ORIGINAL ARTICLE

Infrastructure, value chains, and economic upgrades

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ABSTRACT

Infrastructure development is critical to delivering growth, reducing poverty, and addressing broader development goals, as argued in the World Bank Report Transformation through Infrastructure (2012a). This paper surveys the literature of the linkages between infrastructure investment and economic growth, discusses the role of infrastructure in the participation of global value chains and supporting economic upgrades, highlights the challenges faced the least developed countries, and provides policy recommendations. It suggests that addressing the bottlenecks in infrastructure is a necessary condition to provide a window of opportunity for an economy to develop following its comparative advantage. With the right conditions, good infrastructure can support an economy, particularly a less developed economy, to reap the benefit through the participation in the global value chains to upgrade the economic structure.

Keywords: infrastructure gap; economic growth; structural upgrades; least developed countries; global value chains

1. Introduction

An accessible, affordable, and reliable infrastructure network is crucial for development. It is necessitous for powering business, lowering transactions costs, improving market access, and improving the efficiency of other productive factors, and it is prerequisite for providing people with access to important services such as education and health care, connecting workers to their jobs, and sharing the fruits of growth in an equitable manner. In the global arena, infrastructure is essential for the participation in the value chains to upgrade economic structure. As argued in the World Bank Report Transformation through Infrastructure (2012a), infrastructure development is critical to delivering growth, reducing poverty, and addressing broader development goals[1].

This paper surveys the literature of the linkages between infrastructure investment and economic growth, discusses the role of infrastructure in the participation of global value chains and supporting economic upgrades, highlights the challenges faced the least developed countries, and provides policy suggestions. It suggests that addressing the bottlenecks in infrastructure is a necessary condition to provide a

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1 See World Bank, 2012a, Transformation through infrastructure. Washington, DC: World Bank. http://siteresources.worldbank.org/INTINFRA/Resources/Transformationthroughinfrastructure.pdf

window of opportunity for an economy to develop following its comparative advantage. With the right conditions, good infrastructure can support an economy, particularly a less developed economy, to reap the benefit through the participation in the global value chains to upgrade the economic structure.

2.   Infrastructure investment and economic growth

Infrastructure includes hard (tangible) infrastructure and soft (intangible) infrastructure. Hard infrastructure often refers to transport system (such as roads, airports, port facilities, and rail), public utilities (such as energy, water supply and sewer, and irrigation), communication network (such as telecommunication and broadband), and social infrastructure (such as schools and hospitals). Soft infrastructure often refers to matters related to efficiency such as institutions and regulations[2].

There is a vast literature on the contribution of infrastructure and public capital to aggregate productivity and growth. Arrow and Kurz (1970) examined the relationship between infrastructure investment and productivity using the Ramsey type exogenous growth model and found that volume of public investment conditions marginal productivity. Barro (1990) included public capital in the framework of the endogenous growth model and concluded that growth and saving rate increase initially with productive services, but subsequently decline, while the two rates were negatively associated with consumption services. Futagami *et al*. (1993) extended Barro's method by adding private capital stock into the endogenous growth model and showed that long-run economic growth is maximized when income tax rate equals to output elasticity of public capital. World Bank (2012a) showed a positive correlation between estimated infrastructure investments (per capita) and the level of development (proxied by GDP per capita) using data from 104 countries (Figure 1). World Economic Forum (2013) suggested that if every country improved border administration, transport and communications infrastructure, and related services halfway to the world's best practices, global GDP could increase by US\$ 2.6 trillion (4.7%) and exports by US\$ 1.6 trillion (14.5%).

There is an indication that infrastructure is closely associated with economic development, while the empirical evidence of the causality between infrastructure and productivity growth remains inconclusive and marginal productivity of infrastructure varies across countries. De la Fuente (2010) provided a survey of the literature with a thorough discussion of the econometric complications. Aschauer (1989) found that the slowdown of investment rate in public infrastructure leads to the deceleration of private sector total factor productivity in the U.S. since the early 1970s. Wylie (1996) used a similar approach as Aschauer's analysis and found high returns of infrastructure investment to productivity in Canada's goods sector, and complementarity of infrastructure with goods sector capital and labor inputs during 1964-1991. Fernald (1999) accessed the links between road services and productivity and found that industries intensively used roads often witnessed a faster productivity growth increase when the stock of roads increased, using industry data in the U.S. between 1953 and 1989. Canning and Bennathan (2000), using aggregate production function, found that infrastructure, as complementary to physical and human capital, enhances production capacity. Röller and Waverman (2001) found positive causal link between telecommunication infrastructure and economic development using data from 21 OECD countries spanning the years 1970–1990 with a micromodel endogenizing telecommunication investment and macrogrowth equation, after controlling for country-specific fixed effects and non-linear effects caused by network externalities. Albiman and Sulong (2016) showed that mobile phone and internet were

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2   See more from Lin (2011), Bottini *et al*. (2012), and Ismail and Mahyideen (2015).
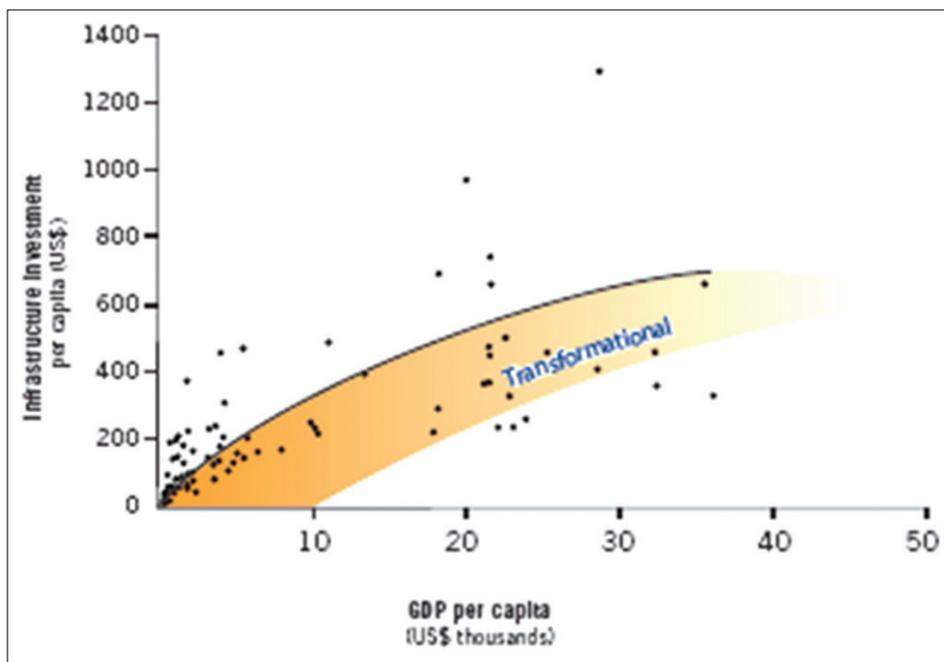
Figure 1. Infrastructure investment and economic development cited from World Bank (2012a), Transformation through infrastructure. Total investments in infrastructure consist of (a) new investment resulting from the variation in infrastructure stocks between 2000 and 2005, valued at unit costs and (b) requirements for maintenance, resulting from multiplying stocks of 200 by a depreciation rate. Infrastructure sectors include paved and unpaved roads, rails, ports, electricity generation and electrification, fixed and mobile communications, and water supply and sanitation. The curve is obtained by a three-degree polynomial trend.

main economic growth drivers in the long run using data in 45 Sub-Saharan African countries from 1990 to 2014.

Infrastructure can contribute to productivity and economic growth through several channels:
- Infrastructure can lower production costs. Seethepalli *et al*. (2008) found that telecommunications, electricity, roads, water, and sanitation had significant positive impact on economic growth in East Asia, after controlling human capital and total investment. Similarly, Straub and Terada-Hagiwara's study (2010) showed that the growth rate of these infrastructure stocks promoted economic growth in most countries in East Asia and South Asia. For production, electricity is often a major constraint in developing countries. Dollar *et al*. (2005) showed that the inconsistent power supply has strong negative impacts on productivity using firm-level survey data. Firms often had to rely on their own generators to supplement the unreliable public electricity supply. However, the cost of maintaining a power generator is often high and burdensome, especially for small and medium firms, where a large share of the poor and vulnerable are employed. Hallaert *et al*. (2011) found that electricity supply is a major constraint to trade expansion in developing countries.
- Infrastructure can lower transactions costs. Limao and Venables (2001) showed poor infrastructure accounts for more than 40% of transport costs. Radelet and Sachs (1998) found that a doubling of the shipping cost is associated with slower annual growth of slightly more than half of 1% point. Cordella and Simon (1997) found that infrastructure can reduce transaction costs (including the costs for gathering information, evaluating alternative options, negotiating, and contracting) by reducing time and cost in communication and information exchange and by flattening the organizational structure to reduce information flux and coordination needs. Lakshmanan (2011) suggests that time and cost savings due to transport infrastructure improvement can better link product and factor markets, promote inter-regional trade and specialization, increase returns to scale, and reallocate economic activities.

- Infrastructure can increase total factor productivity. Good infrastructure can increase efficiency of conventional inputs (Duggal *et al*., 1999). Interconnections and complementarities between infrastructures help improve service efficiency and support innovative technologies adoption (Bottini *et al*., 2012). Based on a large-scale firm-level survey data from China, Wan and Zhang (2017) explored the causality between infrastructure and firm total factor productivity and concluded that road, telecommunication servers, and cable promoted firm productivity. In addition to the conventional productivity effect, Fay *et al*. (2011) found that infrastructure is likely to condition the efficiency of many key areas of productive factors such as the costs of investment adjustment, the durability of private capital, and both demand for and supply of health and education services. Dam (2007) showed that the rule of law is important to unlocking the developing world's full growth potential.

- Infrastructure services can crowd in other productive inputs. Calderón and Servén (2014) suggested that an increase in infrastructure stock or improvement in infrastructure can indirectly "crowd in" other inputs due to the accompanying rise in their marginal productivity, and this indirect effect may take place instantaneously (for variable inputs in elastic supply) or over time (for fixed inputs such as human and non-infrastructure physical capital). As a key element of business environment, infrastructure conditions firms' transaction costs and marginal return to investment[3]. Wheeler and Mody (1992) and Richaud *et al*. (1999) provided evidence that infrastructure can crowd in foreign direct investment, an important element for growth in less developed countries. Eden and Kraay (2014) found that an extra dollar of public investment can raise private investment by roughly two dollars and output by 1.5 dollars, based on data from 39 low-income countries.

The magnitude of contribution of infrastructure to productivity and output varies. Various factors are at play. Calderón *et al*. (2015) found that the long-run output elasticity of infrastructure ranged from 0.07 to 0.1 using a synthetic index combined by power, transport, and telecommunications infrastructure as one of the inputs in a production function, based on a large dataset covering 88 countries spanning the years 1960–2000. Their results suggest that marginal productivity of infrastructure is associated with the ratio of aggregate infrastructure to output. Calderón and Servén (2008), drawing from data of 100 countries in Sub-Saharan Africa over 1960–2005, found that infrastructure development made, on average, a smaller contribution to growth in Sub-Saharan Africa than in other regions - just 0.7% per annum. This is related to the severe deterioration of the quality of infrastructure services in the region - while the expansion in infrastructure stocks raised the growth rate by 1.2% per annum, the deterioration of the quality of infrastructure services reduced the growth rate by 0.5% per annum. Bottini *et al*. (2012) suggested that enhancing service efficiency and supporting innovative technologies adoption can improve the contribution of infrastructure to total factor productivity through better interconnection and stronger complementarities.

The relationship between infrastructure and economic growth is not linear. Hurlin (2006) found that returns to infrastructure exhibit threshold effects and that the highest marginal productivity of investments is found when a network is sufficiently developed but not completely saturated. For example, road construction may have limited effects until it links several locations. After the establishment of a minimum road network, the marginal productivity is high for the new road construction extending the network before congestions kick in Fernald, 1999. Telecommunications investment has strong externality. A subscriber's welfare increases with the increase of the number of people who have access to the network, until reaching the saturation point. Röller and Waverman

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3   See Lin, 2011, New Structural Economics: A Framework for Rethinking Development 1. *The World Bank Research Observer,* 26(2), 193-221. https://openknowledge.worldbank.org/bitstream/handle/10986/13507/wbro_26_2_193. pdf?sequence=1

(2001) found that the impact of telecommunications infrastructure on output is substantially higher in countries where penetration approaches universal coverage.

3.   Infrastructure and global value chains

Infrastructure development includes two main stages: The first stage is the development of transport infrastructure. It significantly lowered transport costs and made it feasible to spatially separate production and consumption. Production became specialized and clustered in large scale (Florida, 2005). The second stage is the development of communication infrastructure. It significantly lowered coordination costs and made it feasible for firm-specific knowledge and know how to be shared across national borders (Baldwin, 2011).

In today's world, with drastic decline of transport costs and communication costs, the potential contribution of infrastructure to productivity and growth is magnified. The infrastructure improvement not only contributed to growth through lowering production costs and transaction costs, increasing total factor productivity, and crowing in other productive factors but also has changed the boundary of production and reshaped the economic (Lewis and Bloch, 1998, and McCann and Shefer, 2004). The transportation and communication technology revolution have redefined the function of time and distance. The interconnectedness across firms or sectors multiplies and intensifies[4].

The separation of stages of production or tasks instead of the full products, which is profitable due to the large differences of wages, land prices, and advantageous policies between developed and developing countries, opens new doors for developing countries to specialize in specific niches of the global value chains. It enables an economy to develop its comparative advantages, including latent comparative advantages, potentially at an earlier stage through focusing on a special niche in the global value chains[5]. Countries become increasingly interdependent through supply chain trade, as they specialize in tasks and business functions rather than products. Products at different stages of value added may be imported, exported, and reexported multiple times. In 2009, world exports of intermediate goods exceeded the combined export values of final and capital goods for the first time, representing 51% of non-fuel merchandise exports (WTO and IDE-JETRO, 2011).

Global value chain integration can increase domestic value added. As indicated by Kowalski *et al*. (2015), global value chain participation can increase domestic value-added embodied in a country's exports, enhance sophistication of export bundle, and improve diversification of export products. Weinberger and Lumpkin (2007) stated that integrating into horticulture global value chain offers opportunities for the least developed countries to alleviate poverty by increasing income and creating employment. Kummritz *et al*. (2017) found that both backward and forward GVC participation can lead the growth of domestic value added, based on a dataset covering 61 countries and 34 industries between 1995 and 2011. Gonzalez (2016) found that using foreign value added is one of the most important factors that contribute to growth in domestic value added in exports. In ASEAN countries, the total domestic value added in exports increased nearly four times during the period of 1995–2011. According to Global Value Chains Development Report (World Bank, 2017), information and communication technology industry in the U.S. and China have experienced an increase of the rate of return in labor or capital by participating in the global value chains.

4   See Gereffi and Luo (2015) for more discussion.
5   See Lin and Monga (2011) and Lin (2012b) for a thorough discussion on the identification of comparative advantages.

The participation in global value chains can be a window of opportunities for developing countries to move up the ladder in the production structure specializing in the niche where they have comparative advantage. Following the metaphor of "ladder" instead of a "chain" used in a recent joint report by OECD, WTO, and World Bank Group, "the disaggregation of production into separate stages allows their firms not only to find their place on the ladder but also to move up the rungs as their capabilities improve"[6]. Entering global value chains are a way to "denationalize comparative advantages," and it has the potential to enhance developing countries' export opportunities and their competitiveness (Del Prete *et al.*, 2017). It allows developing countries to specialize in niches without the need of first building an entire value chain from scratch, as other countries, such as Japan and Korea, experienced in the last century. A small developing country with abundant unskilled labor can join the value chain of garment manufacturing, specializing in only one small niche such as producing buttons before they can have the entire assembly line.

The participation of global value chains can, therefore, encourage upward movement by providing the platform to reward skills, learning, and innovation. Gereffi and Fernandez-Stark (2016) drew an upgrading trajectory in global value chain, in which countries follow the steps of entering the value chain first by offering the most basic products or services, then providing more sophisticated business, subsequently to knowledge activities, offering large spectrum of products or services, and finally being specialized in vertical industries. Costa Rica has experienced product upgrading in medical devices value chains, as shown by Bamber and Gereffi (2013), with its high-tech medical devices accounting for more than half of total medical device exports in 2011, compared with 90% shared by low-tech disposable devices in 2002. Simultaneously, the country also witnessed significant growth of FDI in higher level technology medical devices sectors.

The potential benefit of tapping in the benefit of structural upgrading through the participation in the value chains is large. Development is path dependent. Several economies, including China, are moving up the value chain and releasing millions of labor-intensive jobs (Lin, 2012a). Seizing this opportunity to specialize in the niches following the latent comparative advantages can set an economy on a right path of structural upgrades. Successful cases can be found in countries such as Chile in exporting engineering services related to mining, India in exporting pharmaceutical R and D, and Uruguay in exporting sophisticated expertise on cattle traceability (Gereffi and Fernandez-Stark, 2016).

Improving infrastructure, including hard infrastructure and soft infrastructure, is a necessary condition for reaping the benefit of the participation in the global value chains to upgrade the economic structure. Reliable infrastructure to connect supply, efficient movement of goods and services across borders, fast and reliable information transfer, and sufficiently low coordination costs are prerequisites for participate into global value chains. Yi (2003) indicated that tariffs have large and non-linear impact on global trade, especially for semi-finished goods in the value chains as they need to cross borders for several times. A recent Brookings report (World Bank *et al.*, 2017) shows a clear relationship between better logistics performance and deeper involvement in GVCs using the World Bank's Logistics Performance Indicator. While not all countries with good logistics are deeply involved in GVCs, no countries with poor logistics performance are central to GVCs (Figure 2). According to the World Economic Forum (2014), well-developed infrastructure not only reduces the

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6   See OECD, WTO, & World Bank Group, 2014, Global Value Chains: Challenges, Opportunities, and Implications for Policy. In *Report prepared for submission to the G20 Trade Ministers Meeting Sydney, Australia* (Vol. 19). https://www.oecd.org/tad/gvc_report_g20_july_2014.pdf
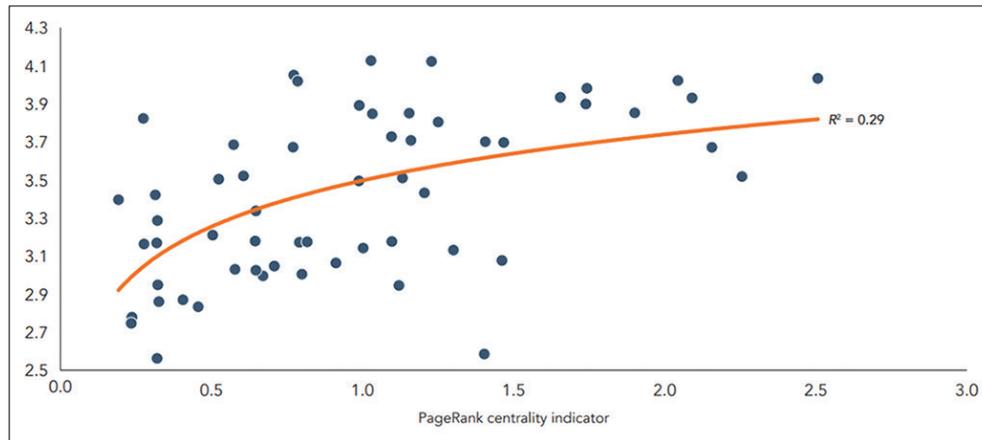
Figure 2. Relationship between the Logistics Performance Index and a centrality measure of country involvement in global value chains cited from World Bank *et al.* (2017) and Diakantoni *et al.* (2017). Based on COMTRADE and World Bank data, the centrality indicator ranks a country's centrality to global value chains, taking into account direct and indirect trade flows to and from trading partners in the global production network.

distance between regions but also integrates national markets and connects them to other economies. The proximity of industries and businesses favors cost reduction and productivity improvement allowing firms in the region to share a similar labor pool and enjoy knowledge spillovers and enables further clustering and agglomeration (Fujita *et al.*, 1999, and Fujita and Thisse, 2013).

4.   Challenges for the least developed countries

Participating and competing in global value chains have become largely inevitable. Firms are collaborating directly or indirectly with foreign firms in the same industry or with their upstream or downstream partners; at the same time, firms are competing with a growing number of foreign firms in the local as well as international markets. As the natural barriers of distance to trade are diminished, countries may benefit or lose in the new global arena. To survive, they need to improve product quality and efficiency of operations. Infrastructure required for firms in least developed countries, which mainly target local markets with small amount of transactions, used to be rudimentary. However, when they attempt to join the global value chains, where business transactions are often long distance and large in quantity and value, more sophisticated and various types of infrastructures are become necessary (Lin, 2011). Countries with poor infrastructure and distant to the economic centers can be marginalized and locked from the opportunity of participating in the global value chains and, consequently, the opportunity of upgrading the economic structure.

Developing countries face daunting challenges, ranging from the accessibility and quality of transportation, telecommunication, and water supply, to institutions and regulations to facilitate trade. The large infrastructure gaps, particularly for the least developed countries, might deprive them of the opportunity to upgrade their economic structural through the participation in the global value chains. World Bank (2017) indicates that the performance of Sub-Saharan Africa's infrastructure currently ranks below all other developing regions: Road density has declined over the past 20 years in Africa, only 35% of the population has access to electricity, with rural access rates less than one-third urban ones. The report estimates that closing the infrastructure quantity and quality gap in Sub-Saharan Africa relative to the best performers in the world could increase the growth of GDP per capita in the region by 2.6% per year or 1.7% per year if it was to close the gap with the median of the rest of the developing world.

Transport costs can be prohibitively high. Transport costs, according to developing country suppliers, remain the main obstacle to entering, establishing, or moving up in GVCs (OECD and WTO, 2013). Transport prices for most African landlocked countries range from 15% to 20% of import costs, approximately two to three times more than in most developed countries (Teravaninthorn and Raballand, 2009). According to a recent IMF report (IMF, 2015), the quality of infrastructure in Africa is about half that found elsewhere in the world, credit-to-GDP ratios about a third of ratios elsewhere, and tariffs on average four times higher than elsewhere. The slow and unpredictable land transport keeps most of Sub-Saharan Africa out of the higher value-added segments of the value chains including electronics (Christ and Ferrantino, 2011).

Firms in the least developed countries are more likely to suffer from the burden of high transaction costs. Besides, conducive business environment and strong human capital, efficient and reliable infrastructure services (including telecoms, internet, express service delivery, and customs clearances) for coordinating the dispersed production become the essential condition of the location choice in the supply chain production. With below average infrastructure quality in most countries and the lack of regional coordination of trade facilitation effort, South Asia has the highest intraregional trade costs after the African regions (Kowalski *et al.*, 2015). Ahmed *et al.* (2010) noted that high transaction costs are bottlenecks for South Asia countries to promote regional or international trade, with 140 to 200 signatures required for trading between India and Nepal, and over 4 days of waiting time for trucks to cross border between Bangladesh and India. Facilitating trade by focusing on publication of customs information, notifications, advance rulings, documentation requirements, and international standards can reduce trade costs mostly in less developed counties (Moïsé and Sorescu, 2013).

High logistics costs due to weak supply chains are often another barrier for the least developed countries. Lack of reliable supply chains, firms in less developed countries encounter much higher logistic costs and are virtually eliminated from the just-in-time production. High inventory costs post a double penalty for firms participating in global manufacturing value chains with extra logistics costs on both inputs and exports. The inefficient and unreliable clearance processes could even render the participation in GVCs impossible. As a result, the offshoring and industrialization after the ICT revolution tend to concentrate in select parts of the developing world, of which a significant share in East Asia followed by select countries in Latin America and East and Central Europe.

Small and medium enterprises (SMEs) stand for the majority of firms in least developed countries. According to Gereffi and Fernandez-Stark (2016), market access, training, and collaboration and cooperation are major constraints for SMEs to sustainably enter into value chains. Infrastructure such as transportation and ICT conditions the linkages between producers and buyers in value chains, and affects the adoption of new technologies to meet the international market requirements. Collaboration and cooperation refer to both horizontal coordination between producers and vertical interaction between segments of the value chains, with the former facilitating economies of scale and providing opportunities for more value added, and the latter helping sharing knowledge along the chain and upgrading.

SMEs are even more vulnerable to supply chain inefficiencies compared with large firms. For SMEs, related to their small scales, logistics costs are disproportionately higher - industrial firms with fewer than 250 workers on average having logistics cost of some 15% of overall revenue for the business unit, more than twice that of firms with over 250 workers (Straube *et al.*, 2013). Small exporters and importers tend to be more affected by a lack of transparency in clearance processes.

They have lower economies of scale, therefore, a higher inventory cost, which can be punitively high in countries with poor logistics performance. Many of them are often forced to confine their business activities to the geographical area close to their production site. For the SMEs in remote areas, the lack of continuity of logistics services beyond the main gateway could make access to GVCs prohibitive.

Evidences show that insufficient infrastructure has put obstacles for less developed countries to integrate into global value chain and upgrade to higher segments on the chains. According to Gereffi (2015), in some Central America countries, inadequate infrastructure investment in wet processing plants limited the abilities of small producers to produce premium coffee, consequently losing the opportunity to capture the price premiums in the global value chain. Report from AfDB *et al*. (2014) suggested that many Africa countries suffer from insufficient infrastructure. Lack of infrastructure and burdensome border procedures accompanied with geographical remoteness, countries in Sub-Saharan African averagely take 38 days to import and 32 days for export across borders. As a result, firms face high costs and uncertainty of supply (World Bank, 2012b; Kowalski *et al*., 2015). Poor infrastructure, especially lack of access to energy, and inadequate skilled workforce are main barriers for Burkina Faso to participate in the global value chains. In Congo, the economy has not been able to build on the comparative advantages in natural resources and move up the value chains due to the lack of decent infrastructure, such as transport and energy, as well as the lagging technology, less qualified labor, and uncongenial business environment. In Tunisia, while the manufactural sector has benefited from the participation in the global value chain, particularly, its further development and structural upgrades are still handicapped by logistics, transport, unbalanced distribution of information and communication technologies, and technology transfers.

The less developed countries with underdeveloped infrastructure, low investment rates, and low per capita incomes can experience a boost in trade flows and benefit from infrastructure development. The development experiences in Africa and Asia such as light manufacturing in Ethiopia, horticulture in Kenya, readymade garments in Cambodia, and textiles in Pakistan have already highlighted these countries' tremendous potential for productive job creation, providing they tackle the "hard" and "soft" infrastructure constraints to help realize this latent comparative advantage.

5.   Conclusions

Improving infrastructure to meet the demand in today's economy is a must. The demand for infrastructure includes not only the traditional facilities but also the new ones that better respond to the rapidly evolving needs and provide quicker and more reliable services. While the "traditional" infrastructure, such as roads, railways, electricity, water, and sanitation, is still fundamental, "new" infrastructure, such as highways, high-speed trains, and broadband internet, has become necessary for an economy to fully participate in the global value chains and to move up the ladder of the economic structure.

Infrastructure is not everything, but without good infrastructure, the most potential will be limited. Improving infrastructure is not only important for growth by boosting firm performance but also facilitating public services delivery and contributing to the inclusiveness and long-term development. The lack of access to basic services undermines living standards for poor people and limited their ability to materialize their full potentials. The inequality of opportunity and inequality of outcomes intertwine perpetuate and prevent poor people from the access to infrastructure services. Alesina *et al*.

(1999) argued that more unequal societies devote less effort to the provision of public goods including infrastructure. Estache *et al*. (2002) showed that income inequality adversely affects access to internet, which aggravates the information asymmetry and deprives the poor from equal opportunities. Some studies, for example, Gonzalez (2016) suggest that participation in GVCs can be an engine of job creation: Forward GVC jobs - domestic jobs linked to the production of intermediate products traded within value chains - have grown over six times faster than total jobs in 1996–2011.

Infrastructure is a necessary but not sufficient condition for growth. The extent to which infrastructure improvement contributes to the growth of a specific industry or location depends on the specific characteristics of the infrastructure and the business environment where the infrastructure locates. To the extent that suboptimal infrastructure investment constrains other investments, it constrains growth (Newbery, 2012). More infrastructure may not necessarily cause more growth if the binding constraints lie elsewhere or the type or quality of infrastructure investment do not match the demand[7]. Building a bridge to nowhere will not add any value.

The constraints of infrastructure, or the benefit from the improvement of a specific type of infrastructure, vary across industries and firms as well as across regions in the same country. For example, a new expressway linking two locations might benefit one more than the others depending on their production and geoeconomic structures. Improvement in connectivity and market accessibility might lead to stronger clustering and agglomeration, which tends to favor the economic centers more than the periphery. Similarly, simplification of the customs clearance might benefit firms specializing in foreign trade or the economy, in general, but at the same time raise the competition for those engaging in import substitution industries or focusing on domestic market.

Infrastructure is not a sufficient condition for benefiting from the participation in the global value chains, and participation in the GVC is not a sufficient condition for structural upgrades. The "smile curve" is deep as value added is high at the pre- and post- manufacturing stages. Based on a sample of more than 2 million firms in the European Union in 2015, the empirical results from Rungi and Del Prete (2017) confirmed a non-linear U-shaped relationship at firm level between the value added generated and position on a productive sequence. Developing countries given the mixed of their factor endowment, often enter GVCs first at the low value-added stage (assembly or production stage) and subsequently seek to move toward higher value adding activities. To what extent they can increase their domestic value added and move up the ladder depends on a variety of factors. With good infrastructure, opportunity is there but success is not guaranteed; however, without good infrastructure, the economy will certainly be deprived of the opportunity to materialize its latent advantage at the global scale early on.

The public good nature of infrastructure calls for support from the governments, and partnership between the public and private sectors in many areas is essential. When the infrastructure investment crosses the national borders, regional and global collaborations are essential. Concerted efforts between national governments and regional or international development agencies can play a crucial role. With the right conditions, infrastructure investment and economic growth can reinforce each other: Good infrastructure investments can accelerate growth, while growth itself can generate greater demand for and usually supply of infrastructure.

Infrastructure is expensive and requires extensive maintenance. The fiscal burden can be high,

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7   See more discussions in Canning, and Pedroni, 2008, Infrastructure, long-run economic growth and causality tests for cointegrated panels. *The Manchester School,* 76(5), 504-527. http://onlinelibrary.wiley.com/wol1/doi/10.1111/ j.1467-9957.2008.01073.x/full

particularly for the less developed countries that face multiple challenges and at the same time has the most urgent needs. Focusing the investment in infrastructure in special economic zones or industrial parks can be a useful approach to jumpstart the process with limited resources. China has spent over 5% of GDP over the past decades in infrastructure investment, cutting transport costs, and helped connect production centers to domestic and international consumers (Huang, 2017). By substituting domestic for imported materials, China has been increasing the domestic content of its exports (Kee and Tang, 2015) and become the world's factory from a largely agrarian economy. The successful experience in China in the past decades shows that well-planned and well-managed special economic zones with targeted investment promotion and catalytic development financing can help to unleash the latent comparative advantages and facilitate the integration and upgrading along the global value chains. Development in sectors where the economy has comparative advantages can stimulate gradual and sustained upgrading in the value chains and start the virtuous cycle building the ecosystem for more beneficial integration in the value chain for the entire economy.

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