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External Opportunities, Innovation and Industrial Growth: The Case of GVCs in Africa

Padmashree Gehl Sampath and Donatus Ayitey

5.1 Introduction

The unprecedented rise in global value chains (GVCs) for trade in both intermediate and final goods has challenged traditional consensus, raising questions of who benefits from GVCs and how their developmental implications can be better channeled (Keane, 2008; Suder et al., 2015; Johnson and Noguera 2012). GVCs segment product cycles in sectors from conceptualization and research and development (R&D), all the way to production, distribution and often also disposal of product waste (Kaplinsky, 2000), leading to a new fragmentation of production worldwide.

A GVC is structured around the creation of *value* along the various stages of the process. It has been argued that participating in GVCs carries multiple benefits, including international information exchanges, new markets for products produced in developing countries, and enhanced learning and innovation. Case studies and other investigations show that GVCs have received mixed responses, particularly insofar as their ability to foster technological upgrading is concerned. A review of the good and the not-so-good cases of ongoing GVCs shows that the ability of firms to participate in and benefit from value chains is accounted for by certain factors, starting with global demand: GVCs are mostly structured around products/services for which there is continuous, foreseeable demand. Participation and benefits are also determined by capabilities for learning and innovation, which dictate how much any supplier can value-add at any node in a GVC. Other factors include competitive production capacity, as defined by variables such as reasonable costs of production and ease of compliance with technical standards, among others (Kaplinsky, 2010; Beugelsvijk, Pedersen and Petersen,

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2009; Morris and Fessehaie, 2013). These factors account for why some participants emerge as winners more than others: those that have the ability to value-add, tend to benefit more (Kaplinsky, 2010; Córcoles et al., 2014).

In Africa alone, trade value-added through GVCs has risen from 6 billion to 24 billion between 1990 and 2011 for African least-developed countries (LDCs) (UNCTAD EORA Data 2014 by Lenzen et al., 2013). The data show that most sub-Saharan African countries are integrated into GVCs as suppliers of low-value-added or resource-based products. Good examples of such products are coffee or cut flowers, where producers/farmers have suddenly found themselves in a position in which an external opportunity can be capitalized upon. Despite some good examples, on a broader basis, GVCs offer employment opportunities for a large number of farmers/local suppliers, especially in the agricultural sector, which still remains one of the largest sources of income and employment for a majority of the population in African countries. For example, in the case of Ethiopia, nine of the ten top export-earning products are natural resource based, led by coffee, and the agricultural sector accounts for 85% of total employment in the country (UNCTADstat). However, many of the essential benefits, particularly those related to technological learning and innovation capacity, do not occur, given the current low levels of capacity in many African countries.

In an effort to address these concerns, and to increase the ability of national actors to produce value-added outputs that can also help benefit more from GVCs, national governments in a large number of African countries embarked on an exercise to reform or enact new policies for innovation in the 1990s (UNCTAD, 2015). The new policy frameworks aim to shift the overall emphasis from just science policy or technology policy to innovation capacity, and target learning and technological upgrading within a landscape in which GVCs play a large role in domestic industry. The newer policy frameworks also aim to replicate the incentives that supported the successes of East Asian economies, which also began their journey toward greater technological change and industrial catch-up through low-value-added products, such as garments, footwear and office goods (Kim, 2003; Feenstra and Hamilton, 2005).

Despite the relevance of these debates, few studies have analyzed the technology implications of GVCs in general, and, specifically, the impact of the new policy frameworks on innovation on benefiting from GVCs, mainly because the GVC literature and innovation and technology research tend to review these questions in isolation (see, for example, Pietrobelli and Rabellotti, 2011).

These are the two concerns that motivate our chapter. First, we analyze the impact of innovation policy frameworks on the promotion of technological upgrading through GVCs in Africa. To examine whether appropriate policies can help countries in sub-Saharan Africa reap dividends from the ongoing surge in GVCs in various product categories, we focus on the renewed emphasis in a large number of African countries on innovation policies. We seek to understand whether such policy emphasis can be measured in terms of its effects on (a) greater participation in GVCs and (b) greater value-added in and through GVCs.

The second question that is dealt with in the chapter relates to *system effects*, that is, whether it is justified to assume that GVCs in low-technology segments will have little or no system effects in terms of promoting learning and upgrading, or whether there can be intersectoral spillovers. In analyzing this issue, we build upon the work by Feenstra and Hamilton (2005), who use a trade-archeology methodology to show that several East Asian countries began their journey toward greater technological change and industrial catch-up through low-value-added products, such as garments, footwear and office products. Moving away from the standard explanation of market-led, export successes of the East Asian countries, these authors show that success in upgrading was first achieved in specific product categories only, most of which were low-technology oriented. Lee (2013) similarly focuses on product categories to show that the eventual success of East Asian economies was dependent on their specialization on certain low-and medium-technology product cycles. Based on these works that shed light on the product categories that supported the East Asian Miracle,[1] this chapter seeks to explore the critical question, how can low-technology exports in specific product categories leverage sector-wide learning effects as it did in the case of East Asia, and what is the role of policy in this process? In order to analyze this issue, our chapter seeks to assess how local innovation systems react to external knowledge sources as in the case of GVCs, to promote capabilities.

The issues considered in this chapter, despite their mounting relevance, have not received much attention due to a variety of reasons (see Kaplinsky, 2010). An impediment to analyzing these aspects has been that traditionally the literature on innovation studies has focused on how local interactions and institutional parameters shape the capabilities of actors, while the GVCs literature has focused mostly on governance structures, production implications and the advantages of participation.

A second difficulty has been that exploring the impact of innovation policy on improving the position of countries in GVCs is a complex task and methodologically demanding (Sturgeon, 2015). It is not only difficult to identify appropriate measures for testing hypotheses but also challenging to create proxies that may reflect what the additional impact of policy is on learning and industrial value-added. In order to measure learning over time, this chapter chooses a proxy each for learning effects in GVCs and the impact of policy frameworks in fostering this. We measure the role of GVCs in technological upgrading and technological capabilities building by proxying for industrial value-added. Existing studies have stressed industrial upgrading and industrial value-added, that is, "the process by which economic actors (nations, firms and workers) move from low value to relatively high-value added activities in global production networks" (Gereffi, 2005, p. 171; Sturgeon and Gereffi, 2009). In this chapter, while analyzing the impact of policy on learning and value-added, we seek to emphasize technological upgrading, which remains a fundamental component of the process of industrial upgrading and industrial value-added. Other studies have used similar methodologies, focusing on industrial upgrading, to derive the extent of technological upgrading (Mahutga and Smith, 2011; Dicken 2003, among others).[2] The logic is that, without the capacity to technologically learn and constantly upgrade production techniques, firms are unable to move from low-value-added to higher-value-added activities as part of the industrial upgrading process.

To measure the policy impact of innovation policies on increased participation and value-added in GVCs, we choose industry R&D as a proxy. We do so because most innovation policy frameworks in African countries have set increased R&D spending (as a percentage of gross domestic product [GDP]) as their targets, and a large number of the countries have scaled up R&D investments and public R&D infrastructure in this regard (see Section 5.3). Finally, we use the term "Africa" to mainly denote sub-Saharan African countries (including South Africa) in this chapter.

5.2 GVCs and data limitations

Much of the GVCs literature and many of the approaches to measuring value distribution have been dominated by the trade literature. Viewing GVCs from a trade theory perspective has many advantages. It helps one to understand a two-way relationship: how the global production networks are evolving, and how global trade is channeling the demand for certain products/services over others to create production networks around them, and thereby influencing industrial structures in developing countries. Methodologies for measuring value-added by trade economists show how the burgeoning global trade is becoming increasingly driven through network trade (i.e., trade in intermediate as well as finished products and services), and how this impacts the trade gains of countries.

Despite the growing body of work, however, there is still some disagreement on how to measure value along the various points of the GVC. Because the GVC literature grew from the perspective of comprehending the impact of various governance forms on performance and value additions, it was not focused on measuring the benefits of participating in any particular GVC as opposed to another for an individual firm. Over time, due to the enormous significance of understanding value addition in GVCs, not only to assess their benefits more accurately but also to codify the gains from trade to developing countries, various approaches have emerged to measure value in real terms or through proxies.

Furthermore, trade data has several shortcomings in measuring value-added through GVCs.[3] Given that GVCs are proliferated by trade in intermediate goods, which is rising more sharply than trade in finished products that embody these goods, using trade data to measure GVCs risks double counting (in terms of intermediate and then final products that embody the same value-added). Measuring the net trade value-added through input-output analyses has therefore been suggested as a reasonable means to measure GVCs, particularly to avoid double counting (see, for example, Suder et al., 2015; Johnson and Noguera, 2012). Other approaches include using local sales versus cross-border sales, shares of retail value-added, and final retail price as proxies for the division of value-added (Beugelsvijk et al., 2009). All these approaches have their strengths and weaknesses. Input-output approaches run the risk of assuming that firms produce in a vacuum, since they does not have any means to factor variables other than the input and the value-added output into the equation. The role of the firm's institutional environment, overall production costs, skills, linkages, and networks, both internal and external, in creating the value-added are overlooked. Similarly, assessing value-added through retail value-added tends to underestimate the retail margins in different contexts (high margins versus lower ones) and also does not factor in production costs (Keane, 2008). Sturgeon and Gereffi (2009, p. 13) note the limitations of using trade data to capture accurately that "trade statistics alone contain very partial information about the location of the value-added, and no information about the ownership of these productive assets and output, when profits are reaped, or how these increasingly complex systems are coordinated." In addition, trade statistics alone cannot help pin down the relative technological learning of local versus external partners, and the knowledge flows and spillovers.

The OECD/World Trade Organization Trade in Value-Added (TiVA) database and UNCTAD-Eora database are currently two important sources of GVC data. While the TiVA database provides data on 57 countries, most of which are members of the Organization for Economic Cooperation and Development (OECD), the UNCTAD-Eora database provides information on value-added trade and covers 187 countries, including over 90% of countries in sub-Saharan Africa (Lenzen et al. 2012 & 2013). Presently, GVC analysis is an emerging area of research, and existing data on value-added trade have their own limitations, which are routinely being highlighted (see Sturgeon, 2015). Despite these limitations, UNCTAD-Eora data currently provide the most comprehensive existing data on value-added trade and GVCs for developing countries when compared with TiVA, which largely focuses on developed countries and only one country in Africa (i.e., South Africa). This chapter therefore relies on the UNCTAD-Eora value-added trade dataset.

We acknowledge that the UNCTAD-Eora data only provide a steppingstone and insights into the trade value-added and GVC situation in developing countries due to certain limitations. The first limitation is that many developing countries generally lack accurate intrafirm trade data upon which UNCTAD-Eora data are based. This creates loopholes in capturing sources of production inputs and the destination of outputs in such countries. The second limitation is that UNCTAD-Eora data have been criticized for reflecting largely activities within the manufacturing sector and not necessarily those in commodity trade, which generally constitute the bulk of trade in LDCs (see Keane, 2014). We therefore proceed with caution, using as many other variables as possible to augment the trade-in value-added data to draw conclusions.

5.3 GVCs, innovation capacity and policy effects

5.3.1 Technological capabilities, upgrading and innovation systems

There is a mutual, virtuous relationship between GVCs and innovation systems in all developing countries, but particularly in least-developed countries (which account for a large part of sub-Saharan Africa), which some scholars have termed "endogenous and non-linear" (Pietrobelli and Rabellotti, 2011, p. 1261). Although the innovation systems literature and the GVCs literature both agree that there is a need to address this, the innovation systems literature has been slow to take account of foreign linkages and sources of knowledge. While the governance forms are critical for dictating what opportunities may ensue for suppliers at different nodes of the value chain, institutional frameworks that determine flows of knowledge, interactive learning and coordination in national innovation systems are equally important. On the one hand, participation in GVCs can help firms in African developing and least-developed countries acquire learning opportunities that may contribute to improving the innovation system on the whole, while on the other hand, the capacity of the local innovation system and its role in promoting firm-level learning is critical for reaping benefits from GVCs.

Specifically, given the important role of GVCs in trade, and by extension, the industrial composition of countries today, there is a large role for the study of innovation effects of GVCs from at least three distinct perspectives:

(a) the impact of the innovation policy and incentives therein (that is, the institutional framework) on building technological capabilities and thereby, greater industry value-added in GVCs
(b) the impact of GVCs on fostering the local innovation systems, in terms of promoting local innovation capabilities through technological spillovers, gradual technological upgrades and access to knowledge
(c) the relationship between greater industrial R&D capacity in countries, particularly less developed countries, and the ability to benefit and harness spillovers from GVCs beyond specific products to improve their innovation systems *per se*

Especially from the perspective of an LDC based in Africa, the most relevant benefits of participating in one particular GVC when compared to another is different at the firm level. From the standpoint of a local firm, the main benefits are export opportunities and the level of technological upgrading that it can eventually expect from being a part of the GVC (field interviews). Processes of upgrading at the firm level can take different forms. While in general, one assumes technological upgrading to include forms of technological learning and skills building,[4] other forms of upgrading activities can also occur as a result of integration in GVCs, all of which contribute to building technological capabilities.

This includes intersectoral and functional upgrading[5] activities both of which are critical to promoting innovation capacity in participating firms (Humphrey and Schmitz, 2000).

We acknowledge that technological upgrading that occurs through any of these channels is difficult to measure, but it remains an essential component of industrial upgrading and value-added, which is more easily measured. In order to find proxies for technological upgrading, we base our analysis on a number of useful taxonomies of technological capabilities that have been elaborated by several scholars, including Lall (1992), Ernst, Ganiatsos and Mytelka (1998), and Bell and Pavitt (1993), among others. We define technological upgrading as a process that results from skills that firms need in order for them to acquire, assimilate, use, adapt, change and create technology. These can range from basic production and manufacturing capabilities (which employ knowledge and skills used in plant operation) to redesign and product modification capabilities (employing firms' abilities to adapt and improve its products), or capabilities for new products and process design (which is required to create innovative technological breakthroughs) (see Oyelaran-Oyeyinka and Gehl Sampath, 2010). Therefore, we consider variables such as tertiary education, exports of high-technology products, and scientific and technological publications, in addition to trade variables in our model.

5.3.2 Policy effects

If policies for innovation are relevant, then one must be able to capture the effects of policy shifts on industry value-added in countries, and by extension, on technological learning over time. If this is not the case, then one would be forced to conclude that innovation policies at the national level do not exert an influence on the participation in, and benefits derived from GVCs, and that these are largely dictated by exogenous factors.

Reviewing the changes in the policy landscape, one finds a dramatic shift in African countries from policies on science or science and technology, to innovation policies that explicity seek to build and strengthen national innovation systems. Table 5.1 highlights the move in countries in the region toward science, technology and innovation policy frameworks with dedicated ministries and agencies for this purpose since the latter half of the 1990s. The critical change in the focus of these policies was the shift in perspective from focusing on the supply side of provision of scientists and engineers, to simultaneously promoting innovation capacity and technological capabilities. Policy reviews of

Table 5.1 Transition from science and technology (S&T) policies to science, technology and innovation (STI) policies in selected African countries

Country	**National initiatives toward development of STI policies and strategies**
Angola	Presidential Decree No. 201/11: July 20 Approves the 2011 National Policy for Science, Technology and Innovation
Ethiopia	First policy on S&T drafted in 1993. Revised and approved as STI policy in 2012
Ghana	Draft National Science, Technology and Innovation Policy in 2009. Adopted in 2010
Kenya	Kenya Science, Technology and Innovation Act, 2013. STI policy approved January 2013
Mauritius	In 1999, the National Productivity and competitiveness Council was set up The process to harness innovation for national competitiveness began in 2002 In 2006, a framework for innovation policy and strategy was crafted
Mozambique	Science and Technology Policy (2003) Mozambique Science, Technology and Innovation Strategy (2006)
Nigeria	Nigeria science, technology and innovation policy, 2004
Tanzania	S&T Master Plan, 2003–2018. Process toward STI policy began in 2006
Tunisia	In 1991, the Secretariat of State for Scientific Research and Technology (SERST) was created In 1992, Higher Council for Scientific Research and Technology was created In 2003, the National Program of Research and Innovation (NPRI) was created
Uganda	Cabinet approved first national STI policy in 2009
Rwanda	Cabinet approved national STI policy in July 2005
South Africa	In 1996, white paper on science and technology entitled “Preparing for the 21st Century” was drafted The white paper was approved by government in the same year
Zambia	In 2008, there was a review of the 1996 Science and Technology (S&T) Policy. Process toward national science and innovation policy began in the same year
Zimbabwe	In 2005, Zimbabwe created its Ministry of Science and Technology, and process toward STI policy began. The president launched the National Science, Technology and Innovation Policy in 2012

Source: Compiled by authors.

the policies show that the new policies have been structured around promoting linkages in national innovation systems, coordinating and strengthening infrastructure to promote industrial R&D, and reviving defunct public sector institutions.

By 2010, it was estimated that there were up to 40 ministries overseeing innovation-related activities across various countries in Africa (UNESCO, 2010). This transition came about to facilitate the coordination between economic and noneconomic actors that is required to promote innovation capacity within countries. Another important facet of these policies is the investment of greater percentiles of GDP into R&D, particularly since the eighth African Union Summit of 2007, which called for reinforcing African R&D spending to 1% of total GDP by 2010. Figures show that some countries managed to accomplish this, much ahead of the 2010 targets set out by the Summit (see African Innovation Outlook (NEPAD, 2010) and Appendix 5.1) and many others are well on their way to increasing their R&D expenditure on an annual basis. Hence, the important issues that stand out are the following: are these policy changes impacting the creation of an innovation environment in these countries differently from before? Even if we assume the time period to be relatively short between their enactments and the current time frame, are there already changes in the institutional infrastructure, particularly for industry support and R&D, that are noteworthy?

5.4 Data and analysis of GVC effects in sub-Saharan Africa

5.4.1 Data and methodology

For the analysis in this section, the UNCTAD-Eora dataset is estimated from national supply and use tables (where available) and input-output tables (where supply and use tables are not available). While supply tables capture products produced by each domestic industry; use tables show product use by each industry. The UNCTAD-Eora dataset is therefore constructed and presented as multiregion input-output tables.[6] This dataset has been supplemented by UNCTADStats and the World Bank's World Development indicators to identify variables that could help us understand the relationship between GVCs and technological capabilities.

In order to comprehend whether appropriate policy emphasis has made a difference in sub-Saharan Africa, we introduce an innovation policy variable in the model. This variable is measured as a dummy that captures whether there was greater policy emphasis on innovation capabilities or not. The policy emphasis in innovation policy important because as noted earlier, the emphasis on greater innovation and R&D funding for further capacity building in the region is due to the shift to innovation policy. In addition, it also promotes greater investment into building human resources that feed further into technology and innovation capabilities. Similarly, we introduce industrial R&D to ascertain its impact on value addition and participation in the GVCs. R&D policy is also measured as a dummy variable capturing whether there was a greater investment in R&D or not. The two policy variables are important to help gauge the kind of investment and emphasis on innovation and R&D being projected in sub-Saharan Africa.

5.4.2 Variables of interest

Since the extent to which sub-Saharan African countries can benefit from the GVC depends on the degree of real industry value-added to which they can contribute, our variables are a combination of trade and innovation variables to construct this scenario. From the perspective of trade, the variables of interest include real industry value-added, real manufacturing value-added, real GDP and value-added trade (US$). From the perspective of technological capabilities building, variables chosen are tertiary school enrollment (% gross), trade (percentage of GDP), high-technology exports (current US$) and scientific and technical journal articles. We construct all the variables of interest as yearly averages across countries. These are augmented by policy-related variables.

Table 5.2 presents descriptive statistics of the variables employed in this analysis. It shows that for sub-Saharan Africa, mean real industry value-added was a little over US$ 4.0 billion over the 1990–2013 period, but there are wide disparities at the country level, ranging from maximum real industry value-added of US$ 7.03 billion in some countries, to the minimum realized by some others at US$ 3.24 billion. Statistics also show that the mean real manufacturing value-added accounted for US$ 1.75 billion, that is, 41% of the real industry value-added.[7] The mean real GDP in the sub-region in the period 1990–2013 reached US$ 12.82 billion, with maximum and minimum at US$ 8.86 billion and US$ 19.80 billion respectively. The mean of trade as a percentage of GDP was at 75.39 and that of value-added trade is US$ 10.7 billion.[8]

In the case of variables to measure technological capabilities, a mean tertiary school enrollment of 4.23% was recorded, with some internal variations. There are countries that record a minimum tertiary school

Table 5.2 Descriptive statistics

	Median	**Mean**	**Std.dev**	**Min**	**Max**
Real industry value-added (in billion US$)	3.82	4.23	1.01	3.24	7.03
Real GDP (in billion US$)	11.42	12.82	3.62	8.86	19.80
Real manufacturing value-added (in billion US$)	1.59	1.75	0.46	1.31	3.13
School enrollment, tertiary (% gross)	3.38	4.23	1.99	2.06	9.18
Trade (percentage of GDP)	77.11	75.39	6.62	61.56	83.66
High-technology exports (in million US$)	46.21	56.32	33.13	2.57	139.13
Scientific and technical journal articles	90.15	93.04	10.34	82.13	115.37
Value-added trade (in billion US$)	7.21	10.69	5.74	5.98	24.24

enrollment of 2.06%, while some also record a maximum enrollment of 9.18%. The mean of high-technology exports amounts to US$ 56.32 million for the region, whereas the mean number of scientific and technical journal articles for sub-Saharan Africa stands at 93.

Table 5.2 shows a wide variation in data across data points, largely because the 48 sub-Saharan African countries captured here vary in size and industrial capacity as well as exports capabilities. For example, high-technology exports across the sub-region vary from US$ 2.57 million to US$ 139.13 million. Real GDP (in billion US$) varies from a minimum of 3.24 to a maximum of 7.03. To minimize this wide variation across data points, variables are log transformed where necessary in our model specifications (see Table 5.3 for variable definition). We use industry value-added as the proxy to deduce industrial and technological upgrading. In isolation, this may not be sufficient, but we juxtapose it with technological variables such as scientific and technological articles and high-technology exports, which help pinpoint whether learning is taking place in the exporting firms (see Lall, 2000).

5.4.3 Specification of the model

To ascertain the effects of policy emphasis on innovation capacity for industrial and technological upgrading in sub-Saharan Africa as a result of the shift from S&T policies to those that focus on innovation, we identify two time periods. We construct these two time periods because, although

Table 5.3 Definition of variables

Global value chains
Value-added trade
Trade (% of GDP)
RGDP = Real GDP
Innovation capabilities
Real industry value-added
High-technology exports
Knowledge capabilities
Scientific and technical journal articles
School enrollment, tertiary
Policy intervention
S&T = Science and technology policy intervention
STI = Science, technology and innovation policy (Low emphasis on innovation = 0, coinciding with the period 1990–2004 in this study; greater emphasis on innovation = 1, coinciding with the period 2005–2013 in this study)
R&D = Industry research and development policy (Low emphasis on R&D = 0, coinciding with the period 1990–2005 in this study; greater emphasis on R&D = 1, coinciding with the period 2006–2013 in this study)

countries began shifting toward innovation policies, there is usually a time lag between policy focus and results in terms of implemented outputs. Therefore, our first period is from 1990 to 2004, which is the period of less policy emphasis on innovation capacity of the kind required to build technological capabilities, and by extension, less emphasis on industrial and technological upgrading. In this period, countries in the region were focused on S&T policies, or in the process of reviewing them to assess means to emphasize upon innovation. The second period spans 2005 to 2013, and is the period of clear policy emphasis on innovation capacity and technological capabilities, and for industrial and technological upgrading. By this time, most countries in the region had enacted policies in this regard and also allotted budgetary and institutional support structures for various aspects relevant to innovation capacity.

Similarly, 1990–2005 is the period of less policy emphasis on industrial R&D, and 2006–2013 is the period of greater policy emphasis on industrial R&D (which is part and parcel of innovation policies, and hence the same logic follows). Our innovation and R&D policy variables assume treatment "0" and "1" for the period from 1990 to 2004 with less policy emphasis on innovation capacity, and for the period from 2005 to 2013 with greater policy emphasis on innovation capacity respectively.

Formally,

$$T_i = \begin{cases} 1 \Leftrightarrow 2005\text{–}2013, \textit{ period of greater policy focus on innovation capacity} \\ 0 \Leftrightarrow 1990\text{–}2004, \textit{ period of less policy focus on innovation capacity} \end{cases} \quad (1)$$

This follows recent developments in the field of economic policy impact evaluation (see Card and Krueger, 1993 and Blundell, Duncan and Meghir, 1998). Let Y_i be our set of dependent variables, X_i be our set of independent variables and D_i be our set of policy dummies. Following Heckman, Lalonde and Smith (1999), we specify our model as

$$Y_i = \alpha + \beta X_i + \rho D_i + \varepsilon_i \text{ where } E(\varepsilon_i / x_i) = 0,\ i \leq j \quad (2)$$

This implies, we have

$$D_i = \begin{cases} 1 \Leftrightarrow \textit{we observer outcome } Y_1 \textit{ (greater policy emphasis on innovation capacity)} \\ 0 \Leftrightarrow \textit{we observer outcome } Y_0 \textit{ (less policy emphasis on innovation capacity)} \end{cases} \quad (3)$$

Therefore, plugging $D = 0$ into Equation (2), we have[9]

$$Y_i = \alpha + \beta X_i + 0.\rho + \varepsilon_i = \alpha + \beta X_i + \varepsilon_i \quad (4)$$

And plugging $D = 1$ into Equation (2), we have

$$Y_i = \alpha + \beta X_i + 1.\rho + \varepsilon_i = (\alpha + \rho) + \beta X_i + \varepsilon_i \quad (5)$$

The assumption in this model is that there is no heterogeneity in policy effects, implying that

$$Y_1 - Y_0 = \rho \quad (6)$$

Policy emphasis on building innovation capacity leads to either an increase (when ρ is positive) or a decrease (when ρ is negative) in value-added and GVV participation across the sub-region. Technically, this results in a parallel shift either upward or downward of the XY curve from Y_0 to Y_1.

5.4.4 Hypotheses

STI and R&D policy effects on the relationship between industry value-added[10] and participation in GVCs are zero.

In other words,

– greater emphasis on STI policies does not drive participation in GVCs and more value-added, and
– greater R&D capacity also does not drive participation in GVCs and more value-added.

Formally, the null hypothesis of the partial effect of policy is

$$H_0: \rho(x) = 0, \forall\, x$$

Against the alternative hypothesis that:

> STI and industrial R&D policy effects on the relationship between industry value-added and participation in GVCs are not equal to zero.

Formally,

$$H_1: \rho(x) \neq 0, \textit{ for some } x$$

In other words,

– greater emphasis on STI policies drives participation in GVCs and more value-added, and

– greater R&D capacity also drives participation in GVCs and more value-added.

5.5 Empirical findings: partial effects

5.5.1 Relationship between industry value-added and participation and value-added in GVCs

Table 5.4 contains the results of four different models. Model (1) presents the relationship between industry value-added and participation in the GVCs (using value-added trade as a proxy for GVC) for sub-Saharan Africa. Results in model (1) show that the effect of real industry value-added on participation in the GVCs is positive and statistically significant at 1%. Specifically, a 1% increase in real industry value-added leads to a 2.63% increase in participation in the GVCs.

5.5.2 Policy effects of greater emphasis on STI capabilities building on participation and value-added in GVCs

Table 5.4, model (2), shows that greater policy emphasis on innovation capabilities building is statistically significant at 1%, and that greater policy focus on innovation positively impacts participation in GVCs when compared to the period of less policy emphasis on innovation-related capacity building for the region. More specifically, greater emphasis on innovation policy makes a difference of 34% in value-added trade through GVCs (Table 5.4). We therefore reject the null hypothesis that greater emphasis on STI policies does not drive participation and value addition in GVCs in favor of the alternative that greater emphasis on innovation policies drives participation and value-added in the GVCs for sub-Saharan Africa. Furthermore, this model also helps substantiate the results of model 1, by showing that a 1% increase in real industry value-added leads to a 1.82% increase in participation in the GVCs.

5.5.3 Policy effects of greater emphasis on industrial R&D building on participation and value addition in GVCs

Table 5.4, model (3) shows that greater R&D capacity positively impacts participation in GVCs, and this result is statistically significant at 5%.

Table 5.4 Policy effects on industry value-added and participation in the GVCs

Dependent variable: – Participation in the global value chains [log (value-added trade) as proxy]:

	(1)	(2)	(3)	(4)
Intercept	–41.98***	–24.23***	–29.79***	–22.95***
	(3.093)	(4.443)	(5.971)	(5.138)
Log (real industry value-added)	2.63***	1.82***	2.07***	1.76***
	(0.139)	(0.202)	(0.271)	(0.234)
STI policy (2005–2013)		0.34***		0.31***
		(0.074)		(0.089)
Industry R&D policy (2006–2013)			0.23**	0.051
			(0.104)	(0.098)
Multiple R-squared	0.946	0.975	*0.958*	*0.975*
Adjusted R-squared	0.944	0.972	0.954	*0.971*

Notes: ***Significant at 1%; **Significant at 5%; *Significant at 10%; Number of observations is 24; Standard errors are in parentheses.

Specifically, greater emphasis on industrial R&D makes a difference of 23% in value-added trade. In other words, greater emphasis on industrial R&D within local innovation systems contributes to a 23% rise in value-added trade through GVCs. We therefore once again reject the null hypothesis that greater R&D capacity for industrial R&D does not drive participation in GVCs in favor of the alternative that greater policy emphasis on industrial R&D drives participation in GVCs for sub-Saharan Africa. We also see in model (3) that a 1% increase in real industry value-added leads to a 2.07% increase in participation in GVCs.

In model (4), the effects of greater emphasis on innovation policies and industrial R&D capacity are simultaneously estimated. The results corroborate the results in models (2) and (3), except that greater emphasis on industrial R&D capacity is not statistically significant in model (4). This might be because industrial R&D is subsumed under the variable for innovation-related capabilities building. The predictive power of models (2) and (3) is the same, with multiple R-squared coefficients of 0.975 and 0.975 respectively, implying that the 98% of the variation in the participation in GVCs is explained by variables in these models.

5.6 Technological capabilities, upgrading and innovation systems: the results

Previously in the chapter, we proposed that there is a large role for the study of innovation effects of GVCs on sub-Saharan Africa from at least three distinct perspectives:

(a) the impact of the innovation policy and incentives therein (that is, the institutional framework) on building technological capabilities and greater value-added in value chains
(b) the impact of GVCs on fostering the local innovation systems, in terms of promoting local innovation capabilities through technological spillovers, gradual technological upgrades and access to knowledge
(c) the relationship between greater industrial R&D capacity in LDCs and the ability to harness spillovers from GVCs beyond specific products to entire innovation systems

We explore these points in detail using empirical data here.

5.6.1 Impact of the policy emphasis on innovation capabilities on greater industry value-added and greater GVC participation

Figure 5.1 presents the results of the tests[11] for the relationship between industry value-added and participation in GVCs over the two policy periods (less and greater emphasis on STI capacity). The lower-left quadrant shows this relationship in the period 1990–2004, when there was less policy emphasis on STI capabilities building and, by extension, less emphasis on industrial R&D. The upper-right quadrant shows the relationship in the period 2005–2013, when there was greater policy emphasis on innovation.

In line with the results presented in Table 5.4, Figure 5.1 depicts a positive relationship between industry value-added and participation in GVCs over the two policy regimes. We assess the impact of greater

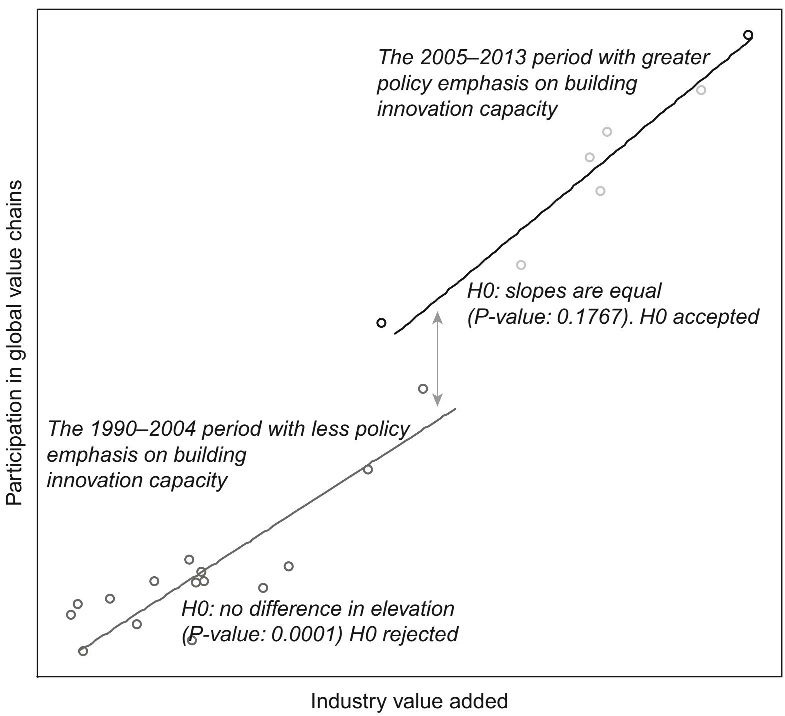

Figure 5.1 Results of policy effects on industry value-added and participation in GVCs over the two policy periods

innovation capabilities, as reflected in the capacity to produce industry value-added, on greater participation of countries in GVCs.

The results show that, in both policy regimes, *regression slopes are equal* (H_0 is accepted). Although the slopes of the two models remain the same (broadly indicating that change is slow in the two time periods), there is an increase in participation in GVCs and industrial value-added over time, as demonstrated by the parallel upward shift in the GVC curve. This implies that policy changes seem to have an emphasis on greater industry value-added. A second important inference from the shift of the GVC curve upward is as follows: the increase in industry value-added is leading to greater participation in GVCs, not necessarily in the same product category, but maybe across other product catgeories. This is an important finding, which helps address the second question raised by this chapter. It shows that opportunities presented by GVCs themselves are not a sufficient precondition for promoting capabilities building in African countries by themselves. But rather, it is innovation policy and the inherent emphasis on innovation-related activities that are extremely relevant to harnessing the system effects of participating in GVCs in sub-Saharan Africa as of 2004, much like in the case of East Asian economies. Therefore, from this point on, innovation policy has led to a greater emphasis on industry value-added and greater participation in GVCs in the same and new product categories.

5.6.2 Impact of the policy emphasis on industrial R&D on greater industry value-added and greater GVC participation

Figure 5.2 presents the results of the tests[12] for the relationship between industry value-added and participation in GVCs over the two policy regimes (less and greater policy emphasis on industrial R&D). Again, the lower-left quadrant shows this relationship in the period from 1990 to 2004, when there was less policy emphasis on industry R&D. The upper-right quadrant shows the relationship in the period from 2005 to 2013, when there was greater policy emphasis on industry R&D. Also, in line with the results presented in Table 5.4, Figure 5.2 shows a positive relationship between industry value-added and participation in GVCs over the two time frames.

However, there is no shift with respect to increase in the intercept, and the results show no statistically significant differences either in the slopes (see upper-right quadrant in Figure 5.2) or in the elevation (see lower-left quadrant in Figure 5.2). The hypotheses that the regression slopes are equal and that there is no difference in elevation are accepted

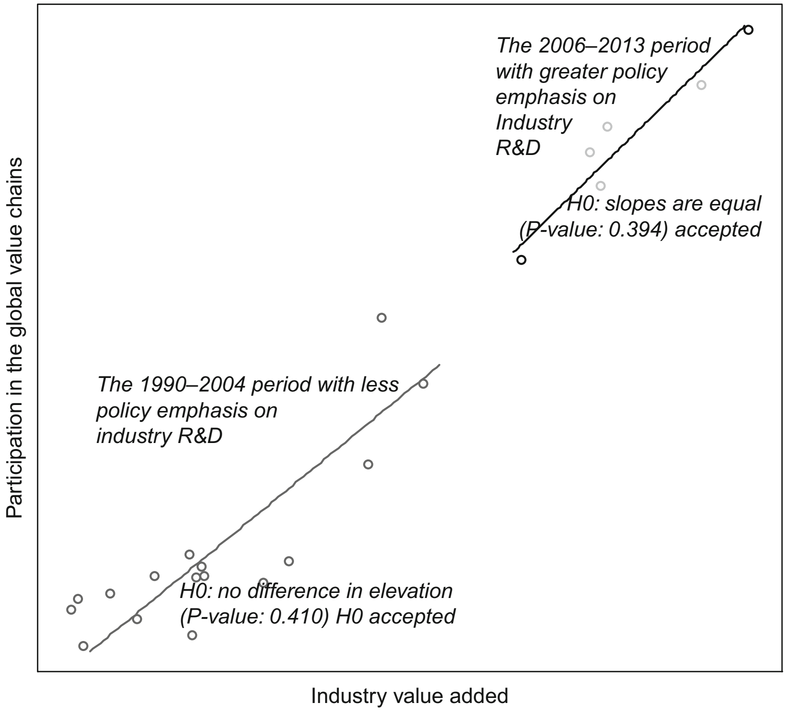

Figure 5.2 Results of R&D policy effects on industry value-added and participation in GVCs over the two policy regimes

(H_0s are accepted) in the test for equal slopes and the test for differences in elevation respectively.

This implies that a greater emphasis on industrial R&D in policies does not necessarily help us pinpoint a greater industrial value-added by way of a shift of the GVC curve upward, as we observe in the case of the emphasis on innovation policy. This implies that over the period 2006–2013, industrial R&D policies have not had much impact on industrial value-added. There are two reasons that could account for this. First, although sub-Saharan Africa countries have set targets for R&D as a percentage of GDP, these have not yet been accomplished in most countries. Gross R&D expenditure (GERD) in selected sub-Saharan African countries varies from 0.11% to 0.98% in 2011 (see Appendix 5.1). The mean R&D expenditure in 2011 was 0.50% for these selected sub-Saharan African countries. Kenya's R&D expenditure was the highest, amounting to 0.98% in 2011. This was followed by South Africa, with R&D expenditure of 0.76% in 2011. Countries like Madagascar and Ethiopia invested 0.11% and 0.25% in R&D respectively in 2011. Second, industrial R&D investments take much more time to materialize and show results than what could be captured by the time periods that are specified in the model in this chapter (specifically 2006–2013). Therefore, although we see stronger effects of STI policy on industrial value-added, we do not have similar results for industrial R&D policies.

5.6.3 Drivers of greater industry value-added

In this last section of the chapter, we return to our original assumption that technological upgrading is a critical prerequisite to achieving industrial upgrading through GVCs and that trade data needs to be supplemented with variables on technological learning, to better understand value addition. In Table 5.5, we estimate the effects of variables on industry value-added in sub-Saharan Africa over the 1990–2013 period. These are real GDP, real manufacturing value-added, tertiary school enrollment (% gross), trade (% of GDP), scientific and technical journal articles and high-technology exports (current US$).

In model (1), we capture GDP as a proxy of participation in GVCs (OECD, WTO and UNCTAD, 2013). Therefore, the greater the GDP, the greater the participation in GVCs. The results show that the effects of real GDP and real manufacturing value-added are statistically significant at 1%, and these two variables account for 97% of the variations in industry value-added over the period (see multiple R-squared equal 0.974). More specifically, in model (1), results show that a 1% increase in real GDP leads to a 0.02% increase in real industry value-added. But a 1% increase in real manufacturing value-added has led to a 0.01% decrease in real industry value-added. This can be explained by the fact that currently a large number of GVCs are structured around mining and natural resource-oriented sectors, and do not necessarily contribute to manufacturing value-added in the region.

In model (2), we introduce tertiary school enrollment to establish the extent to which the generation of knowledge at the tertiary level drives real industry value-added. Results show that the effect of tertiary school enrollment on real industry value-added over the period is not statistically significant, even though there appears to be a positive relationship between them.

In model (3), we find that trade has a statistically significant effect on real industry value-added and that the effect of high-tech exports on

Table 5.5 Estimated multiple linear models (main effects)

Dependent variable: log (real industry value-added):				
	(1)	**(2)**	**(3)**	**(4)**
Intercept	7.32***	7.356***	7.39***	7.395***
	(0.011)	(0.0407)	(0.038)	(0.032)
Log (real GDP)	0.02***	0.019***	0.01***	0.013***
	(0.001)	(0.001)	(0.002)	(0.0017)
Log (real manufacturing value-added)	–0.01***	–0.009**	–0.007***	–0.004
	(0.001)	(0.002)	(0.002)	(0.002)
Tertiary school enrollment (% gross)		0.0001	0.0002	0.001**
		(0.0001)	(0.0001)	(0.0002)
Log (trade)			0.006***	0.0019
			(0.002)	(0.002)
Log (high-technology exports)			0.0001	0.0001
			(0.0001)	(0.0001)
Log (scientific and technical journal articles)				–0.008***
				(0.002)
Multiple R-squared	*0.974*	*0.980*	*0.989*	*0.993*
Adjusted R-squared	*0.972*	*0.977*	*0.986*	*0.990*

Note: ***Significant at 1%; **Significant at 5%; *Significant at 10%.

Number of observations is 24.

Standard errors are in parentheses.

real industry value-added is not statistically significant. Results show that a 1% increase in trade leads to a 0.006% increase in real industry value-added.

In model (4), the results show that our set of independent variables, namely, real GDP, real manufacturing value-added, tertiary school enrollment, trade, high-technology exports and scientific and technical journal articles account for 99% of the variations in industry value-added over the period (see multiple R-squared equal 0.993). This implies that many of these variables are key drivers of industry value-added. A closer look at the effect of scientific and technical journal articles on real industry value-added shows that the effect is statistically significant but negative. A 1% increase in scientific and technical journal articles leads to a 0.008% decrease in real industry value-added. The explanation for this negative relationship lies in the fact that the real industry value-added that is currently occurring in the sectors is not technologically intensive (i.e., mining, natural resources, etc.). These articles need to be exploited for greater value-added, without which the resources invested in their production or acquisition may not be of much value to real industry value-added, and hence the negative relation in the present context.

5.7 Concluding remarks

This chapter has analyzed the linkages between GVCs, technological capabilities building and the relevance of innovation policies (and to some extent, industrial R&D). Our results confirm that greater policy emphasis on innovation capacity and industry R&D within policy frameworks matters for greater value addition and greater participation in GVCs.

The two questions dealt with in detail are as follows. First and foremost, can appropriate policies help African LDCs reap dividends from the ongoing surge in GVCs in various product categories? To assess this, we studied the policy effects of shifting toward policies with a greater emphasis on innovation capabilities on increased participation in GVCs and greater value-added. In this regard, the results show that policy emphasis on innovation capabilities from 2005–2013 in sub-Saharan African countries had a positive impact on increased industry value-added and greater participation in GVCs. Results further confirm that innovation policies are critical to ensuring that system-wide effects on technological learning and industry value-added are harnessed beyond the product categories in which GVCs trade is currently ongoing. These results should not be overlooked in debate on GVCs and development.

The second question relates to system effects, as based on the work done by Feenstra and Hamilton (2005). In this regard, we analyzed the role of local innovation systems in promoting the creation of local capabilities for innovation in and through GVCs, to enhance domestic value-added. The analysis helps conclude that, although opportunities presented by GVCs are important, they are by themselves not a sufficient precondition to promote capabilities building in African countries. It is innovation policy and local innovation system effects that are strengthened through such policies that are both extremely relevant to harnessing the system effects of participating in GVCs in sub-Saharan Africa as of 2004.

We also find that over the time period considered in this chapter (namely 2000–2013), GVCs may not have had a positive impact on manufacturing value-added in the region. However, our results show that the lack of a clear impact is related to the weak interface of GVCs participation with variables for technological capabilities building, due to weak or nonexistent policy, and institutional support for innovation capacity in countries in the region prior to the time period studied in the chapter. Our findings in this regard are as follows:

(a) Greater policy emphasis on local innovation capacities contributes to a 34% rise in value-added trade through GVCs in the period 2006–2013. This could perhaps be larger when measured over a longer period of time in the future, with successive emphases on innovation policy in the same direction as we witness now. We therefore conclude that the low impact on manufacturing value-added, which has been expressed as a criticism against GVCs for sub-Saharan Africa in many studies, can perhaps eventually be reversed through greater policy emphasis on innovation capacity building in the region.
(b) Greater policy emphasis on industrial R&D began to show positive effects (23%) in the period 2006–2013, but its impact is not clearly demonstrable, as in the case of the impact of innovation policies. We conclude that this may be due to the fact that most countries in the region have yet to implement the R&D investment targets that they have set out for themselves, and because the results of industrial R&D can only be measured over longer intervals of time.

A last set of results of this chapter relates to the relationship between GVCs, industrial upgrading and technological upgrading. In the model presented in Table 5.5, we find that many of these variables on technological capabilities and upgrading are key drivers of industry value-added. The results show that real GDP, real manufacturing value-added, tertiary school enrollment and trade have been important drivers of industry value-added in sub-Saharan Africa in the past two decades.

Although the time period considered in this chapter is rather short, it is illustrative of the extreme importance of innovation policies on facilitating learning through GVCs. Based on these empirical findings, we conclude that sub-Saharan Africa needs even greater commitment and investment in the development of local innovation systems, with focus on promoting industry R&D to help boost value addition while promoting greater participation in GVCs and to tap into global knowledge bases and innovation systems.

Appendix 5.1

Table A 5.1 GERD as a percentage of GDP in selected sub-Saharan African countries (2010–2012)

	2010	2011	2012
Cape Verde	...	...	0.07
Ethiopia	...	0.25	...
Gambia	0.02	...	0.13
Kenya	...	0.98	...
Lesotho	0.03	...	0.01
Madagascar	0.15	0.11	0.11
Mali	...	0.66	...
Mozambique	...	0.46	...
Senegal	...	0.54	...
South Africa	0.87	0.76	...
Togo	...	0.25	...
United Republic of Tanzania	...	0.52	...
Mean	*0.27*	*0.50*	*0.08*
Minimum	*0.02*	*0.11*	*0.01*
Maximum	*0.87*	*0.98*	*0.13*
Standard deviation	*0.41*	*0.27*	*0.05*

Source: UIS data.

Notes

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1. See Lee (2013) for a further, strong exposition of these arguments in the East Asian context.
2. Mahutga and Smith (2011), for instance, point out that industrial upgrading to a large degree depends on outsourcing decisions and technological upgrading of firms
3. See Sturgeon and Gereffi (2009) for a detailed account.
4. Note that in theory, as Morrison, C. Pietrobelli and R. Rabellotti (2006) observe, it is often not clear whether upgrading is used as a synonym for innovation or as something that is the result of innovative activities.
5. The movement from assembling to design activities.

6. See http://unctad.org/en/PublicationsLibrary/diae2013d1_en.pdf.
7. In most countries in the region, industry value-added is a sum of manufacturing, mining and utilities.
8. This figure captures all value-added trade in intermediate goods and final products: the larger the amount of intermediate goods, the greater the figure in the case of many developing countries.
9. See Fox John (1997).
10. As the proxy for measuring industrial upgrading, as explained earlier in this paper. Technological upgrading as a component of industrial upgrading is deduced through other variables in our model.
11. See application of SMART 3, an R package for estimation and inference about allometric lines by Warton, Duursma, Falster and Taskinen (2012).
12. See application of SMART 3, an R package for estimation and inference about allometric lines by Warton et al. (2012).

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