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Innovation and Vertical Upgrading in Global Value Chains: The Case of Philippine Manufacturing Firms*

Adrian R. Mendoza

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Abstract

This study assessed the key factors that influence GVC participation from the perspective of firms in a developing country. We extend the firm heterogeneity framework to analyze the patterns of trade in intermediate goods. The results show that bigger and more productive firms self-select into GVC operations. Based on this result, we trace the effects of GVC linkages on participating firms' innovative tendencies, innovation outputs, and productivity. The results suggest that Philippine GVC firms are more likely to be innovative. However, the GVC activities of these firms are associated more with process rather than product innovations. This is as expected since the tasks normally assigned to local firms are more focused on cost and quality controls rather than research and product differentiation. In terms of productivity, the estimates suggest that firms are benefitting from GVC participation mainly in the form labor productivity gains from process innovation and not product innovations. Further, we do not find a significant impact of process and product innovations on TFP. Finally, the above results are contextualized within the middle income trap experience of the Philippines. The analysis shows that the country's innovation and upgrading pattern in GVCs is parallel with its slow transition into a high income economy. Hence, escaping the trap implies moving up and moving out to more productive value chains.

1. Introduction

Since the 1980s, international trade has been increasingly characterized by the growing cross-border fragmentation of manufacturing, with specific countries assigned to particular stages of production (Baldwin and Martin, 1999; Baldwin, 2014b). In what Baldwin (2014b) calls the "second unbundling"[1], firms in developed economies progressively relocated major labor-intensive segments of manufacturing to producers in developing countries. Reduction in transportation costs, advances in information and communication technology (ICT), and more liberal trade policies facilitated this unbundling of production without substantial loss of efficiency (Baldwin, 2014b). State-of-the-art information and telecommunication systems reduced the cost of coordinating complex activities within and between spatially-dispersed firms. In addition, more efficient logistics management cut down transport and

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[1] The first unbundling being the spatial separation of consumption from production (*i.e.*, factories) as powered by the lower transport costs due to advances in railroad and steamship technologies in the 20th century (Baldwin, 2014b).

transaction costs while trade and investment liberalization abolished artificial restrictions that previously limited firms' foreign transactions.

As a result, sequential and/or simultaneous tasks associated with a particular good became easily delegated to different firms that are not necessary near each other.[2] Cheaper coordination and monitoring made it more efficient to slice previously integrated activities into discrete tasks that are executed in different locations (Grossman and Rossi-Hansberg, 2008). This implies that countries can specialize in particular tasks or niches instead of products or industries (Baldwin, 2014a). Each stage is coordinated with the others through different arrangements with varying degree of power relations, from arm's-length transactions to vertical integration. The key role of GVCs then is to integrate the full range of unbundled tasks (from design and production to marketing and distribution) to produce goods and services ready for final consumption (Porter, 1986; Gereffi *et al.*, 2001). Hence, final goods can be viewed as packages of many countries' productive inputs and technologies (Dedrick *et al.*, 2009; Baldwin, 2014b).

The impacts of the rising GVC-centric world trade are profound. First, the nature of international transactions has transformed from the traditional trade in *final goods* into predominantly trade in *tasks* or trade in *intermediate inputs* (Grossman and Rossi-Hansberg, 2008; Baldwin and Robert-Nicoud, 2014). Second, factor endowments become a firm rather than a sectoral or national concept (Baldwin and Robert-Nicoud, 2014). Third, comparative advantage broadened from a national to a GVC concept as implied from Deardorff (2005). Fourth, final goods lost national identity since it becomes hard to trace the origins of the inputs, factors and technologies embodied in the products (Baldwin, 2014b). Lastly, international fragmentation allowed otherwise globally-unfit domestic firms to participate in GVCs via specialization in niche functions (Baldwin, 2014b; OECD 2013; Elms and Low, 2014; WTO, 2014).

The last point is particularly important for developing countries trying to build export-oriented industries. There is growing empirical evidence that countries that chose to integrate into GVCs instead of pursuing domestic-based industrialization experienced better growth outcomes (IMF, 2103; WTO, 2014; Cheng *et al.*, 2015). While the traditional notion of catching up requires building of capital-intensive industries and import substitution (as in South Korea and Taiwan in the 1970s), the increasing role of GVCs in international trade made industrialization easier since countries are no longer required to develop a complete domestic supply chain (Baldwin, 2014b; WTO, 2014). Firms only need to develop comparative advantage in a particular segment of production and operate in accordance with strict international standards (Baldwin, 2014b; De Marchi *et al.*, 2015).

There is a widely-held belief that firms coordinating the GVCs (i.e., the lead firms) produce a positive impact by transferring valuable knowledge and technology to their suppliers (Gereffi, 1999; Gereffi et al, 2005). However, many argue that GVC participation does not automatically lead to firm-level and overall economic upgrading (e.g., Kaplinsky and Morris (2001), Humphrey and Schmitz (2002), Baldwin (2014)). Morrison et al. (2008) note that this results from the loose assumption that integration into GVCs is accompanied by free flow of and easy access to knowledge resources within the chain. Indeed, it is expected that for small suppliers located in developing countries, GVC linkages are the fastest way of accessing and

[2] Baldwin and Venables (2013) classified GVCs into either snakes or spiders. Snakes follow a sequential order from upstream to downstream with value adding in each stage. Spiders involve simultaneous processing of parts, which are ultimately assembled into a single product.

learning about global markets. However, not all firms have similar competencies and not all GVCs are characterized by a single governance pattern. Therefore, a more complete picture should include intricate linkages that are defined by asymmetric power relations and heterogeneous absorptive and technological capacities.

Against this background, this paper aims to analyze the factors that influence GVC participation from the perspective of firms in a developing country. While GVC-active firms from highly-industrialized economies are usually big multinationals with established leadership in terms of size, scope, and technology, the majority of participants from developing countries are smaller and less sophisticated. Within the heterogeneous firms framework (Melitz, 2003; Helpman, *et al*., 2004), this implies that motivations for engagement in cross-country production platforms may not be necessarily symmetric even among firms in the same country. To the extent that GVCs actually create new modes of industrialization within the context of global factories (Baldwin, 2014b; Naudé and Szirmai, 2012), access to these networks may cater to a potentially faster route towards productivity and income growth. A famous hypothesis is that stronger linkages with international production networks will stimulate technological progress though various channels such as induced domestic innovation and knowledge transfers and spillovers. In this light, this current study also aims to test the empirical validity of the innovation effect of GVC connections. In particular, this study looks into mechanisms by with GVCs may increase the innovative tendencies of participating firms. Heterogeneity suggests that the nature of technological upgrading to be implemented will be greatly influenced by the kinds of task or niche being performed by a firm. In terms of value capture, it is most likely that among firms in the international production line, the most productive ones tend to be more innovative and create higher value added.

The prospects of moving up the value ladder maybe considered one of the key reasons why GVC firms want to innovate. A successful upgrading implies increased productivity, and higher value and power capture within the chain. However, successful upgrading depends on a number of internal (i.e., within the boundaries of the firm) and external (i.e., inside and outside the chain) factors. First, upgrading is highly influenced by a firm's capabilities to develop and introduce novel and more efficient features and varieties in each stage of the value ladder (OECD, 2013). While innovation is a key element of upgrading, inadequate technological progress may limit a firm's ability to climb the value ladder. Based on a relative context, Kaplinsky and Morris (2001) suggest that upgrading must be characterized as innovating at a faster rate compared to competitors. On a firm level, a relatively sluggish rate of innovation may result in a reduction of value capture and market shares; on a national level, this may stagnate an economy in low value-added niches and ultimately lead to a low growth trajectory. At lower value-added stages of GVCs, the application of imported technologies in relatively labor-intensive and low-cost activities is sufficient to support productivity gains and rapid growth in developing economies (OECD, 2013). As a next step, moving up the value chain would be necessary to create a new source of this growth.

Second, inter-firm relationships within the chain also matter. Throughout the GVC literature, the interaction of the governance structures and upgrading trajectories has been one of the more extensively explored topics in a number of case-based studies. Since these chains involve different types of firms of all sizes, from large multinational enterprises (MNEs) to small and medium-sized firms (SMEs), central to the GVC framework analysis is the power asymmetry between different actors; in particular, how the so-called lead firms influence the flow of knowledge and the patterns of innovation of smaller firms within its network (Humphrey and Schmitz, 2002; Gereffi et al., 2005; Cattaneo and Miroudot, 2013). Against this background, this research also explores how the GVC governance structure interacts with smaller firms' innovation and upgrading trajectories. According to Gereffi (1994), Humphrey and Schmitz (2001) and Gereffi et al. (2005), the type of governance prevailing in a particular value chain will have a direct effect on task distribution, knowledge flows, and upgrading patterns of firms. The general findings based on numerous case studies of specific chains seem to agree that while global buyers encourage their GVC suppliers to improve process efficiency but not necessarily product and functional upgrading among smaller GVC participants (Kaplinsky and Wamae, 2010; de Marchi et al, 2015).

Against this background, we further expound the implications of GVC firms' upgrading path on an economy's innovation and productivity trajectories and how this may or may not help a country to avoid the middle income trap. We explore the innovation-productivity linkages to provide a micro-level view of the middle income trap experience of the Philippines. In particular, we analyze how the country, through its GVC involvement, may get caught in several traps and how to possibly escape from these traps.

The analyses in this study are mainly based on the results of the 2012 Survey on Adjustments of Establishments to Globalization (SAEG) conducted by then the National Statistics Office (NSO)[3] for the Escaping the Middle Income Trap (EMIT) Research Programme. The SAEG results provide a unique dataset containing information about the impact of globalization on an original sample of 450 Philippine establishments in the manufacturing sector.[4] The survey collected data on firm-level characteristics (e.g., size, age, organization, nature of activity), operations (e.g., products, revenues, costs, compensation, investments, assets, capacity utilization), international transactions, competitiveness position, major operational challenges, innovative activities, and value chain linkages, among others. Additional data from the MIT Observatory of Economic Complexity (Simoes and Hidalgo, 2011) are used in the middle income trap analysis.

This rest of this paper is organized as follows: Section 2 section analyzes firm heterogeneity when firms are evaluated based on their GVC orientation. Section 3 looks at the implication of cross-border linkages on domestic innovation and productivity. Section 4 analyses the productivity effect of GVC participation. Section 5 provides a GVC view of the middle income trap phenomenon. Finally, Section 6 integrates the results and ends with some concluding remarks and policy implications.

2. Firm Heteorgeneity and GVC Participation

Empirical studies on firm heterogeneity generally agree that firms' characteristics are systematically linked to their production and exporting decisions (Pavcnik, 2003; Trefler, 2004; Bernard et al., 2007). As first illustrated by Bernard and Jensen (1995; 1999), there is a substantial variation in the economic attributes of firms even in narrowly-defined industries. In particular, firms that export are bigger, more capital and skill intensive, and pay higher wages compared to non-exporting firms within the same industry (Bernard et al., 2011; Melitz and Redding, 2012). Bernard et al. (2007) find a similar pattern for importers. Kasahara

[3] Now part of the Philippine Statistics Authority (PSA).

[4] The PSA (2015a) defines an establishment as "an economic unit, which engages, under a single ownership or control, in one or predominantly one kind of activity at a single fixed physical location". Throughout this study, establishment and firm are used interchangeably.

and Lapham's (2013) suggest that this may not be random since a firm's imports of intermediate goods and exports of final goods are closely interrelated.

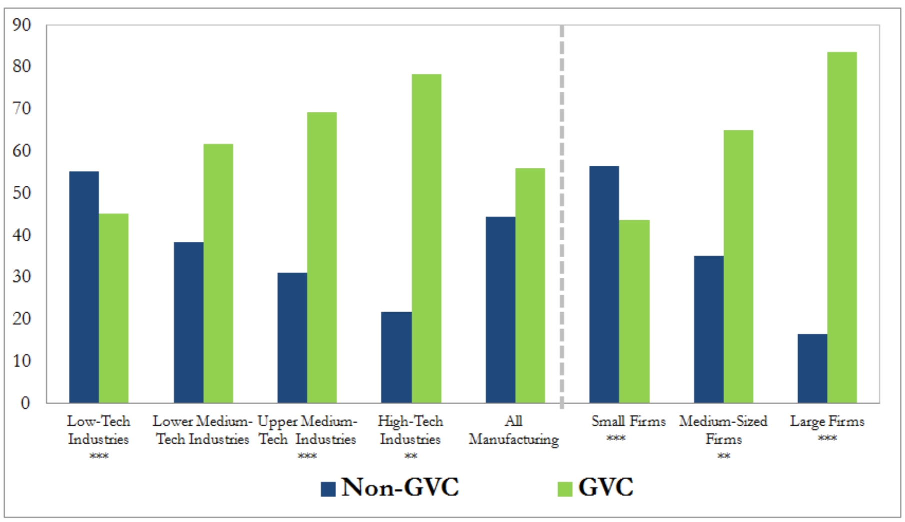
In order to test the predictions of firm heterogeneity (as in Bernard and Jensen (1999) and Melitz (2003)) using the SAEG data, this current research proposed a GVC typology using micro data on input costs, sales, and type of goods produced. We used the UN Broad Economic Categories (BEC) to distinguish firms that produce final and capital goods from manufacturers of intermediate goods (UNSD, 2002). In our analysis, an establishment is classified as a GVC firm using the following *narrow*[5] definition:

$$G_j = \begin{cases} 1 \; if \; (\tilde{X}_j + \widetilde{M}_j) > 0 \\ 0 \; otherwise \end{cases} \quad (1)$$

where $\tilde{X}_j$ and $\widetilde{M}_j$ are firm *j*'s exports and imports of intermediate goods, respectively.[6] In other words, manufacturers with positive intermediates trade are classified as GVC firms (i.e., $G_j = 1$).As a natural extension of the heterogeneity framework, our hypothesis is that GVC and non-GVC firms systematically diverge along many dimensions and that these differences affect firms' tendency to participate in international production networks.

Figure 1. GVC Participation Rate by Technology Intensity and Firm Size

Percent



Source of data: EMIT – SAEG 2012

Note: The asterisks pertain to the results of the test of proportion, i.e., using

$H_0: \max\{\text{Proportion 1}, \text{Proportion 2}\} > \min\{\text{Proportion 1}, \text{Proportion 2}\}$

*p<0.10, **p<0.05, *** p<0.01

Our initial analysis of the SAEG data hints a similar pattern of heterogeneity when firms are grouped according to their GVC orientation. In general, the participation in cross-border production networks is more prevalent among medium-sized and large firms while smaller firms are more common in non-GVC production.[7] This is consistent with the existing evidence that the likelihood of engaging in foreign

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[5] In the *broad* definition, a GVC firm is characterized as any producer that is engaged in exporting or/and importing activities, without further qualifications on the type of goods involved in the transactions (i.e., final or intermediate).

[6] Specifically, $\widetilde{M}_j$ includes firm *j*'s non-oil imported inputs, *i.e.*, raw materials and intermediate goods.

[7] Following PSA convention, firm size based on number of employees is defined as: 1-99 for small; 100-199 for medium; and 200 and up for large.

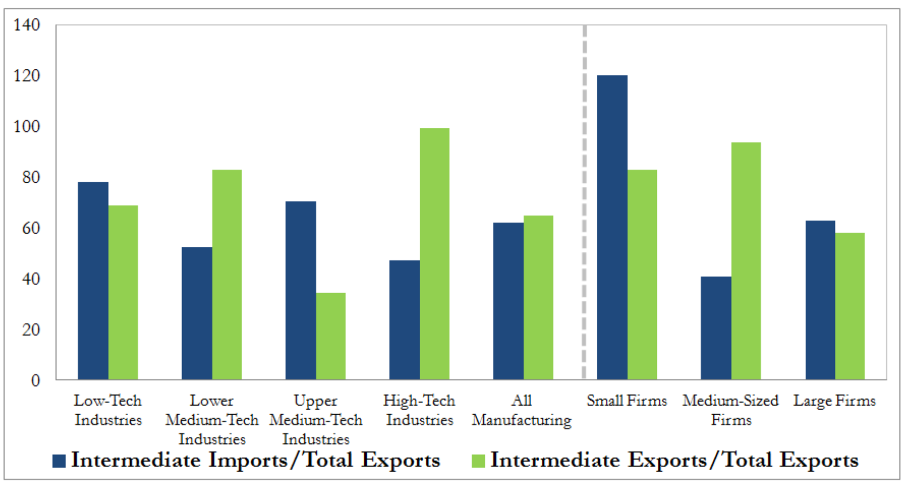
transactions increases with the size of the firm. There is also an increasing pattern of GVC participation rate with respect to the technological intensity of industries, i.e., relatively high-tech industries have higher share of firms operating within GVCs compared to the more basic manufacturing sectors.[8] (See Figure 1.)

While the connection maybe two-directional, this concurs with the observations on the positive relation between capital intensity, productivity, and foreign market entry (Bernard et al., 2011). As prominently shown by Melitz (2003), only the most productive firms can export while the least productive ones will not survive even in the domestic market. Further, Bernard et al. (2007) also show that firms that both export and import outperform purely domestic-oriented manufacturers in many measures of productivity.

The data also suggest that smaller GVC firms are collectively more dependent on backward linkages via imports of raw materials and intermediate goods (See Figure 2). Incidentally, many small firms are operating in low-tech activities such as manufacturing of food, beverages, tobacco and wearing apparels. These industries generally imports raw materials but mostly caters to domestic markets. Conversely, forward linkages are more important for medium-sized GVC firms, a majority of which operate using average technology intensity.

Figure 2. Aggregate Backward and Forward Participation of GVC Firms

Percent



Source of data: EMIT – SAEG 2012

While low-tech sectors are net importers of inputs, the pattern is less defined for medium-tech firms. One possible explanation is that upper medium-tech firms include the assembly of imported durable goods such motor vehicles which are for local distribution. Conversely, medium-tech firms mostly manufacture

[8] Based on ISIC classification, firms are grouped according to technology intensity as follows: a) **low-tech indusries**: wood, pulp, paper, paper products, printing and publishing, food products, beverages and tobacco, textiles, textile products, leather and footwear, reclycling and other manufacturing; b) **lower-medium technology industries**: Building and repairing of ships and boat, rubber and plastics products, coke, refined petroleum products and nuclear fuel, other non-metallic mineral products, basic metals and fabricated metal products; c) **upper-medium-tech industries**: motor vehicles, trailers and semi-trailers chemicals excluding pharmaceuticals, railroad equipment and other transport equipment, other electrical machinery and apparatus, and other machinery and equipment; and d) **high-tech industries:** aircraft and spacecraft, pharmaceuticals, office, accounting and computing machinery, radio, TV and communciations equipment, and medical, precision and optical instruments (OECD, 2005).

industrial inputs such as plastics, base metals and non-metallic minerals which are usually forwarded to foreign partners for further processing. GVC firms in technologically-sophisticated sectors are collectively more active in forward linkages through intermediate goods exports. This is not surprising given that the category includes manufacturers of computers, electronic and optical parts which are a major GVC segment within Philippine manufacturing.

Table 1. Test of Heterogeneity o GVC and Non-GVC Firms in Various Firm Characteristics

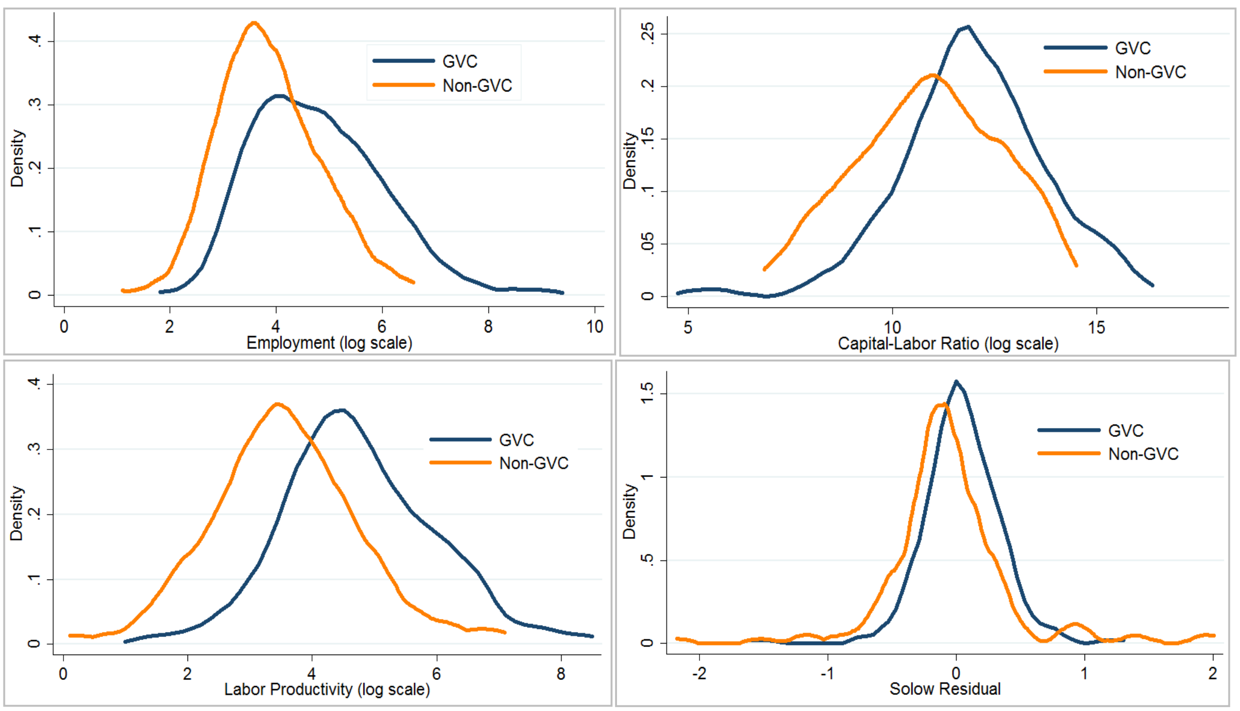
Characteristic	Unit	Non-GVC Firms	GVC Firms	t-test		Kolmogorov-Smirnov Test	
Age	Years	17.64	20.20	-1.55	*	0.0874	
Employees	Persons	79.21	296.94	-3.26	***	0.3361	***
Technical Workers	Percent	5.43	8.82	-2.67	***	0.2956	***
Production Workers	Percent	76.88	73.06	1.78	**	0.1006	**
Foreign Skilled Workers	Percent	0.12	1.13	-1.54	*	0.1281	
Wages	'000 Pesos/Person	69.43	149.02	-6.68	***	0.4624	***
Unit Labor Cost	Pesos	0.40	0.25	2.79	***	0.1820	***
Capital-Labor Ratio	'000 Pesos/Person	185.89	594.46	-3.79	***	0.2706	***
Revenues	Million Pesos	159.00	744.00	-3.20	***	0.5106	***
Value Added	Million Pesos	32.00	172.00	-2.79	***	0.5018	***
Capacity Utilization	Percent	75.16	72.73	1.05		0.1054	
R&D Intensity	Percent	0.21	0.25	-0.28		0.1618	**
New Products	Count	2.30	3.77	-1.34	*	0.0421	
Process Innovations	Count	0.29	0.51	-3.40	***	0.1606	***
Product Innovations	Count	0.42	0.48	-0.82		0.0778	
Labor Productivity	Pesos/Person-Hour	65.78	233.10	-4.57	***	0. 4502	***
Solow Residual (4)	ln	-0.06	0.05	- 2.32	**	0. 2477	***

Source of data: EMIT – SAEG 2012
*p<0.10, **p<0.05, *** p<0.01
Notes:
Amounts are expressed in constant 2000 prices using a manufacturing-specific deflator.
The null hypothesis for the t-test is that the mean values for non-GVC firms are greater than or equal to the mean values for GVC firms. The reverse is used for Production Workers and Unit Labor Cost. The t-statistics and significance are reported.
The Kolmogorov-Smirnov (KS) test is used to verify the null hypothesis that the two subsamples have similar distributions. The KS D-statistics and significance are reported.

The divergence between GVC and non-GVC manufacturers is more apparent when analyzed with respect to specific firm attributes. We summarize in Table 1 the simple t-tests on the equality of the mean characteristics of the two groups. On the average, firms connected to GVCs perform better along many dimensions. GVC firms are typically larger in terms of total employment and wages. The average years of operation is also longer for GVC participants. To the extent that older firms are characterized by more efficient production technologies and higher productivity, this suggests that firms able to survive domestically have built sufficient capacity to deal with the sunk costs of joining GVCs. In addition, the mean shares of highly-skilled and foreign workers is higher for GVC firms while the opposite is true for the share of production workers. The data also show the lower unit labor costs faced by GVC participants. This lends support to the cost-minimizing rationale behind the fragmentation of tasks within production networks. In addition, GVC-connected firms have substantially higher capital-labor ratio compared to exclusively domestic manufacturers and non-GVC exporters. This is consistent with the existing evidence on the higher capital intensity of both exporters and importers relative to purely domestic-oriented firms (Bernard et al., 2011). Together with the higher skill intensity of GVC firms, this concurs with our earlier finding that GVC engagement is more common for high-tech and larger firms.

Measures of firm performance also show that the average revenues and value added are respectively, four and five times higher for manufacturers in GVCs. However, mean R&D intensity and average capacity utilization are not significantly different between the two groups. In terms of innovativeness, GVC participants adopt more process innovations than non-GVC firms but there is no evidence of a similar pattern for product innovations. Nevertheless, the above findings all point to the apparent superiority of GVC participants in terms labor and total factor productivity.

Figure 3. Kernel Densities for Capital Intensity, Revenues, and Labor and Solow Residual



Source of data: EMIT – SAEG 2012

While the previous tests on differences in means show that GVC firms are better than non-GVC firms in many characteristics, we use the Kolmogov-Smirnov (KS) test for equality of distributions to verify that there is divergence between the key attributes of the two groups. Except for age, capacity utilization, the share of foreign employees, new products, and product innovations, the results of the KS tests confirm the divergence suggested by the t-tests. To illustrate the KS tests, we use kernel density which shows the probability that a firm with a particular attribute (e.g., productivity level) is drawn when randomly picked from each GVC category (Vuegelers et al., 2013).

The kernel density for capital intensity, revenues and productivity illustrated in Figure 3 clearly show that GVC firms are more prevalent in higher levels while non-GVC firms are more common in the lower tails of the distributions. This translates to a higher probability that a particular firm is GVC-active given high levels of capital-labor ratio, sales, labor productivity, and TFP. Vuegelers et al. (2013) note that GVC participants' productivity premia are not only due to their size or technological intensiveness but are also connected to the intricate international transactions that they perform. However, the causal relationship is difficult to decompose. Based on the propositions mainstreamed in the *new new trade theory* (Melitz, 2003; Helpman *et al.*, 2004), the more productive firms are more likely to self-select into different modes of internationalization (*i.e.*, combinations of exporting, importing, FDI, and offshoring), as these firms are more potent to deal with the costs and risks associated complex foreign transactions. At the same time, the *learning-by-internationalizing* effect through GVC involvement can be expected to increase firm performance through various channels. Notwithstanding, these findings suggest that a greater GVC exposure will benefit the most productive and capital- and skill- intensive firms within an industry due to their wider access to both export markets and sources of imported intermediates and possible knowledge spillovers (Bernard et al., 2011).

In general, the above findings on the systematic heterogeneity of GVC and non-GVC firms along many important dimensions suggest that these differences possibly interact with firms' decision to participate in international production networks. In the succeeding analysis, we develop an empirical model to test whether these attributes jointly shape firms' tendencies to engage in intermediates trade. Within the tradition of trade models with firm heterogeneity, the presence of positive entry and exit costs is often used to argue that firms will join GVCs only if the present value of the future profits exceeds the sunk costs (J. Baldwin and Yan, 2014).[9] Following Bernard and Jensen (2004), a firm becomes part of GVCs if its current and future revenues exceed the costs. More formally, using past GVC status to proxy for the incurrence of sunk costs, a firm decides to enter the chain if:

$$G_{jt}^{*} = \hat{\pi}_{jt} - (c_{jt} + C[1 - G_{jt-1}]) > 0 \qquad (2)$$

where $\boldsymbol{G_{jt}^{*}}$ is the benefit from participation, $\boldsymbol{\hat{\pi}_{jt}}$ is roughly interpreted as the sum of current export revenues, net gain from importing, and any discounted increase in future value of the firm as the result of current GVC transaction, c_{jt} is the firm-specific variable cost of local inputs, and C is the uniform sunk entry cost.[10] Given the unobservability of G_{jt}^{*}, a firm's GVC participation can instead be modeled as:

$$G_{j}^{*} = f(\boldsymbol{v_{G^{*}j}}, \varepsilon_{G^{*}j})$$

where G_{j}^{*} is a latent variable depicting firm *j*'s benefits from GVC participation; $\boldsymbol{v_{Gj}} = (\boldsymbol{1}, \boldsymbol{x_{Gj}}, \boldsymbol{y_{Gj}}, \boldsymbol{z_{Gj}})$ is a matrix of firm attributes**,** of which $\boldsymbol{x_{Gj}}$ is the vector of basic firm characteristics such as age and size (as measured by the log of employment), $\boldsymbol{y_{Gj}}$ is the vector production-related attributes such as the log of capital-labor ratio, the ratio of technical employees to production workers, R&D intensity, unit labor cost, and quality standard certification (e.g., ISO award), $\boldsymbol{z_{Gj}}$ is the vector of foreign linkages such as foreign equity ownership and connections with multinational corporations (MNCs); and ε_{Gj} is the stochastic term. More explicitly, we model G_{j}^{*} as a linear function of the said variables:

$$G_{j}^{*} = \boldsymbol{v_{G^{*}j}'}\boldsymbol{\beta_{G^{*}}} + \varepsilon_{G^{*}j} \qquad (3)$$

[9] See Roberts and Tybout (1997) and Melitz (2003) for theoretical discussions of firms' export participation along this line.
[10] Bernard and Jensen (1999; 2004) have the original descriptions of $\hat{\pi}_{jt}$ and c_{jt} as applied in exporting only.

where $\boldsymbol{\beta_G}$ is the vector of coefficients, including an intercept term. Since an indicator for G_j^* is difficult to quantify, we instead use a logit rule defined as:

$$G_j = \begin{cases} 1 \; if \; G_j^* > 0 \\ 0 \; if \; G_j^* \leq 0 \end{cases} \tag{4}$$

where the binary indictor $\boldsymbol{G_j}$ takes the value 1 when a particular firm $\boldsymbol{j}$ exports and/or imports intermediate goods as defined in Equation 1. The probability of firm $\boldsymbol{j}$ participating in GVCs given attributes $\boldsymbol{x}_{Gj}, \boldsymbol{y}_{Gj}$, and $\boldsymbol{z}_{Gj}$ is estimated as:

$$\Lambda_{Gj}\left(\boldsymbol{v}_{Gj}'\boldsymbol{\beta}_G + \varepsilon_{Gj}\right) = \frac{\exp\left(\boldsymbol{v}_{Gj}'\boldsymbol{\beta}_G + \varepsilon_{Gj}\right)}{1 + \exp(\boldsymbol{v}_{Gj}'\boldsymbol{\beta}_G + \varepsilon_{Gj})} \tag{5}$$

where $\Lambda_{Gj}(\cdot) = Pr\left(\varepsilon_{Gj} \leq -(\boldsymbol{v}_{Gj}'\boldsymbol{\beta_G} + \varepsilon_{Gj})\middle|\boldsymbol{v_{Gj}}\right)$ is the logistic cdf of ε_{Gj} evaluated at $\boldsymbol{v}_{Gj}'\boldsymbol{\beta_G}$. We also include two-digit industry dummies to account for the possible effect of sectoral peculiarities on GVC participation. (For instance, we've shown earlier that technologically advanced industries are more involved in production networks).

In order to provide a more meaningful interpretation of the results, we compute the marginal effects to indicate the expected change in the probability of the outcome when the explanatory variables are changed one at a time; i.e., the marginal effect of one determinant on the probability of GVC participation, *ceteris paribus*. The marginal effects are summarized in Table 2 below. Column 1 contains the results for the baseline specification. In column 2, foreign capital participation is split into Asian and non-Asian originated foreign equity. Column 3 adds to the baseline a control for domestic supply constraints such as locally unavailable or low quality materials. Finally, Column 4 checks the effect of innovation outputs on the likelihood to join GVCs.

The estimates show that foreign linkages are consistently the most important attributes associated GVC firms. In particular, foreign capital participation has the biggest marginal effect on the average local firm's tendency to integrate operations into international production networks. Similarly, linkages with multinationals (either as a partner, supplier, or subsidiary) also increase the likelihood that a domestic producer will be active in GVCs most probably by exploiting the MNC partner's international connections. When we split foreign equity participation into East Asian and non-East Asian, the results suggest that equity of regional origins are relatively more important in determining a firm's GVC-orientation. This finding lends support to the suggested regional rather than global nature of GVCs. In what Baldwin (2014b) calls a trade-investment-services nexus, the "services" part involves periodic movement of technical people (e.g., quality auditors, consultants and trainors) to facilitate the employment of tacit knowledge in a particular segment.[11] This only makes sense in regionally-compact production chains.[12]

The estimates also show that other basic firm characteristics such as age, size, capital intensity and efficiency indicators also contribute to a firm's propensity to participate in GVCs. The positive effect of age, size, and capital intensity are consistent with the existing evidence on the relationship between scale economies and exporting and importing (Bernard et al., 2011). However, these are relatively modest when compared to the marginal effects of having foreign connections. Baldwin (2014b) explains that the international fragmentation of production made exporting and importing easier for domestic firms by

[11] This also suggests that knowlegde diffision with GVCs will be geographically bounded.

[12] In this fashion, the really important regional GVCs can be grouped into just three: Factory North America, Factory Europe, and Factory Asia (OECD, 2013).

specializing in niche functions rather than striving to be fully-integrated, capital-intensive manufacturers. Consequently, WTO (2014) note that integration into a GVC only requires a country or a firm to be globally competitive in the segment it wants to perform. The ability to gain access to established production networks through foreign partners provides a shortcut to internationalization. In this sense, size and capital intensity become non-binding constraints in GVC-led industrialization.

Table 2. Characteristics of GVC Firms

Marginal Effects

Dependent Variable: $Pr(G_j = 1 \mid \boldsymbol{v_{Gj}})$	1		2		3		4	
Age	0.003	*	0.003	*	0.003	**	0.003	*
	(1.77)		*(1.79)*		*(2.01)*		*(1.80)*	
Employees (ln)	0.080	***	0.082	***	0.025		0.080	***
	(3.49)		*(3.58)*		*(1.28)*		*(3.47)*	
Capital-Labor Ratio (ln)	0.046	***	0.045	***	0.025	**	0.046	***
	(3.30)		*(3.26)*		*(2.17)*		*(3.33)*	
Tech. Staff-Production Worker Ratio	0.031		0.028		-0.04		0.038	
	(0.49)		*(0.44)*		*(-0.83)*		*(0.60)*	
R&D intensity	2.296		2.342		0.698		2.232	
	(1.58)		*(1.62)*		*(0.64)*		*(1.52)*	
Unit labor cost	-0.129	**	-0.119	*	- 0.030		-0.129	**
	(-2.14)		*(-1.91)*		*(-0.75)*		*(-2.14)*	
Dummy: 1 = Has ISO certification	0.116	**	0.124	**	0.082	*	0.119	**
	(2.07)		*(2.20)*		*(1.78)*		*(2.12)*	
Foreign equity share	0.292	***			0.243	***	0.296	***
	(4.60)				*(4.56)*		*(4.63)*	
Foreign equity share: East Asian			0.334	***				
			(4.39)					
Foreign equity share: Non-East Asian			0.210	**				
			(2.12)					
Dummy: 1= Connected to MNC	0.138	***	0.137	***	0.100	**	0.141	***
	(2.82)		*(2.80)*		*(2.48)*		*(2.86)*	
Dummy: 1= Has local supply constraints					0.316	***		
					(12.69)			
Dummy: 1= Past process innovation							0.017	
							(0.33)	
Dummy: 1= Past product innovation							-0.039	
							(-0.73)	
Industry Control	Yes		Yes		Yes		Yes	
N	305		305		305		305	
Pseudo-R-Squared	0.362		0.372		0.544		0.363	
Log Likelihood	-134.08		-132.07		-95.91		-133.81	
LR χ^2	152.26	***	156.29	***	228.60	***	152.80	***
AIC	322.16		320.13		247.82		325.62	

Source of data: EMIT – SAEG 2012

*p<0.10, **p<0.05, *** p<0.01

Note: The reported pseudo R-squared and AIC figures pertain to original logistic regressions.

Efficiency indicators such as ISO certifications and unit labor costs are also significant across all specification (except when controlling for the domestic supply constraints.) Within the GVC platform, cost-effectiveness and quality standards are important considerations for foreign buyers when considering potential suppliers. As suggested by Gereffi et al (2005), efficiency and quality management lies at the core of any successful GVCs since failure at any point along the chain will derail the entire production process. Maskus et al. (2000; 2005) point out that technical barriers to trade such as compliance to client's standards often disqualify firms that are too small to meet the fixed costs of meeting the requirements. Hence, only firms producing at or near world quality standard will be able to participate (WTO, 2014). With spatially dispersed production, quality standards are most relevant when decisions are formed independently by separate producers but frequent monitoring is costly and impractical.

Finally, it is interesting to note that consistent with the earlier finding on capital intensity, the results suggests that domestic capital and knowledge formation seem to be less relevant in the GVC engagement of the sampled Philippine firms. Accordingly, R&D intensity, the relative share technical workers, and product innovation are statistically insignificant in identifying GVC participants in the sample. Within producer-driven GVCs[13] such as the automotive, electronics, and pharmaceuticals sectors, R&D and technology production are core functions normally kept by lead firms (normally headquarters) while assembly is delegated to cost-efficient firms (Gereffi and Fernandez-Stark, 2011). This also explains why process improvements and quality certifications may be more relevant than R&D activities in explaining GVC integration.[14] While our earlier findings suggest that a majority of GVC participants are in high-technology industries, their small R&D spending imply the nature of the production segments they handle; that is, low-skill-intensive tasks relative to more technologically-sophisticated segments in the chain but relatively high-skill and capital intensive compared to local non-GVC firms. As shown in Figure 1, while 60 percent of the total GVC trade happens in upper-middle and high-tech industries, the R&D intensities are relatively higher in less sophisticated industries.

The interaction of GVC participation and innovation will be explored in the next section.

3. Innovation Among GVC Firms

There are several ways by which GVCs can help participating firms learn and innovate. First, importing intermediate goods may involve bringing in the related technology to process these inputs. This may require further skills training when the technology is completely new to the firm (EBRD, 2014). The resulting human capital improvement may cater to further innovations or may spillover to other firms or industries via labor turnover. Second, while the stringent quality requirements in GVCs may mean self-selection of efficient suppliers into the chain, competition for a particular segment may force firms to constantly upgrade (Balwin, 2011; WTO, 2014). Third, lead firms may share a portion of their production techniques or domestic firms may acquire state-of-the art technology to keep updated. This is possible through several options such as FDIs, mergers and acquisition, joint ventures, technology transfers, and licensing arrangements, among others (WTO, 2014). Lastly, as timeliness is a key issue within production networks, GVC participants may adopt process and organizational upgrading to improve logistics and delivery methods (EBRD, 2014).

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[13] In producer-driven GVCs, multinational firms typically take the lead roles in coordinating production networks the supplying critical components (including capital, R&D, and technology) to other segments of the chain. This kind of GVC is common in capital- and technology-driven industries, such as computers, semiconductors, heavy machinery, automobiles, and aircraft (Gereffi, 1994).

[14] We reestimated Equation 5 using contemporaneous instead of past innovation. The results show that process innovation has a positve and highly significant marginal effect (i.e., 0.119) on GVC participation while product innovation is negative and insignificant.

However, it is also possible that GVC participation may discourage innovation when firms specialize in less skill- and technology-intensive segments such as assembly. In these types of functions, the potential for knowledge spillovers may be limited if the processes involved are simple and highly standardized such that procedures can be easily codified. Manufacturing standardized inputs of highly modular products also leaves little space for creativity in terms of product differentiation. In this case, there is only minimal learning opportunity since the capabilities acquired are too basic or are not readily applicable in higher value-added activities (Baldwin, 2014b; EBRD, 2014; WTO, 2014). Since upgrading to tasks with higher value capture is also costly, small domestic firms' technological growth will be limited by their own size, the scope of their niche in the GVCs, and lead firms' decision to transfer technology.

In order to track the effect of GVC participation on innovation outcomes among firms, this current study adopts the three-stage Crépon-Duguet-Mairesse (CDM) model due to Crépon et al. (1998), with modifications based on Griffith et al. (2006). The strength of the model lies on its tractable logical chain from innovation inputs and outputs to firm productivity (Crépon et al., 1998). The standard CDM model is a system of four equations estimated in three recursive steps. The model begins by estimating the innovation tendency and actual innovation inputs (i.e., knowledge expenditures) equations simultaneously. The predicted innovation input then feeds into the knowledge production function. The estimated innovation output ultimately enters the productivity equation as one of the explanatory variables. By design, the model is recursive to exclude feedback effects.

The first stage of the model deals with the firm's decision to spend on *innovation inputs* based on its *innovative tendencies*. Here, a firm's innovation input is proxied by its knowledge expenditures, $\widetilde{K}_j$, defined as sum of current-period R&D spending, royalty fee, and capital expenditures on machinery and equipment, intangible non-produced assets, and computer software and database. However, it is well recognized in previous studies that using innovation inputs as indicators of innovativeness is not without problems. For instance, Gorodnichenko *et al.* (2010) note that not all innovations are R&D-related while R&D activities do not always lead to successful innovations. They also stress that R&D and patent indicators may be biased against small firms and firms in emerging economies that rely more in technology imitation and adaptation. In addition, innovation efforts may be underreported since some are not directly observable such that data collection itself is costly (Griffith et al, 2006; Hall et al., 2009).

In light of previous point on underestimation, we will condition a firm's reported innovation input by its *innovative tendency,* $\tilde{I}_j$. Here, innovative tendency is modeled as the *propensity to be innovative* based on its past innovation efforts. Firms with a history of continuous innovation effort at least one activity in the past three years are assumed to be more likely to spend on innovation input owing to the persistent and often multi-period nature of innovative projects. Table 3 summarizes the indicators used to measure innovative tendency.

Table 3. Indicators of Past Innovation Effort in the SAEG

Type of Input	Description	Type of Data
Internal		
R&D Staff	Employment of staff exclusively for design/innovation/R&D	Binary
Design	Internal R&D on product design	Binary
New Staff	Hiring a key personnel	Binary

Own Technology	Technology developed/adapted within the local establishment	Binary
External		
New Machinery	Acquisition of domestic and foreign-sourced machinery or eqpt.	Binary
Subcontracted R&D	Subcontracting of R&D to other companies/organizations	Binary
Licensing Agreement	New licensing agreement	Binary
Turnkey	Licensing of domestic and foreign-sourced turnkey operation	Binary
Parent	Technology transfer from parent company	Binary
Client	Innovation developed with client company	Binary
Supplier	Innovation developed with supplier	Binary
Industry Association	Innovation acquired from a business or industry association	Binary
Consultant	Innovation acquired from consultants	Binary
R&D Institution	Innovation acquired from universities and public institutions	Binary

Note: for all binary indicators, a value of 0 implies that the firm does not engage in that activity.

In the second stage, the firm's total innovation output, I_j, is modeled as a function of estimated input $\widehat{\tilde{k}_j}$ as conditioned by its innovative tendency $\tilde{I}_j$; i.e., $I_j = f\left(\tilde{k}_j \middle| \tilde{I}_j\right)$. Let $i_{sj} = \{0,1\}$ be a binary indicator where firm j is assigned the value 1 when it adopts or implements a particular innovation s. Therefore, a firm's total innovation output can be calculated as:

$$I_j = \sum_{s=1}^{S} i_{sj} \qquad (6)$$

Between two firms, the one with the higher I is assumed to be more innovative due to its greater involvement in multiple innovative activities. This also partially reveals the nature of the operations of the firm, with more complex tasks often requiring both process and product innovations. In order to operationalize the effect of knowledge expenditures on actual innovation outcomes, we indentify a number of indictors of process, product and non-technological innovations that will be used in this study. Table 4 provides a summary.

GVC participation not only provides direct access to new suppliers and new markets but also plays a critical role in capturing knowledge and technology spillovers. This in turn can potentially boost domestic firms' learning and innovative capabilities (Gereffi, 1994, 1999; Giuliani, *et al.,* 2005; Kaplinsky, 2000; Humphrey and Schmitz, 2002; Pietrobelli and Rabellotti, 2011). As noted by Almeida and Fernandes (2007), exposure through exporting, importing and foreign ownership increases the probability that firms in developing countries will engage in innovative activities. In particular, recent empirical evidence show that relative to firms serving the domestic economy, exporters are more likely to innovate and apply new technologies (Verhoogen, 2008; Bustos, 2011). Criscuolo et al. (2010) also find that globally engaged firms have better learning capabilities as well as stronger linkages to different sources of knowledge. Other studies find that a higher degree of foreign ownership leads to more direct technology transfers (Ramachandran, 1993) which in turn facilitates greater indirect knowledge spillovers (Dimelis and Louri, 2002; Javorcik and Spatareanu, 2003). These suggest that in addition to the traditional trade in final goods and connections with MNCs, participation in global production networks provides an alternative way to increase innovation and accelerate domestic technological growth.

Table 4. Indicators of Innovation Output in the SAEG

Type of Innovation	Description	Type of Data
Process Innovation	Upgrade of machinery and equipment	Binary

	Introduction of a new production technology	Binary
Product Innovation	Introduction of a new major product line	Binary
	Upgrade of an existing product line	Binary
	New patent/utility model or copyright protected material[15]	Binary
Non-Technological Innovation	Internal changes as a business strategy	Binary
	Offshoring of production to foreign location	Binary
	Outsourcing of production to domestic location	Binary
	Entry into a new joint venture agreement	Binary
	Mergers and acquisitions	Binary

Note: For all indicators, a value of 0 implies that the firm does not engage in that innovative activity.

The extent to which a domestic firm can learn from its GVC participation depends on the degree of exposure to and its capacity to internalize the knowledge spillovers. The former depends on the strength of a firm's international linkages while the latter requires a certain level of technical capability to be able adjust, customize or imitate a technology before its productive integration into the firm's own operations (Narula and Marin, 2005). Notwithstanding the ready access to machines and techniques, technology transfer may still be constrained by insufficient physical, financial, and institutional infrastructures as well as deficiencies in the critical aspects of absorptive capacity (Gerschenkron, 1962; Cohen and Levinthal, 1990; Lall, 1992). In other words, the firm's absorptive capacity is heavily influenced by the stock of useful knowledge embedded in its skilled workers, physical capital, and R&D capabilities (Cohen and Levinthal, 1990; Mokyr, 2002).[16] Some forms of absorption may require minimal technological effort (e.g., direct imports of machinery and equipment) while others involve more active types of learning such as customization and reverse engineering. Previous studies try to capture the effect of absorptive capacity on firms' learning patterns and innovative activities by measuring technological complexity, capital intensity, and R&D investments (Cohen and Levinthal, 1989, 1990; Griffith et al., 2006; Kinoshita, 2001). Keller and Yeaple (2003) find evidence of positive (FDI) spillover on US firms in high-tech industries with more R&D investments. Kathuria (2000) also observes that within "scientific" sectors, firms with higher absorptive capacity experience positive spillovers.

While the original estimation of Crepon et al. (1998) only considers firms with positive R&D investment, Griffith et al (2006) corrected for the selection bias by estimating the model using an inclusive sample of both firms that report R&D spending and firms that do not. In this current study, we follow Crespi and Zuniga (2012) to further increase the inclusiveness of the innovation input indicator by using knowledge expenditures, $\widetilde{K}_j$, instead of just R&D spending.[17] This reflects the general consensus that all firms exert efforts to innovate, although this may not be directly observable and not entirely captured in official reports, especially for those in developing countries. In particular, the first stage models a firm's knowledge spending conditional on its propensity to be innovative. More formally, the "true" innovation expenditure equation can be expressed as:

[15] This classification is based on previous evidence that product innovations are more likely to be patented than process innovations (e.g., Harabi (1995) and Hanel (2005)). This reflects the fact that the benefit captured by a process innovator may be minimal especially when the innovation is generic and easily replicated. In contrast, product innovation leads to discernible differentiation on which ownership can easily be established using patents.

[16] Mokyr (2002) classified useful knowledge as either *propositional* (*e.g.*, natural phenomena and regularities or loosely, the set *basic* knowledge) or *prescriptive* (*e.g.*, techniques, instructions, or loosely, the set *applied* knowledge).

[17] To reiterate, $\widetilde{K}_j$ is the sum of current spending on product process innovation, royalty fee, and capital expenditures on machinery and equipment, intangible non-produced assets, and computer software and databases.

$$K_j^* = \boldsymbol{v}_{\boldsymbol{K^*j}}'\boldsymbol{\beta}_{\boldsymbol{K^*}} + \varepsilon_{K^*j} \quad (7)$$

where K_j^* is a latent variable for the actual innovation effort (or input), $\boldsymbol{v}_{K^*j}$ is vector of factors correlated with firm *j*'s innovation effort, $\boldsymbol{\beta}_{K^*}$ is the vector of corresponding parameters, and ε_{Kj} is the error term. Following Aghion and Howitt (2009), these inputs may be interpreted as the sunk costs that firms must incur in order to have a successful innovation output. The variable K_j^* is considered latent since failing to report any R&D spending does not necessarily mean zero knowledge input and output (Griffith et al., 2006). As we've discussed above, using actual level of R&D expenditure as proxy for innovation effort may be biased due to reporting and measurement gaps as well the importance of non-R&D inputs especially for firms in developing countries. The model is structured based on Heckman (1979) and Van de Ven and Van Pragg's (1981) approach in dealing with sample selection bias. In particular, the selection equation used to project a firm's potential innovation effort based on its propensity to be innovative is estimated by:

$$\tilde{I}_j = \begin{cases} 1 \; if \; \boldsymbol{v}_{\tilde{\boldsymbol{I}}\boldsymbol{j}}'\boldsymbol{\beta}_{\tilde{\boldsymbol{I}}} + \varepsilon_{\tilde{I}j} > 0 \\ 0 \; otherwise \end{cases} \quad (8)$$

where $\tilde{I}_j$ is an indicator function that assigns the value 1 to firm *j* when its reported consistent innovation-related effort in the preceding three years. In contrast to Griffith et al. (2006) which used continuous intramural R&D only, $\tilde{I}_j$ incorporates both internal and external innovation efforts summarized in Table 3. The consideration of external effort is cognizant of the fact that producers in developing economies such as the Philippines remain highly dependent on technology sourced from outside the firm. To be considered a consistent innovator, we only require firm to be persistent in at least one activity since multiple innovative efforts are too costly. Likewise, this recognizes the fact that innovation needs may vary from firm to firm. Conditional on $\tilde{I}_j$, we can restate the innovation input equation as:

$$\tilde{k}_j = \begin{cases} K_j^* = \boldsymbol{v}_{\boldsymbol{K^*j}}'\boldsymbol{\beta}_{\boldsymbol{K^*}} + \varepsilon_{K^*j} \; if \; \tilde{I} = 1 \\ 0 \qquad\qquad\qquad\qquad\quad if \; \tilde{I} = 0 \end{cases} \quad (9)$$

where $\tilde{k}_j = 1$ when $\widetilde{K}_j > 0$ and $\tilde{k}_j = 0$ when $\widetilde{K}_j \leq 0$. As in Griffith et al. (2006), this approach assumes a similar process describing the innovation decision of both reporting and non-reporting firms.

To estimate the innovation input of firms, $\tilde{I}_j$ and $\tilde{k}_j$ are modeled as functions of internal features and external stimuli that influence a firm's incentive to innovate. For instance, Crepon et al. (1998) suggest that firm size increases the innovative tendency of a firm. This is reminiscent of the Schumpeter hypothesis that size and R&D intensity are positively related due to the innovation advantage of larger firms (Cohen et al., 1987). Seker (2012) expounds that larger firms tend to be more innovative since current innovation often requires sufficient capital and knowledge stock accumulated from previous technological upgrading. This highlights the inter-temporal nature of innovations such that current innovators usually have a history of past innovations. Other CDM studies also consider appropriability measures (e.g., intellectual property rights) as important mechanisms that encourage higher innovation inputs. As pointed by Griffith et al. (2006) and Crespi and Zuniga (2012), the incentive to do more R&D activities should increase in the presence of a strong formal system that ensures full capture of the returns on innovation investments.

In addition, we control for a number of innovation constraints faced by firms. In particular, low expected returns to innovative activities, insufficient knowledge capital, and high cost of financing have been identified by the surveyed firms as major obstacles to their innovative tendencies. This is particularly true for manufacturers in developing counties where the current technology is too far from the frontier such that incentives to innovate may be weak (Acemoglu et al., 2006). Lack of sufficient scale effects and bureaucratic burdens may also render new innovations prohibitively costly. It is worth noting that these constraints may also reinforce each other. For instance, high cost of innovation inhibits the technical growth of a firm which in turn limits size of its knowledge stock as well as its incentive to upgrade. This means slow productivity growth, low profitability and higher cost of borrowing. Against this background, technologically-lagging firms face the risk of being outdated if their innovation rate is slower than frontier firms. Within the context of GVCs, this may mean being delegated to relatively simple and low-value-added tasks that do not require highly technical skills.

For international exposure, Griffith et al. (2006) and Seker (2012) show that foreign competition pushes firms to exert more innovation effort. Jongwanich and Kohpaiboon (2011) observe that exposure to foreign competition encourage firms in Thailand to increase R&D investments. Robertson and Alvarez (2001) find a similar relationship in Chile and Mexico. In terms of foreign ownership, Guadalupe et al. (2010) find that although multinationals "cherry-pick" the most productive domestic firms to acquire, these firms still engage in post-acquisition process and product innovation. This may be correlated with their access to the sophisticated knowledge and human capital, financial assets and networks of the parent company (Kumar and Agarwal, 2000; Girma, and Gorg, 2007).

The estimates for the innovative tendency and innovation input equations are presented in Table 5. The projected $\hat{\tilde{k}}_j^*$ is obtained from the results and used as an input in the innovation production function. A simple probit model is also estimated as the baseline.

Based on the results, firms that are older and employ more permanent technical workers have higher propensity to be innovative. As an indicator of appropiability, past patent-related transactions also increase the innovative tendency of a firm. Access to formal legal protection encourages persistent innovations since investors are assured that they will have full capture of the benefits during the entire run of the projects. In addition, previous process innovations are more relevant than product innovations in predicting the firm's potential innovativeness. Among the constraints, only the expectation of low return on the innovation investments discourages firms to exert more innovative effort. In terms of size, larger firms have higher propensity to be innovative. However, size does not matter in the firm's decision to invest in actual inputs. As explained by Cohen and Klepper (2006) and Crespi and Zuniga (2012), the relationship between innovation spending and size of the firm, i.e., the Schumpeter hypothesis, is positive but not necessarily proportional. In other words, among firms that decide to invest in innovation, there is no evidence that the larger ones will proportionally spend more.

Table 5. CDM Model Stage 1: Innovative Tendency and Innovation Input

Dependent Variable	$P(\tilde{I}=1)$ (Selection Eqn.)		$P(\tilde{k}=1)$ (Innov. Input)		$P(\tilde{k}=1)$ (Baseline)	
Age	0.016	**	0.020	***	0.011	
	(2.36)		*(2.99)*		*(1.61)*	
Employees (ln)	0.152	**	0.074		0.169	**
	(2.09)		*(0.76)*		*(2.00)*	
Permanent Tech. Staff/Total Employees	2.970	***	2.864	***	2.533	**
	(3.26)		*(2.91)*		*(2.52)*	
Foreign Equity Share	-0.144		0.681	**	0.817	***

	(-0.64)		*(2.29)*		*(3.23)*	
Dummy:1 = Has past patent experience	0.530	**	0.377	*	0.473	**
	(2.43)		*(1.80)*		*(2.38)*	
Constant Source of Past Innovation						
Dummy: 1 = Internal			-0.204		-0.059	
			(-0.48)		*(-0.29)*	
Dummy: 1 = External			0.526	**	0.508	**
			(2.24)		*(2.35)*	
Dummy: 1=Plans future innovation			0.473	**	0.157	
			(2.21)		*(0.82)*	
Dummy: 1= Has past process innovation	0.296	***				
	(4.22)					
Dummy: 1= Has past product innovation	0.029					
	(0.45)					
Dummy: 1 = GVC firm			0.365	*	0.349	*
			(1.66)		*(1.78)*	
Innovation Constraints						
Dummy: 1 = Cost of financing	0.043		0.061		0.072	
	(0.17)		*(0.18)*		*(0.29)*	
Dummy: 1 = Low Expected Returns	-1.178	*	-7.329	***	-0.132	
	(-1.90)		*(-17.98)*		*(-0.25)*	
Dummy: 1 = Low Knowledge Capital	-0.132		-0.420		-0.269	
	(-0.38)		*(-0.90)*		*(-0.82)*	
Industry Control	Yes		Yes		Yes	
N	314		314		293	
Log-likelihood			-250.0		-155.59	
Pseudo-R-Squared					0.23	
Wald χ^2					91.26	***
LR test of independent equations			3.30	*		
AIC			626.18		373.18	

Source of data: EMIT – SAEG 2012
t-statistics (in parentheses) are based on robust standard errors
* p<0.10, ** p<0.05, *** p<0.01

For innovation inputs, domestic firms with higher foreign capital ownership are more likely to spend on innovative projects. Further, plans of introducing new designs or products in the near term expectedly increase the probability of spending more on innovation inputs. However it is interesting to note that the higher innovation inputs are only significantly associated with the persistent use of externally-sourced knowledge (e.g., from clients, suppliers, universities, consultants) but a similar relationship is not observed for technology developed internally. Among external sources of technology, many firms rely on the knowledge embodies in imported machinery and equipment. This is consistent with the widely-tested fact that the technology embodied in imported capital goods encourages other forms of innovation when efficiently absorbed by the firm (*e.g.*, Coe and Helpman (1995); Coe *et al.* (2009); Schiff and Wang (2010)). Ultimately, imported machinery and equipment may lead to productivity improvements through more efficient processes.

Being linked to international production networks is also associated with more expenditure on innovation projects. Together with the importance of foreign equity shares, this confirms the results in previous studies that foreign linkages increase the innovative tendencies of a firm. However, within the context of our earlier findings on significant role of past process innovations, the innovation investments induced by GVC participation seem to be more focused on production efficiency. Further, the kinds of projects pursued involve adopting and assimilating external technology rather than developing capacity within the firm. In addition, the belief that there is no business case in investing too much resources in innovative activities may also mean little incentive to improve when their primary tasks in the chain don't require them to. In other words, there is no urge to "reinvent the wheel especially when the wheel nor the road is not broken".

Going back to the CDM model, we proceed to the second stage by estimating a firms' innovation output through a knowledge production function. Taking into account its projected propensity to invest in innovation inputs $\hat{\hat{k}}_j$, firm *j*'s knowledge output can be modeled as:

$$I_j^* = \boldsymbol{v}_{I^*j}\boldsymbol{\beta}_{I^*} + \beta_{\hat{\hat{k}}}\hat{\hat{k}}_j + \varepsilon_{I^*j} \tag{10}$$

where v_{I^*} is a vector of explanatory variables with the associated vector of parameters β_{I^*}, $\beta_{\hat{\hat{k}}}$ captures the partial effect of the estimated innovation inputs $\hat{\hat{k}}_j$, and ε_{I^*j} is the stochastic term. As in the first stage, Equation 10 is also estimated for the entire sample, recognizing that actual innovation effort is not only limited to firms that reported positive knowledge spending, i.e., $\widetilde{K}_j > 0$. We use $\hat{\hat{k}}$ to correct for the upward bias in γ due to a possible simultaneity of K_j^* and I_j^*. Similar to Griffith et al (2006), we assume that innovation effort is a public good inside the firm such that it can be used to produce many types of innovation outputs without serious depletion. Hence, I_j^* can is a vector containing many specific forms of innovations (i.e., process, product and non-technological).

We deviate from to the tradition popularized by Griliches (1979) and Crepon et al. (1998) which use patents as indicator of innovation output. This recognizes the fact that patenting is not mainstream in developing countries since the forms of innovation are either far from the technology frontier or absorbed from an external source. In addition, weak intellectual property laws may increase rather eliminate the costs of patent applications. We also deviate from more recent CDM papers (i.e., Griffith et al. (2006) and Mairesse and Mohnen (2010)) that used a binary indicator of whether a firm as a process or product innovation. Instead, the innovation output here is proxied by I_j which is the number of innovative activities implemented by a firm, i.e., $I_j = \sum_{s=1}^{S} i_{sj}$. This indicator provides a better measure of the intensity of a firms' involvement in multiple innovative activities. Likewise, it is more reflective of the fact that a firm can innovate in several, probably complementary, forms simultaneously. Against this background, we assume $s = \{0,1,2, \ldots S\}$ to follow a Poisson distribution with mean $\lambda > 0$. If λ can be modeled as log-linear function of $\boldsymbol{v}_{Ij}$ such that $\log(\lambda) = \boldsymbol{v}_{Ij}\boldsymbol{\beta}_I + \hat{\hat{k}}_j\gamma + \boldsymbol{\varepsilon}_{Ij}$, the probability that the number of innovative activities implemented by firm j equals s is given by:

$$P(I_j = s) = \frac{\exp(-\exp(\boldsymbol{v}_{Ij}\boldsymbol{\beta}_I + \beta_{\hat{\hat{k}}}\hat{\hat{k}}_j + \boldsymbol{\varepsilon}_{Ij}))(\boldsymbol{v}_{Ij}\beta_I + \beta_{\hat{\hat{k}}}\hat{\hat{k}}_j + \boldsymbol{\varepsilon}_{Ij})^s}{s!} \tag{11}$$

In order to estimate Equation 11, we use a knowledge production function consistent with the traditional CDM approach. This assumes that innovation output is produced using a combination of technical labor, knowledge stock, and new knowledge inputs. We also include innovation output in the preceding year to test the validity of the "success-breeds-success" hypothesis, i.e., capital and knowledge accumulated through past innovations leads to more innovation (Cohen and Levinthal, 1990; Seker, 2012). In addition, we include as explanatory variables a number of internal and external factors that may influence a firm's demand for innovation. In particular, we control for the degree of domestic and foreign competition faced by the firm to reflect the other half of the Schumpeter hypothesis; i.e., market structure affects a firm's innovative activities (Levin et al., 1985). Contemporaneous non-technological improvements may also motivate firms to pursue accompanying process or product improvements. For instance, plans of internal reorganization may require a manufacturer to upgrade its process management systems. Likewise reorientation of a manufacturer from a domestic player to a more outward-looking firm may increase its demand for new machinery or better products.

Table 6. CDM Model Stage 2: Innovation Output

Marginal Effects

Dependent variable:	Process Innovation				Product Innovation			
	$P(I_j' = 1)$		$P(I_j = s)$		$P(I_j' = 1)$		$P(I_j = s)$	
Estimated Innovation Input	0.258	**	0.292	*	0.202	*	0.343	**
	(2.17)		*(1.69)*		*(1.80)*		*(1.99)*	
Knowledge Capital/Technical Staff (ln)	-0.002		-0.003		-0.025	**	-0.037	**
	(-0.12)		*(-0.13)*		*(-2.40)*		*(-2.31)*	
Lagged dependent variable	0.190	***	0.249	***	0.285	***	0.380	***
	(4.40)		*(4.36)*		*(7.52)*		*(7.05)*	
Dummy: 1 = has non-tech innovation	0.066		0.077	*	0.099	**	0.134	**
	(1.51)		*(1.77)*		*(2.20)*		*(2.43)*	
Innovation Partners:								
Dummy: 1 = Client/Supplier	0.215	***	0.206	***	0.249	***	0.120	*
	(3.51)		*(2.86)*		*(4.42)*		*(1.80)*	
Dummy: 1 = National innovation system	0.126		0.130		0.014		0.035	
	(1.48)		*(1.28)*		*(0.17)*		*(0.35)*	
Dummy: 1 = Faces competition from local	0.090	*	0.116		-0.036		-0.006	
	(1.72)		*(1.63)*		*(-0.71)*		*(-0.08)*	
Dummy: 1 = Faces competition from foreign	0.006		0.048		-0.017		-0.055	
	(0.09)		*(0.48)*		*(-0.28)*		*(-0.71)*	
Industry Control	Yes		Yes		Yes		Yes	
N	289		289		289		289	
Log-likelihood	-146.68		-210.21		-130.39		-215.20	
Wald χ^2	72.39	***	126.32	***	74.04	***	157.97	***
Pseudo R-Squared	0.232		0.119		0.327		0.157	
AIC	347.37		474.43		314.78		484.39	

Source of data: EMIT – SAEG 2012

t-statistics (in parentheses) are based on robust standard errors.

*p<0.10, **p<0.05, *** p<0.01

The estimates from the Poisson regression are presented in Table 6. We conduct separate estimations for process and product innovations. As a baseline specification, we also run logistic regressions with I_j transformed to the binary indicator $I_j^{'} = \{0,1\}$ where firm j take the value 1 when $s > 0$. Here, $P(I_j^{'} = 1)$ can be interpreted as probability of having a successful innovation while I_j measures the "magnitude" of the firm's innovation outputs.

The results suggest that spending on new innovation inputs is necessary for a firm to succeed in its innovation projects. However, innovation expenditures seem more important for product development (e..g., upgrading an existing line) than process improvements (e.g., introducing a new equipment). This is consistent with earlier findings that internal research projects and product innovations are very tightly connected (Aghion et al., 2009; OECD, 2009; Yashiro et al., 2010). Since product innovations require more sophisticated skills and knowledge and produces a higher value-added, one should expect that this also involves higher explicit and implicit (e.g., transactions) costs compared to simple process improvements. This result is also explains why innovations of firms in developing countries are often externally-sourced (Crespi and Zuniga, 2012). When in-house R&D is prohibitively costly, new technology of machinery may instead be acquired from cheaper external suppliers. This is particularly relevant for SMEs that are less R&D-oriented and rely more on knowledge spillovers via innovation linkages (Noteboom, 1994, 1998; Waalkens *et al.*, 2004; OECD, 2009). Within this context, Seker (2012) suggests that the innovative behavior of technology-lagging firms can be interpreted as a catching-up strategy rather exploratory.

The estimates also suggest that firms with previous innovative activities have a higher likelihood of engaging in a related project in the current period. This is supports the view (*e.g.*, OECD (2009) and Seker (2012)) that consistent innovators follow a technology path wherein knowledge accumulates as a result of regular, often incremental, improvements. As Cohen and Levinthal (1990) suggest, prior knowledge is often required to absorb new knowledge. This may also reflect the fact the decision to innovate is rarely a one-shot static problem but often a multi-period endeavor. In addition, the results also show evidence of complementarity between technological and non-technological improvements within a firm. For instance, having offshored/outsourced previously internal functions may allow a firm to reallocate its resources to its core competencies. This implies possible investments in new machinery or embarking in a product development research. Likewise, entering a joint venture agreement or expanding operations via mergers and acquisitions may mean absorbing the skills, processes, and technology of the new partners.

In order to test the role of GVC linkages in firms' innovative activities, we re-estimated the knowledge production function but with the estimated innovation input replaced by its significant covariates from Stage 1. Also, GVC firms were split between importer and exporter of intermediate goods. As shown in Table 7, the results suggest that backward linkages are more relevant in GVC firms' innovation decisions. As observed in Amiti and Koning (2007), technology transfers are stronger for imports of intermediates compared to trade in final goods. Javorcik (2004) also finds that FDIs generate positive vertical spillovers via backward linkages in supply chains. Further, Keller (2000) shows higher spillovers when the imports originated from industrialized countries, reflecting the technological content of these imports while inputs sourced from abroad may allow firms to mix foreign and in-house production methods which my encourage hybrid technologies.

Further, the positive effect of importing intermediate goods is higher for process than product innovation. This corroborates our earlier findings that the nature of GVC segments (*e.g.*, assembly) handled by Philippine firms are less R&D-intensive and more focused on production efficiency and adherence to clients' specifications. This is also contrast with the recent results based on developed countries (e.g., EBRD (2014)) that GVC participation has a higher impact on product innovation and R&D spending. However, these results are not necessarily inconsistent since many GVC participants in developed countries are lead firms that are more oriented towards the creation of new products or novel technologies. Together, these pieces of evidence suggest that while GVC participation increases the tendency of a firm to innovate, the type of innovation it will adopt will be partially dictated by the nature of its role in the chain. Therefore, production stages with higher value added will most likely require more complex forms of innovation (*e.g.*, R&D-intensive product and process upgrading). This means that firms assigned with simpler tasks may be more adaptive than creative when deciding to innovate. Further, to the extent that domestic firms are dependent on a small number of foreign buyers, the clients may impose limitations on local firms' upgrading in less important functions in order for these firms to focus their resources on meeting the quality requirements within GVCs (Schmitz and Knorringa, 2000; Bair and Gereffi, 2001; de Marchi *et al.*, 2015).

Table 7. CDM Model Stage 2: GVC Linkages and Innovation Output
Marginal Effects

	Process Innovation		Product Innovation	
Foreign Equity Share	-0.057		-0.089	
	(-0.61)		*(-0.86)*	
Dummy: 1 = Exporter of Intermediate Goods	0.155	*	0.045	
	(1.88)		*0.530*	
Dummy: 1 = Importer of Intermediate Goods	0.290	***	0.168	**
	(3.72)		*(2.21)*	
Industry Control	Yes		Yes	
N	289		289	
Log-likelihood	-199.57		-203.22	
Wald χ^2	178.02	***	224.58	***
Pseudo-R-Squared	0.163		0.204	
AIC	469.14		476.44	

Source of data: EMIT – SAEG 2012
t-statistics (in parentheses) are based on robust standard errors.
* p<0.10, ** p<0.05, *** p<0.01

With regard to exporting intermediate goods, the weak or insignificant effect suggests that learning-by-exporting is probably not a general phenomenon among GVC firms in the Philippines. This is consistent with earlier mixed results on previous investigations on the learning-by-exporting hypothesis (Wagner, 2007). According to Park *et al.* (2010), the learning-by-exporting effect is possible through technical support from clients, induce innovation due to compliance with quality standards, and wider access to information on new technologies, new products, and new markets. However, Costantini and Melitz (2007) note that productivity gains from exporting does not necessarily mean a learning-by-exporting effect but rather implies firms' joint decisions on exporting and innovation; hence a self-selection effect. Since exports within GVCs primarily involve intermediates manufactured based on pre-agreed specifications and with pre-identified markets, exporting in this set-up may require minimal innovation. First, competition between suppliers may only be serious at the stage when the lead firm is choosing potential partners, wherein quality standard certifications may be used a signal. However, once GVC linkages are established to form long-term buyer-seller relationships, threats of competition may not be credible when changing suppliers is too costly. Second, Baldwin (2014b) argues that the knowledge diffusion within GVCs involves sharing of narrow, task-specific portion of parent company's technology. Since the goal is to get the intermediate goods at the lowest cost for the required quality, foreign buyers may apply stringent selection criteria for possible suppliers such that the need to technology transfer is minimal. Hence, intermediate exports may increase productivity but not necessarily innovativeness.

We expound on the productivity effect in the next section.

4. Productivity Effect in GVCs

So far, the general picture emerging from our previous results suggest a significant divergence between GVC and non-GVC firms along many dimensions. As shown in the first two stages of the CDM model, this has important implications on the innovation decision of firms. In particular, the types of innovative activities pursued by firms seem to be affected by the nature of their roles in the value chain. For instance, importers of intermediate goods are more likely to be innovative but the kind of innovation is more focused on process than product innovation. In addition, successful innovators seem more dependent on knowledge acquired from external sources than in-house R&D efforts. Although these results confirm the well-established facts that globally-engaged firms are, on average, more innovative and more productive, there remains a need for further qualifications when talking about the innovation-productivity link within GVCs. In particular, do all types of innovation have the same effect on productivity? In other words, what forms of innovations are relevant in productivity growth? In succeeding analysis, we proceed to the last stage of the CDM model by estimating the effect of process and product innovations on labor and total factor productivity.

To formally analyze these patterns, we model the innovation-productivity link as:

$$P_j = f(\boldsymbol{v_{Pj}}, \boldsymbol{\hat{I}_J}, \varepsilon_{Pj}) \tag{9}$$

where P_j is a measure of firm-level productivity, $\boldsymbol{v_{Pj}}$ is a vector containing labor and capital inputs; $\boldsymbol{\hat{I}_J}$ is the vector of estimated process and product innovations, and $\boldsymbol{\varepsilon_{Pj}}$ is an i.i.d. stochastic term. Here, we measure productivity in two ways. The first extracted the Solow residual from the Cobb-Douglass production function of the form:

$$y = \alpha_0 + \alpha_1 l + \alpha_2 k + \alpha_3 m + v \tag{10}$$

The second calculated labor productivity as gross value added per labor-hour.

On the firm level, technological and capital investments have been identified in traditional growth equations as drivers of productivity increase. Consequently, innovation and knowledge accumulation are observed to positively contribute to size and output growth of a firm primarily via improvements in absorptive capacity (*e.g.*, Baldwin and Diverty, 1995; Wang and Tsai, 2003). Griffith, *et al.* (2004) also find that R&D activities affect TFP growth via innovation and technology transfers. We also include competition indicators to reflect the prediction of a positive relationship between competition and productivity growth in Schumpeterian models (Aghion et al., 2013).

In particular, we apply ordinary least squares to model productivity as a linear function of $\boldsymbol{v_{Pj}}$ and $\boldsymbol{\hat{I}_J}$:

$$p_j = \boldsymbol{v_{Pj}\beta_P} + \boldsymbol{\hat{I}_J\beta_{\hat{I}}} + \varepsilon_{Pj} \tag{11}$$

where $\boldsymbol{\beta_P}$ and $\boldsymbol{\beta_{\hat{I}}}$ are vectors of parameters. Following Griffith et al. (2006), using predicted rather than actual values of the innovation outputs partially addresses the possible endogeneity of I_j**.** The OLS results are summarized in Table 8. Here, the parameter estimates can be interpreted as semi-productivity elasticities; i.e., the productivity growth resulting from a unit increase in the explanatory variable.

The results of the competition indicators are consistent with the Schumpeterian view and the predictions of firm heterogeneity. In particular, we find a positive effect of foreign entrants on productivity while competition from local firms is not significant. As suggested by Schumpeterian models, incumbent firms' productivity appears to be stimulated by competitive pressures from new entrants that are near the technology frontier (Aghion et al., 2013). In light of bigger and more productive firms self-selecting into international operations, we expect foreign new entrants to pose a competitive threat to the market shares of domestic incumbents.

Table 8. CDM Model Stage 3: Innovation and Productivity

Dependent Variable:	Labor Productivity		Solow Residual	
Share of Technical Labor	2.475	***	0.152	
	3.970		1.290	
Capital Productivity (ln)	0.171	***	0.112	***
	3.000		6.440	
Estimated Process Innovation	0.474	*	0.020	
	1.720		0.290	
Estimated Product Innovation	-0.077		-0.001	
	-0.740		-0.050	
Dummy: 1 = Faces competition from local	-0.092		-0.011	
	-0.560		-0.280	
Dummy: 1 = Faces competition from foreign	0.376	**	0.048	
	2.090		1.170	
Size Control	Yes		Yes	
Industry Control	Yes		Yes	
N	261		261	
Adjusted R-squared	0.226		0.203	
AIC	846.3		128.6	

Source of data: EMIT – SAEG 2012
t-statistics (in parentheses) are based on robust standard errors.
* $p<0.10$, ** $p<0.05$, *** $p<0.01$

The results also show that a higher share of high-skilled labor and more efficient capital also improve labor productivity. For technical workers, the effect may be realized in many forms. For instance, more skilled employees may be assigned to handle critical tasks, operate high-tech equipment, supervise a production unit, or train low-skilled workers. On the other hand, machinery and equipment upgrades have a labor-augmenting effect when properly assimilated by the firm. For example, a shift from manual to machine-assisted assembly improves the speed and accuracy of the workers. This translates to faster delivery and lower rejection rates. Within the context of GVC operations, the domino effect of bad performance at the earlier stages of production can paralyze the entire value chain. In this light, it is clear why both lead firms and producers involved in assembly and lower-tier input manufacturing put a prime importance on process efficiency.

Consequently, the contribution of process improvements on labor productivity is positive and significant. This is intuitive since process innovation in this current study involves upgrading of machinery and equipment and adopting a new technology that has substantially changed the production method. However, there is no evidence of a similar effect from product innovation. There are several possible explanations for this. First, and most probably, firms are not very much involved in internal R&D-based product development projects due to cost and human capital constraints. Second, and in relation to the first, hard-core product innovation maybe irrelevant and unnecessary when the tasks at hand are relatively simple. Lastly, Navarro et al. (2010) suggest that product innovations may require a longer incubation period before the effects start to manifest in productivity. Against the background of a cost minimizing behavior and binding resource constraints, the choice between investing in potentially productivity-augmenting product innovation and implementing immediately effective process improvements may be a serious balancing act that firms have to do. This is particularly true in a high-pressure GVC environment where small suppliers are constantly exposed to strict buyer requirements.

It is also noteworthy that both process and product innovation have no significant impact on our measure of TFP. This is consistent with the view that long-term productivity growth requires the large-scale employment of new ideas and technologies instead of overdependence on knowledge from adaption and imitation (Aghion and Howitt, 1992). To the extent that long-run TFP growth is not driven by capital accumulation, insignificant effect of process innovations may be intuitive since it is mainly characterized by the acquisition of new machinery, equipment, and technology. Moreover, recent findings suggest that achieving sustained productivity gains mainly relies on internally-developed innovations rather than spillovers from international linkages (Cherif and Hasanov, 2015; Felipe et al., 2015). This suggests that over-dependence on externally-acquired technology or on knowledge transfers from foreign partners may not produce the desired effect on TFP. For instance, Cherif and Hasanov (2015) cite the popular case of Taiwan and South Korea's big leap from import-substitution industrialization into a more aggressive industrial policy. In particular, the government of Taiwan implemented large-scale public and quasi-public research programs that helped local firms develop new technologies without relying on MNCs. Further, there was a massive public investment to build a large "technical community". On the other hand, South Korea's successful chaebols (e.g., Hundyai) built internal knowledge through aggressive R&D efforts and technology upgrading. A key regularity from these success stories is that firms decide early on to accumulate knowledge faster via internal efforts rather than rely on knowledge spillovers that may be weak to start with.

In the next section, we further expound the implications of GVC firms' upgrading path on an economy's innovation and productivity trajectories and how this may or may not help a country to avoid the middle income trap.

5. A GVC View of the Middle Income Trap

Following the gains-from-backwardness proposition of Gerschenkron (1962), exploitation of low-cost labor and adoption and assimilation of foreign technology makes sense for economies at the early stages of development. Being far from the technological frontier and having limited domestic capabilities to accumulate knowledge through internal efforts, industrial latecomers enjoy the benefit of a wide choice of already tested innovations. In principle, if the diffusion and adoption of frontier innovations were frictionless regardless of their nature, a lagging country could catch up fast by importing the most advanced technologies (Eaton & Kortum, 1995; Grossman & Helpman, 1994). Hence, the challenge is not to invent but to choose the appropriate technologies to absorb (Lall, 1992). Abramovitz (1986) qualifies that successful exploitation of existing technologies depends on whether a country's capabilities are sufficiently developed. This, in turn results from well-directed technological efforts (Lall, 1992).

However, recent evidence suggests that the latecomer effect starts to dwindle as a low-income country becomes more developed. For instance, Eichengreen et al. (2012) and Aiyar et al. (2013) suggests that growth slowdowns are mainly traced to productivity slowdown where reallocating resource from agriculture to industries and where dependence on imported technologies are no longer sufficient to boost productivity.[18] The growth deceleration also coincides with the situation wherein the role of capital accumulation in sustaining growth becomes less important either due to diminishing marginal returns on physical investments or deteriorating quality of the capital stock while rising wages erodes the competitiveness of domestic industries (Eichengreen et al., 2012; Felipe et al., 2012; Agenor, 2015). Fu et al. (2011) add that income gaps may persist or widen in situations where catching-up economies experience growth slow down due to too much reliance on imported technologies that are not fully appropriate to domestic conditions. Other studies also suggest that a sub-par quality of human capital may limit the ability of the economy to commercialize more advanced innovations, ultimately preventing any further productivity increase (Redding, 1997; Acemoglu et al., 2006). Failure to implement new sources of growth may stagnate or even retrograde the development process of a country.

In their seminal paper, Felipe et al. (2012) identified 35 countries in 2010 that are caught in the middle-income trap. After having breached the middle income mark through some degree of industrialization, these countries failed to graduate to the high income category mainly due lack of capabilities to undergo further structural transformation.[19] Based on the development experience of 124 countries since 1950, Felipe et al. (2012) quantify that countries in the lower middle income trap (including the Philippines) have been in the category for more than 28 years while countries in the upper middle income trap are stuck for more than 14 years. Based on their analysis, Felipe et al (2012) explain that the economies able to graduate to upper-middle income had previously upgraded their export baskets to include more diversified, sophisticated, and non-standard products.

This is consistent with the earlier findings of Hidalgo et al. (2007) which suggest that the development process involves the accumulation of capabilities to produce and export varied and more complex goods. This implies that sustained economic growth would require not only continuously improving the quality of the existing set of goods but also acquiring more sophisticated technologies to be able to produce a wider range of higher value-added products. This also reminiscent of the proposition of Morrison et al . 2008) that technological change requires purposeful efforts to strengthen technological capabilities at the firm level. Using network theory, Hidalgo et al. (2007) builds a product space to show how a country's existing set of capabilities "conditions" the kind set of goods that it can potentially produce and export. Hidalgo et al. (2007) suggest that it is easier to produce a new product whose capability requirement is similar to that of existing products (e.g., expanding from garments to footwear is more likely than jumping from garments to electronics). This means that the direction of a country's expansion will reflect the set of products that its technology and knowledge stock can support. In other words, countries with less complex capabilities are more likely to specialize in less sophisticated products while production in

[18] Eichengreen et al. (2012) estimates that 85 percent of the slowdown in the growth of output can be explained by the sluggish TFP growth.

[19] The middle income trap is distinguished from a typical poverty trap since the latter is associated more with the lack of important production inputs and/or chronic market failures (e.g., inadequate public goods, inefficient or missing credit and capital markets, coordination failures, weak institutions) that ultimately retard growth (Agenor, 2015). However, both the middle income trap and the poverty trap may be considered as bad equilibria based on Acemoglu et al. (2006).

countries near the technology frontier will be characterized by state-of-the-art processes and high R&D intensity. Here, comparative advantage is no longer focused on factor endowments alone but also on the countries' accumulated capabilities.

To illustrate, Figure 4 shows the respective locations of South Korea, Colombia and the Philippines in product space during the time they first become middle income countries and how they evolved through the years.[20] Based on Felipe et al (2012), South Korea became lower middle income country in 1969 and achieved a high income status in 1995. On the other hand, as of 2015, Colombia and the Philippines have been trapped in the lower middle income category for 66 years and 39 years, respectively. In the case of South Korea, it is very apparent how its production and export sector evolved from basic manufacturing (e.g., green dots for garments) to highly sophisticated core goods such as electronics (light blue), cars and machinery (blue), and chemicals (maroon).

Figure 4a. Product Space of South Korea: 1969 vs. 2013

1969 **2013**

Source: MIT Observatory of Economic Complexity

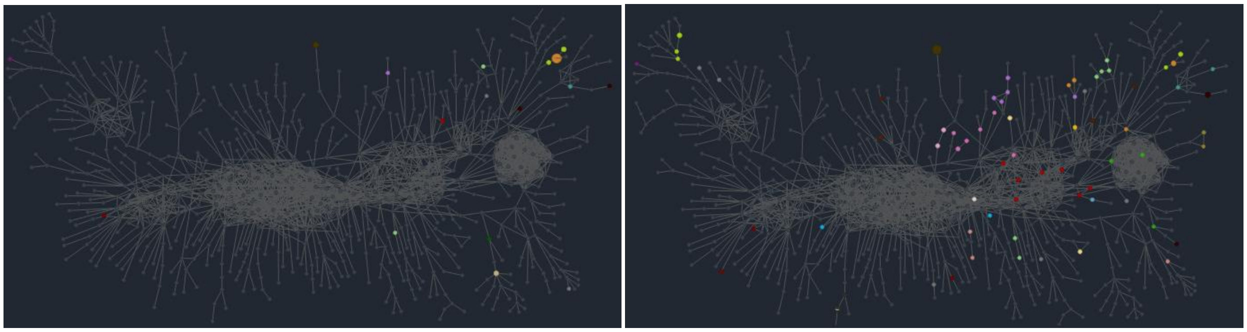
At the other extreme, Colombia, one of the countries longest caught in the lower middle income trap[21], hasn't exhibited considerable progress in the diversification and sophistication of its export basket. In 1962, Colombia was mainly exporting important agricultural commodities such as coffee, banana, sugar and raw cotton. After 53 years, Colombia is still exporting out of agricultural and extractive sectors (mainly livestock, sugar, coffee, minerals, and crude petroleum) and traditional manufactures (e.g., leather and paper). It is noteworthy that Colombia is virtually absent in heavy industries such as equipment and machinery manufacturing as well as in modern and high-tech sectors such as electronics and chemicals and automobiles. This provides an indicative support to the claims of Hidalgo et al. (2007) and Felipe et al. (2012) that sustaining growth, i.e., avoiding the middle income trap, requires a structural transformation towards an economy that can produce and export more complex goods.

Figure 4b. Product Space of Colombia: 1962 vs. 2013

1962 **2013**

[20] Based on Felipe et al (2012), Colombia reached lower middle income status in 1949 but the MIT Observatory of Economic Complexity only has data starting 1962.

[21] The others are Peru, Namibia, and South Africa (Felipe et al., 2012).

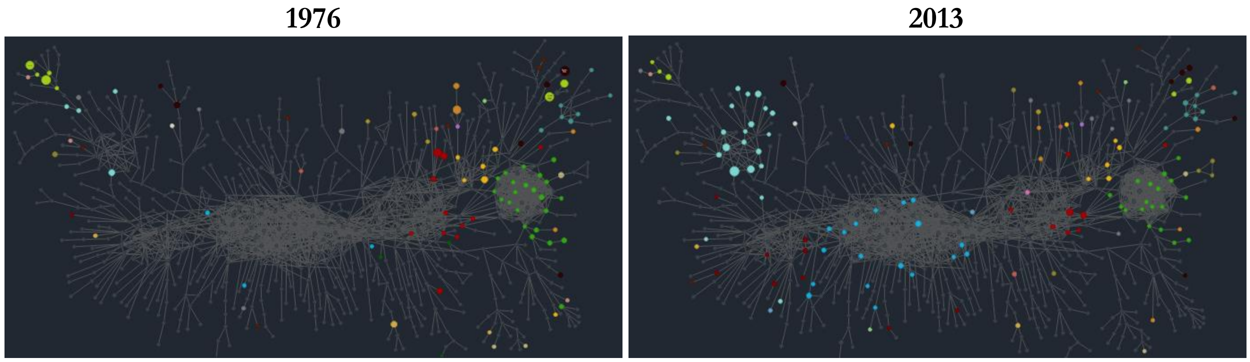


Source: MIT Observatory of Economic Complexity

In the case of the Philippines, comparative advantage in electronics was already established by the 1980s. However, despite the increasing sophistication of the country's export basket, Usui (2011) note that the capabilities acquired from electronics manufacturing did not cater to the growth of more complex industrial products. This lends support to previous observations that the range of tasks performed by Philippine electronics locators is narrowly specialized in the low value adding segment of the chain and provides little upgrading and branching out opportunities. This is also consistent with the findings of Felipe et al. (2012) that many East Asian economies that got into electronics boost their export sophistication but the gains did not necessarily diffused to the sectors. Based on the product space, it is also apparent that the electronics cluster is far from the core where chemicals and heavy industries are located. This implies that attempts to leapfrog to car production or pharmaceutical research using the electronics-specific capabilities may be infeasible and unproductive. Usui (2011) also observe that the rate of modernization and diversification of the Philippine product space was slow, especially when compared for instance to the experience of South Korea and Taiwan which both achieved the high income status 26 years after entering the low middle income range for the first time. Based on our earlier findings, this lagging performance can be partially traced to trivial attention given by both firms and policymakers to the role of innovation in increasing output and productivity.

To the extent that innovation enhances product sophistication and boosts productivity, Aghion and Howitt (1992) and Acemoglu, et al. (2006) suggest that sustaining growth after reaching the middle income stages would require the implementation of novel ideas, processes, and production technologies, rather than simple adoption and imitation. As noted by Perez-Sebastian (2007), while accumulating capital through adoption and imitation is the main engine of productivity growth during the initial stages of development, broad-based innovation becomes the key growth driver as the economy evolve towards the technology frontier. Fu et al. (2011) add that investments in foreign technology only effectively lead to domestic innovation when firms have in-house R&D capabilities. In this light, Acemoglu, et al. (2006) suggest that a developing country must switch from an investment-focused policy to innovation-based strategy before a reaching a "critical point" to avoid a non-convergence trap where the economy fails to catch up with the technology frontier. This implies that a country has to constantly develop new technologies in order to sustain productivity growth. These innovations should ultimately be manifested in the ability to introduce and export more sophisticated goods. As illustrated in Figure 4, different countries with different takes on capabilities accumulation (mainly through innovation) will also have diverging middle income experiences. The case of South Korea clearly shows how aggressive policy towards building internal technological capabilities through higher R&D spending, increased pool of science and engineering professionals, and strengthening the national innovation system led to the diffusion of knowledge to many domestic firms in various sectors (Cherif and Hasanov, 2015). Likewise, the dramatic rise of South Korea was propelled by its ambitious goal to be at par with frontier technologies at an early stage rather than relying on the traditional path of learning by importing and learning from knowledge spillovers.

Figure 4c. Product Space of the Philippines: 1976 vs. 2013



Source: MIT Observatory of Economic Complexity

The foregoing discussions suggest that what countries produce and export reflects what their position in the global economy will be. This is consistent with the findings of Hidalgo and Hausmann (2009) that the complexity of a countries capabilities and products are strongly correlated with income per capita, future growth and the complexity of future exports. Hausmann et al. (2007) also find that that countries with a more sophisticated exports tend to grow faster. Within the context of highly globalized production, this implies that the niche or tasks assigned to a country will have a direct implication on its development strategy. While Felipe et al. (2012) suggest that the middle income trap is essentially a low-product trap[22], we can further elaborate two major forms of traps in GVCs: task trap and sector trap. On a micro level, productivity stagnation reflects the failure of local firms to capture higher value-adding activities (i.e., functional upgrading) in a particular value chain. Specializing in segments with low value capture reflects a small stock of knowledge, bad-quality human capital, and trivial innovative activities. Without radical efforts to augment technological capabilities, i.e., sans large-scale product and functional innovation, these types of firms are highly unlikely to move to more sophisticated tasks; hence, a potential task trap. Further, firms that innovate but at a much slower rate than firms in the higher segments of the chain also face the risk of being trapped or forced out of the chain altogether. As we've already seen in previous empirical investigation, many Philippine GVC firms have developed a niche in lower-tier segments of international value chains, particularly electronics. For instance, Aldaba (2015) elaborates that high-value adding tasks are very rare in the domestic electronics sector of the Philippinees. Thus, what seems relatively sophisticated on an aggregate view looks relatively "basic" on a task level. To the extent that these tasks are highly standardized, there is little incentive to pursue intensive product innovations which in turn means foregone opportunity to build domestic capabilities. Ultimately, this means lower chances of functional upgrading.

[22] This implies an export basket composed mainly of products that are both unsophisticated and not well-connected to other products (Felipe et al., 2012).

Firms producing unsophisticated product using unsophisticated capabilities will most likely to connect to low-technology value chains (e.g., textiles and food processing rather than cars production). Following the argument of Hidalgo et al. (2007), the upgrading trajectory of these firms will be towards similarly basic and less-sophisticated goods within the same or neighboring sectors. Although not impossible, leaping into more high-tech production is prohibitively difficult given minimal innovations and passive efforts to build capabilities; hence, a sector trap. In terms of Hidalgo et al.'s (2007) concept of proximity, upgrading to a new sector is more likely to be successful if the old and the new sectors have "proximate" capabilities requirements. As we've seen in the electronics example, the Philippines was not able move up to other sophisticated chains (e.g., chemicals and automobiles) despite early success in electronics due to the sector's "remoteness" in the product space. In other words, granted that local firms succeed in moving to higher value adding wafer fabrication and packaging, there is still no assurance of spillovers to other high-tech sectors since they require a different set of capabilities.

Both task and sector traps provide a firm-level explanation to Eichengreen et al.'s (2012) conclusion that growth slowdown is essentially due to productivity stagnation. Whereas initial entry in GVCs may increase firms' productivity through scale and sophistication effects, moving up the value chain often requires building internal capabilities through higher spending on training and innovation. To the extent that sustaining productivity increase involves climbing the value ladder through persistent innovations, a task trap may be viewed as firms' failure to upgrade production technologies and introduce non-standard products. Here, firms' inability to perform more sophisticated tasks stagnates output and productivity growth. Our previous result show that manufacturing highly standardized intermediate goods is primarily associated with process innovation (e.g., adoption of imported machinery and knowledge spillovers). However, these are not enough to boost TFP and are often too narrow to support functional and sectoral upgrading. Recall the case of many local semiconductor manufacturers, wherein their niche in testing and assembly understandably focused their innovative activities on efficiency, timeliness, and accuracy. However, we know that increasing productivity coincides with the performance of higher value capture activities which in turn requires more aggressive types of innovations such as massive hiring of engineers and researchers to build an internal R&D unit tasked to create novel products.

Finally, the type of GVC governance structure may also explain an economy's slow transition within the middle income range. Given that sub-par firm-level capabilities translate to lower power capture (or high degree of subordination), GVC participation by "weaker" firms may reinforces task and sector traps. As we've previously shown, firms facing higher degree of control from foreign buyers exhibit low upgrading tendencies. In other words, these firms become confined in lower-tier segments of the chain due to their lack of ability and/or incentive to innovate and build internal capabilities. Previous studies have observed cases of firms that became tied into GVC setups that prevent functional upgrading; leaving them dependent on a few powerful clients.

Within the context of highly internationalized production, the preceding discussions suggest that escaping the middle income trap means moving up to higher value added tasks and moving out to more sophisticated sectors that require more intensive innovation and technological investments. Viewing middle income trap as a bad equilibrium (Acemoglu et al., 2006), the absence of big push will certainly stagnates a country's growth. Based on Lin's (2011) arguments, a country should endeavor rapid, effective, and massive technological change to escape from the trap. On the firm level, this means avoiding task and sector traps through persistent and non-trivial innovations that support functional and inter-chain upgrading.

6. Conclusions and Policy Implications

The increasing importance of GVCs in the current world economic order is often viewed as an alternative entry point to industrial growth and export success for developing countries. The recent trade numbers seem to support this trend with more than half of developing countries' value added exports performed within GVCs (WTO, 2014). Consequently, the share of intermediates trade in developing countries' total trade increased by fourfold since the 1980s (WTO, 2014). There is also evidence on the growth premium experienced by countries that industrialized by joining GVCs instead of internally (IMF, 2103; WTO, 2014; Cheng et al., 2015). To the extent that GVCs facilitate easier intra-industry exchanges between labor-intensive firms in low-income countries and technology-intensive MNCs in developed economies, potential gains are possible for the former by developing efficiency and comparative advantage in a particular niche.

Against this background, we assessed the important factors that influence GVC participation from the perspective of firms in a developing country. We also evaluated the effect of linkages to GVCs on participating firms' innovative tendencies and productivity. Within the context of highly heterogeneous firms, our results show that foreign equity ownership, firm size, and capital intensity are the most robust attributes that affect a firm's decision to participate in GVCs. This is consistent with our finding that firms importing and exporting within GVCs perform better along many dimensions (*e.g.*, total employment, wages, unit labor costs, revenues, and value added). This implies that a greater GVC exposure will benefit the most productive and capital- and skill- intensive firms within an industry due to wider access to export markets and foreign input suppliers.

In terms of innovation, the results suggest that Philippine GVC firms are more likely to be innovative. However, GVC participation of firms in the Philippines is associated more with process innovation than product innovation. This is as expected since the tasks normally assigned to local firms are more focused on cost and quality controls rather than research and product differentiation. This lends support to the supposed task-innovation matching wherein the nature of the firm's task within the value chain influences its innovation strategy. The dominance of process innovation is also consistent with Kaplinsky and Morris's (2001) view that within the hierarchy of innovative activities, process upgrading is usually implemented among firms with the lowest value capture. This again makes sense based our earlier finding on the nature of GVC segments (e.g., assembly) handled by Philippine firms.

For GVC-active firms, the weak or insignificant effect of being an exporter on innovation suggests that learning-by-exporting is probably not a general phenomenon among GVC firms in the Philippines. In fact, the evidence of learning-by-internationalizing effect is observed mainly through imported inputs and capital goods and backward linkages. This mirrors the findings that imported machinery and equipment directly supports process upgrading while imported inputs may allow firms to develop hybrid technologies and improve product quality. When in-house innovation is limited by the firm's size and capabilities, the introduction of new products and processes may not always involve large-scale R&D spending especially with easy access to better and cheaper external technologies. Since we find no support for the learning-by-exporting hypothesis, we conclude that the learning-by-internationalizing effect of GVC participation is mostly captured through technology spillovers from backward linkages.

Our analysis of the productivity gains from GVC transactions confirms a participation premium for firms trading within GVCs. In particular, the results suggest that firms connected to GVCs have significant labor productivity gains from upgraded machinery, equipment, and technology. However, there is no evidence of a productivity increase coming from product innovations. Further, we do not find a significant impact of process and product innovations on TFP as measured by the Solow residual. This is consistent with the view that long-term productivity growth requires the intensive development and application of internal knowledge instead of overdependence externally-sourced technologies.

With regard to total factor productivity gains, our analysis also reveals the absence of any statistically significant productivity effect of GVC participation. While this is expected for intermediate importers given our earlier result that process innovation does not contribute to long run productivity gains, the insignificant effect of GVC exports on productivity further questions the validity of any learning effect.

Within the context of highly internationalized production, the preceding discussions suggest that escaping the middle income trap means moving up to higher value added tasks and moving out to more sophisticated sectors that require more intensive innovation and technological investments. Viewing middle income trap as a bad equilibrium (Acemoglu et al., 2006), the absence of big push will certainly stagnates a country's growth. On a micro level, productivity stagnation reflects the failure of local firms to capture higher value-adding activities. Specializing in segments with low value capture reflects a small stock of knowledge, bad-quality human capital, and trivial innovative activities. Further, leaping into more high-tech production is prohibitively difficult given minimal innovations and passive efforts to build capabilities. According to Lin (2011), a country should endeavor rapid, effective, and massive technological change to escape from the trap. On the firm level, this means avoiding task and sector traps through persistent and non-trivial innovations that support functional and inter-chain upgrading.

The general picture emerging from the preceding analyses is one in which sustained long-term growth is achieved through the strengthening of internal capabilities. On a firm-level, this means constant engagement in innovative activities in order to boost productivity. However, not all firms are created equal in terms of resources and innovative tendencies. Normally, smaller firms have limited access to financial and knowledge resources to support internal knowledge accumulation.

Here, a well-functioning national innovation system may be relevant to coordinate firms with other knowledge users and producers to facilitate efficient flow and exchanges of information. While GVCs require firms to meet elaborate requirements such as quality, timeliness, efficiency, and labor standards, local suppliers' heterogeneous technology profiles and idiosyncratic learning curves may prevent immediate participation in the chain. Since combining incompatible foreign and local technologies may be counterproductive, organization of technology and learning linkages within coordinated national innovation systems can boost the efficiency and productivity of domestic firms. The case of Taiwan and South Korea clearly shows how aggressive policy towards building internal technological capabilities through higher R&D spending, increased pool scientific professionals, and strengthening the national innovation system led to the diffusion of knowledge to many domestic firms in various sectors (Cherif and Hasanov, 2015).

Together, the pieces of evidence presented above suggest that while GVC participation increases the tendency of a firm to innovate, the type of innovation it will adopt will be partially dictated by the nature of its role in the chain. This means that firms whose niche is focused on relatively basic tasks may be more adaptive than exploratory when deciding to upgrade. As Naghavi and Ottaviano (2009) and Kang, et al. (2010) note, productivity gains from foreign exposure are only likely when there are significant knowledge spillovers. In the current context, this implies that although GVCs open faster routes to industrialization through access to foreign markets and inputs, the quality of the industrial base this creates will still depend on the kind of tasks performed and the ability of the firms to climb to higher value-capture innovations (Kaplinsky and Morris, 2001; Baldwin, 2014b; EBRD, 2014; WTO, 2014). Since prior knowledge is often required to absorb new knowledge, only when these tasks induce larger-scale domestic innovation and productivity growth can GVC participation be a meaningful option for economic upgrading.

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