional upgrading

[6] There is an underlying process of 'cumulative causation' that reinforces and increases the pace of economic growth, whereby industrial expansion creates employment, incomes and demand on the one hand and leads to increased productivity on the other (Hirschman, 1958; Myrdal, 1957).

[7] See also studies on the cases of China's electronics and telecommunications equipment (Rodrik, 2003); South Korea's semiconductor and automobile (Mathews & Cho, 2000); Taiwanese computers and telecommunications (Amsden, 1989).

(changing into new functions within the GVC) require greater capabilities on part of the local firms (see also Bazan & Navas-Aleman, 2004). A fourth form of upgrading – inter-chain upgrading –offers the possibility of a firm upgrading its products to move into an associated value chain (Pietrobelli & Rabelloti, 2011).

But in general, the concept of upgrading remains somewhat vague in the GVCs literature, and as Morrison et al (2008) note, it is often unclear whether it is the result of learning and denotes innovation or something that results from existing capabilities to innovate using inputs, inter alia, those available through GVCs. More recently, scholars have sought to address this gap by focusing on explaining upgrading in the context of innovation capacity and knowledge accumulation. Pietrobelli and Rabelloti (2011), for example, link the different forms of governance with differential upgrading prospects for developing countries arguing that modular and relational GVC governance forms may open up wider opportunities for knowledge-based upgrading when compared to captive or hierarchical GVCs, such as those in the commodities or low technology sectors. While this might help explain some aspects of what happens when firms are inserted into particular value chains depending on the sector in question, all insertion into GVCs do not carry positive outcomes for learning and upgrading for a variety of reasons (see Morrison et al., 2008), and as many of the existing studies show, knowledge is increasingly becoming an invaluable asset in value chain governance (WIPO, 2017). It seems more plausible that while some local firms manage to upgrade, others lag behind and even face marginalisation and exclusion within existing GVCs (see Gibbon & Ponte, 2005, p. 138).

The question then is, what then differentiates the successful local firms that learn and upgrade through GVCs creating greater inter- and intra-sectoral spillovers as the East Asian case studies show, and what sets them apart from other firms in countries/ cases where this is not the outcome. Can all of these alternate GVC scenarios where upgrading does not materialise be pinned down to its governance characteristics? Not only would this be too simplistic; it would also not suffice to explain the change in governance structures within GVCs of the kind observed in GVCs in the East Asian economies, where firms managed to move up the value chain ladder and change their relationship not only with the lead firm, but also with all the other firms along the supply chain.

2.2 The relevance of a technology capabilities perspective

The difficulties in explaining many of these causalities in a clear way has led to many scholars question the traditional, rather 'linear' paradigm of GVCs, arguing that many of such processes are non-linear in nature (Horner & Nadvi, 2018). Indeed, from a developing country perspective, learning through GVCs and diversifying export structures are critical stepping-stones for local enterprises to engage in technological efforts because they help to bridge the lack of demand for innovation that is often pervasive in developing countries. But how firms expand, learn and prosper within GVCs is not just a matter of the GVC itself, but it is the result of the dynamic interactions between the firm and the value chain on the one hand, and the firm and its local innovation system that dictates its technological capabilities on the other.

Technology capabilities, simply put, are those competencies that shape the ability of actors to master and use existing technologies to routine or new production processes. They dictate learning and allow actors to innovate. Several useful taxonomies on technological capabilities exist in the literature (see Bell & Pavitt, 1993, 1995; Lall, 1992 among others; 2001; K. Pavitt, 1984). The compelling argument of the technological capabilities approach is that dynamic comparative advantages of firms depend much more on the ability of actors to master the technologies, as shaped by a number of factors within the local innovation system. In general, the literature defines and classifies technological capabilities in several categories that follow a rough order of complexity. They position knowledge and skills as the core elements of five functional categories (Oyelaran-Oyeyinka & Gehl Sampath, 2007):

Production and manufacturing capabilities: These refer to knowledge and skills used in plant operation for production management; production engineering, and repair and maintenance of physical capital.

Investment capabilities: These are knowledge and skills needed to undertake the functions of identification, preparation, design, setting up and commissioning of new industrial projects, or the expansion and/or modernisation of existing ones. This category includes pre-investment capabilities and project execution capabilities.

Re-design and product modification capabilities: These are the firm's ability to adapt and improve continuously its products and processes. This category includes reverse engineering; analytical design, and system engineering capabilities.

Marketing and network capabilities: These includes the knowledge and skills required for collecting market intelligence the development of new markets, the establishment of distribution channels and the provision of customer services. Firms also possess the ability and organisational competence to transfer technologies within the firm, among firms and between firms and the domestic scientific and technological infrastructure.

Design and new products and process capabilities: These refer to knowledge and skills required for the creation of new technology, design new features of products and processes, and the ability to spread out scientific knowledge in developing patentable ideas.

All these five forms of capabilities translate into the ability to export in different technological intensity sectors. For example, if you operate in low technology sectors, you need basic production and manufacturing capabilities, whereas to operate in medium technology sectors and create value added, you need at least the first four kinds of capabilities listed above (Lall, 2000). The degree of development of capabilities affects the extent of value added.

A firm seeking to innovate seeks to access to knowledge both from sources within the economy and outside. Within the economy, a number of organisations shape a firm's ability of access knowledge to build the aforementioned capabilities, key amongst which are universities (for human skills), public sector institutes (for R&D and technology incubation support), consumers and local demand (as reflected in innovations that are patented anticipating their market value or payments for intellectual property), and financing and risk agencies that help firms tailor and diversify their innovation risks. These support structures enable the capabilities building process, and support diversification of production structures by facilitating continuous product or process improvements that help firms to move horizontally into sectors with similar technological complexity, or vertically into sectors that have greater technological complexity, thereby enhancing their ability to create manufacturing value added.[8]

[8] Variables help capture these strengths, such as public R&D investments, scientific and technological publications, patents owned by residents, enrolment in tertiary education, intellectual property payments made by local firms, among others.

Hence, the evolution of exports of a country – whether through trade or GVC participation – will depend equally on local support to firms to develop their technological capabilities, as it does on international technological progress, competition or collaboration with foreign firms (see Lall, 2000). If over time there is a ‘deepening’ of technological capabilities, then we should be able to see two kinds of outcomes: firms will upgrade quality and technology within existing activities, and also move to new sectors or technologies with more complex activities (Lall, 2000, p. 5). By extension, when firms are exposed to GVCs in a situation of where technological capabilities are well buttressed by local institutions, it results in upgrading where "increasingly complex technologies that are mastered to international levels of efficiency" hereby creating intra- and inter-sectoral externalities (Cassen & Lall, 1996, p. 331) within these economies. This is the reason why although current export capacity might dictate the integration of local firms into existing GVCs, the evolution of export structures over time sheds light on whether firms were able to deepen their capabilities through trade and GVCs, and what the role of local innovation factors in that process were.

3 Empirical analysis

3.1 The data

The dataset used in this paper was constructed using four different databases: UNSD National Accounts Main Aggregates Database, UNCTADStat, WIPO database and the World Development Indicators (WDI) Database.

The UNSD Database was used to compute our dependent variable, total manufacturing value added. Trade in manufacturing exports and imports as per their technological intensity come from UNCTADStat; this database uses the Lall classification to categorise these variables (see Lall (2000) for more information).[9] The learning variables used in the analysis come from the WDI database of the World Bank and the WIPO database.

The analysis considers developing countries (including LDCs) [10] and contains information for year 2000 and year 2010 in constant USD (base year 2005). Although the WDI Database categorises countries as low-, medium-, and high-income countries, the data from the WDI database was mapped on to the UNCTAD list of developing countries and LDCs in order to create the database for the analysis.

[9] https://unstats.un.org/unsd/tradekb/Knowledgebase/50658/Technological-classification-of-exports-by-SITC
[10] http://unctadstat.unctad.org/EN/Classifications/DimCountries_DevelopmentStatus_Hierarchy.pdf

Table 1 summarises each of these variables.

3.2 Model specification

Due to difficulties in constructing a balanced panel for the entire time period that contains the same variables for all developing countries, we constructed a dataset with 78 countries and we choose two years 2000 and 2010 for which we have data on all variables for these countries. We run eight cross-sectional regressions that allow us to assess the situation in year 2000 and compare it with the situation in year 2010. We run four regressions for year t, namely, (a) a regression including all developing countries, (b) a robust regression controlling for outliers; (c) a regression excluding seven outperforming developing countries from the sample; and, (d) a robust regression controlling for outliers and excluding outperforming developing countries. The same procedure is presented for year t_{+10}.

The sample, follows the form:

$\hat{Y}_{it} = b_{0t} + b_{1t}X_{1it} + b_{2t}X_{2it} + b_{3t}X_{3it}$ (Equation 1)

where $\hat{Y}it$ = predicted or expected value of manufacturing value added for country *i* in year *t* in constant USD. b_{0t} = value of $\hat{Y}_{it}$ when all independent variables are equal to zero in year *t*. b_{1it} to b_{3it} = value of the estimated regression coefficients for year *t*. X_{1it} = value of manufacturing export variables with different levels of technological intensity for country *i* in year *t* in constant USD. X_{2it} = value of manufacturing import variables with different levels of technological intensity country *i* in year *t* in constant USD. X_{3it} value of learning variables with different levels of technology for country *i* in year *t*

Each trade variable related to manufacturing exports and imports with different levels of technological intensity is divided by real GDP (constant 2005 USD) to control for country-size effects. We choose this method instead of including real GDP as a variable in the regression because it allows us to factor the level of development of each country in the sample more effectively. Learning variables, such as number of journal publications and number of patents are presented in their logarithmic form to reduce skewness and improve normality. During the regression, we identify several data points located far outside the mean of the group. To identify these data points, which are observations with large residuals that affect the dependent-variable value in an unusual form, we first calculate the leverage by standardising the predictor variable to a mean equal to zero and a standard deviation equal to one. The transformation of a row score X is then done by using the following formula:

$X_{standardised} = (X - \mu) / \sigma$ (Equation 2),

where μ = the mean and σ = the standard deviation. The second step is to compute the leverage by squaring the observation's value on the standardised predictor variable, adding 1 and dividing by the number of observations (n).

Since the influence of an observation is dependent on how much the predicted scores on other observations would differ if the observation in question would not be included, we use a Cook's D to calculate this influence, as those points with largest influence produce the largest change in the equation of the regression line (Altman & Krzywinski, 2016; Cook, 1979).[11] The first step in calculating the value of Cook's D for an observation is to predict all the scores in the data using a regression equation based on all observations and once using all the observation except the observation in question. Cook's distance is defined as:

[11] Cook's D is a common tool used in behavioural and medical sciences, but its use is strongly supported in applied statistics. See Bollen and Jackman (1990)

$D_{it} = \sum_{it,i=1}^{n}(\hat{Y}it - \hat{Y}it(i))^2/(k+1)s^2$ (Equation 3),

where $\hat{Y}it$ = regression estimate of the conditional mean $E(Y_{it} \mid x_{it} \ldots x_{kt})$; $\hat{Y}it$ (i) = regression estimate of the conditional mean with the it^{th} data point removed. k = independent variables in the model. s = estimated root mean square error.

Cook's distance is a measure of the change in the mean vector when the i^{th} point is removed. It combines the effects of distance and leverage to obtain one metric. In practice, values of Cook's distance that are larger than 1 are generally viewed to be on the higher side. To identify potential outperformers, we use: $Dij \geq 4/n - (k+1)$ (Equation 4). We repeat this exercise for both years.

Given that our variables are related to each other, it is important to test for multicollinearity. We run a Variation Inflation Factor (VIF) test to quantify the extent to which the variance is inflated and that helps us detect multicollinearity. VIF_k helps us to estimate the inflation factor for the variance of estimated coefficient b_k. That is to say,

$VIF_k = \frac{1}{1-R_k^2}$ (Equation 5),

where R_k^2 is the R^2 value obtained by regressing the k^{th} predictor on the remaining predictors. We accept that if the VIF is larger than 10 it implies severe multicollinearity issues and we remove those variables from our analysis.

3.3 The dependent variable

Manufacturing value added (MVA) measured as the net output of country *i* after adding up all outputs and subtracting intermediate inputs that are invested into production in constant USD (base year 2005). This variable is divided by GDP to control for country-size effects and then log transformed to correct for skewness.

3.4 Explanatory variables

The explanatory variables used in the model are those on trade in manufactured goods classified into technological export categories using the Lall classification (Lall, 2000) and those on learning, proxied through variables such as patents of residents, scientific and technological publications, research and development expenditure and intellectual property payments. Drawing on Section 2, these variables show the strength of local institutions for building technological capabilities that reinforce the ability of firms to create more complex products in other sectors by accessing knowledge in GVCs. As indicated in

Table 1 we expect a positive relationship between exports of manufactures with different levels of technological complexity and MVA. The same positive relationship is expected between our dependent variable and our learning variables. A negative relationship is expected between imports of manufactures of different (especially higher) technological complexity and the capacity to generate value added in manufactures, assuming that countries that import more of such manufactured categories do so because of their incapacity to locally produce them.

3.4.1 Trade in manufactured goods: exports and imports

After normalising, by dividing them by GDP and controlling for country-size effects, the variables are:[12]

3.4.1.1 Low technological manufactures

These manufactures call for relatively simple skills and capital equipment. Labour costs (wages) are the major element in competitiveness. This category is divided into: (a) low-technology manufactures: textile, garment and footwear (L1), and (b) low-technology manufactures: other products (L2).

3.4.1.2 Medium technological manufactures

These manufactures are the core of industrial activity in mature economies, and call for capital intensity and economies of scale, along with mature technological skills that can be applied to short to medium-term product and process technologies. They imply moderately high levels of R&D, advanced skills needs and lengthy learning periods, and strong backward and forward linkages, including learning linkages. This category is divided into: medium technology manufactures: automotive (M1), medium technology manufactures: process (M2), and, medium technology manufactures: engineering (M3).

3.4.1.3 High technological manufactures

These manufactures are mostly at the frontier of the field, impute high levels of R&D investments, with prime emphasis on design, and new product and process capabilities. Engaging in such manufacturing requires sophisticated technology infrastructures, high levels of specialised technical skills, advanced R&D capabilities with the ability to compete globally. This category is divided into: high technological manufactures: electronic and electrical (H1); and high technological manufactures: other (H2).

3.4.2 Learning variables

3.4.2.1 Patents by residents

Collected from the WIPO database, this variable denotes the number of patents by residents, implying domestic inventions and R&D capacity. This variable was log transformed to control for skewness.

3.4.2.2 R&D expenditure

Collected from the WDI database, this variable contains expenditure in R&D as percentage of GDP. This variable has been divided by GDP to control for country-size effects.

3.4.2.3 Scientific publications

Collected from the WDI database, this variable denotes the number of scientific publications in technical journals. This variable was log transformed to control for skewness.

[12] For the sake of simplification, we will only refer to the variables by their name and will not mention divided by GDP or log every time we refer to the variable.

3.4.2.4 Intellectual property payments

Collected from the WDI database, this variable denotes payments to intellectual property payments in constant 2005 USD. This variable is divided by GDP to control for country-size effects.

3.5 Identification of outliers

First, we analysed the standardised residuals for 2000 and for 2010. By examining the leverage of the observations, we identified those with potential great influence on the regression coefficient estimates. Second, we analysed the overall influence of the observations in the sample looking at Cook's d. After analysing the outliers, when comparing regressions with and without these outliers no major changes in the results were identified. Since the outliers were cases of spurious technical errors, we dropped four observations in both years 2000 and 2010.

3.6 Descriptive statistics and correlations

Table 2 presents descriptive statistics (i.e., number of observations, mean and standard deviation) for the dependent and explanatory variables in the study for the year 2000 and the year 2010. The observations used in the regression in their transformed states correspond with the number of observations in the Table. Columns (2) to (5) of Table 2 present the statistics for all developing countries for year 2000. Columns (6) and (9) refer to year 2010. Columns (4) to (5) and (8) and (9) present the descriptive statistics for years 2000 and 2010 without the outliers respectively. The standard deviations for all variables do not show a large spread of the data respect to the mean (i.e., less than 3 times the mean). Columns (2), (4), (6) and (8) show that the mean of MVA of all developing countries slightly decreased in 2010 with respect to the year 2000. However, the means of all explanatory variables increased in this period with the exception of IP payments and patents. The data indicate that in 2010, there was a slight decrease in number of patents by residents when compared to year 2000.

Table 3 presents the Pearson product-moment correlation coefficient, which measures the direction and strength of the relationships between any two continuous variables. Since we are only interested in the correlation between the explanatory variables and our dependent variable, the correlations among explanatory variables are not discussed here. The signs of the Pearson correlation coefficients, *r*, with respect to our dependent variable (value added in manufacturing) are positive, indicating a positive correlation among these variables, except for M1 imports, intellectual property payments and expenditure in R&D, which present negative correlations. This indicates that higher values of imports of M1, IP payments and expenditure in R&D are associated with lower levels of value added in manufacturing. Higher values amongst the rest of the variables are associated with greater levels of value added in manufacturing. This holds for both years under consideration, namely, 2000 and 2010.

Table 3 shows a large correlation[13] between the dependent variable and exports of L2 and exports of M3, and the number of publications in both years, 2000 and 2010. Additionally, the exports of M2 presents a large correlation with manufactured value added in 2010. A moderate correlation[14] between the dependent variable and exports of M2 and patents by residents is also observed in both years, 2000 and 2010. The rest of the variables present a smaller level of correlation[15] with value added in manufacturing in both years, 2000 and 2010.

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[13] $|r| > 0.5$

[14] $0.3 < |r| < 0.5$

[15] 0.1<||r|<0.3

3.7 Multicollinearity in the sample

Expecting relationships between the variables used in the regression, we run multicollinearity tests with all the variables in our sample before proceeding with the analysis. Our results indicate high levels of multicollinearity among certain variables which would affect the results of the regression if included. This is the case particularly with imports and exports of high technological manufactures: electronic and electrical (H1). This variable is highly correlated to imports and exports of medium technology manufactures, particularly those regarding engineering (M3). Therefore, we excluded H1 for both imports and exports from the analysis.

3.8 Identifying the outperformers

Scatter plots of the observations shows a group of outperforming developing countries, where the extent of MVA across all manufacturing exports categories surpassed all other countries in our sample with a large variance in 2000 and 2010. These observations are not outliers (as described in section 3.5) as these do not have a high leverage or influence in the analysis.[16] We however consider it important to consider these countries differently because in the scatter plots, these countries constantly diverge significantly from the mean of the sample. Table 4 presents the list of these so called 'outperformers' for years 2000 and 2010. We find that these countries are precisely those that are identified as emerging or new industrial economies in the literature on economic catch-up in the broader literature.

4 Results and discussions

Table 5 presents the results of the regressions performed.[17] Columns (1) and (3) correspond to a simple regression for the year 2000 and 2010 respectively. Columns (2) and (4) present the robust regression for these two years. The regressions excluding the group of outperforming developing countries (as identified in Table 4) are presented in columns (5) to (8) for 2000 and 2010.

Our results show that exports of low-technology manufactures (L1), that is, exports of textile, garment and footwear is the only category of exports that is positively and significantly associated with MVA in 2000 and 2010 for all developing countries. This holds true both with and without the outperformer countries. We perform a graphic analysis of this relationship and find that China is the only country that increased its volume of exports of low-technological manufactures while maintaining almost the same level (with a slight decrease) of MVA in both years.

Figure 1 presents this result clearly, showing that more countries were outperforming in this activity, this changed importantly by 2010 where only South Korea and India are the other two countries apart from China to register manufacturing value added in the sector over the ten years in consideration. This result needs to be considered in the broader light that over the same time, the volume of exports of this type of activity increased (as shown by our data) and countries like Hong Kong integrated with the group mean of exporters of low-tech manufacturing with little increases in MVA in this period of 10 years. Other countries like Mexico, Brazil and Singapore, as shown in Figure 1 are performing just slightly better than the sample average.

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[16] Since our sample is divided by GDP to control for country effects, it is not surprising that these countries are not influencing the analysis.

[17] The analysis is only focused on the direction and significance of the relationship between our explanatory variables and value added in manufacturing; therefore, the value of the coefficients is not here discussed

In 2000, exports of low technology manufactures in the category of other products including office equipment and stationery (L2) were positively and significantly associated with MVA both with and without outperforming economies. However, the relationship between these two variables although positive, was not significant for all countries in 2010 but with and without the outperformers. Figure 2 suggests that there were no important changes in the levels of MVA in sectors employing such technologies between 2000 and 2010. Brazil and Mexico remained without important changes, while S. Korea increased its MVA and India is an outperformer in 2010 in this category.

The results also show that in year 2000, there was a negative relationship between MVA and exporting of medium technology manufactures, mostly in the sub-category automobiles (M1), with and without outperformers. This relationship however, became positive and significant (at 10%) in 2010 for all developing countries in the sample, both with and without the outperforming countries, indicating that countries exporting manufactured goods in the automobile sector exhibited greater level of value added in manufacturing when compared with 2000. This result suggests that learning and technological upgrading took effect not only for the group of identified outperformers, but also for the mean of all developing countries analysed in our sample. The evolution in the assembling operations characterising the auto industry in many developing countries is critical to explain this change, as analysed by a number of innovation studies of the automobile sector in developing countries. These studies note that inbound firms have undergone generational changes to assembly operations of a kind where more local research and development is involved (Doner, Noble, & Revenhill, 2014; Vallejo, 2010) . Our graphical analysis (Figure 3) confirms the results, showing that the leading countries accounting for this change in causality are India, Brazil, Turkey, Thailand, South Korea and Mexico.

There is a negative and significant relationship between MVA and exports of medium technology manufactures based on process technologies (M2) in 2000 with and without outperformers. In 2010, this relationship was negative but not significant, both with and without the outperformers. This suggests that in all developing countries in our sample, greater exports of medium process technologies are associated with lower levels of MVA. Although the relationship is not statistically significant in 2010, it highlights that a critical technological sector - M2 - which could serve as the backbone of diversified production structures is not developed/ supported sufficiently enough in the countries in our sample in order to facilitate manufacturing value added in the countries in our sample. The continuation of the trend in 2010 lends support to conclude that learning variables are not helping the creation of capabilities in this sector over time. Figure 4 shows how the volumes of exports of this type of goods increased between 2000 and 2010, but not the MVA levels, which supports our findings of a negative relationship between these two variables. Figure 4 also shows that although China increased notoriously its levels of exports in this category during these 10 years, but it also decreased slightly its levels of MVA. The same applies for S. Korea and India in a lower scale. Hong Kong and Singapore, as well as Brazil and Mexico do not longer outperform in 2010.

Exports of M3 technologies (engineering technologies of a broad spectrum that are once again critical for manufacturing productivity) is associated positively for all countries in 2000 and 2010. However, it is positive and significant in 2000 for all developing countries excluding the outperformers and in 2010 for developing countries in the sample only when the outperformers are included. This suggests that when compared to 2000, developing countries in general, seem to have lost ground in MVA exports of engineering technologies to the outperformers, who have emerged by 2010 as those leading the sector in generating MVA.

The growth of this sector, which is the second sector seen in the technological capabilities literature as critical to diversified production structures (in addition to M2), seems to explain the rising competitiveness of the outperforming countries between 2000 and 2010. Figure 5 shows that while in 2000, countries like Hong Kong, Singapore, Malaysia, and Thailand showed much more exports when compared with the rest, by year 2010, their performance was similar to all other developing countries in the sample in terms of export levels and MVA. Apart from China which is a notorious outperformer in this category as well, S. followed by Mexico, India and Brazil, increased both their exports and MVA but to a much lower extent.

With respect to the imports, none of the imports were significantly associated with value added in manufactures for all countries in 2000 and 2010 except for the category of medium technology engineering products (M3) which shows a negative relationship with value added in manufacturing in 2010 for all countries in our sample. This indicates that developing countries importing this type of products demonstrated lower MVA in a significant level over time, suggesting that it might be both the result of, and leading to, lower learning and capabilities formation in the local economies. These results are supported by other studies that suggest that as countries acquire more and more ready products, particularly those products with high content of engineering skills, they do not present significant learning and technological upgrading possibilities and also eliminate several local firms actively engaged in producing such products, thereby deskilling.

We sought to understand what might be the underlying factors accounting for this decline in technological capabilities across the range of countries we studied. Our analysis shows that from all the different learning variables, only patents by residents had a significant and positive relationship with value added in manufacturing for 2010 and 2010 both with and without outperformers.

The number of scientific publications is also positively associated to manufacturing value added in both years. However, it was only found significantly associated in year 2000. This suggests that countries with higher number of publications generated more knowledge that fed into higher levels of MVA in 2000 but this feedback loop seems to be weakened for all countries in our sample by 2010.

5 Interpreting the results: some further thoughts

The empirical results confirm that for most developing countries in our sample, participation in GVCs in 2000 was concentrated in exports of low technology exports in textiles, ready-made garments and footwear (L1) and other low technology exports including office stationary and equipment (L2) where they showed the maximum value added. However, many developing countries were also engaged in manufacturing exports in the L2 category (which is low technology goods with some level of diverse skills, such as for office stationery and equipment) which was significantly and positively associated with their manufacturing value added, but this is no longer the case by 2010. Other interesting changes that we observe are that developing countries as a whole display greater local manufacturing value added in the automobile sector (M1) when compared to 2000 and have a negative relationship with medium technology process technologies M2. The sample as a whole shows a decline in positive manufacturing value added with medium technology engineering products M3 in 2010 when compared to 2000, which seems to be concentrated in the set of outperformers by 2010. Figure 6 plots this trend in structural change in all countries in our sample, showing that except for a few countries, most developing countries are technologically specialising in low manufacturing exports over the period 2000-2010.

Assessing these developments in conjunction with technological capability variables, we conclude the following. For all developing countries in our sample, especially LDCs, integration in trade and GVCs in 2000 is explained by their initial comparative advantages and low technological capabilities. As of 2000, the regression results show a positive and causal relationship between patents of residents was a significant factor contributing to increase in manufacturing value added (but mainly only for the outperformers according to the data). Only one another variable – scientific and technological publications – was strongly linked to manufacturing performance of all countries in the sample, potentially explaining learning and the manufacturing value added capacity of engineering products M3. By 2010, we observe the downsizing of manufacturing value added of all developing countries in categories L2, and while we observe no changes in growth of medium technology process exports M2 but we see a negative shift in the capacity to generate value-added in medium technology engineering products M3 from developing countries in general to the outperforming countries (which register a positive and significant causality with manufacturing value added in this sector by 2010). Only one learning variable - patents residents – was significantly associated with the capacity to generate value-added in the outperforming countries, with no variable showing clear links to manufacturing value added in the other developing countries in our sample.

Our results lead us to the following general conclusions that deserve further research. First, while countries are integrated into trade and GVCs based on their static comparative advantages, in the countries under consideration, there has been a change in capacity to generate manufacturing value added, moving away from those sectors that are seen as critical for capabilities building (M2 and M3) in the literature on learning and industrial catch-up. Second, we find a weakening relationship between learning variables and export participation in all countries over time and deduce that this is a key factor why countries are unable to leverage trade to create diversified production structures over the period of time under consideration. We also find that the gap of ten years is a good period to measure this, since in the case of outperformer countries, we can find a significant movement towards manufacturing value added in engineering products (M3) which is seen as key to diversify production and build competencies across several sectors. We find that in these outperformer countries, manufacturing value added is significantly associated with only patents of residents playing a role by 2010, explaining their emergence as global leaders. Third, our analysis corresponds neatly with the rise of the emerging economies globally; there is a significant overlap between the countries that are outperformers in our sample and those denoted as emerging economies in the wider literature (UNCTAD, 2012). China's exceeding performance (especially when compared to all the other developing and least developed countries in our sample) is explained by its consistent investments into learning, export capabilities and export surplus, its current global position in trade and macroeconomic analysis (UNCTAD, 2016, 2017). Finally, our analysis points to the critical role of national learning variables in accounting for how countries in trade and GVCs participation. While the reasons for the gradual delinking of export value added from learning can be attributed to several reasons, predominant of which are the weakening of the national innovation systems linkages in developing countries, institutional responses to building export pressures in certain sectors leading to de-industrialisation and low emphasis on learning, weak public support for innovation as exacerbated by the financial crises of 2007-2008, we conclude that upgrading in and through trade and GVCs can be understood at best with the parallel association of these phenomenon with technological capabilities. More work in this direction is required to study how countries can address these issues effectively.

6 References

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Table 1. The Variables
(N=74)

Variable	Description	Measurement	Expected relationship with MVA
rva_man_d_gdp	Manufacturing value added (MVA)/ GDP	Constant USD (2005)	
x_l1_gdp	Exports of low-technology manufactures: textile, garment and footwear (L1) / GDP	Constant USD (2005)	(+)
x_l2_gdp	Exports of low-technology manufactures: other products (L2)/ GDP	Constant USD (2005)	(+)
m1_x_gdp	Exports of medium technology manufactures: automotive (M1) / GDP	Constant USD (2005)	(+)
m2_x_gdp	Exports of medium technology manufactures: process (M2)/ GDP	Constant USD (2005)	(+)
m3_x_gdp	Exports of medium technology manufactures: engineering (M3)/ GDP	Constant USD (2005)	(+)
h2_x_gdp	Exports of high technological manufactures: other (H2)/ GDP	Constant USD (2005)	(+)
m_low_gdp	Imports of low-technology manufactures (L1+L2)/ GDP	Constant USD (2005)	(-)
m1_m_gdp	Imports of medium technology manufactures: automotive (M1)/ GDP	Constant USD (2005)	(-)
m2_m_gdp	Imports of medium technology manufactures: process (M2)/ GDP	Constant USD (2005)	(-)
m3_m_gdp	Imports of medium technology manufactures: engineering (M3)/ GDP	Constant USD (2005)	(-)
h2_m_gdp	Imports of high technological manufactures: other (H2)/ GDP	Constant USD (2005)	(-)
lpatent	Log of patents by residents	Number of patents	(+)
Rdexp	R&D expenditure / GDP	Constant USD (2005)	(+)
ljournal	Log of scientific publications	Number of publications	(+)
IP_gdp	Intellectual Property Payments / GDP	Constant USD (2005)	(+)

Table 2 Descriptive statistics

	2000				2010			
	N=78		N=74		N=78		N=74	
	Sample including outliers		Sample without outliers		Sample including outliers		Sample without outliers	
Variable (1)	Mean (2)	Std. Dev. (3)	Mean (4)	Std. Dev. (5)	Mean (6)	Std. Dev. (7)	Mean (8)	Std. Dev. (9)
Exports L1 / GDP	0.1286093	0.0681775	0.1322371	0.0688815	0.1236671	0.0676946	0.1266121	0.0688023
Exports L2 / GDP	0.0000307	0.0000538	0.0000313	0.0000551	0.0000338	0.0000724	0.0000358	0.0000743
Exports M1 / GDP	6.56E-06	9.85E-06	6.87E-06	1.01E-05	0.0000146	0.0000221	0.0000149	0.0000223
Exports M2 / GDP	2.46E-06	5.36E-06	2.59E-06	5.51E-06	5.28E-06	0.0000116	5.60E-06	0.0000119
Exports M3 / GDP	6.73E-06	0.0000111	6.71E-06	0.0000111	0.0000179	0.0000317	0.0000161	0.000023
Exports H2 / GDP	8.46E-06	0.0000218	8.81E-06	0.0000225	0.0000196	0.0000353	0.0000206	0.0000362
Imports Low / GDP	0.0000414	0.000036	0.0000408	0.0000363	0.0000708	0.0000501	0.0000703	0.0000511
Imports M1 / GDP	0.0000157	9.68E-06	1.50E-05	9.27E-06	0.0000315	0.0000199	0.0000309	0.0000187
Imports M2 / GDP	0.0000218	0.0000148	0.0000216	0.0000146	0.0000433	0.0000244	0.000043	0.000025
Imports M3 / GDP	0.0000329	0.0000288	0.0000319	0.0000286	0.0000693	0.0000516	0.0000685	0.0000521
Imports H2 / GDP	0.0000104	7.93E-06	1.04E-05	8.19E-06	0.0000202	0.000012	0.0000203	0.0000123
Expenditure in R&D / GDP	1.46E-09	3.87E-09	1.15E-09	2.62E-09	2.12E-09	4.42E-09	1.98E-09	4.10E-09
Intellectual Property ~~Rights~~ Payments / GDP	4.02716	2.384493	1.40E-08	2.57E-08	1.78E-08	4.00E-08	1.62E-08	4.01E-08
log (Patents by residents)	2.181295	2.528705	2.293017	2.560484	2.000199	2.442429	2.046723	2.480665
log (Publications)	4.02716	2.384493	4.215921	2.304805	4.465254	2.380819	4.623013	2.351605

Table 3. Correlation analysis

Year=2000	rva_ma~p	x_l1_gdp	x_l2_gdp	m1_x_gdp	m2_x_gdp	m3_x_gdp	h2_x_gdp	m_low_~p	m1_m_gdp	m2_m_gdp	m3_m_gdp	h2_m_gdp	IP_gdp	Rdexp_~p
rva_man_gdp	1													
x_l1_gdp	0.2764	1												
x_l2_gdp	0.6175	0.117	1											
m1_x_gdp	0.2923	-0.0735	0.4437	1										
m2_x_gdp	0.392	0.0031	0.8544	0.3281	1									
m3_x_gdp	0.5221	0.0337	0.9056	0.4207	0.7941	1								
h2_x_gdp	0.3537	-0.0142	0.7627	0.2311	0.7534	0.8006	1							
m_low_gdp	0.1822	0.8119	0.2804	-0.0442	0.1869	0.2326	0.2199	1						
m1_m_gdp	-0.083	0.1305	0.2319	0.1156	0.2468	0.1393	0.3342	0.4062	1					
m2_m_gdp	0.3409	0.5736	0.5852	0.0562	0.4536	0.4835	0.4392	0.7808	0.496	1				
m3_m_gdp	0.3128	0.149	0.7382	0.1928	0.6695	0.814	0.723	0.4208	0.3282	0.626	1			
h2_m_gdp	0.2426	0.0979	0.6924	0.0852	0.7412	0.6597	0.7075	0.3792	0.4478	0.5753	0.7398	1		
IP_gdp	-0.0357	0.3199	-0.1076	-0.1393	-0.1758	-0.093	0.0532	0.4003	0.2772	0.2482	0.1416	0.0233	1	
Rdexp_gdp	0.1004	0.3275	0.0849	-0.0855	-0.0246	0.0838	0.1607	0.3252	0.0141	0.21	0.3068	0.1126	0.176	1
lpatent	0.4799	0.1091	0.367	0.3294	0.3012	0.3216	0.2081	0.0067	0.0091	0.1847	0.2197	0.0771	-0.2156	0.0002
ljournal	0.5297	-0.1463	0.3904	0.4553	0.3844	0.3608	0.2522	-0.258	-0.1686	-0.0269	0.1221	0.0348	-0.3091	-0.1139

Year: 2010	rva_ma~p	x_l1_gdp	x_l2_gdp	m1_x_gdp	m2_x_gdp	m3_x_gdp	h2_x_gdp	m_low_~p	m1_m_gdp	m2_m_gdp	m3_m_gdp	h2_m_gdp	IP_gdp	Rdexp_~p
rva_man_gdp	1													
x_l1_gdp	0.3399	1												
x_l2_gdp	0.5945	0.2503	1											
m1_x_gdp	0.5742	0.0469	0.4382	1										
m2_x_gdp	0.4076	-0.0501	0.6309	0.4454	1									
m3_x_gdp	0.5192	0.1117	0.6917	0.5561	0.6919	1								
h2_x_gdp	0.2321	0.0093	0.4677	0.2755	0.5725	0.7032	1							
m_low_gdp	0.1477	0.7307	0.2995	0.0472	0.0646	0.2247	0.1858	1						
m1_m_gdp	-0.1283	0.0528	0.015	-0.0385	0.2298	-0.0428	0.0794	0.4375	1					
m2_m_gdp	0.3067	0.465	0.5904	0.1269	0.2682	0.3046	0.181	0.7532	0.4301	1				
m3_m_gdp	0.038	0.1742	0.4562	0.1494	0.3873	0.6752	0.625	0.4737	0.2686	0.4636	1			
h2_m_gdp	0.2156	0.1653	0.5165	0.1144	0.4676	0.6075	0.5763	0.5228	0.2672	0.5402	0.6042	1		
IP_gdp	-0.046	0.2931	-0.1345	-0.1007	-0.1908	-0.0604	-0.0488	0.591	0.3676	0.3281	0.1884	0.2728	1	
Rdexp_gdp	-0.1542	-0.132	-0.127	-0.127	-0.1523	-0.1264	-0.056	-0.0438	-0.0418	-0.074	-0.0885	0.0658	0.0801	1
lpatent	0.4828	0.0479	0.3426	0.2163	0.2818	0.2092	0.1171	-0.1086	-0.1497	0.1487	-0.0359	-0.0262	-0.1966	-0.1576
ljournal	0.5869	-0.0492	0.4288	0.4972	0.4738	0.4001	0.2191	-0.294	-0.1394	-0.0444	-0.0269	0.0018	-0.3189	-0.1429

Table 4. Outperforming developing countries

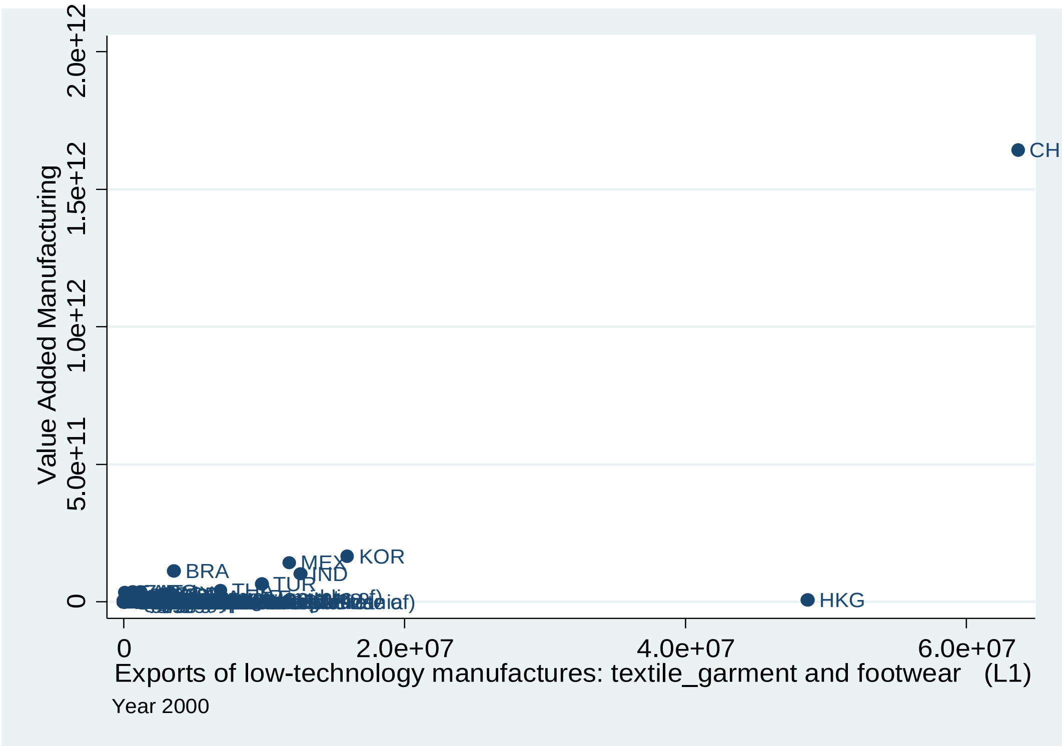
2000		2010
Economy	**Code**	**Economy**
China	156	China
S. Korea	410	S. Korea
India	356	India
Brazil	76	Brazil
Singapore	702	Singapore
Turkey	792	Turkey
Mexico	484	
Malaysia	458	Malaysia
	152	Chile
	710	South Africa
	764	Thailand

Table 5. Empirical Results

Independent Variable: Manufacturing Value Added /GDP								
	2000 **N=74**		**2010** **N=74**		**2000 (without outperformers)** **N=67**		**2010 (without outperfor** **N=67**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
No. observations:	Simple regression	Robust regression	Simple regression	Robust regression	Simple regression	Robust regression	Simple regression	Robus
	Coefficient (Std. Err)	Coefficient (Std. Err)	Coefficient (Std. Err)	Coefficient (Std. Err)	Coefficient (Std. Err)	Coefficient (Std. Err)	Coefficient (Std. Err)	Co (S
Explanatory variables								
Exports of low-technology manufactures: textile, garment and footwear (L1)/GDP	286.5547 (197.3479)	**310.2331*** **(182.7568)**	**379.4348**** **(131.9047)**	**347.7039*** **(140.43)**	**330.2446*** **(166.6038)**	**323.0214*** **(183.441)**	**352.5096*** **(132.5955)**	**323** **(14**
Exports of low-technology manufactures: other products (L2)/GDP	**6901.569***** **(1722.574)**	**5094.129**** **(1595.214)**	566.3618 (432.4568)	540.6267 (460.4074)	**4417.634*** **(1774.367)**	**4339.841*** **(1953.686)**	162.2557 (468.4152)	12 (50
Exports of medium technology manufactures: automotive (M1)/GDP	-1995.74 (1275.818)	-685.3932 (1181.489)	**1165.116*** **(577.5133)**	**1144.252*** **(614.8392)**	-1981.672 (1373.1)	-2028.427 (1511.867)	**1739.341*** **(705.7215)**	**163** **(76**
Exports of medium technology manufactures: process (M2)/GDP	**-2821.275*** **(1086.521)**	**-2024.324*** **(1006.188)**	-428.564 (375.6666)	-402.0207 (399.9468)	**-1900.662*** **(998.7917)**	**-1954.483*** **(1099.73)**	-166.065 (408.4748)	-20 (43
Exports of medium technology manufactures: engineering (M3)/GDP	470.9438 (811.9646)	744.6615 (751.9311)	**1033.83**** **(350.0665)**	**1071.975**** **(372.6921)**	**1870.003*** **(1005.308)**	**1943.722*** **(1106.905)**	688.0343 (475.7075)	77 (51
Exports of high technological manufactures: other (H2)/GDP	-1226.023 (2188.84)	-1382.651 (2027.006)	187.1539 (440.8784)	141.6339 (469.3733)	237.6779 (2200.742)	241.4372 2423.151)	156.3593 (472.992)	10 (50
Imports of low-technology manufactures (L1+L2)/GDP	-43.86972 (382.9794)	-219.1229 (354.6634)	-509.751 (320.2205)	-427.2403 (340.9171)	-218.8849 (326.3286)	-209.367 359.3077)	-411.4025 (322.8821)	-33 (34
Imports of medium technology manufactures: automotive (M1)/GDP	-728.4205 (824.8548)	-598.9295 (763.8683)	273.1654 (395.4725)	349.0092 (421.0328)	-706.6509 (742.7665)	-697.9631 (817.8311)	85.3343 (410.3464)	21 (44
Imports of medium technology manufactures: process (M2)/GDP	-370.5467 (818.8935)	161.6582 (758.3477)	626.0452 (422.1748)	558.1784 (449.4609)	113.0066 (726.3059)	112.8987 (799.707)	716.8375 (438.2206)	64 (47
Imports of medium technology manufactures: engineering (M3)/GDP	-715.8024 (454.8073)	-691.4978 (421.1806)	**-643.2787***** **(168.5237)**	**-638.7724**** **(179.4158)**	-650.213 (389.2018)	-650.5697 (428.5349)	**-514.2357*** **(200.0794)**	**-51** **(21**
Imports of high technological manufactures: other (H2)/GDP	1002.607 (1263.068)	1209.003 (1169.681)	287.844 (691.5241)	150.6555 (736.2188)	1083.16 (1089.772)	1110.238 (1199.906)	377.7055 (696.4809)	30 (75
Intellectual Property Payments/GDP	394395.2 (250730.6)	356193.2 (232192.6)	268515.4 (167981.1)	250303.6 (178838.1)	322183.5 (215228.3)	312580.1 (236979.5)	178949.3 (172561.5)	16 (18
R&D expenditure/GDP	894619.6 (2463519)	1652575 (2281376)	-259765.1 (1195137)	-40422.78 (1272381)	628036.3 (2149443)	639317.6 (2366668)	-144017.4 (1188865)	1 (12
Patents of residents (log)	0.0038351 (0.0026307)	**0.0043074*** **(0.0024362)**	**0 .004318*** **(0.0025153)**	**0.0048336*** **(0.0026779)**	**0.0038013*** **(0.0022233)**	0.0039709 (0.002448)	**0.0051855*** **(0.0025152)**	**0.00** **(0.0**
Number of scientific publications (log)	**0.0107399**** **(0 .0033201)**	**0.0059631*** **0.0030746**	0 .0035372 (0.0034781)	(0.0033994 (0.0037029)	0.0061237* (0.0032981)	0.0060053 (0.0036314)	0.0016065 (0.0040608)	0.0 (0.0
constant	**0.0713655***** **(0.0190057)**	**0.0784452***** **(0.0176005)**	**0 .0918826***** **(0.0206503)**	**0.0883245***** **(0. .021985)**	**0.0806155***** **(0.0164778)**	**0.0803981***** **(0.0181431)**	**0.0889129***** **(0.0209567)**	**0.07** **(0.0**
	R2 = 0.6817		R2=0.7374		R2=0.6521		R2=0.6452	

Note: * Significant at 1%, ** significant at 5%, ***significant at 10%

Figure 1. Exports of low level manufacturing vs value added in manufacturing (2000 and 2010)



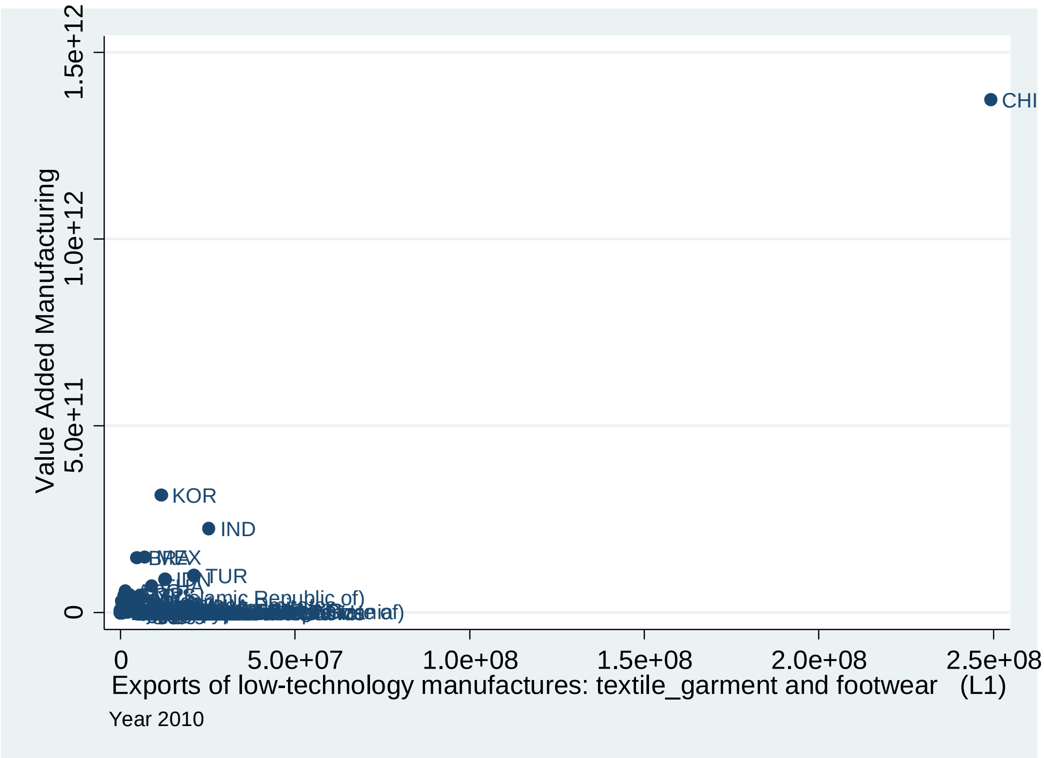
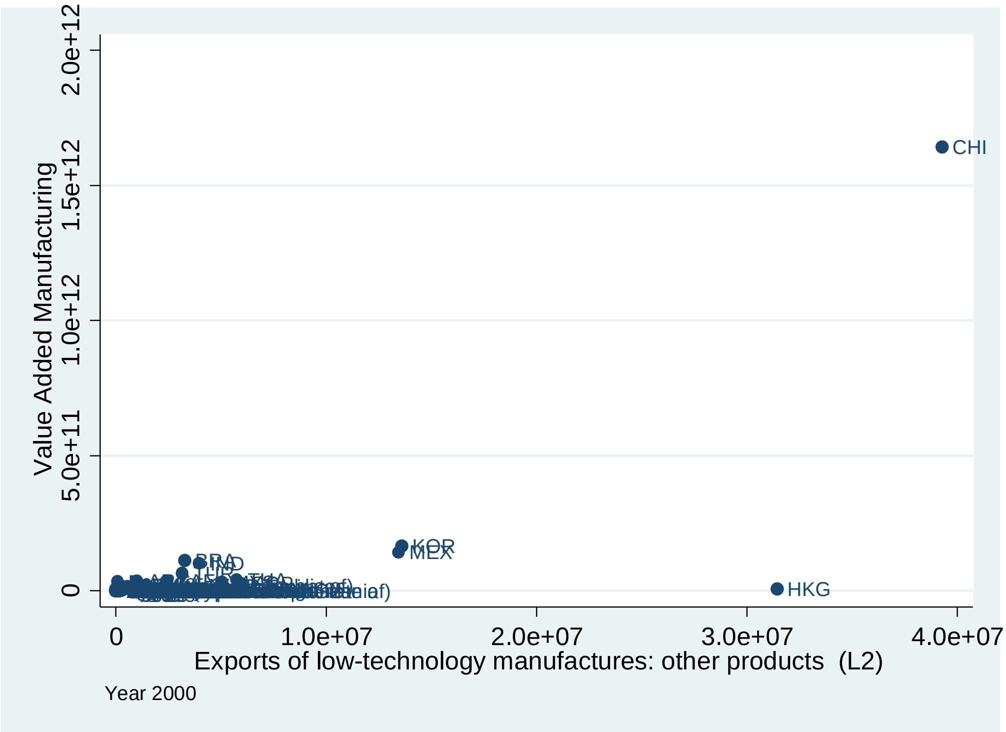


Figure 2. Exports of low level manufacturing (other products) vs value added in manufacturing , 2000 and 2010



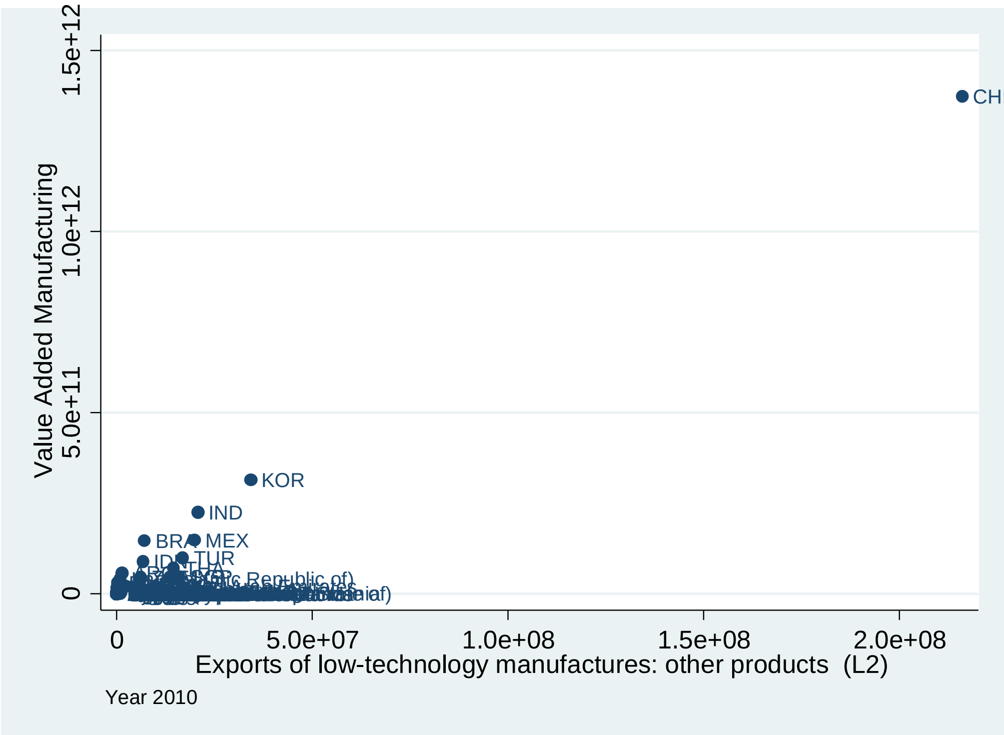


Figure 3. Exports of medium level manufacturing (automotive) vs value added in manufacturing , 2000 and 2010

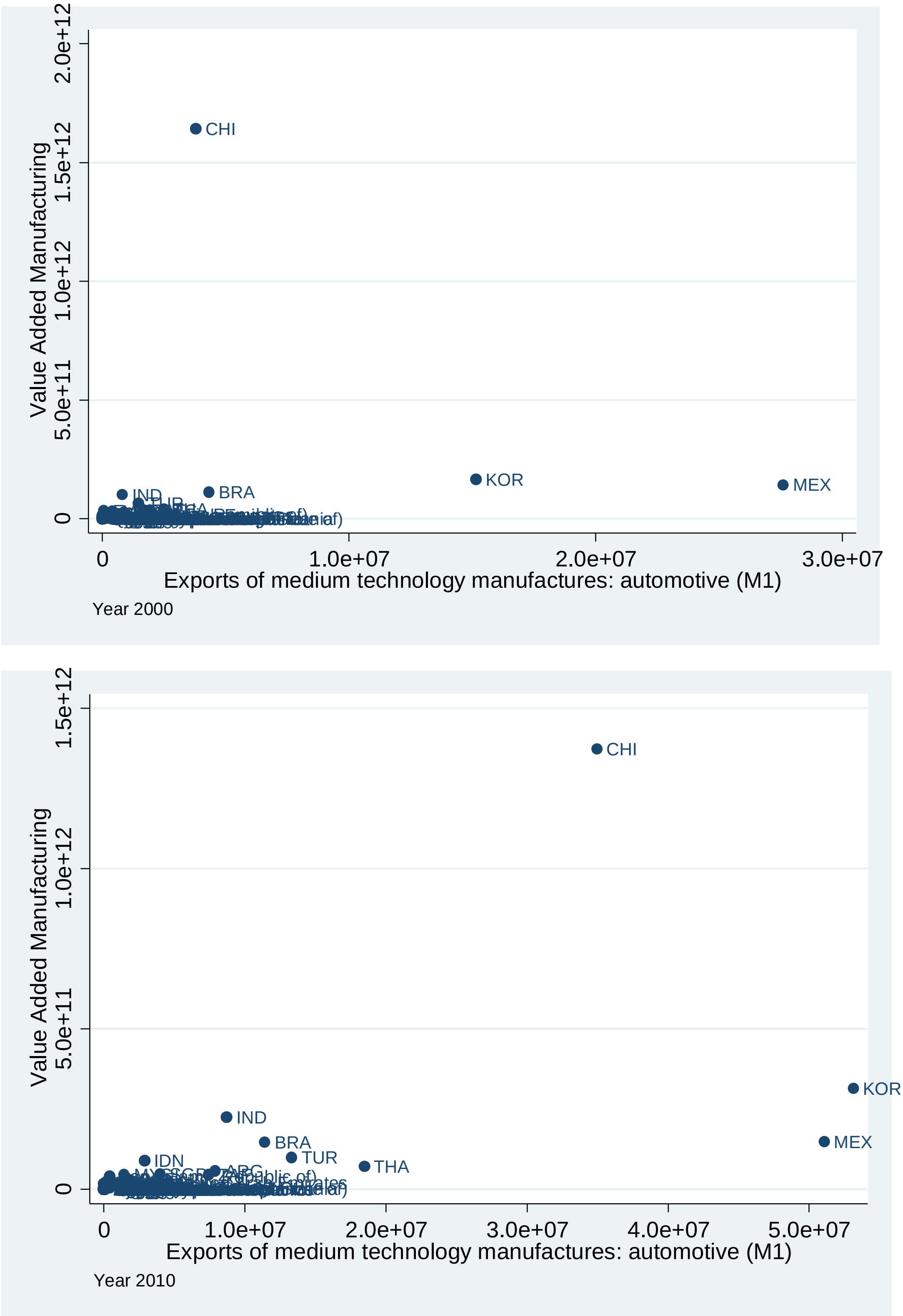
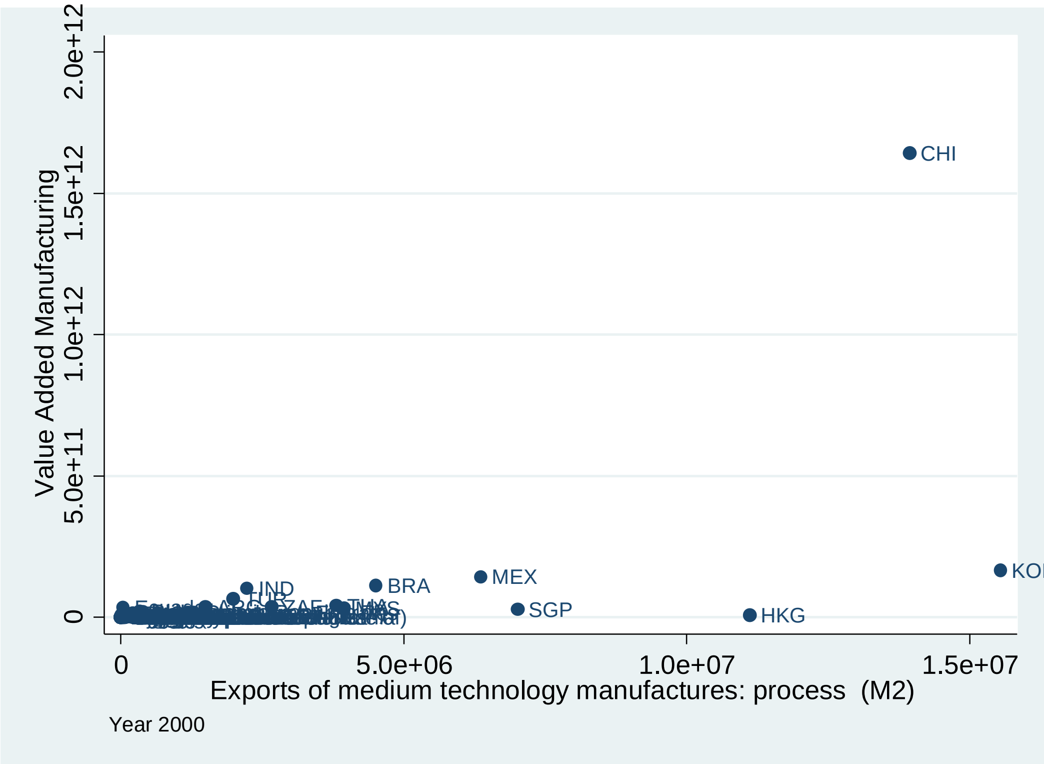


Figure 4. Exports of medium level manufacturing (processes) vs value added in manufacturing , 2000 and 2010



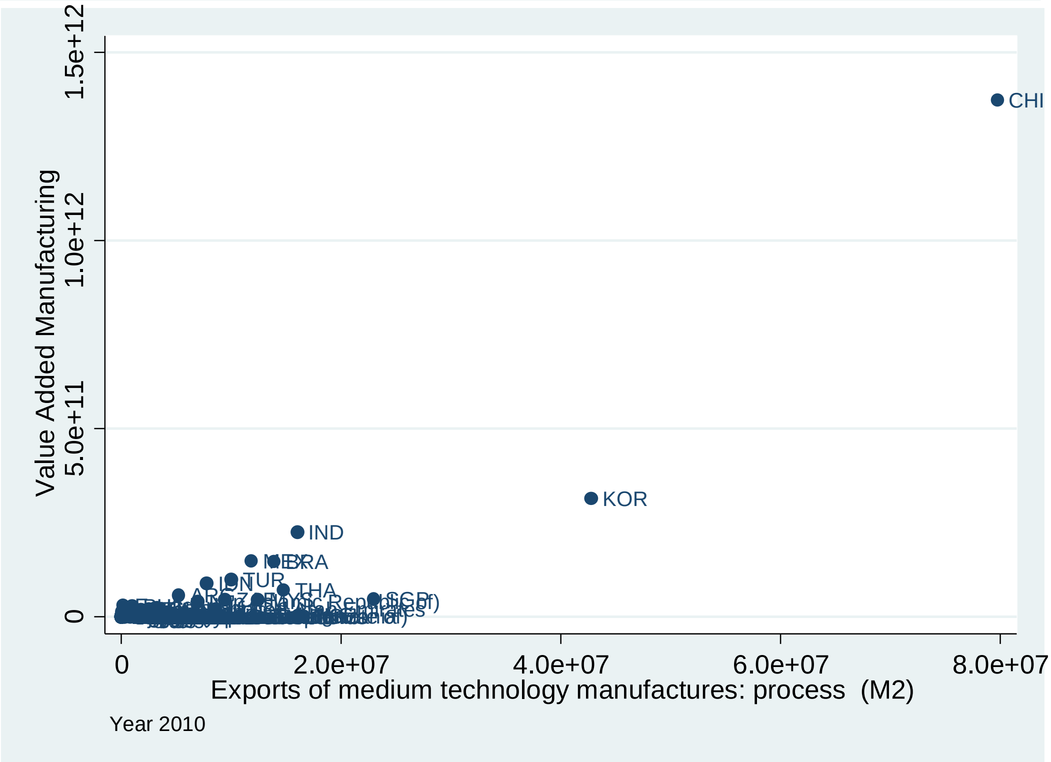


Figure 5 Exports of medium level manufacturing (engineering) vs value added in manufacturing , 2000 and 2010

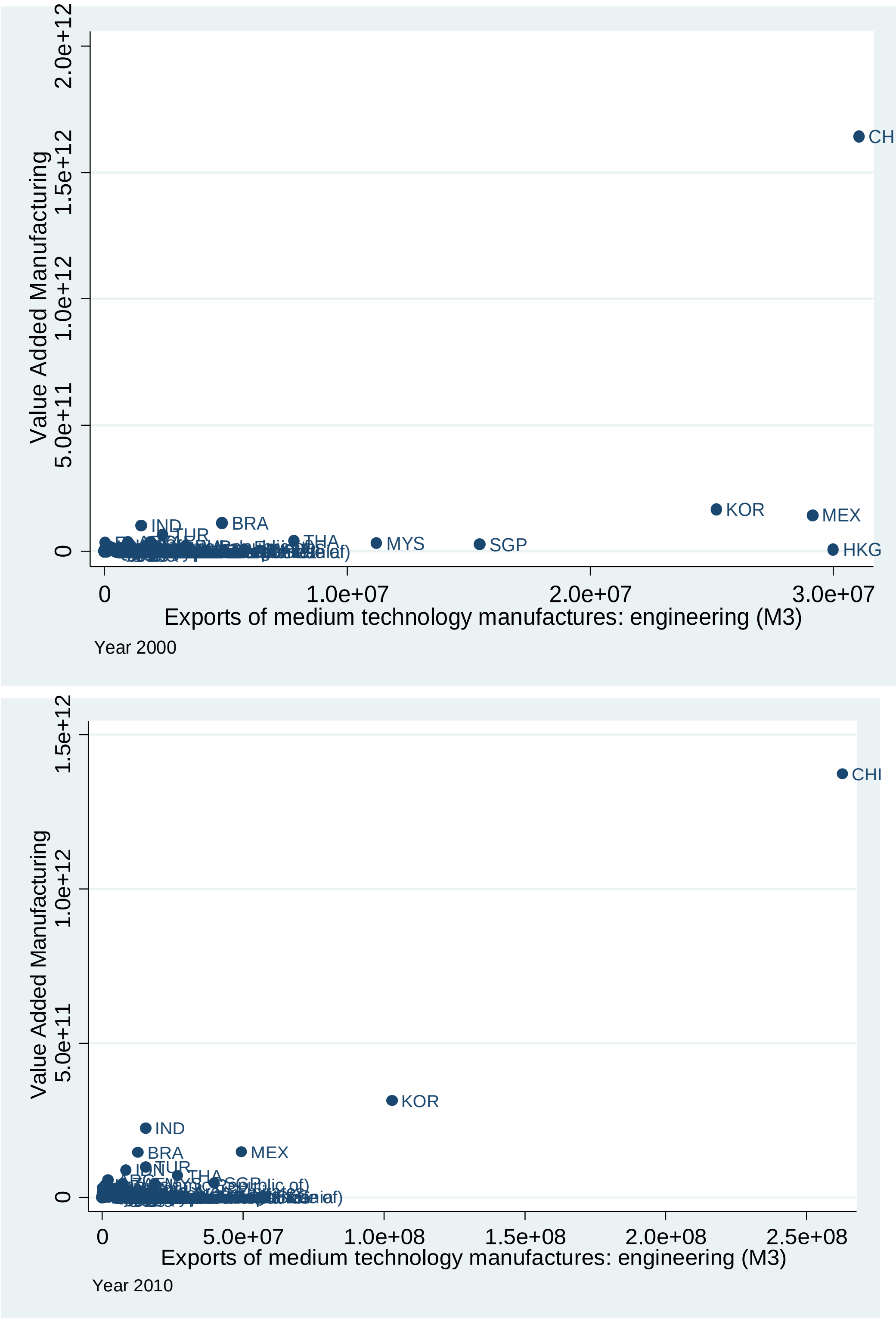
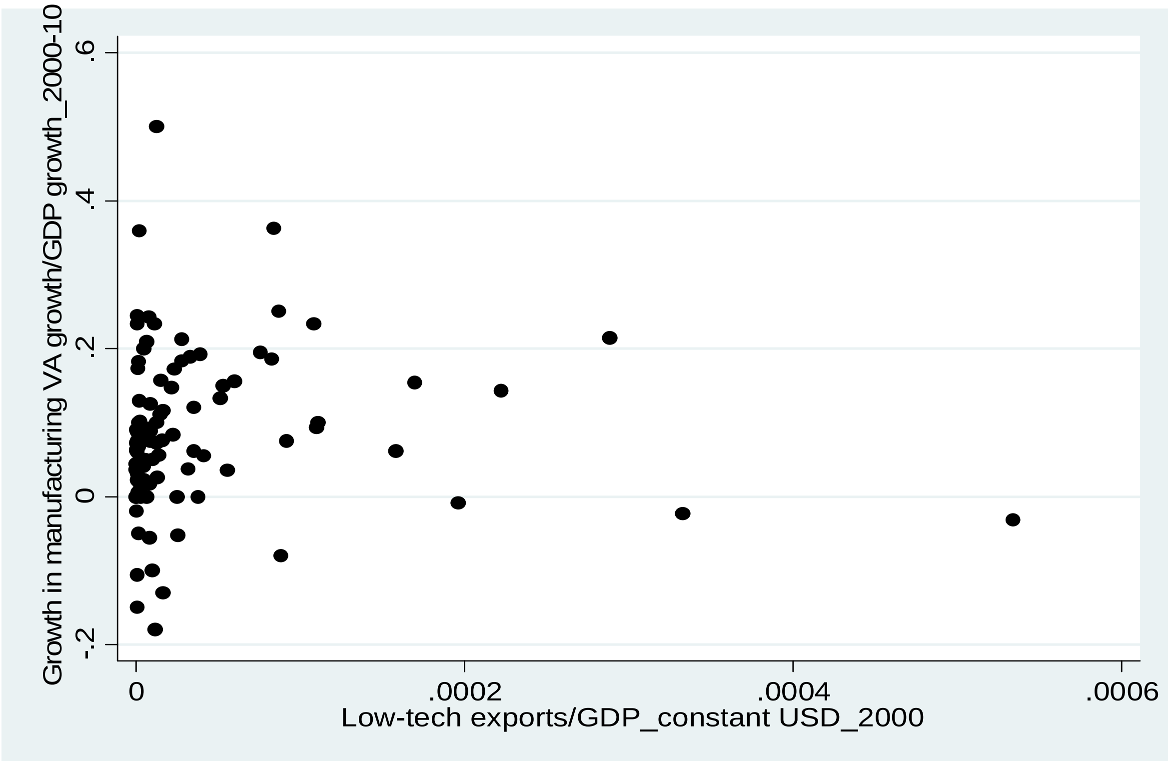


Figure 6. Technological specialization trends in developing countries, 2000-2010



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