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# State Enabling and Comparative Advantages

**Justin Yifu Lin[a] , Xin Wang[b]**

[a] Institute of New Structural Economics, Institute of South-South Cooperation and Development, National School of Development, Peking University

[b] Institute of New Structural Economics, Peking University

**Abstract**: International trade plays a crucial role in driving structural transformation and fostering economic growth. However, not all countries have equally engaged in international trade. This paper argues that while theories of comparative advantage predict a country's potential to trade with others primarily based on relative production costs, the emergence of industries with low production costs can be hindered by high transaction costs. Therefore, the factors outlined in traditional theories are only sufficient to identify the presence of a "latent" comparative advantage (LCA). Transforming LCA into an "actual" comparative advantage (ACA) requires the active involvement of the state, as many factors influencing transaction costs are beyond the control of individual ″rms. Using cross-country data, we demonstrate that most African and Latin American countries struggle to export products that align with their LCA, whereas Asian countries exhibit a smaller discrepancy between LCA and ACA. Moreover, the export structure in Asian countries shows high dynamism and evolves alongside the upgrading of their endowment structure. In contrast, most countries in Africa and Latin America experience a stagnant export structure. Additionally, the dynamics of the export structure positively correlate with the development of physical and institutional infrastructure, as well as the government's public investment. We then present a model illustrating the crucial role of the state in reducing transaction costs, thereby facilitating the conversion of LCA into ACA industries. Through proactive state engagement in infrastructure investment, barriers for production can be overcome, fostering a more conducive environment for international trade and economic growth.

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*Lin: Institute of New Structural Economics, Institute of South-South Cooperation and Development, National School of Development, Peking University, Beijing, China, 100871 (email: justinlin@nsd.pku.edu.cn); Wang (corresponding author): Institute of New Structural Economics, Peking University, Beijing, China, 100871 (email: xin.wang@nsd.pku.edu.cn). We acknowledge the financial support of the National Social Science Foundation of China (Grant No. 21CJL011).

# I. Introduction

Since Ricardo's seminal work, an extensive body of theoretical and empirical research has emphasized that countries benefit from international trade by specializing in industries with comparative advantages. Trade is also a critical driver of structural transformation and economic growth (Uy et al., 2013; Erten and Leight, 2021; Commission on Growth and Development, 2008). However, not all countries have equally been active in and benefited from international trade. For instance, according to a World Bank report on light manufacturing in Africa (2012), in 2010, Ethiopia's wages were only half of Vietnam's, and the labor productivity in its large leather firms was comparable to that of Vietnam. However, Vietnam employed 600,000 workers in the leather sector, while Ethiopia employed only 8,000 workers, despite having a similar land area and population. Additionally, Ethiopia imported a substantial amount of leather products from China, where wages for skilled and unskilled labor were four and six times that of Ethiopia, respectively, while Ethiopia's labor productivity in large leather firms was approximately 80 percent of that in China.

International variations in factors that determine comparative production costs, namely, factor endowment structure, production efficiency, and economies of scale, are not enough to account for the substantial discrepancy in export performance between high-growth developing economies and other developing economies. This paper argues that comparative advantage cannot be realized spontaneously and must be enabled by the state. Specifically, enterprises make their entry and production decisions based on total costs, which include not only production costs but also transaction costs involved in acquiring inputs and necessary information about buyers or sellers, enforcing exchange agreements, and transferring products to consumers. Even if an economy has a comparative advantage in an industry from the viewpoint of relative production costs, the industry may not exist at all if transaction costs are too high. Therefore, the classical theories of comparative production costs can be referred to as theories of latent comparative advantage (hereafter LCA). For an LCA industry to become an actual comparative advantage (hereafter ACA), its total cost should be relatively low. Although transaction costs have been widely recognized as critical factors that affect production decisions, they have received little attention as determinants of the transformation from LCA to ACA in trade theory.

There are various reasons why firms in certain countries experience significantly higher transaction costs than those in other countries, such as inadequate infrastructure, supply chain shortages, high entry barriers, and excessive factor market frictions. Since most of these factors are beyond the control of firms, the government needs to play a crucial role in addressing these challenges. For example, during the 1980s and 1990s, neoliberalism gained dominance, and most international development organizations and governments believed that

the private sector should play a significant role in supplying infrastructure. The World Bank, in line with neoliberalism, abolished its infrastructure department in the 1990s. However, reducing the government's role in infrastructure has resulted in severe underinvestment in infrastructure for decades, leading to infrastructure bottlenecks in developing and even developed countries (Lin, 2013). Although the private sector has become more important as a source of finance, public infrastructure investment is still documented as "an indispensable complement to private efforts" (Commission on Growth and Development, 2008).

In this paper, we argue that it's important for the state to play an active role in reducing transaction costs to enable the transformation of LCA to ACA, particularly in developing countries where the cost of private provision of public infrastructure tends to be high. These countries generally exhibit underdeveloped formal institutions as well. We present three key features of the data that provide compelling support for our argument. First, we demonstrate large variations in the gap between LCA and ACA across countries. Most countries in Africa and Latin America fail to export products that align with their LCA, while Asian countries have a relatively smaller gap between LCA and ACA. Second, the export structure in Asian countries is highly dynamic and evolves alongside the upgrading of their endowment structure. In contrast, most countries in Africa and Latin America exhibit a stagnant export structure. Third, we show that the degree of dynamics in the export structure is positively correlated with the development of physical and institutional infrastructures. The first two observations emphasize the difference between ACA and LCA, while the third observation suggests that LCA will not automatically become ACA in most cases without the development of hard and soft infrastructures facilitated by the state.

These findings are consistent with previous research that documents poor performance in economies with inadequate public infrastructure. In Ethiopia, for instance, scholars find that the development of light industries is hindered by high transaction costs due to a lack of sufficient infrastructure (World Bank, 2012). Similarly, Reinikka and Svensson (1999) report that unreliable electricity provision in Uganda is a significant obstacle to investment, discouraging many firms from initiating production or exporting. The failure of labor-intensive manufacturing industries in African economies to become their ACA results in poor economic performance since economic growth is contingent upon the structural transformation from low-productivity agriculture to higher-productivity manufacturing (Kuznets 1966, Lin 2011; African Center for Economic Transformation, 2014). A similar scenario is prevalent in Latin America, where the pace of infrastructure development has lagged behind that of East Asian countries, impeding the upgrading of export structures toward more capital- and technology-intensive industries. As a consequence, some middle-income Latin American countries find themselves entrenched in a pattern of constrained economic growth, commonly referred to as the "middle-income trap" (Gill and Kharas, 2007; Im and Rosenblatt, 2013).

We develop a theoretical model to illustrate how an enabling state could facilitate the transformation of LCA to ACA by reducing transaction costs. Specifically, we introduce public infrastructure into a two-country version of the Heckscher-Ohlin model with a continuum of industries. We assume that infrastructure is provided by a partnership between the government and private supplier, in which the government supplier has a lower financing cost than the private supplier. In addition, infrastructure serves to lower transaction costs associated with entering markets, enforcing production agreements, and transferring products. We begin by examining the case of a small open economy in which the production structure in the foreign country is exogenously determined. Our model predicts that increased government involvement in infrastructure provision leads to a rise in the supply of public infrastructure, expands the production set, and affects how the production structure in one country responds to changes in its trading partner. Then, we relax the assumption of a small open economy so that the structure of production and trade is determined by both the relative endowment structure and the supply of public infrastructure. We demonstrate that in this model, the response of production and trade structures to changes in factor endowments depends on the relative supply of infrastructure across countries. In countries with a laissez-faire state, the production structure is not as responsive to changes in LCA compared to countries where the government plays an active role in infrastructure development.We present a numerical example and perform comparative statics to highlight the importance of government participation in promoting the realization of LCA.

In the theory of international trade, the state plays a limited role in most cases. Besides imposing tariffs and other trade restrictions that directly impede trade flows, the state is also modeled to affect export structures through various industrial policies, such as tax reductions, production subsidies and cheap credit, that encourage investment and promote exports in specific industries. While it is a well-known theoretical result that public inputs will be undersupplied by private providers, few papers have explicitly examined how the state affects the specialization pattern by improving public infrastructure and reducing transaction costs.[1]

The key argument in this paper draws on the insights of the extensive literature that examines how physical and institutional infrastructures affect transaction costs. In addition to papers discussing the impacts of physical infrastructures on trade costs (Limao and Venables, 2001; Donaldson, 2018; Banerjee et al., 2020; Coşar and Demir, 2016), a substantial strand of literature dating back to Coase's seminal work, "The Nature of the Firm" (1937), has

[1]There is a strand of literature on the importance of trade facilitation (Djankov et al., 2010; Portugal-Perez and Wilson, 2012; Hummels and Schaur, 2013). However, this paper's focus is not the state's role in promoting international trade by reducing export and import costs through measures such as tariffs, subsidies, and quantitative measures. Instead, we examine the government's role in enhancing public infrastructure in general. In addition, this paper focuses on how the state enables the transformation of LCA to ACA, instead of other economic outcomes in the literature, such as trade volumes, export diversification, and economic growth.

argued that institutional frictions affect transaction costs between firms. Efficient institutions can help to reduce these costs and promote market efficiency (North, 1990; Djankov et al., 2002). Although we acknowledge that the precise mechanisms through which each type of infrastructure affects firms' total costs of operation may differ, our paper does not delve into the details of these mechanisms but instead focuses on the broader implications of public infrastructure for reducing transaction costs and promoting the transformation of LCA into ACA.

There exists a body of work that examines the impacts of infrastructure on comparative advantages. Both theoretical (Clarida and Findlay, 1992; Anwar, 2001; Tawada et al., 2022) and empirical studies (Clague, 1991; Yeaple and Golub, 2007; Harrison et al., 2014) have shown that differences in public infrastructure provision, such as transportation systems, communication networks, and electricity generation facilities, are crucial in explaining comparative advantages. A more recent and growing strand of literature explores how domestic institutions can serve as a source of comparative advantage. Various aspects of institutions have been examined, including contracting and property rights institutions (Nunn, 2007; Levchenko, 2007; Feenstra et al., 2013), financial institutions (Beck, 2003; Manova, 2008, 2013), and labor market-related institutions (Costinot, 2009; Cuñat and Melitz, 2012; Helpman and Itskhoki, 2010). This line of research argues that countries with superior institutions have a comparative advantage in products whose costs are sensitive to the quality of institutions (Nunn and Trefler, 2014). This paper departs from the literature by emphasizing the state's role in facilitating infrastructure and/or institutional improvement to reduce transaction costs. Rather than providing additional discussions on how the state influences LCA, our analysis highlights the necessity of reducing transaction costs to turn an industry from LCA to ACA within a country. This change requires the state to play a facilitating role due to the unavoidable externality and coordination involved in improving both hard and soft infrastructure.

Our analysis also contributes to the literature on the dynamics of production specialization. As documented by the OECD (2011), changes in specialization are driven by various factors, such as factor accumulation, technological progress, geographical agglomeration or dispersion, shifts in demand patterns, and targeted policies. Although prior research has put forward various theories to predict dynamics in LCA, yet few papers have discussed when ACA reflects these dynamics. As noted by Adelman (2000), "new comparative advantage is achieved through a large variety of coordinated means whose nature and magnitude change dynamically... This implies that comparative advantage is man-made, not God-given". Infrastructure plays a critical role in enabling firms to enter into new industries, facilitating structural changes, and promoting export diversification (Commission on Growth and Development, 2008). Our analysis shows that even with factor accumulation or other changes

affecting LCA, the export structure might be stagnant due to high transaction costs resulting from insufficient infrastructure; thus, comparative advantages as well as trade need to be enabled by the state.

The remainder of the paper is structured as follows. Section II describes the data and presents the evidence and facts motivating this article. Section III develops the model and illustrates the key implications. Section IV concludes.

## II. Data and Some Stylized Facts

### (1) Data

To illustrate the difference between LCA and ACA and the importance of the enabling state, we draw data from multiple sources. The first set of datasets provides variables to identify the LCA and ACA for different countries across various products[2]. First, the product factor intensity is measured by the Revealed Factor Intensity (RFI) indices developed by Shirotori et al. (2010). The RFI indices for a particular product are calculated as a weighted average of the factor abundance of the countries exporting that good, with the share of exports as weights. The rationale of the RFI indices is based on the theoretical prediction that countries specialize in products that are intensive in their relatively abundant factors. These indices have been employed in other studies on topics related to comparative advantages (Bahar and Rapoport, 2018; Bahar et al., 2014)

Endowment data are also obtained from Shirotori et al. (2010) and are available annually until 2007. Physical capital stock is estimated by the perpetual inventory method that calculates investment flows by recursively adding up current investment to the previous period's capital stock, appropriately depreciated. Human capital is proxied by years of education based on Barro and Lee (2013). The number of workers is inferred from the Penn World Table (PWT) using real GDP per worker, GDP per capita and population.

To measure the ACA that each country has in each product, we rely on bilateral trade data from the United Nations Commodity Trade Statistics Database (UN COMTRADE). We compute the Revealed Comparative Advantage (RCA) (Balassa, 1965) for each product, which is defined as the ratio between the share of the total exports that the product represents in the country's export basket and the product's share of global trade. In the following analysis, we mainly focus on two types of goods: those with a trade value of zero and those with an RCA index greater than one, which indicates that this product is over represented in a country's export basket.

[2]The analysis is at the HS 6-digit product level instead of ISIC industry level due the existence of intra-industry heterogeneity in factor intensity within each 4-digit ISIC industry (Schott, 2003).

We obtain information on transaction costs and the behavior of the state from three other datasets. First, our measure of physical infrastructure comes from the dataset assembled by Canning (1998), which contains information on the length of the paved road, number of telephone main lines in use, and electrical power-generating capacity during 1950-2005. Soft infrastructure is proxied by institutional quality and the ease of doing business. We use four composite indicators to measure institutional quality, namely, Law and Order, Bureaucracy Quality, Corruption, and Investment Profile, from the International Country Risk Guide (ICRG 2016). Additionally, we select three indicators from the Doing Business Index (World Bank 2019) to capture the barriers to entry in a country's business environment, including time required to enforce a contract, time required to start a business, and cost of business start-up procedures.

We exclude high-income countries and oil countries from our analysis and consider only developing countries in Asia, Latin America, and sub-Sahara Africa. For the static analysis, we used cross-country data from the year 2000, and our sample consisted of 30 countries. For the dynamic analysis, we utilized panel data spanning the years 1995-2013.

## (2) Facts on LCA, ACA and Transaction Costs

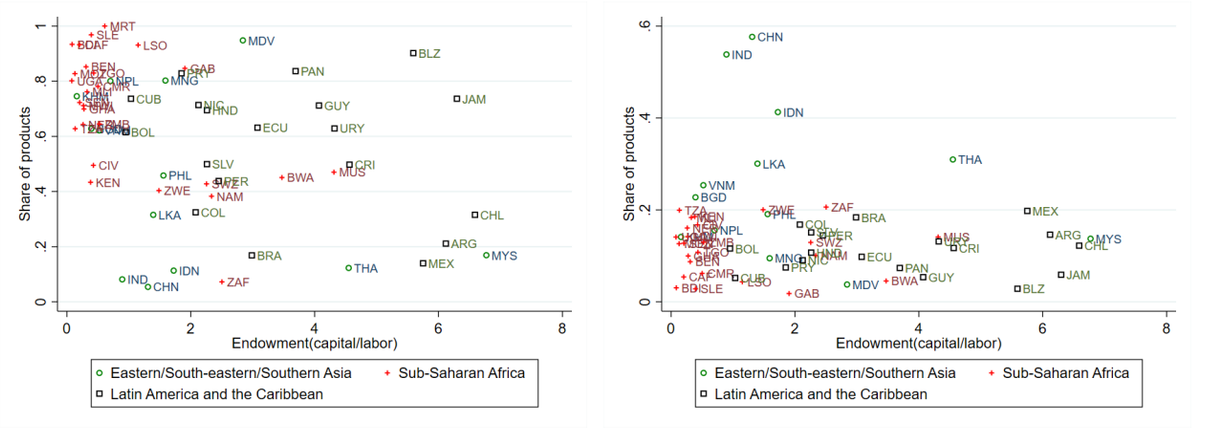
We start by documenting three basic facts about the gap between LCA and ACA, as well as the role of transaction costs in explaining this gap, which motivate our theory model.

*Fact 1. There exist large variations in the gap between LCA and ACA across countries.* This is illustrated in Figure 1 and Table 1. Most measures of comparative advantages in the literature rely on observed patterns of trade. However, there are many cases where a country may have a low comparative production cost for a particular good but fails to export it due to high transaction costs. To identify products in which each country has a LCA but may or may not currently make, we calculate the Euclidean distance between the factor endowment of each country—including both physical capital and human capital—and the factor requirements of each product.[3] This measure is developed by Cadot et al. (2011) and captures the extent to which the production of a good deviates from the endowment structure of a country. Based on this measure, all products are classified equally into four distance bins. The products that a country is likely to have a comparative advantage in based on its endowment structure are those with factor intensities similar to its endowment structure and located in the first or second distance bin.

Whether countries export the products in which they have LCA? In Panel A of Figure 1,

[3]We consider the LCA implied by each country's endowment structure. Although studies show that production efficiency variation is important to explain differences in comparative costs and trade patterns (Eaton and Kortum, 2002; Costinot et al., 2012), explaining patterns of relative efficiency is challenging. In addition, studies show that omitting Ricardian forces do not bias tests of the Heckscher-Ohlin model (Morrow, 2010).

we plot on the $y$-axis the share of products that each country did not export in 2000 among all products in the first distance bin, i.e., the products in which a country is most likely to have LCA. The $x$-axis shows the capital abundance of each country. Different marker symbols present countries in different regions. We can see that Asian countries in our sample are mainly positioned in the lower proportion of the graph, indicating that in most Asian countries, only a small proportion of products in the LCA category had zero exports. For instance, India, Indonesia, and China have shares of 8.1%, 11.3%, and 5.4%, respectively. In contrast, this share for most African countries is significantly larger, which suggests that these countries were not able to export most of the products that reflect their LCA. That is, they fail to effectively convert their LCA products into ACA.




(A) No exports (B) $RCA > 1$

Figure 1: Share of products with different export statuses in the first distance bin

Note: This graph shows the share of products with different export statuses among products in the first distance bin. The vertical axis in Panel (A) shows the share of products that each country did not export in 2000, while the vertical axis in Panel (B) shows the share of products that have RCA greater than 1. The horizontal axis in both paneles shows the capital/labor ratio of each country.

One possible explanation for the poor export performance of African economies is their low production efficiency. However, surveys show that in 2000 the labor productivity of large firms in some African countries, such as Ethiopia, Tanzania, and Zambia, falls within the range observed in Chinese and Vietnamese firms in the light manufacturing sectors (World Bank, 2012). Furthermore, the disparity in the export patterns between Asian and African countries cannot be attributed to differences in the tradability of their LCA products, as the factor endowment structure is comparable across these regions. Latin American countries, on average, have a higher capital-labor ratio than Asian countries, but they also fail to export most of their LCA products.

Panel B of Figure 1 illustrates the complementary perspective of the analysis in Panel A

and presents the share of products in each country that exhibit RCA greater than 1 among products in the first distance bin. Among all LCA products, only a small fraction of products exhibit RCA greater than 1 in most African and Latin American countries, while the share is relatively larger in Asian countries such as China, India, Indonesia, and Thailand. This exercise is repeated in Figure A1 in the Appendix, where the distance between a country's factor endowment and a product's factor intensity is calculated using information on physical capital only, and a similar pattern is observed.

Table 1 examines variations in the gap between LCA and ACA across countries from a different perspective. Instead of asking whether a country exports its LCA products, this analysis examines whether the products that each country exports a lot are indeed those that it has LCA in. Columns (1)-(4) in Table 1 present the share of products in each distance bin among products with RCA greater than 1. We can see that, on average, products with high RCA in Asian countries are more likely to lie in the first distance bin and much less likely to lie in the last distance bin than in African countries, suggesting a smaller gap between LCA and ACA in Asian countries. Columns (5)-(6) provide information on the capital abundance and human capital stock in each country, which show a comparable range for countries in different regions in our sample.

*Fact 2. The structure of exports is highly dynamic and evolves along with the endowment structure of the economy in Asian countries, but is stagnant in some countries in Africa and Latin America.* Figure 2 plots the RFI indices of the top 20 products exported by selected countries in 1995, 2005, and 2013. Different marker symbols denote observations from different years. The primary goods are highlighted with the 2-digit ISIC code of the industry to which they belong as marker labels. Panel A shows that Zambia's top 20 exported products have remained relatively stable over time, with several primary goods playing a prominent role. In contrast, China's top 20 products exported in 1995 and 2013 display minimal overlap, with the main products becoming increasingly capital and human capital intensive (panel B). As shown in Figure A2 in the Appendix, China's dynamic export structure is accompanied by the accumulation of physical and human capital, consistent with theoretical predictions that specialization patterns evolve endogenously over time (Bond et al., 2003).

The disparity between Zambia and China in Figure 2 is not unique when we compare more countries in Asia with those in Africa and Latin America. Figure 3 examines the share of products that remain absent in each country's export basket over a 5-year time horizon during 1995-2000 among all goods in the first distance bin. We can see that this share is much smaller for Asian countries than for countries in Latin America and Africa. Figure A3 in the Appendix shows a similar pattern when we only consider physical capital to calculate the distance to comparative advantage. This could be considered as evidence that Asian countries on average are making more efforts than countries in Africa and Latin America to

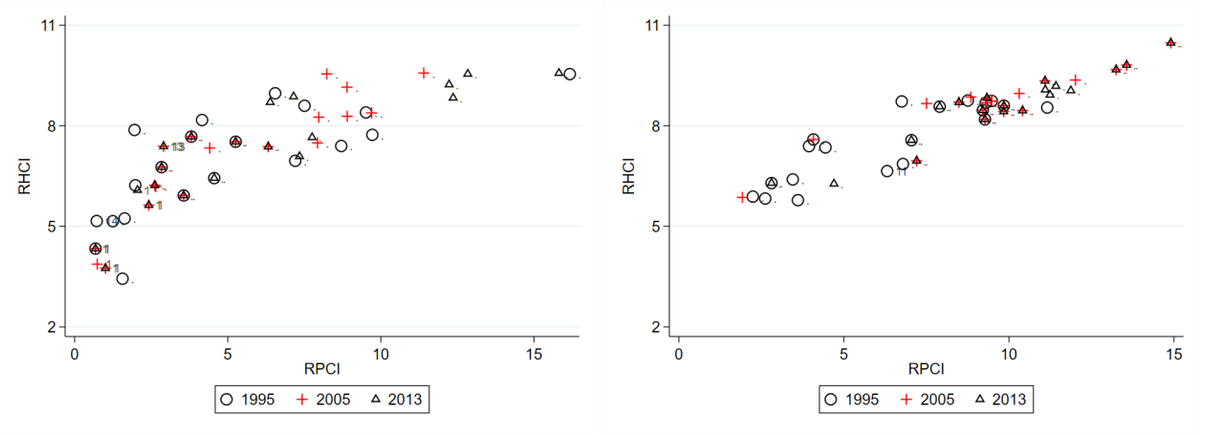
Table 1: Share of products in each distance bin when RCA>1

| Countries | ISO3 | Share in each distance bin | | | | Capital/labor | Human capital |
|---|---|---|---|---|---|---|---|
| | | 1st | 2nd | 3rd | 4th | | |
| **Asia** | | | | | | | |
| Cambodia | KHM | 45.45 | 38.64 | 12.27 | 3.64 | 0.16 | 5.68 |
| Bangladesh | BGD | 5.06 | 18.04 | 56.33 | 20.57 | 0.39 | 3.69 |
| Viet Nam | VNM | 11.13 | 25.21 | 43.70 | 19.96 | 0.52 | 4.49 |
| Nepal | NPL | 2.91 | 8.14 | 31.40 | 57.56 | 0.70 | 2.35 |
| India | IND | 3.42 | 11.81 | 31.95 | 52.82 | 0.89 | 3.58 |
| China | CHN | 36.60 | 37.86 | 24.70 | 0.84 | 1.31 | 6.6 |
| Sri Lanka | LKA | 53.79 | 38.64 | 7.20 | 0.38 | 1.39 | 7.58 |
| Philippines | PHL | 48.05 | 41.95 | 8.78 | 1.22 | 1.56 | 7.97 |
| Mongolia | MNG | 44.44 | 38.33 | 15.56 | 1.67 | 1.59 | 8.12 |
| Indonesia | IDN | 14.78 | 28.14 | 36.54 | 20.55 | 1.72 | 4.76 |
| Maldives | MDV | 0.00 | 4.76 | 66.67 | 28.57 | 2.84 | 3.05 |
| Thailand | THA | 21.34 | 30.25 | 39.07 | 9.34 | 4.55 | 5.37 |
| Malaysia | MYS | 57.89 | 32.09 | 9.34 | 0.68 | 6.77 | 8.16 |
| **Sub-Saharan Africa** | | | | | | | |
| Senegal | SEN | 7.42 | 14.13 | 29.68 | 48.76 | 0.21 | 3.65 |
| Niger | NER | 0.00 | 1.91 | 10.83 | 87.26 | 0.26 | 1.09 |
| Malawi | MWI | 2.91 | 9.71 | 38.35 | 49.03 | 0.27 | 3.05 |
| Ghana | GHA | 37.37 | 39.39 | 21.21 | 2.02 | 0.28 | 6.11 |
| Benin | BEN | 1.80 | 13.51 | 24.32 | 60.36 | 0.31 | 2.55 |
| Mali | MLI | 0.00 | 3.33 | 14.17 | 82.50 | 0.33 | 1.02 |
| Kenya | KEN | 31.71 | 39.53 | 26.22 | 2.54 | 0.38 | 5.93 |
| Côte d'Ivoire | CIV | 2.39 | 9.16 | 26.29 | 62.15 | 0.43 | 2.75 |
| Zambia | ZMB | 38.55 | 31.30 | 25.57 | 4.58 | 0.53 | 5.89 |
| Zimbabwe | ZWE | 31.03 | 31.78 | 32.71 | 4.49 | 1.49 | 5.89 |
| **Latin America** | | | | | | | |
| Bolivia | BOL | 46.12 | 38.78 | 13.88 | 1.22 | 0.95 | 7.44 |
| Colombia | COL | 36.25 | 42.57 | 20.45 | 0.74 | 2.08 | 6.5 |
| Peru | PER | 54.11 | 36.60 | 8.22 | 1.06 | 2.45 | 7.73 |
| Brazil | BRA | 13.56 | 22.31 | 49.30 | 14.83 | 2.99 | 5.57 |
| Mexico | MEX | 42.52 | 49.02 | 8.21 | 0.25 | 5.75 | 7.43 |
| Argentina | ARG | 63.39 | 27.29 | 6.74 | 2.59 | 6.12 | 8.56 |
| Chile | CHL | 61.89 | 27.67 | 8.98 | 1.46 | 6.59 | 8.75 |

address infrastructure bottlenecks that previously hindered the realization of LCA into ACA.

*Fact 3: The degree of dynamics in a country's export structure is positively correlated with the supply of hard and soft infrastructures and government's public investment.* To measure the extent of the export structure's dynamism, we first classify the industry-level exports [4] into two sets, zero ($s_1$) and others ($s_2$). Following Redding (2002), we then calculate

[4]We aggregate at the 3-digit industry level instead of using disaggregated product-level data.




(A) Zambia (B) China

Figure 2: Top 20 export goods in 1995, 2005, and 2013

Note: The horizontal axis shows the revealed physical capital intensity of each products and vertical axis shows the revealed human capital intensity.

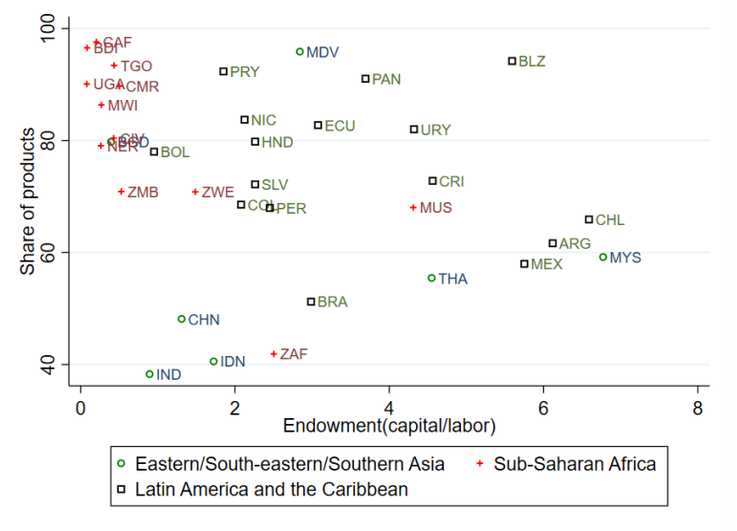



Figure 3: Probability of goods staying with zero exports in the 1st distance bin (1995-2000)

Note: The vertical axis shows the share of products that stay with zero exports in the first distance bin, while the horizontal axis in shows the capital/labor ratio of each country.

a matrix of transition probabilities $\mathbf{P}$, whose element $p_{ij}$ denotes the probability that an industry beginning in $s_i$ moves to $s_j$ over a 5-year time horizon during 2000-2010[5], and is estimated by counting the number of transitions out of and into each $s_i$. In the last step, we divide all economies equally into three categories according to $p_{11}$. A higher $p_{11}$ indicates

[5]The analysis begins in 2000 due to data limitations regarding institutional quality measures.

that it's less likely to observe new products in this country's export basket over time than in other countries, resulting in fewer dynamics in the export structure. We then compare the average levels of physical and institutional development between the top 1/3 group and the bottom 1/3 group.

Table 2 presents the results. The last row shows that the average values of $p_{11}$ are 0.549 and 0.846 for the high and low dynamic groups, respectively. Comparing the supply of physical infrastructure among these two groups, we note that on average, countries with more dynamic specialization structures have higher values of paved road network lengths, numbers of telephone main lines and electrical power-generating capacity per capita than countries with more stagnant export structures. Moreover, the average annual growth rate of these three types of physical infrastructure is also higher in the high dynamic group of countries. The evidence presented here is consistent with the previous two facts and the literature documenting the inadequate infrastructure system in Africa. For instance, Limao and Venables (2001) and Foster and Briceno-Garmendia (2010) report that Sub-Saharan Africa has the lowest coverage of paved roads of any world region, and the interregional trade costs in Africa are the highest globally. Furthermore, these countries have failed to make progress to keep up with the demands of economic growth. For example, Sub-Saharan Africa had almost three times the generating capacity per million people as South Asia in 1970, while in 2000, South Asia had almost twice the generation capacity per million people as Sub-Saharan Africa.

Countries with more dynamic export structures have better performance in the supply of soft infrastructure as well. We employ two sets of indicators: one is the Doing Business Index from the World Bank, and the other is the Institutional Quality Index from ICRG. As shown in Table 2 Panel B, countries with more dynamic export structures have better performance in both sets of indicators. On average, businesses in these countries spend less time enforcing a contract, require fewer days to complete procedures to legally operate a business, and have lower costs to register a business. Additionally, these countries perform better in all four aspects of institutional quality measurements, including law and order, bureaucracy quality, corruption within the political system, and factors affecting investment risk. Panel B also presents the economic freedom summary index from the Economic Freedom of the World database, which ranks countries based on five aspects of intuition and is provided by the Fraser Institute. The evidence is consistent with the previous two sets of indicators.

Panel C compares other policy and geographical features of countries between the two groups. On the one hand, countries with less dynamic export structures are more likely to be landlocked. On the other hand, these countries are closer to world markets, as measured by the foreign market potential indicator derived in Mayer (2008). Therefore, natural geographical disadvantages seem not to be the main obstacles for countries with stagnant

Table 2: Dynamics of export structure and infrastructure

| | High dynamic | Low dynamic | Mean | min | max | Std. Dev. |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| **Hard infrastructure** | | | | | | |
| Road | 7.67 | 3.78 | 6.24 | 0.14 | 31.68 | 7.81 |
| Telephone | 309.84 | 271.33 | 286.77 | 4.38 | 960.23 | 277.06 |
| Electricity | 0.96 | 0.83 | 0.84 | 0.01 | 4.21 | 0.94 |
| Road $\Delta\%$ | -0.5 | -6.4 | -2.2 | -29.2 | 7.9 | 9.2 |
| Telephone $\Delta\%$ | 3.7 | 3.0 | 3.9 | -8.5 | 23.6 | 6.9 |
| Electricity $\Delta\%$ | 0.2 | -1.6 | -0.1 | -44.5 | 18.3 | 8.2 |
| **Institution** | | | | | | |
| Enforce Time | 661.22 | 627.56 | 647.30 | 231.25 | 1459.00 | 260.06 |
| Start Time | 38.30 | 39.12 | 38.37 | 9.75 | 145.29 | 24.01 |
| Start Cost | 58.40 | 78.23 | 71.45 | 3.09 | 364.30 | 74.53 |
| Corruption | 2.26 | 1.98 | 2.13 | 0.05 | 4.02 | 0.69 |
| Investment profile | 8.30 | 7.97 | 8.08 | 1.63 | 11.23 | 1.68 |
| Law | 3.42 | 3.01 | 3.15 | 1.38 | 5.22 | 1.02 |
| Bureaucracy quality | 1.79 | 1.62 | 1.65 | 0.00 | 3.00 | 0.71 |
| Fra sum grade | 6.55 | 6.25 | 6.43 | 3.69 | 7.75 | 0.77 |
| **Policy and geographical features** | | | | | | |
| Landlocked | 0.29 | 0.36 | 0.26 | 0.00 | 1.00 | 0.44 |
| Foreign market | 13.76 | 13.86 | 13.81 | 12.59 | 15.06 | 0.54 |
| Share of open years | 0.17 | 0.19 | 0.17 | 0.00 | 1.00 | 0.29 |
| CA openness | 0.38 | 0.42 | 0.42 | 0.00 | 1.00 | 0.34 |
| Public investment/GDP% | 4.93 | 1.56 | 60.41 | 0.03 | 232.44 | 30.28 |
| TCI | 3.73 | 4.01 | 3.84 | 0.59 | 14.95 | 3.67 |
| **Mean** $p_{11}$ | 0.549 | 0.846 | - | - | - | - |

specialization patterns. However, landlocked countries might rely more on domestic infrastructure than other countries, so poor infrastructure has a more significant negative impact on their development of LCA.

We also examine several policy indicators directly. First, one concern is that countries with less dynamic export structures are less open to the international market. However, as shown in Table 2 , the two groups of countries have similar shares of years when the economy is considered to be open during 1960-1989, based on the openness index constructed by Aschs and Warner (1995). In addition, while most countries are integrated into the global goods market after the 1990s, there exists a significant disparity in capital account openness across nations, which could potentially influence each country's export development. To address this issue, we employ the capital control indicator developed by Fernández et al. (2015), which captures the overall restrictions on all capital inflows and outflows, and find that countries

with less dynamic export structures tend to have more liberalized capital markets.

Data on public investment in infrastructure are difficult to obtain since it may be carried out by various agencies whose expenditures are not part of the budget (Commission on Growth and Development, 2008). Therefore, we have looked at general government investment in each country. The ratio of public investment to GDP is found to be higher in countries with more dynamic export structures, which is in line with our previous findings on infrastructure supply. The last indicator that we utilize is the Technology Choice Index ($TCI$), which is derived from Lin's work (2009). It is constructed as the value added per worker in the manufacturing sector relative to the GDP per capita of the whole economy, and is considered a measure of the extent of how the economic structure is distorted toward a country's comparative disadvantage sectors. We find that countries with a more stagnant export structure have a higher value of this index, indicating that more resources are allocated to the comparative disadvantage sectors.

# III. Theoretical Model

Motivated by the facts presented in Section II regarding LCA, ACA and transaction costs, in this section we extend the model in Romalis (2004) by introducing the role of public infrastructure to illustrate the idea of how government behavior can affect the structure of production and exports by changing transaction costs.

## (1) The Environment

Consider a two-country (Home and Foreign) version of the Heckscher-Ohlin model with a continuum of industries and differentiate products within each industry. For any variable, $x$ denotes its value in Home while $x^*$ denotes its value in Foreign. Assume (i) Home is more labor abundant ($L/K > L^*/K^*$); (ii) There is a continuum of industries $z$ on the interval [0,1], and industries with higher $z$ have higher capital intensity. In the following we introduce assumptions for Home. Production in Foreign is determined in a symmetric way.

### Demand

Each economy is inhabited by a continuum of identical households that can be aggregated into a representative household. The representative household's preference over different goods is summarized by

$$U = \int_0^1 b(z) \ln Q(z) dz, \ \int_0^1 b(z) dz = 1$$

where $b(z)$ is the expenditure share for industry $z$. Firms in each industry produce a number of varieties that are imperfect substitutes for each other. $Q(z)$ is the sub-utility function over the quantity of individual varieties $\omega$ consumed and is given by the following CES aggregation:

$$Q(z) = (\int_0^{N(z)} q^D(z,\omega)^{(\sigma-1)/\sigma} d\omega)^{\sigma/(\sigma-1)},\ \theta \in (0,1]$$

where $\sigma$ is the elasticity of substitution between varieties. $N(z)$ equals to $n(z)+n^*(z)$, where $n(z)$ and $n^*(z)$ are the endogenously determined number of varieties in industry $z$ in Home and Foreign, respectively. Let $\hat{p}(z,\omega)$ be the price paid by the consumer. Let $E(z)$ denote the total expenditure on industry $z$. Given the preference, we have $E(z) = b(z)Y$, where $Y$ is the total income that could be used to purchase goods. It equals to $wL+rK$, where $r$ and $w$ are the prices of capital and labor, respectively. The demand function for each variety $\omega$ can be solved as:

$$q^D(z,\omega) = \frac{\hat{p}(z,\omega)^{-\sigma}}{P(\omega)^{1-\sigma}} E(z) \tag{1}$$

with the price index $P(z)$ defined as:

$$P(z) = [\int_{\omega \in I(z)} \hat{p}(z,\omega)^{1-\sigma} d\omega]$$

$I(z)$ is the set of varieties produced in industry $z$.

**Production and firm behavior**

Assume that each firm employs labor $L$ and capital $K$ with a constant marginal cost and a fixed cost for production. Public infrastructure is assumed to affect total costs by changing transaction costs, which also have a fixed and a variable part. To simplify matters, it is assumed that all costs in each industry have the same factor intensity. In particular, the total cost function is assumed to be:

$$TC(q^s(z,\omega)) = [f(G) + \frac{q^s(z,\omega)}{A(G)}] r^z w^{1-z}$$

where $q^s(z,\omega)$ is the quantity supplied in industry $z$ of variety $\omega$. $G$ is the quantity of public infrastructure available to all firms without charge. $f(G)$ is a non-increasing function of $G$ and $A(G)$ is a non-decreasing function of $G$. It is worth noting that we can further divide $f$ and $A$ into two parts: one relates to the traditional fixed and variable costs of production, such as labor and capital expenses, while the other is not directly associated with the production process but rather incurred due to frictions in market entry, factor input procurement, and

production contract enforcement. These frictions constitute what we term transaction costs, which are not dependent on traditional determinants of comparative advantages, namely, factor endowment structure or production technology. Instead, they are more likely to be affected by the supply of hard and soft infrastructure.

It is not difficult to find micro foundations for this reduced-form representation in the literature. For example, the following logic is established in papers on contracting institutions following Williamson (1989): if enforcement of supplier contracts is costly, firms will perform a larger part of the production process within the firm instead of outsourcing it. This increases the total cost of production. Harrison, Lin and Xu (2014) find that lack of infrastructure and access to finance are the key factors explaining Africa's disadvantage in productivity at the firm level. With respect to the impacts of hard and soft infrastructure on the cost of entry, Kletzer and Bardhan (1987) argues that manufacturing sector firms face up-front fixed costs, and credit market imperfections make it costly to finance the fixed costs. Copeland (2008) shows that investments in information acquisition could be part of the fixed costs as they have a public good aspect.

The presence of a fixed cost implies that each firm will produce only one variety. Profit maximization implies that the equilibrium price is a constant mark-up over the marginal cost if $z$ is produced in the economy:

$$p(z) = \frac{\sigma}{1-\sigma}\frac{1}{A(G)}r^z w^{1-z} \tag{2}$$

In addition, since there is free entry and exit of firms, firms earn zero profits in the equilibrium, i.e., $p(z)q^s(z,\omega) = TC(q^s(z,\omega))$. Combined with the pricing rule, we have:

$$q^s(z,\omega) = A(G)f(G)(\sigma-1) \tag{3}$$

Assume that trade is costly and firms need to ship $\tau(G)$ units of goods for 1 unit of goods to arrive in foreign market, which decreases with infrastructure supply. Since each firm charges the same price within an industry, the price index $P(z)$ can be expressed as:

$$P(z) = [n(z)p(z)^{1-\sigma} + n^*(z)(p^*(z)\tau(G))^{1-\sigma}]^{\frac{1}{1-\sigma}} \tag{4}$$

In addition, the revenue of each firm is given as:

$$r(z,\omega) = E(z)[\frac{p(z)}{P(z)}]^{1-\sigma} + E(z)^*[\frac{p(z)\tau(G))}{P^*(z)}]^{1-\sigma}$$

**The state and supply of public infrastructure**

Extensive literature has discussed the reasons for the under-supply of public inputs by private providers. Externalities are a classic source of inefficiency. For instance, road construction not only reduces transportation costs for firms but also increases the price of land along the road. While private road constructors can charge tolls to firms, they cannot charge the landowner. Another crucial reason for inadequate public infrastructure investment is the challenge of financing significant one-time initial investment outlays. In developing countries with underdeveloped capital markets, it is difficult for private individuals to obtain sufficient capital for infrastructure construction. Moreover, private investment in roads benefits from toll fees, which rely on how many companies will use the road in the future. Thus, the benefit of road construction is ultimately determined by the overall state of economic development, over which private investors have little influence. Private investors' income is therefore highly uncertain, making it challenging to obtain bank loans.

To keep our discussion as straightforward as possible, we are not employing a more complex setup from the literature about why private investors have more difficulties raising funds than the government, but only using the simplest reduced-form assumptions about the cost function to distinguish private investors from the government. In particular, assume that the capital expenditure of building the infrastructure needed to provide service level $G$ is given by $C(G)$, which includes initial investment outlays and variable costs to provide services and we assume that $C' > 0, C'' \leq 0$. The infrastructure could be provided by partnerships between the government and private providers. The government and private providers differ in their cost to financing $C(G)$. Relative to the private sector, the government tends to have lower financing costs (IMF, 2004; Grout, 2003; Deng et al., 2016), especially in developing countries with poor capital markets. In addition, as a simplification, we assume that in the partnership the government and private providers choose the optimal supply of $G$ to maximize their joint profits so that the actual cost of proving $G$ is given by

$$I(G;\alpha) = [\alpha(1+\lambda_g) + (1-\alpha)(1+\lambda_p)]C(G)$$

where $\lambda_g$ and $\lambda_p$ denote the financing cost for government[6] and private sector, respectively, with $\lambda_g < \lambda_p$. $\alpha$ is an exogenous parameter that measures the contribution of government to the infrastructure supply and lies in [0,1]. $\alpha = 0$ means a laissez-faire state. The cost of infrastructure supply decreases with $\alpha$ for each level of $G$.

Assume that the provider of the infrastructure collects a payment of $R(G)$ from the

[6]The cost for government financing could be direct financing cost, or a reduced form of other opportunity cost, such as the distortionary effect of taxation, and spending in another sector.

consumers, with $R' > 0, R'' \geq 0$. It maximizes its profit[7] by providing the optimal $G^*$ that equates the marginal cost and marginal benefit ($I'(G^*;\alpha) = R'(G^*)$). Since a larger government participation share reduces the financing cost of infrastructure supply, $G^*$should increase with $\alpha$. We could rewrite $f(G)$, $A(G)$, and $\tau(G)$ as $f(G(\alpha))$, $A(G(\alpha))$, and $\tau(G(\alpha))$ respectively, which are functions of $\alpha$.

Please note that this paper primarily focuses on examining the effects of $\alpha$ on the production structure. Therefore, all other parameters related to infrastructure supply are assumed to be the same in Home and Foreign. However, extended exercises could consider exploring cross-country variations in other parameters. For instance, the cost function may differ across countries due to varying efficiency levels of infrastructure construction. The difference between $\lambda_p$ and $\lambda_g$ may vary across countries as well, with poor developing countries with underdeveloped capital markets having the largest gap between these two. Additionally, the ability of the government and private providers to collect $R$ may differ, leading to heterogeneity in supply from these two providers. This disparity between the government and private providers may also vary across countries, resulting in varying infrastructure supply.

**Market clearing**

In equilibrium, we require that the total revenue of each firm equals to the value of its domestic production:

$$p(z)q^s(z) = b(z)Y[\frac{p(z)}{P(z)}]^{1-\sigma} + E(z)^*[\frac{p(z)\tau(G))}{P^*(z)}]^{1-\sigma} \tag{5}$$

In addition, all factors must be fully employed in each country. Therefore, we also have the factor market clearing condition as follows:

$$\int_0^1 l(z)dz = L, \int_0^1 k(z)dz = K \tag{6}$$

where $l(z)$ and $k(z)$ are demands in Home for labor and capital in industry $z$, respectively.

## (2) Trade Structure and the State

This section discusses the impact of changes in $G$ on the structure of production and export and the role of the state in shaping the actual comparative advantages. We first consider a small open economy case in which the production structure in Foreign is exogenously given and the price index is independent of the price of goods produced in Home. Then, these assumptions are relaxed so that the structure of production and trade is determined by both

[7] $R$ could be designed to fully captures the social benefits of infrastructure so that the setup here is a reduced form to model a government as a social welfare maximizer.

the relative endowment structure and the supply of public infrastructure. Except where needed, the "$z$" notation is suppressed.

**Small open economy**

First, we assume Home can be treated as a small economy. Following Demidova and Rodríguez-Clare (2013), foreign demand for a domestic variety is given by $B^*(p\tau)^{-\sigma}$, where $B^*$ includes both the industrial expenditure $E^*$, the price $p^*$ and price index $P^*$ in Foreign. $B^*$ is assumed to be independent of changes at Home. In addition, the number of firms in each industry $n^*$ in Foreign is exogenous as well. The number of firms in Home is determined by substituting the pricing rule in (2) and the supply function (3) into (5):

$$np^{1-\sigma} = \frac{E}{p^\sigma Af(\sigma-1) - B^*\tau^{1-\sigma}} - n^*p^{*1-\sigma}\tau^{*1-\sigma}$$

For industry $z$ to be produced in Home, it requires n>0, or:

$$\frac{E}{p^\sigma Af(\sigma-1) - B^*\tau^{1-\sigma}} > n^*p^{*1-\sigma}\tau^{*1-\sigma}$$

Substituting the expression of $p$ in (2) into the inequality, we get

$$r^z w^{1-z} < [\frac{E}{n^*p^{*1-\sigma}\tau^{*1-\sigma}} + B^*\tau^{1-\sigma}]^{\frac{1}{\sigma}} A^{1-\frac{1}{\sigma}} f^{-\frac{1}{\sigma}} (\frac{\sigma}{1-\sigma})^{\frac{1}{\sigma}}$$

where $r$ and $w$ are determined by the factor market clearing condition. If $r > w$ , $r^z w^{1-z}$ is a continuous and monotonically increasing function in $z$. Then no firms in Home enter industries with capital intensity above $\bar{z}$, with $\bar{z}$ satisfying:

$$\bar{z} = \frac{v(\bar{z}) + \frac{\sigma-1}{\sigma}\ln A - \frac{1}{\sigma}\ln f}{\ln r - \ln w} \tag{7}$$

where

$$v(z) = \frac{1}{\sigma}\ln[\frac{E(z)}{n^*(z)p^*(z)^{1-\sigma}\tau^{*1-\sigma}} + B^*(z)\tau^{1-\sigma}] - \frac{1}{\sigma}\ln\frac{\sigma}{1-\sigma} + \ln w$$

Since $\sigma > 1$, equation (7) implies that if there is an increase in the price of goods produced in Foreign ($p^*(z) \uparrow$) due to endowment structure change or technology change, a decrease in the number of firms ( $n^*(z) \downarrow$) resulting from higher entry barriers in Foreign, or an increase in the Foreign demand ($B^*(z) \uparrow$), the set of industries produced in Home will expand. In addition, for given levels of $n^*(z)$, $p^*(z)$, and $B^*(z)$ in Foreign and the endowment structure in Home, higher $A$, lower $f$, or lower $\tau$ is associated with a higher level of $\bar{z}$. In other words, an increase in the supply of public infrastructure expands the production set in Home. Since $G$ is further determined by $\alpha$, Equation (7) implies that the structure of production depends

on the government's contribution to infrastructure construction.

More importantly, equation (7) implies that the level of public infrastructure affects how the production structure in the Home responds to changes in the Foreign. Consider two different levels of $\alpha$ ($\alpha_1 > \alpha_2$), and the corresponding levels of $A$, $f$, $\tau$ ($A_1 > A_2$, $f_1 < f_2$, $\tau_1 < \tau_2$). Let $p_1^*$ and $p_2^*$ denote the original price and the new price in Foreign, respectively, with $p_2^* > p_1^*$. With equation (7) we know that $\bar{z}(p^*, \alpha_1) > \bar{z}(p^*, \alpha_2)$ for both $p^* = p_1^*$ and $p^* = p_2^*$, while $\bar{z}(p_2^*, \alpha) > \bar{z}(p_1^*, \alpha)$ for both $\alpha = \alpha_1$and $\alpha = \alpha_2$. Then $\exists z$ such that

$$\bar{z}(p_1^*, \alpha_2) < \bar{z}(p_1^*, \alpha_1) < z$$

$$\bar{z}(p_2^*, \alpha_2) < z < \bar{z}(p_2^*, \alpha_1)$$

That is, industry $z$ is not produced in both scenarios with different levels of public infrastructure supply before the price increase in Foreign. However, when the price of goods in industry $z$ is increased from $p_1^*$ to $p_2^*$, industry $z$ is produced in the case with a more active facilitating state ($\alpha = \alpha_1$), but is not produced in the other case ($\alpha = \alpha_2$).

**The two-economy case**

To illustrate the role of the factor endowment structure, we now consider two large economies. Substituting the pricing rule in (2) and the supply function (3) into (5) and dividing it by its foreign equivalent, we obtain:

$$\frac{n}{n^*} = \frac{\frac{1}{\tilde{A}\tilde{f}}(1 + \frac{Y^*}{Y}\tau^{1-\sigma}\tau^{*1-\sigma}) - \tilde{p}^{\sigma}\tau^{*1-\sigma}(\frac{Y^*}{Y} + 1)}{\tilde{p}^{1-\sigma}[\tilde{p}^{\sigma}(\tau^{1-\sigma}\tau^{*1-\sigma} + \frac{Y^*}{Y}) - \frac{1}{\tilde{A}\tilde{f}}\tau^{1-\sigma}(\frac{Y^*}{Y} + 1)]} \tag{8}$$

where for any variable $x$, $\tilde{x} = \frac{x}{x^*}$. Let

$$\bar{\tilde{p}} \equiv [\frac{1}{\tilde{A}\tilde{f}}\frac{1 + \frac{Y^*}{Y}\tau^{1-\sigma}\tau^{*1-\sigma}}{\tau^{*1-\sigma}(\frac{Y^*}{Y} + 1)}]^{\frac{1}{\sigma}} \tag{9}$$

and

$$\underline{\tilde{p}} \equiv [\frac{1}{\tilde{A}\tilde{f}}\frac{\tau^{1-\sigma}(\frac{Y^*}{Y} + 1)}{\tau^{1-\sigma}\tau^{*1-\sigma} + \frac{Y^*}{Y}}]^{\frac{1}{\sigma}} \tag{10}$$

We have $\underline{\tilde{p}} < \bar{\tilde{p}}$ since

$$(\frac{\bar{\tilde{p}}}{\underline{\tilde{p}}})^{\sigma} = \frac{\frac{Y^*}{Y}(\tau^{1-\sigma}\tau^{*1-\sigma} - 1)^2}{\tau^{1-\sigma}\tau^{*1-\sigma}(\frac{Y^*}{Y} + 1)^2} + 1 > 1$$

When $\tilde{p} = \bar{\tilde{p}}$, we have $\frac{n}{n^*}$=0; when $\tilde{p} = \underline{\tilde{p}}$, $\frac{n}{n^*} \to \infty$. In addition, when $\tilde{p} > \bar{\tilde{p}}$ or $\tilde{p} < \underline{\tilde{p}}$, $\frac{n}{n^*} < 0$. If $\underline{\tilde{p}} < \tilde{p} < \bar{\tilde{p}}$, $\frac{n}{n^*} > 0$. Therefore, for industries with $\tilde{p} \in [\underline{\tilde{p}}, \bar{\tilde{p}}]$, there are positive numbers of firms in both countries. On the contrary, for industries with $\tilde{p} > \bar{\tilde{p}}$, $n = 0$ so that products in these industries are only produced in Foreign, while for industries with $\tilde{p} < \underline{\tilde{p}}$, $n^* = 0$ and

all products are produced in Home only. In addition, we have

$$\tilde{p} = \frac{p}{p^*} = \frac{1}{\tilde{A}}(\frac{r}{r^*})^z(\frac{w}{w^*})^{1-z}$$

It can be proven that if $\frac{K}{L} < \frac{K^*}{L^*}$ and the endowment structures in two countries are sufficiently different, we have $\frac{r}{r^*}/\frac{w}{w^*} > 1$. Therefore, $\frac{d\tilde{p}}{dz} > 0$ and there exist cutoffs $\bar{z}$ and $\underline{z}$ that satisfy

$$\tilde{p}(\bar{z}) = \bar{\tilde{p}} \tag{11}$$

$$\tilde{p}(\underline{z}) = \underline{\tilde{p}} \tag{12}$$

such that for industries with $z > \bar{z}$, there is no firms in Home, while industries with $z < \underline{z}$ are only produced in Home. Both countries produce industries with $z \in (\underline{z}, \bar{z})$. Figure 4 illustrates the production and trade structure and two cutoffs.

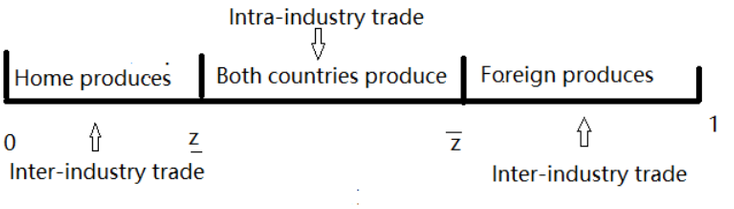



Figure 4: Factor intensity cutoffs and production structure

To consider the determinants of production sets in Home, we can solve $\bar{z}$ as

$$\bar{z} = \frac{\frac{\sigma-1}{\sigma}\ln\tilde{A} - \frac{1}{\sigma}\ln\tilde{f} + \frac{1}{\sigma}\ln(1 + \frac{Y^*}{Y}\tau^{1-\sigma}\tau^{*1-\sigma}) - \frac{1}{\sigma}\ln\tau^{*1-\sigma}(\frac{Y^*}{Y} + 1) - \ln\frac{w}{w^*}}{\ln(\frac{r}{r^*}/\frac{w}{w^*})} \tag{13}$$

Equation (13) has two important implications, which are similar to what we have for the small economy case. First, with everything else equal, a more enabling state leads to larger relative supply of infrastructure, higher $\tilde{A}$, lower $\tilde{f}$, and lower $\tilde{\tau}$. This increases $\bar{z}$, encourages firms to enter new industries and expands the production set in Home. Second, higher foreign income or relatively faster capital accumulation in Home might expand the sets of active industries in Home, while how exactly the production structure in Home responds to these changes depends on its relative supply of public infrastructure. For instance, consider an increase in $\frac{Y^*}{Y}$ raises $\bar{z}$ to $\bar{z}'$ and $\alpha_1 > \alpha_2$. Since we have $\bar{z}(\alpha_2) < \bar{z}(\alpha_1)$, $\bar{z}'(\alpha_2) < \bar{z}'(\alpha_1)$ and $\bar{z}(\alpha_1) < \bar{z}'(\alpha_1)$, there exists $z$ such that $\bar{z}(\alpha_2) < \bar{z}(\alpha_1) < z$ and $\bar{z}'(\alpha_2) < z < \bar{z}'(\alpha_1)$. Put it in other words, with the same changes in $\frac{Y^*}{Y}$, $z$ becomes active in the case with larger government participation in infrastructure supply but remains inactive in the case with low infrastructure supply. This implies that for countries with a laissez-faire state, the actual

production structure might be less sensitive to changes in LCA than in countries with a state active in enabling the conversion of LCA to ACA.

### (3) A Numerical Example

In this section, we illustrate the equilibrium properties of the model with a numerical example. The cost function of infrastructure supply is assumed to be $C(G) = c_1G^3 - c_2G^2 - c_3G$, and the payment that the provider of the infrastructure could collect from the consumers is set as a constant $R$. We normalize the household expenditure share $b(z)$ to 1 for all industries. The parameters chosen are shown in Table 3. In this example, Home is sufficiently labor abundant

Table 3: Main parameters in the numerical example

| Variables | Definition | Value |
|---|---|---|
| $K$ | capital stock in Home | 50 |
| $L$ | labor stock in Home | 300 |
| $K^*$ | capital stock in Foreign | 300 |
| $L^*$ | labor stock in Foreign | 50 |
| $\sigma$ | elasticity of substitution | 3.4 |
| $\alpha$ | government share in infrastructure financing in Home | 0.1 |
| $\alpha^*$ | government share in infrastructure financing in Foreign | 0.9 |
| $\lambda_p$,$\lambda_p^*$ | private infrastructure financing costs | 1000 |
| $\lambda_g$,$\lambda_g^*$ | government infrastructure financing costs | 1/100 |
| $R$ | payment to the infrastructure providers | 1000 |

so it only produces the set of industries with $z$ below the capital intensity cutoff $\bar{z}$ as defined in equation (11). As in Romalis (2004), the share of world revenues in each industry $z$ that accrue to firms in Home is

$$v = \frac{npq^s}{npq^s + n^*p^*q^{s*}}$$

With equation (8) we can derive out $v$ as

$$\begin{aligned} v &= 1 \quad \text{if} \quad z \in [0, \underline{z}] \\ &= \frac{Y}{Y+Y^*} \frac{\frac{Y^*}{Y}\tau^{1-\sigma}\tau^{*1-\sigma} - \tilde{A}\tilde{f}\tilde{p}^{\sigma}\tau^{*1-\sigma}(\frac{Y^*}{Y}+1)+1}{1+\tau^{1-\sigma}\tau^{*1-\sigma} - [\tilde{A}\tilde{f}\tilde{p}^{\sigma}\tau^{*1-\sigma} + (\tilde{A}\tilde{f}\tilde{p}^{\sigma})^{-1}\tau^{1-\sigma}]} \\ &\quad \text{if} \quad z \in (\underline{z}, \bar{z}) \\ &= 0 \quad \text{if} \quad z \in [\bar{z}, 1] \end{aligned} \tag{14}$$

In addition, given the production technology, factor shares in each industry depend only on the factor intensity of that industry. Combining the discussion of production structure and

equation (14), the factor market clearing condition in equation (6) can be written as

$$\int_0^{\underline{z}} z(Y+Y^*)dz + \int_{\underline{z}}^{\bar{z}} z(Y+Y^*)v(z)dz = rK$$

$$\int_0^{\underline{z}} (1-z)(Y+Y^*)dz + \int_{\underline{z}}^{\bar{z}} (1-z)(Y+Y^*)v(z)dz = wL$$

$$\int_{\underline{z}}^{\bar{z}} z(Y+Y^*)[1-v(z)]dz + \int_{\bar{z}}^{1} z(Y+Y^*)dz+ = r^*K^*$$

$$\int_{\underline{z}}^{\bar{z}} (1-z)(Y+Y^*)[1-v(z)]dz + \int_{\bar{z}}^{1} (1-z)(Y+Y^*)dz+ = w^*L^*$$

where $\bar{z}$ and $\underline{z}$ are the factor intensity cutoffs defined in equations (11) and (12). Figure 5 shows the capital intensity of each industry $z$ and the share of industry produced in Home $v(z)$. Consistent with Figure 4, we can see that industries with capital intensity below that of the lower cutoff industry are produced only in Home and industries that are more capital intensive than the upper cutoff industries are produced only in Foreign. Both countries produce industries with medium capital intensity, while Home has a larger share of production in the more labor intensive industries.

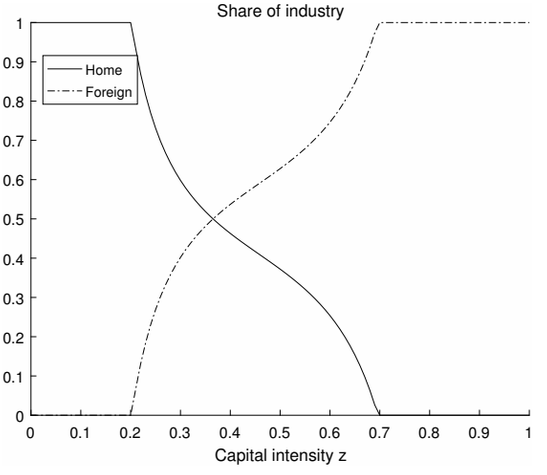



Figure 5: Factor intensity and production structure

We next perform some comparative statics to show how the production and trade structures in equilibrium respond to changes in factor endowments and government behavior. This helps illustrate how our model captures the key facts in our empirical analysis.

First, we increase the capital stock in Home and keep all other exogenous parameters unchanged. Figure 6 shows how this change in factor endowment structure affects the upper cutoff industry $\bar{z}$(shown by the dashed line and the left $y$-axis) and the lower cutoff industry $\underline{z}$ (shown by the solid line and the right $y$-axis). As discussed in the previous section, an increase in the capital-labor ratio in Home raises $\bar{z}$, which expands the production set in Home. Meanwhile, $\underline{z}$ decreases with $K$, indicating that the share of intra-industry trade increases as the two countries become more similar. The prediction is in line with the findings in Romalis (2004) and Huang et al. (2017).

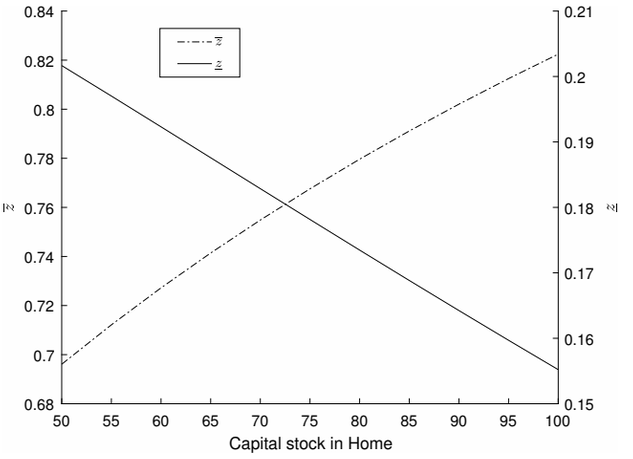
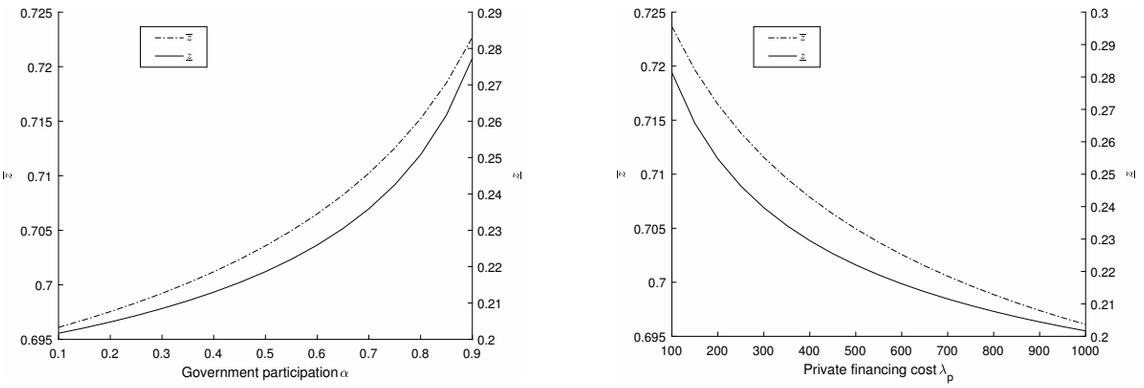



Figure 6: Factor intensity and production structure

In the next exercise, we analyze the effects of variations in government participation in public infrastructure supply on the range of industries produced in Home. Panel A in Figure 7 presents comparative statics results that demonstrate how both the upper bound ($\bar{z}$) and lower bound ($\underline{z}$) of the range of industries produced in Home increase with government participation $\alpha$. This suggests that for the labor abundant country, a more active state in facilitating the improvement in infrastructure increases the production set in this country as well as the range of industries that are only produced in this country. This is due to lower financing costs of infrastructure and greater infrastructure supply associated with larger government participation, which reduces transaction costs. This pattern aligns with the fact we find in the empirical analysis that countries with better hard and soft infrastructure have larger production sets compared to other countries with similar endowment structures. In other words, the heterogeneity in government participation in infrastructure supply is crucial to understanding variations in the LCA-ACA gap across countries.

Although this paper focuses on the impacts of $\alpha$, the cost of financing is another factor that affects the supply of public infrastructure. For instance, in the absence of an efficient financial market, the cost of raising funds for road construction and electricity supply may




(A) Impacts of $\alpha$ (B) Impacts of $\lambda_p$

Figure 7: Government behavior and production structure

be prohibitively high in some underdeveloped economies, leading to a high cost of public infrastructure supply when the government's involvement is limited. As shown in panel B of Figure 7, this reduces bot $\bar{z}$ and $\underline{z}$. Decreases in the ability of infrastructure providers to collect payments from the users of infrastructure would have a similar impact on production structure.

Now let's consider a thought experiment that helps us understand the production structure in African countries and the bilateral trade between African and Asian countries. Assume that at the initial stage, the two countries in our model have the same infrastructure supplies. If they also possess equivalent endowment structures and country sizes, both countries produce all products, and there is only intra-industry trade. If then Foreign accumulates capital at a faster rate than Home, the world progresses to the second stage where Home becomes more labor-abundant than Foreign. When the difference in factor endowment between these two countries becomes sufficiently significant, Home starts to produce goods in industries with capital intensity lower than a cutoff determined by equation (10), which is decreasing in the capital stock in Foreign. In other words, the range of industries produced in Home contracts as Foreign becomes more capital-abundant. Meanwhile, Home's comparative advantage in labor-intensity goods increases, leading to an increase in $\underline{z}$ and in inter-sector trade between Home and Foreign.

As we have noted earlier, changes in the set of specialized industries depend not only on the LCA based on the factor endowment structure but also on the relative supply of public infrastructure. With a laissez-faire state, the infrastructure supply may be insufficient for labor-intensive industries to thrive in Home. In addition, if infrastructure supply in Foreign improves substantially during the same period of capital deepening, both $\bar{z}$ and $\underline{z}$ decrease in Home. This results in a reduction in the set of both inter-industry trade and intra-industry

trade goods. Our findings are in line with the inadequate infrastructure supplies and stagnant export structure in African countries documented in section II. This also sheds light on the phenomenon of premature deindustrialization in Africa and Latin America documented in Rodrik (2016). Since labor supply is fixed, as the set of tradable industries shrinks in Home, labor is reallocated to industries that are nontradable and less dependent on the supply of public infrastructures, such as service industries with low entry barriers.

Government behavior and public infrastructure also matter for the responses of the production structure to changes in factor endowments. As shown in Figure 8, since there are gaps between the factor intensity cutoff $\bar{z}$ with different values of $\alpha$, the same changes in capital stock may lead firms in Home to enter industries with high capital intensity in the economy with a large $\alpha$ but not in the economy with a small $\alpha$. For instance, in our numerical example, the industry with a capital intensity of 0.78 is not produced in both economies in the benchmark when the capital stock is 50. While when capital increases to 70, it would be produced in the economy with $\alpha = 0.9$, but still not in the economy with $\alpha = 0.1$. Therefore, even with the same capital accumulation, countries with better infrastructure still capture a larger range of industries.

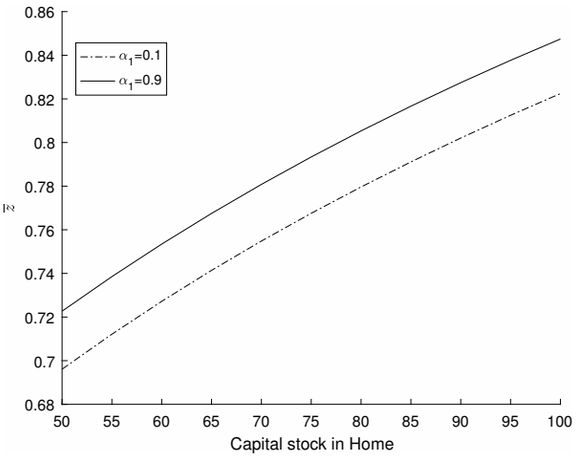



Figure 8: Government behavior, factor endowment structure and $\bar{z}$

## IV. Conclusion

The primary objective of this paper is to underscore the disparity between LCA and ACA due to transaction costs and the critical role of the state in enabling the transformation from LCA to ACA. While the comparative advantage theories of Ricardo, Heckscher-Ohlin, and Krugman only consider production costs, whether a product can be produced and exported also depends on transaction costs, which are influenced by institutional and physical infras-

tructure. When transaction costs are prohibitively high, industries with LCA may not emerge or be exported, regardless of their comparative production cost advantages. Given that providing infrastructure involves disparities between social and private costs (and benefits) and coordination failures, the government must play an enabling role in transforming LCA to ACA. The enabling role of the government in trade structure is not limited to trade promotion industrial policies, such as import tariff exemptions and preferential credit. Instead, the government reduces transaction costs in general and clears the path for firms to enter new industries.

Our paper provides a complementary perspective to traditional trade theories by highlighting the conditions under which LCA can be transformed into ACA, and has important policy implications for how countries could have dynamic trade growth and structural transformation by exploiting their LCA (Lin 2011, Rodrik 2011). In addition, since well-integration with the global market and export diversification is important for economic growth, our findings lend support to the importance of public infrastructure investment for long-term economic growth, as emphasized by the Commission on Growth and Development (2008). While previous studies on state capacity have focused on the government's capability to raise revenue (Besley and Persson, 2009), our discussion on the state emphasizes the right thing for the government to do in economic development. Our discussion also implies that multilateral development institutions and bilateral aid agencies can effectively assist poor countries by providing funds to eliminate infrastructure bottlenecks (Lin and Wang, 2017) to facilitate the transformation of LCA into ACA, and thus promote structural transformation, employment creation, poverty reduction, and economic growth.

The model presented in this paper serves as a simple baseline for the theory of state enabling trade. However, it is important to note that there is no discussion in the current model regarding the specific methods through which the government may play an enabling role. Further research could delve into the various types of soft and hard infrastructures. For example, when companies switch from OEM production to their own brands, the entry barrier to the new market is one of the biggest obstacles they face. In other words, the transaction cost between the producers and the consumers is too high in this case, which is not included in our baseline model. In addition, there are transaction costs between different production processes along the production chain. In some cases, it may not be the high production cost of an industry that hinders its development at a particular location, but rather the lack of supporting upstream and downstream industries locally. The transaction cost of purchasing intermediate products from other locations may be prohibitively high, which can impede the transformation from LCA to ACA.

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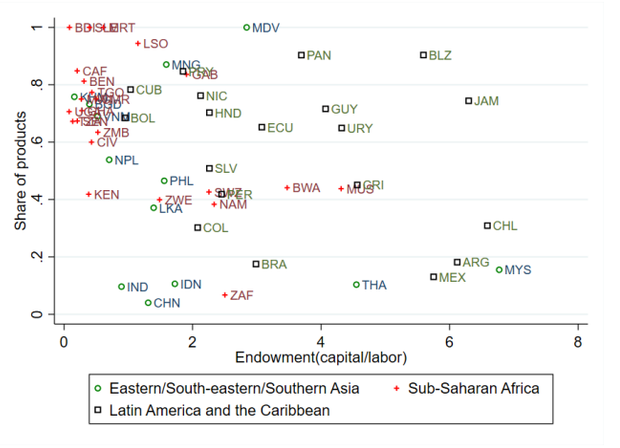
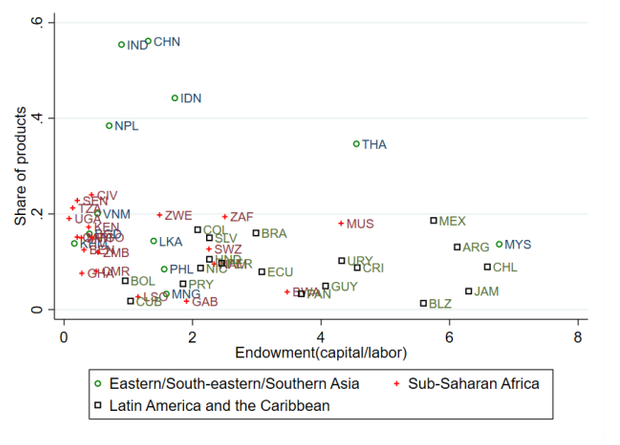
# Appendix




(A) No exports




(B) $RCA > 1$

Figure A1: Share of products with different export statuses in the first distance bin

Note: This graph shows the share of products with different export statuses among products in the first distance bin. The vertical axis in Panel (A) shows the share of products that each country did not export in 2000, while the vertical axis in Panel (B) shows the share of products that have RCA greater than 1. The horizontal axis in both paneles shows the capital/labor ratio of each country.


Figure A2: Top 100 products exported and factor endowment structure in China

Note: The horizontal axis shows the revealed physical capital intensity of each products and vertical axis shows the revealed human capital intensity. The vertical red line indicates the physical abundance in China and the horizontal red line indicates the human capital abundance in China in each year.

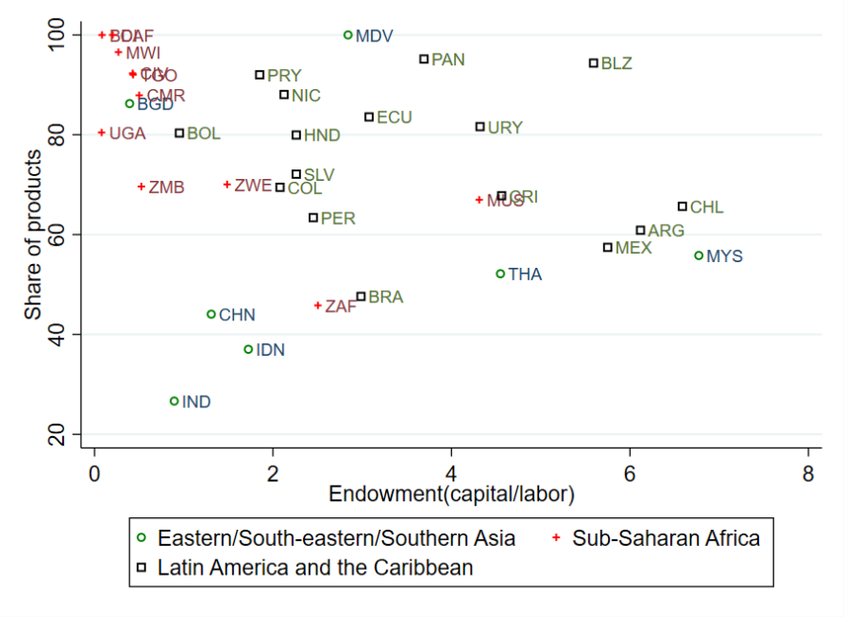



Figure A3: Probability of goods staying with zero exports in the 1st distance bin (1995-2000)

Note: The vertical axis shows the share of products that stay with zero exports in the first distance bin, while the horizontal axis in shows the capital/labor ratio of each country.