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Mini Symposium on Perspectives on Structural Change

The traditional view of structural change involves a movement of resources out of agriculture, with the industry shares in total employment and gross domestic product (GDP) initially rising before eventually declining, and the share of services rising. Recently, the analysis of structural change has been augmented by considering reallocations across firms, tasks, and occupations. These forms of structural change are influenced by a myriad of factors, with international trade and global value chains (GVCs) considered important drivers. Moreover, the process of structural change is increasingly thought to have impacts beyond productivity, potentially impacting upon the environment, inequality, and labor markets. This mini symposium includes five papers addressing structural change from a variety of perspectives and focuses on three main themes: (i) whether the traditional path of moving from agriculture to industry and eventually services still holds (papers by Sen and by Anderson and Ponnusamy), (ii) the impact of globalization on structural change (Athukorala and Veeramani), and (iii) the effect of structural change on labor markets (papers by Foster-McGregor and by Hasan and Molato).

Sen argues that the traditional pattern of structural change may no longer hold, with structurally underdeveloped countries witnessing shifts from agriculture directly to services, particularly nonbusiness services, bypassing the movement to manufacturing. With productivity in nonbusiness services being lower than in manufacturing, these developments imply lower growth potential in these countries. These observations lead Sen to argue that traditional approaches to structural change are less relevant in understanding contemporary structural change in many countries. Sen simulates a neoclassical model of structural change and shows that it does a poor job at predicting sectoral shares in structurally underdeveloped countries. Sen argues that this is because relative productivity differences are not a key determinant of labor reallocation in poor countries. As such, there is a need to rethink the mainstream approach to structural change, with new approaches putting less emphasis on productivity.

Anderson and Ponnusamy also begin from the traditional view of structural change but argue that this ignores the sectoral composition of exports, which is more varied than those of employment and output. Anderson and Ponnusamy identify the roles of per capita income, factor endowments, and sectoral productivity growth as drivers of sectoral GDP, employment, and export shares. The relationships between per capita income and both GDP and employment shares are largely in line with the existing literature. Results when considering sectoral export shares display much greater heterogeneity, however, with a number of developing countries achieving export specialization in services at relatively low levels of per capita income. Similarly, there are a small number of high-income countries that have been able to develop, despite specializing in a relatively small number of primary products. Anderson and Ponnusamy conclude that countries can pass directly from the production and export of primary products to services, and that this alternative path need not constrain development opportunities.

Athukorala and Veeramani consider the role of globalization as a driver of structural change in the Indian automobile industry, a sector which has successfully entered production networks. After being heavily protected for much of India's post-independence period, the liberalization of the automotive sector began in the 1990s, becoming stronger in the 2000s. Joint ventures in India increased significantly after 1990, with the reforms of the 2000s further increasing inward foreign direct investment, including entry of wholly owned subsidiaries. The entry of parts suppliers also intensified in the 2000s when local content requirements were dropped. In response, the production of passenger cars increased rapidly in the 2000s. Athukorala and Veeramani suggest that learning and capacity development, through foreign market participation and the entry of parts producers, has been the key factor behind India's emergence as a production base. Likewise, market-conforming policies, which constituted a notable departure from the protectionist past, have played a key role in transforming the Indian automobile industry.

Foster-McGregor decomposes employment into demand from domestic and foreign sources, with foreign demand further split into demand for final and intermediate goods. Applying this decomposition to six Asian countries, Foster-McGregor finds that domestic demand remains the dominant source of demand, albeit with trade being relatively large in some small countries. The relative importance of final and intermediate exports in generating employment varies by country, with some countries relying to a relatively large extent on intermediate exports, reflecting their importance as suppliers in GVCs; and others relying to a greater extent on final exports, reflecting their role as assemblers in GVCs. Foster-McGregor reports a declining role for trade as a source of employment in most countries in recent years, possibly due to the general plateauing of GVC participation and to the efforts of some countries to raise the domestic value-added content of their production.

Hasan and Molato focus on the labor market impacts of structural change in India, examining how wages and employment evolved during the process of structural change not only across production sectors, but also across occupational groups, rural and urban areas, and small and large firms. They note that recent employment developments have largely followed the traditional path of structural change, with workers moving out of agriculture and toward manufacturing and service sectors, and from rural to urban areas, and large cities within urban areas. Such movements have further involved a shift toward more productive activities. These structural changes are also found to be important drivers of increasing wages, accounting for up to a quarter of the total change in average wages.

The papers in this mini symposium approach structural change from different perspectives, providing some important implications. First, the papers by Sen and by Anderson and Ponnusamy argue that there is a need to rethink the traditional models of structural change. The evidence indicates that many developing countries today are not following the traditional path of structural change, in the sense that they are bypassing manufacturing. However, it is not clear that this route will deliver the same benefits as the traditional one. This is because of the well-known benefits of manufacturing and the fact that labor is moving into service activities with lower productivity than manufacturing. Second, Athukorala and Veeramani underscore that globalization has been an important driver of structural change, with GVCs, foreign direct investment, and services trade considered relevant. As a result, countries should think seriously about imposing protectionist policies to try to counteract the negative impacts of structural change. Some of these effects may be painful (especially on labor), yet these policies may be ultimately fruitless if they limit the learning capacity needed to move toward more productive activities. Finally, the papers by Foster-McGregor and by Hasan and Molato highlight that structural change is an important driver of labor market outcomes, an area in which there are significant opportunities for future research.

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Structural Transformation around the World: Patterns and Drivers

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The conventional view of structural transformation is informed by three stylized facts of economic development: (i) all economies exhibit declining employment in agriculture, (ii) all economies exhibit a hump-shaped share of employment in industry, and (iii) all economies exhibit an increasing share of employment in services. In this paper, I show that this presumed path of structural transformation may no longer be the route to economic development in low-income economies. Classifying economies as either structurally developed, structurally developing, or structurally underdeveloped, I observe a different path of structural transformation in structurally underdeveloped economies in which workers are moving directly from agriculture to nonbusiness services, which as a sector does not have the same productivity gains as manufacturing. I also show that the mainstream approach is unable to explain the patterns of structural transformation observed in low-income developing economies. This suggests the need to rethink the theoretical premises behind much of the mainstream approach to structural transformation and to identify alternate causal mechanisms to explain the different types of structural transformation underway in the developing world.

Keywords: deindustrialization, employment, productivity, structural transformation
JEL codes: O11, O14, O47

I. Introduction

Economists have long searched for patterns that relate successful economic development to structure and policy (Syrquin and Chenery 1989). This comparative approach in development economics was initiated by Simon Kuznets and predicated on "the existence of common, transnational factors and a mechanism of interactions among nations that will produce some systematic order in the way modern economic growth can be expected to spread around the world" (Kuznets 1959, 170). One of the most striking findings of this comparative approach to economic development was the "universal inverse association of income and the share of agriculture in income and employment" (Syrquin and Chenery 1989, 172).

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As Kuznets argued, one of the key features of modern economic growth was the movement of workers from agriculture to manufacturing and services (Kuznets 1966). The comparative approach identified the manufacturing sector as the engine of economic growth for most economies and the rate at which industrialization occurred differentiated successful economies from unsuccessful ones (McMillan, Rodrik, and Verduzco-Gallo 2014; Haraguchi, Cheng, and Smeets 2017). However, at a certain stage of economic development, as productivity growth in manufacturing exceeds productivity growth in agriculture and services, and as demand for services expands, the service sector becomes the major provider of employment, and the manufacturing sector lessens in importance in terms of providing employment, though not in terms of output growth (Chenery and Syrquin 1975, Syrquin 1988, Syrquin and Chenery 1989).

The movement of workers from agriculture to manufacturing to services has been the path of structural transformation in all economies that comprise the high-income club as well as the pattern of successful growth in East Asia. This path of structural transformation has received a great deal of attention among economists and underpins most of the theoretical understanding of structural transformation—all the way from scholars in classical economics such as Kuznets, Lewis, Chenery, and Syrquin to more modern approaches that are rooted in the neoclassical tradition (see, for example, Duarte and Restuccia 2010; Dabla-Norris et al. 2013; Herrendorf, Rogerson, and Valentinyi 2014; McMillan, Rodrik, and Verduzco-Gallo 2014; Diao, McMillan, and Rodrik 2017). However, as will be documented, this path of structural transformation may no longer be the route to economic development among low-income economies. Instead, I observe a different path of structural transformation where workers are moving directly from agriculture to nonbusiness services, which as a sector does not have the same productivity gains observed in manufacturing. If this is the path of structural transformation that we are likely to see in the developing world, especially among the poorest economies, what implications does this have for our conventional view of structural transformation? What are the implications of the direct movement of workers from agriculture to nonbusiness services for economic growth? What are the drivers of such an alternate path of structural transformation? How well does the mainstream approach to structural transformation explain recent patterns, especially in low-income economies?

In this paper, I first review the recent theoretical approach to structural transformation in the mainstream literature. I then document the patterns of structural transformation observed in developing and developed economies. I then examine the implications of different paths of structural transformation for economic growth. I next examine the drivers of the alternate paths of structural transformation. Finally, I take a prototype mainstream model of structural transformation—Duarte and Restuccia (2010)—and examine how well the model does in explaining patterns of structural transformation.

II. Theoretical Perspectives on Structural Transformation

In the 1950s, led by economists like Hollis Chenery, Moses Syrquin, and Simon Kuznets, a program of research was developed to understand the features and preconditions of modern economic growth (Lewis 1954, Chenery and Syrquin 1975, Syrquin 1988). Core to this research was the interest in understanding "the interrelated processes of structural change that accompany economic development . . . jointly referred to as structural transformation" (Syrquin 1988, 206). One of the most robust findings from this program of research was that "in the economies where per capita income grew significantly, the proportion of the labour force engaged in agriculture declined and that engaged in nonagriculture increased" (Kuznets 1965, 24). Kuznets also noted that, in more advanced economies, "the shares of mining and manufacturing in the total labour force grew significantly, but the increases have ceased or slowed down in recent decades . . . the shares of trade and other services have grown steadily in recent decades" (Kuznets 1965, 25).

A more recent analysis of the pattern of structural transformation is provided by Duarte and Restuccia (2010), who use sectoral employment data for 29 high- and middle-income economies that are obtained from the EU KLEMS data and the International Labour Organization's LABORSTA database (ILOSTAT). Duarte and Restuccia (2010) find that "all economies in the sample follow a common process of structural transformation. First, all economies exhibit declining shares of hours in agriculture, even the most advanced economies in this process, such as the United Kingdom and the United States (US). Second, economies at an early stage of the process of structural transformation exhibit a hump-shaped share of hours in industry, whereas this share is decreasing for economies at a more advanced stage. Finally, all economies exhibit an increasing share of hours in services" (Duarte and Restuccia 2010, 135). They go on to state: "The processes of structural transformation observed in our sample suggest two additional observations. First, the lag in the structural transformation observed across economies is systematically related to the level of development: poor economies have the largest shares of hours in agriculture, while rich economies have the smallest shares. Second, our data suggest the basic tendency for economies that start the process of structural transformation later to accomplish a given amount of labor reallocation faster than those economies that initiated this process earlier" (Duarte and Restuccia 2010, 135).

A. The Neoclassical (Mainstream) Approach to Structural Transformation

The workhorse model of economic growth is the Solow–Swan model, which by its very nature, abstracts from sectoral allocation issues in the process of economic development, focusing on the role of capital accumulation and technological change in the aggregate. As Herrendorf, Rogerson, and Valentinyi

(2014) note: "The one-sector growth model has become the workhorse of modern macroeconomics. The popularity of the one-sector growth model is at least partly due to the fact that it captures in a minimalist fashion the essence of modern economic growth, which Kuznets (1973) in his Nobel prize lecture described as the sustained increase in productivity and living standards. By virtue of being a minimalist structure, the one-sector growth model necessarily abstracts from several features of the process of economic growth. One of these is the process of structural transformation, that is, the reallocation of economic activity across the broad sectors agriculture, manufacturing and services" (Herrendorf, Rogerson, and Valentinyi 2014, 855).

For a long time, there was limited interest in the question of structural transformation in the neoclassical school of economics. This changed in the 2000s, with a series of path-breaking papers that developed multisector versions of the one-sector growth model that were consistent with the stylized facts of structural transformation, such as Rogerson (2007); Ngai and Pissarides (2007); Duarte and Restuccia (2010); and Herrendorf, Rogerson, and Valentinyi (2014). Two classes of models were developed: (i) one where the causal explanation was technological in nature and which attributed structural transformation to different rates of sectoral total factor productivity growth, and (ii) a utility-based explanation that required different income elasticities for different goods and could yield structural transformation even with equal total factor productivity growth across all sectors.

Here, we describe a model of structural transformation that combines both of these explanations. The model is drawn from Duarte and Restuccia (2010).

B. A Model of Structural Transformation

In the Duarte and Restuccia (2010) model, there are three sectors—agriculture (a), manufacturing (m), and services (s)—which are produced using constant returns-to-scale production functions. Sector-specific technology is given by A_i, where i is agriculture, manufacturing, and services.

The model assumes a continuum of homogenous firms in each sector that are competitive in goods and factor markets. The representative household is endowed with L units of labor, which is supplied inelastically to the market. The representative household consumes agricultural goods (c_a) and a composite nonagricultural good comprising manufacturing (c_m) and services goods (c_s). The model assumes a closed economy and abstracts from intertemporal optimization (hence, the model is static and the problem of the household is effectively a sequence of static problems).

The per period utility is given by

$$u(c_{a,t}, c_t) = a \log(c_{a,t} - \bar{a}) + (1 - a) \log(c_t), \quad a \in [0, 1] \tag{1}$$

The subsistence level of agricultural goods below which the household cannot survive is given by $\bar{a} > 0$. The composite nonagricultural good (c_t) is given by

$$c_t = [bc_{m,t}^{\rho} + (1 - b)(c_{s,t} + \bar{s})^{\rho}]^{1/\rho} \tag{2}$$

where $\bar{s} > 0$, b is between 0 and 1, and $\rho < 1$. For $\bar{s} > 0$, these preferences imply that the income elasticity of services is greater than 1. Therefore, $\bar{s}$ works as a negative subsistence consumption level: when the income of the household is low, fewer resources are allocated to the production of services, and when the income of the household rises, resources are reallocated to services.

Both product and labor markets clear, so that $L_a + L_m + L_s = L$ and $c_a = Y_a$, $c_m = Y_m$, and $c_s = Y_s$. The first-order conditions for consumption imply that the optimal labor input in agriculture (L_a) is given by

$$L_a = (1 - a)\frac{\bar{a}}{A_a} + a\left(L + \frac{\bar{s}}{A_s}\right) \tag{3}$$

When $a = 0$, the household consumes $\bar{a}$ of agricultural goods each period, and labor allocation in agriculture depends on the level of labor productivity in that sector. As labor productivity in agriculture increases, labor moves away from the agriculture sector.

The first-order conditions for consumption of manufacturing and service goods imply that

$$L_m = \frac{(L - L_a) + \bar{s}/A_s}{1 + x}, \tag{4}$$

where

$$x \equiv \left(\frac{b}{1 - b}\right)^{1/(\rho-1)}\left(\frac{A_m}{A_s}\right)^{\rho/(\rho-1)}$$

This equation reflects the two forces that drive labor reallocation between manufacturing and services in the model. The technological explanation will stress the role of differential productivity growth in explaining structural transformation. This is evident if we assume homothetic preferences (that is, $\bar{s} = 0$). In this case, $L_m/L_s = 1/x$ and differential productivity growth in manufacturing relative to services is the only source of labor reallocation between these sectors as long as ρ is not equal to 0. In particular, when $\bar{s} = 0$, the model can be consistent with the observed reallocation of labor from manufacturing to services as labor productivity grows in manufacturing relative to services and as long as the elasticity of substitution between manufacturing and services is low. The second explanation is the utility-based explanation, which is evident if $\bar{s} > 0$ (that is, preferences are nonhomothetic) and labor productivity grows at the same rate in manufacturing and services, or $\rho = 0$, so that x is constant. Here, for a given L_a there is a reallocation of labor from manufacturing to services as the latter is more income elastic than the former, per the so-called Engel effects (see, for example, Clark 1940).

III. Paths of Structural Transformation

A. Data

The data on structural transformation come from the Groningen Growth and Development Centre (GGDC) database of the University of Groningen (Timmer, de Vries, and de Vries 2015). The GGDC data are widely used in the recent literature on structural transformation (see, for example, Diao, McMillan, and Rodrik 2017; Comin, Lashkari, and Mestieri 2018). There are 41 economies in the database, which includes annual disaggregated data on real value added and employment by sector from 1960 to 2012. For the purpose of this paper, the GGDC data provide information on manufacturing and nonmanufacturing industries (construction, mining, and utilities) separately, as well as disaggregated data on services by type of sector (business services, government services, trade, and hotels and restaurants, among others). Table A1 in the Appendix provides details on the 10 sectors in the GGDC data. Employment is defined as "all persons employed," including all paid employees, as well as self-employed and family workers.

The GGDC dataset includes 12 African economies (including North Africa), 9 Latin American economies, 11 Asian economies (including Japan), and the US, with the rest coming from Europe. A key strength of the employment data is that the source for each economy is the population census, which ensures full coverage of the working population as well as a precise sectoral breakdown. The population census, which tends to be quinquennial or decennial in most economies, is supplemented by the labor force surveys and the business surveys to derive annual trends. The use of the population census also ensures that informal employment, which is important in many low- and middle-income economies, is captured in the GGDC data. Another feature of the data is the careful attention paid to intertemporal, international, and internal consistency (Timmer and de Vries 2009; Diao, McMillan, and Rodrik 2017). This differentiates the quality of the data from other sources of employment data, such as ILOSTAT, which compiles data directly obtained from economy sources without the consistency checks undertaken by GGDC.[1] The GGDC data has two limitations: (i) limited coverage of low-income economies; and (ii) Egypt and Morocco do not report disaggregated employment

[1] An alternate source of employment data are the labor force surveys (e.g., ILOSTAT). Though labor force surveys are conducted more frequently than the population census, the data are often not representative in many developing economies and are sometimes restricted to particular areas, such as urban areas. See Baymul and Sen (2019) for a discussion of the limitations of ILOSTAT.

data for community, social, and personal services. I exclude these two economies from the sample, leaving 39 economies.[2]

I categorize economies by the different stage of structural transformation that they are in. The first set of economies are those where agriculture is still the largest sector in terms of the share of employment in the most recent period available. In our sample, these economies are Ethiopia, India, Kenya, Malawi, Nigeria, Senegal, Tanzania, and Zambia. These economies are almost all in sub-Saharan Africa, with India the only exception. These economies are considered structurally underdeveloped. The next set of economies are those where more people are employed in the service sector than in agriculture, with agriculture being the second-largest sector. These economies—Bolivia, Botswana, Brazil, Colombia, Costa Rica, Ghana, Indonesia, the People's Republic of China, Peru, the Philippines, South Africa, and Thailand—are called structurally developing economies. These economies span Africa, Asia, and Latin America. The final set of economies are those with more people employed in the manufacturing sector than in agriculture. The economies in the sample from Africa, East Asia, and Latin America include Argentina; Chile; Hong Kong, China; Malaysia; Mauritius; Mexico; the Republic of Korea; Singapore; Taipei,China; and Venezuela. This set also includes advanced market economies from Europe—Denmark, France, Italy, Japan, the Netherlands, Spain, Sweden, and the United Kingdom—as well as the US. These economies are known as structurally developed. Table 1 provides a list of economies by stage of structural transformation.[3]

B. Paths of Structural Transformation

Figure 1 plots the share of employment in each major sector—agriculture, manufacturing, nonmanufacturing industry, business services, and nonbusiness services—in total employment over time for all 39 economies. As expected, the share of employment in agriculture falls steadily over time. The share of manufacturing employment exhibits an inverted U-shaped behavior, again as expected. The share of employment in nonbusiness services shows a steady increase. There is virtually no change in the share of employment in nonmanufacturing industry. The share of employment in business services shows a sharp increase after the 1990s.

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[2]An additional limitation of the dataset is that it does not differentiate between informal and formal employment in the manufacturing and service sectors.

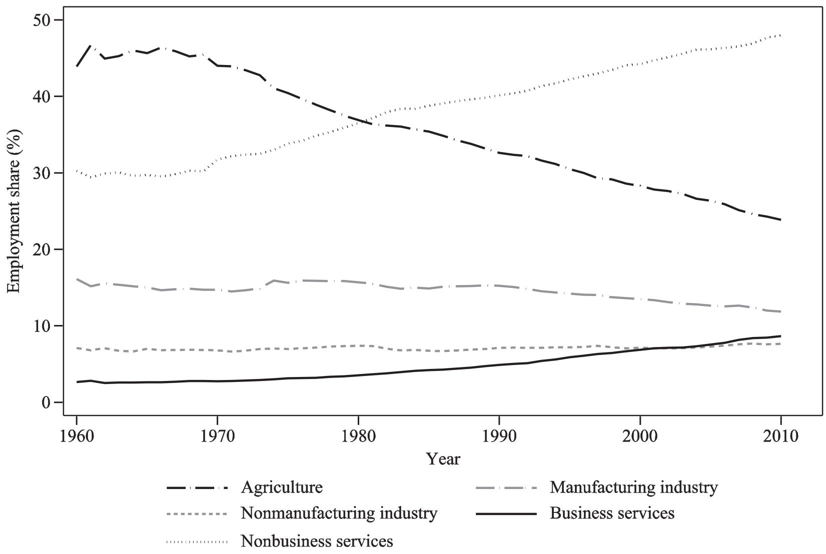
[3]I experimented with an alternate approach to classifying economies by stages of structural transformation by using the share of employment in agriculture in the last period available as the sorting criteria. Using this criteria, economies are classified as structurally developed if their share of employment in agriculture is below 10%, structurally developing if their share of employment in agriculture is between 10% and 50%, and structurally underdeveloped if their share of employment in agriculture is above 50%. I did not find any difference in the findings using this criteria of classifying economies in different stages of structural transformation. Note that using the share of employment in manufacturing instead of agriculture as a way to classify economies is misleading, as manufacturing employment shares had peaked in many economies by the beginning of the review period.

Table 1. **Stages of Structural Transformation—Economy Classification**

Structurally Underdeveloped (8)	**Structurally Developing (12)**	**Structurally Developed (19)**
Ethiopia	Bolivia	Argentina
India	Botswana	Chile
Kenya	Brazil	Denmark
Malawi	Colombia	France
Nigeria	Costa Rica	Hong Kong, China
Senegal	Ghana	Italy
Tanzania	Indonesia	Japan
Zambia	People's Republic of China	Malaysia
	Peru	Mauritius
	Philippines	Mexico
	South Africa	Netherlands
	Thailand	Republic of Korea
		Singapore
		Spain
		Sweden
		Taipei,China
		United Kingdom
		United States
		Venezuela

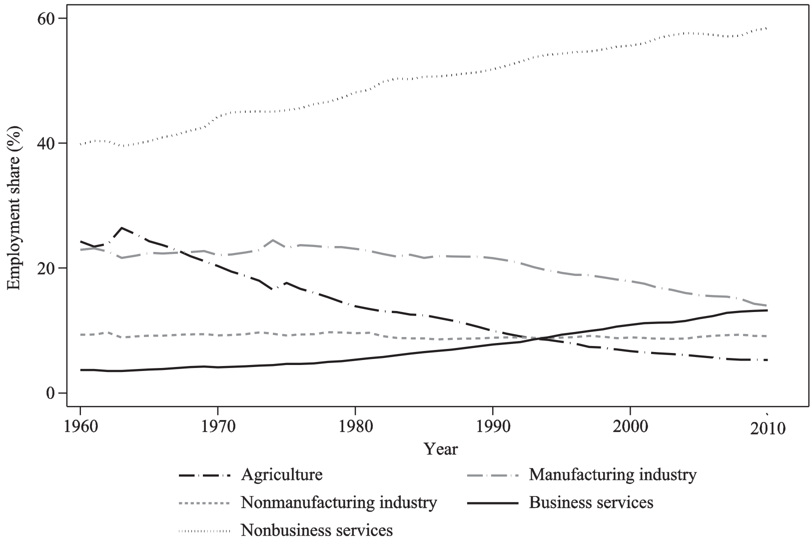
Source: Author's compilation.

Figure 1. **Share of Employment by Major Sector, All Economies**



Note: Share of employment by sector in total employment.
Source: Author's calculations based on GGDC data.

Figure 2. **Share of Employment by Major Sector, Structurally Developed Economies**



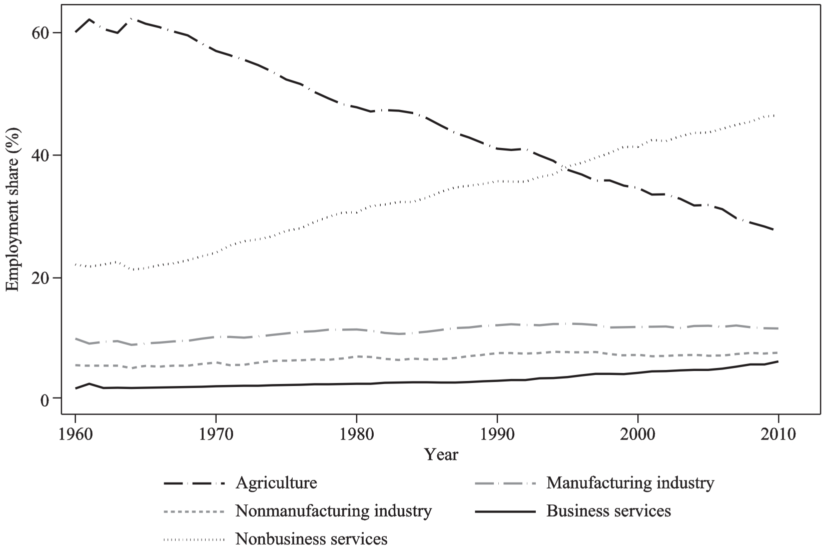
Note: Share of employment by sector in total employment.
Source: Author's calculations based on GGDC data.

Figure 2 shows the pattern of structural transformation for structurally developed economies. The share of employment in agriculture was low to start with at the beginning of the review period and falls below 10% by the end of the period. The share of employment in nonbusiness services increases from around 40% to around 60% of total employment. The manufacturing employment share, which had already peaked for most of these economies prior to 1960, shows a steady decline. Strikingly, the share of employment in business services rises steadily to the point where it has almost reached the level of the share of manufacturing employment by the end of the review period. The share of employment in nonmanufacturing industry shows no clear trend in the period under consideration.

Figure 3 shows the pattern of structural transformation for structurally developing economies. There is a remarkable fall in the share of employment in agriculture from around 60% in 1960 to around 30% in 2010. This is matched by a corresponding increase in employment in nonbusiness services from just over 20% to over 40% of total employment. The manufacturing employment share shows a gradual increase, and the share of employment in business services increases beginning in the 1990s. There is no perceptible change in the share of employment in nonmanufacturing industry.

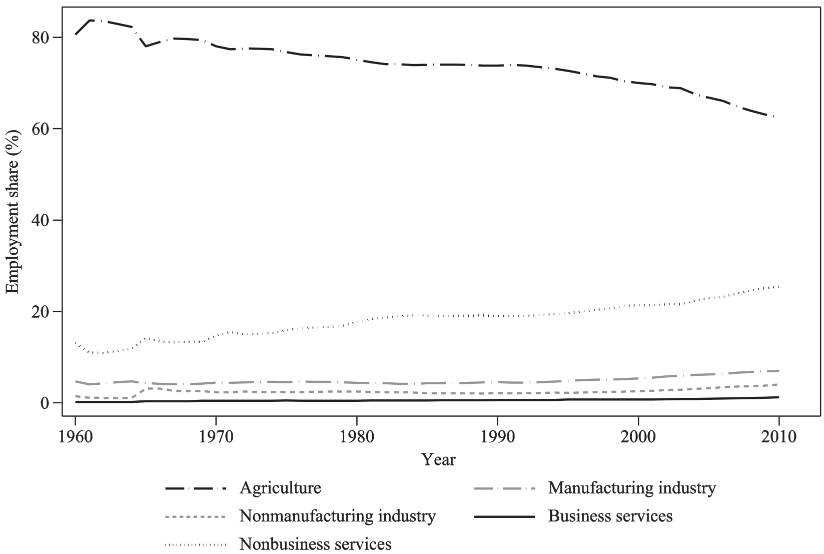
Finally, Figure 4 shows the pattern of structural transformation for structurally underdeveloped economies. A remarkable feature of structural transformation in these economies is the very slow movement of workers out of

Figure 3. **Share of Employment by Major Sector, Structurally Developing Economies**



Note: Share of employment by sector in total employment.
Source: Author's calculations based on GGDC data.

Figure 4. **Share of Employment by Major Sector, Structurally Underdeveloped Economies**



Note: Share of employment by sector in total employment.
Source: Author's calculations based on GGDC data.

Table 2. **Patterns of Structural Transformation: Employment Shares by Sector (%)**

Economy Group	Period	Agriculture	Manufacturing Industry	Non-manufacturing Industry	Business Services	Non-business Services
Underdeveloped	1960–1979	78.2	4.4	2.3	0.4	14.6
	1980–1999	73.3	4.5	2.2	0.6	19.3
	2000–2012	66.4	6.2	3.2	1.0	23.1
Developing	1960–1979	56.3	10.3	6.0	2.3	25.1
	1980–1999	42.0	11.9	7.3	3.4	35.5
	2000–2012	31.1	12.0	7.5	5.3	44.1
Developed	1960–1979	20.1	22.8	9.4	4.2	43.4
	1980–1999	10.4	20.9	8.9	7.8	52.1
	2000–2012	5.9	15.8	9.0	12.1	57.2

Note: Unweighted averages as percentages of total employment.
Source: Author's calculations based on GGDC data.

agriculture. These workers mostly go to the nonbusiness service sector and not to manufacturing, which shows no clear increase in employment share. The share of employment in business services is very low as well. The share of employment in nonmanufacturing industry shows no clear trend in the period under consideration.

Table 2 summarizes the information provided in Figures 1–4. It shows the very slow movement of workers away from the agriculture sector in structurally underdeveloped economies: from a 78% employment share in 1960–1979 to 66% in 2000–2012. These economies also saw a very slow increase in the share of employment in manufacturing from 4% in 1960–1979 to 6% in 2000–2012. In the case of structurally developing economies, the average share of employment in services overtakes employment in agriculture only in the period 2000–2012. Nevertheless, these economies experience a rapid decline in the share of employment in agriculture from 56% in 1960–1979 to 31% in 2000–2012, as well as an increase in the share of employment in manufacturing from 10% in 1970–1979 to 12% in 2000–2012. For structurally developed economies, the share of employment in agriculture was low to start with at 20% in 1960–1979. By the period 2000–2012, more workers are employed in nonmanufacturing industry in these economies than in agriculture, while services provide the largest employment share by far at 69%. Here, we observe a fall in the share of employment in manufacturing over time.

The share of employment in the five subsectors that make up the service sector—business, transport, trade, government, and personal—also differ between economy groups as well over time. All services except business services are classified as nonbusiness services.[4] There are three reasons to make a distinction between business and nonbusiness services. Firstly, as we will show later in the paper, the productivity of the business service sector far exceeds that of the nonbusiness service sector, and is comparable to the productivity of the

[4]More disaggregated data are available in Baymul and Sen (2019).

manufacturing sector. Secondly, the business service sector includes the more tradable parts of the service sector (e.g., information technology), while the nonbusiness sector broadly corresponds to the nontradable service sector. Thirdly, most of the activity that occurs in the business service sector is in enterprises that are in the formal sector (e.g., information technology firms and banks), while a large part of the activity in the nonbusiness service sector is in the informal sector—including self-employed or household enterprises in trade, hotels and restaurants, and personal services (e.g., fruit and vegetable street vendors).[5] For structurally underdeveloped economies, most of the growth of employment in the service sector occurs in nonbusiness services rather than business services. This is very different from what is experienced in structurally developing and developed economies, where the most rapid increase in employment for any particular sector is observed in the business service sector; for structurally developing economies, it rises from 2% of total employment in 1960–1979 to 5% in 2000–2012, and for developed economies, it rises from 4% to 12% during the same period (Table 2). In contrast, the business service subsector remains a paltry 1% of total employment in structurally underdeveloped economies during 2000–2012.

To ascertain whether or not the shares of employment in manufacturing, business services, and nonbusiness services follow a clear trend, I regress the share of employment in manufacturing on a time trend, averaging the data over 5-year periods. I also add the square of the time trend to account for the fact that the manufacturing employment share peaks at some point along a country's path of economic development. I do the same for business services and nonbusiness services, except that here I do not add a time trend as there is no clear turning point in these shares in the data. I first run the regressions for all economies and then by structural economy groups. I estimate these equations using random effects and report the results in Table 3.

For all economies, manufacturing employment exhibits an inverse U-shaped behavior with time—the coefficient on the time trend is positive and significant, while the coefficient on the square of the time trend is negative and significant, both at the 1% level. Both business services and nonbusiness services' shares of total employment show a clear increase over time for all economies. However, the trend analysis by structural economy group shows clear differences in the rate of change of the shares of employment in manufacturing, business services, and nonbusiness services over time across the three economy groups (columns 1, 2, and 3). As expected, manufacturing employment's share of structurally underdeveloped economies does not exhibit an inverted U-shaped behavior over time—when both the time trend and its square are included in the regression, both are insignificant (column 10). When only the time trend is included, it is positive and statistically

[5]The only exception here is the government sector where workers are usually in permanent jobs that are reasonably well paying.

Table 3. **Trend Analysis of Paths of Structural Transformation**

	(1)	(2)	(3)	(4)		(5)	(6)
	All			**Structurally Developed**			
	Manufacturing Employment	**Business Services Employment**	**Nonbusiness Services Employment**	**Manufacturing Employment**	–	**Business Services Employment**	**Nonbusiness Services Employment**
Time trend	0.007^{***}	0.007^{***}	0.021^{***}	0.008^{*}	–	0.011^{***}	0.020^{***}
	(2.67)	(21.15)	(33.36)	(1.69)		(30.13)	(26.88)
Square of time trend	-0.0008^{***}	–	–	-0.001^{***}	–	–	–
	(−3.83)			(−3.80)			
Wald Chi-square	35.07^{***}	447.17^{***}	1106.05^{***}	87.88^{***}	–	907.52^{***}	722.66^{***}
No. of economies	39	39	39	19	–	19	19
No. of observations	408	408	408	198	–	198	198

	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	Structurally Developing			**Structurally Underdeveloped**			
	Manufacturing Employment	**Business Services Employment**	**Nonbusiness Services Employment**	**Manufacturing Employment (1)**	**Manufacturing Employment (2)**	**Business Services Employment**	**Nonbusiness Services Employment**
Time trend	0.011^{***}	0.004^{***}	0.026^{***}	0.001	0.002^{***}	0.0008^{***}	0.011^{***}
	(4.13)	(8.68)	(31.24)	(0.60)	(21.15)	(6.63)	(7.02)
Square of time trend	-0.0008^{***}	–	–	0.0001	–	–	–
	(−2.90)			(0.39)			
Wald Chi-square	40.52^{***}	75.36^{***}	976.14^{***}	17.92^{***}	18.01^{***}	43.92^{***}	49.21^{***}
No. of economies	12	12	12	8	8	8	8
No. of observations	128	128	128	82	82	82	82

Notes: *** indicates level of significance at the 1% level. *t* statistics are in brackets. Employment shares as dependent variables range from 0 to 1.
Source: Author's calculations based on GGDC data.

significant, suggesting that there is movement into manufacturing for structurally underdeveloped economies over time (column 11). However, as indicated by the magnitude of the coefficients on the time trend variable, the movement into manufacturing is the weakest among all three economy groups, confirming what had been observed in Figures 1–4 (columns 4, 7, and 11). I also obtain a similar finding for the shares of employment of business services and nonbusiness services, where the rate of increase for structurally developing economies is far lower than that for structurally developed and underdeveloped economies (columns 5, 6, 8, 9, 12, and 13). Further, for structurally underdeveloped economies, the rates of increase of the manufacturing employment and business employment shares are significantly lower than that for the nonbusiness services employment share (columns 11, 12, and 13). In contrast, for structurally developing economies, the rate of increase in the manufacturing employment share is higher than that for the business services employment share.[6]

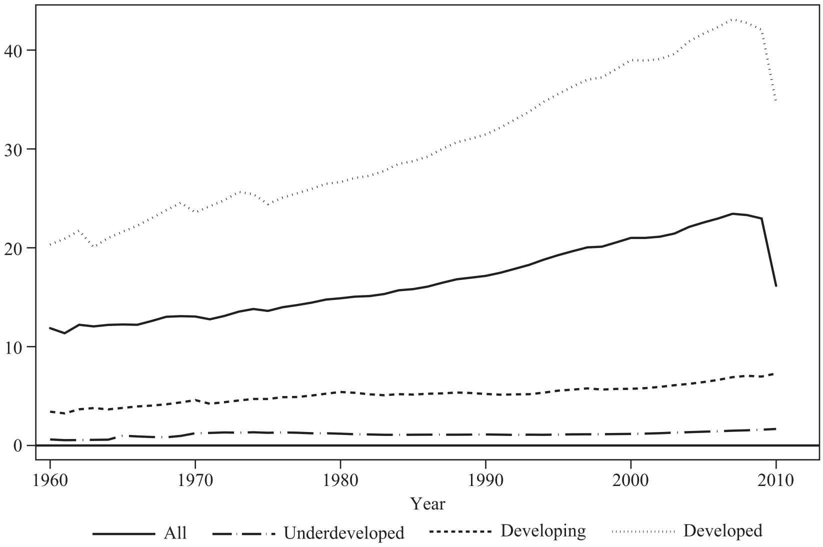
To sum up, different paths of structural transformation are observed in the historical employment data for 39 high-, middle-, and low-income economies. The high- and middle-income economies—which comprise the structurally developed and structurally developing set of economies, respectively—have mostly followed the conventional path of structural transformation in which workers move from agriculture to manufacturing and services first, and then out of manufacturing and into services. In contrast, the low-income economies, which are the structurally underdeveloped economies, exhibit the slow movement of workers out of agriculture; where this movement has occurred, it has mostly been to nonbusiness services rather than to manufacturing. I also observe a clear difference across the economy groups in terms of within-sector movement into services. While there has been a distinct movement of workers in structurally developed economies into business services along with nonbusiness services (and to a lesser extent in structurally developing economies), there is very little movement of workers into business services for structurally underdeveloped economies, with most of the movement to nonbusiness services. I will show later why this difference in the movement of workers into business versus nonbusiness services is important for understanding the long-term drivers of structural transformation and economic development.

IV. Drivers of Structural Transformation

The discussion of the theoretical perspectives on structural transformation indicated that one of the key drivers of structural transformation has been differential productivity growth across sectors. To what extent can we attribute

[6]The findings on the different paths of structural transformation in the developing world have also been observed in other studies such as ADB (2013).

Figure 5. **Aggregate Productivity**



Source: Author's calculations based on GGDC data.

the patterns of structural transformation observed in section III to differential productivity growth across sectors? To address this question, I first look at the behavior of sectoral productivity for all economies and then by economy group. Beginning with a plot of aggregate labor productivity for the three economy groups in Figure 5, it is not surprising to see that the aggregate labor productivity of structurally developed economies is much higher than that for structurally developing economies, which itself is higher than that for structurally underdeveloped economies. Furthermore, while aggregate labor productivity increased steadily for structurally developed economies from the beginning of the review period until the dip in 2008 due to the global financial crisis (and also, to a lesser extent, for structurally developing economies), there is no sign of an increase in aggregate productivity for structurally underdeveloped economies.

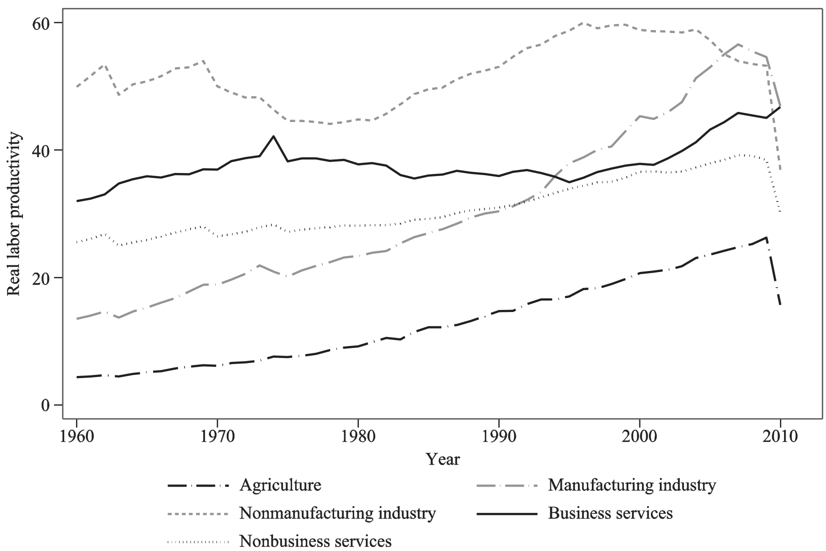
Figures 6–9 examine the behavior of sectoral productivity first for all economies and then by economy group. For all economies, sectoral productivity is the highest in nonmanufacturing industry, manufacturing industry, and business services. This is followed by nonbusiness services and then agriculture. Interestingly, real labor productivity in manufacturing industry shows a distinct behavior of catch-up with nonmanufacturing industry and business services (Figure 6).

For structurally developed economies, there is a similar pattern with respect to sectoral productivity, except that the productivity of nonbusiness services is not very different from that of nonmanufacturing industry, manufacturing industry, and

Figure 6. **Sectoral Productivity, All Economies**

Note: Productivity calculated as real value added per worker (unweighted averages).
Source: Author’s calculations based on GGDC data.

Figure 7. **Sectoral Productivity, Structurally Developed**

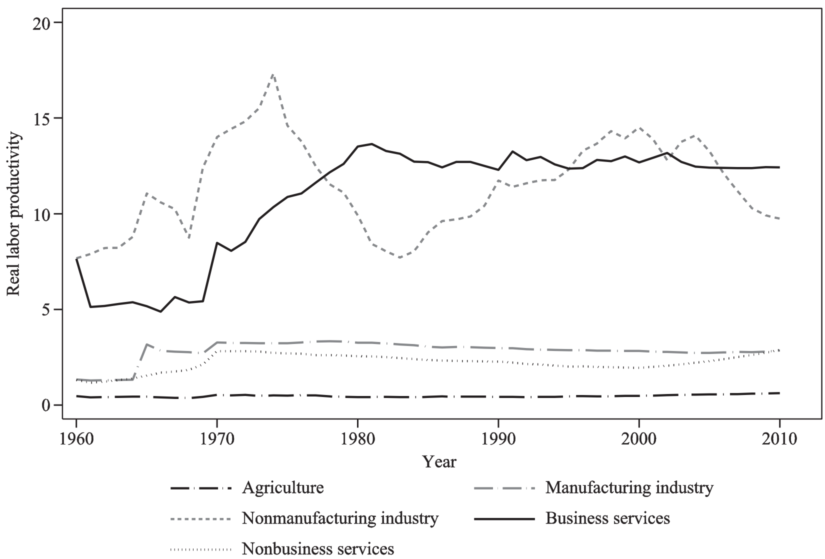


Note: Productivity calculated as real value added per worker (unweighted averages).
Source: Author’s calculations based on GGDC data.

Figure 8. **Sectoral Productivity, Structurally Developing**

Note: Productivity calculated as real value added per worker (unweighted averages).
Source: Author's calculations based on GGDC data.

Figure 9. **Sectoral Productivity, Structurally Underdeveloped**



Note: Productivity calculated as real value added per worker (unweighted averages).
Source: Author's calculations based on GGDC data.

business services (Figure 7). For structurally developing economies, there is not a similar pattern of behavior with nonbusiness services, which is a less productive sector than nonmanufacturing industry, manufacturing industry, and business services among this economy group (Figure 8). For structurally underdeveloped economies, quite remarkably, we see that manufacturing industry productivity is not very different than agricultural productivity and, in fact, seems to be converging to the latter over time. We also see that the levels of productivity in manufacturing industry and nonbusiness services are almost identical, a surprising finding given that a large proportion of nonbusiness services are neither tradable nor produced in competitive markets as in the case of manufacturing industry (Figure 9).

What do these findings on sectoral productivity imply for the Duarte and Restuccia model of structural transformation that was discussed in section II? Examining the implications of the findings for the theoretical modeling of structural transformation, while differential productivity growth across sectors provides an adequate explanation of structural transformation in structurally developed and developing economies, it does not do so for structurally underdeveloped economies. For structurally developed and developing economies, the higher rate of productivity growth in manufacturing industry compared with nonbusiness services can explain why there has been a reallocation of workers from manufacturing to services over time. However, for structurally underdeveloped economies, we have already observed that the rate of productivity growth in manufacturing industry is not very different from that of nonbusiness services, or for that matter, agriculture. This suggests that the mainstream approaches to structural transformation that are prevalent in the literature are not particularly useful in understanding contemporary structural transformation. This point was also made by Rodrik (2016), who shows via a simple open economy, two-sector model of structural transformation that differential total factor productivity growth in manufacturing cannot be the culprit for the "premature deindustrialization" that Rodrik observes for many low-income economies. In Rodrik's formulation, the causal factor for the deindustrialization in developing economies is globalization, whereby developing economies "imported" deindustrialization from developed economies. The evidence for this claim is not weak. As Sen (2019) shows, globalization has had both a positive and negative effect on employment in manufacturing—the first by the scale effect and the second by the labor intensity effect.[7]

What about the utility-based explanation of structural transformation? For structurally developed and developing economies, which have seen very high rates of economic growth, the high income elasticity of services, and business services in particular, can explain why employment in these sectors increased with

[7]Sen (2019) uses disaggregated industry data for 92 developing and transition economies for the period 1970–2010 to show that the impact of globalization on manufacturing employment is positive through the scale and composition effects, and it is negative through the labor intensity effect.

economic growth. However, for structurally underdeveloped economies, which have not seen sustained economic growth and are mostly low-income economies, it is difficult to argue that Engel effects can explain why there has been so much movement of workers into nonbusiness services right from the start of the process of economic development. What this suggests is that there needs to be a rethinking of the theoretical premises behind much of the mainstream approach to structural transformation and the identification of alternate causal mechanisms that can explain the varieties of structural transformation observed in the developing world.

V. How Well Does the Mainstream Approach Explain Structural Transformation?

I now evaluate the explanatory power of the mainstream approach to structural transformation by taking a prototype mainstream model—the Duarte and Restuccia model—to the data. Recall that the model has the following parameters: a, $\bar{a}$, $\bar{s}$, b, and ρ. In addition, to generate the values for labor allocation in agriculture, manufacturing, and services requires the actual productivity levels from 1960 to 2010 in agriculture, manufacturing, and services.

Duarte and Restuccia (2010) first calibrate their model to US data for the period 1956–2004. Their calibration strategy involves selecting parameter values so that the equilibrium of the model matches the salient features of structural transformation for the US economy from 1956 to 2004. The parameter a is the share of employment in agriculture in the initial year, the parameter $\bar{a}$ is the share of employment in agriculture in the terminal year, the parameter $\bar{s}$ is the share of employment in manufacturing in the terminal year, and b is the average share of employment in manufacturing for the period under consideration; all of these parameters are for the US. Duarte and Restuccia (2010) then use this parameter model to simulate shares of employment in agriculture, manufacturing, and services for individual economies using actual sectoral productivity data for these economies. They find that their model "reproduces the salient features of structural transformation and aggregate productivity across economies" (Duarte and Restuccia 2010, 150). The model replicates basic trends in the agricultural employment share for all economies, though it underpredicts the share of employment in services and overpredicts the share of employment in manufacturing in less developed economies.

A limitation of Duarte and Restuccia's (2010) analysis is that their sample does not include any low-income economies, with the economies in their sample being either high- or middle- income economies. Moreover, they do not differentiate between business and nonbusiness services, when, as has been argued in this paper, these two subsectors have very different profiles of productivity.

I now simulate the Duarte and Restuccia model with the sample of 39 economies for the period 1960–2010. I do it by economy group to see how

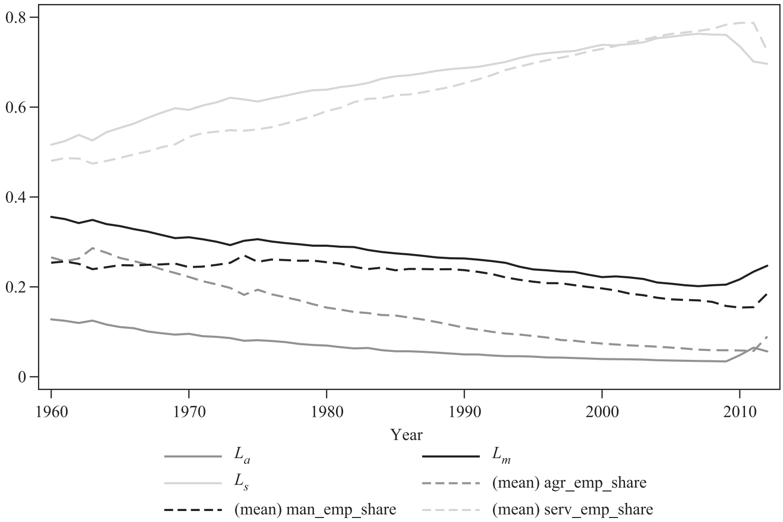
Table 4. **Simulation Scenarios**

Scenario	**1**	**2**	**3**	**4**
Parameters	Baseline as in Duarte and Restuccia (2010); services = business services + nonbusiness services	Baseline as in Duarte and Restuccia (2010); services = nonbusiness services; manufacturing + business services as one sector	Using actual data for initial year and final year; services = business services + nonbusiness services	Using actual data for initial year; services = nonbusiness services; manufacturing + business services added together
a	0.01	0.01	Share of agricultural employment in 2010	Share of agricultural employment in 2010
$\bar{a}$	0.11	0.11	Share of agricultural employment in 1960	Share of agricultural employment in 1960
$\bar{s}$	0.89	0.89	Share of nonbusiness and business services employment in 1960	Share of nonbusiness services employment in 1960
b	0.04	0.04	Share of manufacturing employment during the period 1960–2010	Share of manufacturing + business services employment during the period 1960–2010
ρ	−1.5	−1.5	−1.5	−1.5

Source: Modified from Duarte, Margarida, and Diego Restuccia. 2010. "The Role of Structural Transformation in Aggregate Productivity." *The Quarterly Journal of Economics* 125 (1): 129–73.

well the Duarte and Restuccia model does in explaining the paths of structural transformation that were observed in section III. Table 4 shows four simulations for each economy group. In the first scenario, I use the same parameter values as in the Duarte and Restuccia (2010) calibration exercise and include business and nonbusiness services in one all-inclusive service sector. In the second scenario, I group business services with manufacturing as one sector; as has been noted, the business service sector has a similar productivity profile as the manufacturing sector, and parts of business services also have similar properties as manufacturing in terms of externalities and tradability, among others (see, for example, Amirapu and Subramanian 2015). The third and fourth scenarios relax the stringent assumption in Duarte and Restuccia (2010) of the US being the benchmark economy for the calibrations. This is important as several economies are quite far from the US in terms of their structural features. Our third and fourth scenarios use parameter values that correspond to the average in a particular economy group for the initial and terminal years. The difference between the two scenarios is that Scenario 3 groups business and nonbusiness services as one service sector,

Figure 10. **Scenario 1, Structurally Developed Economies**



L_a = agricultural employment share, simulation results; L_m = manufacturing employment share, simulation results; L_s = services employment share, simulation results; (mean) man_agr_share = actual agricultural employment share; (mean) man_emp_share = actual manufacturing employment share; (mean) serv_emp_share = actual services employment share.
Source: Author's calculations based on GGDC data.

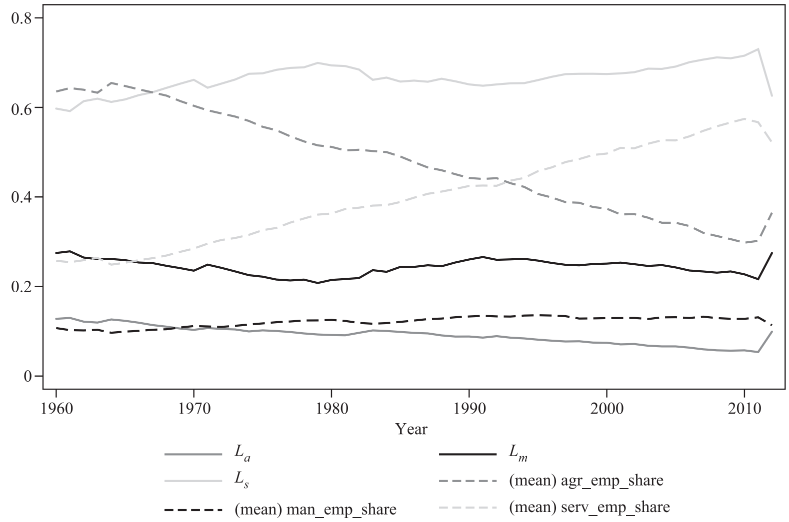
while Scenario 4 groups manufacturing and business services as one sector and nonbusiness services as another sector.[8]

Figures 10, 11, and 12 provide the simulations and actual shares of agriculture, manufacturing, and services for structurally developed, developing, and underdeveloped economies for Scenario 1, respectively. Figures 13, 14, and 15 provide the simulations and actual shares of agriculture, manufacturing, and services for structurally developed, developing, and underdeveloped economies for Scenario 2, respectively. Figures 16, 17, and 18 provide the simulations and actual shares of agriculture, manufacturing, and services for structurally developed, developing, and underdeveloped economies for Scenario 3, respectively. Figures 19, 20, and 21 provide the simulations and actual shares of agriculture, manufacturing, and services for structurally developed, developing, and underdeveloped economies for Scenario 4, respectively.

Across all four scenarios, the Duarte and Restuccia model predicts actual employment shares in agriculture, manufacturing, and services in structurally

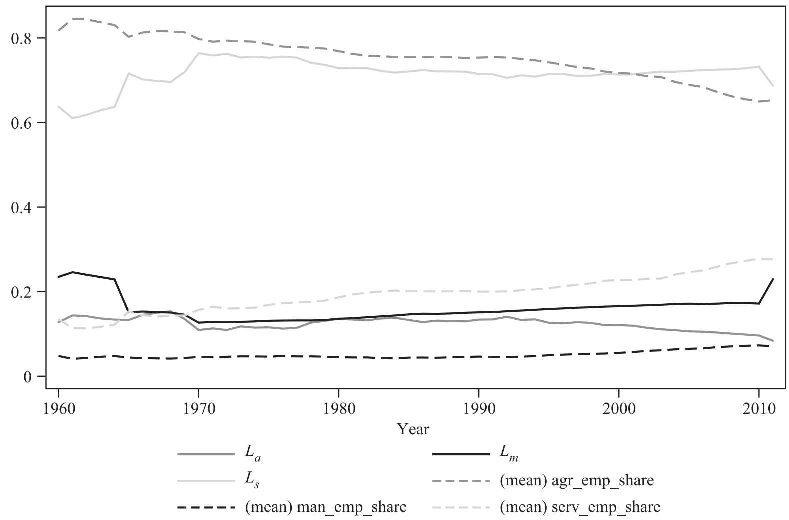
[8] While Duarte and Restuccia (2010) include nonmanufacturing industry with manufacturing as one sector, I take the level of employment in nonmanufacturing industry as exogenously given in my simulations. This is done for two reasons: (i) the share of employment in mining, which is one important subsector in nonmanufacturing industry, is not a function of productivity or income elasticities, and depends on whether the economy has mining resources; and (ii) both utilities and construction, the other subsectors in nonmanufacturing industry, are very different in their properties from the manufacturing sector.

Figure 11. **Scenario 1, Structurally Developing Economies**



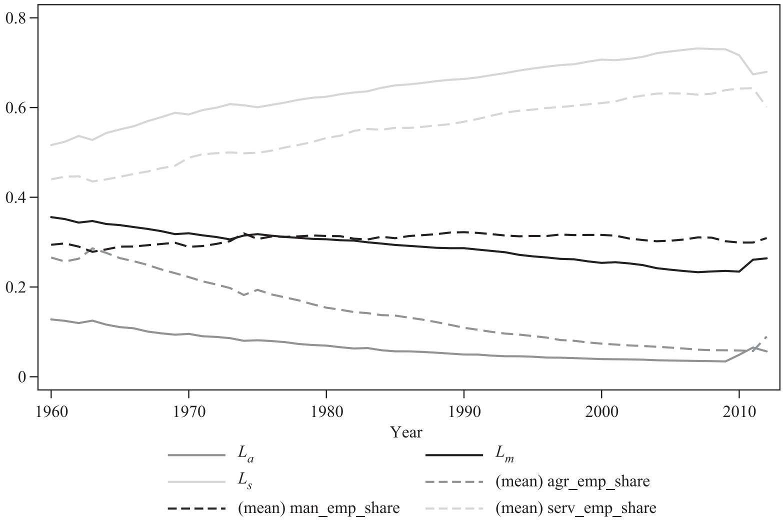
L_a = agricultural employment share, simulation results; L_m = manufacturing employment share, simulation results; L_s = services employment share, simulation results; (mean) man_agr_share = actual agricultural employment share; (mean) man_emp_share = actual manufacturing employment share; (mean) serv_emp_share = actual services employment share.
Source: Author's calculations based on GGDC data.

Figure 12. **Scenario 1, Structurally Underdeveloped Economies**



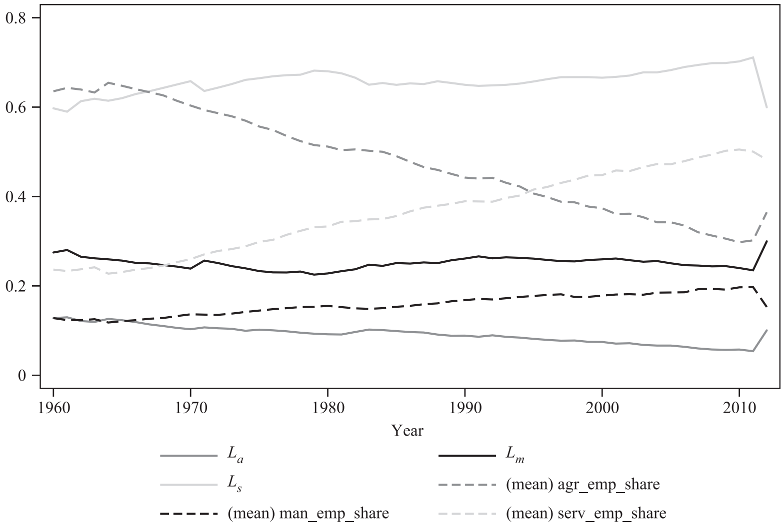
L_a = agricultural employment share, simulation results; L_m = manufacturing employment share, simulation results; L_s = services employment share, simulation results; (mean) man_agr_share = actual agricultural employment share; (mean) man_emp_share = actual manufacturing employment share; (mean) serv_emp_share = actual services employment share.
Source: Author's calculations based on GGDC data.

Figure 13. **Scenario 2, Structurally Developed Economies**



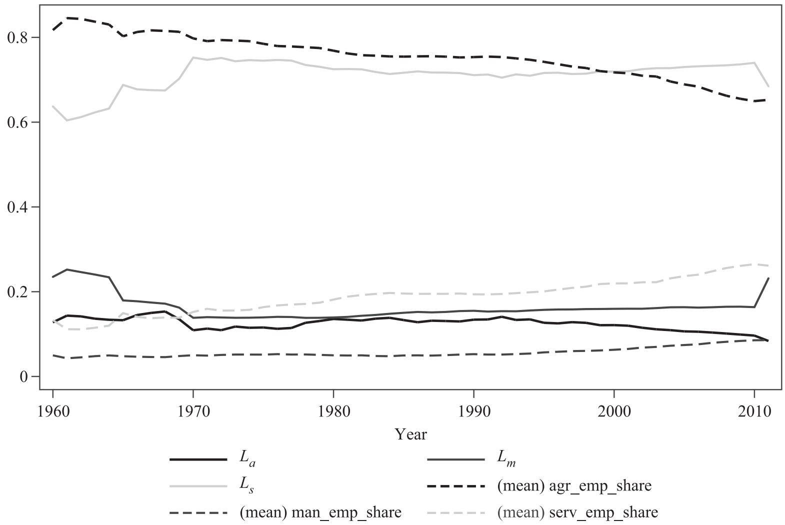
L_a = agricultural employment share, simulation results; L_m = manufacturing employment share, simulation results; L_s = services employment share, simulation results; (mean) man_agr_share = actual agricultural employment share; (mean) man_emp_share = actual manufacturing employment share; (mean) serv_emp_share = actual services employment share.
Source: Author's calculations based on GGDC data.

Figure 14. **Scenario 2, Structurally Developing Economies**



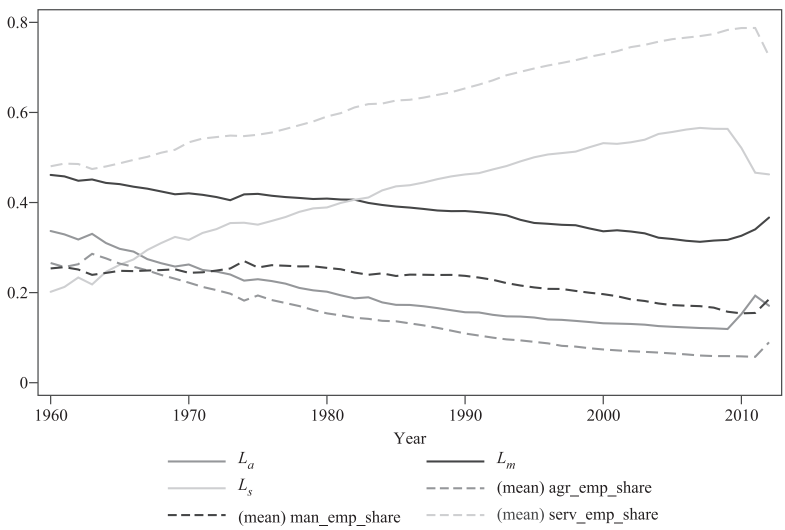
L_a = agricultural employment share, simulation results; L_m = manufacturing employment share, simulation results; L_s = services employment share, simulation results; (mean) man_agr_share = actual agricultural employment share; (mean) man_emp_share = actual manufacturing employment share; (mean) serv_emp_share = actual services employment share.
Source: Author's calculations based on GGDC data.

Figure 15. **Scenario 2, Structurally Underdeveloped Economies**



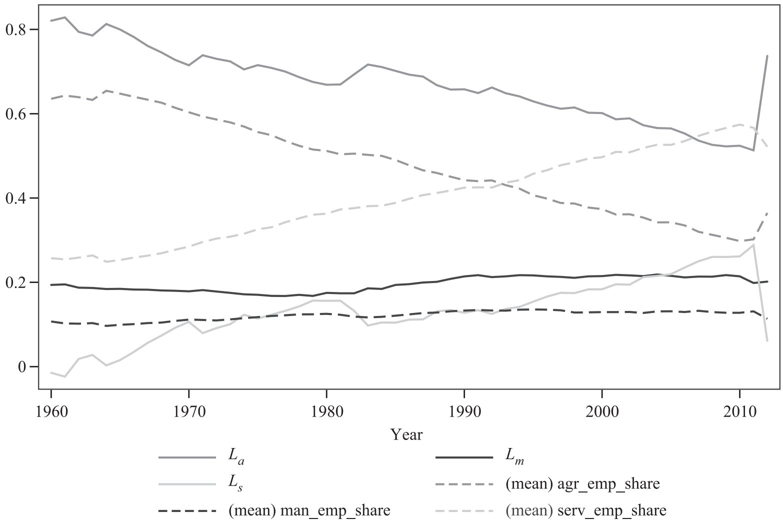
L_a = agricultural employment share, simulation results; L_m = manufacturing employment share, simulation results; L_s = services employment share, simulation results; (mean) man_agr_share = actual agricultural employment share; (mean) man_emp_share = actual manufacturing employment share; (mean) serv_emp_share = actual services employment share.
Source: Author's calculations based on GGDC data.

Figure 16. **Scenario 3, Structurally Developed Economies**



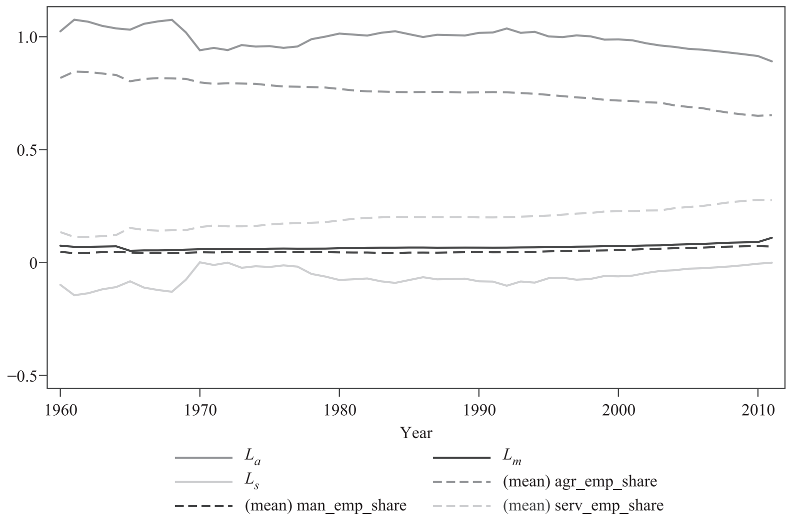
L_a = agricultural employment share, simulation results; L_m = manufacturing employment share, simulation results; L_s = services employment share, simulation results; (mean) man_agr_share = actual agricultural employment share; (mean) man_emp_share = actual manufacturing employment share; (mean) serv_emp_share = actual services employment share.
Source: Author's calculations based on GGDC data.

Figure 17. **Scenario 3, Structurally Developing Economies**



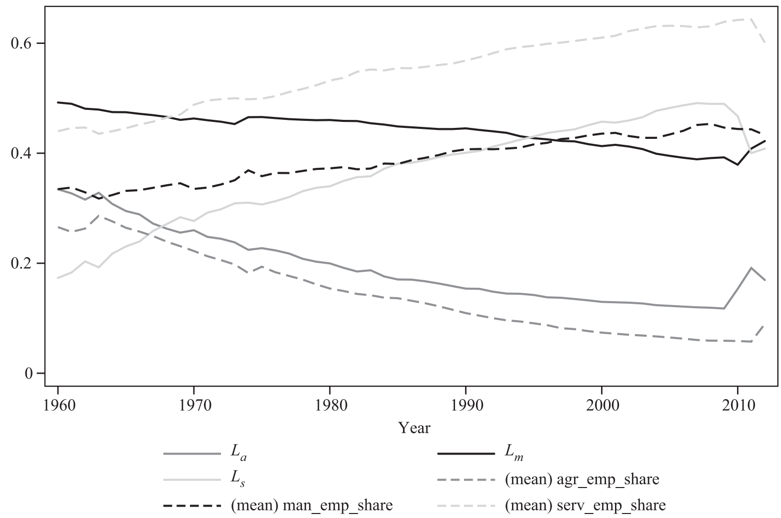
L_a = agricultural employment share, simulation results; L_m = manufacturing employment share, simulation results; L_s = services employment share, simulation results; (mean) man_agr_share = actual agricultural employment share; (mean) man_emp_share = actual manufacturing employment share; (mean) serv_emp_share = actual services employment share.
Source: Author's calculations based on GGDC data.

Figure 18. **Scenario 3, Structurally Underdeveloped Economies**



L_a = agricultural employment share, simulation results; L_m = manufacturing employment share, simulation results; L_s = services employment share, simulation results; (mean) man_agr_share = actual agricultural employment share; (mean) man_emp_share = actual manufacturing employment share; (mean) serv_emp_share = actual services employment share.
Source: Author's calculations based on GGDC data.

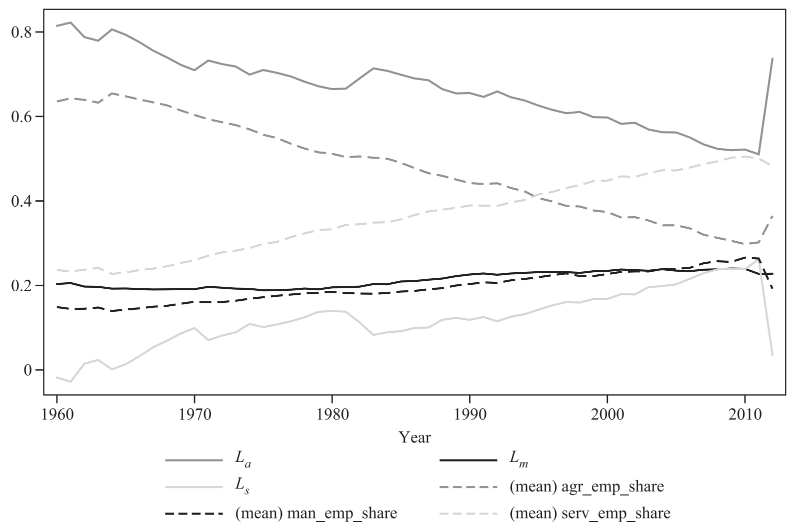
Figure 19. **Scenario 4, Structurally Developed Economies**



L_a = agricultural employment share, simulation results; L_m = manufacturing employment share, simulation results; L_s = services employment share, simulation results; (mean) man_agr_share = actual agricultural employment share; (mean) man_emp_share = actual manufacturing employment share; (mean) serv_emp_share = actual services employment share.

Source: Author's calculations based on GGDC data.

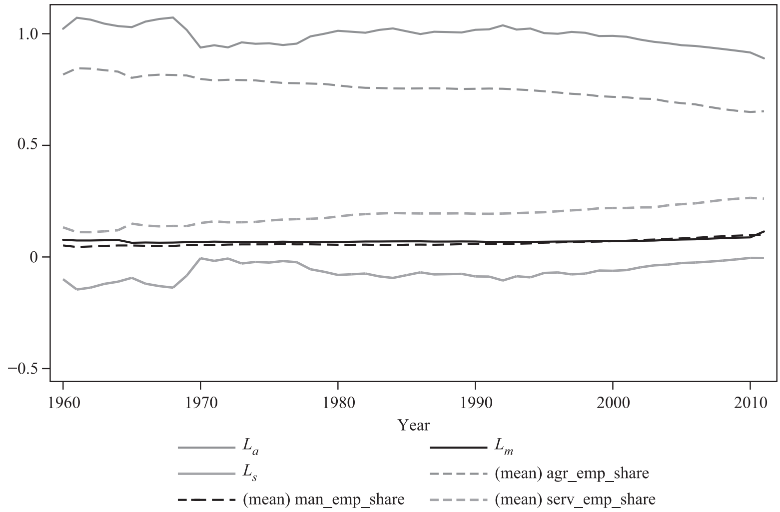
Figure 20. **Scenario 4, Structurally Developing Economies**



L_a = agricultural employment share, simulation results; L_m = manufacturing employment share, simulation results; L_s = services employment share, simulation results; (mean) man_agr_share = actual agricultural employment share; (mean) man_emp_share = actual manufacturing employment share; (mean) serv_emp_share = actual services employment share.

Source: Author's calculations based on GGDC data.

Figure 21. **Scenario 4, Structurally Underdeveloped Economies**



L_a = agricultural employment share, simulation results; L_m = manufacturing employment share, simulation results; L_s = services employment share, simulation results; (mean) man_agr_share = actual agricultural employment share; (mean) man_emp_share = actual manufacturing employment share; (mean) serv_emp_share = actual services employment share.
Source: Author's calculations based on GGDC data.

developed economies well, as may be expected. However, there are systematic errors in prediction across all four scenarios for structurally developing and underdeveloped economies. The Duarte and Restuccia model overpredicts the share of employment in services and underpredicts the share of employment in agriculture, particularly for structurally underdeveloped economies. For example, the percentage difference between the actual employment share in services and its predicted share is 76% for structurally developing economies and 286% for structurally underdeveloped economies. In contrast, the difference is a paltry 5% for structurally developed economies.

Across all four scenarios, there are clear differences in how the model does in explaining actual employment shares, especially for structurally developing and underdeveloped economies. For structurally underdeveloped economies, the model overpredicts the services employment share by 286% and 295% for Scenarios 1 and 2, respectively. For Scenarios 3 and 4, the model underpredicts the services employment share by 139% and 136%, respectively, and generates a negative employment share for services. This suggests that the Duarte and Restuccia model can provide a realistic explanation of structural transformation for rich economies but not for poor economies. While more realistic versions of the model may be able to generate simulations that are closer to the actual employment shares, an important reason behind the model's inability to capture structural transformation in low-income economies is that relative productivity changes are not as key a determinant of labor reallocation in poor economies as they are for rich economies. Therefore, it is necessary to rethink mainstream approaches to structural transformation that put a great deal of weight on sectoral productivity growth and income effects.[9]

VI. Conclusions and Policy Implications

The conventional view of structural transformation is informed by three stylized facts of economic development: (i) all economies exhibit declining employment in agriculture; (ii) economies at an early stage of the process of structural transformation exhibit a hump-shaped share of employment in industry, whereas this share is decreasing for economies at a more advanced stage; and (iii) all economies exhibit an increasing share of employment in services. In this paper, I show that this presumed path of structural transformation may no longer be the route to economic development for low-income economies. Classifying economies as either structurally developed, developing, or underdeveloped, I observe a different path of structural transformation in structurally underdeveloped economies, where workers are moving directly from agriculture to nonbusiness services, which as a sector does not have the same productivity gains as manufacturing. I also find that a prototype mainstream model does a poor job of replicating the patterns of structural transformation observed in low-income economies. This suggests that there needs to be a rethinking of the theoretical premises behind much of the mainstream approach to structural transformation and the identification of alternate causal mechanisms to explain the different types of structural transformation observed in the developing world.

What implications do these results have for policy? Clearly, for many of the middle-income economies in the sample, several of which are in Asia, productivity growth in manufacturing relative to nonbusiness services remains the key driver for the reallocation of workers from manufacturing to services. Further, for these economies, the Engel effects become important as per capita income increases, leading to an increase in the employment share of the highly productive business service sector over time. In contrast, for structurally underdeveloped economies, the

[9]An alternate mainstream approach that emphasizes income effects instead of relative productivity differentials as the key explanatory variable for structural transformation is provided by Comin, Lashkari, and Mestieri (2018). This approach assumes nonhomothetic preferences and shows that income effects account for 75% of the observed patterns of structural change. However, a limitation of this approach is that it essentially sees structural transformation as a consequence of economic development rather than a cause. While income effects have a role to play in explaining the hump-shaped nature of the manufacturing employment share, and the rapid growth in the services employment share in middle- and high-income economies, it cannot in itself explain why low-income economies have not been able to follow the path of structural transformation observed in middle- and high-income economies, where the movement of workers into manufacturing was the primary driver of growth at the early and middle stages of economic development.

low productivity of the manufacturing sector provides a more challenging setting for both economic growth and structural transformation. For these low-income economies, whatever limited possibilities that may exist for manufacturing-driven structural transformation must be focused on policies that can increase the productivity of the manufacturing sector, as well as on exploring options for growth that are based on the nonbusiness service sector, which remains the major sector of employment outside agriculture for structurally underdeveloped economies.

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Appendix

The Groningen Growth and Development Centre’s database provides annual employment data for 10 different sectors in 41 economies. The time spans for available data vary between economies; however, most economies in the database have observations from 1960 to 2012. Table A1 lists the 10 sectors with their respective ISIC Revision 3.1 codes and definitions.

Table A1. **Description of Sectors**

ISIC 3.1 Code	**Sector Name**	**Description**
A+B	Agriculture	Agriculture, hunting and forestry, and fishing
C	Mining	Mining and quarrying
D	Manufacturing	Manufacturing
E	Utilities	Electricity, gas, and water supply
F	Construction	Construction
G+H	Trade services	Wholesale and retail trade; repair of motor vehicles, motorcycles, and personal and household goods; hotels and restaurants
I	Transport services	Transport, storage, and communications
J+K	Business services	Financial intermediation, renting, and business activities (excluding owner-occupied rents)
L, M, N	Government services	Public administration and defense, education, health, and social work
O, P	Personal services	Other community, social and personal service activities, and activities of private households

ISIC = International Standard Industrial Classification of All Economic Activities.
Source: Timmer, Marcel, Gaaitzen de Vries, and Klaas de Vries. 2015. “Patterns of Structural Change in Developing Countries.” In *Routledge Handbook of Industry and Development*, edited by John Weiss and Michael Tribe, 65–83. London: Routledge.

Agriculture is the primary sector. The secondary industry sector can be divided into two groups—manufacturing industry and nonmanufacturing industry; the latter comprises mining, utilities, and construction. The tertiary service sector consists of trade, transport, business, government, and personal services. The ISIC classification of manufacturing includes primary processed products. Employment in each category is defined as all persons engaged in labor, and hence encompasses self-employed and family workers both in the formal and informal sectors.

Structural Transformation to Manufacturing and Services: What Role for Trade?

Kym Anderson and Sundar Ponnusamy*

Understanding how and why economies structurally transform as they grow is crucial for making sound national policy decisions. Typically, analysts who study this issue focus on sectoral shares of gross domestic product and employment. This paper extends those studies to include exports, including exports of services. It also considers mining, in addition to agriculture and manufacturing, and recognizes that some of the products of these four sectors are nontradable. The section on theory presents a general equilibrium model that provides hypotheses about structural change in different types of economies as they grow. These are then tested econometrically with annual data for the period 1991–2014 for a sample of 117 countries. The results point to the futility of adopting protective policies aimed at slowing deagriculturalization and subsequent deindustrialization in terms of sectoral shares, since those trends inevitably will accompany economic growth. Fortuitously, governments now have more efficient and equitable ways of supporting adjustments needed by people who choose or are forced to leave declining industries.

Keywords: comparative advantage, declining sectors, patterns of structural change, productivity growth
JEL codes: F11, F43, F63, N50, O14

I. Introduction

Most countries begin the process of economic growth with the vast majority of people engaged in producing staple food. As labor productivity improves with industrial capital accumulation or importation, an increasing number of workers are attracted to manufacturing and service activities—what Lewis (1954) simply called the modern sector. Lewis assumed that labor was more productive in the modern sector than in the traditional (mainly subsistence agriculture) sector (Gollin 2014), which leads one to expect the share of the population employed in agriculture and eventually the absolute number employed on farms to decrease. Later in

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the development process, the manufacturing sector's share of employment and eventually the number of workers in manufacturing decline as well (Herrendorf, Rogerson, and Valentinyi 2014; Fort, Pierce, and Schott 2018). Those economies fortunate enough to be well endowed per capita in minerals and energy raw materials or in natural forests find that mining (including of native forests by felling trees) employs some workers, but that its share of total employment tends to be quite small and also declines in the course of a nation's economic development.

Gross domestic product (GDP) shares follow a similar pattern to employment shares. However, agriculture's GDP share often declines faster than its employment share. By contrast, GDP shares of mining and manufacturing often decline slower than their employment shares, implying that labor productivity in those two sectors grows faster than the national average. Such labor productivity differences mean that, at the margin, migration of labor from traditional agriculture to manufacturing is likely to speed up economic growth. The GDP share of services has tended to grow slower than its employment share because (like traditional agriculture) it is relatively labor intensive, and it has had relatively slow productivity growth—although that is beginning to change for some services thanks in part to the information and communication technology (ICT) revolution (Duernecker, Herrendorf, and Valentinyi 2017).

This pattern of structural transformation in the course of national economic growth has been going on for many decades (Clark 1957; Kuznets 1966; Syrquin 1988; Syrquin and Chenery 1989; Timmer, de Vries, and de Vries 2015). The pace of these sectoral changes varies widely across countries, however, and not only because of their different rates of economic growth (Nickell, Redding, and Swaffield 2008).[1] Also, over time, peak shares of manufacturing in total GDP and employment have gradually fallen, and this has been occurring at earlier real per capita income levels. Moreover, in some developing countries, urbanization is occurring without much industrialization (Rodrik 2016; Gollin, Jedwab, and Vollrath 2016; Felipe, Mehta, and Rhee 2018; Nayyar, Vargas Da Cruz, and Zhu 2018).

Far more varied across countries are developments in the sectoral shares of national exports—a feature that is often ignored in comparative studies of structural transformation. Some of the world's high-income countries have managed to retain a comparative advantage in a small number of primary products, while some low-income countries have already built a comparative advantage in one or more services (Table 1). Moreover, as part of the current wave of globalization, further lowering of trade costs and government restrictions on trade is accelerating the

[1]There is also a vast literature on structural transformation within sectors as growth proceeds and its consequences in terms of inequality, poverty alleviation, and other indicators of inclusiveness. See, for example, Laborde et al. (2018) on agricultural transformation patterns. In this paper, we treat economic growth as exogenous, and we leave in the background its impact on factor markets, factor shares of GDP, and income distribution across occupations, regions, households, and individuals.

Table 1. **Top 30 Economies by 'Revealed' Comparative Advantage[a] in Agriculture, Mining, Manufacturing, and Services, 2014**

Agriculture		Mining		Manufacturing		Services	
Malawi	8.35	Angola	6.07	Bangladesh[b]	1.65	Bermuda	4.60
Guyana	7.90	Algeria	5.76	People's Republic of China	1.65	Macau, China	4.55
Benin	7.81	Kuwait	5.70	Botswana	1.55	Grenada[b]	4.36
Paraguay	7.49	Nigeria	5.67	Slovak Republic	1.53	Palau	4.32
Burkina Faso	7.18	Brunei Darussalam	5.58	Czech Republic	1.50	Maldives	4.25
Cote d'Ivoire	7.02	Saudi Arabia	5.24	Mexico	1.44	Antigua and Barbuda	4.23
New Zealand	6.65	Oman	5.20	Republic of Korea	1.40	St. Kitts and Nevis	4.19
Uruguay	6.14	Mongolia	5.17	Japan	1.37	Sint Maarten	4.18
Ethiopia	5.98	Azerbaijan	5.13	Viet Nam	1.37	Cabo Verde	4.15
Argentina	5.87	Qatar	5.06	Germany	1.34	Aruba	4.15
Burundi	5.73	Kazakhstan	4.99	Slovenia	1.33	Dominica[b]	4.05
Moldova	5.38	Sierra Leone	4.84	Italy	1.32	French Polynesia	4.05
Zimbabwe	5.29	Guinea	4.83	Hungary	1.31	Vanuatu[b]	3.94
Nicaragua	5.25	Zambia	4.62	Switzerland	1.24	Luxembourg	3.93
Honduras	5.22	Bolivia	4.62	Poland	1.23	St. Lucia	3.91
Fiji	4.55	Russian Federation	4.18	Thailand	1.18	Timor-Leste[b]	3.87
Uganda	4.49	Niger	3.87	Israel	1.17	Malta	3.84
Ecuador	4.48	Colombia	3.84	Pakistan	1.17	St. Vincent and the Grenadines[b]	3.77
Guatemala	4.44	Democratic Republic of Congo	3.67	Tunisia	1.15	Sao Tome and Principe	3.75
Tanzania	4.38	Republic of Yemen	3.66	Austria	1.14	Samoa	3.72
Belize	4.38	Bahrain	3.64	Romania	1.14	Cyprus	3.62
Brazil	4.13	Mozambique	3.51	Macedonia	1.14	Bahamas	3.58
Kiribati	4.09	Mauritania	3.48	Turkey	1.14	Lebanon	3.58
Mauritania	4.01	Trinidad and Tobago	3.47	Cambodia	1.12	Montenegro[b]	3.54
Senegal	3.54	Australia	3.36	Belgium	1.10	Tonga	3.52
Ukraine	3.15	Peru	3.34	Philippines	1.08	Djibouti[b]	3.49
Chile	3.13	Norway	3.33	Hong Kong, China	1.06	Afghanistan	3.29
Iceland	2.98	Ecuador	3.15	France	1.02	Curacao[b]	3.28
Costa Rica	2.97	Chile	3.14	El Salvador	1.01	Jamaica	3.14
Myanmar	2.91	Cameroon	2.62	Malaysia	1.01	Nepal	2.85

Notes:
[a]Index of "revealed" comparative advantage (RCA) is the share of a sector in an economy's total goods and service exports divided by that sector's share in global international trade in goods and services (Balassa 1965). The export shares range from 62% to 24% for agriculture, 96% to 41% for mining, 86% to 52% for manufacturing, and 98% to 61% for services. (There are well over 30 more economies whose services share of exports exceeds twice the global average of 21%.)
[b]Due to insufficient data for some other variables, these economies are not included in Figures 4, 6, and 7 and in the regressions reported in subsequent tables.
Source: Authors' compilation based on United Nations (2018) export value data for goods and International Monetary Fund balance of payments data for services as presented in World Bank (2018).

fragmentation of production processes. This is making an ever-higher proportion of goods and services internationally tradable and changes in comparative advantage less predictable (Baldwin 2016, 2019; Constantinescu, Mattoo, and Ruta 2018; Rodrik 2018).

Economies that are well endowed with natural resources per worker and per unit of produced capital, and thus have a comparative advantage in farming or mining, often fret that specializing in primary production and exports slows their economic growth. That concern stems from two facts. First, the international terms of trade for such countries have faced a long-term decline and are more volatile than those for other countries.[2] Second, the tradable sectors of high-income countries typically have been dominated by manufactures. Spurred by Prebisch (1950, 1959) and Singer (1950), pessimism about primary products caused many newly independent developing countries to provide import protection for their manufacturing sectors from the 1960s to at least the 1980s. Ironically, that protectionist policy choice, far from boosting their long-run economic growth, led resource-rich developing economies—as well as Australia and New Zealand—to grow slower than others until they belatedly opened their economies (Anderson 1998). Even during the present decade, that pessimism has led governments of some resource-rich emerging economies to seek ways to diversify away from their main export activities when prices of those primary exports slumped. It stems in part from not realizing that growth in, say, the mining sector creates jobs not only in that sector but also in the industries producing nontradables, as that boost in the nation's income translates to more consumption of all normal products, including those that have to be produced domestically.

There are numerous explanations for the differences in structural transformation patterns across countries. Commonly included in these explanations are differences in rates of technological improvements (since multifactor productivity growth rates differ across sectors and in their factor-saving bias), rates of change in relative factor endowments (since factor intensities of production vary across sectors), and international terms of trade (since countries differ in their comparative advantages). Demand considerations are less commonly considered, yet per capita incomes matter because income and price elasticities of demand for products differ across sectors, including nontradables. Also important are policies that distort relative domestic producer and consumer prices of products in each sector.

Recent empirical attempts to explain observed structural changes have tended to focus on one or a subset of countries, sectors (normally ignoring mining), or contributing factors (particularly labor productivity), and they have tended to

[2] See, for example, Spraos (1980); Pfaffenzeller, Newbold, and Rayner (2007) and the references therein on price trends; and Williamson (2012) on historical evidence of volatile terms of trade leading to slower growth rates for commodity exporters than rates enjoyed by exporters of predominantly manufactured goods.

focus on employment or GDP shares and ignore the trade dimension (as pointed out by Matsuyama 2009). Yet changes in sectoral export shares may reflect changes in a country's comparative advantages or in policies affecting their trade specialization and may help explain differences in changes in sectoral shares of not just exports but also GDP and employment.

The purpose of this paper is to explore, for each of the four key sectors (agriculture, mining, manufacturing, and services), the contributions of changes in per capita incomes, relative factor endowments, and sectoral productivity growth on sectoral shares of GDP, employment, and exports since 1990. We chose this limited time period so as to have a large sample of countries covering the full spectrum of per capita incomes.

The paper begins by summarizing standard theory that can explain the above trends and stylized facts regarding structural changes in a closed economy as it grows and thus also in the global economy. It then examines how that theory differs when one considers a small open economy that is able to trade with the rest of the world given that country's terms of trade. The differences between closed and open economies are small for sectoral shares of GDP and employment, but can be large for sectoral shares of exports. The paper then takes that theory to a panel of annual data for 117 countries over the 25 years until 2014, to show the extent to which declines in the relative importance of primary and manufacturing sectors in GDP, employment, and exports are explained by changes in per capita income, relative factor endowments, and sectoral productivity growth.

The results are unsurprising for GDP and employment shares, whose decline in primary production and then manufacturing can be viewed as symptoms of successful economic growth. However, sectoral export shares, and thus indexes of "revealed" comparative advantage, are far more varied across the spectrum of per capita incomes: there are numerous developing countries with export specialization in services even at low per capita income levels, while high-income countries that are relatively well endowed in agricultural land or mineral reserves per worker have retained export specialization in a few primary products. This makes clear that it is not inevitable that a growing economy will pass from production and export specialization in primary products to manufactures and then services: some will skip the manufacturing phase while others will grow rich (and have a large nontradables sector) and remain specialized in exports of primary products (Gill et al. 2014).

The structure of this paper is as follows. The first section summarizes what trade and development theory would lead one to expect about structural transformation as economies grow. Sources of the data to be used to test a set of hypotheses are then described. As a prelude to the econometrics, scatter diagrams are presented to show the spread and mean of sectoral shares at different levels of real per capita income. Regression results are then presented to show the extent to which sectoral share changes are explained by changes in per capita income, relative factor endowments, and, in the case of agriculture, productivity growth in that sector. The final section draws out several important implications for policies of both high-income and emerging economies, including those with extreme relative factor endowments.

II. Theory

It is helpful to begin by first considering a closed economy, then an open two-sector economy, and then one that also includes a sector producing nontradable products. To keep the analysis as simple as possible, we assume that there are no intermediate inputs and all markets are perfectly competitive and free of government interventions so that there is full employment of all factors of production.[3] Growth is assumed initially to come exogenously from improvements in total factor productivity (TFP) with no changes in aggregate factor endowments.[4] The influence of factor endowment changes is considered later in this section.

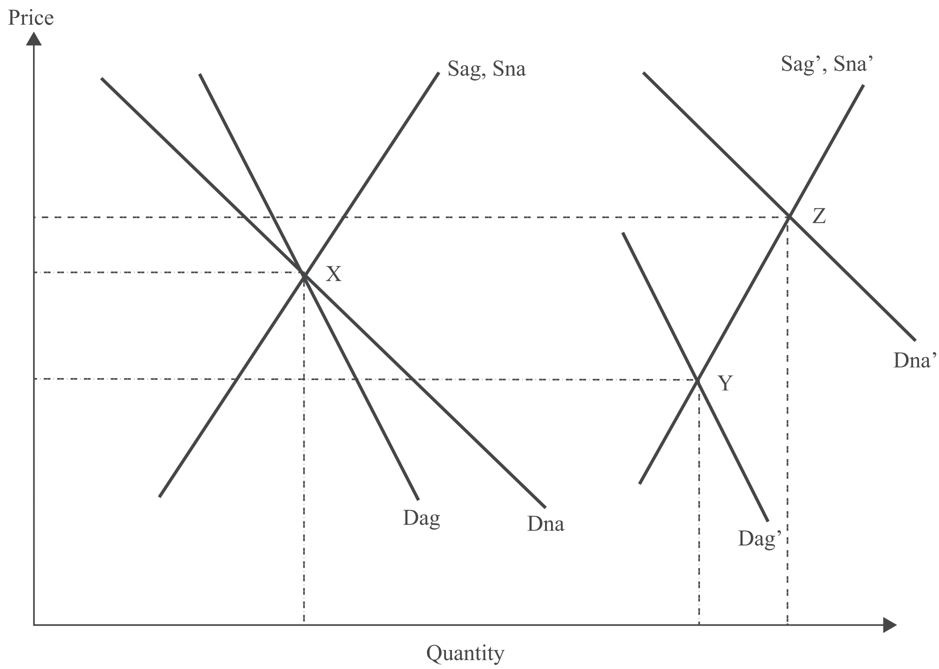
A. Gross Domestic Product Shares of a Closed Economy

Consider first a closed economy with only two sectors: agriculture and nonagriculture. If its economic growth was due to productivity growth occurring equally rapidly in both sectors, their supply curves would shift out at the same rate. This is illustrated in Figure 1, where it is assumed that the two sectors' supply curves coincide initially and hence also subsequent to productivity growth, which lowers marginal costs equally in the two sectors. In this closed economy, the demand curves for the two sectors' outputs are shown to cross on that common supply curve and hence each sector has a 50% share of GDP at point X, given the assumed absence of intermediate inputs. Because people spend a declining proportion of their incomes on food as their incomes rise, the demand curve shifts out less for agricultural goods than for other products after productivity-improving income growth. Thus, outputs of both sectors rise but less so for agriculture, and the price of farm products falls relative to the price of nonfarm products—and more so the more price inelastic the demand for food. The GDP share of agriculture (nonagriculture) is below (above) 50% at the new equilibrium points Y and Z. It would fall even more over time in that growing economy as income and price elasticities of demand for food fall further below 1 as per capita income rises (Engel 1857). And a faster rate of reduction in marginal costs in agriculture than in the rest of the economy (as suggested by the

[3] Changes in taxes, subsidies, or quantitative restrictions on production, consumption, or trade in products or factors used to produce them also affect the structural transformation of an economy but are ignored here.

[4] The emphasis on technical change as the key source of economic growth that is inducing structural transformation is consistent with recent empirical literature (Herrendorf, Rogerson, and Valentinyi 2013, 2014; Herrendorf, Herrington, and Valentinyi 2015).

Figure 1. **Shifts in Demand and Supply Curves for Agricultural and Nonagricultural Products in a Closed Growing Economy**



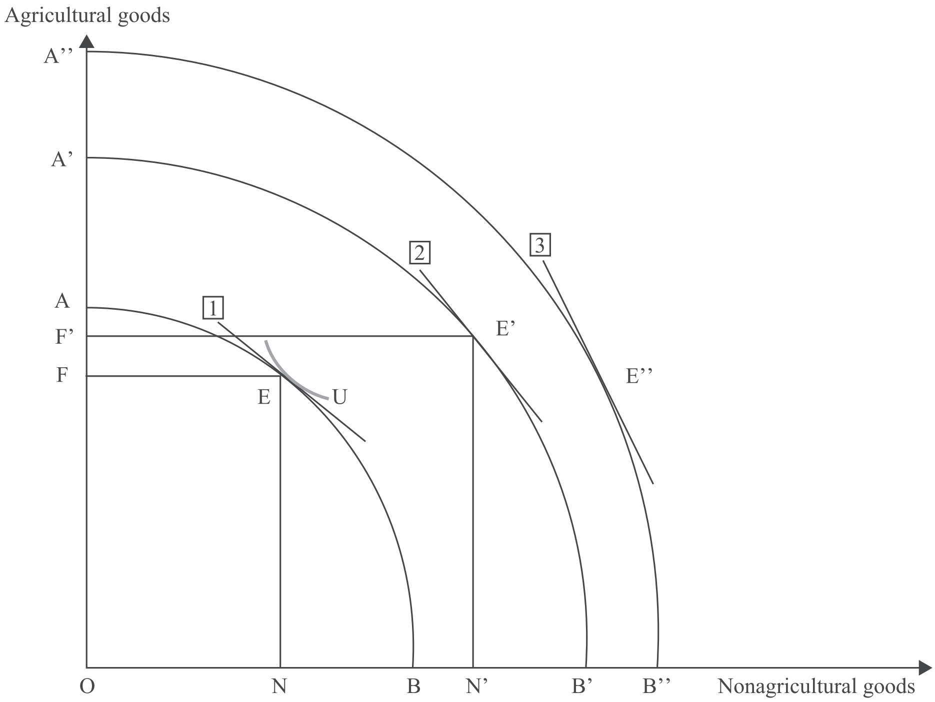
Sag = agricultural supply, Sna = nonagricultural supply, Dag = agricultural demand, Dna = nonagricultural demand.
Source: Authors' adaptation from Figure 5.2 of Johnson, D. Gale. 1991. *World Agriculture in Disarray*, revised edition. London: St. Martin's Press.

empirical work of Martin and Mitra 2001; and Gollin, Parente, and Rogerson 2002) would reinforce that tendency.

This model is appropriate not only for a closed economy but also for the world economy as a whole: it suggests that the ratio of the international prices of agricultural products to other products will decline over time as global per capita income grows. This is consistent with what happened over the 20th century (Pfaffenzeller, Newbold, and Rayner 2007).

The effects of these tendencies in a closed economy can also be seen in Figure 2, where AB represents the initial production possibility curve and U captures the community's preferences (that is, society would be indifferent about consuming any bundle of farm and nonfarm products indicated by that curve). The tangency point E is the initial equilibrium outcome where supply equals demand for each of the two products in this closed economy. The initial equilibrium price of all other products in terms of farm goods is given by the (negative) slope of price line 1, and the two sectors are shown again to have a 50% share of GDP initially. Then economic growth, whether due to productivity growth or an increase in factor endowments,

Figure 2. **Effects of Productivity Growth in Agriculture and Nonagriculture Sectors in a Closed Growing Economy**



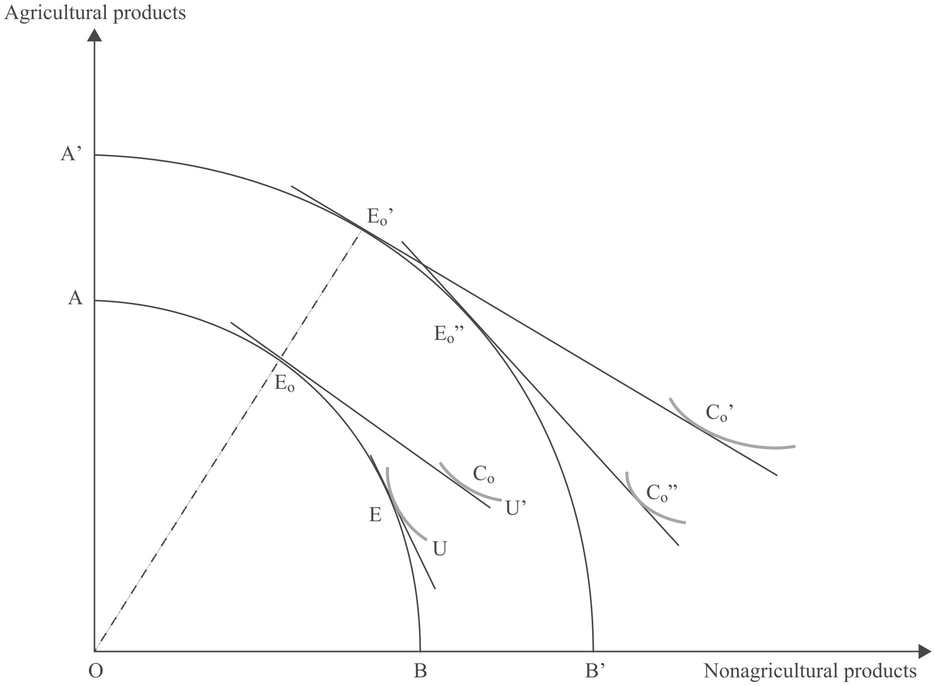
Source: Authors' adaptation from Anderson, Kym. 1987. "On Why Agriculture Declines with Economic Growth." *Agricultural Economics* 1 (3): 195–207.

would shift AB to the northeast to A'B' if the shift is equiproportionate. The associated growth in per capita income would lead to a new equilibrium at E', where the share of income spent on farm products would be lower than at E (because the income and price elasticities of demand for food are less than 1). Even though the quantity of food consumed may have risen (from F to F'), the consumed quantity of other products has risen more (from N to N'); and the relative price of farm products is lower (price line 2 is steeper than price line 1). In this simple model with no intermediate inputs, so that price times quantity summed over all products is equal to GDP, the share of agriculture in GDP falls. It would fall even more if productivity growth in agriculture exceeded that of the rest of the economy, such that E moves to E" where price line 3 is even steeper than price line 2.

B. Gross Domestic Product Shares of a Small Open Economy

What about a small open economy that can export any share of its production or import any share of its consumption of both farm and nonfarm products at the

Figure 3. **Effects of Productivity Growth in Agriculture and Nonagriculture Sectors in a Small Open Growing Economy**



Source: Authors' adaptation from Anderson, Kym. 1987. "On Why Agriculture Declines with Economic Growth." *Agricultural Economics* 1 (3): 195–207.

prevailing international terms of trade? Then instead of its initial equilibrium at point E in Figures 2 and 3, this economy would produce at point E_o and consume at point C_o in Figure 3, where the international terms of trade are given by (the negative of) the slope of E_oC_o. In that case, this economy's farm sector would have a larger share of GDP at E_o than it had at E when it was closed.

If productivity growth occurred in this small open economy but the international terms of trade remained unchanged, agriculture's share of GDP would rise or fall depending only on whether that growth is biased toward farm or nonfarm production. If productivity growth is sectorally unbiased, agriculture's share would remain unchanged at E_o' in Figure 3. If economic growth abroad is similarly unbiased, it would lower the relative price of farm products for reasons mentioned above, in which case this small economy's international terms of trade would deteriorate and its new equilibrium would be at point E_o''.

To generalize, if productivity growth is occurring abroad and is not heavily biased against agriculture, the farm's share of GDP in this small open economy will decline unless its own productivity growth is sufficiently biased toward agriculture (contrary to the rest of the world) for the change in quantity to more than offset its terms of trade deterioration.[5] The agricultural growth bias would have to be even stronger in a large farm-exporting economy since its growth would further depress the country's international terms of trade.

C. Adding a Nontradables Sector

In reality, a large part of each economy involves the production and consumption of nontradable goods and services because of these products' prohibitively high trade costs. The prices of nontradables are determined solely by domestic demand and supply conditions and related policies because the quantity demanded has to equal the quantity produced domestically.

If one were to combine the two tradable sectors into one "super sector" of tradables, then the above closed economy conclusion that agriculture's share of GDP is likely to decline over time will be stronger if the share of tradables in GDP declines in growing economies.

Available evidence suggests that the income elasticity of demand for services—which make up the vast majority of nontradables—is well above unity in developing countries and tends to converge toward unity as incomes grow (Lluch, Powell, and Williams 1977; Kravis, Heston, and Summers 1983; Theil and Clements 1987). If productivity growth is equally rapid for nontradables as for tradables, while demand grows faster for nontradables than for tradables, both the price and quantity and hence the value of nontradables will increase relative to that of tradables. This is illustrated in Figures 2 and 3 if the axes are relabeled "tradables" and "nontradables" in place of "agricultural goods" and "nonagricultural products", respectively. If productivity growth is faster in tradables than in nontradables, it is even more likely that the share of nontradables in GDP would rise and the real exchange rate (the price of nontradables relative to tradables) would appreciate. In that case, the share of tradables in GDP would fall.

At the global level, the income elasticity of demand for manufactured consumer goods also matters, as Figures 2 and 3 showed for agriculture. While that elasticity may be above 1 in low-income countries, it falls increasingly below 1 as countries become more affluent.[6] Hence, the manufacturing sector is also likely—thanks to the nature of demand for services—to come under pressure to decline eventually even in small open economies as they become affluent, following the pattern for agriculture. Again, the exceptions would be in those small open economies where manufacturing TFP growth is exceptionally rapid.

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[5] If the source of growth was entirely learning-by-doing in the manufacturing sector, it is even more certain that agriculture will decline in this small open economy, as shown formally by Matsuyama (1992).

[6] Empirical estimates for the United Kingdom and the United States support a declining income elasticity of demand for manufactured goods as per capita income rises (Herrendorf, Rogerson, and Valentinyi 2014, Figure 6.7). See also Matsuyama (2009), Boppart (2014), and Lawrence (2018).

D. Allowing for Mining

To also be relevant to resource-rich economies, we assume now that the natural resource-based tradables sector involves mining as well as agriculture. Domestic demand for ores, minerals, and energy raw materials rise as a country begins to industrialize, build more infrastructure, and become more affluent. But then, such demand tends to fall as high-tech manufacturing and services increasingly dominate nonprimary production, although improvements in technology can at times alter this inverted U-shaped relationship with real GDP per capita (Radetzki and Tilton 1990, Crowson 2018). Mining differs from other sectors in that it can expand not only because of sectoral TFP growth but also following the discovery of new reserves, which is commonly exploited with the help of mining-specific foreign capital inflows.

E. Allowing for Some Services to Be Tradable and Some Goods to Be Nontradable

As trade costs fall, an increasing range of goods and services are becoming internationally tradable (Liu et al. 2018). By 2014, services accounted for at least 40% of national export earnings in about one-third of all countries (the global average was 21%). Some of these tradable services are based on natural resources (e.g., tourism in conservation parks, beaches, and ski resorts; and gas pipelines or transport corridors), while others take advantage of low wages (call centers) or sophisticated financial sectors (international banking and insurance). To accommodate these activities, we include resource-based services in agriculture and mining in the natural resources sector and the rest in manufactures in the "other tradables" sector.

The sectoral GDP and employment shares data for each economy do not indicate the proportion of each sector's jobs or output that are producing nontradables. One can think of the service shares as being "nontradables" if it were the case that the number of service jobs or GDP value related to tradables were equivalent to those for goods that are nontradables.

F. Employment Shares

Given our initial assumption of no changes in aggregate factor endowments, the above reasoning is close to sufficient for understanding changes in sectoral shares of labor employment: agriculture (services) shares decline (rise) as per capita income grows, while manufacturing shares follow an inverted U-shaped path. Complications arise, however, when (i) there are lags in labor migrating out of declining sectors or (ii) labor productivity growth differs substantially between sectors.

Historically, out-migration from agriculture has been sluggish because it typically requires a physical, social, and cultural move from living on or near a farm to a town or city—something that is far less likely to be necessary for an urban worker moving to a new manufacturing or service sector job. Thus, the decline in the share of employment in agriculture may lag the decline in agriculture's share of GDP. It is also possible that the employment share statistics are biased because they do not take into account the full extent to which off-farm activities provide farm households with some of their income (often a substantial share—see Otsuka, Estudillo, and Sawada 2009). Because those data refer simply to main occupations rather than hours worked, they also understate the productivity of farm workers per hour, since they do not account for the degree of underemployment in farming given its seasonality (McCullough 2017).

The share of mining in employment, by contrast, is typically less than its share of GDP in settings where mining is highly capital intensive. Indeed, that is the norm, not only in high-income countries but also in numerous resource-rich developing countries that are open to mining-specific (including human) capital inflows from abroad. Such capital inflows, and the (often associated) discovery of new subsoil or subseabed reserves, can be a significant source of both mining sector GDP growth and structural transformation—but not necessarily of more local jobs if local workers lack the skills required for those tasks. This contrasts with mining booms before World War I that attracted immigrants for such labor-intensive tasks as panning for gold.

Productivity impacts on sectoral employment can be positive or negative.[7] On the one hand, the adoption by one sector of labor-saving technologies can raise its output and perhaps exports but reduce its employment, thereby pushing labor to other sectors (Gollin, Parente, and Rogerson 2002, 2007). On the other hand, labor could be pulled out of a sector due to new job prospects in another sector that is enjoying faster TFP growth and/or faster demand growth associated with spending higher incomes (Lucas 2004; Gollin, Parente, and Rogerson 2007). The push element has always been present for farmers and, more recently, for factory workers where robotics and digitalization are the latest influences. Artificial intelligence will replace some workers, but the income growth it generates will lead to the creation of new jobs (Acemoglu and Restrepo 2018, Baldwin 2019). The net effect of the latter pull factor on sectoral employment is uncertain, but if it favors nontradable services, that would be a further reason to expect declines in employment in the various tradable goods sectors.

[7] According to the induced innovation hypothesis, productivity growth will be biased in favor of saving the scarcest factor of production (Hicks 1963, Hayami and Ruttan 1985). That hypothesis is more likely to be supported in countries at the technological frontier, while producers in emerging economies will choose whatever is most profitable from among the full spectrum of available technologies as their relative factor prices change.

G. Allowing for Factor Endowment Changes

The assumption at the outset of this theory section has been that national income growth comes from exogenous technological change. Productivity also changes as climates change, affecting various sectors unevenly. Growth also results from investments in innovation or importation and adaptation of technologies from more advanced economies. Income growth can also result from net factor accumulation over and above depreciation.[8] Natural resource capital, for example, can be discovered through mining exploration or improved through investment (e.g., clearing and fencing farmable land). Produced capital can also be enhanced through domestic investment or by importing capital from abroad; and the stock of labor can change through births exceeding deaths, changes in labor force participation (e.g., more women choosing paid work), population aging, and immigration net of emigration.

Any of these changes alters the per worker endowments of natural resources and produced capital and hence the country's comparative advantages. According to Rybczynski (1955), growth in the aggregate stock of capital per worker can have the effect, at constant relative product prices, of expanding the output of the most capital-intensive industries and shrinking that of the most labor-intensive industries. In developing countries where agriculture is among the most labor-intensive industries, along with such industries as clothing and footwear, the growth in the stock of capital per worker can be another source of relative decline in those sectors of growing economies. Martin and Warr (1993, 1994) found that this has been the case for agriculture in Indonesia and Thailand.

H. Export Shares: Less Clear-Cut

What about sectoral export shares? These shares depend on the country's comparative advantage and on how rapidly the tradability of each sector's output increases as trade costs are lowered. For example, if investments in transport-related infrastructure cause a small economy's trade costs to fall relative to those of the rest of the world, this will alter its comparative advantages and cause it to be internationally competitive in a larger number of products (Venables 2004). Should its farm products gain more from the decline of trade costs than its nonfarm products, for example, the country would see its comparative advantage in agriculture strengthen.

The two key workhorse theories of comparative advantage developed in the 20th century are the Heckscher–Ohlin model, in which all factors of production are intersectorally mobile, and the specific-factors model, in which one factor is

[8] Indeed, Jorgenson and Griliches (1967) argue that if all investments in capital were fully taken into account, they would fully explain economic growth, leaving no residual to be labeled as "technological change."

specific to each sector. These two models have been blended to account for primary sectors that use specific natural resource capital (farmland and mineral deposits) in addition to intersectorally mobile labor and produced capital (Krueger 1977, Deardorff 1984). This blended model suggests we should expect primary product exports from relatively lightly populated economies that are well endowed with agricultural land and/or mineral resources to those economies that are densely populated with few natural resources per worker.

Leamer (1987) developed this Krueger–Deardorff blended model further and related it to paths of economic development. If the stock of natural resource capital is unchanged, rapid growth of produced capital (physical capital plus human skills and technological knowledge) per hour of available labor tends to strengthen comparative advantage in nonprimary products. By contrast, a discovery of minerals or energy raw materials would strengthen that country's comparative advantage in mining and weaken its comparative advantage in agricultural and other tradable products, other things being equal.[9] Such a mineral discovery would also boost the country's income and hence the demand for nontradables, which would cause its sectorally mobile resources to move into the production of nontradable goods and services, further reducing farm and industrial production.

At early stages of economic development, a country with high trade costs is typically agrarian, with most GDP and employment in the agriculture sector (when home-produced food is included in the national accounts). If such a country has a relatively small stock of agricultural land and other natural resources per worker, labor rewards will be low. It may be autarkic initially, but as its trade costs fall or government trade restrictions are removed, it will develop a comparative advantage in unskilled labor-intensive, standard-technology manufactures. Then as the stocks of industrial and human capital per worker grow, there will be a gradual move toward exporting more of those manufactures that are relatively intensive in their use of physical capital, skills, and knowledge.[10]

In the standard Heckscher–Ohlin model of international trade, in which factors of production are perfectly intersectorally mobile, international trade in

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[9]Columns 3–5 of Table 2 are close to the relative factor endowment ratios in the trade theory developed by Leamer (1987). They require imagining Leamer's triangle in which countries are points and each of the three sides represents one of the factor endowment ratios (natural resources per worker, produced capital per worker, and natural resource per unit of produced capital). The closer a point is to the natural resource apex of the triangle, the stronger that country's comparative advantage in resource-based products.

[10]The above theory of sectoral changes and evolving comparative advantages has been used successfully to explain the 20th century "flying geese" pattern of comparative advantage and then disadvantage in unskilled labor-intensive manufactures, as some rapidly growing economies expand their endowments of industrial capital per worker relative to the rest of the world (Ozawa 2009). It has also been used to explain the evolving patterns and project future patterns of trade between Asia's resource-poor first- and second-generation industrializing economies and their resource-rich trading partners (Anderson and Smith 1981, Anderson and Strutt 2016). It is less likely to explain bilateral trade patterns in the current century due to fragmenting production processes and lengthening regional and global value chains (Baldwin 2016, 2019; Constantinescu, Mattoo, and Ruta 2018; Liu et al. 2018; Rodrik 2018).

Table 2. **Gross Domestic Product, Agricultural Land, Mineral Resources, and Other Capital Endowments in Asia and Other Economies Relative to the World (per capita), 2000–2004 and 2014**

	Total Land per Worker[a] 2000–2004	Agricultural Land per Capita[a] 2000–2004	Agricultural Land Value per Capita[b] 2014	Mineral Resources per Capita[b] 2014	Other Capital per Capita[b,c] 2014	GDP per Capita[b] 2014
Bangladesh	4	8	36	1	6	10
Taipei,China	8	5	low	1	high	208
Republic of Korea	9	5	48	1	273	256
Japan	12	5	25	1	355	350
India	15	22	59	15	9	14
Viet Nam	18	14	104	35	13	18
Philippines	21	19	65	8	17	26
People's Republic of China	28	54	156	63	60	71
Thailand	32	39	131	9	35	54
Indonesia	40	27	78	43	25	32
Myanmar	59	42	n/a	low	low	12
Cambodia	65	49	82	0	6	10
Malaysia	74	41	143	109	136	103
Lao People's Democratic Republic	151	42	135	51	12	20
Asia	**24**	**34**	**102**	**63**	**33**	**37**
United States	144	178	117	119	640	503
Sub-Saharan Africa	165	148	78	39	11	17
Latin America	207	171	139	122	73	91
Middle East and North Africa	280	91	83	2,287	19	108
New Zealand	326	550	366	n/a	high	409
Australia	1,799	2,856	202	1,584	500	571
World	100	100	100	100	100	100

GDP = gross domestic product.
Notes:
[a]A percentage of the world average, based on hectares.
[b]A percentage of the world average, based on United States dollars at the market exchange rate.
[c]Other capital refers to non-natural produced (including human) capital.
Source: Authors' compilation drawing on 2000–2004 World Development Indicators data assembled in Sandri, Valenzuela, and Anderson (2006) and 2014 World Bank data in Lange, Wodon, and Carey (2018).

products is a perfect substitute for trade in factors in that product price equalization across countries due to product trade would generate factor price equalization (Mundell 1957). This is not so in the specific-factor or blended-trade models, however, where rewards to intersectorally mobile labor will tend to be above (below) the global average in countries that are lightly (densely) populated. This wage difference may be sufficient to induce international labor movements.

Specifically, natural resource-abundant economies may attract, from more densely populated countries, migrants who seek to become farmers or miners in frontier regions. That would raise the settler economy's total, if not per capita GDP, and cause its primary sector's share of GDP to fall more slowly than in economies that are growing equally rapidly but are less abundant in natural resources. Also, if resource-rich economies direct some of their capital investment to forms of capital (including new technologies) that are specific to primary production, they would not develop a comparative advantage in manufacturing or services until a later stage of development, at which time their exports from those nonprimary sectors would be relatively capital intensive. This is all the more likely if new technologies developed for the primary sector become increasingly labor saving as real wages rise—leading potentially to what are known as factor intensity reversals. This happens when a primary industry in a high-wage country retains competitiveness against low-wage countries by that industry becoming more capital intensive. The primary sector's share of GDP would decline more slowly the faster its productivity growth compared to the average global rate, both relative to that of other sectors.

International prices of some commodities typically have cycles around their long-run trends. Moreover, new discoveries of raw materials are made from time to time. A boom in one of the main tradable sectors of a country that is not matched in (many) other countries has the effect of strengthening that country's real exchange rate. This, in turn, draws resources to that sector and to the sectors producing nontradables, such as services, and thus away from other sectors producing tradables, other things being equal. It also raises national income and thus boosts the domestic demand for both locally produced and imported products. Together, these forces reduce the volume of exports from nonbooming sectors and the domestic currency price of those exports and hence their aggregate value (Corden 1984).

Such a boom in a key export sector could be supply driven (e.g., the discovery of a mineral or energy raw material deposit) or demand driven (e.g., a rise in the international price of that sector's output). In both cases, the boom may attract immigrants and capital inflows and thus expand the domestic economy. In the latter case, it will show up as an improvement in the country's international terms of trade. The more capital funding for new investment coming in from abroad, the earlier and larger will be the initial appreciation in the real exchange rate. Later, the exchange rate appreciation will reverse as the boom moves from its investment phase to its export phase and starts to return dividends, and possibly repatriate capital, to foreign investors (Freebairn 2015). Even so, if a newly discovered mineral deposit takes many decades to deplete, the economy will continue to have a higher per capita income, and shares of mining and nontradables in GDP and employment will continue to be higher than prior to the mineral discovery, as will the share of exports from mining. This is another way in which trade can alter one's expectations about structural transformation of a particular economy to manufacturing and services.

Sectoral shares of exports (and imports) are also affected by preferences if (contrary to the assumptions of most trade theories) consumer preferences are nonhomothetic (Markusen 2013). As already noted, many foods (services) have an income elasticity of demand below (above) 1, and that elasticity declines toward 0 (1) as incomes grow. Within the food bundle, demand elasticities for staples fall much earlier than for nonstaples such as horticultural and livestock products (Bennett 1936, 1941). Producer demands for minerals and energy raw materials rise as countries begin to industrialize and become more affluent, but then fall as services increasingly dominate GDP. Meanwhile, the income elasticity of demand for mainstream manufactured consumer goods, while it may be above 1 in low-income countries, falls increasingly below 1 as countries become affluent. Because production of income-elastic goods tends to use skilled labor relatively intensively (Caron, Fally, and Markusen 2014), this alters the skill premium in wages and hence also affects the competitiveness of different sectors.

Three further examples of how trade can affect structural transformation relate to tradable services. The first is tourism: as international passenger transport costs fall or real incomes grow rapidly in populous countries, the comparative advantage in tourist-related services strengthens for countries with natural beauty and a pleasant climate located near high-income countries with fewer such assets. Another example relates to transit services. Landlocked countries, especially smaller ones with large neighbors, have a comparative advantage in providing transit services, such as underground pipelines or access to roads, rail, and rivers. Yet another example are call centers and information technology services requiring English-language capability: the ICT revolution has strengthened the comparative advantage in such labor-intensive services for those low-wage countries where English is widely spoken. However, these specific factors contributing to trade specialization of certain developing countries (natural beauty, transport or pipeline corridors, English-language skills) are not included in the regressions below.

I. Impact of Market-Distorting Policies

Changes in taxes, subsidies, or quantitative restrictions on the production, consumption, or trade of products, or the factors or intermediate inputs used to produce them, can affect the structural transformation of an economy.

The large differences in relative factor endowments and hence comparative advantages among growing economies ensure that concerns vary regarding the consequences of uninhibited structural transformation for rural–urban income disparities, food and energy security, food safety, and environmental degradation. This has contributed to systematic differences in the use of trade and other price-distorting policies in responding to those concerns. Differing perceptions of risk have also led to different policies toward new technologies.

Specifically, developing country governments tend to depress agricultural relative to manufacturing incentives facing producers, but they gradually change to the opposite sectoral bias as the country passes through the upper-middle-income stage. This has the effect of artificially boosting initial shares of manufacturing in GDP and employment but slowing the relative decline of agriculture as the economy becomes affluent (Anderson 2009), for reasons explained in Anderson, Rausser, and Swinnen (2013). Since these sectoral support policies typically have a strong antitrade bias, they reduce the ratio of trade to GDP and reduce the number of products in which the country is internationally competitive. How they alter sectoral shares of exports is less certain: they may raise or lower agriculture's share of that shrunken volume of exports, for example.

In addition to keeping food prices artificially low, developing country governments also commonly subsidize fuel consumption. As countries become more affluent, however, emerging economies will begin to worry more about pollution and the rapidly rising fiscal cost of fuel subsidies, and so those subsidies are phased out and eventually replaced by taxes on at least hydrocarbon sources of fuel (OECD 2015, Coady et al. 2017). This means that mining's share of exports initially goes down but less so as income growth proceeds, and it may eventually be inflated if fuel consumption by firms and households is discouraged less domestically than in the rest of the world as the country becomes more affluent. That pattern will be accentuated if national carbon emission taxes are adopted and more effectively enforced in countries with high per capita incomes, especially if border tax adjustments are not used to discourage the relocation of fossil fuel-intensive industries to less regulated poorer countries.

Apart from these long-run trends in sectoral policies, governments in some natural resource-rich countries assist tradable sectors that lag behind when there is a boom in, for example, the mining sector. This may offset the burden of adjustment to real exchange rate movements for some tradable industries, but it exacerbates that burden on other tradable industries. Moreover, adjustment needs change as the mining sector transitions from its investment phase to its export phase and eventually to the end of the boom (Corden 1984, Freebairn 2015), making it difficult for such interventions to target particular groups in a timely and temporary manner.

An alternative source of sectoral boom can result from new technologies. The Green Revolution that resulted from investments in agricultural research provided a boom to wheat, rice, and maize production from the 1960s in countries for which it was most suited. That lowered prices of staples in those adopting countries and in international markets, which reduced the competitiveness of grain farmers elsewhere. Likewise, the adoption of genetically modified (GM) varieties of corn, soybean, and cotton since the mid-1990s has boosted agriculture in countries that have approved their production, but again this has depressed the output and net exports of GM-free substitutes in countries that have chosen to not allow the production or use of GM crops.

J. Summary of Structural Transformation Hypotheses

The following hypotheses are among those suggested by the above theory:

1. The shares of agriculture (services) in GDP and employment will fall (rise) as per capita income rises, while the manufacturing sector's shares will initially rise and then eventually fall after countries reach a high per capita income. However,

   (a) in lightly populated settler economies, the agriculture (or mining) sector's decline may be postponed if large numbers of immigrants are allowed to expand the farming (mining) frontier, and more so if productivity growth in this economy is especially fast in that primary sector;

   (b) the share of exports of labor-intensive manufactures in total exports will decline as the stock of capital and hence per capita income grows, while the share of exports of capital-intensive manufactures in total exports will rise;

   (c) the decline in the share of employment in agriculture will lag the decline in agriculture's share of GDP to the extent that out-migration of farm workers is sluggish, implying farm labor productivity will become relatively low;

   (d) the share of agriculture (services) in global employment will eventually decline (rise), but it is not clear whether global employment in manufacturing will rise or fall as the share transfers from high-income to developing countries; and

   (e) the shares of services may be high, especially in exports, for developing countries with a strong comparative advantage in tourism, transit, call centers, or information technology services.

2. The share of employment in mining will be below mining's share of GDP, particularly in developing countries that encourage the inflow of foreign mining-specific capital, implying that the sector's labor productivity will be high.

3. Countries with a relatively large endowment of natural resources per worker will have a relatively large share of nontradables (hence possibly of services) in GDP as well as a relatively high share of exports from one or both primary sectors.

4. Manufacturing shares of GDP, employment, and especially exports will be relatively large in countries with a relatively small endowment of natural resources per worker except in those developing countries with a strong comparative advantage in such services as tourism, transit, call centers, or information technology.

5. Exports of manufactures will be less capital intensive the smaller a country's per worker endowment of capital (both natural resources and produced capital).

6. Agriculture's shares of GDP and exports (if not also employment) will be higher the higher the rate of TFP growth in that sector relative to the rest of the economy. In particular, those shares will be higher for countries that have adopted high-yielding green revolution or GM crop varieties.

III. Data for Pertinent Variables

In order to test the above hypotheses, we have assembled annual data from 1990 to 2016 for more than 160 countries. An earlier start year is not possible without having to shrink the sample size and thereby reduce the spectrum of countries in terms of income per capita. Even then, we had to draw on several sources to get all the desired variables. Ultimately, we were constrained to 117 countries and the years 1991–2014 for a full set of data for all the variables listed below.

Specifically, the three sets of national variables whose trends we seek to explain for each of the four sectors (agriculture, mining, manufacturing, and services) are

(i) sectoral shares of GDP (value added), S_v;

(ii) sectoral shares of employment, S_e; and

(iii) sectoral shares of exports of goods and services, S_x.

Data sources are as follows: S_v are from World Bank (2018); S_e are from World Bank (2018), except for manufacturing shares which are from International Labour Organization (2018); and export value data in current United States dollars to generate S_x are from World Bank (2018), which draws from United Nations (2018) trade data for goods and from the International Monetary Fund balance of payments data for services.[11]

[11] The Standard International Trade Classification (SITC) codes for agriculture are SITC 0, 1, and 2, except for 27, 28, and 4. For mining they are SITC 27, 28, 3, and 68; and all other merchandise items are classified as manufactures. Within the latter are labor-intensive manufactures such as textiles, clothing, and footwear (SITC 65, 84, and 85).

The explanatory variables used to explain shares and indexes are:

(i) Real income per capita. This is defined as the natural log of GDP per capita, measured at purchasing power parity (constant 2011 international dollars). The data are from World Bank (2018).

(ii) Factor endowments. The data are from Lange, Wodon, and Carey (2018) expressed in 2014 US dollars for the years 1995, 2000, 2005, 2010, and 2014. We have expressed them per worker using employment data from World Bank (2018), interpolating linearly for the years in between, extrapolating back to 1990 using the same rate of change between 1995 and 2000, and extrapolating forward to 2016 using the same rate of change between 2010 and 2014. Three factor endowment per worker ratios are used:

   (a) agricultural land, defined as the discounted sum of the future value of crop and pasture land rents;

   (b) mineral and energy raw material reserves, defined as the discounted sum of the value of rents generated over the lifetime of the reserves; and

   (c) produced capital (physical and human), where physical capital includes machinery, equipment, buildings, and urban land measured at market prices, and human capital is defined as the discounted value of earnings over each person's lifetime (disaggregated by gender and employment status).

(iii) National TFP growth rate estimates for agriculture. These are available up to 2012 from Fuglie, Ball, and Wang (2012).

IV. Evidence of Structural Transformation as Per Capita Incomes Grow

Before turning to the regression results in the next section, this section looks at just the relationship between per capita income and sectoral shares. In Figures 4a–4d, the four sectors' shares of GDP, employment, and exports are plotted against the natural log of per capita real GDP (our indicator of real income). Each dot is a country–year pair, and the bold local polynomial line is the best fit of the data. These figures provide support for hypothesis 1, that is, shares of agriculture (services) in GDP and employment are lower (higher) the higher is per capita income, while the manufacturing sector's shares initially rise and then eventually fall after countries reach a high per capita income.

Figure 4. **Sectoral Shares of GDP (value added), Employment, and Exports as Real Per Capita Incomes Rise, 1990–2016**

(a) Agriculture

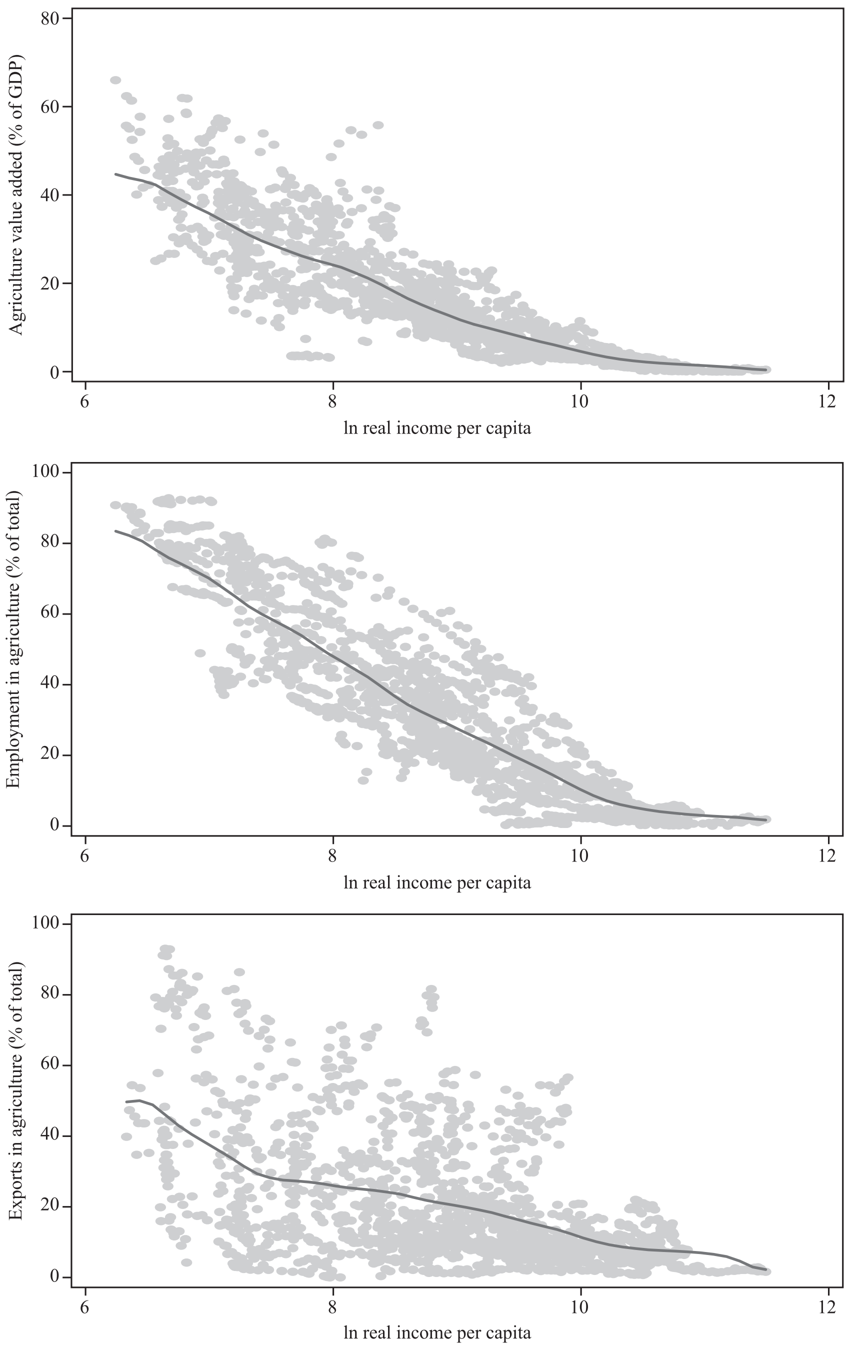
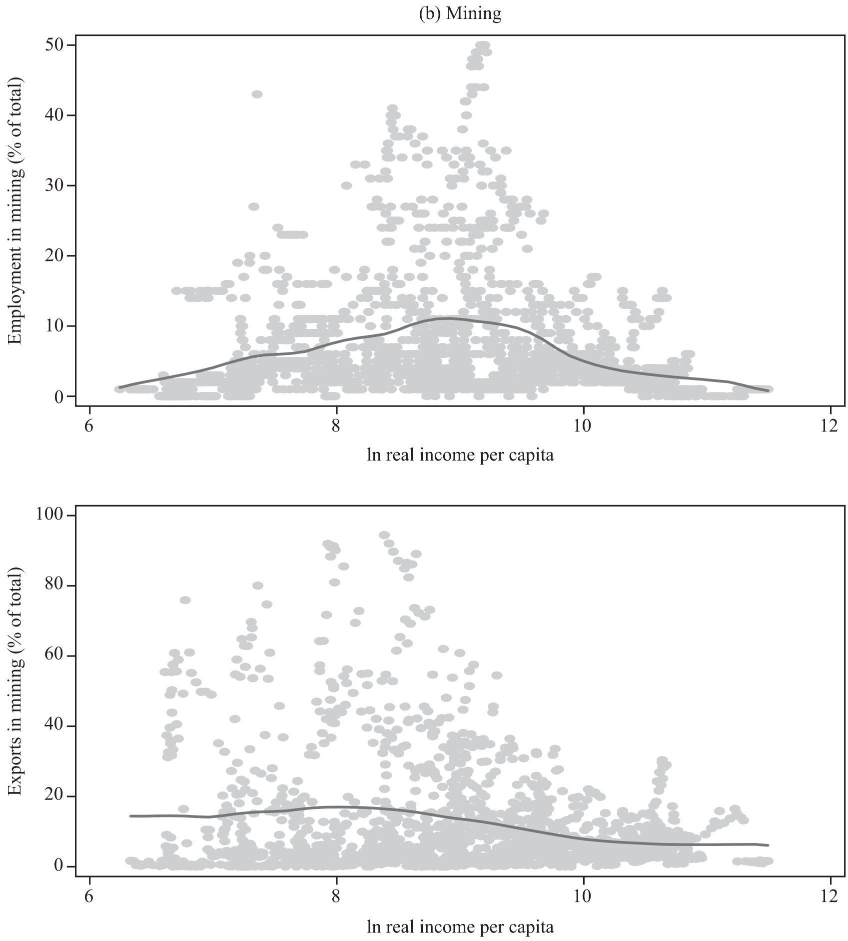


Figure 4. *Continued.*



Exceptions to this hypothesis can also be found in the results. A particularly striking one is agriculture's GDP share in Australia: in the 10 decades to 1950, that share remained within the 20%–30% range (Figure 5a) even though real per capita income more than doubled over that period. The reason was very rapid farm productivity growth: this lightly populated settler economy's high real wages encouraged the development and widespread adoption of labor-saving farm technologies as well as rapid immigration (Anderson 2017). This is consistent with hypothesis 1a. Also clear from Figure 5a, and supporting hypothesis 1, is the rise and fall in the manufacturing sector's share of Australia's GDP. That share peaked in 1960 at 30%, similar to the peak for other high-income countries. But as Australia's protection to manufacturing declined after removing import quotas in the 1960s and lowering tariffs from 1972, that sector's share fell very rapidly.

Figure 4. *Continued.*

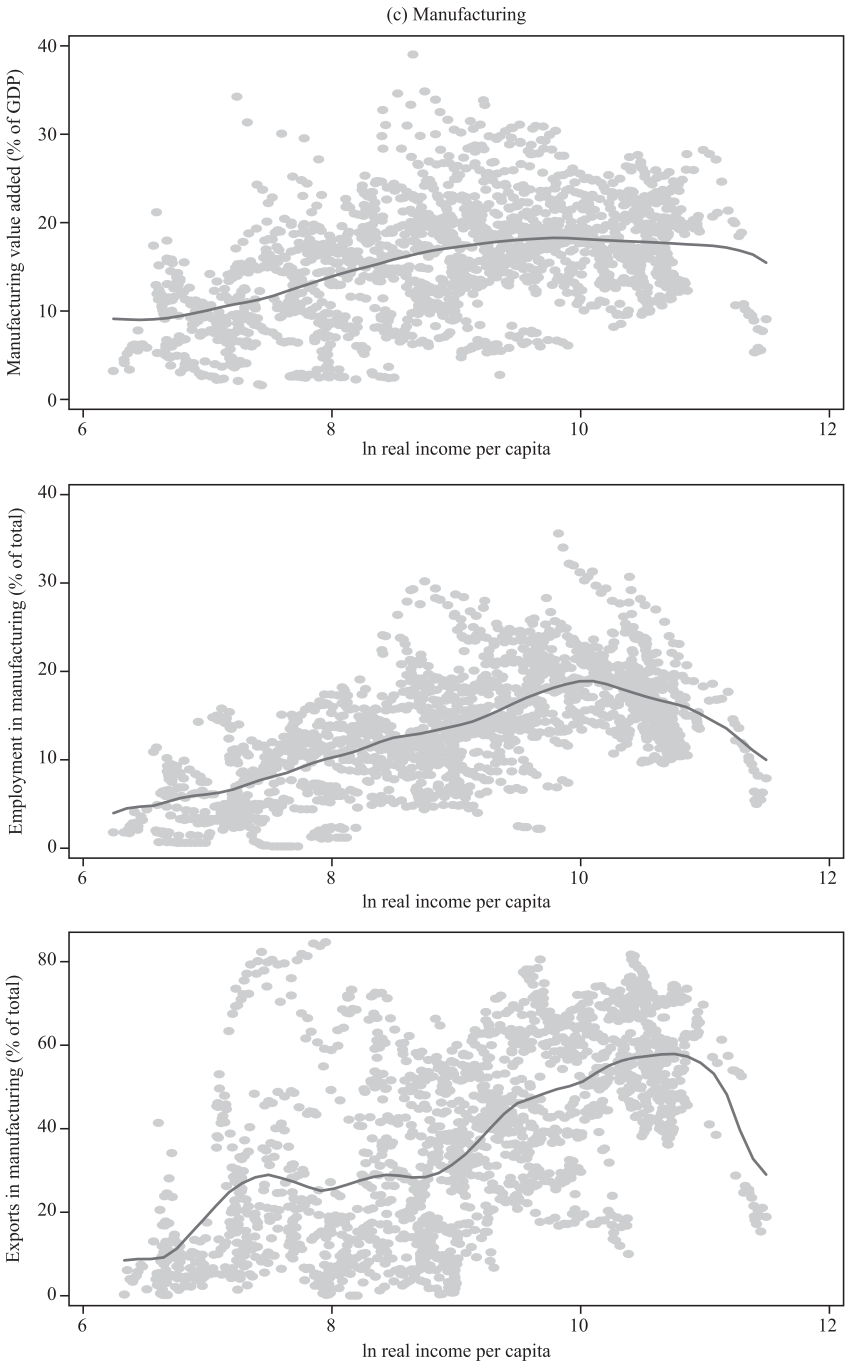
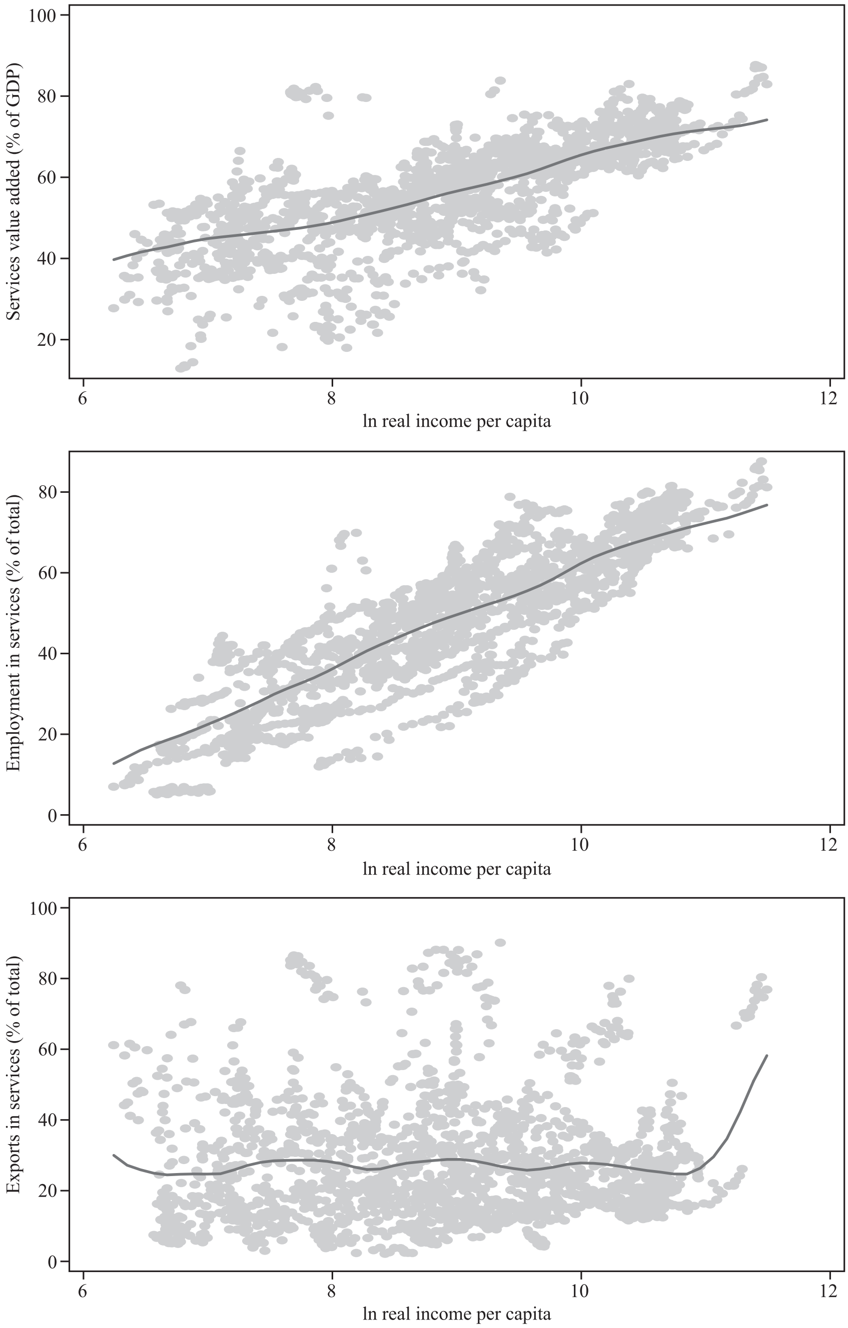


Figure 4. *Continued.*

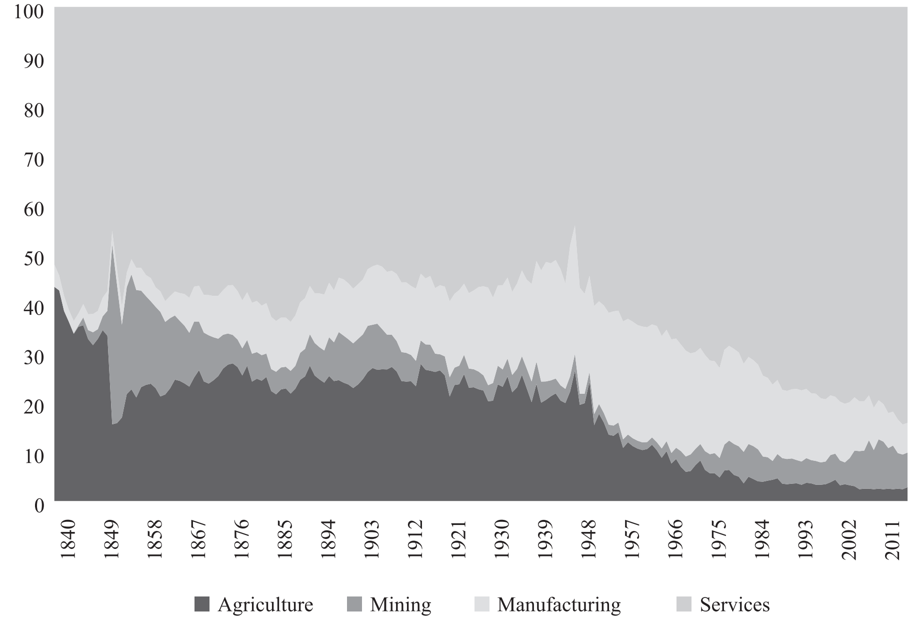
(d) Services



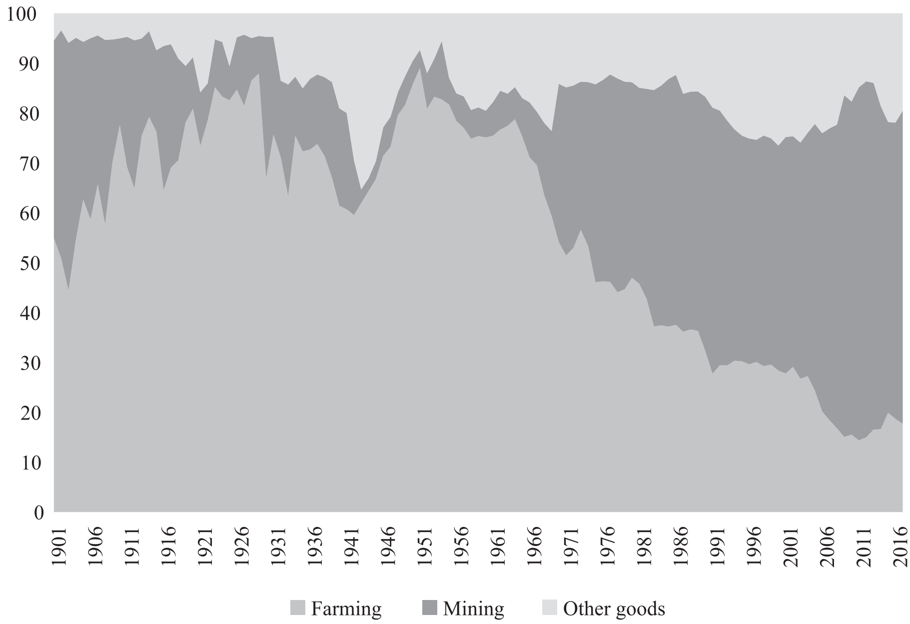
GDP = gross domestic product.
Source: Authors' compilation (see text).

Figure 5. **Sectoral Shares of Gross Domestic Product and Exports in Australia, 1840–2017**

(a) % of GDP at current prices, 1840–2017

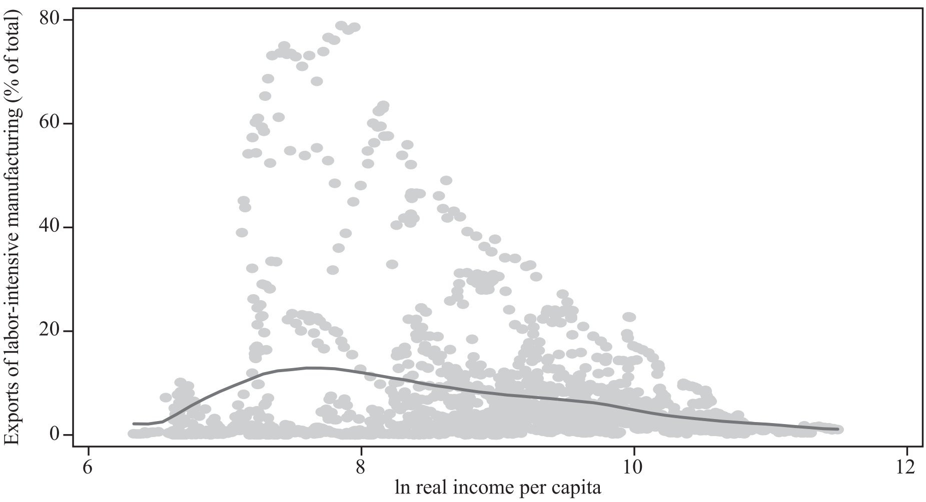


(b) % of merchandise exports at current prices, 1901–2017



GDP = gross domestic product.
Source: Anderson (2017), updated and backdated by the authors.

Figure 6. **Shares of Exports of Labor-Intensive Manufactures in Total Exports as Real Per Capita Incomes Rise, 1990–2016**



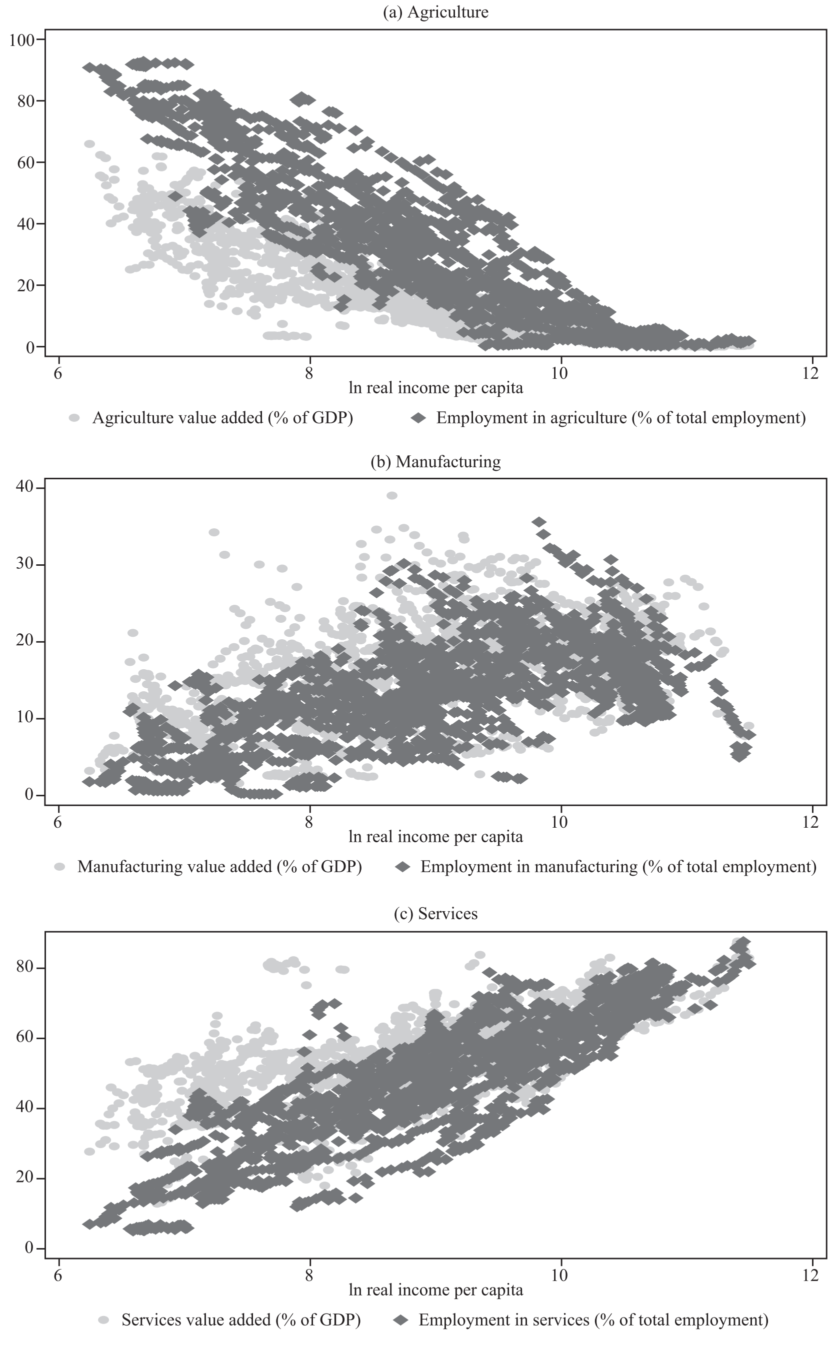
GDP = gross domestic product.
Source: Authors' compilation (see text).

By 2016 it was just 6%, compared with an average of 14% in other high-income countries (World Bank 2018). Figure 5 also strongly supports hypothesis 3: having a relatively large endowment of natural resources per worker, Australia's goods exports are dominated throughout by primary products, either mining or agricultural depending on relative prices and timing of mineral discoveries, and services (mostly nontradables) are a large share of its GDP.

To explore hypothesis 1b, we separated exports of labor-intensive manufactures (defined simply as textiles, clothing, and footwear, which are SITC 65, 84, and 85, respectively) from other manufactures and plotted the share of this subsector of exports against real per capita income. Figure 6 shows strong support for that hypothesis: the share of exports of labor-intensive manufactures in total exports initially rises but then declines as per capita incomes rise.

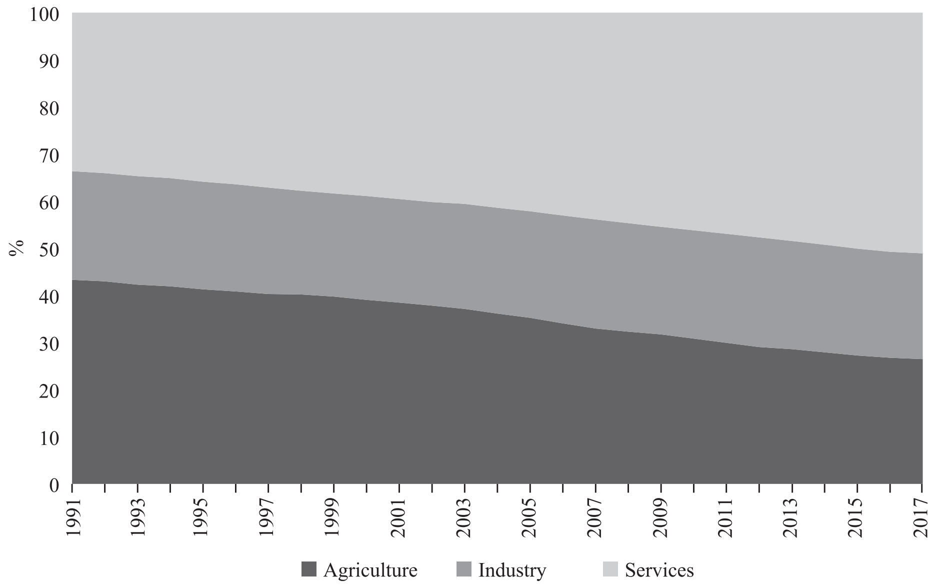
To explore hypothesis 1c, we can examine labor productivity for each sector by comparing the sector's shares of GDP and employment. A GDP share above (below) the employment share suggests that the sector's labor productivity is above (below) the national average. These shares are jointly plotted in Figure 7. The images are indeed consistent with the hypothesis that farm labor productivity is relatively low. Figure 7 also reveals that it is manufacturing rather than services that tends to have above-average labor productivity. Unfortunately, data on mining value added are not separately available for many countries and so it is not possible to explore hypothesis 2 to confirm if mining also tends to have above-average labor

Figure 7. **Sectoral Proportions of Gross Domestic Product and Employment as Real Per Capita Incomes Rise, 1990–2016**



GDP = gross domestic product.
Source: Authors' compilation (see text).

Figure 8. **Share of Global Employment by Sector, 1991–2017**



Source: Compiled by the authors from data in World Bank. 2018. *World Development Indicators.* Washington, DC. https://data.worldbank.org/products/wdi (accessed 10 November 2018).

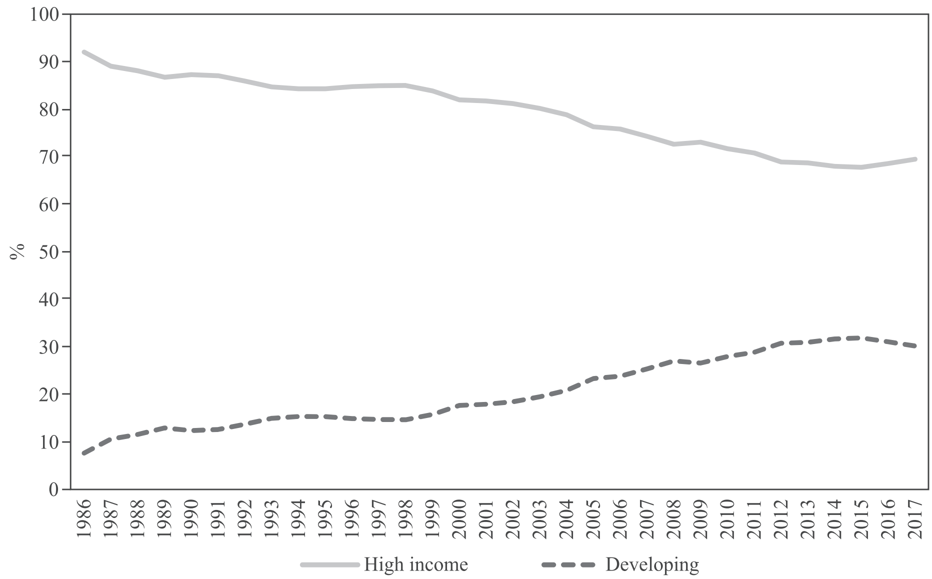
productivity (although it often does because of the very high capital intensity of mining even in low-income countries).

Hypothesis 1d concerns shares of global employment. Figure 8 shows that the share of agriculture (services) in global employment has indeed been declining (rising), while employment in industry has maintained its share at 22%–23%, consistent with Felipe and Mehta's (2016) finding that there is little trend in the estimated global share of manufacturing.[12] With slower growth and greater capital intensity of industry in high-income countries than in developing countries, the share of industry jobs that are in the high-income countries has dropped by one-third between 1991 and 2014, from 27% to 18%. The share of global exports of manufactures originating from developing countries is rapidly converging to the share from high-income countries, which has fallen from above 90% prior to the mid-1980s to less than 70% since 2012 (Figure 9).

As for hypotheses 1e and 3, Table 1 reveals that the 30 countries with the highest shares of services in their exports are mostly small developing countries (often tropical tourist islands), and there is only one high-income country

[12]Industry includes manufacturing, mining, construction, electricity, water, and gas (ISIC divisions 10–45). Unfortunately, more disaggregated global employment data are not available in World Bank (2018).

Figure 9. **Share of Global Exports of Manufactured Goods in High-Income and Developing Countries, 1986–2017**



Source: Compiled by the authors from data in World Bank. 2018. *World Development Indicators.* Washington, DC. https://data.worldbank.org/products/wdi (accessed 10 November 2018).

in that list (Luxembourg, although data were unavailable for some rich, tiny tax-haven countries). Table 1 also reveals that the 30 countries with the highest shares of primary products in their exports include some high-income countries (Australia, New Zealand, and oil-rich countries of the Middle East) and numerous middle-income countries, not just low-income countries. Also clear from Table 1 is that countries specializing relatively heavily in manufactures cover the full spectrum of national per capita incomes. That is, specializing in primary production and exports is not inconsistent with an economy growing to high-income status, just as being internationally competitive in manufactures or services is not confined only to high-income countries.

V. Regression Results

We now turn to the results of a fixed effects panel regression. Since the hypothesized relationships between sectoral shares and per capita income are not linear, we use the natural log of per capita income and the square of that term. The other key variables are the three factor endowment ratios, since trade theory suggests they should influence production specialization of open economies. These ratios are the value per worker of the stock of agricultural land, mineral and energy

Table 3. **Determinants of Sectoral Shares of Valued Added, 1991–2014** (% of GDP)

	Agriculture	Manufacturing	Services
ln YPC	-41.909^{***}	8.828	10.126
	(−4.46)	(1.44)	(1.01)
ln YPC squared	2.014^{***}	−0.415	−0.485
	(3.99)	(−1.24)	(−0.84)
Agricultural endowment	2.071^{*}		
	(1.82)		
Capital endowment		−1.858	4.064
		(−1.10)	(1.64)
R-squared (adjusted)	0.39	0.14	0.33
Observations	2,504	2,409	2,500
No. of countries	117	116	117
Country fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes

GDP = gross domestic product, ln = natural logarithm, YPC = income per capita.
Notes: *t* statistics in parentheses. $^{*}p < 0.1$, $^{***}p < 0.01$.
Source: Authors' computations.

resources, and produced capital (physical and human). In addition, we test whether agriculture's sectoral shares are impacted by farm productivity growth.

Table 3 presents the results aimed at explaining the sectoral shares of GDP (value added).[13] Consistent with the convex line in Figure 4a for the agriculture sector, both the log of income per capita and its square have significant coefficients. The endowment of agricultural land per worker also has a significant coefficient and its sign is positive, which is consistent with trade theory. The income coefficients for manufacturing also have the expected signs and are consistent with the inverted U-shaped line in Figure 4c. The coefficient for produced capital per worker is negative but not significant for manufacturing. For services, the coefficient on the income terms are not significant, but their values suggest that the sector's share of GDP rises almost linearly with income, which is consistent with Figure 4d. The services' coefficient on produced capital per worker is positive but again not significant. The adjusted R-squared values range from 0.14 to 0.39.

The results aimed at explaining the sectoral shares of employment are in Table 4. In this case, the income terms are all very significant. Agriculture and manufacturing have the same signs as in the value added equations. For mining, the signs of the coefficients are consistent with the inverted U-shape in Figure 4b, while for services they again imply close to a linear upward trend. Agricultural and mineral endowments contribute positively to employment in those primary sectors, but the coefficients are not quite significant at the 10% level. Capital endowments per worker again make insignificant contributions to aggregate employment in manufacturing and services. The adjusted R-squared value for mining is low

[13]Mining is missing because we had an insufficient number of countries with data on mining's share of GDP.

Table 4. **Determinants of Sectoral Shares of Employment, 1991–2014**
(% of total employment)

	Agriculture	Mining	Manufacturing	Services
ln YPC	−46.42***	1.994***	32.846***	1.614+++
	(−4.46)	(2.68)	(6.34)	(0.25)
ln YPC squared	1.934***	−0.129***	−1.901***	0.453+++
	(2.95)	(−2.89)	(−6.63)	(1.16)
Agricultural endowment	1.189			
	(1.26)			
Mineral endowment		0.025		
		(1.42)		
Capital endowment			−0.285	0.045
			(−0.37)	(0.03)
R-squared (adjusted)	0.39	0.10	0.40	0.59
Observations	2,599	2,303	2,598	2,599
No. of countries	113	104	113	113
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes

ln = natural logarithm, YPC = income per capita.
Notes: *t* statistics in parentheses. ***p < 0.01. For services, *F* statistics in parentheses. +++p(*F*) < 0.01.
Source: Authors' computations.

Table 5. **Determinants of Sectoral Shares of Exports, 1991–2014**
(% of all merchandise and service exports)

	Agriculture	Mining	Manufacturing	LIM	Services
ln YPC	−51.343***	−10.631	64.43***	17.49++	15.661
	(−2.42)	(−0.71)	(2.82)	(1.28)	(0.60)
ln YPC squared	3.241***	0.560	−3.443***	−1.232++	−0.872
	(2.71)	(0.64)	(−2.76)	(−1.63)	(−0.63)
Agricultural endowment	2.779				
	(1.44)				
Mineral endowment		0.258			
		(0.76)			
Capital endowment			−0.980	−1.523	4.042
			(0.25)	(−0.82)	(1.21)
R-squared (adjusted)	0.21	0.16	0.06	0.11	0.03
Observations	2,063	1,837	2,061	2,049	2,369
No. of countries	109	100	109	108	112
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes

LIM = labor-intensive manufacturing, ln = natural logarithm, YPC = income per capita.
Notes: *t* statistics in parentheses. ***p < 0.01. For labor-intensive manufacturing, *F* statistics in parentheses. ++p(*F*) < 0.05. Labor-intensive manufacturing includes textiles, clothing, and footwear.
Source: Authors' computations.

(consistent with the wide range of incomes between countries with a comparative advantage in mining), but for other sectors they range from 0.39 to 0.59.

The results for sectoral shares of exports are in Table 5. The income terms are somewhat less significant than in the employment equations but still have

Table 6. **Determinants of Agriculture's Shares of Value Added, Employment, and Exports, 1991–2014** (%)

	Value Added	**Employment**	**Exports**
ln YPC	-46.855^{***}	-38.806^{***}	-48.918^{*}
	(−3.77)	(−3.56)	(−1.87)
ln YPC squared	2.201^{**}	1.522^{**}	3.123^{**}
	(3.23)	(2.39)	(2.18)
Agricultural endowment	1.539	2.218^{**}	3.159
	(1.48)	(2.07)	(1.52)
Agricultural TFP growth	2.811	−0.225	8.071^{**}
	(0.99)	(−0.18)	(2.33)
R-squared (adjusted)	0.40	0.45	0.22
Observations	1,995	2,088	1,669
No. of countries	99	98	95
Country fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes

ln = natural logarithm, TFP = total factor productivity, YPC = income per capita.
Notes: t statistics in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.
Source: Authors' computations.

the expected signs. This is also true for endowments per worker. The adjusted R-squared values are lower for the export equations than for the value added and employment equations. This is expected, given the wide range of comparative advantages between countries at each income level.

The agricultural equations are repeated in Table 6 but with an additional explanatory variable: TFP growth rate in agriculture. The coefficients for this variable are not very significant, but their signs suggest that faster farm TFP growth adds to the sector's shares of GDP and exports but reduces its employment share (perhaps because of its labor-saving bias). Ideally, this variable should measure agriculture's TFP growth relative to that of other sectors, but unfortunately there are no estimates available for nonagricultural TFP growth during 1991–2014 for the more than 95 countries in our sample.

In short, these results are at least somewhat supportive of the following structural transformation hypotheses:

1. The shares of agriculture (services) in GDP and employment are lower (higher) the higher a country's per capita income, while the manufacturing sector's shares initially rise and then eventually fall as countries approach high-income status.

2. The share of exports of labor-intensive manufactures in total exports declines as per capita income expands.

3. The decline in the share of employment in agriculture lags the decline in agriculture's share of GDP.

4. Countries well endowed with farm land (mineral or energy resources) per worker have a larger share of their exports from the farm (mining) sector.

5. Exports of manufactures are more labor intensive the smaller a country's per worker endowment of capital.

6. Agriculture's shares of GDP and exports are higher, and its share of employment is lower the higher the rate of TFP growth in that sector.

Even though the statistical significance of relative factor endowments is not strong in the above equations for our sample of 117 countries, openness to trade is important to the structure of economies with extreme endowments, including affluent resource-rich countries still specialized in primary products and developing countries already heavily specialized in exporting services.

VI. Policy Implications

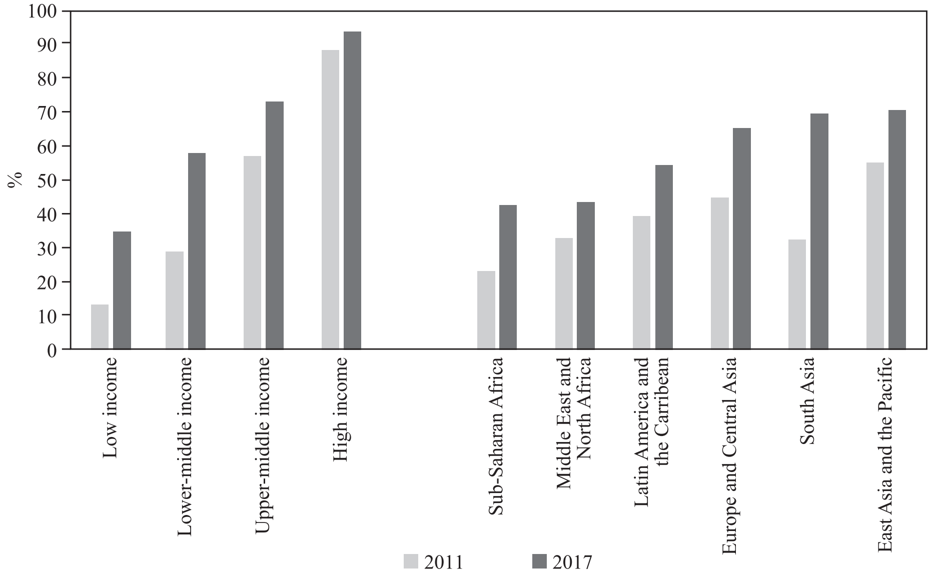
The theory outlined earlier, and the above empirical results provide clear lessons for governments. The most fundamental lesson is that the agriculture sector inevitably will eventually decline in the course of economic growth. Hence, intervening to prevent that decline with price-supportive policies will require those supports to continue to rise over time, at ever-greater cost to consumers and/or taxpayers per farm job retained or farm business saved.

Second and equally well known, the activities of producing and exporting manufactured products that use unskilled labor intensively are likely to expand initially in densely populated, natural resource-poor countries, but, as national real wages rise, such industries will also inevitably decline as a share of growing economies. Hence, protecting jobs and factories in such industries from import competition will also become ever more expensive over time.

Third and less well known, manufacturing as a whole as a share of GDP will inevitably decline, and in high-income countries its share of employment has been declining even faster than its GDP share (Figure 4c). Hence, policies aimed at slowing deindustrialization, like those aimed at slowing deagriculturalization, will become ever more expensive over time per job or factory saved.

Abandoning protectionist trade policies aimed at slowing the relative decline of such sectors, and thereby accelerating economic growth via dynamic gains from trade, does not of course prevent governments from assisting those exiting and declining industries. Indeed, the economy will be more able to afford to do so by being more open. Moreover, there are now far cheaper and easier ways for governments to target income supplements to needy households. Such

Figure 10. **Share of Adults with a Bank Account, Mobile-Money Account, or an Equivalent in Developing Economy Regions and High-Income Countries, 2011 and 2017**



Source: Demirgüç-Kunt, Asli, Leora Klapper, Dorothe Singer, Saniya Ansar, and Jake Hess. 2018. *The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution.* Washington, DC: World Bank. https://datacatalog.worldbank.org/dataset/global-financial-inclusion-global-findex-database (accessed 10 November 2018).

payments were unaffordable in developing countries in the past because of the fiscal outlay involved and the high cost of administering small handouts. However, the ICT revolution has brought financial inclusion to developing countries at an astonishingly fast pace in recent years: the share of adults with a bank or mobile money account rose from 42% to 63% in developing countries between 2011 and 2017 (Demirgüç-Kunt et al. 2018), and it rose substantially in all regions in those 6 years (Figure 10). This phenomenal advance in access to electronic banking is making it possible for conditional cash transfers to be provided electronically as direct government assistance to even remote rural households and females of low-income countries.

If open countries are still unsatisfied with the contribution of their farmers to national food security, as reflected in food self-sufficiency ratios, an alternative to protectionism would be to subsidize investments in agricultural research and development, rural education and health, rural roads, and other rural infrastructure improvements. If countries currently underinvest in such activities, extra support could also boost economic growth.

Finally, a comparative advantage in mining is not confined to low- and middle-income countries (Table 1). This is not consistent with the resource curse theory (van der Ploeg 2011, Frankel 2012). In fact, the very long-term growth rates of some oil-abundant economies have been exceptionally high (Michaels 2011). This finding, together with general evidence that opening up contributes to economic growth (e.g., Lucas 2009), calls into question the efficacy in emerging economies of governments contemplating policies designed to diversify the economy away from primary production—which they often consider when commodity prices slump. Rather than distortive sectoral policies that discourage mining (or cash cropping), a better response to concerns over volatile terms of trade involves macroeconomic and generic social protection policies that can help ease adjustments to the nation's real exchange rate changes as international commodity prices go through their inevitable cycles.

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From Import Substitution to Integration into Global Production Networks: The Case of the Indian Automobile Industry

Prema-chandra Athukorala and C. Veeramani*

This paper examines the growth trajectory and the current state of the Indian automobile industry, paying attention to factors that underpinned its transition from import substitution to integration into global production networks. Market-conforming policies implemented by the government of India over the past 2 decades, which marked a clear departure from protectionist policies in the past, have been instrumental in transforming the Indian automobile industry in line with ongoing structural changes in the world automobile industry. India has emerged as a significant producer of compact cars within global automobile production networks. Compact cars exported from India have become competitive in the international market because of the economies of scale of producing for a large domestic market and product adaptation to suit domestic market conditions. Interestingly, there are no significant differences in prices of compact cars sold in domestic and foreign markets. This suggests that the hypothesis of "import protection as export promotion" does not hold for Indian automobile exports.

Keywords: automobile industry, foreign direct investment, global production networks, India
JEL codes: F13, F14, L92, L98

I. Introduction

The global landscape of the automobile industry has been in a process of notable transformation over the past 3 decades. Until about the late 1980s, automobile production remained heavily concentrated in the United States, Japan, and Western Europe (known as the "triad"). While the leading automakers headquartered in the triad had assembly plants in many developing countries, most of these plants served domestic markets under heavy tariff protection. Since then the industry has become increasingly globalized, driven by a combination

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of technological advances in the industry, changes in global demand patterns, and widespread trade and investment reforms in the developing world (Shapiro 1994, Humphrey and Memedovic 2003, Klier and Rubenstein 2008, Bailey et al. 2010, Kierzkowski 2011, Amighini and Gorgoni 2014, Traub-Merz 2017).[1] On the supply side, production standards have become increasingly universal, accompanied by a palpable shift in production process from generic to modular technology. Consequently, parts and components production has grown rapidly to cater to multiple assemblers. On the demand side, growth prospects for vehicle sales are increasingly promising in emerging market economies, whereas the principal automobile markets in the triad have been rapidly approaching a point of saturation in recent years. These structural changes in the global automobile industry have led automakers to set up new assembly bases in countries with large domestic markets to serve regional markets. With this regional focus, carmakers tend to consolidate their assembly facilities within a region and decide which models to produce at which locations (country), at what prices and quality standards, and for which markets (either regional or global). The process of trade and investment liberalization across the world has facilitated this global spread, creating cost-efficient plants aimed at global markets.

This massive transformation in the structure, conduct, and performance of the world automobile industry has opened opportunities for countries in the periphery to join the global automobile production network. However, an important unresolved question is whether the government in these countries should follow the conventional "carrot and stick" (activist) approach to promote export orientation of indigenous industries with significant domestic value added or a "market-conforming" approach in which multinational enterprises (MNEs) play the leading role in integrating domestic industry into global production networks (GPN).

The purpose of this paper is to contribute to this policy debate by examining the emergence of India as a significant production hub within global automobile networks. The Indian automobile industry is an ideal case study of this subject given the government's long history of protecting domestic industry and the significant structural changes following liberalization reforms that were initiated in the early 1990s and gathered momentum from about 2000. For over a half a century from the late 1940s, the Indian automobile industry remained a canonical example of a high-cost industry that evolved and survived under heavy trade protection. However, over the past 2 decades, the industry has shown promising signs of gaining significant capabilities and global competitiveness through integration into GPNs. Most of the world's leading automakers now have well-established production bases in India. According to data reported by the International Organization of Motor

[1] In 2000, 74% of total world car production (in terms of number of cars) took place within the triad. This declined to 39% by 2017 (OICA 2017).

Vehicle Manufacturers (OICA), India's ranking among automobile producing countries increased from 16th to 6th between 1999 and 2017, and its share in global passenger car production (in terms of number of cars) increased from 1.3% to 5% (OICA 2017).

A study of the automobile industry is also relevant for the policy debate in India given its contrasting growth experience compared to other major manufacturing industries in the country. India's economic growth has been primarily driven by the service sector while manufacturing growth has been sluggish. Manufacturing accounts for only about 17% of India's gross domestic product (GDP) compared to about 30% for the People's Republic of China (PRC). Engagement in GPNs has been the prime mover of manufacturing export expansion in the PRC and other high-performing East Asian economies. However, the manufacturing sector in India remains generally cutoff from GPNs (Athukorala 2019, Joshi 2017, Krueger 2010). The automobile industry is an exception—over the past 2 decades it has recorded impressive growth and export expansion through global production sharing.

To preview the paper's key findings, the analysis suggests that market-conforming policies over the past 2 decades, which marked a notable departure from protectionist policies of the past, have played a key role in transforming the Indian automobile industry. Learning and capacity development through foreign market participation and entry of parts and components producers to set up production bases in India has been the key factor behind the country's emergence as a production base within automobile GPNs. Interestingly, there are no significant differences between prices of cars sold in domestic and foreign markets. This suggests that the competitiveness of Indian cars sold in foreign markets is not rooted in the prevailing tariffs on completely built-up units (CBUs) in India. Rather, this competitiveness seems rooted in the economies of scale of producing for a large domestic market and product adaptation to suit domestic market conditions under a natural protection arising from the bulky nature of the product (unlike most electronics and electrical products). An important question in the present context of economic globalization, therefore, is whether trade protection has outlived its purpose.

The rest of the paper is organized as follows. Sections II and III set the background by providing a survey of the evolution of the Indian policy regime relating to the automobile industry and by describing the entry of the main players in the industry. Section IV examines the growth and composition of automobile production, with emphasis on the experience following the policy transition from import substitution to global integration since the early 2000s. Section V analyzes the extent of India's engagement in automobile GPNs in terms of the MNEs' involvement in domestic industry, export expansion, and international sourcing of components. Section VI provides a comparative perspective on automobile and electronics industries with a view to highlighting the importance of differences in the underlying policy regimes and product characteristics as possible explanations for India's contrasting performance in these industries. Section VII supplements the analytical narrative in the previous sections with an econometric analysis of the determinants of automobile exports from India using the gravity modeling approach. The final section summarizes the main findings and policy implications.

II. Policy Context

The automobile industry has figured prominently in India's industrialization strategy since its independence in 1947 (Bhagwati and Desai 1970). The ensuing 6 decades can be divided into four subperiods in terms of the policy regime affecting the automobile industry.

The period from late 1940s to mid-1970s was characterized by progressive regulation, protection, and indigenization. In 1948, automobiles and tractors were included in the list of industries subject to "central regulation and control," which involved banning imports of CBUs and increasing tariffs on component imports (Arthagnani 1967, 1424). From 1953, only companies with plans to manufacture components and CBUs were permitted to operate, and the existing assemblers of imported completely knocked down (CKD) units were required to terminate operations within 3 years. The Industrial Policy Resolution of 1956 permitted private sector initiative and enterprise in the automobile industry subject to state control through industrial licensing. This was in sharp contrast to industry policy in other capital-intensive industries (such as iron and steel, machinery, and electronics), of which the prime responsibilities for capability development rested with state-owned enterprises (SOEs). Further regulations introduced in the first half of the 1970s required all production expansion plans to have government approval subject to local content requirements while capping foreign ownership of Indian automobile companies at 40% (Kathuria 1987).

The period from the early 1980s to 1990 saw some easing of restrictions, with emphasis on technological upgrading through foreign collaboration and a relatively liberal import policy for capital goods and components (D'Costa 1995, 2009). The government loosened its tight grip on industrial licensing in favor of increased competition and greater participation of foreign capital. Automakers were permitted to adjust their product mix and produce a range of related products instead of only one type of product as decreed by industrial licensing. In 1982, the Indian government for the first time became an investor in a car project when it created Maruti Udyog Limited as a joint venture (80% government owned) with Suzuki Motors of Japan. Restrictions on capacity expansion of all automobile assemblers were lifted. However, local content and technology transfer requirements and reservation of the production of some automobile components for small and medium-sized enterprises (SMEs) continued to remain in force.

Table 1. **Tariff Rate on Automobile Imports in India (%)**

	Commercial Vehicles (HS 8702/04)	Cars and Utility Vehicles (HS 8703)				Parts and Components (HS 8708)
		General	Used Vehicles	New CBU	CKD	
1990	53	150	QR	QR		40
1992	60	65	QR	QR		65
1995	50	50	QR	QR		n.a.
1996	50	50	QR	QR		52
1997	40	40	QR	QR		40
1998	40	40	QR	QR		n.a.
1999	40	40	QR	QR		40
2000	35	35	QR	QR		38.5
2001	35		105	60	35	35
2002	30		105	60	30	30
2003	25		105	60	25	25
2004	20		105	60	20	30
2005	15		100	60	15	15
2006	12.5		100	60	12.5	12.5
2007	10		100	60	10	12.5
2008–2011[a]	10		100	60	10	10
2011–2012	10		100	60	10[b]/30[c]	8.57
2012–2013	10		100	60/75[d]	10[b]/30[c]	10
2013–2016[a]	10		125	60/100[d]	10[b]/30[c]	10

CBU = completely built-up, CKD = completely knocked down, HS = Harmonized System, n.a. = not available. QR = quantitative restrictions

Notes: Data for HS code 8708 are on a calendar-year basis. Other data are based on the Indian fiscal year: 1 April in the reporting (given) year to 31 March in the following year.

[a]No change in tariffs during these subperiods.

[b]Contains engine, gearbox, and transmission mechanism not in preassembled condition.

[c]Contains engine, gearbox, or transmission mechanism in preassembled form.

[d]For vehicles valued above $40,000.

Sources: Data for 1990,1992, and HS 8708 (all years) are from UNCTAD-TRAINS database (calendar-year based), and other data are from the Society of Indian Automobile Manufacturers (SIAM 2016).

As part of the liberalization reforms initiated in 1991, several reforms were introduced incrementally. First, licensing requirements were abolished for commercial vehicles and automobile component production in 1991 and for passenger vehicles in 1993. Second, automatic approval for foreign holding of up to 51% of equity was announced in 1991 in several sectors including automobiles. Third, importation of capital goods and automobile components were placed in 1997 under open general license. Fourth, the import tariff rates for CKD units and parts and components were brought down from 65% in 1992 to 35% during 2000–2001 (Table 1).

The liberalization reforms during the 1990s, however, were halfhearted. Import of cars and utility vehicles continued to remain under import licensing (quantitative restrictions) (Table 1). An indigenization requirement was reintroduced in 1995 making it compulsory for all new joint ventures to indigenize ownership up to 70%–75% over a period of 5–7 years. Effective December 1997, joint ventures involved in passenger vehicle production were required to sign a memorandum of understanding stipulating, among other things, to stop importing CKD or semi-knocked down kits for "mere assembly", increase the share of domestically procured components to at least 50% of the components used within 3 years and 70% within 5 years, and balance export earnings with the value of imported components during the 3-year memorandum of understanding period (Pursell 2001).

The early 2000s witnessed major policy initiatives aimed at integrating the Indian automobile industry into GPNs. In 2001, as part of the membership commitments under the World Trade Organization, all quantitative import restrictions on used vehicles and CBUs were removed while tariffs were imposed (Table 1), and the local content requirement for automobile production was abolished. Full foreign ownership was permitted for firms both in automobile and components production, enabling several MNEs to enter the industry by setting up wholly owned subsidiaries. Import tariffs on commercial vehicles, CKD, and components were progressively reduced, from 35% during 2001–2002 to about 10% by the end of the decade. Since 2011–2012, CKD in preassembled form attracted a higher duty of 30% while those not in preassembled form attracted a lower tariff of 10%. Excise duties on cars were also progressively reduced from 40% during the 1990s to 32% in 2002 and 25% in 2004. The excise duty on smaller cars was reduced further to 17% in 2006. During the period 2008–2017, excise duties for small cars varied in the range of 9%–13.5% and bigger cars in the range of 21%–28%.

III. Entry of Main Players

Table 2 summarizes information on the timing and mode of entry of MNEs in the Indian automobile industry. The wholly owned subsidiaries of General Motors and Ford Motor Company started the assembly of CKD trucks and cars in India in the late 1920s. Both companies left India in 1954 following the imposition of stringent import restrictions and local content requirements. During the first half of the 1940s, Hindustan Motors and Premier Automobiles set up production plants under license agreements with Morris Motors and Chrysler, respectively. Ashok Motors (later renamed Ashok-Leyland) started manufacturing Austin cars and Leyland commercial vehicles in 1948. Tata Engineering and Locomotive Company started manufacturing commercial vehicles in 1954 in collaboration with Daimler-Benz. Mahindra & Mahindra, another important player in the commercial vehicles segment, started production of jeeps in 1955. Bajaj Tempo began producing light commercial vehicles in 1958 under license from Vidal and Sohn Tempo-Werk of Germany (Arthagnani 1967).

Until the mid-1980s, there were only two key firms in the passenger car segment (Hindustan Motors and Premier Automobiles), while all other firms

Table 2. **Profile of Main Players in the Indian Automobile Industry**

Company	Mode of Entry	Year of Entry
Ford Motor Co. of Canada	100% subsidiary	1926, left in 1954
General Motors	100% subsidiary	1928, left in 1954
Hindustan Motors	License agreement with Morris Motors	1942
Premier Automobiles	License agreement with Chrysler	1944
Ashok Motors/Ashok Leyland	License agreement with Austin Motor Company and Leyland	1948
TELCO/Tata Motors	JV with Daimler-Benz	1954
Mahindra & Mahindra	License agreement with Willys Jeep	1955
Bajaj Tempo/Force Motors	License agreement with Vidal and Sohn Tempo-Werk of Germany	1958
Standard Motor Products	License agreement with Standard-Triumph	1949, left in 2006
Suzuki	JV with Maruti	1983
Mercedes-Benz	JV with TELCO	1995
PAL Peugeot	JV with Premier Automobiles	1995
Daewoo Motors	JV with DCM	1995
Honda Siel	JV with Shriram	1995
Ford	JV with Mahindra & Mahindra	1996
General Motors	JV with Hindustan Motors	1996
Hyundai	100% subsidiary	1996
Toyota Kirloskar	JV with Kirloskar	1997
Fiat	JV with Tata Motors	1997
Skoda (Volkswagen)	100% subsidiary	2001
Renault	JV with Mahindra	2005
Nissan	100% subsidiary	2005
BMW	100% subsidiary	2007
Isuzu Motors	100% subsidiary	2012

JV = joint venture, TELCO = Tata Engineering and Locomotive Company.
Note: Data are based on calendar years.
Source: Assembled from various internet sources.

manufactured commercial vehicles. The arrival in 1983 of Suzuki Motors as the Indian government's joint venture partner in Maruti Udyog Limited (later renamed Maruti Suzuki) was an important landmark in the history of the Indian automobile industry (Hamaguchi 1985).[2] At that time, the government was concerned about its oil import bill, and Suzuki, a world leader specializing in small fuel-efficient cars, was an ideal joint venture partner (D'Costa 2004). Following the entry of Suzuki, other major Japanese automobile manufacturers (Toyota, Mitsubishi, Nissan, and Mazda) arrived, perceptibly changing the stature of the Indian automobile industry.

The other joint ventures established in the 1990s included Mercedes-Benz with Tata Engineering and Locomotive Company (1994), General Motors with Hindustan Motors (1994), Peugeot with Pal Automotives (1994),

[2]As already noted, the government initially owned 80% of the joint venture's equity, but this share was reduced over the years. Maruti Suzuki became fully foreign owned when the Indian government sold the remaining 18% of its shares in 2007. The company continued to remain the largest small and compact car producer in India. In 2016, Maruti Suzuki accounted for 51% of the annual global vehicle production of Suzuki Motors Corporation (1.5 million out of 2.9 million units) (OICA 2017).

Daewoo with Toyota (1995), Honda Motors with Siel Ltd. (1995), Ford with Mahindra & Mahindra (1996), Fiat with Tata Motors (1997), and Toyota with Kirloskar Group (1997). Hyundai and Volvo entered the Indian market by setting up fully owned subsidiaries in 1996 and 1997, respectively.

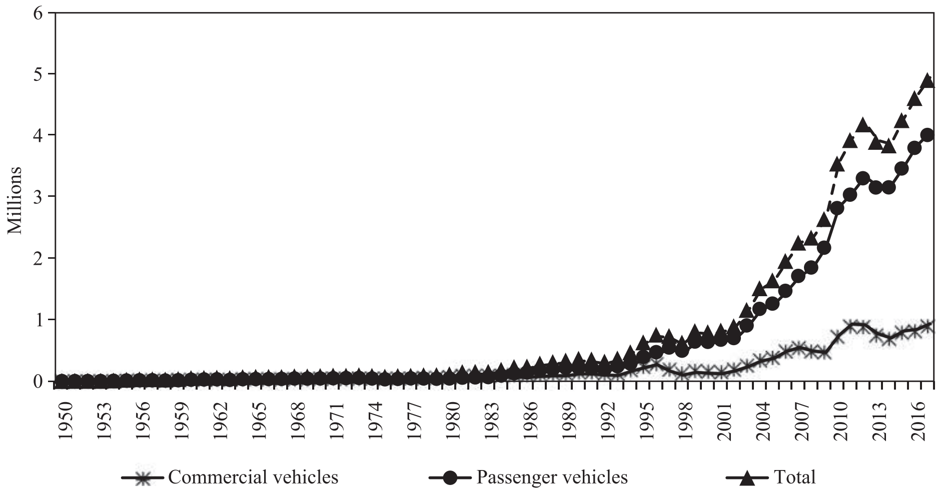
Following the abolition of ownership restrictions in 2000, the dominant mode of entry changed from license agreements and joint ventures to wholly owned subsidiaries. Hyundai was the first automobile MNE to establish a 100% subsidiary in the country. Volkswagen, Nissan, BMW, and Isuzu Motors followed suit. Companies that first entered as joint ventures, such as Honda, Ford, Fiat, and Renault severed links with their local partners and established 100% subsidiaries (Foy 2012).

Following the entry of Japanese carmakers in the 1980s, several Tier 1 automobile parts suppliers (such as Denso, Aisin Seiki, and Toyota Boshoku) set up operations in India. However, operations of foreign-owned automobile parts producers faced constraints until early 2000s because of local content requirements for automobile assembly and the SME reservation policy. Following the removal of these restrictions in 2001, many more global automobile parts producers arrived (such as Robert Bosch, Delphi, Magna, Eaton, Visteon, and Hyundai Mobil). As we will discuss below, the Tier 1 automobile parts market play a pivotal role in the expansion of the Indian automobile industry as intermediaries between the local automobile parts makers and automobile producers. Automobile parts suppliers account for almost two-thirds of the value of the average car. Therefore, the competitive advantage of a carmaker depends crucially on its ability to maintain a harmonious relationship with its parts suppliers (Klier and Rubenstein 2008, Dyer 2000). In fact, Japanese carmakers consider a long-standing constructive relationship with their parts suppliers as “legitimate semi-insiders” a key factor of their success (Sako 2004).

IV. Growth and Composition of Production

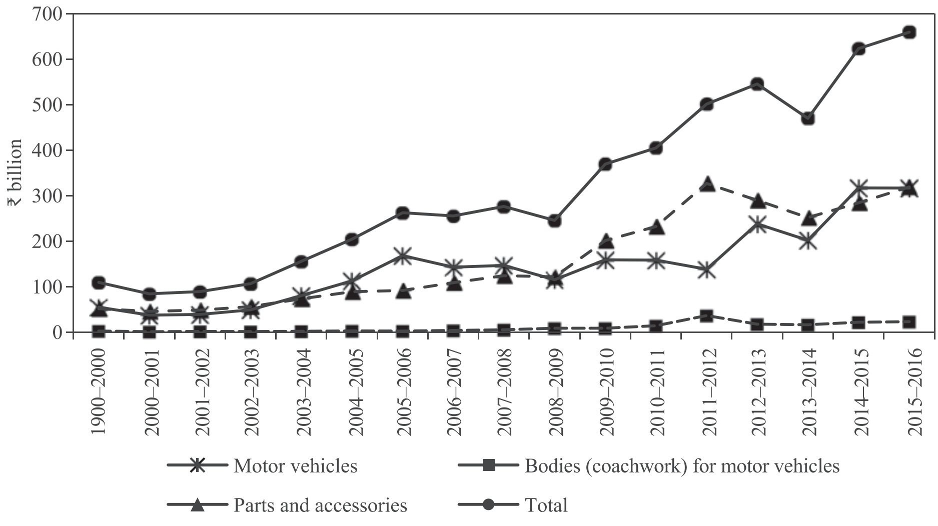
Figure 1 shows the trends in passenger and commercial vehicle production during the period 1950–2017. Total production remained at fewer than 100,000 units until the mid-1980s. The production of passenger vehicles gradually increased during the second half of the 1980s, picked up pace during the 1990s, and then grew much faster since the early 2000s. Production of passenger vehicles crossed the 1 million mark in 2004 while that of commercial vehicles remained below 1 million throughout the ensuing years. The share of passenger vehicles in the total number of vehicles produced stood at 82% in 2017, up from 56% in 1985. Real gross output (value added) in the automobile industry, which includes final assembly, manufacture of bodies (coach work), and parts and components production, grew at an average annual rate of 18.5% during 2000–2015, compared to about 6% during the previous 2 decades (Figure 2).

Figure 1. **Vehicle Production in India**



Source: Constructed using data from the Society of Indian Automobile Manufacturers (SIAM 2016).

Figure 2. **Real Output (value added) of the Automobile Industry**



Sources: Nominal value-added data are from the Annual Survey of Industries (ASI), Central Statistical Organization (CSO); and nominal values are deflated using the gross domestic product deflator for transport equipment obtained from the National Accounts Statistics, CSO.

During 1999–2016, compact cars accounted for over 80% of passenger vehicles, followed by midsize cars (engine size of 4,001 millimeters [mm] to 4,500 mm) with 18%, and large cars (engine size of over 4,500 mm) accounting for the balance. Maruti Suzuki (with a market share of 51%) and Hyundai (27%)

Table 3. **Passenger Car Production in India: Shares of Automakers (%) and Total Number of Vehicles Produced**

	Compact (up to 4,000 mm)		Midsize (4,001–4,500 mm)		Large (>4,500 mm)
	2009	**2014**	**2009**	**2014**	**2009**
Maruti Suzuki	50.8	51.3	37.5	16.4	0.0
Hyundai	33.6	27.5	17.6	14.7	0.8
Tata Motors	9.4	5.6	9.9	0.7	0.0
Nissan	0.0	4.9	0.0	12.0	0.0
Honda	0.6	3.7	17.3	20.8	18.3
Volkswagen	0.0	1.8	0.0	18.4	0.6
Ford	0.5	1.8	10.6	2.5	0.0
Toyota Kirloskar	0.0	1.8	0.0	9.0	18.8
General Motors	3.7	1.1	1.4	1.8	9.5
Fiat	0.9	0.3	0.0	0.0	21.6
Renault	0.0	0.1	0.0	0.2	0.0
Mahindra & Mahindra	0.0	0.1	2.3	0.5	0.0
BMW	0.0	0.0	0.0	0.0	5.3
Hindustan Motors	0.0	0.0	3.4	0.0	0.0
Mercedes-Benz	0.0	0.0	0.0	0.0	6.5
Skoda	0.4	0.0	0.0	3.1	18.5
Total	100	100	100	100	100
Number	1,614,539	2,021,676	265,993	372,876	52,088

mm = millimeters.

Notes: Data are based on the Indian fiscal year: 1 April in the reporting (given) year to 31 March in the following year.

Source: Compiled from the Society of Indian Automobile Manufacturers (SIAM 2016).

dominate the compact car segment (Table 3).[3] By contrast, the market structure for midsize cars is less concentrated, with the following carmakers accounting for more or less similar market shares: Honda (21%), Volkswagen (18%), Maruti Suzuki (16%), Hyundai (15%), and Nissan (12%). In commercial vehicles, Tata Motors accounts for the largest share in light commercial vehicles (43%) and medium and heavy commercial vehicles (54%), with the next largest players being Mahindra & Mahindra (39.8%) and Ashok Leyland (29.2%), respectively.

Notwithstanding the entry of foreign parts suppliers, domestic firms still account for the bulk (about 80% during 1997–2017) of locally procured automobile parts and components.[4] As expected, within the components industry, most (if not all) firms with foreign partners are Tier 1 suppliers who work closely with automobile producers. Most of the fully Indian firms are operating at the Tier

[3]The term "compact cars" is used here to refer to cars with ignition engine capacity of less than 1,500 cubic centimeters (cc). In automobile production statistics, this category of cars is recorded under two subcategories: compact <1,000cc (ignition engine capacity of less than 1,000cc) and compact >1,000cc (ignition engine capacity between 1,000cc and 1,500cc).

[4]Estimated using data from the Center for Monitoring the Indian Economic Prowess database. Foreign firms are defined as those with a foreign equity share of 25% or more.

2 and Tier 3 levels (Dash and Chanda 2017, Saripalle 2016). Undoubtedly, the domestic content requirements and SMEs reservation policy imposed during the import substitution era have played a role in the continued dominance of local firms in the automobile components segment. However, it is important to note that the "direct" output shares of Tier 1 firms (20%) grossly understate their role in globally integrating the Indian automobile industry. As already noted, these firms play a vital role in linking Tier 2 and Tier 3 suppliers with automakers.

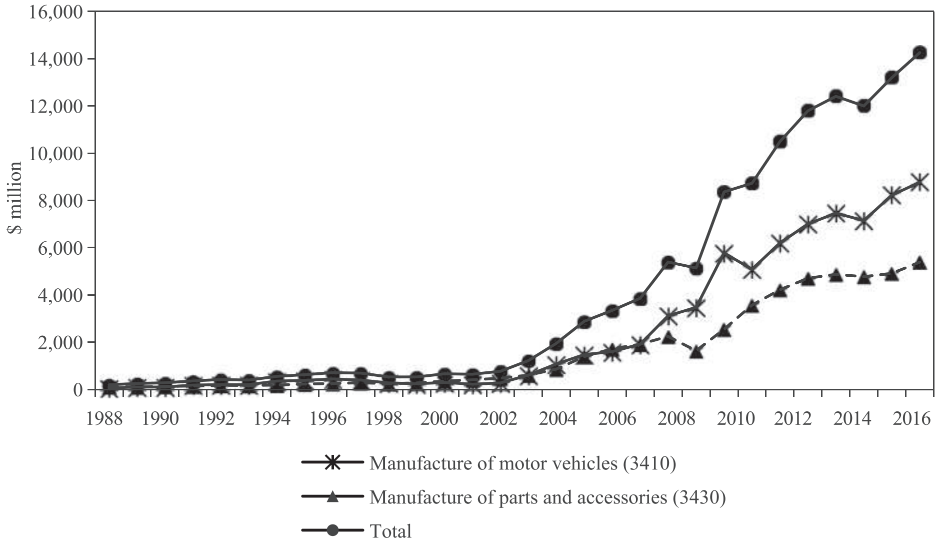
Some automobile MNEs have begun to use India as an export platform within their GPNs. For example, Toyota Kirloskar Auto Parts, a joint venture between Toyota and a local manufacturer, is exporting gearboxes from India to assembly plants in various countries, including Argentina, South Africa, and Thailand. Toyota Indonesia, which specializes in multipurpose vehicles, has integrated its production system with its operations in India, importing engine components from Indonesia and exporting gearboxes and automobile parts. Suzuki India has developed a two-way sourcing network encompassing its plants in India, Indonesia, and the PRC.

Hyundai has its largest overseas production base in India, with industrial clusters in Bengaluru, Chennai, Delhi, and Mumbai. Hyundai Motors India is playing an important role in expanding the parent company's presence in neighboring Southeast Asian countries. It exports a compact car designed in India (Santro) as semi-knocked down and CBUs to Pakistan, Bangladesh, Nepal, and Sri Lanka. Interestingly, Santro was launched in the Republic of Korea under the name Visto, with body panels, engine, and transmission components entirely imported from India. This is the first-known case in the history of the Indian passenger car industry of reverse technology transfer: a car designed by an MNE in India subsequently becoming part of the parent company's domestic production base (Park 2004).

V. Export Performance

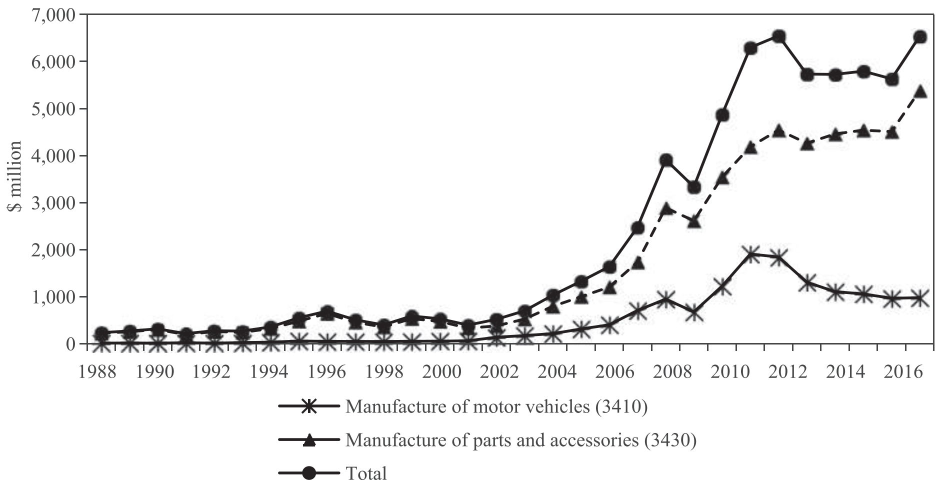
India's exports of CBUs increased from about $225 million in 2001 to $8.8 billion in 2017, while exports of parts and accessories increased from $408 million to $5.5 billion between these 2 years (Figure 3). The pattern is quite different on the import side with parts and accessories growing significantly faster than assembled vehicles during the same period (Figure 4). In 2017, the import value of assembled vehicles stood below $1 billion compared to about $5.4 billion of imports of parts and accessories. While assembled motor vehicles constitute the bulk of India's automobile exports (parts and components plus final assembly, which was 62% in 2017), parts and accessories account for the lion's share of total automobile imports (82% in 2017). This pattern is consistent with the emergence of India as an assembly center of automobiles.

Figure 3. **Automobile Exports, 1988–2017**



Note: Data based on International Standard Industrial Classification (ISIC). ISIC codes are in parentheses.
Source: Constructed with United Nations Comtrade data accessed using the World Bank's World Integrated Trade Solution.

Figure 4. **Automobile Imports, 1988–2017**



Note: Data based on International Standard Industrial Classification (ISIC). ISIC codes are in parentheses.
Source: Constructed with United Nations Comtrade data accessed using the World Bank's World Integrated Trade Solution.

The export–output ratio (the share of exports in total domestic production) for passenger vehicles is significantly higher (in the range of 15% to 20%) than for commercial vehicles (in the range of 8% to 13%) (Table 4). Within the passenger

Table 4. **Number of Vehicles Exported as a Share of the Number of Vehicles Produced (%)**

	2009	2010	2011	2012	2013	2014	2015	2016	2017
Passenger vehicles	18.9	15.2	16.2	17.2	19.3	19.3	18.8	20.0	18.6
Passenger cars	22.9	18.2	19.8	22.4	23.7	22.4	n.a.	n.a.	n.a.
Utility vehicles	1.0	1.1	1.2	1.2	5.9	10.0	n.a.	n.a.	n.a.
Commercial vehicles	7.9	10.1	9.9	9.6	11.0	12.3	13.1	13.4	10.8

n.a. = not available.
Notes: Data are based on the Indian fiscal year: 1 April in the reporting (given) year to 31 March in the following year.
Source: Compiled from the Society of Indian Automobile Manufacturers (SIAM 2016).

vehicles segment, export orientation for passenger cars is significantly higher (in the range of 18%–24%) than for utility vehicles.

Passenger vehicles dominate the composition of automobile exports. The share of passenger vehicles in total vehicle exports increased from 31% in 1988 to 84.5% in 2017. A striking feature of passenger vehicle exports is their heavy concentration in compact cars. Cars belonging to this size category accounted for over 80% of passenger vehicle exports from India, compared to a global average of a mere 15% during 2000–2015. In Thailand, the largest car exporter in the region, compact cars accounted for only 38% of total passenger vehicle exports during this period. Between 2000 and 2015, India's share in world exports of compact cars increased from 0.7% to 5.6%, whereas India accounted for only about 1.4% of world passenger vehicle exports in 2015.[5]

Data on the geographic profile of compact car exports covering the top 25 destinations are given in Table 5. Markets in middle-income countries account for 45% of exports while high-income countries account for 37%. Among the middle-income group, the top individual country destinations include South Africa (16.4%), Algeria (7.6%), Eswatini (5.2%), and Mexico (3.8%). Among high-income countries, the top destinations include the United Kingdom (UK) (10.3%), Spain (4.5%), the United Arab Emirates (3.9%), Australia (3.9%), the Netherlands (3.6%), Italy (2.7%), and Germany (2.1%). In contrast to popular perception, the markets for Indian cars are not restricted only to developing countries. The high concentration of exports in South Africa and the UK is underpinned by the investment of Indian automobile companies in these countries. For example, Tata Motors acquired Jaguar Land Rover in the UK. Tata Motors and Mahindra & Mahindra have begun to penetrate markets in African countries from their bases in South Africa. Tata has invested over $700 million to set up a production base in South Africa. Mahindra & Mahindra exports automobiles to Botswana, Eswatini, Namibia, Zambia, and Zimbabwe using South Africa as the center of its operations in the region (Nyabiage 2013).

[5]Figures reported in this section, unless otherwise stated, are calculated from the United Nations Comtrade database (using export data at the 6-digit level of the Harmonized System).

Table 5. **Top 25 Destinations for India's Exports of Compact Cars, 2011–2014**

Countries	$ Million	Number	Share in Value (%)
(a) High-income countries			
United Kingdom	115.4	14,890	10.3
Spain	50.8	6,322	4.5
United Arab Emirates	43.7	4,444	3.9
Australia	43.7	4,578	3.9
Netherlands	40.8	4,933	3.6
Italy	30.8	4,293	2.7
Germany	23.7	3,374	2.1
Israel	17.1	2,153	1.5
Saudi Arabia	15.6	1,709	1.4
Chile	15.1	2,462	1.3
Bahrain	11.3	1,168	1
Ireland	8.9	896	0.8
Total	416.9	51,222	37.0
(b) Middle-income countries			
South Africa	184.3	24,196	16.4
Algeria	85.6	13,609	7.6
Eswatini	58	2,252	5.2
Mexico	43.1	7,194	3.8
Indonesia	21.7	3,251	1.9
Lebanon	18.8	2,438	1.7
Colombia	18.2	3,829	1.6
Libya	15.8	2,643	1.4
Tokelau	14.9	1,652	1.3
Angola	14.6	1,747	1.3
Peru	13	2,178	1.2
Turkey	11.8	1,263	1.1
Panama Republic	8.7	1,180	0.8
Total	508.5	67,432	45.3
(c) Low-income countries	198	26,386	17.6

Source: Compiled from data provided by the Directorate General of Commercial Intelligence and Statistics, Ministry of Commerce, Government of India.

Having shown that India has been successful in carving out a niche in compact cars in both high- and middle-income countries, a pertinent question is how do Indian compact cars compare with those of competitors in terms of price? To address this question, we compare India's export unit values with those of the US for compact cars (Table 6).[6] The US is used here as the comparator country because of the availability of comparable data, and the comparison is appropriate given that India has a significant market presence in developed countries where it faces direct competition from carmakers in advanced countries, including the US.

[6]Unit values have well-known limitations as price proxies (particularly for manufactured goods), including spuriously capturing price changes associated with quality and brand changes as true price changes (Lipsey, Molineri, and Kravis 1991). Mindful of these limitations, we have used unit values here and in the next paragraph solely for making an overall comparison of price levels, rather than for analyzing intertemporal variations in prices.

Table 6. **Unit Value of Compact Car Exports from India and the United States, 2003–2013 ($)**

	Compact <1,000cc Cars		Compact >1,000cc Cars	
Year	**India**	**US**	**India**	**US**
2003	3,872	4,697	5,697	8,776
2004	4,437	4,946	4,622	8,618
2005	4,284	5,390	5,601	9,100
2006	3,877	5,500	9,828	13,012
2007	3,779	5,580	5,753	15,061
2008	3,888	5,952	6,135	15,274
2009	6,475	6,324	6,869	15,326
2010	5,200	7,454	6,946	15,164
2011	5,740	7,402	6,849	15,318
2012	5,494	7,873	7,395	15,763
2013	5,743	7,986	7,347	15,232

cc = cubic centimeters, US = United States.
Note: Data are based on the calendar year.
Sources: Unit values for India are estimated using data (at the 8-digit level of the Harmonized System) from the Directorate General of Commercial Intelligence and Statistics, Ministry of Commerce, Government of India. Unit values for the US for the same product description are obtained from the US Census Bureau.

We find that Indian unit values are significantly lower than for the US. Thus, price competitiveness seems to be an important factor behind India's export success in this segment of the global automobile market.

It is also pertinent to compare unit-value realization from domestic sales with unit-value realization from exports. This comparison will help us understand the importance of tariff protection as a determinant of India's attractiveness as a production base for automakers, that is, whether tariff protection helps exporting firms maintain international competitiveness by relying on excessive profits earned domestically at tariff-ridden prices (Krugman 1984).

For this price comparison we computed the unit value of domestic sales of two major automobile producers in India—Hyundai and Maruti Suzuki—and export unit values of total compact car exports from India (Table 7). To facilitate the comparison, it is important to note that Hyundai mostly exports cars in the compact >1,000 cubic centimeters (cc) segment while Maruti Suzuki exports both types of compact cars (that is, cars with ignition engine capacity of less than 1,000cc and between 1,000cc and 1,500cc). It is evident that the export unit value of exports is not significantly different from the domestic unit value for Hyundai, and the domestic unit value for Maruti Suzuki is approximately the weighted averages of export unit values for the two types of cars. Allowing for spikes, which possibly reflect limitations of unit values as a proxy for price (footnote 7), it appears overall that domestic prices are approximately equal to export prices, implying that tariff protection is virtually redundant as a determinant of India's attractiveness as

Table 7. **Unit Value of Domestic Sales and Exports of Compact Passenger Cars**

	Unit Value Realization from Domestic Sales ($)		Unit Value Realization from Export Sales ($)	
	Hyundai	Maruti Suzuki	Compact <1,000cc Cars	Compact >1,000cc Cars
2003	n.a.	4,910	3,933	4,816
2004	n.a.	5,348	4,535	6,275
2005	n.a.	5,540	4,118	7,905
2006	n.a.	5,424	3,713	5,926
2007	n.a.	6,367	3,960	6,755
2008	7,089	5,271	4,549	6,876
2009	7,102	6,414	6,547	7,001
2010	7,079	6,612	5,103	7,096
2011	6,779	6,671	5,818	7,248
2012	6,796	6,922	5,410	7,391
2013	7,676	6,188	5,825	7,557
2014	6,434	6,081	6,238	7,754
2015	7,505	6,095	5,783	7,486

cc = cubic centimeters, n.a. = not available.
Notes: Data are based on the Indian fiscal year: 1 April in the reporting (given) year to 31 March in the following year.
Sources: Unit values of domestic sales are computed using firm-level data from the Center for Monitoring the Indian Economy database. Unit values of exports are computed using export data (8-digit Indian Trade Classification) from the Directorate General of Commercial Intelligence and Statistics, Ministry of Commerce, Government of India.

a production base of compact cars. Ex-showroom prices gathered from various newspaper clippings also indicate a similar pattern. For example, the average ex-showroom price for Maruti Alto, the major brand exported in the compact car segment, was about $5,710 in 2012. Similarly, the ex-showroom price for Hyundai, the most exported brand in the 1,000cc–1,500cc car segment, was about $7,320 in 2013. In sum, the cost competitiveness of Indian cars sold in foreign markets does not seem to be rooted in tariff protection.

VI. Comparison with Electronics and Electrical Goods

Electronics and electrical goods account for the bulk of manufacturing exports from the PRC and other East Asian economies, which have integrated well into GPNs. The PRC has emerged as the global hub of electronics assembly in the world (Athukorala 2014). However, these products account for only a tiny share of India's exports (Athukorala 2019). An important question in this context, therefore, is what are the specific conditions which have made it possible for India's automobile industry to successfully integrate into GPNs but not the electronics industry? We argue that the divergent outcomes are related to both differences in the policy regime and industry characteristics.

Under planning for industrialization in India during the first 3 decades of independence, electronics and electrical machinery remained reserved for the public sector and the private SME sector. Until the late 1980s, foreign collaboration was not permitted in these sectors other than in 100% export-oriented ventures (Subramanian and Joseph 1988). In contrast, government policy was more accommodative of a private sector role and MNE participation in the automobile industry, even during the heydays of import substitution (section II). This long history of opening up for the private sector and allowing MNE participation presumably set the stage for global integration of the automobile industry following the liberalization of reforms initiated in the early 1990s and which gathered momentum from about the start of the new millennium.

Turning to industry characteristics, both electronics and automobiles have production processes conducive to global production sharing: discrete (separable) stages of production with different scales, skills, and technological needs and that can be located in different sites. However, unlike electronics, automobiles are bulky and have a low value-to-weight ratio and hence transport cost is a key determinant of market price. There is also a need to design the product to suit the tastes and budget of the consumer. Therefore, there is a natural tendency for car assembly plants to locate in countries with large domestic markets (Lall, Albaladejo, and Zhang 2004).

Once automakers choose to set up assembly plants in a given country, parts and component producers follow them because of two reasons. First, and perhaps more important, most automobile parts are also bulky and characterized by low value-to-weight ratios, which make it too costly to use air transport to ensure the timely delivery required by the final assembler's just-in-time production schedule.[7] Second, there is an asymmetrical market power relationship between component makers and automakers within the global automobile industry—products of many automobile parts manufacturers are used in vehicles made by a handful of carmakers. Electronics parts such as integrated circuits and semiconductors, by contrast, are used in many industries. Thus, there is an incentive for automobile parts makers to set up factories next to the assemblers to secure their position in the market (Klier and Rubenstein 2008, Dyer 2000).

Once a complete production base (involving both final assembly and component assembly and/or production) is established in a given (large) country, exporting to third countries becomes a viable option for automakers. Scale economies gained from domestic expansion makes exporting both parts and components and assembled vehicles profitable as part of their global profit maximization strategy. Adapting products to suit domestic demand conditions and lower transportation costs compared to exporting from the home base also become important drivers of exporting to regional markets from the new production base.

[7]By contrast, air shipping is the mode of transport for over two-thirds of electronics exports from Malaysia, the Philippines, Singapore, and Thailand to the US (Hummels 2009).

In electronics, the value-to-weight ratio of the final products and most components is generally much higher than in the automobile industry. Therefore, the industry has the flexibility to locate various slices and/or tasks of the production process in different sites based on relative cost advantages, provided the reduction in production cost more than offsets the "service link" cost (Lall, Albaladejo, and Zhang 2004; Jones and Kierzkowski 2004). The term service link refers to arrangements for connecting and coordinating activities in each country with what is done in other countries within the production network. Service link costs are determined by the overall investment climate of a given country encompassing foreign trade and investment regimes and the quality of trade-related infrastructure and logistics. India's average manufacturing wage is much lower than in the PRC and other major East Asian countries (Athukorala 2019). As labor costs are rising sharply in the PRC, India has an opportunity to make inroads into GPNs. The experience in the PRC clearly demonstrates that the availability of a large labor pool is an advantage, particularly for final goods assembly within GPNs, which require production in factories that employ a large number of workers. However, notwithstanding significant trade and investment policy reforms over the past 2 decades, India has not been able to meet the service link standards required for electronics to fit into GPNs.[8]

VII. Determinants of Exports: Gravity Model Analysis

In this section, we undertake an econometric analysis of the determinants of automobile exports. The analysis uses the standard gravity modeling framework, which has now become the workhorse for modeling bilateral trade flows (Head and Mayer 2014). The export equation is estimated separately for compact $<$1,000cc cars, which accounted for the largest share of total automobile exports during the 1990s, and compact $>$1,000cc cars, which started to gain a bigger share of the export mix from the early 2000s.

A. The Model

After augmenting the basic gravity model by adding several explanatory variables, which have been found to improve its explanatory power in previous studies (Head and Mayer 2014, van Bergeijk and Brakman 2010), the empirical model is specified as

$$\begin{aligned} EXP_{jt} = f(&L(GDP)_{jt}, L(POP)_{jt}, L(PRD)_{jt}, L(RER)_{jt}, L(TAR)_{it}, L(MPC)_{it},\\ &DP2000, DHI_{jt}, DUMI_{jt}, DLMI_{jt}, DFTA_{it}, DEU_{jt}, DNAFTA_{jt},\\ &DSACU_{jt}, TREND_t, \delta_t, \varepsilon_{jt}) \end{aligned}$$

[8]For details, see Athukorala (2019) and the studies cited therein.

where i stands for India, j is India's trade partner, t is year, and L denotes the natural logarithm. The notation δ_t represents partner fixed effects, which captures time-invariant, partner-specific variables such as distance from India, business language, and a common border, and precludes the need to explicitly control for these factors. ε_{jt} is a stochastic error term, assumed to have a normal distribution. The variables are defined below, with the postulated signs of the coefficient for explanatory variables given in parentheses.

EXP	Bilateral exports, \$ million.
GDP	Gross domestic product of trade partner, \$ million (+)
POP	Midyear population (+)
PRD	Automobile production (gross output), \$ million (+)
RER	Bilateral real exchange rate index (2010 = 100) (+)
TAR	Nominal applied import tariff rate (%) (− or +)
MPC	Import of vehicle parts and components, \$ million (+)
D2000	A dummy variable to capture policy shifts from 2000, 1 for the years after 2000 and 0 otherwise (+)
DHI	A dummy variable that takes a value of 1 if a partner country belongs to the group of high-income countries and 0 otherwise (+)
DUMI	A dummy variable that takes a value of 1 if a partner country belongs to the group of upper-middle-income countries and 0 otherwise (+)
DLMI	A dummy variable that takes a value of 1 if a partner country belongs to the group of lower-middle-income countries and 0 otherwise (+)
DFTA	A binary dummy that takes a value of 1 if both India and its trade partner belong to the same free trade agreements (+)
DEU	A binary dummy variable that takes a value of 1 if a partner country is a member of the European Union or 0 otherwise (+ or −)
DNAFTA	A binary dummy variable that takes a value of 1 if a partner country is a member of the North American Free Trade Agreement and 0 otherwise (+ or −)

DSACU A binary dummy variable which takes a value of 1 if a partner country is a member of the Southern African Customs Union or 0 otherwise (+ or −)

TREND A linear time trend to capture secular changes in exports over time (+ or −)

Among the explanatory variables, *GDP* and *POP* of partner countries capture external demand for Indian automobile exports, and *PRD* captures Indian supply capability. Bilateral real exchange rate (*RER*), measured as the domestic currency price of the trading partner's currency adjusted for relative prices between the two countries, is included to capture the relative profitability of exporting compared to selling in the domestic market.

The variable *TAR* represents India's nominal import tariff rate for CBU imports. According to the Lerner symmetry theorem, import tariffs act as an export tax by reducing the relative profitability of exporting compared to selling in the domestic market (Lerner 1936). However, the theory of import protection as export promotion postulates that producing for a protected domestic market helps achieve scale economies that, in turn, enhance export competitiveness (Krugman 1984). Therefore, the sign of the regression coefficients can be positive or negative.

MPC is a proxy for the positive effect on export performance of procuring parts and components within automobile GPNs. *D2000* is included to capture the impact of an acceleration of reforms in the early 2000s aimed at integrating the Indian automobile industry into GPNs compared to the early years (first 9) of reforms (see section II). *DFTA* represents the impact of tariff concessions offered under various trade agreements, while *DEU*, *DNAFTA*, and *DSACU* aim to capture the impact of major trade blocs in which India is not a member.[9] The three income group variables (*DHI, DUMI*, and *DLMI*) are specified based on the World Bank country classification and using the low-income country group as the base dummy. These three variables are included to test whether the stage of development of destination countries has a distinctive effect on export demand in addition to their GDP levels. Finally, *TREND* captures secular changes in exports over time.

As a robustness check, we estimate the above export equation by including four time-invariant variables, which are commonly used in gravity models in place of country-pair fixed effects (δ_j). The variables are *DST*, the geographical distance between New Delhi and capital city of partner countries; *BDR*, a common border dummy (1 if India and the partner share a common land border and 0 otherwise); *CLK*, a colonial economic link dummy (1 for India–UK bilateral exports and 0

[9] It is possible to include these variables along with partner fixed effects, as they are defined with respect to the year and the partner. The time subscripts in these variables refer to the years during which the trade blocs have been in operation.

for other country); and *CML*, a common language dummy (1 if India and the partner use a common business language and 0 otherwise). The expected sign of the regression coefficient is negative for *DST* and is positive for the other three variables.

B. Data and the Estimation Method

The dataset covers 196 trading partner countries during the period 1988–2015. Export data are from the United Nations Comtrade database. Data on value of output for motor vehicles are from the Annual Survey of Industry conducted by the Central Statistical Office of India. Data on *GDP*, *POP*, and the variables used for computing *RER* (bilateral exchange rate and GDP deflator for India and partner countries) are from the World Bank's World Development Indicators. Data on *TAR* and the information used for constructing *DFTA*, *DEU*, *DNFT*, and *DSACU* are from the World Bank's World Integrated Trade Solution and Global Preferential Trade Agreement databases. Following recent trade flow analyses using the gravity model, we use nominal US dollar values for *EXP*, *GDP*, *MPC* to avoid estimation biases associated with deflating (Head and Mayer 2014). Within the gravity modeling framework, *TREND* serves as a deflator of the nominal US dollar series used.

The estimation method used is the Poisson pseudo maximum likelihood (PPML) estimator (Santos Silva and Tenreyro 2006, 2010). PPML is a multiplicative estimator that has the advantage of retaining 0 export values. It also yields consistent coefficient estimates in the presence of heteroscedasticity. The PPML requires that the dependent variable enters in level (nonlog) form, but the coefficient estimates of the independent variables, used in log form, can still be interpreted as elasticities.

C. Results

Table 8 presents estimates of the export equation with country-pair fixed effects. Alternative estimates with the standard time-invariant variable in place of country-pair fixed effects are reported in the Appendix for comparison.

Looking first at the equation for compact <1,000cc cars, the coefficient of the trade partner's GDP is statistically significant, with the coefficient indicating that a 1% increase in the partner country's GDP on average is associated with an increase in India's exports by 0.11%, other things being equal. The coefficient for population has the perverse (negative) sign and is significant only at the 10% level. Taken together, the results for *GDP* and *POP* seem to suggest that the stage of development as measured by per capita income, rather than the absolute market size measured by GDP or population, is more relevant for explaining changes in India's

Table 8. **Determinants of India's Bilateral Exports (*EXP*): Gravity Model Estimation Results**

	Compact <1,000cc Cars	Compact >1,000cc Cars
log *GDP*	0.105***	−0.002
	(0.027)	(0.033)
log *POP*	−0.069*	−0.011
	(0.036)	(0.042)
log *PRD*	0.934***	−0.043
	(0.235)	(0.289)
log *RER*	−0.042	0.173***
	(0.065)	(0.068)
log *TAR*	−0.886***	0.108
	(0.268)	(0.229)
log *MPC*	0.396**	1.417***
	(0.227)	(0.327)
D2000	1.141***	3.010***
	(0.427)	(0.648)
DHI	1.234**	0.418
	(0.625)	(0.761)
DUMI	1.035***	0.589
	(0.327)	(0.473)
DLMI	1.309***	0.200
	(0.428)	(0.594)
DFTA	0.513	0.969**
	(0.397)	(0.484)
DEU	−1.376***	2.920***
	(0.291)	(0.571)
DNFT	0.769	3.057**
	(1.237)	(1.277)
DSACU	3.150***	4.336***
	(0.157)	(0.256)
TREND	−0.067	−0.014
	(0.042)	(0.048)
Partner fixed effects	Yes	Yes
Observations	4,393	4,411
R-squared	0.776	0.775

cc = cubic centimeters.
Notes: Robust standard errors clustered by trading partner are in parentheses. ***, **, and * indicate statistical significance of the regression coefficients at 1%, 5%, and 10%, respectively. See footnote 3 for the definition of the two types of compact cars.
Source: Authors' estimates.

export patterns over time.[10] This finding is also consistent with the coefficient estimates of the three dummy variables classifying destination countries by income groups (*DHI*, *DUMI*, and *DLMI* with low-income countries as the base dummy). The coefficients of these three variables, which are highly statistically significant, show that the geographic profile of compact car exports has a bias toward high- and middle-income partner countries relative to low-income partners.

[10]Note that change in per capita *GDP* is equal to change in *GDP* minus change in *POP*.

The coefficient of *PRD* is positive and highly significant, suggesting that a 1% increase in domestic production is associated with a 0.93% increase in exports. The result for the import tariff variable (*TAR*) suggests that a 1% reduction in India's import tariff rate is associated with an 0.89% increase in exports. Similarly, there is evidence that a 1% increase in imports of parts and components (*MPC*) is associated with a 0.4% increase in exports. According to the coefficient of *D2000*, export earnings during the period after 2000 are on average 1.14% higher compared to the previous years covered in the analysis. Overall, the results for these four variables confirm the importance of supply-side reforms in the emergence of India as a dynamic player within global compact car markets.

Interestingly, the coefficient of *RER* is not statistically different from zero, suggesting that relative profitability of exporting compared to selling domestically is not a significant determinant of the export decisions of Indian automobile firms. This is understandable because exporting decisions of firms operating within GPNs depend on the parent firm's locational decision at the global level, rather than on the relative profitability of selling in the domestic market of a given country. As discussed, Indian subsidiaries of compact automobile producers (in particular, Suzuki and Hyundai) have gained a competitive edge within the global automobile networks.

Turning to the equation for compact >1,000cc cars, the coefficients of the three main gravity variables—*GDP, POP*, and *PRD*—are not statistically different from zero. The coefficient of *TAR* is also not statistically significant. These results are understandable because India has emerged as an important player in this segment only in recent years and production is still predominantly for the middle-income domestic market. The results for *MPC* and *D2000* are consistent with those for compact cars. Providing easy access to intermediate inputs and broadening of reforms to facilitate carmakers to integrate within global production seem equally important for the export expansion of both types of compact cars.

Unlike in the case of compact <1,000cc cars, the bilateral real exchange rate (*RER*) coefficient is statistically significant for compact >1,000cc cars and has the expected sign. The coefficient suggests that a 1% depreciation of the *RER* is associated with a 0.17% increase in exports. This somewhat intriguing contrast presumably suggests some export spillover from predominantly domestic-oriented production in response to changes in relative profitability of exporting compared to selling in the domestic market. This finding is also consistent with a comparison of results for *DFTA* between the two equations. The coefficient for this variable is statistically significant with a positive sign only for compact >1,000cc cars. The highly significant and positive coefficient of *DSACU* in both equations is consistent with our observation (section V) that India-based carmakers expand exports to countries in the Southern African Customs Union using South Africa as the entry point.

The inferences made so far in this section are generally consistent with an estimation of the export equations that includes a time-invariant gravity variable instead of country-pair fixed effects (compare Table 8 with the Appendix). However, the overall fit of the two alternative export equations is much lower (measured by R-squared) compared to their fixed effects counterparts. The upshot is that export patterns are significantly influenced by unobservable destination country-specific effects over and above the four observable time-invariant variables we have included in the equations. This justifies our choice of the fixed effect estimates as the preferred econometric evidence.

In alternative estimates, colonial dummy (*CLK*) is highly significant with the expected positive sign in both equations. This result indicates the importance of colonial links in explaining the growing importance of the UK as the largest destination among developed countries for automobile exports from India (section V). Interestingly, geographic distance (*DST*), which has been commonly found as a key determinant of trade patterns in applications of the gravity model to aggregate trade flows, is not a significant determinant of automobile exports from India. It could be that consideration of "natural" trade cost associated with distance to market is overwhelmed by other specific considerations relating to MNE's production sharing within GPNs.

VIII. Concluding Remarks

From about the early 2000s, the Indian automobile industry has undergone a remarkable transformation from domestic market-oriented production that prevailed for over a half century to global integration. During the past 2 decades, most major automobile MNEs have set up wholly owned subsidiaries in India to produce for the growing domestic market as well as to use India as a production base for global markets of compact cars. Several global Tier 1 parts and component suppliers have also established production facilities in India. As a result, the country has emerged as a major assembly center for compact cars. Our analysis shows that Indian compact cars are highly price competitive in the international market.

Our analysis also suggests that simply granting trade protection in the absence of enabling conditions for foreign technology transfer is not an effective strategy to build a globally competitive automobile industry. Learning and capacity development through foreign market participation and entry of parts and components producers to set up production bases has been the key factor behind India's emergence as a production base within automobile GPNs. Market-conforming policies in the automobile sector over the past 2 decades, which constituted a notable departure from the protectionist policies in the past, have played a key role in transforming the Indian automobile industry.

Both car manufacturing and component production in India are dominated by foreign firms, with local firms mostly involved as suppliers of parts and components. However, this does not seem to make a case for government intervention to promote local interest; increased involvement of foreign firms in both car assembly and parts production has been a universal phenomenon driven by a structural shift in the global automobile industry, from the traditional multimarket mode of production to a globally integrated system of production. In the new era of a "world car," strategic alliances forged between key players in the industry and firms of different national origin have become the norm for cross-border operations. This by no means implies that Indian companies do not have the ability to move up the production ladder as they acquire expertise and technological capabilities over time. There are already indications that this is happening.

Trade protection, in the form of quantitative restriction and tariffs on imported cars, was presumably important in the early stage for attracting foreign firms to set up production bases in India. An important question in the present context of industry globalization is whether trade protection has outlived its purpose. Interestingly, there are no significant differences in prices of cars sold in the domestic and foreign markets. This suggests that the competitiveness of Indian cars sold in foreign markets is not rooted in the prevailing high tariffs in India.

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Appendix. **Determinants of India's Bilateral Exports (*EXP*): Gravity Model Estimation Results without Partner Fixed Effects**

	Compact <1,000cc Cars	**Compact >1,000cc Cars**
log *GDP*	0.125^{***} (0.049)	0.036 (0.033)
log *POP*	-0.123^{**} (0.071)	-0.104^{**} (0.057)
log *PRD*	0.890^{***} (0.300)	0.190 (0.345)
log *RER*	−0.064 (0.073)	0.137^{***} (0.055)

Continued.

Appendix. *Continued.*

	Compact <1,000cc Cars	**Compact >1,000cc Cars**
	−0.498***	0.051
log *TAR*	(0.292)	(0.237)
	0.433**	1.144***
log *MPC*	(0.205)	(0.342)
	0.365***	2.936***
D2000	(0.045)	(0.626)
	1.161**	2.940***
DHI	(0.595)	(0.589)
	1.787***	2.222***
DUMI	(0.476)	(0.610
	1.261***	3.098***
DLMI	(0.512)	(0.652)
	0.413	0.862**
DFTA	(0.387)	(0.482)
	1.818***	1.781***
DEU	(0.406)	(0.439)
	0.251	1.958***
DNAFTA	(0.827)	(0.550)
	0.427	2.636***
DSACU	(1.096)	(0.9333)
	−0.068	−0.004
TREND	(0.052)	(0.045)
	−0.395	−0.273
log *DST*	(0.444)	0.273)
	−0.716	−0.435
BDR	(1.238)	(0872)
	3.329***	4.378***
CLK	(0429)	(0.455)
	0.230	−0.866
CBD	(0.548)	(0.871)
Partner fixed effects	No	No
Observations	4,393	4,411
R-squared	0.185	0.365

cc = cubic centimeters.

Notes: Robust standard errors clustered by trading partner are in parentheses. ***, **, and * indicate statistical significance of the regression coefficients at 1%, 5%, and 10%, respectively. See footnote 3 for the definition of compact cars.

Source: Authors' estimates.

Global Value Chains and Employment Growth in Asia

NEIL FOSTER-MCGREGOR*

This paper considers the sources of employment demand in Asian economies. Using data from the World–Input Output Database, I examine the relative importance of domestic and foreign demand in generating employment. Despite some degree of heterogeneity across the sample, domestic demand is found to be the major driver of employment in all cases. Further, the relative importance of final and intermediate exports in generating employment varies by economy, with some economies relying on intermediate exports to generate employment to a greater extent than others, reflecting their importance as suppliers of intermediate inputs in global value chains, while others rely to a greater extent on final exports, reflecting their role as assemblers within global value chains. Considering developments over time, I find that employment is driven by two offsetting factors: (i) final demand (either domestic or foreign) and (ii) labor productivity, with changes in interindustry structure also being important in the case of intermediate exports.

Keywords: crisis, decomposition, employment, global value chains
JEL codes: F14, F62, O19

I. Introduction

International trade and the globalization of supply chains have been important drivers for the growth and development of a number of economies in Asia and beyond, most notably the People's Republic of China (PRC). Global value chains (GVCs) are often considered a relatively easy route to industrialization (Baldwin 2016). By enabling economies to contribute to certain stages of production, they avoid the problems associated with developing whole industries. In addition, GVCs are considered important channels for technology spillovers and technology upgrading. Despite concerns about potential negative consequences for workers (ILO 2011), there is also an expectation that GVC participation can promote employment in developing economies. With some notable exceptions (e.g., Los, Timmer, and de Vries 2015; Portella-Carbo 2016), however, there is a

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paucity of evidence on the impact of trade generally, and GVC participation in particular, on employment, both in absolute terms and relative to domestic sources of employment.

This issue of the relationship between trade and employment generation is even more relevant in the context of the recent global financial crisis that has been associated with weak and volatile demand in world markets. Indeed, there is evidence that levels of global trade and GVC participation have plateaued since the financial crisis and in recent years have actually declined (Timmer et al. 2016). A number of potential explanations for these recent developments in trade and GVC performance have been proposed: weak demand in response to the crisis; the lack of progress in multilateral and bilateral trade policy negotiations—in particular with regard to standards, regulations, and rules of origin, among others—that have limited further fragmentation; the possibility of overfragmentation that is now being corrected; an increase in the extent of reshoring; and the possibility that the benefits of major technological developments, particularly in information and communication technology, have been exhausted.

In this paper, I am interested in identifying recent (2000–2014) developments in employment in a sample of six Asian economies and decomposing these developments along a number of dimensions. In particular, I decompose employment developments into effects due to domestic and foreign demand, where this latter effect is further split into effects due to foreign final demand (final exports) and foreign intermediate demand (intermediate exports). I use a structural decomposition analysis to decompose employment growth in the sample of economies into effects due to labor productivity growth, final demand growth, changes in interindustry structure, and changes in the ratio of value-added growth.[1] Finally, I identify differences in employment growth and the drivers of employment growth between the precrisis and postcrisis periods.

The analysis is linked to a number of different strands of literature. It is linked, for example, to the small existing literature on measuring the employment effect of exporting.[2] A number of these papers consider this relationship in the context of the PRC, with Feenstra and Hong (2010) using input–output analysis to estimate the employment effects of exporting. They find that export growth contributed around a third of overall employment growth during 1997–2005, with most growth coming from nontraded goods like construction. While exports grew

[1] This study includes ex post analysis and does not identify the cause of changes in labor productivity or final demand, which are exogenously given.

[2] The analysis is also linked to the literature estimating econometrically the relationship between offshoring and employment (e.g., Hijzen and Swaim 2010; Foster-McGregor, Poeschl, and Stehrer 2016). In these studies, offshoring is considered to have two offsetting effects: (i) a substitution effect that leads to the destruction of jobs, and (ii) a productivity effect that increases overall output and impacts positively upon employment. The approach adopted in these studies is to identify the overall effect of offshoring on employment, with a positive (negative) effect being interpreted as implying that the productivity effect is stronger (weaker) than the substitution effect. In the decomposition in section IV.B, I split up the effects of labor productivity and final demand, isolating the effects of each of these variables on employment demand.

much faster during 2000–2005, developments in domestic demand continued to dominate. Similar results were found by Chen et al. (2012), who show that the impact on employment of processing exports was lower than that of nonprocessing exports, which in turn was significantly lower than the effect due to domestic demand. Los, Timmer, and de Vries (2015) adopt a similar approach to identify the direct and indirect employment effects of exports in the PRC. Their results indicate that between 1995 and 2001, rapid growth in foreign demand was offset by large increases in labor productivity, with the result being that foreign demand had essentially no effect on net employment. During 2001–2006, however, a strong rise in foreign demand resulted in about 70 million jobs being added. In the most recent period for which data were available (2006–2009), domestic demand became more important than foreign demand, which the authors argue may signal a rebalancing of the global economy.

Other studies conduct similar analyses for different economies. Feenstra and Sasahara (2017), for example, estimate the impact on employment in the United States (US) from exports and imports during 1995–2011. They find that growth in US exports led to increased demand for workers that generated around 6.6 million new jobs. Imports into the US from the PRC reduced labor demand by about 2 million jobs, which still resulted in an overall net gain for the US during the review period in terms of employment demand from importing and exporting. Kiyota (2014) considers the impact of exports on employment in the cases of the PRC, Indonesia, Japan, and the Republic of Korea, with the results indicating a positive and increasing effect of exports on employment in Japan, the PRC, and the Republic of Korea. The study further shows the important role of machinery-related industries in generating employment through exports, with indirect employment effects through vertical interindustry linkages also playing an important role.

In a recent paper, Portella-Carbo (2016) extends this kind of analysis to consider the super-multiplier effects of international trade. In his model, trade impacts employment in a manner similar to the studies mentioned above, but has additional impacts by stimulating household consumption, private business investment, and the production of intermediate goods. In short, autonomous demand impacts employment through the Keynesian multiplier and the accelerator mechanism. His results indicate that the effects of trade on employment vary greatly across economies, with the effects in upswings being particularly large in economies such as the PRC and Germany, but smaller in other economies such as France and the United Kingdom, which rely to a greater extent on domestic demand.

The current paper is also linked to recent work on the effects of the crisis on trade patterns. Timmer et al. (2016) consider the decline in world trade in the postcrisis period, arguing that there are two competing explanations for the changed circumstances. The first is that the composition of demand has changed, in particular from durable investment and consumer goods toward services that are less trade intensive (Bems, Johnson, and Yi 2011, 2013; and Bussière et al. 2013). The second relates to the possible decline of GVC activity that may have occurred for a number of reasons already mentioned above (Evenett and Fritz 2015; Kee and Tang 2016; Harms, Lorz, and Urban 2012). Timmer et al. (2016) find that both channels have played a role in the stalled development of international trade. My analysis of the precrisis and postcrisis periods in this study's dataset extends the analysis of Timmer et al. (2016) to consider the employment implications of changes in international trade activity.

The starting point for the approach that I adopt in this paper is the analysis of Los, Timmer, and de Vries (2015), who consider the impact of foreign demand on employment creation in the PRC. The approach builds upon recent applications of input–output tables to issues of international trade (Timmer et al. 2013, 2014; Foster-McGregor and Stehrer 2013; Koopman, Wang, and Wei 2014; Wang et al. 2017) by estimating the consequences of developments in international trade for domestic employment. The analysis is based upon the recently released update to the World Input–Output Database (WIOD) (Timmer et al. 2015), which has data from 2000 to 2014. I concentrate on the six Asian economies included in the WIOD: India; Indonesia; Japan; the PRC; the Republic of Korea; and Taipei,China.

The main interest of the analysis is to identify to what extent the crisis has impacted labor demand and whether there has been a shift away from foreign demand toward domestic demand. At the same time, there are a number of additional hypotheses that are implicit in the analysis. In particular, I expect that the smaller economies in the sample are reliant to a larger extent on exports for generating labor demand than larger economies, which in turn are likely to have a more diversified production structure. As such, the smaller economies in the sample may be affected to a greater extent in the postcrisis period by the observed declines in trade and GVC activity. In addition, theory indicates that changes in the terms of trade between primary products and manufactures will affect natural resource-poor economies in the opposite way as resource-rich economies such as Indonesia. The period 2000–2014 was one in which the terms of trade improved dramatically for resource-rich economies such as Indonesia and deteriorated substantially for the other five Asian economies in the sample. As such, I may expect that the resultant real exchange rate changes would favor growth in the demand for nontradables—and as a result the demand for domestic goods—in Indonesia, with the opposite being the case in the other five sample economies.

The results of the analysis indicate that domestic demand is the major driver of employment in all six economies, albeit to a lesser extent in some economies. The relative importance of final and intermediate exports in generating employment also varies by economy. Some economies such as Taipei,China rely on intermediate exports to generate employment to a greater extent than others, likely reflecting their importance as suppliers of intermediate inputs in GVCs. Other economies such as the PRC rely to a greater extent on final exports, reflecting their role as assemblers within GVCs. Considering developments over time, I find that employment is driven by two offsetting factors: (i) final demand (either domestic or foreign) and (ii) labor productivity. In the case of intermediate exports, changes in interindustry structure have also played a role in many economies.

The remainder of the paper is set out as follows. Section II describes the methodology used in the analysis. Section III briefly discusses the data. Section IV presents the results. Section V concludes.

II. Methodology

The initial approach to identify the employment effects of international trade and GVCs follows closely that adopted by Los, Timmer, and de Vries (2015), which in turn was based upon the contribution of Johnson and Noguera (2012). Here, the approach of Los, Timmer, and de Vries (2015) is described in detail before discussing the extension of this approach.

I begin by assuming that there are N economies, S industries in each economy, and F production factors in each economy–industry. Industry output in a particular economy is determined using domestic production factors, in this case capital and labor, and intermediate inputs, which may be sourced either domestically or from foreign sources. The output produced in each industry can be used as either final demand or as intermediate inputs in the production of other goods. Demand for final goods is assumed to come from three sources: (i) households, (ii) government, and (iii) firms.[3] When considering shipments of final goods and intermediates, both within and across economies, there needs to be a distinction between the source and destination economy–industry. Following Los, Timmer, and de Vries (2015), I use i to denote the source economy, j the destination economy, s the source industry, and t the destination industry. It is assumed that markets clear and the additional assumption of a single price irrespective of a product's use is imposed. By definition, when markets clear, the product-market-clearing condition can be written as

$$y_i(s) = \sum_j f_{ij}(s) + \sum_j \sum_r m_{ij}(s,t) \tag{1}$$

Here, $y_i(s)$ is the value of output in industry s in economy i, $f_{ij}(s)$ is the value of goods sold by this industry for final use in economy j, and $m_{ij}(s,t)$ is the value of products sold by this industry for intermediate use by industry t in economy j.

Los, Timmer, and de Vries (2015) go on to express the market-clearing conditions for each of the SN industries using matrix algebra. To do this, let $\mathbf{y}$

[3]In the WIOD 2016 release, final demand is split into five sources: (i) final consumption expenditure by households, (ii) final consumption expenditure by nonprofit organizations serving households, (iii) final consumption expenditure by government, (iv) gross fixed capital formation, and (v) changes in inventories and valuables.

be the output vector of dimension ($SN \times 1$), the elements of which represent output levels in each economy–industry. A global input–output matrix $\mathbf{A}$ of dimension ($SN \times SN$) is also defined. The matrix has elements $a_{ij}(s,t) = m_{ij}(s,t)/y_j(t)$, which capture the ratio of intermediate inputs per unit of output and are termed the technical coefficients. Los, Timmer, and de Vries (2015) describe these terms as giving the cost shares of output from industry s in economy i used by industry t in economy j. The matrix $\mathbf{A}$ can be written as

$$\mathbf{A} \equiv \begin{bmatrix} \mathbf{A}_{11} & \mathbf{A}_{12} & \cdots & \mathbf{A}_{1N} \\ \mathbf{A}_{21} & \mathbf{A}_{22} & \cdots & \mathbf{A}_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{A}_{N1} & \mathbf{A}_{N2} & \cdots & \mathbf{A}_{NN} \end{bmatrix}$$

with $\mathbf{A}_{ij}$ being an $S \times S$ matrix with typical element $a_{ij}(s,t)$. Given this setup, it should be clear that the submatrices on the main diagonal contain the cost shares of domestically produced intermediate inputs, while those on the off-diagonal contain the cost shares of foreign intermediate inputs. The matrix $\mathbf{A}$ thus summarizes the input requirements of all intermediate goods across industries and economies.

Using the matrix $\mathbf{A}$, equation (1) can be expressed in matrix form as

$$\begin{bmatrix} \mathbf{y}_1 \\ \mathbf{y}_2 \\ \vdots \\ \mathbf{y}_N \end{bmatrix} \equiv \begin{bmatrix} \mathbf{A}_{11} & \mathbf{A}_{12} & \cdots & \mathbf{A}_{1N} \\ \mathbf{A}_{21} & \mathbf{A}_{22} & \cdots & \mathbf{A}_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{A}_{N1} & \mathbf{A}_{N2} & \cdots & \mathbf{A}_{NN} \end{bmatrix} \begin{bmatrix} \mathbf{y}_1 \\ \mathbf{y}_2 \\ \vdots \\ \mathbf{y}_N \end{bmatrix} + \begin{bmatrix} \sum_j \mathbf{f}_{1j} \\ \sum_j \mathbf{f}_{2j} \\ \vdots \\ \sum_j \mathbf{f}_{Nj} \end{bmatrix}$$

with $\mathbf{y}_i$ being the S-vector with production levels in economy i, and $\mathbf{f}_{ij}$ being the S-vector of final demand in economy j for the products of economy i. This can be written as

$$\mathbf{y} = \mathbf{A}\mathbf{y} + \mathbf{f} \tag{2}$$

which can further be expressed as

$$\mathbf{y} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \mathbf{B}\mathbf{f} \tag{3}$$

with $\mathbf{I}$ being an $SN \times SN$ identity matrix and $\mathbf{B} = (\mathbf{I} - \mathbf{A})^{-1}$ being the well-known Leontief inverse (Leontief 1936) that captures the gross output values in all stages of production that are generated in the production process of one unit of final output.

To complete their model, Los, Timmer, and de Vries (2015) assume that the quantity of output in an industry is a function of the quantities of the labor, capital, and intermediate inputs used in production. The value of output in an industry is then equal to the value of all inputs used. Denoting the value of output in industry s of economy i as $y_i(s)$, and letting $l_i(s)$ denote the number of workers in this industry, I can then define $p_i(s)$ as the number of workers required per US dollar of output in industry s in economy i:

$$p_i(s) = l_i(s)/y_i(s)$$

which can be written as an $SN \times 1$ column vector, $\mathbf{p}$. As Los, Timmer, and de Vries (2015) point out, the elements in this vector are economy and industry specific. The requirement vector $\mathbf{p}$ indicates the labor per US dollar of output needed in one particular production stage. To consider the labor required in all the stages of production of a final product, a new vector, $\mathbf{k}$, is defined. This can be constructed for any final demand vector by postmultiplying the labor requirement vector by the gross outputs needed for production of the final good, that is:

$$\mathbf{k} = \hat{\mathbf{p}}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \hat{\mathbf{p}}\mathbf{B}\mathbf{f} \tag{4}$$

with a hat indicating a diagonal matrix with the elements of a vector on the diagonal. For a particular economy–industry, $\mathbf{k}$ represents the labor required in each economy–industry in the world to meet this demand, both in the economy–industry of interest and also in upstream industries—both domestically and abroad—delivering intermediates to produce the final output of the economy–industry of interest.

Equation (4) is the main equation of interest in capturing the importance of final demand for employment generation. I extend this approach in two ways. Firstly, I use the recent approach of Wang et al. (2017) to further decompose the sources of employment generation. Secondly, I use a structural decomposition approach to identify the sources of recent developments in employment generation.

The approach of Wang et al. (2017) decomposes production activities into three terms: (i) production for domestic demand, (ii) final goods exports, and (iii) intermediate exports (what they term GVC activities and which may also involve the reimportation of intermediates at later stages of the production process). The approach of Wang et al. (2017) begins by rewriting equation (2) as

$$\mathbf{y} = \mathbf{A}\mathbf{y} + \mathbf{f} = \mathbf{A}^D\mathbf{y} + \mathbf{f}^D + \mathbf{A}^F\mathbf{y} + \mathbf{f}^F = \mathbf{A}^D\mathbf{y} + \mathbf{f}^D + \mathbf{E} \tag{5}$$

where $\mathbf{A}^D = \begin{bmatrix} \mathbf{A}^{11} & \mathbf{0} & \cdots & \mathbf{0} \\ \mathbf{0} & \mathbf{A}^{22} & \cdots & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{0} & \mathbf{0} & \cdots & \mathbf{A}^{gg} \end{bmatrix}$ is a $GN \times GN$ diagonal block matrix of domestic input coefficients; $\mathbf{A}^F = \mathbf{A} - \mathbf{A}^D$ is a $GN \times GN$ off-diagonal block matrix of imported input coefficients; $\mathbf{f}^D = [\mathbf{f}^{11}\mathbf{f}^{22} \cdots \mathbf{f}^{gg}]'$ is a $GN \times 1$ vector of final production for domestic consumption; $\mathbf{f}^F = \mathbf{f} - \mathbf{f}^D$ is a $GN \times 1$ vector of final product exports; and $\mathbf{E} = [\sum_{h \neq 1}^{G} \mathbf{E}^{2h} \sum_{h \neq 2}^{G} \mathbf{E}^{2h} \cdots \sum_{h \neq m}^{G} \mathbf{E}^{gr}]'$ is a $GN \times 1$ vector of gross exports.

Rearranging equation (5) gives

$$\mathbf{y} = (\mathbf{I} - \mathbf{A}^D)^{-1}\mathbf{f}^D + (\mathbf{I} - \mathbf{f}^D)^{-1}\mathbf{E} = \mathbf{L}\mathbf{f}^D + \mathbf{L}\mathbf{E} = \mathbf{L}\mathbf{f}^D + \mathbf{L}\mathbf{f}^F + \mathbf{L}\mathbf{A}^F\mathbf{y}$$

where $\mathbf{L} = (\mathbf{I} - \mathbf{A}^D)^{-1}$ is the local Leontief inverse. Premultiplying by the (diagonal) labor requirements vector and replacing $\mathbf{y} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \mathbf{B}\mathbf{f}$ gives

$$\hat{\mathbf{p}}\mathbf{B}\mathbf{f} = \hat{\mathbf{p}}\mathbf{L}\mathbf{f}^D + \hat{\mathbf{p}}\mathbf{L}\mathbf{f}^F + \hat{\mathbf{p}}\mathbf{L}\mathbf{A}^F\mathbf{B}\mathbf{f} \tag{6}$$

This equation decomposes the labor used in each economy–industry into the following:

(i) Employment generated domestically for domestic final demand ($\hat{\mathbf{p}}\mathbf{L}\mathbf{f}^D$)

(ii) Employment generated domestically for final production exports ($\hat{\mathbf{p}}\mathbf{L}\mathbf{f}^F$) (i.e., employment generated for production that crosses borders for final consumption only)

(iii) Employment generated through the export of intermediate goods ($\hat{\mathbf{p}}\mathbf{L}\mathbf{A}^F\mathbf{B}\mathbf{f}$)

Equation (6) indicates that labor induced through these different channels of demand depends upon three sets of factors: (i) changes in labor requirements ($\hat{\mathbf{p}}$); (ii) changes in the intermediate input structure ($\mathbf{L}, \mathbf{B},$ and $\mathbf{A}^F$); and (iii) changes in the level of final demand ($\mathbf{f}, \mathbf{f}^D,$ and $\mathbf{f}^F$). For ease of exposition, I can rewrite equation (6) as

$$\mathbf{k} = \mathbf{k}^D + \mathbf{k}^E + \mathbf{k}^I \tag{7}$$

where the superscripts D, E, and I refer to domestic final demand, export final demand, and the export of intermediates, respectively.

The description above is based closely upon that provided by Los, Timmer, and de Vries (2015) and has been extended to introduce the approach of Wang et al. (2017). Within this framework, I now use the time series that I have available to decompose the growth in employment due to final demand. To do this, I begin by noting that 1 plus the growth rate of employment between two time periods (0 and 1) (or the ratio of employment due to final demand) can be expressed as follows:

$$1 + \dot{\boldsymbol{k}} = \frac{\boldsymbol{k}_1}{\boldsymbol{k}_0} = \frac{\hat{\boldsymbol{p}}_1\boldsymbol{B}_1\boldsymbol{f}_1}{\hat{\boldsymbol{p}}_0\boldsymbol{B}_0\boldsymbol{f}_0} \tag{8}$$

where similar expressions for the three subterms of equation (7) can also be written down.

Using standard decomposition methods, it is possible to decompose this expression into an effect due to changes in (i) employment to gross output (i.e., employment requirements); (ii) interindustry structure, both domestically and internationally); and (iii) foreign final demand. The resulting decomposition is as follows:

$$\frac{\hat{\boldsymbol{p}}_1\boldsymbol{B}_1\boldsymbol{f}_1}{\hat{\boldsymbol{p}}_0\boldsymbol{B}_0\boldsymbol{f}_0} = \frac{\hat{\boldsymbol{p}}_1\boldsymbol{B}_1\boldsymbol{f}_1}{\hat{\boldsymbol{p}}_0\boldsymbol{B}_1\boldsymbol{f}_1} \times \frac{\hat{\boldsymbol{p}}_0\boldsymbol{B}_1\boldsymbol{f}_1}{\hat{\boldsymbol{p}}_0\boldsymbol{B}_0\boldsymbol{f}_1} \times \frac{\hat{\boldsymbol{p}}_0\boldsymbol{B}_0\boldsymbol{f}_1}{\hat{\boldsymbol{p}}_0\boldsymbol{B}_0\boldsymbol{f}_0} \tag{9}$$

This expression can be further decomposed to capture the role of labor productivity changes in driving employment changes. To see this, the standard definition of labor productivity (i.e., value added per worker) can be written as

$$lp_i(s) = \upsilon_i(s)/l_i(s)$$

with $lp_i(s)$ being labor productivity in economy i in industry s, and $\upsilon_i(s)$ being value added in economy i in industry s. This can further be expressed as

$$\upsilon_i(s)/l_i(s) = \upsilon_i(s)/y_i(s) \times y_i(s)/l_i(s)$$

which can be rearranged to give

$$l_i(s)/y_i(s) = l_i(s)/\upsilon_i(s) \times \upsilon_i(s)/y_i(s)$$

and expressed in matrix form as

$$\hat{\mathbf{p}} = \hat{\mathbf{q}}\hat{\mathbf{w}} \tag{10}$$

This states that the ratio of employment to gross output is equal to the inverse of labor productivity multiplied by the ratio of value added to gross output. Substituting equation (10) into equation (8) gives

$$1 + \dot{\boldsymbol{k}} = \frac{\hat{\mathbf{q}}_1\hat{\mathbf{w}}_1\boldsymbol{B}_1\boldsymbol{f}_1}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\boldsymbol{B}_0\boldsymbol{f}_0}$$

which can be decomposed as

$$\frac{\hat{\mathbf{q}}_1\hat{\mathbf{w}}_1\boldsymbol{B}_1\boldsymbol{f}_1}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\boldsymbol{B}_0\boldsymbol{f}_0} = \frac{\hat{\mathbf{q}}_1\hat{\mathbf{w}}_1\boldsymbol{B}_1\boldsymbol{f}_1}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_1\boldsymbol{B}_1\boldsymbol{f}_1} \times \frac{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_1\boldsymbol{B}_1\boldsymbol{f}_1}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\boldsymbol{B}_1\boldsymbol{f}_1} \times \frac{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\boldsymbol{B}_1\boldsymbol{f}_1}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\boldsymbol{B}_0\boldsymbol{f}_1} \times \frac{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\boldsymbol{B}_0\boldsymbol{f}_1}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\boldsymbol{B}_0\boldsymbol{f}_0}$$

The first term captures the impact of changing labor productivity on employment, the second captures the impact of changing value added to gross output ratios, the third captures the impact of changes in technical coefficients (i.e., intermediate use), and the final term captures changes in foreign final demand. This is the final decomposition of overall employment demand. Note, however, that the approximate growth rate of employment (due to foreign demand) between two time periods can be written as

$$\dot{\boldsymbol{k}} \approx \ln(1+\dot{\boldsymbol{k}}) = \ln\left(\frac{\hat{\mathbf{q}}_1\hat{\mathbf{w}}_1\boldsymbol{B}_1\boldsymbol{f}_1}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_1\boldsymbol{B}_1\boldsymbol{f}_1}\right) + \ln\left(\frac{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_1\boldsymbol{B}_1\boldsymbol{f}_1}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\boldsymbol{B}_1\boldsymbol{f}_1}\right) + \ln\left(\frac{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\boldsymbol{B}_1\boldsymbol{f}_1}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\boldsymbol{B}_0\boldsymbol{f}_1}\right) + \ln\left(\frac{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\boldsymbol{B}_0\boldsymbol{f}_1}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\boldsymbol{B}_0\boldsymbol{f}_0}\right) \tag{11}$$

which allows the growth rate of employment (due to final demand) to be expressed as the sum of the four logged decomposition terms:

(i) an effect due to changes in labor productivity (**q**);

(ii) an effect due to changes in the ratio of value added to gross output (**w**), which is often considered to be driven by upgrading within GVCs;

(iii) an effect due to changes in the interindustry structure (**B**), including the role of a changing trade structure in intermediate goods, that may be due to such things as factor substitution, technological change, and (GVC) sourcing patterns; and

(iv) an effect due to changes in final demand.

The studies of Feenstra and Hong (2010) and Chen et al. (2012) mentioned above argued that the employment impact of (foreign) demand growth crucially depend on the levels and growth rates of the labor productivity of the various activities. In particular, they argue that the employment effect of foreign demand is mainly a race between increases in productivity levels and demand levels, with higher productivity reducing the induced demand for labor (holding foreign demand constant). The decomposition defined above allows this hypothesis to be addressed in a more formal way.

A similar decomposition can be written for the individual terms of equation (7) as follows:

$$\dot{\boldsymbol{k}}^D \approx \ln\left(\frac{\hat{\mathbf{q}}_1\hat{\mathbf{w}}_1\mathbf{L}_1\boldsymbol{f}_1^D}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_1\mathbf{L}_1\boldsymbol{f}_1^D}\right) + \ln\left(\frac{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_1\mathbf{L}_1\boldsymbol{f}_1^D}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_1\boldsymbol{f}_1^D}\right) + \ln\left(\frac{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_1\boldsymbol{f}_1^D}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_0\boldsymbol{f}_1^D}\right) + \ln\left(\frac{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_0\boldsymbol{f}_1^D}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_0\boldsymbol{f}_0^D}\right) \tag{12}$$

$$\dot{\boldsymbol{k}}^E \approx \ln\left(\frac{\hat{\mathbf{q}}_1\hat{\mathbf{w}}_1\mathbf{L}_1\boldsymbol{f}_1^F}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_1\mathbf{L}_1\boldsymbol{f}_1^F}\right) + \ln\left(\frac{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_1\mathbf{L}_1\boldsymbol{f}_1^F}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_1\boldsymbol{f}_1^F}\right) + \ln\left(\frac{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_1\boldsymbol{f}_1^F}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_0\boldsymbol{f}_1^F}\right) + \ln\left(\frac{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_0\boldsymbol{f}_1^F}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_0\boldsymbol{f}_1^F}\right) \tag{13}$$

$$\dot{\boldsymbol{k}}^{I} \approx \ln\left(\frac{\hat{\mathbf{q}}_1\hat{\mathbf{w}}_1\mathbf{L}_1\mathbf{A}_1^F\boldsymbol{B}_1\boldsymbol{f}_1}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_1\mathbf{L}_1\mathbf{A}_1^F\boldsymbol{B}_1\boldsymbol{f}_1}\right) + \ln\left(\frac{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_1\mathbf{L}_1\mathbf{A}_1^F\boldsymbol{B}_1\boldsymbol{f}_1}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_1\mathbf{A}_1^F\boldsymbol{B}_1\boldsymbol{f}_1}\right) + \ln\left(\frac{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_1\mathbf{A}_1^F\boldsymbol{B}_1\boldsymbol{f}_1}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_0\mathbf{A}_1^F\boldsymbol{B}_1\boldsymbol{f}_1}\right)$$
$$+ \ln\left(\frac{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_0\mathbf{A}_1^F\boldsymbol{B}_1\boldsymbol{f}_1}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_0\mathbf{A}_0^F\boldsymbol{B}_1\boldsymbol{f}_1}\right) + \ln\left(\frac{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_0\mathbf{A}_0^F\boldsymbol{B}_1\boldsymbol{f}_1}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_0\mathbf{A}_0^F\boldsymbol{B}_0\boldsymbol{f}_1}\right) + \ln\left(\frac{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_0\mathbf{A}_0^F\boldsymbol{B}_0\boldsymbol{f}_1}{\hat{\mathbf{q}}_0\hat{\mathbf{w}}_0\mathbf{L}_0\mathbf{A}_0^F\boldsymbol{B}_0\boldsymbol{f}_0}\right) \tag{14}$$

Note that equation (14) includes additional terms capturing the effects of $\mathbf{A}^F$ (the imported input coefficients) and $\mathbf{B}$ (the full Leontief matrix). While I do calculate the full decomposition in this case, the results combine the three terms capturing the interindustry structure ($\mathbf{L}$, $\mathbf{A}^F$, and $\mathbf{B}$), which allows for a ready comparison with the results from the other decompositions. In addition, foreign final demand can be further decomposed by the source of that demand. In the analysis that follows, I decompose foreign final demand across four regions—Asia, the Americas, Europe, and the rest of the world—to examine the regional sources of employment growth in Asia.

III. Data and Descriptive Statistics

The analysis is conducted using the 2016 version of the WIOD, which builds upon and extends the 2013 version of the dataset.[4] WIOD constructs a world input–output table for 43 economies (plus the rest of the world) for the period 2000–2014 and includes data on 56 sectors, mainly at the 2-digit ISIC Revision 4 level (see Timmer et al. [2015, 2016] for details on construction and coverage). In addition to world input–output tables, WIOD also reports a set of socioeconomic accounts that include information on employment levels (in terms of both hours worked and persons engaged).

The WIOD therefore has all the relevant information needed to conduct the analysis that follows. I make use of (i) the international input–output tables (reporting the values of intermediate flows between all industries and economies), (ii) value added by economy and industry, (iii) gross output by economy and industry, (iv) domestic and foreign final demand by economy and industry, and (v) employment by economy and industry.[5] In this analysis, I am forced to measure employment in thousands of workers rather than hours worked. This is largely because data on hours worked are not available for the PRC.

[4]The major drawback of the 2016 version compared with the 2013 version is the lack of information on employment by skill type, which thus does not allow for an analysis of the changing role of demand on employment composition.

[5]The sources for data on employment, which can be found in Gouma et al. (2018), are varied and do not always coincide with official national data.

Table 1. **Employment Levels (Million), 2000**

		Employment Due To:		
Economy	**Employment**	**Domestic Consumption**	**Final Exports**	**Intermediate Exports**
India	410.1	372.9	19.8	17.5
		91%	5%	4%
Indonesia	96.9	76.3	8.6	12.0
		79%	9%	12%
Japan	65.3	59.5	2.6	3.1
		91%	4%	5%
PRC	719.6	620.5	57.8	41.3
		86%	8%	6%
Republic of Korea	18.2	14.6	1.7	2.0
		80%	9%	11%
Taipei,China	16.9	12.6	1.8	2.6
		74%	11%	16%

PRC = People's Republic of China.
Source: Author's calculations based on Timmer et al. (2015).

The time series of world input–output tables on which the empirical analysis is based are expressed in current US dollars. Given the interest in developments over time, this creates an issue when variables are expressed as ratios of quantities (e.g., number of employees) to values (e.g., the value of gross output). To deal with this, I follow the approach of Los, Timmer, and de Vries (2015) and deflate all nominal values using the gross domestic product deflator from the World Development Indicators database.

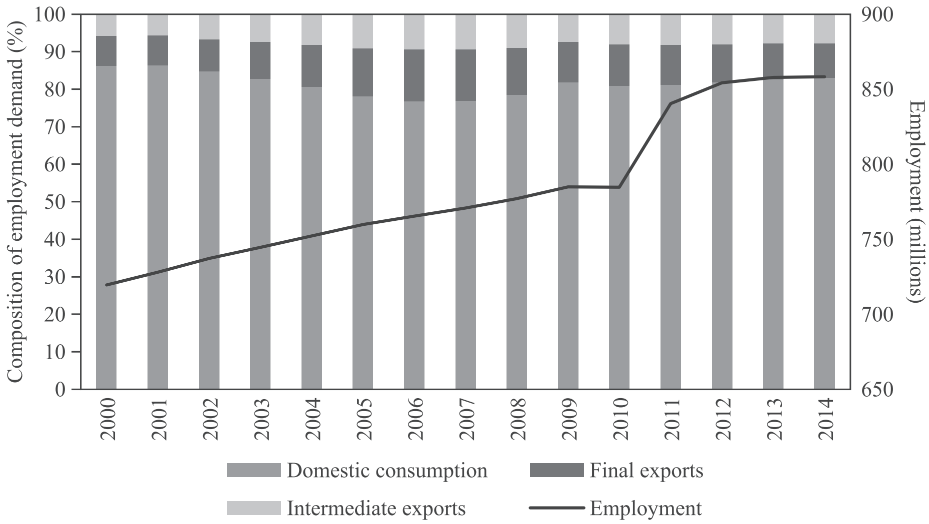
IV. Results

A. Employment Developments in Asia

In this subsection, I present initial descriptive results, describing developments in employment generation in Asian economies over the period 2000–2014 and the sources of demand for this employment.

Table 1 presents the initial level of employment in 2000 for the six sample economies, along with the decomposition of employment given by equation (5) into employment due to domestic demand and the two sources of foreign demand (final exports and intermediate exports). The table shows that employment in 2000 was around 720 million and 410 million in the two economies with the largest populations, the PRC and India, respectively. The two smallest economies in population terms, Taipei,China and the Republic of Korea, had employment levels in 2000 of around 17 million and 18 million, respectively. Domestic consumption accounted for the vast majority of employment in all of the sample economies, being as high as 91% in India and Japan, with lower levels reported in the Republic

Figure 1.1. **Employment Developments in the People's Republic of China**



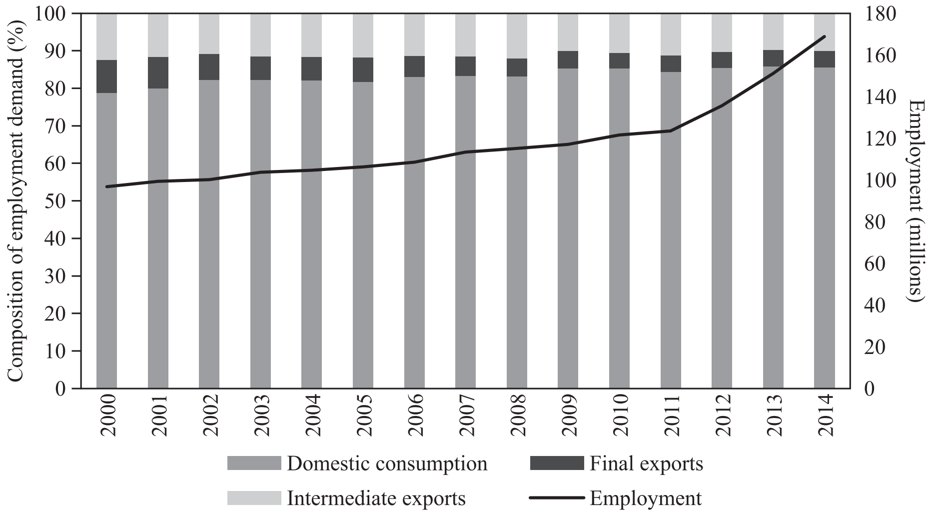
Source: Author's calculations based on Timmer et al. (2015).

of Korea (80%); Indonesia (79%); and Taipei,China (74%).[6] The fact that these latter economies rely to a greater extent on trade for their labor demand may reflect the fact that they are relatively small in terms of gross domestic product and are therefore generally more open to trade. Among trade channels, final exports accounted for the greatest share of employment in the PRC and India, possibly indicating the importance of assembly activities for the PRC in particular. Intermediate exports accounted for the greatest share in the other four economies, with the difference between employment due to intermediate and final exports being relatively large in Taipei,China.

Figures 1.1–1.6 report employment levels for each of the six economies over the full review period (2000–2014), as well as the decomposition of employment into three sources (domestic consumption, final exports, intermediate exports). Considering each economy in turn, Figure 1.1 shows that employment in the PRC rose steadily during the review period, despite a small decline around the time of the global financial crisis, with a notable increase in employment during 2010–2011. The role of domestic demand dropped somewhat during the early 2000s, but increased after the financial crisis. This may be related to a general reorientation of the PRC's economy toward domestic demand. The declining share of domestic demand in generating employment in the early 2000s was offset by a rising share of

[6]This study only accounts for the direct effect of the different trade channels on employment. The adopted approach is not able to account for indirect effects on employment through increases in the incomes of workers and firms that can raise domestic demand and demand for employment through increased household consumption and firm investment.

Figure 1.2. **Employment Developments in Indonesia**

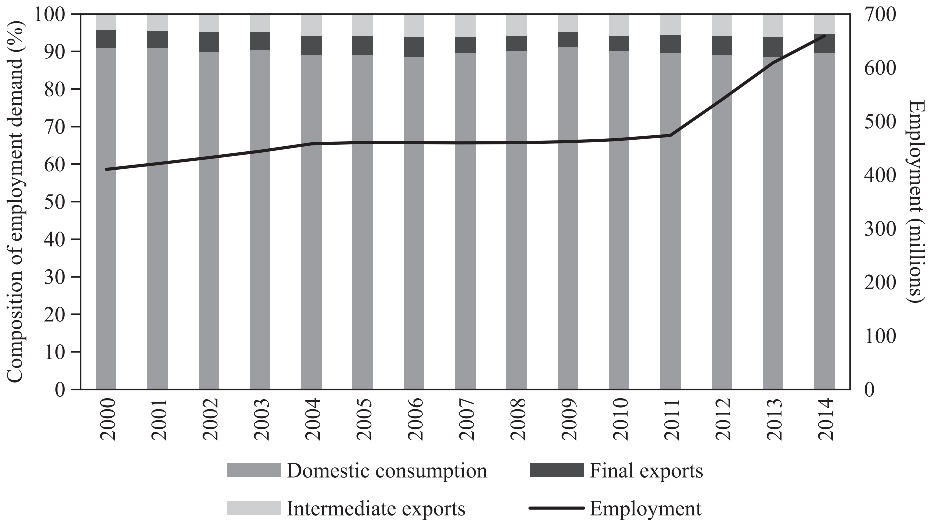


Source: Author's calculations based on Timmer et al. (2015).

both forms of exports, with demand due to final exports rising to a larger extent than demand due to intermediate exports. In the case of Indonesia, Figure 1.2 shows increasing employment, with a relatively rapid rise after 2011. Unlike the PRC, there was no observed decline in employment around the time of the financial crisis. Also, in contrast to the PRC, there is a rising share of domestic final consumption in employment generation across the whole review period, with declining contributions of both final exports and intermediate exports over time. This provides some support to the view expressed above that developments in the terms of trade may have led to increased demand for nontradables in relatively resource-rich Indonesia. The results for India in Figure 1.3 also confirm a positive employment trend, with a noticeable increase after 2011. In general, there is little in the way of changes in the composition of employment sources.

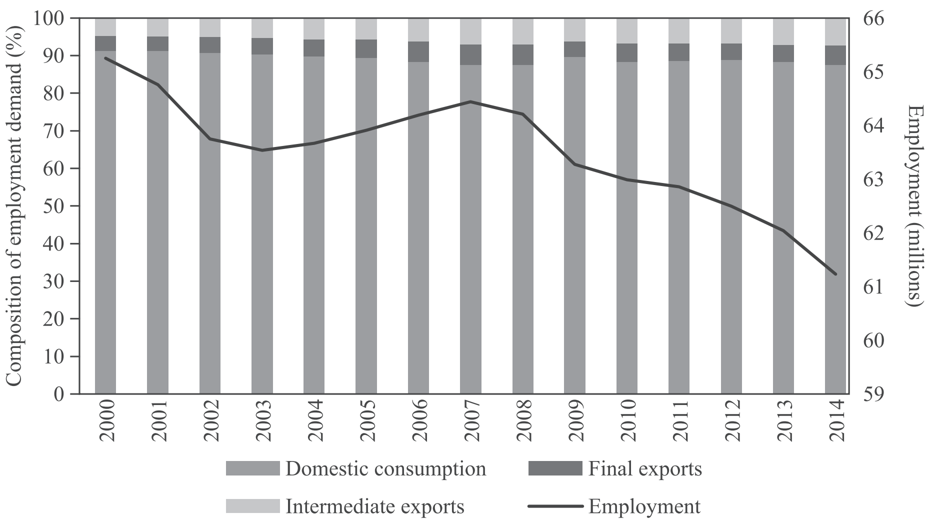
In the case of Japan, Figure 1.4 shows a different pattern of generally declining employment, which was more pronounced after the global financial crisis. In terms of the sources of employment demand, there was a slight decline in the role of domestic consumption over time, with small increases in the role of all trade activities. Developments in the Republic of Korea, as shown in Figure 1.5, fit with the pattern found for all sample economies other than Japan, with a rising trend in employment demand. The importance of domestic consumption for employment generation tended to decline over time, with a rising share of employment demand for the two forms of exports, particularly intermediate exports, observed. The results for Taipei,China in Figure 1.6 largely mimic those for the Republic of

Figure 1.3. **Employment Developments in India**



Source: Author's calculations based on Timmer et al. (2015).

Figure 1.4. **Employment Developments in Japan**

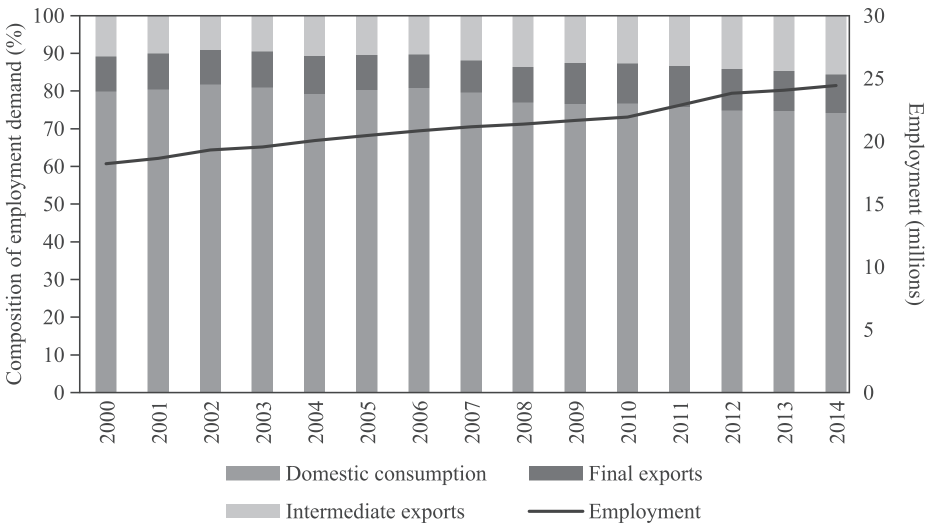


Source: Author's calculations based on Timmer et al. (2015).

Korea, with a rising trend in employment demand and a declining role for domestic consumption in generating this demand during the review period.

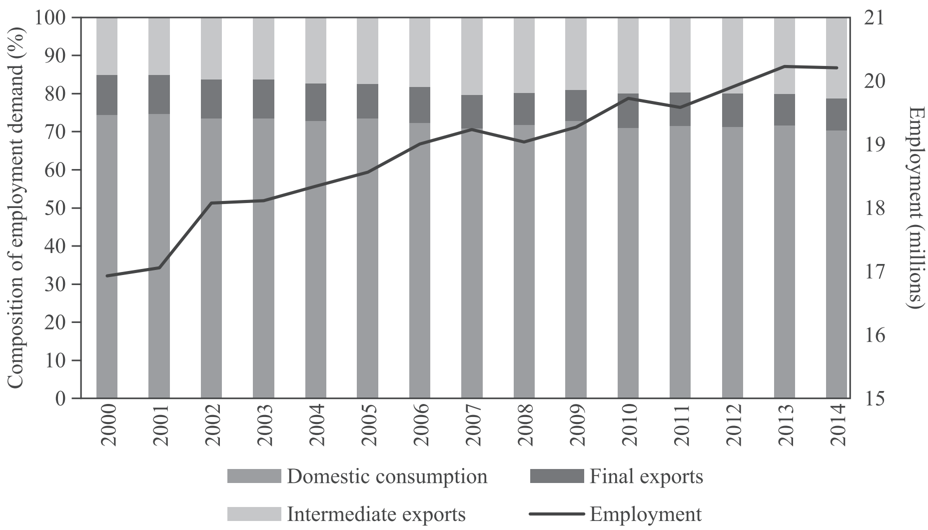
To emphasize changes in the contributions of the different sources of employment demand over time, Figure 2 reports changes (in percentage points)

Figure 1.5. **Employment Developments in the Republic of Korea**



Source: Author's calculations based on Timmer et al. (2015).

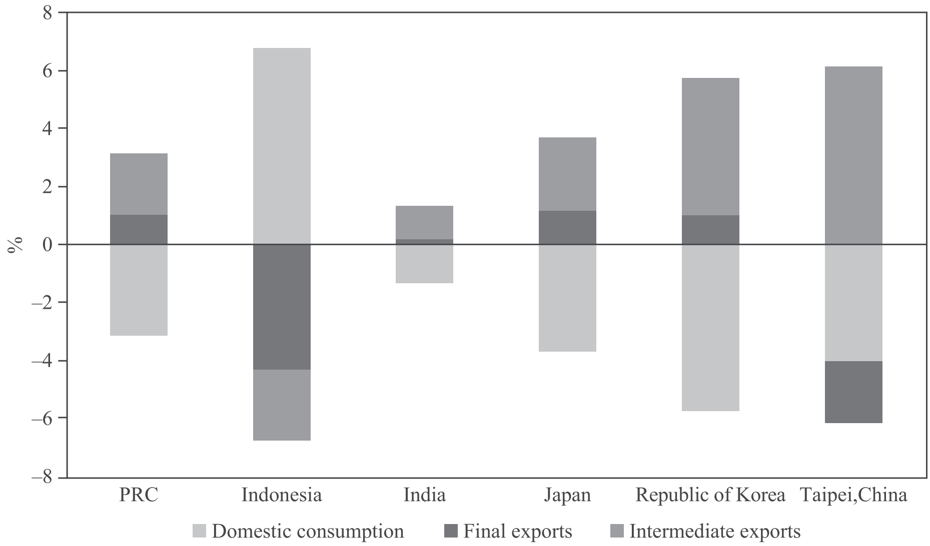
Figure 1.6. **Employment Developments in Taipei,China**



Source: Author's calculations based on Timmer et al. (2015).

in the different sources of employment demand for the six sample economies between 2000 and 2014. In most economies, the share of domestic consumption in generating employment declined during the review period. The only exception to this was Indonesia where the share of employment due to domestic consumption

Figure 2. **Changes in Contributions to Employment, 2000–2014**



PRC = People's Republic of China.
Source: Author's calculations based on Timmer et al. (2015).

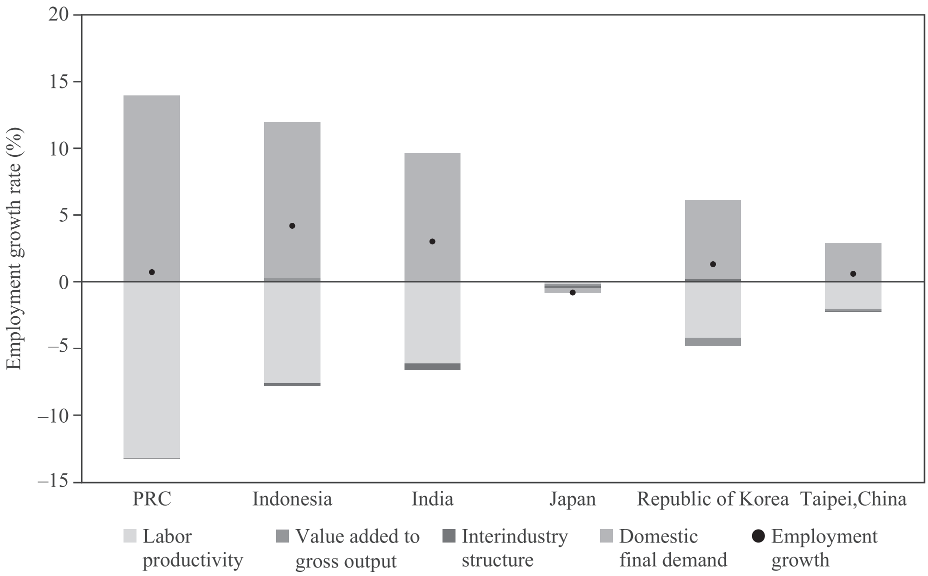
increased by nearly 7 percentage points, with both forms of international trade seeing a declining share, most notably final exports. In the other economies, a declining share of domestic consumption was observed, with declines ranging from a low of around 1.5 percentage points in India to a high of nearly 6 percentage points in the Republic of Korea. In all of these cases, the contributions of both trade channels tended to increase, with the exception of Taipei,China for final exports, where employment due to intermediate exports accounted for much of the increase.

B. Decomposition Results

The previous subsection described developments in employment demand and the sources of this demand. This subsection reports results from decomposing the different sources of employment demand as shown in equations (12), (13), and (14).[7] Figure 3 shows the average annual growth rate of employment during 2000–2014 due to domestic final demand, along with the decomposition of this growth. In most economies, the average growth rate of employment due to domestic final demand was low, and even negative in the case of Japan. The exceptions to this were Indonesia and India, which reported average growth rates of employment due to domestic final demand of 4.2% and 3%, respectively. In terms of the

[7] The decomposition as described above decomposes employment growth at the economy-sector level. In order to aggregate up to the economy level, sectoral employment weights are used in equations (12), (13), and (14).

Figure 3. **Decomposition of Employment Growth Due to Domestic Final Demand, 2001–2014**

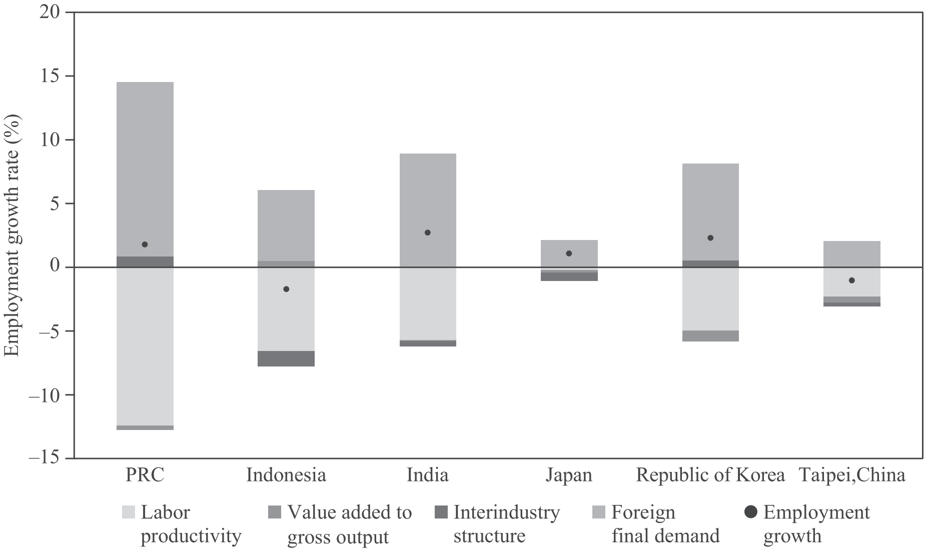


PRC = People's Republic of China.
Source: Author's calculations based on Timmer et al. (2015).

decomposition of employment growth, I tended to find a relatively large positive effect of domestic final demand and a relatively large negative effect of labor productivity growth. In the PRC, the Republic of Korea, and Taipei,China, these two effects tended to offset each other, resulting in a muted effect of domestic final demand on employment growth. In Indonesia and India, the growth in domestic final demand was higher than the growth in labor productivity during the review period, resulting in relatively strong employment growth. The final case of Japan is interesting, with essentially no growth in either domestic final demand or labor productivity during 2000–2014. The other thing to note from this figure is the almost complete lack of a role for either the growth in the ratio of value added to gross output or the interindustry trade structure.

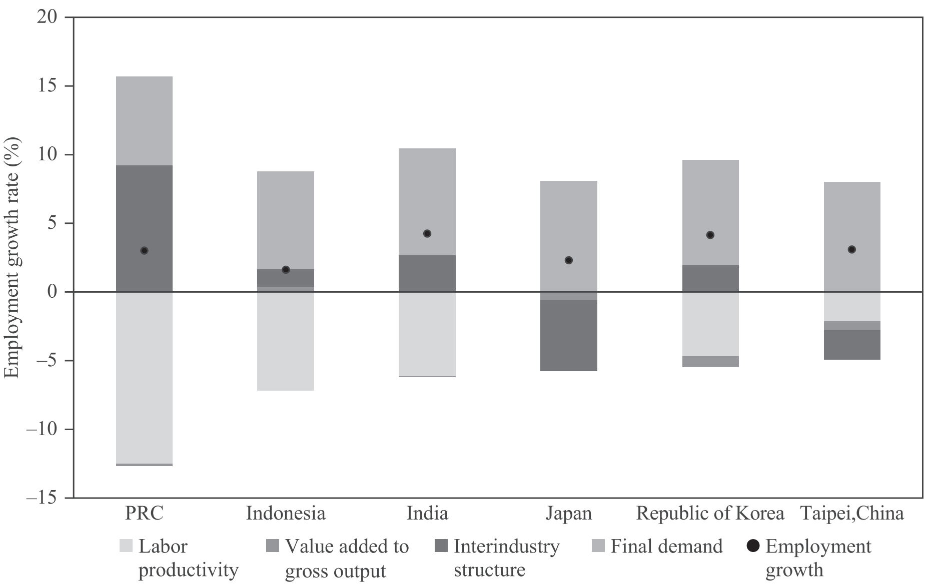
Figures 4 and 5 report information on employment growth due to the two forms of international trade, final exports and intermediate exports, along with the corresponding decomposition of these effects. Considering final export demand (Figure 4), relatively low growth rates of employment due to final export demand are again observed. The growth effects range from a low of –1.7% in Indonesia to a high of 2.7% in India. Once again, the overall effects are driven by the (offsetting) growth effects of final demand and labor productivity, with the effects of changes in the interindustry structure and the growth rate of value added to gross

Figure 4. **Decomposition of Employment Growth Due to Final Export Demand, 2001–2014**



PRC = People's Republic of China.
Source: Author's calculations based on Timmer et al. (2015).

Figure 5. **Decomposition of Employment Growth Due to Intermediate Exports, 2001–2014**



PRC = People's Republic of China.
Source: Author's calculations based on Timmer et al. (2015).

output being generally small. Despite similar and muted growth effects, there are important differences across the sample economies. In the case of the PRC, the growth of foreign final demand was relatively high (around 14%), with relatively high growth rates also being observed in India (8.9%) and the Republic of Korea (7.6%). Labor productivity growth in these economies was also relatively high, however, leading to a small overall growth effect. In other economies, most notably Japan and Taipei,China, the growth of foreign final demand was relatively low at around 2%.

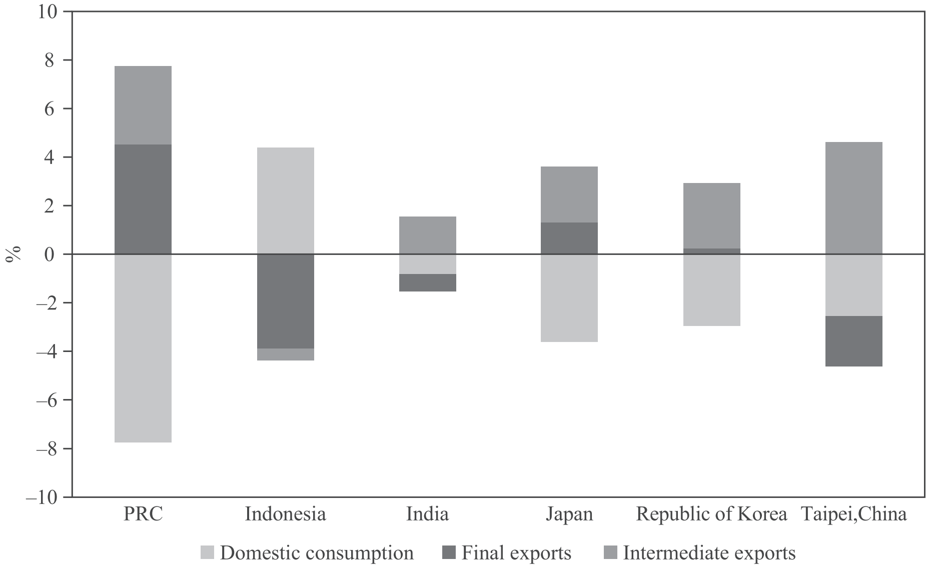
Turning to the case of intermediate exports and their impact on employment growth (Figure 5), somewhat similar results are observed.[8] Firstly, employment growth due to intermediate exports tends to be higher than the rates observed for the case of foreign final demand. Growth rates range from 1.6% (Indonesia) to 4.2% (India). Secondly, final demand is usually the main driver of employment growth due to intermediate exports, with the growth effects of final demand ranging between 6.5% and 8.1%. Thirdly, labor productivity growth has a strong (negative) impact on employment growth due to intermediate exports across economies, with the main exception being Japan, where labor productivity growth has been muted, and to a lesser extent Taipei,China. Fourthly, and unlike the previous cases, changes in the interindustry structure play an important role in driving employment growth due to intermediate exports in a number of economies. The most important example in this context is the PRC, where the effect of interindustry structure is large and dominates the effect of final demand. This suggests that in the PRC, developments in sourcing patterns have strongly impacted employment growth due to GVC participation. This may indicate the movement from a reliance on upstream intermediate imports to an increasing reliance on domestic upstream intermediate inputs in the PRC. Changes in interindustry structure also impacted positively upon employment growth in India, Indonesia, and the Republic of Korea. Negative effects were observed in the cases of Japan and Taipei,China, with changes in sourcing patterns reducing employment growth in both of these economies.

C. Precrisis and Postcrisis Developments in Employment

The previous subsection showed that of the different forms of international trade considered, the employment effects of intermediate exports tended to grow more rapidly during 2000–2014. This subsection considers whether there were differences in employment developments (and the corresponding decompositions) between the precrisis and postcrisis periods. As already discussed, developments in trade flows and GVC participation tended to differ in the precrisis and postcrisis

[8]As discussed above, the three terms that capture the effects of changes in interindustry structure—broadly defined—are combined in order to provide a ready comparison with the other two decompositions.

Figure 6. **Changes in Contributions to Employment, 2000–2008**



PRC = People's Republic of China.
Source: Author's calculations based on Timmer et al. (2015).

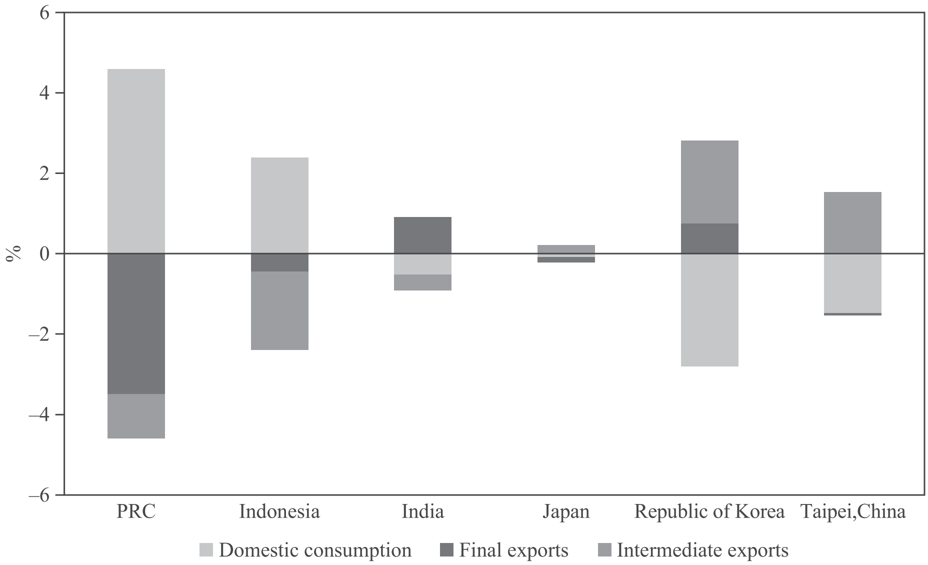
periods, with this subsection examining whether there have been similar effects on employment.

Figures 6 and 7 report results that are similar to Figure 2 but for the two subperiods, 2000–2008 and 2009–2014, respectively.[9] Changes in the composition of employment demand tended to be larger during 2000–2008 than 2009–2014. During the former period, results indicate that employment demand due to international trade tended to increase relative to demand due to domestic consumption. This was true for all cases except Indonesia. In most economies, the rise in employment demand resulting from international trade was due largely to intermediate exports, with the effect of final exports being negative for India; Indonesia; and Taipei,China. The major exception was the PRC, where demand due to final exports was dominant.

While smaller than during 2000–2008, the changing composition of employment demand during 2009–2014 followed a similar pattern in the Republic of Korea and Taipei,China, with an increasing contribution of intermediate exports at the expense of domestic consumption. In the PRC, there was a change in the relative roles of international trade and domestic consumption, with the role of

[9]Average growth rates are reported for the periods 2000–2008 and 2009–2014, implying that the growth rate of 2009 includes information on employment levels in 2008. Using 2007 as the cutoff year rather than 2008 does not alter the qualitative results significantly.

Figure 7. **Changes in Contributions to Employment, 2009–2014**



PRC = People's Republic of China.
Source: Author's calculations based on Timmer et al. (2015).

Table 2. **Growth Rate of Employment Due to Trade Channels in the Precrisis and Postcrisis Periods (%)**

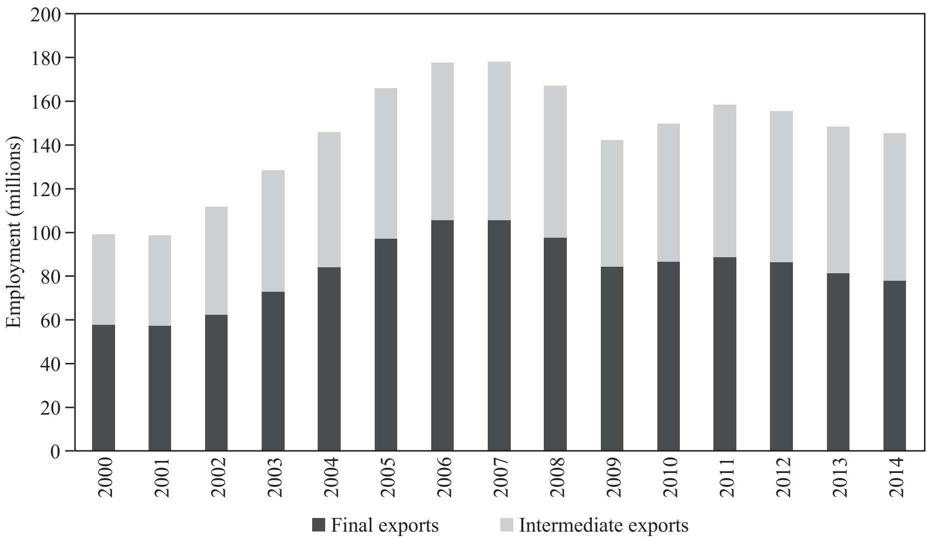
	Domestic Consumption		**Final Exports**		**Intermediate Exports**	
	2001–2008	**2009–2014**	**2001–2008**	**2009–2014**	**2001–2008**	**2009–2014**
India	1.34	6.20	−0.17	10.28	5.78	5.89
Indonesia	2.89	7.18	−4.62	5.23	1.77	3.88
Japan	−0.70	−0.80	3.45	−0.47	4.95	−0.01
PRC	−0.20	2.68	7.10	−3.54	7.00	−0.10
Republic of Korea	1.57	1.64	2.59	3.81	5.23	4.84
Taipei,China	1.05	0.66	−1.16	1.09	5.08	2.33

PRC = People's Republic of China.
Source: Author's calculations based on Timmer et al. (2015).

domestic consumption increasing and the role of international trade, most notably final exports, falling. The pattern in Indonesia during 2009–2014 was similar to that during 2000–2008, albeit with intermediate exports accounting for most of the decline in the contribution of international trade. In India and Japan, the overall changes and the changes in composition were relatively small.

Table 2 reports the average growth rates of employment for three different demand sources during 2001–2008 and 2009–2014. The table reveals a number of interesting outcomes. In a number of economies, the growth rate of employment generation in the postcrisis period actually exceeded that in the precrisis period

Figure 8.1. **Employment Due to International Trade in the People's Republic of China, 2000–2014**

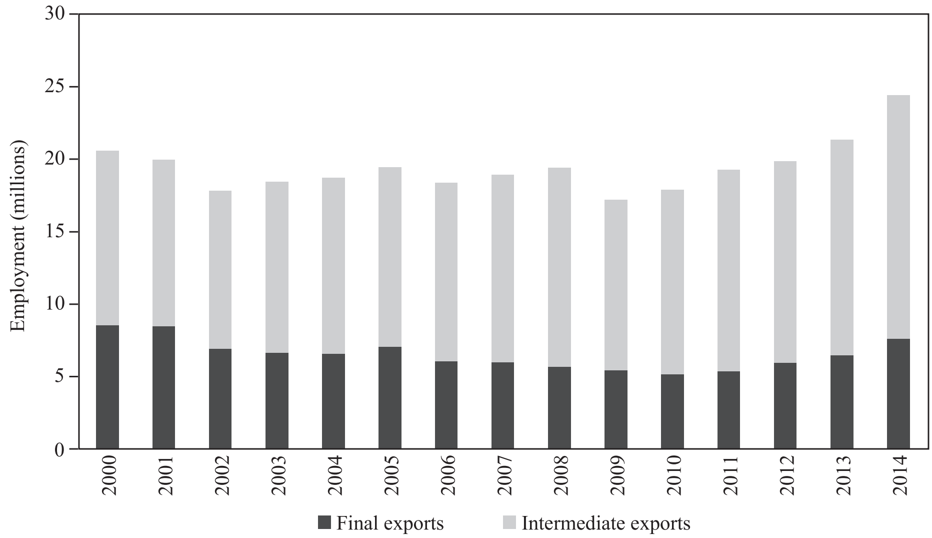


Source: Author's calculations based on Timmer et al. (2015).

for all three sources of demand. This is true for Indonesia and India, and, except in the case of intermediate exports, also for the Republic of Korea. For two of these economies—Indonesia and India—employment growth due to final exports was actually negative in the precrisis period. In the cases of the PRC and Japan, there is negative employment growth due to final exports in the postcrisis period, following relatively rapid growth in the precrisis period, with a small negative growth rate of employment for Japan (−0.5%) and a larger negative effect for the PRC (−3.5%). For these two economies, a similar pattern is also observed in the case of intermediate exports, with a small negative growth rate of employment in the postcrisis period after experiencing relatively rapid growth in the precrisis period. For the PRC, this relatively poor performance in the postcrisis period is offset by relatively rapid employment growth due to domestic consumption; while in the case of Japan, employment demand due to domestic consumption was also sluggish.

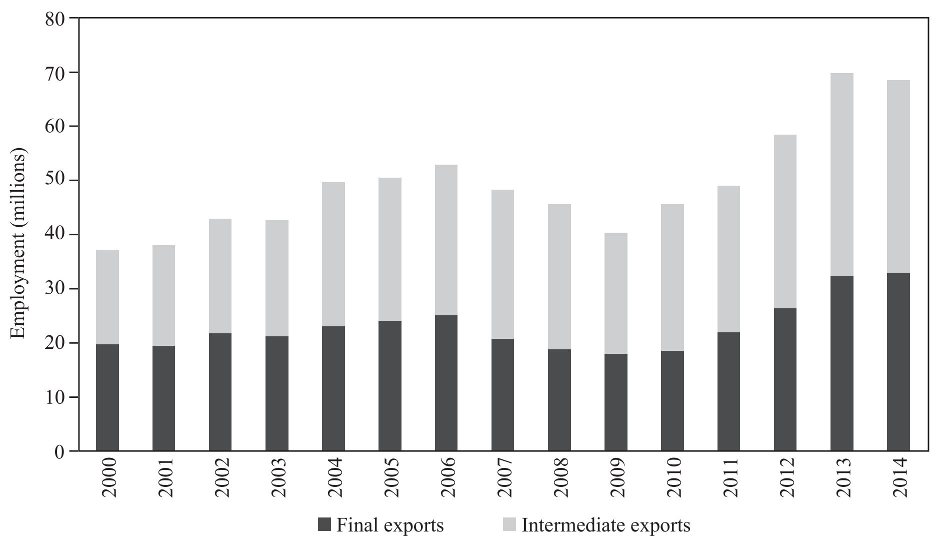
Given the interest in the effect of the crisis on employment and the channels of employment generation, Figures 8.1–8.6 report the employment generated by international trade for each of the six economies during 2000–2014. Considering each economy in turn, Figure 8.1 shows that in the PRC, employment due to international trade dropped dramatically around the time of the crisis. Between 2008 and 2009, employment due to foreign demand dropped 14.9%, following a drop of about 6% between 2007 and 2008. The decline was driven by changing demand due to both final and intermediate exports, with a somewhat larger percentage

Figure 8.2. **Employment Due to International Trade in Indonesia, 2000–2014**



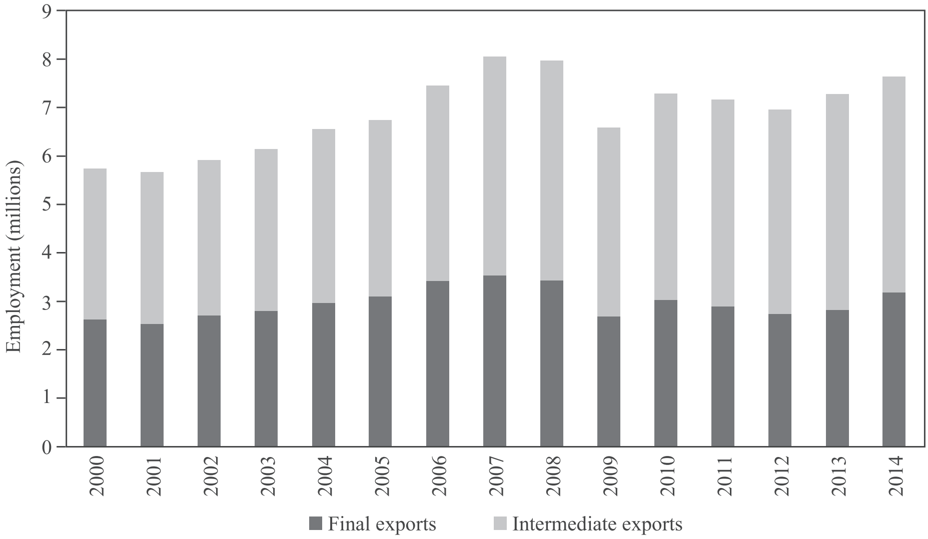
Source: Author's calculations based on Timmer et al. (2015).

Figure 8.3. **Employment Due to International Trade in India, 2000–2014**



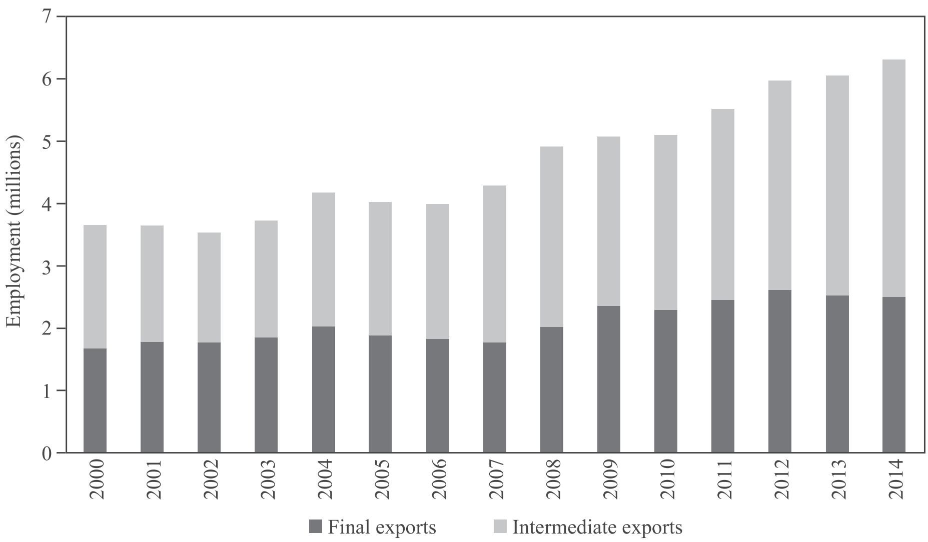
Source: Author's calculations based on Timmer et al. (2015).

Figure 8.4. **Employment Due to International Trade in Japan, 2000–2014**



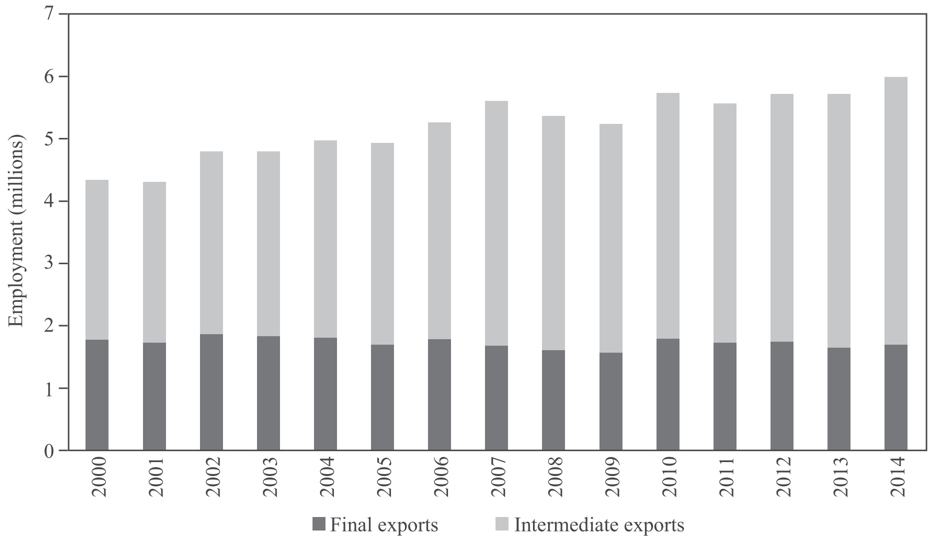
Source: Author's calculations based on Timmer et al. (2015).

Figure 8.5. **Employment Due to International Trade in the Republic of Korea, 2000–2014**



Source: Author's calculations based on Timmer et al. (2015).

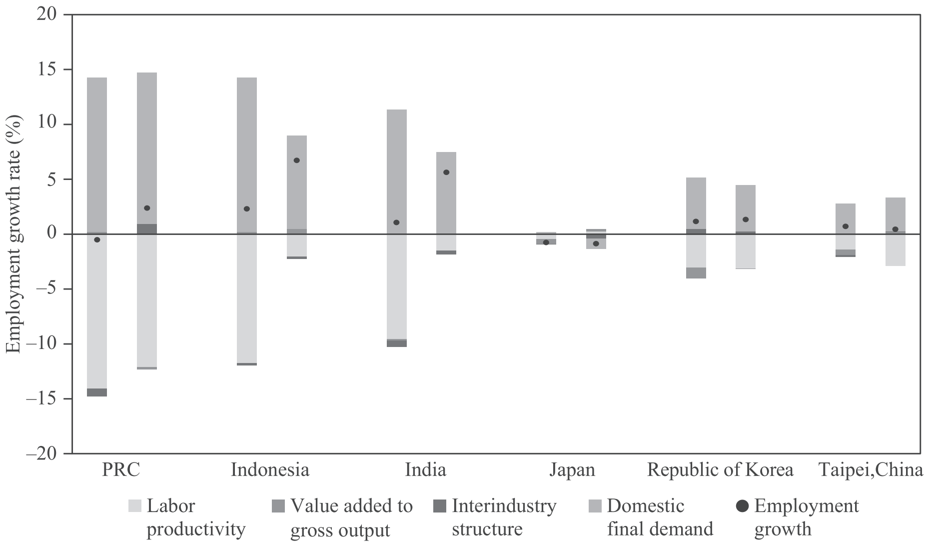
Figure 8.6. **Employment Due to International Trade in Taipei,China, 2000–2014**



Source: Author's calculations based on Timmer et al. (2015).

decline in employment demand due to intermediate exports. However, the recovery in employment following the crisis also tended to be more rapid in the case of intermediate exports. Figure 8.2 shows that in Indonesia, there was a more prolonged drop in employment due to final exports, though at the time of the crisis, the percentage decline in demand due to intermediate exports was much stronger (though, as with the PRC, it also recovered more quickly). This was also the case with India, as shown in Figure 8.3, which saw relatively large percentage declines in employment demand due to final exports in the lead-up to the crisis and a large drop in demand due to intermediate exports at the time of the crisis during 2008–2009. Figure 8.4 shows that the case of Japan is somewhat different, with the decline in demand at the time of the crisis due to final exports being significantly larger than that due to intermediate exports. The recovery in Japan was also slower, with levels of employment due to final exports and intermediate exports not having reached their precrisis levels by 2014. The Republic of Korea also exhibited a pattern dissimilar to some of the other economies. Figure 8.5 shows rising employment demand due to final exports continuing to grow throughout the crisis alongside a relatively minor contraction in employment due to intermediate exports. Results thus suggest that the Republic of Korea was largely shielded from the effects of the crisis, at least in terms of the employment impact of foreign demand. The negative impacts of the crisis on employment demand were also relatively muted in the case of Taipei,China. Figure 8.6 shows the declines in demand being fairly evenly split between final and intermediate exports.

Figure 9. **Decomposition of Employment Growth Due to Domestic Final Demand in the Precrisis and Postcrisis Periods**

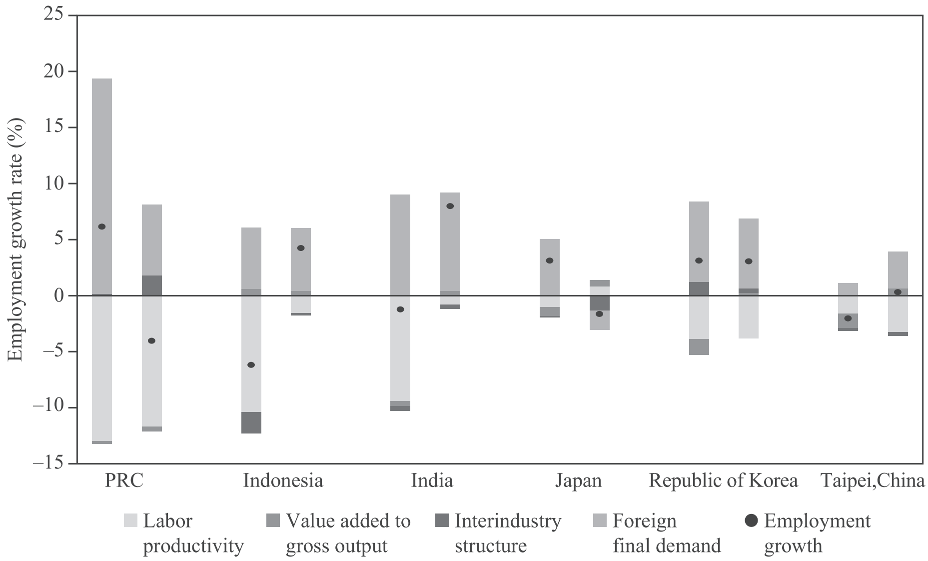


PRC = People's Republic of China.
Note: The precrisis period refers to 2001–2008, while the postcrisis period refers to 2009–2014.
Source: Author's calculations based on Timmer et al. (2015).

The final part of this subsection reports the decomposition results for the precrisis and postcrisis periods separately. The decomposition results are reported for domestic consumption in Figure 9, for final exports in Figure 10, and for intermediate exports in Figure 11. In these figures, the left-hand side of each pair of bars for each economy reports the decomposition for the precrisis period (2001–2008) and the right-hand side bars are for the postcrisis period (2009–2014).

I begin with the decomposition of employment growth due to domestic final demand. Figure 9 reveals that employment growth due to domestic demand tended to be higher in the postcrisis period than in the precrisis period. The difference in growth rates between the two periods was particularly large in the case of Indonesia (2.3% versus 6.7%) and India (1.1% versus 5.6%). Decomposition results indicate largely offsetting effects of domestic demand growth and labor productivity growth, with only small effects of either changes in interindustry structure or the ratio of value added to gross output. The majority of cases show a declining role for labor productivity growth in the postcrisis period, with the difference between the precrisis and postcrisis periods being particularly large in the case of Indonesia and India. The role of domestic demand growth in the postcrisis period also declined in many of the sampled economies—and became negative in the case of Japan—with a slight increase in the contribution of domestic demand growth observed only in Taipei,China.

Figure 10. **Decomposition of Employment Growth Due to Final Exports in the Precrisis and Postcrisis Periods**



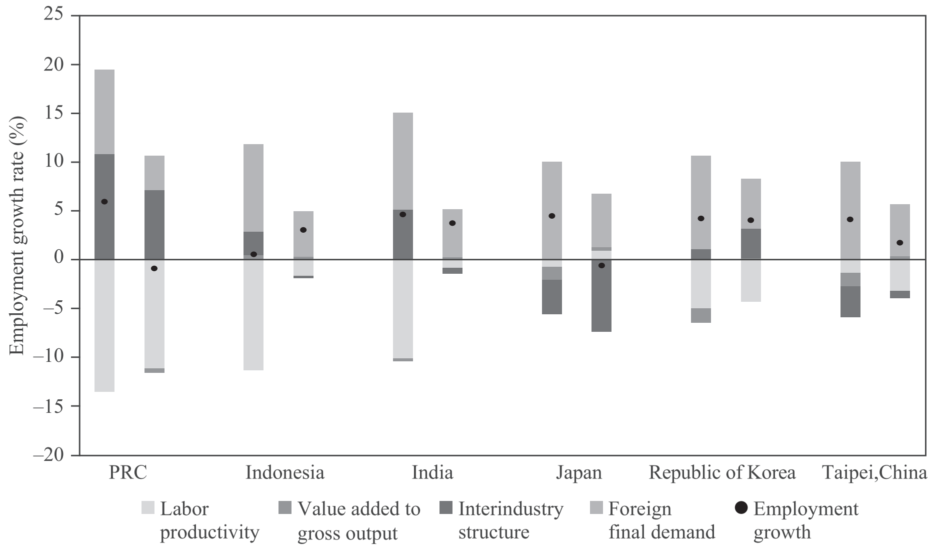
PRC = People's Republic of China.
Note: The precrisis period refers to 2001–2008, while the postcrisis period refers to 2009–2014.
Source: Author's calculations based on Timmer et al. (2015).

Turning to the trade channels, Figures 10 and 11 reveal that the (negative) effect of labor productivity on employment growth diminished in most economies (most notably Indonesia and India) in the postcrisis period relative to the precrisis period, with declines in labor productivity increasing employment in the case of Japan (implying a reduction in labor productivity). The (positive) effect of final demand growth also tended to decline in the postcrisis period relative to the precrisis period. This is particularly the case for employment growth due to intermediate exports (Figure 11), with large changes in the case of final exports limited to the PRC and Japan (Figure 10). In the case of intermediate exports, there was an important role for changes in the interindustry structure in many economies, most notably the PRC and Japan. Comparing the precrisis and postcrisis periods, changes in interindustry structure tended to lead to a decline in employment growth in the postcrisis period. This is true for all of the sample economies except the Republic of Korea and Taipei,China.

V. Conclusion

There is evidence of declining engagement in GVCs since 2008 at the global level, as well as for a number of Asian economies, most notably the PRC;

Figure 11. **Decomposition of Employment Growth Due to Intermediate Exports in the Precrisis and Postcrisis Periods**



PRC = People's Republic of China.
Note: The precrisis period refers to 2001–2008, while the postcrisis period refers to 2009–2014.
Source: Author's calculations based on Timmer et al. (2015).

the Republic of Korea; and Taipei,China. This paper considers the employment implications of these developments. While it is difficult to generalize across the diverse set of Asian economies considered, the results suggest that despite declining trade and GVC participation, growth in employment demand has been stable, and in some cases has increased, since 2008. Domestic demand accounts for the vast majority of employment demand, though effects differ by economy. Domestic demand is found to be relatively less important in the Republic of Korea and Taipei,China, possibly reflecting their relatively small size, and it has declined in importance for a number of economies in the postcrisis period. The case of the PRC is particularly interesting and suggests a reorientation toward domestic sources of demand. Indonesia is also relying increasingly on domestic sources of demand, possibly driven by global and regional terms of trade developments. Such results may raise questions about the overall importance of GVC involvement for employment, though the employment (and incomes) generated through foreign final demand may have relatively large multiplier effects, indirectly impacting employment through domestic demand.

In terms of the role of trade in generating employment, results differ by economy. Some economies rely on intermediate exports to generate employment to a greater extent than others, reflecting their importance as suppliers of intermediate inputs (e.g., Taipei,China) or raw materials and primary products (e.g., Indonesia).

Others, most notably the PRC, generate more employment through final exports, reflecting their role as assemblers within GVCs. Developments in employment tend to be driven by two offsetting factors: (i) final demand (either domestic or foreign) and (ii) labor productivity. The positive role of final demand and changes in interindustry structure have tended to more than offset the negative effects of labor productivity growth. In the case of intermediate exports, changes in interindustry structure have also played a role in many economies, suggesting that there has been a reorientation in supply chains that have impacted employment positively in some economies (e.g., the PRC) and negatively in others (e.g., Japan). Since the global financial crisis, developments in interindustry structure have in general tended to impact negatively upon employment growth relative to the precrisis period.

The importance of foreign demand for employment growth has diminished for most economies since 2008. This has been offset by weaker labor productivity growth in the postcrisis period for most economies, which has minimized the effect of weak foreign demand on employment growth. As such, and despite the weak foreign demand growth, the declines in labor productivity growth have resulted in an increased growth rate of employment due to foreign demand in economies such as India and Taipei,China (in the case of final demand).

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Wages Over the Course of Structural Transformation: Evidence from India

RANA HASAN AND RHEA MOLATO*

This paper uses labor force survey data from India for 2000 and 2012 to examine how wages behave over the course of structural transformation. We find that wage employment between 2000 and 2012 displays the patterns one would expect for an economy undergoing structural transformation, with employment shares shifting from agriculture to industry and services, and from rural to urban areas and larger cities within urban areas. These shifts, as well as a shift to nonroutine occupations and routine manual occupations outside of agriculture, are associated with an improvement in average wages. Finally, simple Mincerian wage regressions confirm that jobs in larger firms and big cities are associated with significantly higher wages—even more so for women. Overall, our results are consistent with the notion that policies that encourage the expansion of the formal sector and employment in larger firms are crucial for development.

Keywords: structural change, wage level and structure, wages
JEL codes: E24, J31, L16

I. Introduction

There is a large empirical literature on structural transformation that documents and analyzes the shift of output and employment across sectors. (See Asian Development Bank [ADB] 2013 for a comprehensive survey and analysis for Asia and the Pacific.) By and large, the shift takes place from lower to higher productivity sectors and locations over the course of development. This is what McMillan, Rodrik, and Verduzco-Gallo (2014) find for Asia, for example, in contrast to Africa and Latin America. On average, labor productivity in the region increased 3.87% from 1990 to 2005, of which 3.31% of the growth was registered by "within" sector improvements in labor productivity and 0.57% by shifts in employment shares from lower to higher productivity sectors (called "structural change" by the authors). In the case of India, the labor productivity growth figures

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are 4.23% for the overall economy and 3.24% and 0.99% for the within and structural change components, respectively. In contrast, labor productivity growth in Africa and Latin America has been associated with negative contributions from the structural change component (in addition to being relatively low compared with Asia).

What is rarer in the literature is an examination of how wages behave over the course of structural transformation and its various component processes. An exception is analysis of the significant wage gaps that exist between agriculture and other sectors. Several studies, including recent ones such as Alvarez (2017) and Herrendorf and Schoellman (2017), examine these gaps and attempt to determine whether they can be explained by barriers to mobility across sectors or whether unobserved worker characteristics (e.g., innate capabilities that enable some individuals to benefit more from schooling) lead to a systematic sorting of workers, with the more capable finding employment outside of agriculture.

In this paper, we take a step back and use labor force survey data from India to examine how wages behave over the course of structural transformation, especially in terms of its less studied aspects. Specifically, we first examine how wages and employment have evolved not only across production sectors, but also in terms of shifts across occupation groups and from rural to urban areas, distinguishing the latter in terms of whether urban areas take the form of large cities (population of 1 million or more in the first year of our analysis) or smaller cities and towns. We then use a standard decomposition that describes how important such shifts have been in driving average wages in the economy. We also examine employment shifts and wages across firms with fewer than 10 workers and those with 10 or more workers. We call the former small firms and treat them as synonymous with operations in the informal sector; the remaining firms are called large. In keeping with practice in Indian manufacturing where firms with 10 or more workers (and those using power in the production process) must be registered under the Factories Act, we treat these large firms as belonging to the formal sector.[1] Finally, we use simple Mincerian wage regressions to examine the relationship between wages and the more novel elements of structural transformation we examine—i.e., employment in larger firms and cities—while controlling for individual characteristics, sector, and occupation.

Our work adds to the standard macro analysis of structural transformation in two ways. First, rather than examine the evolution of productivity over the course of structural transformation, we consider the evolution of wages. Though intimately related, arguably it is wages that are more directly linked to individual welfare than productivity. Second, we extend the usual analysis of shifts in the sector of employment to also consider the role of shifts in occupation and rural–urban location, and to a more limited extent the role of small firms versus larger firms, in

[1]Unfortunately, and as explained later, data gaps prevent us from understanding the role large firms have actually played in driving average wages in India from 2000 to 2012.

driving average wages. In doing so, we are able to consider the role of occupational changes and urban agglomerations—factors that the recent literature on growth and development has been paying much attention to. As Duernecker and Herrendorf (2017) note, occupations play an important role in the behavior of key labor market outcomes such as worker mobility and job polarization. They are also not affected by a "relabeling" of employment as certain types of work get outsourced from manufacturing firms to arm's-length service providers. Similarly, cities are often viewed as engines of growth. As Henderson (2014) notes, this is because the reallocation of employment from agriculture into industry, in particular, takes place most effectively in cities given agglomeration economies. These additional dimensions we analyze are closely tied to the idea that structural transformation involves the capability to produce more diversified and complex products. The latter requires the emergence of more capable and sophisticated firms, a proxy for which would be the expansion of employment in firms in the formal sector and/or firms with employment above some threshold level (e.g., 10 or more workers), and a shift in occupations—specifically, a growth in occupations that involve more analytical work.

We examine the case of India not only because it is interesting in and of itself, but also because it has broader relevance given that India's labor force survey allows one to examine aspects of employment that are typically not possible, such as employment in firms and cities of different sizes. Starting from 2000, labor force surveys from India (the employment–unemployment surveys conducted by the National Sample Survey Office, henceforth NSS-EUS) enable us to identify whether wage workers are employed in small (informal) or large (formal) enterprises, and whether urban wage workers are employed in urban centers with a population of 1 million or more. As far as we are aware, this is not possible with other labor force surveys in the region.

Our paper mainly focuses on the earnings of wage and salaried workers because information on earnings of self-employed workers is not readily available in labor force surveys. However, we extend our analysis to self-employed workers by imputing their earnings based on the earnings of wage and salaried workers with similar characteristics.

Our main findings are as follows. First, we find that employment in India over the 12 years from 2000 to 2012 displays the patterns one would expect for an economy undergoing structural transformation. That is, the employment shares of wage workers shift from agriculture to industry and services, and from rural to urban areas. Based on the previous literature, these shifts are in the direction of the higher productivity group—for example, see Hasan et al. (2017) on labor productivity across informal and formal sector firms in Indian apparel.

Second, and more importantly, we find that such shifts in employment have been associated with an improvement in average wages. In particular, we use the decomposition of changes in aggregate labor productivity into within sector and structural change (or between sector) components—as in ADB (2013) and McMillan, Rodrik, and Verduzco-Gallo (2014)—to decompose changes in average national wages into analogous components. We find that structural change in some dimensions can account for as much as a quarter to almost a third of the increase in average wages.

Finally, simple Mincerian wage regressions confirm that—when controlling for individual demographics, educational attainment, and even industry of employment and occupational status—a job in a firm with 10 or more workers (and thus a formal sector firm for all practical purposes) and in a large city is associated with higher wages. Significantly, the "premium" to being male is lower in larger firms and cities, suggesting that gender biases diminish along the path of structural transformation. More generally, we find that returns to education are higher in larger firms and in urban areas.

Overall, our results are consistent with the idea that policies that encourage expansion of the formal sector and employment in larger firms are crucial for development. Whether this expansion needs to occur through the formalization or expansion of small firms, or whether policy needs to encourage investment by larger firms in the first place, is not something we can comment on. Our results are also consistent with the idea that urban agglomerations have a key role in providing better paying jobs—regardless of the sector of economic activity—especially for females.

This paper is structured as follows. Section II explains how it fits with the literature on structural transformation and labor market outcomes. Section III describes the wage decomposition framework and the Mincerian wage equation used in our analysis. Section IV explains how variables are constructed using India's labor force survey data. Section V gives the results, describing employment and wages in India over the course of its structural transformation. Section VI contains the conclusions.

II. Literature Review

This paper is motivated by at least two strands of the development literature: (i) structural transformation and (ii) labor market outcomes. ADB (2013) provides a comprehensive discussion of structural transformation, covering both conceptual and empirical issues. Structural transformation involves the transformation of the productive structure of an economy and involves a variety of interrelated processes. These include (i) changes in the structure of production and employment of an economy—the starkest manifestation of which involves a reduction in the shares of output and employment from agriculture and a corresponding increase in output and employment shares in industry and services; (ii) the production of more diversified and complex products, which, in turn, may be captured by two related processes: (a) the emergence of more "capable and sophisticated" firms, a crude proxy for which, would be the expansion of employment in firms in the formal sector and/or firms with employment above some threshold level (e.g., 10 or more workers); and (b) a shift in occupations (e.g., growth in occupations that involve more cognitive or analytical work); and (iii) the process of urbanization, which involves a growing share of population, employment, and production in urban areas.

While the various processes listed above involve an increase in productivity, how these affect workers is less well documented. The widespread concern about the quality of jobs and the widespread use of terms such as "good jobs" is a testimony to the idea that even as countries develop and experience structural transformation, workers may not be benefiting (at least in a commensurate manner). Notwithstanding the fact that labor productivity and wages are related, the relationship between the two is far from watertight. Wage growth depends not only on how much labor productivity grows, but also on how workers' share in output evolves. This is partly determined by the nature of technological change, but other factors also matter, such as the extent of competition in product markets, workers' bargaining power, the relative mobility of capital versus labor, and even social norms. Moreover, general equilibrium considerations also kick in as overall supply and demand conditions in labor markets influence wages over and above sectoral labor productivity. For early expositions of this point, see the works of Lewis (1954) and Harris and Todaro (1970).

This is where the large literature on labor market outcomes comes in. There are many different types of studies, including those which examine the relationship between different types of regulations (especially labor regulations) on outcomes such as wages; studies that examine employment and wage relationships across sectors and types of firms (including formal and informal firms); and, more recently, studies that examine the relationship between urban agglomerations and employment and wages.

Focusing on the last, cities are widely believed to be engines of economic growth and good jobs. In this context, the urbanization process under way in India (and Asia more generally) is good news. However, the link between urbanization and economic dynamism is not assured and a number of urban experts have raised concerns about the nature of urbanization underway in the developing world. For example, Gollin, Jedwab, and Vollrath (2016) bring up the case of two cities, Shanghai and Lagos. Both are large cities in countries with similar urbanization rates. However, it is highly unlikely that their potential to deliver on better economic outcomes for their residents is the same. Similar concerns are raised by Henderson (2014). In a nutshell, the concern that the urbanization underway in the region may not lead to significantly better jobs is driven by the possibility that underinvestment in infrastructure, weak spatial planning, and poor land-use policies lead the forces of congestion to overwhelm the standard benefits of agglomeration (i.e., thicker local labor markets, better input–output linkages, and the potential for knowledge spillovers).

One strand of the literature on structural transformation that focuses directly on wages seeks to understand why wages in agriculture—the largest single employer in most Asian economies—tend to be far lower than wages in other sectors. Alvarez (2017) and Herrendorf and Schoellman (2017) are two recent contributions in this line of the literature. Using labor force survey data from around the developing world, including panel survey data for Brazil by Alvarez (2017) that allows him to track entry and exit by workers across sectors, the papers find more support for the role of unobserved worker characteristics, such as innate capabilities that enable some individuals to benefit more from schooling, to drive a large part of the wage gaps. This is contrary, however, to studies that ascribe an important role to barriers to reallocation of resources across sectors (see, for example, McMillan, Rodrik, and Verduzco-Gallo 2014).

III. Framework for Analysis

Much of our analysis relies on reporting average wages for groupings that are economically meaningful. In particular, in addition to reporting wages across production sectors, we document average wages across occupational groups; locations (rural areas, smaller cities and towns, and large cities); and small (informal) and larger (formal) firms. We also decompose wage growth to understand how much of it is driven by shifts in employment from lower-wage to higher-wage groupings. Finally, we run standard Mincerian regressions to check whether some of the more important average wage differentials we work with in our decompositions remain after controlling for observable characteristics of workers (age, gender, and educational attainment).

The decomposition of wage growth parallels the work on decomposing the components of labor productivity growth (see, for example, ADB 2013; and McMillan, Rodrik, and Verduzco-Gallo 2014) and is computed as follows:

$$\Delta W_t = \sum_i \left(\Delta E_t^i\right) W_{t-1}^i + \sum_i \left(\Delta W_t^i\right) E_{t-1}^i \quad (1)$$

where ΔW_t is the change in average wages; E_t^i is the share of workers in a given sector, region, or occupation of type i in year t; and W_t^i is the average wage of workers in that sector, region, or occupation type. The first term captures the growth of wages caused by the movement of workers from one grouping to another, which we call structural change, while the second term captures the growth of wages caused by rising wages within a group.

As for the Mincerian wage regressions, these simply involve estimating the following equation for worker i:

$$\ln(\text{wage}_i) = \beta_1 age_i + \beta_2 age_i{}^2 + \beta_3 sex_i + \beta_4 education_i + \sum \beta_j state_j + \sum \beta_k \boldsymbol{X_i} + \varepsilon \quad (2)$$

where $\boldsymbol{X_i}$ refers to variables of interest and controls such as firm size, rural–urban, big cities, sector dummies, and occupation dummies. We introduce education in terms of years of schooling.

IV. Data and Variable Construction

Our main source of data is the NSS-EUS. We use two rounds of the surveys, the 55th (1999–2000, henceforth 2000) and 68th (2011–2012, henceforth 2012). Like standard labor force surveys, they provide us information on individual demographics (gender and age), wages, educational attainment, and sector of employment and occupation. As they are based on nationally representative surveys of households, they capture information on workers in both the formal and informal sectors; they also capture wage and salaried workers as well as self-employed workers.

Earnings data are collected only from wage and salaried workers. For this reason, we limit much of our analysis to wage workers. Unfortunately, information on wages is missing for 35% of the sample of wage workers in 2000 and for 29% in 2012. Thus, average wages have to be computed on the basis of information provided by 65% of wage workers in 2000 and 71% of wage workers in 2012. Fortunately, the pattern of missing wage information across groups appears to be somewhat random, with sufficiently large sample sizes of nonmissing wage observations across sectors, occupations, and educational categories with which to compute what should be reliable estimates of average wages.[2] For the wage decomposition analysis, average wages are based on the sample with wage responses, while employment shares are based on the full sample of wage workers.

Significantly, India's labor force surveys also provide us information on the size of firms that workers are employed in (i.e., whether the firms have 1–5, 5–9, 10–19, or 20 or more workers) and also whether urban respondents to the survey reside in a big city or not (i.e., cities with a population of 1 million or more in 2001). Unfortunately, a large number of nonresponses to the question on firm size, especially in the 2000 labor force survey, limits our ability to draw reliable conclusions on the role of firm size in our wage decompositions. In particular, while in 2012, 8% of wage workers' firm size is reported as unknown, it is 24% in 2000.[3] Thus, we exclude firm size from our analysis of wage decompositions. However, in

[2]Appendix Table A1 shows the number of sample observations for all wage workers (i.e., those with and without wage information) and for wage workers with wage data across industry, occupation, and location groups. The sample sizes are 1,000 or more in almost all cases. Further, the distribution of sample observations is fairly similar within any group. For example, in 2012, 17.3% of all sample wage employees belong to agriculture (10,726 observations out of 61,912) versus 16.5% of all sample wage employees with nonmissing wages (7,193 observations out of 43,691). The equivalent shares in 2000 are 42% and 38.5%, respectively.

[3]It is difficult to ascertain any specific pattern to the nonresponses. The share of unknowns and bad codes is substantial in both urban and rural areas in 2000; about 22% of urban workers and 26% of rural workers have no meaningful response to the firm size question. Unknowns and bad codes are also spread out across sectors: 19% of manufacturing workers; 34% of workers at public utilities; 16% of wholesale and retail trade workers; and 23% of workers in transport, storage, and communication services.

our analysis of Mincerian wage regressions, we use the firm size variable as these regressions are conducted only for 2012.

We ensure that our wage decompositions (equation [1]) are based on defining big cities consistently across the two rounds of the labor force surveys. We do this by taking the list of big cities in the 68th round and checking whether each one had a population of at least 1 million in the 1991 census. This is because big cities in the 55th round were identified on the basis of the 1991 population census. Cities with a population of 1 million or more in 1991 were retained as big cities in the 68th round. Implicitly, we assume that all big cities in the 55th round would also be classified as big in the 68th round.[4]

We use the data on earnings of wage and salaried workers over the reference period (7 days) and information on the number of half days worked over the week to compute daily wage rates. Since it is likely that workers reporting 6 or 7 days of work a week are actually working 5 or 6 days (e.g., those employed in the central government or the corporate sector and getting Saturdays and Sundays off), we top code days worked per week at 5 days. Fewer than 4% of workers in each year report working fewer than 4 days a week.

Like many other labor force surveys, India's does not collect information on the earnings of the self-employed. To extend the analysis to self-employed workers, we impute their earnings by predicting wages for them based on the empirical relationship between the wages of wage workers and individual characteristics observed in the labor force surveys, and a correction for selection of workers into self-employment based on Heckman's two-step procedure in line with a similar exercise by Das et al. (2015). For the selection equation, we let z_i be the probability that worker i is a wage worker, and $z_i = 1$ if

$$z_i^* = w_i\delta + u_i > 0$$

where δ is the set of identification factors including age, sex, marital status, and household size; w_i is the coefficient of δ; and u_i is the error term. If $z_i^* \leq 0$, then worker i is self-employed. We estimated a Mincerian wage equation for wage workers as follows:

$$\ln(\text{wage}) = \beta_1 X + \rho\sigma_u\lambda(w_i\delta)$$

where X is a vector of worker characteristics that include dummies of age, gender, education, location, marital status, and industry. ρ is the correlation between unobserved determinants of propensity to be a wage worker and unobserved determinants of wages, σ_u is the standard deviation of u_i, and λ is the inverse Mills ratio evaluated at $w_i\delta$. Finally, the wages of self-employed workers are estimated

[4]For the wage decompositions, the following cities in the 68th round were reclassified as towns and small cities in order to make the classification consistent across the 55th and 68th rounds: Agra, Faridabad, Meerut, Nashik, Patna, and Pimprichinchwad. However, for the Mincerian wage regressions, as these only involve data from the 68th round, the original classification of big cities in the 68th round was retained.

as the predicted wages of self-employed workers based on the coefficients of this regression. In both 2000 and 2012, 49% of workers were self-employed. Outside of agriculture, the shares are 43% and 39% for 2000 and 2012, respectively. Appendix Tables A2.1 and A2.2 compare the means of worker characteristics between self-employed and wage workers in 2000 and 2012, respectively, and provide *t* statistics on the difference between means of these two groups of workers. The imputed wages of self-employed workers are on average lower than the actual wages of wage workers (Appendix Table A2.3).

We adjust wages for temporal and spatial cost-of-living differences using the national Consumer Price Index and state and urban–rural cost-of-living adjustments based on official poverty lines, as reported in Saxena (2001) and Government of India (2013). Wages beyond 3 standard deviations from the mean are considered outliers and are dropped (less than 1% of the sample).

Since the surveys provide information on levels of education attained, we convert these into years of education by assuming the following correspondence between levels of education and years of education: 0 years for those who are illiterate, 1 year for those with preprimary education, 5 years for those with a primary education, 8 years for a middle school education, 10 years for a secondary education, 12 years for a senior secondary education, 14 years for those who finished a diploma course, 16 years for college graduates, and 19 years for those who completed postgraduate studies.

We work primarily with economic sectors based on the Groningen Growth and Development Centre 10-sector Database (Timmer, de Vries, and de Vries 2015), but we also experiment with a simple breakdown between tradable and nontradable sectors. For the latter classification, we follow Mano and Castillo (2015), who use the World Input–Output Database to calculate the ratio of exports to gross value added across countries for each industry and year, and then compute the average exports-to-gross-value-added ratio during the period 1995–2011. They classify an industry as tradable if the average exports-to-gross-value-added ratio is greater than 10%.

We also classify occupations in terms of whether they involve primarily routine or nonroutine work, and manual or analytical work, based on the work of Autor, Levy, and Murnane (2003) and Reijnders and de Vries (2018), and as described in ADB (2018). Prominent examples of routine manual workers include production workers, while routine analytical workers include clerical workers. Nonroutine manual workers include drivers and personal service workers. Nonroutine analytical workers include legislators, managers, engineering professionals, health professionals, teaching professionals, other professionals, and sales workers.

We use the occupation codes reported in the survey for this purpose. In 2012, 0.4% of wage workers did not have an occupation code, while 1% of wage workers did not have an occupation code in 2000. We drop these observations for decompositions involving occupations (and for the Mincerian regressions).

We work with the following states and union territories: Andhra Pradesh, Assam, Bihar, Chandigarh, Delhi, Goa, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, and West Bengal.

V. Results

A. Employment and Wages by Groups: A Snapshot

Table 1 provides a snapshot of employment shares of wage and salaried workers, average real wages (correcting for temporal changes in prices as well as both temporal and spatial variations in prices), and average years of education across various groups. In terms of employment shares across production sectors, we see a large reduction from 2000 to 2012 in agricultural wage employment (18 percentage points), a large increase in construction (10 percentage points), and a moderate increase in manufacturing (3 percentage points).[5] As for average wages, agriculture experiences one of the highest rates of growth at 4.2% annually. (This dips to 4% annually when spatial price differentials in addition to temporal changes in prices are taken into account.) Business services, which are one of the highest paying sectors on average, experience the lowest growth in wages: 1% annually when correcting only for temporal price changes and 1.8% annually when spatial price differentials are also taken into account.

There are few surprises as far as educational attainment is concerned. Workers in agriculture tend to be the least educated (at most 3 years of education on average), while those in business services and public administration, defense, education, and health services are the best educated.

Turning to locational groupings, the rural share of wage workers declined to two-thirds by 2012, while the employment share of big cities increased by 3 percentage points between 2000 and 2012. The share of smaller cities and towns also increased by 3 percentage points. Not surprisingly, the most educated are to be found in bigger cities. Such cities have considerably higher wages on average.

Firms with 10 or more workers (and outside agriculture) pay better and also have better educated workers. Regarding changes in their prevalence between 2000 and 2012, given the large share of nonresponses on firm size by wage employees—especially in the 2000 labor force survey, it is difficult to draw conclusions. But taken at face value, the share of wage employment in large firms increased slightly between 2000 and 2012.

Turning to the distinction between tradables and nontradables, we see that the main differences arise from the inclusion of agriculture in the former. Without

[5]Appendix Table A3 provides employment shares across the various groups of interest for the self-employed and all workers (i.e., wage and salaried workers plus the self-employed). For ease of reference, the share of wage employees is also provided in the table.

Table 1. **Summary Statistics for Wage and Salaried Employees**

	Employment Shares (%)		Wages, Temporal (₹)		Wages, Temporal + Spatial (₹)		Years of Schooling	
Sectors	**2000**	**2012**	**2000**	**2012**	**2000**	**2012**	**2000**	**2012**
Agriculture	55	37	96	158	94	151	2	3
Mining	1	1	310	504	307	512	4	6
Manufacturing	11	14	275	355	285	390	7	7
Utilities	1	1	529	651	546	733	8	9
Construction	8	18	176	247	181	249	3	4
Trade services	6	7	225	318	233	349	7	8
Transport services	5	7	352	548	363	605	8	9
Business services	2	3	654	739	675	834	13	13
Public administration and defense, education, health and social work	10	9	561	764	572	817	12	13
Personal services	3	3	146	242	150	266	3	6
Urban–Rural	**2000**	**2012**	**2000**	**2012**	**2000**	**2012**	**2000**	**2012**
Rural	73	67	145	232	145	223	3	4
Urban—towns and small cities	19	22	355	490	361	548	7	9
Urban—big cities	8	11	430	582	459	688	9	10
Firm size (without agriculture)	**2000**	**2012**	**2000**	**2012**	**2000**	**2012**	**2000**	**2012**
Large firms[a]	42	43	474	588	489	648	9	10
Small firms[a]	58	57	222	304	228	317	6	6
Tradables (with agriculture)	**2000**	**2012**	**2000**	**2012**	**2000**	**2012**	**2000**	**2012**
Tradable	74	62	159	263	161	275	3	5
Nontradable	26	38	352	436	361	464	8	7
Tradables (without agriculture)	**2000**	**2012**	**2000**	**2012**	**2000**	**2012**	**2000**	**2012**
Tradable	41	39	318	426	328	468	7	8
Nontradable	59	61	352	436	361	464	8	7
Occupation categories	**2000**	**2012**	**2000**	**2012**	**2000**	**2012**	**2000**	**2012**
Routine manual	23	32	219	280	225	295	5	5
Nonroutine manual	8	11	274	369	282	399	5	7
Routine analytic	4	4	507	680	525	748	13	13
Nonroutine analytic	10	15	581	789	594	864	13	13
Agriculture	55	38	94	158	92	150	2	3

[a]A large firm is defined as a firm with 10 or more workers. In 2012, 8% of wage workers reported that their firm size was unknown, while 24% of wage workers in 2000 did not know the size of their firm.

Notes: Employment shares and average years of schooling are based on the full sample of wage workers, while average wages are based on the sample of wage workers with wage data. Wages are expressed as the average daily wage in constant 2012 rupees. Temporal uses the Consumer Price Index to adjust for changes in prices over time. For Temporal + Spatial, differences in spatial prices are taken into account, in addition to changes in prices over time. A big city is defined as a city with a population of 1 million or more as per the 1991 census. This sample is limited to states included in the wage decomposition analysis and Mincerian wage regressions.

Source: Authors' calculations using data from National Sample Survey Office. 2000. "National Sample Survey 1999–2000 (55th round): Schedule 10–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation; and National Sample Survey Office. 2012. "National Sample Survey 2011–2012 (68th round): Schedule 1.0–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation.

agriculture, the two groups are quite similar in terms of average wages and educational attainment.

Finally, for occupational groupings, we see a large (9 percentage points) increase in routine manual occupations. This group includes the second-least-educated group on average, ahead of only agriculture. As we shall see below, this seems to be driven by an exit of wage workers from agriculture to routine manual work in industry and services.

Given the growing interest in urbanization issues in developing countries (see, for example, Hasan, Jiang, and Kundu 2018), Table 2 provides a snapshot of the employment shares of wage and salaried workers across rural areas, small cities and towns, and big cities in both 2000 and 2012. Not surprisingly, agriculture contributes marginally to wage and salaried employment in towns and small cities, and hardly at all in big cities. However, even within rural areas, the share of agricultural wage employment declined (from 73% to 54%). What is interesting is how important manufacturing is in India's big cities—accounting for almost 30% of wage employment. Additionally, the role of public administration, defense, and social services declines during the review period, as does that of personal services.

Interestingly, there is a sharp contrast in the structure of occupational change across rural areas and big cities. Rural areas see a large increase in routine manual work. This seems to be driven by an almost commensurate decline in agricultural occupations and growth in construction employment. In contrast, big cities see a drop of 6 percentage points in the share of routine manual work and an increase of 8 percentage points in nonroutine analytic work. Thus, unlike the case of developed countries, where a decline in routine manual work is attributed to the growing use of robotics and computers (the so-called fourth industrial revolution), India's pattern is consistent with the idea of "overlapping industrial revolutions" (ADB 2018), where some parts of a developing country are going through first or second industrial revolution processes (thanks to the advent of electricity and the internal combustion engine), while other parts are experiencing more recent technological revolutions.

B. Wage Decompositions

Table 3a summarizes the decomposition of average wages of wage and salaried workers into within and structural change (or between) components for various groupings of interest. When adjusting only for temporal changes in prices using the Consumer Price Index (first three data columns), the average real wage growth is between 3.9% and 4.2% per annum.[6] It is slightly higher when we adjust

[6]There is a slight difference in the average wage growth across decompositions due to differences in the number of observations across decompositions. As noted earlier, a small number of workers do not report their occupations. Additionally, 0.3% of wage workers in 2012 do not report the sector of employment. These observations get dropped in the decompositions involving occupation or sector.

Table 2. **Employment Statistics for Wage and Salaried Employees by City Size**

Year: 2000

	Employment Share (%)			Wages, Temporal (₹)			Wages, Temporal + Spatial (₹)		
Sectors	**Rural**	**Towns and Small Cities**	**Big Cities**	**Rural**	**Towns and Small Cities**	**Big Cities**	**Rural**	**Towns and Small Cities**	**Big Cities**
Agriculture	73	9	1	99	127	211	98	131	184
Mining	1	2	0	244	503	908	248	485	964
Manufacturing	7	21	29	192	325	362	195	332	389
Utilities	1	2	1	477	671	576	504	658	589
Construction	6	12	8	168	191	259	174	195	275
Trade services	2	14	16	175	228	299	181	231	317
Transport services	3	10	12	290	406	519	296	410	557
Business services	1	3	6	538	712	770	549	712	816
Public[a]	6	21	20	528	631	678	542	628	715
Personal services	2	5	8	135	140	178	146	137	188
Total	100	100	100	168	386	434	170	388	461

	Employment Share (%)			Wages, Temporal (₹)			Wages, Temporal + Spatial (₹)		
Occupation Categories	**Rural**	**Towns and Small Cities**	**Big Cities**	**Rural**	**Towns and Small Cities**	**Big Cities**	**Rural**	**Towns and Small Cities**	**Big Cities**
Routine manual	17	42	39	185	253	286	190	255	306
Nonroutine manual	5	17	23	263	296	292	270	297	317
Routine analytic	2	8	10	444	552	595	453	553	634
Nonroutine analytic	5	24	27	534	645	679	549	645	714
Agriculture	72	9	1	96	138	181	96	142	193
Total	100	100	100	167	386	434	169	388	461

	Employment Share (%)			Wages, Temporal (₹)			Wages, Temporal + Spatial (₹)		
Tradable	**Rural**	**Towns and Small Cities**	**Big Cities**	**Rural**	**Towns and Small Cities**	**Big Cities**	**Rural**	**Towns and Small Cities**	**Big Cities**
Tradable	84	46	47	122	344	428	122	348	459
Nontradable	16	54	53	331	418	438	341	418	462
Total	100	100	100	168	386	434	170	387	461

Continued.

wages for both temporal and spatial differences in the cost of living (between 4.2% and 4.5% per annum). Nevertheless, the qualitative patterns are quite similar. As in the case of labor productivity decompositions analyzed by other studies, we find the within term to be the main driver of growth in economy-wide average wages. Nevertheless, for all the groups we consider, structural change contributes

Table 2. *Continued.*

Year: 2012

Sectors	Employment Share (%) Rural	Employment Share (%) Towns and Small Cities	Employment Share (%) Big Cities	Wages, Temporal (₹) Rural	Wages, Temporal (₹) Towns and Small Cities	Wages, Temporal (₹) Big Cities	Wages, Temporal + Spatial (₹) Rural	Wages, Temporal + Spatial (₹) Towns and Small Cities	Wages, Temporal + Spatial (₹) Big Cities
Agriculture	54	5	0	167	212	393	161	232	465
Mining	1	2	0	493	828	1,323	447	882	1,648
Manufacturing	9	22	28	283	399	461	280	451	553
Utilities	1	3	1	698	846	817	712	970	951
Construction	20	15	9	237	285	352	229	316	419
Trade services	3	13	14	273	288	400	274	318	474
Transport services	4	11	15	392	568	880	384	627	1,047
Business services	1	7	10	633	808	840	646	900	1,004
Public[a]	6	17	16	719	847	898	683	943	1,055
Personal services	1	4	7	204	205	271	197	231	319
Total	100	100	100	337	517	605	326	576	719

Occupation Categories	Employment Share (%) Rural	Employment Share (%) Towns and Small Cities	Employment Share (%) Big Cities	Wages, Temporal (₹) Rural	Wages, Temporal (₹) Towns and Small Cities	Wages, Temporal (₹) Big Cities	Wages, Temporal + Spatial (₹) Rural	Wages, Temporal + Spatial (₹) Towns and Small Cities	Wages, Temporal + Spatial (₹) Big Cities
Routine manual	30	40	33	258	330	369	251	367	441
Nonroutine manual	7	18	23	365	409	414	358	456	492
Routine analytic	2	7	8	642	754	792	615	838	942
Nonroutine analytic	7	29	35	727	822	960	698	916	1,136
Agriculture	55	6	1	171	202	246	164	221	284
Total	100	100	100	338	517	606	327	576	720

Tradable	Employment Share (%) Rural	Employment Share (%) Towns and Small Cities	Employment Share (%) Big Cities	Wages, Temporal (₹) Rural	Wages, Temporal (₹) Towns and Small Cities	Wages, Temporal (₹) Big Cities	Wages, Temporal + Spatial (₹) Rural	Wages, Temporal + Spatial (₹) Towns and Small Cities	Wages, Temporal + Spatial (₹) Big Cities
Tradable	69	47	49	244	473	577	239	527	692
Nontradable	31	53	51	420	548	632	404	611	745
Total	100	100	100	337	517	605	326	576	719

[a]Public refers to public administration and defense, education, health, and social work.

Notes: Employment shares are based on the full sample of wage workers, while average wages are based on the sample of wage workers with wage data. Wages are expressed as the average daily wage in constant 2012 rupees. Temporal uses the Consumer Price Index to adjust for changes in prices over time. For Temporal + Spatial, differences in spatial prices are taken into account, in addition to changes in prices over time. A big city is defined as a city with a population of 1 million or more as per the 1991 census. This sample is limited to states included in the wage decomposition analysis and Mincerian wage regressions.

Source: Authors' calculations using data from National Sample Survey Office. 2000. "National Sample Survey 1999–2000 (55th round): Schedule 10–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation; and National Sample Survey Office. 2012. "National Sample Survey 2011–2012 (68th round): Schedule 1.0–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation.

Table 3. **Wage Decomposition Results**

(a) Wage workers only

	Temporal			Temporal + Spatial		
Configuration	**Structural Change (%)**	**Within (%)**	**Economy-wide Wage Growth (%)**	**Structural Change (%)**	**Within (%)**	**Economy-wide Wage Growth (%)**
Sector (10 sectors)	1.0	3.1	4.0	1.0	3.3	4.4
Occupations (5 categories)	1.3	2.9	4.2	1.4	3.2	4.5
Urban–Rural	0.5	3.4	3.9	0.5	3.7	4.2
Rural, big cities, towns and small cities	0.5	3.4	3.9	0.6	3.7	4.2
Urban–Rural × Sector (2 × 10)	1.0	3.0	4.0	1.0	3.3	4.4
Sector × Occupation (10 × 5)	1.2	2.9	4.1	1.2	3.2	4.5
Urban–Rural × Sector × Occupation (2 × 10 × 5)	1.2	2.9	4.1	1.2	3.2	4.5

(b) Wage workers and self-employed workers

	Temporal			Temporal + Spatial		
Configuration	**Structural Change (%)**	**Within (%)**	**Economy-wide Wage Growth (%)**	**Structural Change (%)**	**Within (%)**	**Economy-wide Wage Growth (%)**
Sector (10 sectors)	0.7	2.3	3.0	0.8	2.5	3.3
Occupations (5 categories)	0.7	2.3	3.1	0.8	2.5	3.3
Urban–Rural	0.3	2.7	3.0	0.3	2.9	3.3
Rural, big cities, other urban areas	0.3	2.7	3.0	0.4	2.9	3.3
Urban–Rural × Sector (2 × 10)	0.7	2.3	3.0	0.8	2.5	3.3
Sector × Occupation (10 × 5)	0.8	2.2	3.0	0.9	2.4	3.3
Urban–Rural × Sector × Occupation (2 × 10 × 5)	0.8	2.2	3.0	0.9	2.4	3.3

Notes: Temporal uses the Consumer Price Index to adjust for changes in prices over time. For Temporal + Spatial, differences in spatial prices are taken into account, in addition to changes in prices over time. A big city is defined as a city with a population of 1 million or more as per the 1991 census. This sample is limited to states included in the wage decomposition analysis and Mincerian wage regressions. There is a slight difference in the average economy-wide wage growth across decompositions due to differences in the number of observations across configurations (0.3% of wage workers in 2012 have no sector data, 0.4% in 2012, and 1% in 2000 have no occupation data). These observations get dropped in the decompositions involving occupation or sector.

Source: Authors' calculations using data from National Sample Survey Office. 2000. "National Sample Survey 1999–2000 (55th round): Schedule 10–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation; National Sample Survey Office. 2012. "National Sample Survey 2011–2012 (68th round): Schedule 1.0–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation.

positively to growth in average wages. The contribution of structural change is around 23%–25% in the sectorwise decomposition (row 1) and around 31% in the occupationwise decomposition (row 2). The contribution of structural change is around 12%–13% when we decompose wages in terms of just urban and rural areas, and 13%–14% when we further distinguish urban areas between those comprising big cities and other cities and towns (rows 3 and 4). The table also considers what happens when we consider a more disaggregated grouping based on combining the sector, occupation, and location groups. Interestingly, the largest such grouping (row 7)—involving a total of 100 groups formed over 10 sectors, 5 occupations, and 2 locations—reveals that structural change drives 27%–29% of total wage growth, which is similar to when just occupation groups are considered.

Table 3b carries out the wage decomposition by including the self-employed and their predicted wages. Economy-wide average wage growth is now lower (due to the lower predicted wages of the self-employed). But, the decompositions yield similar results in terms of the relative importance of the structural change and within group terms. For example, the contribution of structural change remains at 23%–24% in the sector-wise decomposition (row 1), and it remains close at 9%–12% when we decompose wages in terms of urban and rural areas and when we further distinguish urban areas between those comprising big cities and other cities and towns (rows 3 and 4).

Thus far, our results indicate that India's economy has undergone structural transformation in a fairly standard manner. Employment is exiting agriculture, rural areas, and less remunerative occupations for better-paying production sectors and occupations, and for urban areas, especially big cities. Although not shown, employment also appears to be moving from smaller (informal) firms to larger (formal) firms, subject to the data caveat noted earlier (i.e., that the missing observations for the firm size variable are randomly distributed in both 2000 and 2012). All of these shifts have helped raise average wages in the economy.

C. Wages across Locations and Firm Type

We now turn to the issue of whether the higher real wages of larger firms and cities, especially larger cities, holds even when controlling for individual demographics and educational attainment. Tables 4a–4d present the results of the Mincerian wage regressions using data only for 2012, the year for which our information on firm size of workers is fairly complete.[7] We drop the agriculture sector from this analysis since firm size is not a well-defined concept for farms. To avoid the possibility that the coefficients on wage determinants are largely driven

[7]We do not adjust for population weights. Also, we divide age by 10 and age^2 by 100 to improve the readability of their coefficients.

Table 4. **Mincerian Wage Regressions**

(a) Base

	Base	**Sector and Occupation Dummies**				
Variables	**(1) log wage**	**(2) log wage**	**(3) log wage**	**(4) log wage**	**(5) log wage**	**(6) log wage**
Age/10	0.5138***	0.4257***	0.4187***	0.4308***	0.4272***	0.4236***
	(0.0181)	(0.0171)	(0.0167)	(0.0170)	(0.0170)	(0.0166)
Age^2/100	–0.0446***	–0.0376***	–0.0375***	–0.0381***	–0.0379***	–0.0381***
	(0.0023)	(0.0021)	(0.0021)	(0.0021)	(0.0021)	(0.0021)
Sex (Male = 1)	0.2644***	0.3245***	0.3393***	0.3256***	0.3339***	0.3451***
	(0.0108)	(0.0108)	(0.0106)	(0.0107)	(0.0107)	(0.0105)
Years of schooling	0.0735***	0.0479***	0.0435***	0.0472***	0.0465***	0.0424***
	(0.0006)	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)
Large firm = 1			0.2625***			0.2488***
			(0.0073)			(0.0073)
Big city = 1				0.2077***		0.1493***
				(0.0119)		(0.0121)
Urban = 1					0.1201***	0.0745***
					(0.0071)	(0.0072)
Constant	3.7331***	4.4820***	4.3028***	4.4716***	4.4074***	4.2584***
	(0.0370)	(0.0437)	(0.0431)	(0.0434)	(0.0437)	(0.0430)
Sector dummies	No	Yes	Yes	Yes	Yes	Yes
Occupation dummies	No	Yes	Yes	Yes	Yes	Yes
State dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	30,519	30,519	30,519	30,519	30,519	30,519
R-squared	0.4175	0.4873	0.5080	0.4924	0.4921	0.5136

Continued.

Table 4. *Continued.*

(b) Firm size										
	Large Firms					Small Firms				
	Base	Sector + Occupation Dummies				Base	Sector + Occupation Dummies			
Variables	(1) log wage	(2) log wage	(3) log wage	(4) log wage	(5) log wage	(6) log wage	(7) log wage	(8) log wage	(9) log wage	(10) log wage
Age/10	0.5171***	0.4245***	0.4314***	0.4255***	0.4302***	0.4856***	0.3910***	0.3933***	0.3919***	0.3937***
	(0.0319)	(0.0300)	(0.0299)	(0.0299)	(0.0298)	(0.0205)	(0.0193)	(0.0192)	(0.0192)	(0.0192)
$Age^2/100$	−0.0389***	−0.0322***	−0.0329***	−0.0325***	−0.0329***	−0.0469***	−0.0392***	−0.0393***	−0.0393***	−0.0394***
	(0.0040)	(0.0038)	(0.0037)	(0.0037)	(0.0037)	(0.0026)	(0.0024)	(0.0024)	(0.0024)	(0.0024)
Sex (Male = 1)	0.1779***	0.2374***	0.2397***	0.2500***	0.2498***	0.3145***	0.4240***	0.4214***	0.4268***	0.4234***
	(0.0172)	(0.0168)	(0.0168)	(0.0168)	(0.0168)	(0.0130)	(0.0132)	(0.0131)	(0.0132)	(0.0132)
Years of schooling	0.0811***	0.0541***	0.0537***	0.0524***	0.0524***	0.0573***	0.0302***	0.0299***	0.0298***	0.0297***
	(0.0009)	(0.0013)	(0.0013)	(0.0013)	(0.0013)	(0.0008)	(0.0010)	(0.0010)	(0.0010)	(0.0010)
Big city = 1			0.1416***		0.0996***			0.1795***		0.1648***
			(0.0167)		(0.0172)			(0.0162)		(0.0167)
Urban = 1				0.1269***	0.1082***				0.0530***	0.0328***
				(0.0116)	(0.0120)				(0.0085)	(0.0087)
Constant	3.7746***	4.4686***	4.4511***	4.3876***	4.3872***	3.8319***	4.1125***	4.1081***	4.0901***	4.0946***
	(0.0642)	(0.0674)	(0.0672)	(0.0675)	(0.0674)	(0.0427)	(0.0673)	(0.0671)	(0.0673)	(0.0671)
Sector dummies	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Occupation dummies	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
State dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	12,001	12,001	12,001	12,001	12,001	18,518	18,518	18,518	18,518	18,518
R-squared	0.4690	0.5367	0.5395	0.5413	0.5426	0.3340	0.4226	0.4264	0.4238	0.4268

Continued.

Table 4. *Continued.*

(c) Urban versus rural

	Urban					Rural				
	Base	Sector + Occupation Dummies				Base	Sector + Occupation Dummies			
Variables	**(1) log wage**	**(2) log wage**	**(3) log wage**	**(4) log wage**	**(5) log wage**	**(6) log wage**	**(7) log wage**	**(8) log wage**	**(9) log wage**	**(10) log wage**
Age/10	0.5903***	0.5152***	0.5229***	0.5046***	0.5113***	0.4342***	0.3167***	0.3167***	0.3136***	0.3136***
	(0.0261)	(0.0245)	(0.0243)	(0.0238)	(0.0237)	(0.0247)	(0.0232)	(0.0232)	(0.0230)	(0.0230)
Age^2/100	−0.0541***	−0.0480***	−0.0486***	−0.0476***	−0.0481***	−0.0351***	−0.0261***	−0.0261***	−0.0261***	−0.0261***
	(0.0033)	(0.0031)	(0.0030)	(0.0030)	(0.0030)	(0.0031)	(0.0029)	(0.0029)	(0.0029)	(0.0029)
Sex (Male = 1)	0.2270***	0.2498***	0.2483***	0.2689***	0.2673***	0.3171***	0.4528***	0.4528***	0.4541***	0.4541***
	(0.0148)	(0.0150)	(0.0149)	(0.0146)	(0.0145)	(0.0155)	(0.0153)	(0.0153)	(0.0152)	(0.0152)
Years of schooling	0.0789***	0.0558***	0.0554***	0.0497***	0.0495***	0.0651***	0.0326***	0.0326***	0.0310***	0.0310***
	(0.0008)	(0.0011)	(0.0011)	(0.0011)	(0.0011)	(0.0008)	(0.0011)	(0.0011)	(0.0011)	(0.0011)
Big city = 1			0.1629***		0.1370***			–		–
			(0.0131)		(0.0128)					
Large firm = 1				0.3155***	0.3081***				0.1684***	0.1684***
				(0.0103)	(0.0102)				(0.0105)	(0.0105)
Constant	3.5904***	4.4650***	4.4471***	4.2496***	4.2396***	3.8711***	4.4526***	4.4526***	4.3455***	4.3455***
	(0.0528)	(0.0611)	(0.0609)	(0.0598)	(0.0596)	(0.0514)	(0.0610)	(0.0610)	(0.0608)	(0.0608)
Sector dummies	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Occupation dummies	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
State dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15,880	15,880	15,880	15,880	15,880	14,639	14,639	14,639	14,639	14,639
R-squared	0.4340	0.5064	0.5112	0.5342	0.5376	0.3872	0.4714	0.4714	0.4805	0.4805

Continued.

Table 4. *Continued.*

(d) Big cities versus towns and small cities

	Big Cities			Towns and Small Cities		
	Base	Sector + Occupation		Base	Sector + Occupation	
Variables	**(1) log wage**	**(2) log wage**	**(3) log wage**	**(4) log wage**	**(5) log wage**	**(6) log wage**
Age/10	0.4594***	0.4247***	0.4338***	0.6324***	0.5395***	0.5232***
	(0.0527)	(0.0494)	(0.0480)	(0.0297)	(0.0277)	(0.0270)
$Age^2/100$	−0.0401***	−0.0375***	−0.0394***	−0.0584***	−0.0504***	−0.0494***
	(0.0067)	(0.0063)	(0.0061)	(0.0037)	(0.0034)	(0.0034)
Sex (Male = 1)	0.1971***	0.1935***	0.2160***	0.2328***	0.2661***	0.2829***
	(0.0319)	(0.0321)	(0.0313)	(0.0165)	(0.0167)	(0.0163)
Years of schooling	0.0841***	0.0593***	0.0530***	0.0767***	0.0533***	0.0475***
	(0.0018)	(0.0022)	(0.0022)	(0.0009)	(0.0012)	(0.0012)
Large firm = 1			0.2894***			0.3127***
			(0.0211)			(0.0117)
Constant	3.8504***	4.3288***	4.1234***	3.5100***	4.4271***	4.2275***
	(0.1059)	(0.3918)	(0.3814)	(0.0602)	(0.0672)	(0.0657)
Sector dummies	No	Yes	Yes	No	Yes	Yes
Occupation dummies	No	Yes	Yes	No	Yes	Yes
State dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,278	3,278	3,278	12,602	12,602	12,602
R-squared	0.5039	0.5684	0.5919	0.4233	0.5019	0.5289

Notes: This sample excludes public administration and defense. Standard errors are in parentheses. *** = $p < 0.01$, ** = $p < 0.05$, * = $p < 0.1$.
Source: Authors' calculations using data from National Sample Survey Office. 2000. "National Sample Survey 1999–2000 (55th round): Schedule 10–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation; and National Sample Survey Office. 2012. "National Sample Survey 2011–2012 (68th round): Schedule 1.0–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation.

by government workers, we remove workers belonging to the industry division of public administration and defense in all the analysis.

The main results are as follows. First, even after controlling for age, gender, and educational attainment, employment in a large firm is associated with a wage premium of around 26%. (It is slightly lower at 25% if dummies for urban areas and big cities are included.) Interestingly, employment in a big city is associated with higher wages as well, but the premium to being in a big city falls dramatically in models that also include the dummy for employment in large firms. For example, comparing the coefficients in columns 4 and 6 in Table 4a, the wage premium to being in a large city falls from around 21% to 15%.

Given the apparent importance of working in a large firm, Table 4b splits the sample into two by separating workers in large firms from those in small firms. This reveals that returns to an extra year of education are a little higher in larger firms than in smaller firms. For example, while the estimated coefficient on years of education is 0.05 in large firms, it is 0.03 in small firms (columns 2–5). Perhaps more significantly, the premium to being male—or put differently, the gender bias against females—is dramatically lower in larger firms. For example, column 5 reveals that the male dummy takes on a value of 0.25 for large firms, which is much less than the 0.42 estimated for small firms. On the other hand, the big city premium is higher for small firms than in large firms. Table 4c splits the overall sample between rural and urban areas. The returns to an extra year of education and working in a large firm are both larger in urban areas, while the wage premium to being male is less. Table 4d splits the urban sample into big cities and towns and small cities. The returns to an extra year of education and working in a large firm are similar. However, the apparent disadvantage of being female is clearly less in larger cities.

We conduct a series of robustness checks to see whether the main results of our Mincerian wage regressions remain. The robustness checks confirm that they do. First, we introduce district dummies. These control for any unobservable differences across districts that might influence wages. Controlling for unobserved characteristics at the district level yields wage premiums that are very close to our main results and slightly improved goodness-of-fit (R-squares of up to 0.54).[8] The wage premium to working in a large firm is around 24%. Between large firms and small firms, the returns to an extra year of education and the gender bias against females remain the same as in the main results. The big city premium is slightly higher in small firms than in large firms. The main results are also preserved when splitting the sample between urban and rural areas, and when splitting the urban sample into big cities and towns and small cities.

Second, we address the possibility that state-owned enterprises are driving our main results—such as lower biases against female workers in large firms. We

[8]The results of our robustness checks are available upon demand.

exclude state-owned enterprises from the analysis by dropping from the sample workers employed in government or public sector enterprises. In this robustness check, the wage premium to working in a large firm is slightly lower at 22%, but still close to the 26% that we have shown in the main results. The returns to education in large firms remain at 5% per year of schooling. The returns are 2% in small firms. The gender bias against females is still lower in large firms than in smaller firms, although the gap between large firms and smaller firms with respect to this gender bias is down to 8 percentage points. The returns to education and working in a large firm both remain higher in urban areas than in rural areas. The wage premium to being male increases to 34% in urban areas, but it remains lower than the 41% wage premium in rural areas. Within urban areas, the wage premium to being male rises to 38% in towns and small cities, while it remains close to our main results for big cities. Thus, even after dropping all government workers, the gender bias against females remains lowest in big cities, in contrast to rural areas, towns, and small cities. Finally, we restricted the wage regressions to the manufacturing sector only. The wage premiums in the manufacturing sector reflect the main results as well.

VI. Conclusions

This paper uses labor force survey data from India to examine how wages behave over the course of structural transformation, especially in terms of its less studied aspects. Focusing on wage and salaried employment, we find first that employment in India over the 12 years between 2000 and 2012 displays the patterns one would expect for an economy undergoing structural transformation. During the review period, wage employment shares shift from agriculture to industry and services; from rural to urban areas, and to larger cities within urban areas; and from agricultural occupations toward occupations involving both more routine manual work and more nonroutine analytic work. The last of these shifts is consistent with the idea of developing countries undergoing overlapping industrial revolutions (ADB 2018).

Second, we find that such shifts in employment have been associated with an improvement in average wages. Finally, simple Mincerian wage regressions confirm that—when controlling for demographics, educational attainment, and even industry of employment and occupational status—a job in a larger firm and bigger city is associated with significantly higher wages. The premium to being male is lower in larger firms and cities, suggesting that gender biases diminish along the path of structural transformation. More generally, returns to education are higher in larger firms and in urban areas.

Overall, we take our results to emphasize the importance of policies that encourage the expansion of the formal sector and employment in larger firms.

Whether this needs to occur through the formalization or expansion of small firms, or whether policy needs to encourage investment in larger firms in the first place, is not something we can comment on. Less directly, our results are consistent with the idea that urban agglomerations have a key role in providing better-paying jobs—regardless of the sector of economic activity—especially for females.

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Appendix 1

Table A1. **Sample Sizes (Unweighted): All Wage Workers and Wage Workers with Wage Data**

	All Wage Workers	Wage Workers with Wage Data	All Wage Workers	Wage Workers with Wage Data
	2000		2012	
Sectors				
Agriculture	50,732	29,962	10,726	7,193
Mining	1,486	1,044	741	596
Manufacturing	15,618	10,724	9,179	6,536
Utilities	1,337	955	1,010	771
Construction	9,750	6,238	13,355	9,523
Trade services	9,391	6,370	5,533	3,167
Transport services	7,589	5,256	5,966	3,973
Business services	2,776	1,923	2,595	1,791
Public administration and defense, education, health, and social work	17,634	12,322	10,552	8,786
Personal services	4,481	3,026	2,089	1,355
Missing			166	
Total	120,794	77,820	61,912	43,691
Urban–Rural				
Rural	70,171	42,895	34,330	23,436
Urban—towns and small cities	38,010	26,063	22,449	16,586
Urban—big cities	12,613	8,862	5,133	3,669
Total	120,794	77,820	61,912	43,691

Continued.

Table A1. *Continued.*

	All Wage Workers	Wage Workers with Wage Data	All Wage Workers	Wage Workers with Wage Data
	2000		**2012**	
Firm size (without agriculture)				
Large firms[a]	23,501	16,415	17,988	14,140
Small firms[a]	30,890	20,538	26,408	19,311
Missing	15,671	10,905	6,790	3,047
Total	70,062	47,858	51,186	36,498
Occupation categories				
Routine manual	31,660	21,179	23,127	16,478
Nonroutine manual	12,914	8,864	9,511	6,630
Routine analytic	5,976	4,211	3,144	2,564
Nonroutine analytic	19,113	13,322	14,322	10,149
Agriculture	49,931	29,518	11,541	7,774
Missing	1,200	726	267	96
Total	120,794	77,820	61,912	43,691

[a] A large firm is defined as a firm with 10 or more workers. In 2012, 8% of wage workers reported that their firm size was unknown, while 24% of wage workers in 2000 did not know the size of their firm.

Note: This sample is limited to states included in the wage decomposition analysis and Mincerian wage regressions.

Source: Authors' calculations using data from National Sample Survey Office. 2000. "National Sample Survey 1999–2000 (55th round): Schedule 10–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation; and National Sample Survey Office. 2012. "National Sample Survey 2011–2012 (68th round): Schedule 1.0–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation.

Appendix 2

Table A2.1. **Comparison of Means between Wage Workers and Self-Employed Workers, 2000**

	Wage Workers		Self-Employed			
Variable	**Mean**	**std. dev.**	**Mean**	**std. dev.**	***t* statistic**	***p* value**
Age	34.7597	12.4752	37.0746	14.4777	−42.9798	0.0000
Gender (Male = 1)	0.7498	0.4331	0.7622	0.4258	−7.2666	0.0000
Household size	2.3040	1.3087	2.7645	1.6218	−78.2823	0.0000
Education (share of workers in each category)						
Not literate	0.3865	0.4869	0.3639	0.4811	11.7675	0.0000
Literate without formal schooling (EGS, NFEC, AEC)	0.0022	0.0465	0.0020	0.0451	0.7551	0.4502
Literate without formal schooling (TLC)	0.0017	0.0416	0.0020	0.0446	−1.5421	0.1231

Continued.

Table A2.1. *Continued.*

Variable	Wage Workers Mean	Wage Workers std. dev.	Self-Employed Mean	Self-Employed std. dev.	*t* statistic	*p* value
Literate without formal schooling (others)	0.0071	0.0842	0.0082	0.0904	−3.1365	0.0017
Literate: below primary	0.0959	0.2945	0.1037	0.3049	−6.5506	0.0000
Literate: primary	0.1083	0.3108	0.1283	0.3344	−15.5614	0.0000
Literate: middle	0.1313	0.3377	0.1619	0.3684	−21.7602	0.0000
Literate: secondary	0.1062	0.3081	0.1139	0.3177	−6.2170	0.0000
Literate: higher secondary	0.0569	0.2316	0.0558	0.2296	1.1399	0.2543
Literate: graduate and above in agriculture	0.0036	0.0600	0.0025	0.0498	5.1901	0.0000
Literate: graduate and above in engineering or technology	0.0058	0.0756	0.0018	0.0427	16.3251	0.0000
Literate: graduate and above in medicine	0.0024	0.0490	0.0025	0.0501	−0.5507	0.5818
Literate: graduate and above in other subjects	0.0921	0.2892	0.0534	0.2248	37.8954	0.0000
Marital status (share of workers in each category)						
Never married	0.2166	0.4119	0.1880	0.3907	17.9544	0.0000
Currently married	0.7296	0.4442	0.7629	0.4253	−19.3431	0.0000
Widowed	0.0457	0.2089	0.0443	0.2058	1.7191	0.0856
Divorced or separated	0.0081	0.0897	0.0047	0.0687	10.6790	0.0000

AEC = Adult Education Centre, EGS = Education Guarantee Scheme, NFEC = Non-Formal Education Course, TLC = Total Literacy Campaign.
Note: This sample is limited to states included in the wage decomposition analysis and Mincerian wage regressions.
Source: Authors' calculations using data from National Sample Survey Office. 2000. "National Sample Survey 1999–2000 (55th round): Schedule 10–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation; and National Sample Survey Office. 2012. "National Sample Survey 2011–2012 (68th round): Schedule 1.0–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation.

Table A2.2. **Comparison of Means between Wage Workers and Self-Employed Workers, 2012**

Variable	Wage Workers Mean	Wage Workers std. dev.	Self-Employed Mean	Self-Employed std. dev.	*t* statistic	*p* value
Age	36.7707	12.1132	39.8818	13.7260	−43.2183	0.0000
Gender	0.7873	0.4092	0.7860	0.4101	0.5737	0.5662
Household size	4.8128	2.3155	5.7097	2.9165	−61.0940	0.0000
Education (share of workers in each category)						
Not literate	0.2238	0.4168	0.2304	0.4211	−2.8407	0.0045
Literate without formal schooling (EGS, NFEC, AEC)	0.0015	0.0385	0.0022	0.0464	−2.8278	0.0047
Literate without formal schooling (TLC)	0.0003	0.0180	0.0005	0.0219	−1.4150	0.1571
Literate without formal schooling (others)	0.0015	0.0387	0.0020	0.0443	−2.0126	0.0442

Continued.

Table A2.2. *Continued.*

Variable	Wage Workers Mean	Wage Workers std. dev.	Self-Employed Mean	Self-Employed std. dev.	*t* statistic	*p* value
Literate: below primary	0.0887	0.2844	0.0943	0.2922	−3.4717	0.0005
Literate: primary	0.1234	0.3289	0.1317	0.3382	−4.5178	0.0000
Literate: middle	0.1596	0.3662	0.1853	0.3885	−12.2806	0.0000
Literate: secondary	0.1228	0.3282	0.1579	0.3646	−18.2118	0.0000
Literate: higher secondary	0.0804	0.2719	0.0947	0.2928	−9.1415	0.0000
Literate: diploma or certificate course	0.0280	0.1649	0.0110	0.1041	22.5028	0.0000
Literate: graduate	0.1144	0.3183	0.0716	0.2579	26.7958	0.0000
Literate: postgraduate and above	0.0557	0.2294	0.0185	0.1348	36.1190	0.0000
Marital status (share of workers in each category)						
Never married	0.1969	0.3977	0.1402	0.3472	27.5144	0.0000
Currently married	0.7467	0.4349	0.8134	0.3896	−29.2546	0.0000
Widowed	0.0487	0.2152	0.0426	0.2020	5.2277	0.0000
Divorced or separated	0.0077	0.0875	0.0037	0.0610	9.6243	0.0000

AEC = Adult Education Centre, EGS = Education Guarantee Scheme, NFEC = Non-Formal Education Course, TLC = Total Literacy Campaign.
Note: This sample is limited to states included in the wage decomposition analysis and Mincerian wage regressions.
Source: Authors' calculations using data from National Sample Survey Office. 2000. "National Sample Survey 1999–2000 (55th round): Schedule 10–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation; and National Sample Survey Office. 2012. "National Sample Survey 2011–2012 (68th round): Schedule 1.0–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation.

Table A2.3. **Daily Wage of Wage Workers and Imputed Daily Wage of Self-Employed Workers in Current Rupees**

	Wage Workers	Self-Employed Workers	Wage Workers	Self-Employed Workers
	2000		2012	
Mean	101.2	66.3	349.0	197.2
25th percentile	35.0	39.9	140.0	128.5
Median	55.0	54.8	210.0	165.6
75th percentile	100.0	77.5	342.8	223.5

Note: This sample is limited to states included in the wage decomposition analysis and Mincerian wage regressions.
Source: Authors' calculations using data from National Sample Survey Office. 2000. "National Sample Survey 1999–2000 (55th round): Schedule 10–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation; and National Sample Survey Office. 2012. "National Sample Survey 2011–2012 (68th round): Schedule 1.0–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation.

Appendix 3

Table A3. **Employment Shares of Wage Workers, Self-Employed Workers, and All Workers** (%)

	Wage Workers		**Self-Employed Workers**		**Wage Workers and Self-Employed Workers**	
	2000	**2012**	**2000**	**2012**	**2000**	**2012**
Sectors						
Agriculture	55	37	65	57	60	47
Mining	1	1	0	0	1	1
Manufacturing	11	14	11	10	11	12
Utilities	1	1	0	0	0	1
Construction	8	18	2	4	5	11
Trade services	6	7	15	17	10	12
Transport services	5	7	3	5	4	6
Business services	2	3	1	2	1	3
Public administration and defense, education, health, and social work	10	9	1	2	5	6
Personal services	3	3	3	3	3	3
Urban–Rural						
Rural	73	67	82	78	78	72
Urban—towns and small cities	19	22	14	16	16	19
Urban—big cities	8	11	4	6	6	8
Firm size (without agriculture)						
Large firms[a]	42	43	2	3	23	27
Small firms[a]	58	57	98	98	77	73
Tradables (with agriculture)						
Tradable	74	62	80	75	77	68
Nontradable	26	38	20	25	23	32
Tradables (without agriculture)						
Tradable	41	39	44	41	42	40
Nontradable	59	61	56	59	58	60
Occupation categories						
Routine manual	23	32	14	13	19	23
Nonroutine manual	8	11	5	6	7	9
Routine analytic	4	4	0	0	2	2
Nonroutine analytic	10	15	17	23	14	19
Agriculture	55	38	64	57	59	47

[a]A large firm is defined as a firm with 10 or more workers. In 2012, 8% of wage workers reported that their firm size was unknown, while 24% of wage workers in 2000 did not know the size of their firm.

Notes: Employment shares are based on the full sample of workers (with or without wage data). A big city is defined as a city with a population of 1 million or more as per the 1991 census. This sample is limited to states included in the wage decomposition analysis and Mincerian wage regressions.

Source: Authors' calculations using data from National Sample Survey Office. 2000. "National Sample Survey 1999–2000 (55th round): Schedule 10–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation; and National Sample Survey Office. 2012. "National Sample Survey 2011–2012 (68th round): Schedule 1.0–Employment and Unemployment Survey." Government of India, Ministry of Statistics and Program Implementation.

Improving Public Infrastructure in the Philippines

Takuji Komatsuzaki*

This paper explores the macroeconomic effects of improving public infrastructure in the Philippines, modeling the infrastructure scale-up plan being implemented by the current administration. After benchmarking the Philippines' level of infrastructure investment, quantity and quality of public infrastructure, and public investment efficiency relative to its neighboring countries, the analysis uses a dynamic general equilibrium model to quantitatively assess the macroeconomic implications of raising public investment expenditure with different financing schemes and different rates of public investment efficiency. Critically dependent on a model structure in which accumulation of publicly provided infrastructure raises the overall productivity of the economy, the model simulations show that (i) increasing public infrastructure investment results in sustained gains in output, (ii) the effects of improving public investment efficiency are substantial, and (iii) deficit-financed increases in public investment lead to higher borrowing costs that constrain output increases over time. These results underscore the importance of improving public investment efficiency and revenue mobilization.

Keywords: infrastructure, Philippines, public investment efficiency, revenue mobilization
JEL codes: E22, E62, H54

I. Introduction

Upgrading public infrastructure is a major structural challenge in the Philippines. At 20.6% of gross domestic product (GDP) in 2014, the investment rate in the Philippines is well below its regional peers (Figure 1). Main impediments to private investment are inadequate infrastructure, a weak investment climate, and restrictions on foreign direct investment. In the past, a low revenue base and fiscal consolidation prevented sufficient resource allocation for public investment, while weak implementation capacity led to budget underexecution. Raising investment, particularly in infrastructure, would allow the country to reap the dividends of its

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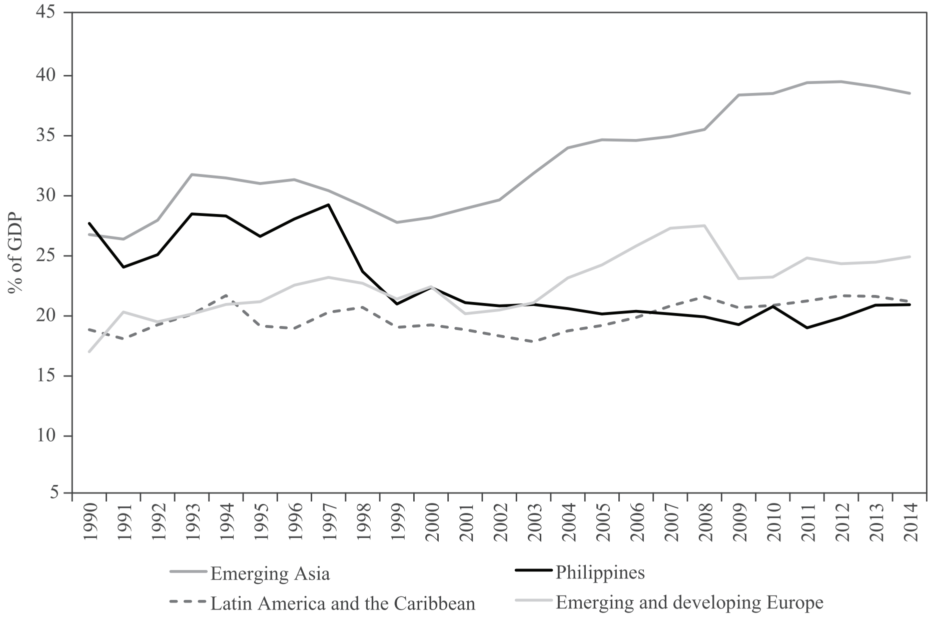
Figure 1. **Investment, Philippines**



GDP = gross domestic product.
Source: International Monetary Fund. World Economic Outlook Database. https://www.imf.org/en/Publications/SPROLLS/world-economic-outlook-databases#sort=%40imfdate%20descending (accessed 26 February 2019).

young and growing population. To address this issue, the Philippine government embarked on an infrastructure push under the Duterte administration. It started with increasing capital expenditure by 1% of GDP in 2016 and a further 0.3% of GDP in 2017, and the government plans to increase this further over the medium term. Immediate priorities include implementing a transport system in Manila and improving airports, road connectivity, and seaports across the country.

Although there is a consensus that public infrastructure needs to be improved, the macroeconomic effects of doing so may differ depending on how this is done. First, there is a choice between deficit financing and tax financing to support an increase in government spending. In this context, the expenditure increase, so far, has mostly been financed by deficits, although the administration aims to implement a comprehensive tax reform to make the tax system simpler, fairer, and more efficient. In fact, in December 2017, the government passed the first round of tax reform, which lowered personal income taxes while raising duties on fuel, cars, coal, and sugar-sweetened drinks and also broadened the value-added tax base. The government is committed to a 3% of GDP deficit target at the national government level, which suggests that the increase in infrastructure spending in 2018 and thereafter will be financed by increasing revenue. Revenue mobilization has always been challenging in the Philippines, however, and there is uncertainty on whether the government's plan will be legislated and implemented as envisaged. Moreover, the effect of a spending increase also depends on public investment efficiency. The same level of government spending will lead to a higher stock of public infrastructure when spending is planned, budgeted, and implemented more efficiently.

This paper explores the macroeconomic implications of improving public infrastructure by increasing public investment expenditure.[1] The analysis first benchmarks the Philippines relative to its neighbors in terms of size of infrastructure investment, quantity and quality of public infrastructure, and public investment efficiency. It confirms that infrastructure investment and the quantity and quality of public infrastructure are relatively low in the Philippines relative to other countries in the Association of Southeast Asian Nations (ASEAN), and that there is room for improvement in public investment efficiency. Subsequently, the paper simulates an increase in public investment expenditure to illustrate its macroeconomic effects using the Global Integrated Monetary and Fiscal (GIMF) model of the International Monetary Fund (IMF) and then distills policy implications from the analysis.

Model simulations suggest that improving public infrastructure would result in a sustained output increase. The baseline scenario considers the government's program, in which public investment increases by 1.2% of GDP for the first 2 years (2016–2017) and a further 2% of GDP in subsequent years. The increase in spending is financed by deficits for the first 2 years but by revenue mobilization thereafter. Assuming the same increase in public investment, two alternative scenarios are considered to illustrate the effects of alternative financing and public investment efficiency. In the first alternative scenario, no further tax reform will take place after December 2017, implying that deficit financing of infrastructure spending will increase from 2018 onward. In the second alternative scenario, public investment efficiency is higher. All scenarios exhibit sustained gains in output driven by the particular structure of the GIMF model, in which improving public infrastructure leads to gains in overall productivity of the economy, which crowds in private investment. Specifically, real GDP is higher than the steady state by 9.5% in the baseline scenario and 8.5% in the first alternative scenario after 15 years. The improvement in public investment efficiency generates substantial additional benefits. Assuming that the size of the inefficiency is halved, the increase in real GDP after 15 years is 11.7%.

Alternative schemes to finance increases in public investment generate different dynamics in public debt, consumption, and investment. While the public debt-to-GDP ratio increases by about 9 percentage points in the baseline scenario,

[1]Public–private partnership (PPP) will also play an important role in improving public infrastructure in the Philippines, which has embarked on an ambitious PPP program. Moreover, the appropriate types of financing could vary depending on the types of projects. This paper focuses on government budget spending on public infrastructure.

the increase is more substantial at 24 percentage points in the first alternative scenario because it relies more on deficit financing. The larger increase in public debt increases borrowing cost and constrains investment over time in the first alternative scenario. In contrast, consumption is initially subdued in the baseline scenario because the increase in consumption tax lowers households' disposal income. While output gains are initially higher in the first alternative scenario, these gains become higher in the baseline scenario over time, with the increase in government's borrowing cost in the first alternative scenario playing a key role.

Increases in public investment expenditure also influence the current account and inflation. It initially leads to a worsening current account and also generates additional domestic demand and thus inflationary pressures. Over time, an increase in supply capacity alleviates inflationary pressures.

Sensitivity analyses exhibit the expected results and also highlight the critical role of the structure of the model in generating the baseline results. Three sensitivity analyses are performed and compared with the baseline to highlight the role of important model features: (i) altering sovereign borrowing cost parameters, (ii) altering tax instruments, and (iii) shutting down the role of public capital in enhancing overall productivity. In (i), the size of the increase in output, private investment, consumption, inflation, and the worsening current account are negatively associated with the slope of the sovereign borrowing cost vis-à-vis the public debt-to-GDP ratio. In (ii), equal distribution of revenue mobilization to corporate income tax, personal income tax, and consumption tax results in a smaller drag on consumption initially, a larger drag on investment, and lower output, relative to the baseline scenario in which a consumption tax is the sole source of revenue mobilization. In (iii), shutting down the role of public capital on overall productivity results in no medium-term effect from fiscal spending. This result highlights that sustained economic growth crucially depends on the model property that publicly provided infrastructure improves overall productivity of the economy.

With the country's low capital stock and fast-growing young population, addressing the large infrastructure gap is needed to raise potential growth and reduce poverty. This paper shows that increasing public investment spending can generate sustained output growth, and improving public investment efficiency can bring about substantial additional benefits. It also shows that deficit financing and tax financing can have different dynamics in some macroeconomic variables. Given the need to ensure debt sustainability amid the large spending needs in other priority spending areas for inclusive growth, continued efforts to mobilize revenue through a comprehensive tax reform will be critical.

II. Literature Review

This study is closest to the literature that investigates the quantitative effects of public investment increases on economic growth using dynamic general equilibrium models. While studies have applied these models to a wide variety of countries to examine the effect of scaling up public investment (see Elekdag and Muir [2014] for application to Germany), few of them incorporate public investment efficiency outside of applying it to low-income countries.[2] A study by the IMF (2014) takes a first step in modeling the effect of public investment efficiency, whose structure this paper also adopts.

There is an extensive empirical literature on the effect of public investment and public infrastructure on economic growth, but the results are not conclusive. There are several issues, including data availability on infrastructure, measurement of infrastructure spending and its efficiency, and potential reverse causation in which higher economic growth generates an increase in public capital spending. Straub (2008), Romp and de Haan (2005), and Pereira and Andraz (2013) provide comprehensive reviews. Two studies by the IMF (2014 and 2015) are among the attempts to control for public investment efficiency. These studies estimate stronger growth effects of public investment in a high public investment efficiency regime, consistent with the results in this paper.

Weak public infrastructure and low public investment in the Philippines have been well documented in the literature. Historical accounts include papers by Montes (1986), Dohner and Intal (1989), Rodlauer et al. (2000), Bocchi (2008), and Warner (2014). The literature consistently documents low investment rates for the Philippines and considers this a major challenge. It also documents governance and public investment management problems. A study by the Asian Development Bank (ADB) (2017) provides the latest estimates of the status of public infrastructure and infrastructure investment needs in Asia, which this paper draws on.

III. The State of Public Infrastructure in the Philippines

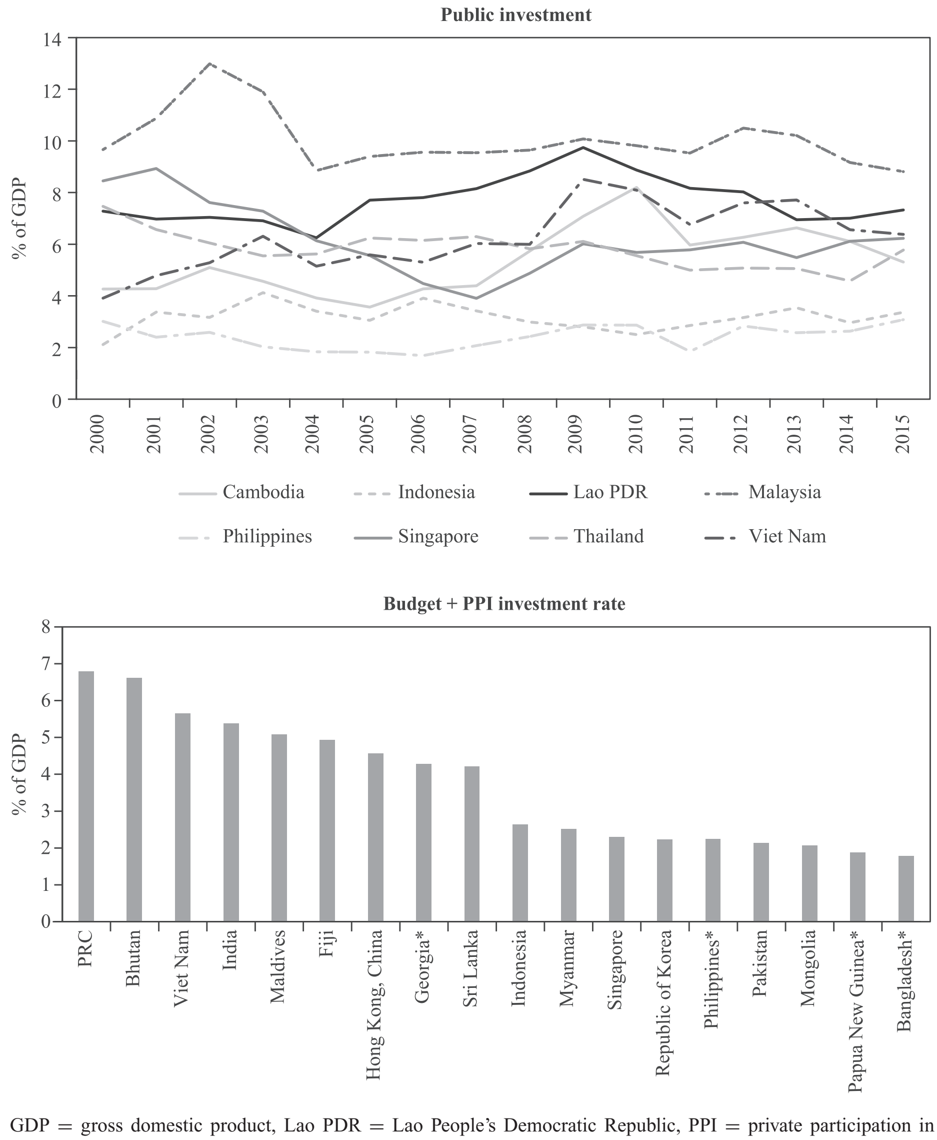
This section documents stylized facts on the status of infrastructure investment, the level of infrastructure, and public investment efficiency in the Philippines. The analysis confirms that the Philippines had low infrastructure investment in the past and that the quality and quantity of the currently available infrastructure are low relative to other ASEAN countries. The analysis also introduces a cross-country estimate of public investment efficiency, which is an important element in translating infrastructure spending into actual improvements in infrastructure.

A. Infrastructure Investment

Public investment has been consistently low in the Philippines, in fact the lowest among ASEAN countries in recent years, averaging 2.5% of GDP

[2]There is a series of papers, such as by Buffie et al. (2012); Melina, Yang, and Zanna (2014); Gupta, Li, and Yu (2015); and Balma and Ncube (2015), that study financing for development and scaling up public infrastructure using a model that captures the economic structure of low-income developing countries.

Figure 2. **Public Investment and Public Capital Stock, Association of Southeast Asian Nations**



GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic, PPI = private participation in infrastructure, PRC = People's Republic of China.
Note: *Central government budget only.
Sources: International Monetary Fund. 2015. "Making Public Investment More Efficient." IMF Policy Paper; Asian Development Bank. 2017. *Meeting Asia's Infrastructure Needs*. Manila; and IMF staff estimates.

in 2000–2014 (Figure 2, upper panel). Public investment is an imperfect measure of infrastructure investment, however, because state-owned enterprises and the private sector also invest in infrastructure, not just the government. A study by

ADB (2017) took a careful look at the measurement of infrastructure investment in developing Asia, focusing on transportation, electricity generation capacity, and telecommunication and water infrastructure, collecting information from multiple data sources. Using its preferred measure of infrastructure investment that includes only budget spending on infrastructure and private participation in infrastructure, the Philippines' infrastructure investment is a little over 2% of GDP, 1.5 percentage points lower than the sample average (Figure 2, lower panel). This pattern is confirmed using two other measures of infrastructure investment (ADB 2017). Therefore, the analysis concludes that the Philippines' infrastructure investment has been low relative to other countries in the region.

B. Status of Infrastructure

Quantitative indicators show an uneven picture (Figure 3). Electricity generation capacity per capita is among the lowest in ASEAN. Given the continuing and prospective high economic growth in the Philippines, there is an acute need to enhance capacity. Power transmission and distribution loss is at the ASEAN average, but with room for further improvement. On the other hand, mobile cellular subscription is high at more than one per person, similar to most ASEAN countries. Access to improved water sources and sanitation facilities are both at the ASEAN averages.

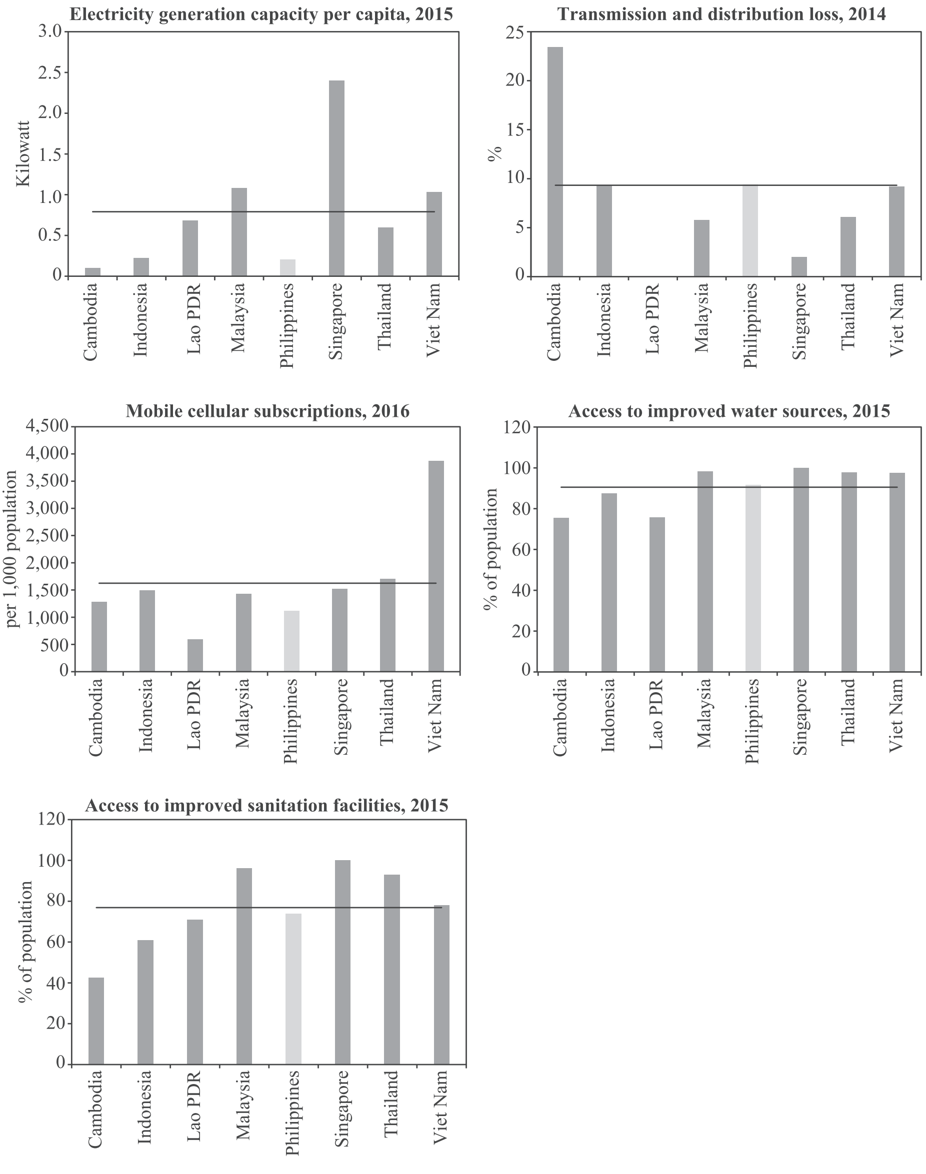
Survey-based indicators paint an unfavorable picture (Figure 4). The World Economic Forum's global competitiveness report surveys business leaders' impressions on a wide range of topics in the business environment on a scale of 1–7. The report places the Philippines among the lowest in ASEAN in key infrastructure services and substantially lower than the ASEAN average in overall infrastructure and all of its subcomponents.

In sum, most indicators of infrastructure suggest that the Philippines' infrastructure lags behind its ASEAN peers, which, given the prospects of high demand for infrastructure from economic and demographic growth, indicates that there is a need for a significant upgrade.

C. Public Investment Efficiency

An IMF study (2015) developed the public investment efficiency indicator, an outcome-based estimation of public investment efficiency (Figure 5). First, the public capital stock (input) and indicators of access to and quality of infrastructure assets (output) are documented for over 100 countries. Then the public investment efficiency frontier is estimated as the highest levels of output that can be achieved for given levels of input. Finally, an efficiency score is derived for each country as the distance from the frontier. A country's score is higher if a given level of public capital stock is associated with higher access to and quality of infrastructure assets.

Figure 3. **Quality of Infrastructure**

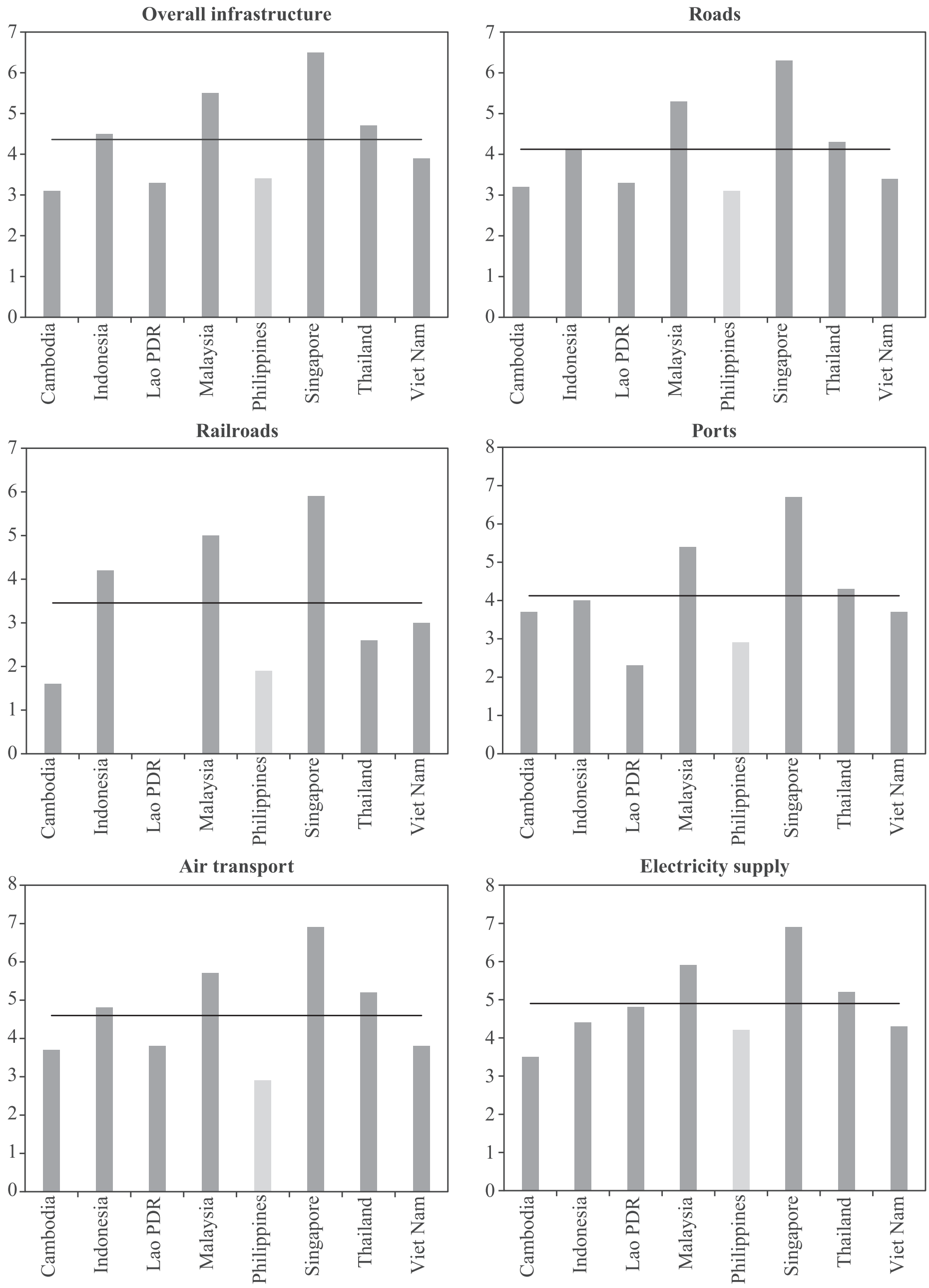


Lao PDR = Lao People's Democratic Republic.

Note: The horizontal lines are averages.

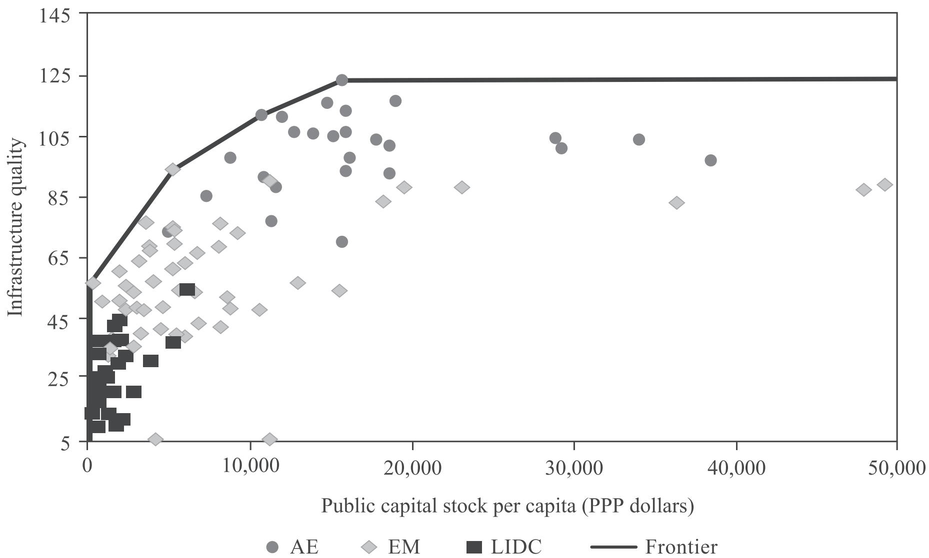
Sources: International Energy Statistics. https://www.iea.org/statistics/index.html; World Bank. World Development Indicators. https://datacatalog.worldbank.org/dataset/world-development-indicators (both accessed 31 October 2018).

Figure 4. **Quality of Infrastructure, Association of Southeast Asian Nations**
(Scale of 1–7)



Lao PDR = Lao People's Democratic Republic.
Note: The horizontal lines are averages.
Source: World Economic Forum. 2017. *The Global Competitiveness Report 2017–2018.* Geneva.

Figure 5. **Cross-Country Comparison of Public Investment Efficiency**



AE = advanced economies, EM = emerging market, LIDC = low-income developing countries, PPP = purchasing power parity.
Notes: The efficiency frontier shows the level of infrastructure quality (output) at a given capital stock per capita (input). The closer a country is to the efficiency frontier, the more efficient its public investment.
Source: International Monetary Fund. 2015. "Making Public Investment More Efficient." IMF Policy Paper.

The score is defined separately for advanced, emerging market, and low-income economies because of the large divergence in income per capita, and the relationship between input and output is likely to be nonlinear as income per capita increases. The estimation results show that the efficiency gap is around 30% on average for the full sample and the emerging market economies subsample.

IV. Global Integrated Monetary and Fiscal Simulations

A. Model and Calibration

This section simulates the macroeconomic effects of public investment expenditure using the GIMF model. The GIMF is a multiregion general equilibrium macroeconomic model developed by the IMF's Research Department. It has optimizing producers and households, frictions in the form of sticky prices and wages and real adjustment costs, a financial accelerator mechanism, monetary policy that follows inflation-forecast targeting, and fiscal policy that ensures debt sustainability. The model allows for discretionary fiscal policy in the short run, and includes a detailed description of fiscal policy that allows for the choice of seven different fiscal policy instruments encompassing both revenue and expenditure measures. The finite lifetime of households, some of whom are liquidity constrained, implies that the model generates strong macroeconomic responses to fiscal shocks. Moreover, public investment creates public capital, which contributes to overall domestic output, as the final output uses both private and public capital as inputs. In addition to this default structure of the GIMF model, this paper introduces an endogenous change in sovereign borrowing premium as a function of public debt-to-GDP ratio in a stylized way, to take into account the macroeconomic effects of debt accumulation through borrowing costs. A three-region (Philippines, rest of emerging Asia, and rest of the world) version of the model is used, and the focus is on dynamics in the Philippines. Parameters for the Philippines are calibrated to the current state of the Philippine economy (see table on page 173). Below is a more detailed description of notable features of the model that are most relevant to this paper. Kumhof et al. (2010) and Anderson et al. (2013) elaborate further on the theoretical structure and main simulation properties of the GIMF model more generally.

1. Households

There are two types of households who receive utility from consumption and disutility from labor in a standard utility function and who maximize lifetime utility. First, there are overlapping-generation (OLG) households who make decisions on borrowing, saving, and labor supply over a 20-year planning horizon. Second, there are liquidity-constrained (LIQ) households who differ from OLG households in that they do not save and have no access to credit. The finite horizon in both households' optimization problem and the LIQ households' large propensity to consume out of income generate a strong effect for fiscal policy in the model. The relative size of LIQ households (η) is calibrated to be 50% of total households.

2. Production

Domestic manufacturers produce either tradables (Y_t^{TH}) or nontradables (Y_t^N) and solve profit maximization problems. They are monopolistically competitive in output, and price setting is subject to nominal rigidities. Manufacturers use private capital (K_t) and labor (L_t) as inputs, which capital goods producers and households provide, respectively. For firm i in sector $J = TH, N$, the production function is

$$Y_t^J(i) = \left((1-\alpha_J)^{\frac{1}{\xi_J}}\left(K_t^J(i)\right)^{\frac{\xi_J-1}{\xi_J}} + (\alpha_J)^{\frac{1}{\xi_J}}\left(T_t A_t^J L_t^J(i)\right)^{\frac{\xi_J-1}{\xi_J}}\right)^{\frac{\xi_J}{\xi_J-1}} \tag{1}$$

where $T_t A_t^J$ is labor-augmenting productivity comprised of trend technology growth (T_t) and sector-specific technology shock (A_t^J).

Production of private capital is standard but is subject to a financial accelerator mechanism adapted from Bernanke, Gertler, and Gilchrist (1999), which amplifies business cycle dynamics. Unions organize households' labor supply in the labor market, which generates nominal rigidity in wages.

Distributors combine output of domestically produced tradables (Y_t^{TH}) and foreign-produced tradables (Y_t^{TF}) and produce composite tradables (Y_t^T). They then combine Y_t^T and Y_t^N, aggregating them into final private goods (Y_t^A) according to the following production function:

$$Y_t^A = \left((\tilde{\alpha}_{T_t})^{\frac{1}{\xi_A}} (Y_t^T)^{\frac{\xi_A - 1}{\xi_A}} + (\tilde{\alpha}_{N_t})^{\frac{1}{\xi_A}} (Y_t^N)^{\frac{\xi_A - 1}{\xi_A}} \right)^{\frac{\xi_A}{\xi_A - 1}} \tag{2}$$

Then Y_t^A are combined with public goods to produce the final domestic output of the country (Z_t^D):

$$Z_t^D = Y_t^A \left(K_t^{G1}\right)^{\alpha_{G1}} S \tag{3}$$

where S is a technology scaling factor used to normalize steady-state technology to 1 ($(\bar{K}^{G1})^{\alpha_{G1}} S = 1$). Z_t^D is distributed to producers of domestic consumer goods and producers of domestic investment goods or exported to importers of foreign final goods. Consumer goods are consumed by households and the government, and investment goods are demanded by producers of capital goods and the government to produce private and public capital, respectively. Final goods exported are used for foreign consumption and production.

A higher K_t^{G1} increases overall productivity of the economy for a given level of Y_t^A if $\alpha_{G1} > 0$. This also leads to higher marginal productivities of capital and labor. Combining (1), (2), and (3), marginal productivities of capital and labor in sector $J = TH, N$ are $MPK_t^J = (K_t^{G1})^{\alpha_{G1}} \underbrace{\frac{\partial Y_t^A}{\partial K_t}}_{>0}$ and $MPL_t^J = (K_t^{G1})^{\alpha_{G1}} \underbrace{\frac{\partial Y_t^A}{\partial L_t}}_{>0}$, respectively. Therefore marginal productivities increase in K_t^{G1} as long as $\alpha_{G1} > 0$, while K_t^{G1} does not affect marginal productivities if $\alpha_{G1} = 0$.

Output elasticity of public capital (α_{G1}), a key parameter, is set at 0.1, more conservative than the estimate in Bom and Ligthart (2014), where estimated elasticities of output to public capital installed by the national government are 0.122 for all public capital and 0.17 for core infrastructure capital.

Government investment spending augments the stock of publicly provided infrastructure capital per capita K_t^{G1}. Evolution of K_t^{G1}, after rescaling by growth in technology (g) and population (n), is given by[3]

$$K_{t+1}^{G1} (1 + g) (1 + n) = (1 - \delta_{G1}) K_t^{G1} + G_t^{inv}$$

[3] In the model, n and g are used to allow for trend growth in technology and population that is region specific while ensuring stationarity of the model.

Government investment spending is part of fiscal policy, which the analysis turns to in the next section.

3. Fiscal Policy

The government's budget constraint after rescaling by growth and technology is

$$b_t + \tau_t = \frac{i_{t-1}}{\pi_t gn} b_{t-1} + p_t^G G_t + \Upsilon_t$$

where b_t is public debt, i_{t-1} is gross nominal interest rate, and

$$\tau_t = \tau_{L,t} \underbrace{w_t L_t}_{\text{labor income}} + \tau_{c,t} \underbrace{p_t^c C_t}_{\text{consumption}} + \tau_{ls,t} + \tau_{k,t} \underbrace{\sum_{j=N,T} \left[u_t^J r_{k,t}^J - \delta_{K_t}^J q_t^J - a\left(u_t^J\right)\right] \bar{K}_t^J}_{\text{return to capital}}$$

$$G_t = G_t^{cons} + G_t^{inv}$$

$$\tau_{ls,t} = \tau_{ls,t}{}^{OLG} + \tau_{ls,t}{}^{LIQ}$$

$$\Upsilon_t = \Upsilon_t^{OLG} + \Upsilon_t^{LIQ}$$

The model allows a choice of seven different revenue and expenditure policies: taxes on capital ($\tau_{k,t}$), labor ($\tau_{L,t}$), and consumption ($\tau_{c,t}$); government consumption (G_t^{cons}); government investment (G_t^{inv}); general transfers (Υ_t) or lump-sum tax ($\tau_{ls,t}$); and transfers exclusive to LIQ households (Υ_t^{LIQ}).

From the budget constraint, overall fiscal surplus (gs_t) is

$$gs_t = -\left(b_t - \frac{b_{t-1}}{\pi_t gn}\right) = \tau_t + g_t^X - p_t^G - \Upsilon_t - \frac{i_{t-1} - 1}{\pi_t gn} b_{t-1}$$

Fiscal policy ensures a nonexplosive government debt-to-GDP ratio by adjusting tax rates or by reducing expenditure so that the debt-to-GDP ratio always returns to the calibrated steady-state values in the long run. This implies that fiscal deficit can deviate temporarily, but not permanently, from the level that is consistent with the steady-state debt-to-GDP ratio. In this paper, the Philippines' long-run overall fiscal deficit-to-GDP ratio ($-gss_t^{rat}$) is set to 2% to be consistent with recent history. Thus, the deficit level under the current administration is interpreted as a temporarily higher deficit. The steady-state long-run debt-to-GDP ratio (bss_t^{rat}) is 45%, set to be consistent with the steady-state overall fiscal deficit of 2%.

Public investment inefficiency is introduced in the model by assuming that not all public investment spending contributes to the formation of public capital. Specifically, part of the budgeted public investment (G_t^{inv}) is reclassified as public consumption (G_t^{cons}), which is unproductive in the model by construction.[4] The size of the reclassification is dependent on the degree of inefficiency, which is set at 30% in the baseline, drawing on the emerging market economy average in an IMF study (2015) (see section III.C). Reflecting this assumption, steady-state government investment is assumed to be 2.3% of GDP, although officially it has been 3.3% of GDP on average since 2011 at the general government level.

4. Monetary Policy

Monetary policy follows an inflation-forecast targeting interest rate rule that responds to deviations of inflation forecasts from the target. In particular, the short-term rate is set by targeting a weighted average of current and 1-year ahead inflation, while steady-state inflation is set at 2%.

5. Risk Premium of Sovereign Debt

It is assumed that there is a premium in the government's borrowing cost that is increasing in the debt-to-GDP ratio. Following Schule (2010), it is specified as

$$\log(1 + premium_t) = \beta_1 + \beta_2/(B\text{limit} - B_t/GDP_t)^{\beta_3} + \varepsilon_t$$

The premium is set to rise by 3 basis points per increase in the debt-to-GDP ratio in the baseline, but sensitivity analyses will also be performed given the uncertainty on this calibration. Changes in the borrowing cost by the government are translated to the borrowing cost of the private sector in the GIMF model.

B. Scenarios

The baseline scenario follows the government's program in which an infrastructure scale-up of 1.2% of GDP for the first 2 years and another 2% of GDP in subsequent years takes place, financed by a deficit increase for the first 2 years but by revenue mobilization thereafter. This is based on the Duterte administration's record so far and its plan going forward, starting in 2016. Public investments in the first 2 years are actual increases, equal to 1.2% of GDP during 2016–2017 and financed by a deficit increase, according to the IMF (2018). Infrastructure increase for 2018 onward is a projection. The authorities envisage ₱8 trillion–₱9 trillion public infrastructure spending over 2017–2022.[5] Dividing ₱8.5 trillion by the average of the 2017–2022 nominal GDP projection in the IMF (2018) results in 6.8% of GDP. This is 2% of GDP higher than the 2017 actual spending. With respect to financing, the authorities passed the first tax reform package in December 2017

[4] This specification follows a similar exercise in IMF (2014).
[5] BuildBuildBuild. Philippine Infrastructure Transparency Portal. http://www.build.gov.ph/.

Calibration for the Philippines

Parameters	Value	Description
$\xi_J, J = TH, N$	1	Capital–labor elasticity of substitution for domestic tradables and nontradables production; default value in GIMF
ξ_A	0.5	Tradable–nontradable elasticity of substitution; default value in GIMF
η	0.5	Share of LIQ households; set relatively high as typical in emerging markets and low-income countries
α_{G1}	0.1	Elasticity of output to public capital; more conservative than Bom and Ligthart's (2014) estimate of all public capital (0.122) and core infrastructure capital (0.17), which was used in IMF (2014)
δ_{G1}	0.04	Depreciation rate of public capital; default value in GIMF
β_1		Endogenously derived as $\beta_1 = -\frac{\beta_2}{\left(B\text{limit} - \frac{\overline{B}}{GDP}\right)^{\beta_3}}$ so that $\log(1 + premium_t) = 0$ at steady state
β_2	-0.0003	Slope of sovereign debt premium function; lower than Peiris (2015) estimate of 0.0005–0.0006 to account for recent improvements in fiscal management
β_3	-1	Curvature of sovereign debt premium function; -1 implies linearity
Blimit	80	Upper limit for public debt-to-GDP ratio; higher than historical maximum
$\overline{bss}$	45	Steady-state public debt-to-GDP ratio
$\overline{gss}$	-2	Steady-state overall fiscal balance-to-GDP ratio

GDP = gross domestic product, GIMF = Global Integrated Monetary and Fiscal, IMF = International Monetary Fund, LIQ = liquidity constrained.
Sources: Kumhof, Michael, Douglas Laxton, Dirk Muir, and Susanna Mursula. 2010. "The Global Integrated Monetary and Fiscal Model (GIMF)—Theoretical Structure." IMF Working Paper No. 10/34; International Monetary Fund. 2014. *World Economic Outlook, October 2014,* Chapter 3. Washington, DC; and author's calculations.

amounting to 0.5% of GDP while also planning for further tax reform to prevent the deficit from increasing further. Consumption tax is envisaged as the main source of revenue mobilization.

The first alternative scenario considers the same increase in infrastructure spending, but assumes there is no further revenue mobilization after the tax legislation passed in December 2017. Therefore, the increase in infrastructure spending is financed by an increase in overall fiscal deficit, except for the 0.5% of GDP covered by the December 2017 legislation.[6] Expenditure reallocation is not considered as a tool to finance public investment given the small size of total government expenditure in the Philippines and the existence of other spending priorities that makes it difficult to reallocate expenditure at a large scale.

The second alternative scenario considers efficiency gains from the baseline. In this improved efficiency scenario, the size of public investment inefficiency is half the 30% inefficiency in the baseline.

[6]To ensure that all scenarios go back to the same level of debt-to-GDP ratio in the long run, the deficit-financed public investment scale-up is limited to the first 25 years. The study's comparison focuses on the periods in which the public investment scale-up is financed by the deficit in the first alternative scenario.

C. Results

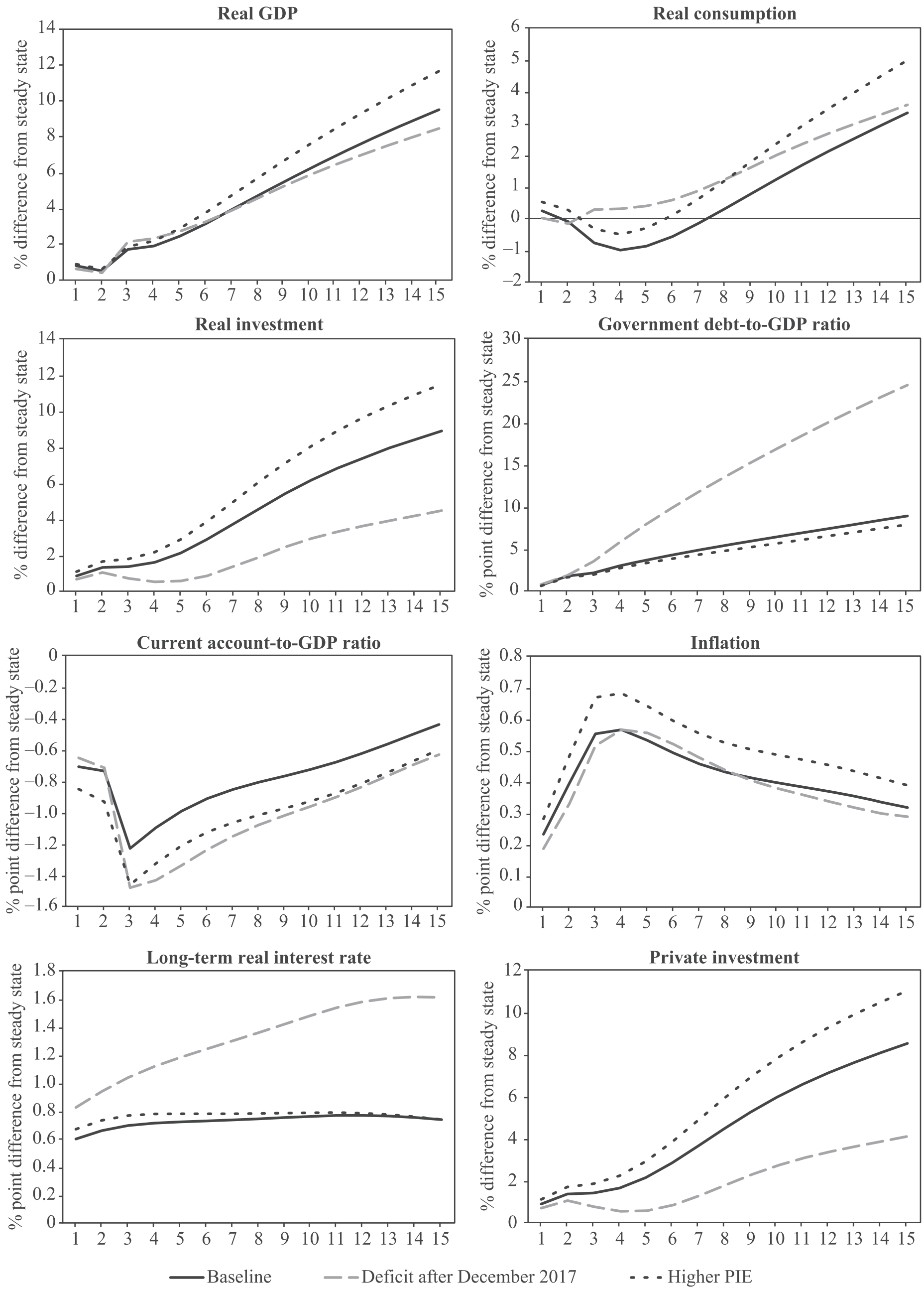
The baseline scenario leads to sustained gains in real GDP (Figure 6). Public investment increases have sustained output effects beyond the direct demand effect of the spending increase because of the productivity-enhancing impact of public infrastructure. As public capital is an input to the aggregate production function of the economy, the improved public infrastructure raises overall productivity, akin to an increase in total factor productivity from the perspective of the private sector. The resulting increase in marginal productivity of capital and labor crowd in private investment and increase demand for labor, which induce a higher consumption due to higher household income. The increase in public investment results in a 9.5% cumulative increase in real GDP relative to the steady state after 15 years.

In the first alternative scenario with no further tax reform package, the output gains are initially higher than in the baseline scenario, although the gains will become larger in the baseline over time, with the increase in the government's borrowing cost playing a key role. The baseline scenario results in smaller output gains in the short to medium term because the tax increase reduces consumption, partially offsetting the demand increase from higher public investment. Over time, however, the continuous increase in the debt-to-GDP ratio in the first alternative scenario increases domestic interest rates, with negative effects on private investment and consumption and leading to decelerating output growth.

The increasing influence of the government's borrowing cost over time can be seen by comparing the paths of long-term real interest rates, the interest rate most relevant for the investment decisions of the private sector. In the GIMF model, an increase in the government's borrowing cost due to an increase in the risk premium leads to a parallel increase in all domestic interest rates. Additionally, domestic interest rates are also affected by monetary policy. The long-term real interest rates reflect both of these factors and increase on impact for both the baseline scenario and the first alternative scenario. However, the increase is larger for the latter in anticipation of the future increase in the risk premium. The paths further diverge from each other over time, driven by the increasing risk premium in the first alternative scenario.

Improving public investment efficiency generates an additional impact. Raising public investment efficiency to about 85% increases output by 2.1 percentage points after 15 years compared with the baseline scenario. In the baseline scenario of 30% inefficiency, a 6% of GDP public investment results in a 4.2% of GDP contribution to public infrastructure. When public investment inefficiency is reduced to 15%, the same 6% of GDP public investment results in a 5.1% of GDP contribution to public infrastructure and a cumulative increase in GDP of 11.7% after 15 years. This improvement in efficiency generates balanced effects, increasing consumption and investment and decreasing the

Figure 6. **Main Simulation Results**



GDP = gross domestic product, PIE = public investment efficiency.
Notes: The x-axis shows the number of years since the start of the simulation. T = 1 is set to the year 2016.
Source: Author's calculations.

debt-to-GDP ratio relative to the scenarios without improvements in public investment efficiency.

Additional demand from higher public infrastructure gives rise to inflationary pressures and a positive output gap, inducing an increase in the policy interest rate. Different degrees of inflation can be explained by the different sizes of private investment crowding in and the resulting consumption increase. Over time, an increase in supply capacity alleviates the inflationary pressures and the policy rate increases are gradually reversed in all scenarios.

The current account exhibits an initial deterioration, mostly because of higher imports. Exports also decline initially due to the initial real appreciation associated with the policy interest rate increase. Subsequently, exports increase as investment stimulates production and the initial real appreciation is reversed, in line with the reversal of initial monetary tightening, which partially offsets the worsening current account. The size of the current account deficit-to-GDP ratio increase is roughly proportional to the output increase and reaches 1.2 percentage points after 3 years in the baseline scenario and 1.5 percentage points after 3 years in the two alternative scenarios.

D. Sensitivity Analysis

This subsection considers three types of sensitivity analyses: changes in the assumption on the borrowing cost premium, changes in the tax mix, and shutting down the role of public capital in enhancing overall productivity.[7]

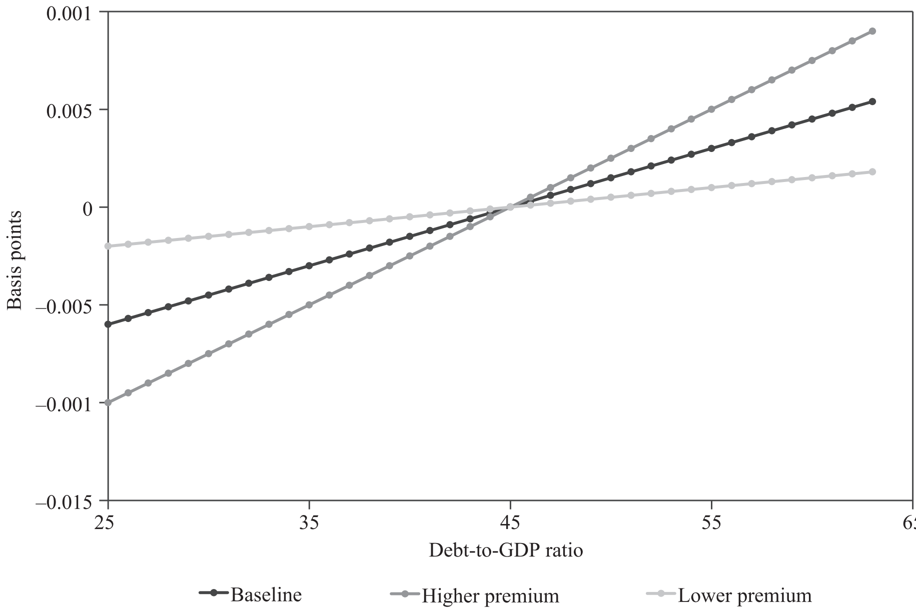
1. Alternative Borrowing Cost Premia

Given the key role of borrowing interest rates on output dynamics, two additional calibrations on the borrowing cost premium are examined. The relationship between public debt and the borrowing cost is uncertain and affected by various factors, both global and local.[8] A higher calibration sets the premium at 5 basis points per unit increase in the debt-to-GDP ratio. This draws on Peiris (2015), who estimated the determinants of 10-year government bond yields in the Philippines, while controlling for a comprehensive list of variables, and finds that the marginal effect of a unit increase in the debt-to-GDP ratio is 5–6 basis points. The baseline in this study has adopted a lower estimate of the borrowing cost based on recent improvements in the Philippines' fiscal management, as reflected in credit rating upgrades in recent years, interpreting these improvements as structural changes. It is also possible to assume that the transformation has led to an even

[7] Simulation results are based on no improvements in public investment efficiency. Improvements in public investment efficiency would result in a parallel increase in output, investment, consumption, etc.

[8] Baldacci and Kumar (2010), and the review therein, estimate that the response of borrowing costs to changes in public debt ranges from 3 to 7 basis points per unit increase in the debt-to-GDP ratio.

Figure 7. **Sovereign Risk Premia for Different Assumptions**



GDP = gross domestic product.
Source: IMF staff estimates.

lower borrowing cost. This is the lower premium calibration, which assumes a 1 basis point response per unit increase in the debt-to-GDP ratio. Figure 7 shows the borrowing cost premia for the three scenarios.

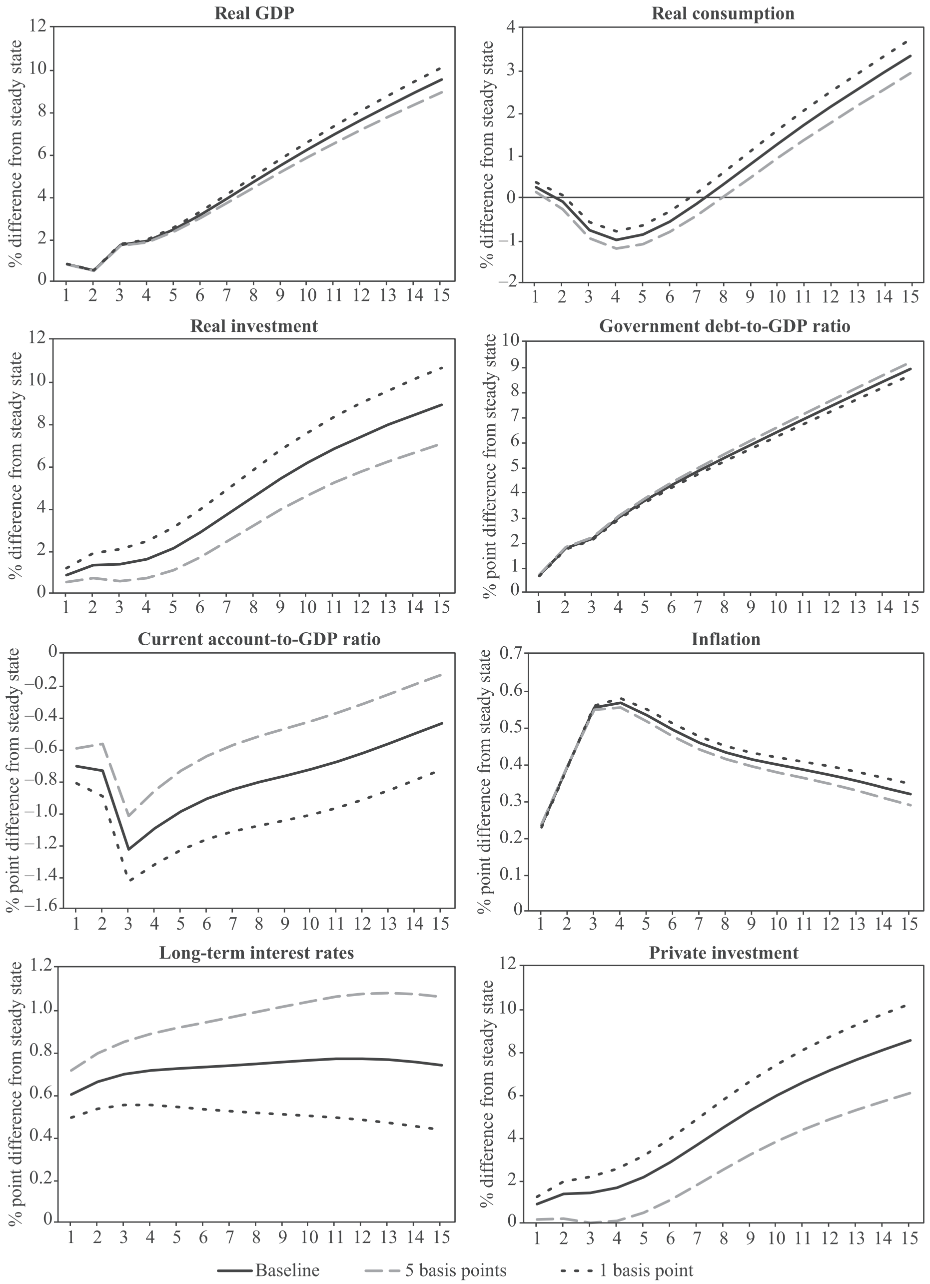
The simulations show the expected results (Figure 8). The effect on output of scaling up public investment is more subdued the higher the increase in borrowing cost. Trajectories of all the other variables change accordingly.

2. Alternative Tax Instruments

Revenue mobilization to finance public investment may require the use of multiple sources. Reliance solely on the consumption tax, assumed in the baseline scenario, implies a tax rate increase of around 2.7%. This may not be politically feasible and other revenue sources may be found. To capture this possibility, the analysis assumes that revenue mobilization is equally distributed to capital, labor, and consumption taxes in this alternative scenario.

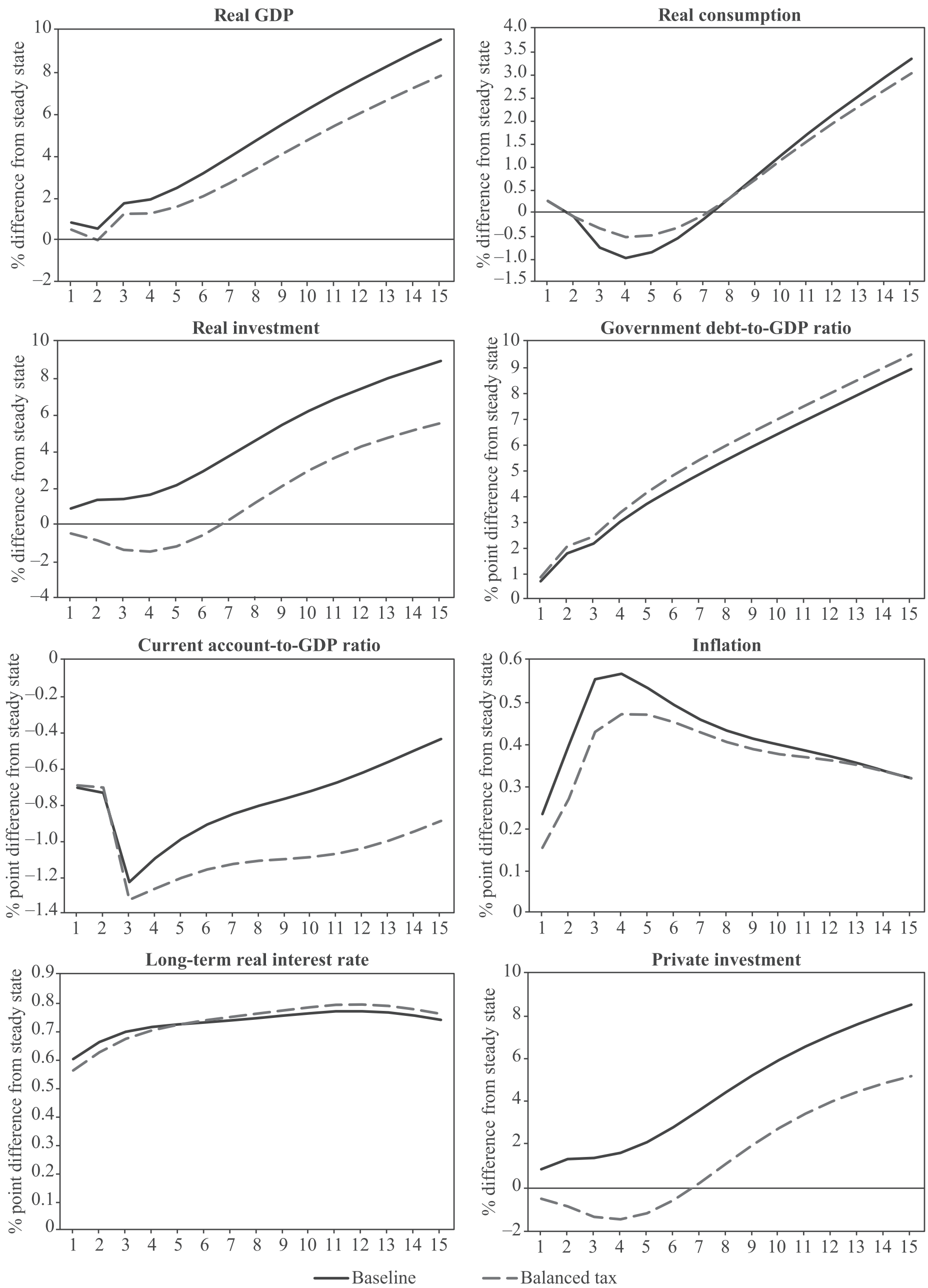
The results show that there is less drag on consumption initially and more drag on investment (Figure 9). Output growth is lower in this alternative scenario than in the baseline. The superiority of indirect taxes on growth is a general feature of the GIMF model (Anderson et al. 2013) and is consistent with Lucas (1990) and

Figure 8. **Alternative Borrowing Cost Results**



GDP = gross domestic product.
Notes: The x-axis shows the number of years since the start of the simulation. T = 1 is set to the year 2016.
Source: Author's calculations.

Figure 9. **Alternative Revenue Mobilization Results**



GDP = gross domestic product.
Notes: The x-axis shows the number of years since the start of the simulation. T = 1 is set to the year 2016.
Source: Author's calculations.

Chari, Christiano, and Kehoe (1994), which demonstrate the distortionary effect of capital and labor taxation on investment and labor supply. It has also been established empirically on average, as documented in Johansson et al. (2008) and Acosta-Ormaechea and Yoo (2012).

Rationalization of tax incentives has the potential to mobilize revenue while mitigating negative effects on growth. It has been shown that tax incentives in the Philippines are not well targeted (Botman, Klemm, and Baqir 2008). Their rationalization could raise revenue without raising statutory rates, thus mitigating the negative effects on private investment. Tax exemptions, however, are outside of the model in this paper.

3. No Contribution of Public Capital to Production

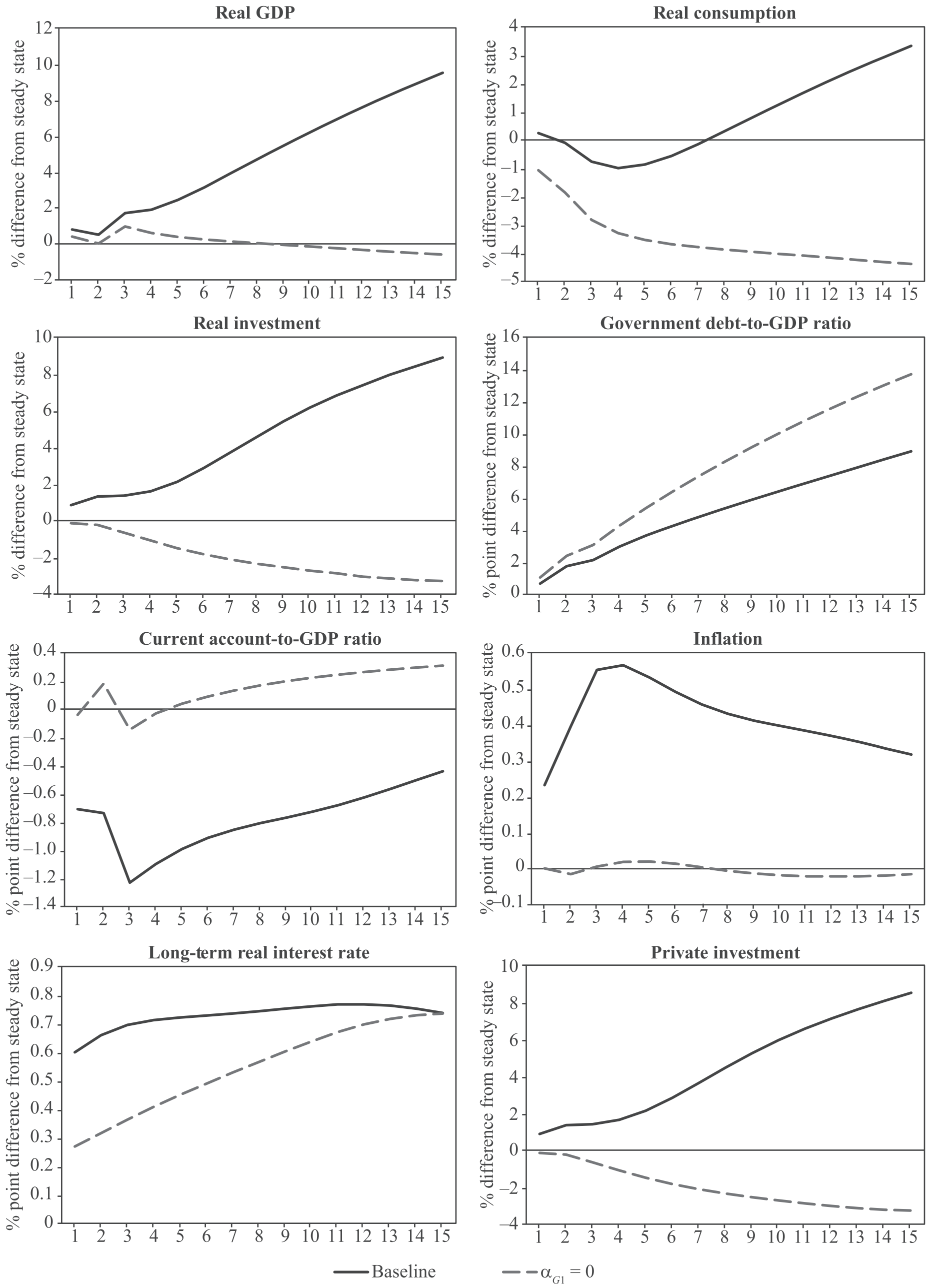
When $\alpha_{G1} = 0$ instead of the baseline value of 0.1, the model's dynamics change dramatically (Figure 10). Most importantly, economic growth is not sustainable without an increase in productivity. After an initial increase due to deficit-financed fiscal expansion, real GDP goes back toward the steady state. Consumption and investment are negatively affected as the borrowing cost increases more than the baseline, as shown in the higher paths of government debt and long-term real interest rate. Because this alternative scenario does not generate higher demand, inflation does not increase, and the current account does not worsen. While the long-term real interest rate increases due to an increase in public debt, the size of the increase is lower than that in the baseline scenario. This is because of the lack of a monetary policy response when there is no inflationary pressure, unlike in the baseline scenario.

V. Conclusion

This paper studied the macroeconomic implications of scaling up public investment in the Philippines. After benchmarking the Philippines relative to its neighbors in terms of the level of public capital, quality of public infrastructure, and public investment efficiency, the analysis used a dynamic general equilibrium model to quantitatively assess the macroeconomic implications of raising public investment and improving public investment efficiency.

The paper finds that the Philippines' public infrastructure investment is lower than its neighbors. Persistently low public investment in the Philippines has resulted in a low public capital stock relative to other ASEAN countries. While quantitative indicators show an uneven picture, survey-based indicators paint an unfavorable picture of the current state of public infrastructure in the Philippines. An outcome-based estimation of public investment efficiency suggests there is substantial room for improvement in emerging markets, including the Philippines.

Figure 10. **Alternative Public Capital Contribution Results**



GDP = gross domestic product.

Notes: α_{G1} refers to the output elasticity of public capital. The x-axis shows the number of years since the start of the simulation. T = 1 is set to the year 2016.

Source: Author's calculations.

Scaling up public investment results in sustained growth, driven by the particular structure of the GIMF model, in which improving public infrastructure leads to gains in the overall productivity of the economy, which crowds in private investment. In the baseline scenario that models the Duterte administration's infrastructure scale-up plan and comprehensive tax reform, the increase in public investment results in a 9.5% cumulative increase in real GDP relative to the steady state after 15 years. If no further tax reform takes place after the legislation that was passed in December 2017, the same public investment infrastructure increase would need to be financed by running higher deficits. Sustained output growth is realized in this alternative scenario as well, but the size is smaller due to the negative effects of higher borrowing costs from a higher level of public debt. Separately, improving public investment efficiency has substantial additional benefits. Eliminating half of the inefficiency would lead to an additional 2.1 percentage points in real GDP.

With a relatively low level of public infrastructure and a fast growing young population, addressing the large infrastructure gap is needed to raise potential growth and reduce poverty. This paper showed that increasing public investment spending can generate sustained output growth, and improving public investment efficiency can bring about substantial additional benefits. It also showed that deficit financing and tax financing will generate different outcomes, especially in consumption, investment, and output. Given the need to ensure debt sustainability amid the large spending needs in other priority spending areas for inclusive growth, continued efforts to mobilize revenue will be critical, by persevering with a comprehensive tax reform.

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The Cost of Being Under the Weather: Droughts, Floods, and Health-Care Costs in Sri Lanka

Diana De Alwis and Ilan Noy*

We measure the impact of extreme weather events—droughts and floods—on health-care utilization and expenditures in Sri Lanka. We find that frequently occurring local floods and droughts impose a significant health risk when individuals are directly exposed to these hazards. Individuals are also at risk when their communities are exposed even if they themselves are unaffected. These impacts, especially the indirect spillover effects to households not directly affected, are associated with land use in affected regions and access to sanitation and hygiene. Finally, both direct and indirect health risks associated with floods and droughts have an economic cost: our estimates suggest that Sri Lanka spends $19 million per year directly on health-care costs associated with floods and droughts. This cost is divided almost equally between the public purse and households, with 83% of it spent on flood-related health care and the rest on drought-related health care. In Sri Lanka, both the frequency and intensity of droughts and floods are likely to increase because of climatic change. Consequently, the health burden associated with these events will likely increase.

Keywords: drought, flood, health-care costs, health impact, Sri Lanka
JEL codes: I15, Q54

I. Introduction

Extreme weather events or disasters can potentially lead to significant and adverse health outcomes. There are myriad ways in which disasters can lead to a deterioration of health and to the economic challenges associated with this deterioration. In many places, climate change is predicted to increase both the frequency and intensity of extreme events, such as heat waves, drought, storms, and floods (Elsner, Kossin, and Jagger 2008; Emanuel 2005; Intergovernmental Panel on Climate Change 2014). The financial costs of the health burden associated with such

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events could increase as well (Yonson 2018). This health risk will grow significantly if global warming continues unabated, the economic burden of climate-induced health risks goes unchecked, and the investment to avoid these costs is not made. Maybe surprisingly, there is a paucity of quantitative evidence on the extent of the current cost burden of health risks associated with extreme weather events (Smith et al. 2014, United Nations International Strategy for Disaster Reduction 2011). This paper therefore examines the impact of such risks on health-care utilization and costs (public and private), by focusing on floods and droughts and their effects on the health sector in Sri Lanka.

Extreme weather events cause physical injuries, but they may also increase health risks, including stress-related ailments, communicable diseases, and indirect mortality (Cook et al. 2008; Heutel, Miller, and Molitor 2017; Philipsborn et al. 2016). For example, increasing intensity of rainfall and subsequent floods likely elevate the risk of waterborne and vector-borne diseases, while extreme heat can cause deaths due to heat stress and increase the incidence of cardiovascular and respiratory diseases. Droughts decrease food production and, in poor regions, may result in malnutrition and its associated health risks. Floods and droughts can also cause health spillovers into unaffected populations in disaster-affected regions since health consequences occur through complex interactions. These interactions include the impaired ability of the health system to reduce these risks and the adverse economic consequences borne by indirectly affected households through reduced potential income and the strain on public services provision (Smith et al. 2014, Nomura et al. 2016, Noy and Patel 2014).

Health consequences can vary with individual characteristics (age, education, income, and occupation) and the community-wide socioeconomic and political context (the health-care system, national and international involvement, public security concerns, and public health policy). Changes in land use, urbanization, trade, and travel are other drivers that can affect the spread of diseases in the aftermath of extreme events (Sutherst 2004). For example, changes in land use can increase the risk of infectious diseases (McFarlane, Sleigh, and McMichael 2013; Eisenberg et al. 2007). Higher population densities with inadequate urban infrastructure, changes in vegetation and ground cover, deforestation, and artificial water storage facilities can all determine the link between adverse events and the spread of diseases (Sutherst 2004; Cheong, Leitão, and Lakes 2016; Kweka, Kimaro, and Munga 2016; Berazneva and Byker 2017; Deryugina et al. 2017).

Our analysis uses a cross section of households from the national Sri Lankan household income and expenditure survey of almost 80,000 individuals conducted during 2012–2013. We match this survey data with disaster, meteorological, and land use data across the 25 administrative districts in the country to assist us in identifying the links in question. We ultimately aim to quantify the cost burden of providing more health-care services associated with extreme weather events.

The findings of this paper can also inform us about the additional future cost burden we should expect should climate change predictions materialize and lead to a significant change in the likelihood and intensity of extreme weather events. Without accounting for these health-care costs, we are potentially underestimating the benefits of disaster risk reduction and climate mitigation policies.

The next section discusses the relevant literature, section III describes the Sri Lankan context, and section IV focuses on the methodology and data used in this study. Sections V and VI describe the results and their robustness, respectively, and section VII concludes with some relevant caveats and policy implications.

II. Related Literature: The Health Impact of Disasters

Nomura et al. (2016) analyzed 28 peer-reviewed observational studies on mid- and long-term health impacts of major disasters in the postemergency period (3 months or more after the event). The studies address seven health outcomes: mortality (discussed in 4 studies), suicide (1), mental and behavioral disorders (17), diseases of the circulatory system (4), infectious and parasitic diseases (2), nutritional diseases (1), and biometric measures such as blood pressure (4). In the authors' metastudy, these health impacts are influenced by 35 factors related to the socioeconomic and political context, personal characteristics, and intermediating factors (e.g., behavioral responses, health system functioning, sanitation, food supply, and psychosocial circumstances). In online Appendix 1, we describe in detail the main diseases relating to both inpatient and outpatient treatments in Sri Lanka and some of the related epidemiological literature that examined the determinants of disease outbreaks.

Ultimately, we are interested in the economic burden that disasters impose via the increasing incidence of diseases and the increasing need to provide both inpatient and outpatient health services. In Sri Lanka, much of health care is provided by the government (and paid for by tax revenue). Some services are provided by both the private and public sectors, with the private sector usually serving the high-end market. As such, market prices of various services frequently do not exist or are rather inaccurate in proxying for well-being (welfare) costs associated with these services. Studies in health economics attempt to understand the total welfare cost of health care in terms of three components: resource costs (costs of health and nonhealth goods and services used in medical treatments), lost productivity due to an illness, and the disutility that accompanies many inflictions (experienced pain and inconvenience). We focus on the first component.

When deriving the health costs of infectious diseases, a number of studies focusing on malaria have found a substantial increase in household and public sector expenditures for preventing and treating the disease. For example, two studies identified a decrease in labor inputs and low school attendance due to malaria (Chima, Goodman, and Mills 2003; Malaney, Spielman, and Sachs 2004).

Bleakley (2010) observed higher earnings among people who were born just after the eradication of malaria in the United States, enabling a calculation of the previous cost associated with malaria there. Using the estimated costs of the disease, and assuming that these costs are equivalent to a benefit should the disease be prevented, other studies have calculated the benefit–cost ratios for malarial prevention interventions (e.g., Mills and Shillcutt 2004).

Another strand of this literature examined pandemics. For example, Smith et al. (2009) modeled the economic impact of influenza in the United Kingdom, while another study examined the impact on income associated with an outbreak of severe acute respiratory syndrome (SARS) (Keogh-Brown and Smith 2008). Research in poorer countries identified, for example, the direct cost of illnesses due to waterborne diseases in Pakistan (Malik et al. 2012) or the overall economic burden of waterborne diseases in the South Pacific (Asian Development Bank 2014).

There is, however, only a limited amount of work evaluating the health cost burden associated specifically with extreme natural hazard events such as floods and droughts (Merson, Black, and Mills 2006; Intergovernmental Panel on Climate Change 2014; Dell, Jones, and Olken 2014). The available literature on this topic can be grouped into three types of studies: health impacts, adaptation costs, and health economics evaluation. This last strand uses different monetary valuation methods such as the value of statistical life, disability-adjusted life years, treatment cost estimations, household health expenditure measures, and preventive health provision cost estimates (e.g., Noy 2016).

For example, when isolating the health impact of a 1°C increase in global annual temperature, Bosello, Roson, and Tol (2006) estimate the costs for attributed cases using a multicountry general equilibrium model. Mortality due to vector-borne diseases (such as malaria, dengue, and schistosomiasis) is calculated first using temperature, diseases, and associated mortality risks as parametrized in previous studies, and then the associated health costs in terms of death avoidance are calculated using treatment costs as reported by the World Health Organization. These provide inputs into the authors' general equilibrium model. Kovats, Lloyd, and Watkiss (2011) also use a modeling approach to estimate the marginal effect of climate change in 27 European Union countries by quantifying the value of lives lost due to heat mortality, deaths from additional cases of salmonella, and fatalities due to coastal floods.

The estimates produced from these models inevitably depend on the many assumptions associated with their construction. Statistical quantification of observed data provides a different approach that is less structural and assumption dependent. Knowlton et al. (2011), for example, attempt to calculate the cost of health impacts associated with events that can be related to climate change—ozone air pollution, heat waves, hurricanes, outbreaks of infectious diseases, river flooding, and wildfires—for over a decade in the United States. Mortality and morbidity from such events are measured using epidemiological studies, aggregate public health data, and extrapolations when required. These are then matched with statistical estimates of the value of life, medical care costs, and lost productivity.

In low- and middle-income countries, micro-observational approaches are more common and probably more accurate. Lohmann and Lechtenfeld (2015), for example, empirically estimate the household-level impact of a drought on health expenditure in Viet Nam by first estimating an illness and drought shock model, aggregating drought-associated illnesses at the household level, and then regressing household health expenditure on the instrumented illness measure. This study identified a 9% to 17% health expenditure burden on households due to drought-related health shocks. Our study uses a similar microeconometric approach to reveal more insights into the health economic impact of floods and droughts at the individual household level.

Another segment of the literature estimates the costs of adapting to climate change-related differences in health risks. These studies focus on preventing treatment costs of diarrheal cases for Europe and Central Asia (World Health Organization 2013); the total net cost savings in disease treatment (Agrawala et al. 2009); preventing the risk of malaria and diarrheal diseases using preventive service costs in Europe (Ebi 2008); evaluation of cardiovascular and respiratory disease treatment due to air pollution (Hutton 2008); and waterborne disease vaccination programs (Goossens et al. 2008, Melliez et al. 2008).

III. Background on Natural Hazards and Health in Sri Lanka

Sri Lanka has a land area of 65,610 square kilometers. Rainfall is largely associated with tropical monsoons, but rain also occurs in other seasons. The mean annual rainfall varies from under 900 millimeters in the driest parts (southeastern and northwestern regions) to over 5,000 millimeters in the wettest parts (western slopes of the Central Highlands). The mean annual temperature of the lowlands varies between 26.5°C and 28.5°C. In the highlands, the temperature can fall to 15.9°C.[1] The country has an irregular topography comprising a broad coastal plain and a central mountainous area rising to elevations of 2,500 meters. This topography and differences in regional climates are underlying causes of the variation in agroecological zones that are identified based on variation in rainfall and its seasonal distribution, soil, and altitude. About 33% of the land is covered

[1]The island is divided into three climatic zones based on the annual rainfall: dry, wet, and intermediate. The location of the southern part of the central highlands causes interception of monsoonal rains from the southwest and creates a "rain shadow" on the other side. This has given rise to an ever-wet region which receives abundant rainfall from two monsoons and a dry zone that receives rainfall from only the northeast monsoon. The northeast dry zone is characterized by long spells of drought during other months. See Department of Meteorology. http://www.meteo.gov.lk/ (accessed 6 November 2015).

with forest, 43% is used for agriculture (permanent and temporary crops), and 4% is surface water bodies.[2]

Sri Lanka is affected by numerous disasters. The most frequent weather-related disasters are floods, cyclones, and droughts. For the period 1974–2008, the Sri Lankan government reported 1,397 flood events; 1,263 instances of cyclones, strong winds, surges, and gales; and 285 drought events (Disaster Management Centre 2010).[3] The seasonal distribution of floods shows two peaks: one from April to June and the other from October to December, representing the two monsoon seasons.

Sri Lanka is a lower-middle-income country, with a per capita income of $11,500 (purchasing power parity) and a population of 20.9 million in 2015, according to World Bank data. Sri Lanka has made considerable progress on immunization against infectious diseases. Still, the most prevalent infectious diseases in recent years include vector-borne ones, such as dengue and leptospirosis, and diseases transmitted orally through contamination of food or water, such as diarrhea (dysentery), hepatitis, and typhoid fever (Ministry of Health 2012a, 2012b). About 18% of the population suffer from chronic diseases and 15% from acute diseases (United Nations 2015, Department of Census and Statistics 2014).

During 2012–2013, the government reported more than 64,000 cases of dengue, a vector-borne (mosquito) viral disease, with 270 reported deaths. Leptospirosis is the second-highest prevalent disease. Caused by bacteria and transmitted mainly by rodents, there were almost 7,000 cases of leptospirosis and almost 100 deaths in the same time period (Ministry of Health 2012a, 2013). There are more reported outbreaks of both diseases during high-rainfall months. Mumps, measles, and chicken pox are other common infectious diseases. The national communicable disease surveillance undertaken in 2012 also reported 80,660 outpatient visits for influenza-like illnesses and 2,580 inpatients for severe respiratory tract infections (Ministry of Health 2012b). In the last few years, influenza in Sri Lanka has been generally observed from April to June and again from November to January.[4]

Health care in Sri Lanka is mainly provided by the public sector. Total health expenditure accounts for 3.3% of total gross domestic product. According to World Bank data, health expenditure in Sri Lanka in 2015 is comparable to those of Bangladesh and the Philippines, which are in the same income category, and to upper-middle-income countries such as Thailand.

[2]Sri Lanka has many major river basins as well as a large number of artificial reservoirs. See World Data Atlas. https://knoema.com/atlas/Sri-Lanka/topics/Land-Use/Area/Inland-water (accessed 19 March 2016).

[3]By far the worst disaster experienced in Sri Lanka since its independence was the Boxing Day tsunami in 2004 (following an earthquake in Indonesia). Details about this event are available from numerous sources. De Alwis and Noy (2019) document the tsunami's long-term impact on Sri Lankan households.

[4]Sri Lanka faced an outbreak of influenza (mainly due to the H1N1 virus) in 2015, causing 74 deaths (World Health Organization 2015).

The government health sector is predominantly financed from general revenue taxation, while private sector financing is from out-of-pocket spending, private insurance, enterprise direct payments, insurance paid for by enterprises, and contributions from nonprofit organizations. Public sector health care is universally accessible to the entire population and is almost wholly free of charge. Annual per capita total expenditure (from all sources) is $105, for which the government contribution is $62 (Institute for Health Policy 2015). According to the 2013 national health accounts, the largest health expenditure is attributed to the treatment of noncommunicable diseases (35%) followed by infectious and parasitic diseases (22%). Reproductive health services accounted for nearly 10% of health expenditures, while injuries required 7.7%. Classified by the way health care is delivered and based on government health sector data, inpatient care accounted for 37.1% of total health expenditure by the public sector, and outpatient treatment with medical products (e.g., medicines) was 46.5%. Inpatient care is mainly provided by the public sector (Institute for Health Policy 2015).

In this context, this study attempts to

(i) quantify the individual health risk attributable to floods and droughts,

(ii) quantify health spillovers from flood- and drought-affected populations to those not directly affected and identify the associated trigger factors, and

(iii) identify the costs associated with the health-related disaster impacts identified in (i) and (ii) for both the private and public health sectors.

IV. Data and Methodology

Our data come from the National Household Income and Expenditure Survey (NHIES) conducted between June 2012 and July 2013. The data include information on whether each household member received inpatient hospital treatment in the past year and visited a hospital (private or public) for outpatient treatment in the previous month.[5] The survey questionnaire also posed a question on whether the households were affected in the past year by a flood or drought. We combine this data with flood and drought information compiled in a separate national database to identify our treatment variables for each district, that is,

[5] In a study about health expenditure surveys, Xu et al. (2009) specify the standard recall period as 1 month for frequent health expenditures and 1 year for infrequent ones, including hospitalizations. As such, the Sri Lanka survey follows the global practice. O'Donnell et al. (2008) investigate health expenditures in Asia and argue that recall mistakes most likely do not bias their estimations (i.e., they are not systematically biased). We note that because the outpatient data request a recall of the past month, and because utilization of outpatient services might not be evenly distributed throughout the year, it is impossible to directly compare the extrapolated data from the survey with the aggregate numbers available at the end of each year from the Ministry of Health.

Table 1. **Data Summary**

Variables	**Mean**	**Std. Dev.**	**Min**	**Max**
Sex (dummy for male = 1)	0.48	0.50	0	1
Age (years)	32.60	21.50	0	99
Education (years)	8	4.70	0	19
Ethnicity Singhalese (dummy)	0.65	0.48	0	1
Ethnicity Tamil (dummy)	0.34	0.47	0	1
Employed (dummy)	0.23	0.42	0	1
Employer (dummy)	0.01	0.80	0	1
Own family worker (dummy)	0.12	0.33	0	1
Reside in rural sector (dummy)	0.65	0.48	0	1
Reside in estate sector (dummy)	0.10	0.29	0	1
Outpatient visit at least once last month	0.28	0.45	0	1
Inpatient visit at least once last year	0.09	0.28	0	1
Flood affected last year (dummy for self-reported)	0.04	0.20	0	1
Flood affected last year (dummy for district-wide flood)	0.72	0.45	0	1
Drought affected (dummy for self-reported)	0.03	0.17	0	1
Drought affected last year (in affected district)	0.32	0.47	0	1
Flood affected last month (in affected district)	0.11	0.31	0	1
Drought affected last month (in affected district)	0.14	0.35	0	1
Flood spillover	30	46	0	1
Drought spillover	68	46	0	1
Households toilet shared (dummy)	0.06	0.24	0	1
Households toilet public (dummy)	0.04	0.19	0	1
Households drinking water well (dummy)	0.48	0.49	0	1
Households drinking water open sources (dummy)	0.18	0.38	0	1
Agricultural water retention area (% of land in district)	11.09	5.73	0	23.7
Natural water retention area (% of land in district)	4.98	3.24	0	18.6
Household income (Sri Lanka rupees)	29,790	31,656	−3,750	324,275
Household health expenditure (Sri Lanka rupees)	1,544	13,645	0	1,103,400

Note: There are 79,381 observations.
Source: Authors' estimates of National Household Income and Expenditure Survey 2012/2013 data.

whether districts were affected by flood and drought in the past year or in the month before the NHIES survey was undertaken in the 25 administrative districts across the country. District-level land use data come from the district profiles maintained by the Sri Lanka Census and Statistics Department. We also use district land use data to identify how land use affects the health-care costs associated with floods and droughts.

The summary statistics for our sample (Table 1) show that 28% of household members sought outpatient treatment in the previous month and 9% sought inpatient treatment in the previous year.[6] About 4% reported they were affected by a flood

[6]Inpatient care generally refers to any medical service that requires admission into a hospital and is typical for more serious ailments and trauma. Outpatient care, on the other hand, is any medical service that does not require a prolonged stay at a facility. This can include routine services such as checkups or visits to clinics (even more involved emergency care procedures are included, so long as the hospital or facility allows the patient to leave on the same day). In Sri Lanka, there are accident and emergency care units (A&E units) in secondary and tertiary care hospitals (around 120 hospitals) that allow patients to stay a maximum of 4 hours; after which the patient is

and 3% by a drought in the past year. In the month before the survey was conducted, 11% (14%) were residing in districts affected by floods (droughts).[7]

We estimate individual (inpatient and outpatient) health impacts using a probit model specification. Our outcome variable is a binomial response for inpatient or outpatient treatment. The empirical model specification is

$$\begin{aligned} Y_{id} = {} & \beta_1 Z_{id} + \beta_2 D_{id} + \beta_3 DSpill_{id} + \beta_5 \left[Z_{id} * D_{id}\right] + \beta_6 \left[Z_{id} * DSpill_{id}\right] \\ & + \delta_m + \gamma_d + U_{id} \end{aligned} \tag{1}$$

In the benchmark model, Y_{id} is the dependent variable—a dummy variable for hospital inpatient or outpatient treatment, and the unit observed is for household i in district d. D_{id} is the flood or drought variable (a "treatment" binary indicator) and the demographic and household covariates. Z_{id} are incorporated to control for heterogeneity of health outcomes due to structural factors. Month fixed effects (δ_m) and district fixed effects (γ_d) are incorporated to control for seasonality and district heterogeneity, respectively, in some of the reported specifications (when the district-level land-use measures X_d are not included). The coefficient of interest is β_2, which denotes the marginal effect of floods and droughts on the probability of needing inpatient or outpatient treatment. U_{id} controls for unobserved variation and is assumed to be independent and identically distributed with mean 0. To isolate health vulnerability to floods and droughts based on structural factors (age groups, rural and urban sectors, household sanitation), model specifications incorporating the interaction of treatment with structural factors $\beta_5[Z_{id} * D_{id}] + \beta_6[Z_{id} * DSpill_{id}]$ are estimated.

The previous literature finds that both floods and droughts affect human health directly (e.g., deaths; injuries; mental health; and cardiovascular, respiratory, and kidney diseases) and through indirect pathways (e.g., vector-borne and waterborne diseases). Both can lead the affected population to seek inpatient or outpatient health-care services (see more details in online Appendix 1). As the health impacts associated with disasters are hypothesized to be mediated through other characteristics (vulnerabilities such as limited household sanitation), these can also affect households that are not directly impacted. These spillovers may lead

admitted to a continuum care unit, short stay unit, or intensive care unit, depending on care needs and the expected length of the patient's stay. These are then classified as inpatient care. Admission to an A&E unit is decided locally (at the local facility) or by a senior medical officer at the A&E. All other hospitals (965 hospitals) have emergency care rooms (inpatient). Therefore, we can expect that only sometimes will an intravenous fluids (IV) treatment be given to a patient and not be classified as inpatient. In particular, while larger (urban) hospitals have good emergency care services, the smaller hospitals in rural areas that are more vulnerable to droughts and floods do not have such facilities for outpatient IV delivery (Wimalaratne et al. 2017).

[7] Thus, the majority of residents in affected districts do not report being affected by either floods or droughts. For floods, these nonaffected households may live farther away from waterways and reservoirs that were flooded. For droughts, these households might live in areas of the district that were less affected by the drought, or their agricultural land might be irrigated, or they might not work in agriculture, and therefore the drought had no direct observable impact on their lives.

to impaired health outcomes for people who are not directly affected by a flood or drought but live in the vicinity of directly affected households. To identify these spillovers, we estimate the model including a variable ($DSpill_{id}$) that defines a separate treatment group for those people who live in flood- or drought-affected districts but did not self-report as being affected by a flood or drought in the survey questionnaire. β_3 is the coefficient of interest to quantify the indirect health spillovers associated with these natural hazards. To identify how land use factors may induce disaster-triggered health risks, we incorporated these into the estimation as well; in these specifications, the district fixed effects are replaced with these district-level measures (X_d), as shown in equation (2):

$$\begin{aligned} Y_{id} = {} & \beta_1 Z_{id} + \beta_2 D_{id} + \beta_3 DSpill_{id} + \beta_4 X_d + \beta_5 \left[Z_{id} X_d * D_{id} \right] \\ & + \beta_6 \left[Z_{id} X_d * DSpill_{id} \right] + U_{id} \end{aligned} \tag{2}$$

To identify how the external household-specific and district-level factors may induce disaster-triggered health risks, we incorporated these into the estimation in several interaction terms. In these specifications in equation (2), interaction terms of the disaster measure and the district-level factors are also introduced to the model ($Z_{id}X_d * D_{id}$) to examine the causal connection between these factors and disaster exposure and between the same factors and the disaster spillover indicator ($Z_{id}X_d * DSpill_{id}$). β_5 and β_6 are therefore the coefficients of interest in equation (2) that identify the answer to our second question.[8]

Unfortunately, interpreting interaction terms in nonlinear regressions is not straightforward, as the marginal impact of a variable depends on the values that other variables take. In fact, even the sign of the coefficient of the interaction term may depend on the level of other independent variables and may even change along their distribution (Hoetker 2007). We present our results on the interaction effects in a series of graphs that describe the marginal effect at various points. To construct these figures, we employ the Stata command routine developed and described in Norton, Wang, and Ai (2004).

In order to estimate the private cost of health impacts due to natural hazards, we use the household health expenditure data collected in the survey. Most health care in Sri Lanka is provided by the public sector (which is free). However, many households choose to use the private sector instead (because of queues for specialists or because of a perceived difference in the quality of service) and much of the expenditure on medicines is paid privately. The monthly household health expenditure for a member experiencing inpatient treatment (at least once in the

[8]We also estimated a more restricted model: $Y_{id} = \beta_1 + \beta_2 Z_{id} + \beta_3 D_{id} + \gamma_d + U_{id}$. This model does not include the hypothesized spillover effects (directly unaffected households that reside in affected districts). Results for these regressions are available from the online Appendix: https://sites.google.com/site/noyeconomics/research/natural-disasters.

last year) and receiving outpatient treatment (in the past month) is derived from estimating the household health expenditure model shown in equation (3):

$$Y_{hd} = \beta_1 + \beta_2 X_{ihd} + \beta_3 I_{ihd} + \gamma_d + U_{id} \tag{3}$$

Y_{hd} is the household health expenditure and I_{ihd} is the inpatient or outpatient i in family h and district d. γ_d is the district dummy variable to control for district heterogeneity in health costs. Using equation (3), we can then estimate the average private health-care costs associated with both inpatient and outpatient treatment.

Finally, the total public costs of health care due to floods and droughts are calculated using the average per capita public health expenditure for inpatient and outpatient treatment in each district. These numbers are reported in the national health accounts of Sri Lanka (Institute for Health Policy 2015).

In the last step, the marginal effects estimated in our models are used to predict the number of inpatients and outpatients associated with extreme weather events at the district level. The estimated figures are used in conjunction with the per capita public and private health expenditure costs, estimated as described in equation (3), to calculate the overall health-care costs of floods and droughts for each Sri Lankan district.

We note that our main identifying assumption, if we were to argue that causality is identified, would be to assume that the shocks are randomly distributed. Since, obviously, some areas are more prone to disasters than others, that assumption is too restrictive, and it is possible that people "sort out" according to their willingness to take on disaster risk. Since mobility is not that high, especially in between rural areas, we do not believe that this is a major source of bias in our estimates.[9] Still, a strict interpretation of our model would argue that we are identifying only correlations between disaster occurrence and health-care utilization. We retain this interpretation in the rest of the paper.

V. Results

We estimate our models (1) and (2) separately for inpatient and outpatient care. Table 2 provides the results for the inpatient model based on equation (1), Table 3 for the inpatient model based on equation (2), and Table 4 and Table 12 in the online Appendix for outpatient services (using equations [1] and [2], respectively). All of these are discussed separately in each of the sections below.

A. Health Impacts of Extreme Weather: Inpatient Care

Estimates of the parameters for equation (1) are provided in Table 2. In all columns, controls for demographic factors are included, and the results for their

[9]There is significant movement of people from rural areas to urban centers.

Table 2. **Health Impacts of Floods and Droughts: Inpatient Health Treatments**

Variables	**(i)**		**(ii)**		**(iii)**		**(iv)**		**(v)**		**(vi)**	
Self-reported flood (dummy)	0.02*	(0.010)	0.02*	(0.010)	0.02*	(0.010)	0.02*	(0.010)	0.02*	(0.010)	0.01	(0.009)
Flood spillover (dummy)	0.02**	(0.005)	0.02**	(0.005)	0.02**	(0.005)	0.01***	(0.004)	0.01***	(0.004)	0.02***	(0.004)
Self-reported drought (dummy)	0.04***	(0.014)	0.04**	(0.014)	0.04**	(0.014)	0.07	(0.050)	0.07	(0.050)	0.03**	(0.010)
Drought spillover (dummy)	0.01	(0.008)	0.01	(0.006)	0.01	(0.010)	0.05	(0.050)	0.05	(0.050)	0.00	(0.010)
Shared toilet (dummy)					0.02***	(0.005)	0.02**	(0.005)	0.02**	(0.005)	0.02**	(0.010)
Public toilet (dummy)					0.04***	(0.005)	0.04***	(0.004)	0.04***	(0.004)	0.04***	(0.010)
Drinking water well (dummy)					0.02**	(0.005)	0.01**	(0.005)	0.01**	(0.005)	0.01**	(0.006)
Drinking water unsafe source (dummy)					0.00	(0.006)	0.00	(0.006)	0.00	(0.040)	−0.01	(0.010)
Water reservoirs (%)											0.003***	(0.001)
Natural water bodies (%)											0.00	(0.001)
Month fixed effects	No		Yes		Yes		Yes		No		Yes	
District fixed effects	No		No		No		Yes		Yes		Yes	
District land use (%)	No		No		No		No		No		Yes	
Pseudo R-squared	0.03		0.03		0.03		0.04		0.04		0.03	

Notes: Robust standard errors in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively. There are 79,381 observations. Structural demographic covariates included in all specifications are sex, age, years of education, ethnicity, employment status, living in rural sector, living in estate sector, income, and time to hospital. Model (v) is used for cost calculations.
Source: Authors' estimates.

Table 3. **Health Impacts of Floods and Droughts: Inpatient Health Treatments for Different Groups**

Variables	**Rural**		**Urban**		**Estate**		**Young**		**Old**	
Self-reported flood (dummy)	0.02^{*}	(0.010)	0.00	(0.003)	0.00	(0.00)	0.01	(0.010)	0.03^{***}	(0.010)
Flood spillover (dummy)	0.01^{**}	(0.005)	0.00	(0.002)	-0.05^{*}	(0.03)	0.02^{***}	(0.005)	0.02^{***}	(0.006)
Self-reported drought (dummy)	0.07	(0.060)	0.02^{**}	(0.006)	-0.96^{***}	(0.07)	0.05	(0.050)	0.10^{*}	(0.060)
Drought spillover (dummy)	0.05	(0.060)	0.10^{***}	(0.030)	-0.94^{***}	(0.08)	0.04	(0.050)	0.08	(0.060)
Shared toilet (dummy)	0.02^{***}	(0.005)	0.00	(0.002)	0.05^{***}	(0.02)	0.02^{**}	(0.006)	0.02^{**}	(0.007)
Public toilet (dummy)	0.04^{***}	(0.006)	0.01^{***}	(0.003)	0.05^{**}	(0.02)	0.03^{***}	(0.005)	0.05^{***}	(0.007)
Drinking water well (dummy)	0.01^{**}	(0.005)	0.00	(0.001)	0.10^{***}	(0.02)	0.01	(0.005)	0.02^{**}	(0.006)
Drinking water unsafe source (dummy)	0.00	(0.007)	0.00	(0.001)	0.09^{***}	(0.01)	0.00	(0.004)	0.00	(0.009)
Pseudo R-squared	0.05		0.06		0.05		0.04		0.04	
No. of observations	51,364		20,451		7,514		40,300		39,081	

Notes: All models estimated in this table include month and district fixed effects but not land use variables. Robust standard errors in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively.
Source: Authors' estimates.

Table 4. **Short-Run Health Effects (district-wide exposure): Outpatient Health Treatments**

Variables	**(i)**		**(ii)**		**(iii)**		**(iv)**		**(v)**		**(vi)**	
Flood last month	0.01	(0.010)	0.01	(0.010)	0.01	(0.010)	0.00	(0.010)	0.00	(0.010)	0.00	(0.010)
Drought last month	0.04^{***}	(0.010)	0.04^{***}	(0.010)	0.04^{***}	(0.010)	0.02	(0.020)	0.03^{**}	(0.010)	0.01	(0.020)
Shared toilet (dummy)					0.02^{**}	(0.010)	0.02^{**}	(0.010)	0.03^{***}	(0.010)	0.02^{**}	(0.010)
Public toilet (dummy)					0.01	(0.010)	0.02	(0.020)	0.02	(0.020)	0.01	(0.010)
Drinking water well (dummy)					−0.01	(0.010)	0.00	(0.010)	0.00	(0.010)	−0.01	(0.010)
Drinking water unsafe source (dummy)					−0.01	(0.010)	0.00	(0.010)	0.00	(0.010)	0.00	(0.010)
Water reservoirs (%)											0.01^{***}	(0.001)
Natural water bodies (%)											-0.01^{***}	(0.002)
Month fixed effects	No		Yes		Yes		Yes		No		Yes	
District fixed effects	No		No		No		Yes		Yes		No	
District land use (%)	No		No		No		No		No		Yes	
Pseudo R-squared	0.03		0.04		0.05		0.05		0.05		0.05	

Notes: Robust standard errors in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively. There are 79,381 observations. Structural demographic covariates include sex, age, years of education, ethnicity, employment status, living in rural sector, living in estate sector, income, and time to hospital. Model (v) is used for cost calculations.
Source: Authors' estimates.

coefficients are presented in the online Appendix. The basic specifications are presented in columns (i) and (ii), which include self-reported and spillover flood and drought binary indicators and month fixed effects in column (ii). In these results, we find that having been directly affected by floods or living in a community affected by floods increases the probability of needing inpatient care by about 2 percentage points, while the impact for those directly affected by a drought is about 4 percentage points.

Columns (iii)–(vi) in Table 2 include hygienic factors (shared or public toilet indicators and access to drinking water) and combinations of month and district fixed effects. Throughout the estimations in columns (iii)–(v), we consistently observe that the likelihood of receiving inpatient treatments associated with direct exposure to flooding increases by about 2 percentage points. The spillover risk, once we control for other factors, is lower by about 1 percentage point and less consistently estimated. Relying on either shared or public toilets (the default being private ones) is associated with increased inpatient treatment, as is drinking water that comes only from wells. Surprisingly, unsafe drinking water (as reported in the survey) is not associated with increased use of inpatient services. The presence of water bodies is investigated in column (vi)—we find that reservoirs are associated with increased use of inpatient care, but the magnitude of this coefficient is quite small. We find no association between the presence of natural water bodies and inpatient services.

In Table 3, we divide the population sample we have into several subsamples and estimate these separately. In particular, we estimate rural households, urban households, and those residing in estates (the first three columns in Table 3).[10] In the last two subsamples (columns 4 and 5), we separate the sample according to age (at the median age). Maybe not surprisingly, the impact of floods is higher for rural households than it is for urban households in terms of inpatient health treatments. This is also true for droughts, though the coefficient estimates for rural households are not statistically significant. Surprisingly, the coefficient for the drought spillover indicator, which is statistically significant, is twice as large for the urban sample as it is for the rural sample.

More important than these distinctions between rural and urban are the estimated coefficients in the estate sector. These are much larger for droughts, suggesting that this population, already the poorest and most disadvantaged, also suffers from a much higher need for inpatient care as a consequence of droughts (and spillover from floods). Also notable is that the impacts of hygiene and water on the estate sector are also both larger and more statistically significant, which is surprising given that the size of the estate sample is much smaller. This is a further

[10]Estate sector consists of all plantations that are 20 acres or more in extent and have 10 or more resident laborers. Estate laborers reside in the plantation areas.

indication of the intensity of the impact of natural hazards on health utilization in the estate sector.

The differences between the estimated coefficients for the young and old populations are less pronounced. However, we do note that the impact of both hazards on inpatient health services appears to be higher for the older subsample and also more statistically significant.

In an additional set of regressions, we investigate the interaction effects of the occurrence of floods and droughts using hygiene and water as interaction terms. The interpretation of interaction effects in limited dependent variable models is more involved and, as Norton, Wang, and Ai (2004) show, frequently misestimated and misunderstood. We follow their recommendation and present these results in a series of graphs discussed below in section V.C.

B. Health Impacts of Extreme Weather: Outpatient Care

Table 4 presents the impact of floods and droughts on the likelihood of outpatient treatment, similar to the presentation of results for inpatient hospitalizations in Table 2. The dependent variable in Table 4 is whether a household member used outpatient services in the previous month, and the main variable of interest is whether a district-wide flood occurred during that same month. We no longer have the data available to allow us to separate those that were directly and indirectly (spillovers) affected.

Unlike earlier results (for inpatient care), we no longer observe that households that live in a district that was flooded are significantly more likely to require outpatient services. The results in all the regressions for the district-wide flood measure are always statistically not significantly different from zero. One explanation for this lack of statistical significance is that our flood indictor is no longer identified precisely, so that it erroneously identifies many households that were not actually affected by floods.

Droughts are a more spatially widespread hazard, and therefore our identifying independent variable (district-wide exposure) is more relevant in this context. We indeed find more consistent results for the drought-treatment variable—the coefficient in most of the estimates is both statistically and economically significant, with droughts increasing the likelihood of outpatient treatment in the following month by 1–4 percentage points. It is, however, important to note that once we estimate the full model with all controls, neither the flood nor the drought indicators retain their statistical significance.

The estimated model consistently shows that households that share toilet facilities with other families are at a significantly higher risk of requiring outpatient health treatment (irrespective of their weather-hazard exposure). When households do not possess an in-house source for drinking water, evidence of their need for outpatient health services is less consistent (columns [iii]–[vi]). Where the presence of water bodies is included in the estimation, the presence of artificial reservoirs is associated with an increased probability of requiring outpatient health-care services, while the presence of natural water bodies is associated with the opposite (in both cases the results are statistically significant and not very large; column [vi]).

C. Interactions of the Hazard Variables with Hygiene Controls

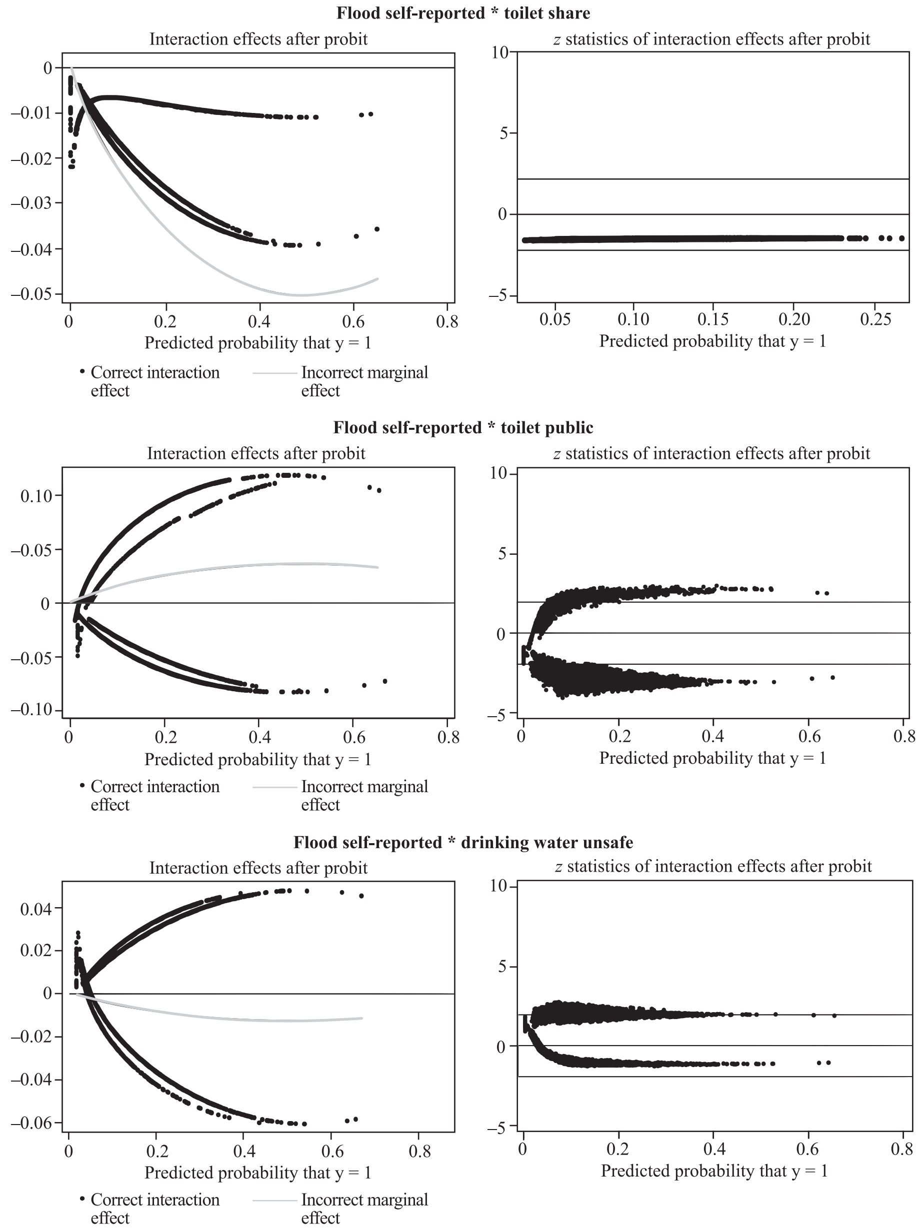
As stated earlier, the magnitude and even the sign of the interaction effects are difficult to present because in nonlinear models these depend on the level of all the variables. As suggested by Norton, Wang, and Ai (2004), the easiest way to present these interactions is through a series of graphs where the coefficient size is presented on the vertical axis while the estimated probability of the event (in this case, seeking inpatient or outpatient care) is presented on the horizontal axis. We note that there might be multiple combinations of independent variables that lead to a similar estimated probability, and the size of the interaction coefficient associated with each one of these combinations might be different.

These interaction effects for inpatient care are presented in the figure. In each case, the companion figure to each of the estimated interaction effect (per estimated probability) describes the statistical significance of these results, with the 5% significance threshold noted in the graph. Examining the inpatient model, for example, the interaction between having shared toilets and being affected by floods (self-reported) appear to be negative, but it is not statistically significant for any estimated probability. More nuanced and more difficult to interpret is the interaction effect between the same flood-affected measure and having access to a public toilet. In this case, the results appear to be statistically significant for estimated probabilities >0.2, but the sign of the coefficient associated with this interaction can be either negative or positive for different combinations of the independent variables yielding these larger estimated probabilities.

Overall, the estimated interaction effects in most cases are not consistently statistically significant and of the same sign all across the range of associated probabilities. Exceptions are few but worth noting. A household that is indirectly affected by flooding and has access only to a well or unsafe drinking water faces a higher likelihood of needing inpatient care for the whole distribution of estimated probabilities. Rural households that are exposed to flood risk also appear to experience much larger impacts (this is a result we only reported using different subsamples in this section). All interaction effects of floods and droughts on seeking inpatient health are available in online Appendix 14.

The figure available in online Appendix 15 presents the interaction effects for outpatient care. In this case, none of the interaction effects are statistically significant. This might be because there are no interactions, or because our identification of hazard exposure at the district level is not precise enough, as we discussed in section V.B.

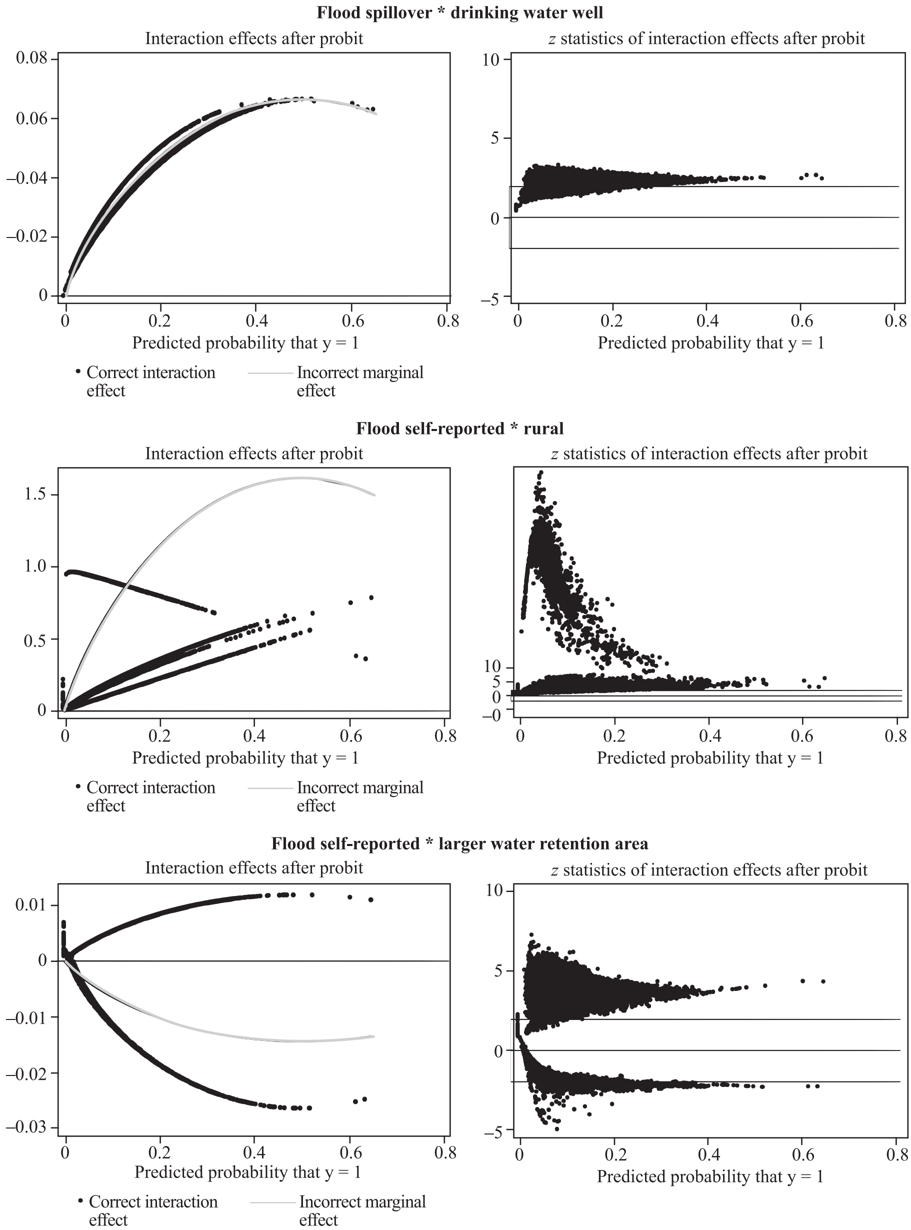
Figure 1. **Interaction Effects of Floods and Droughts on Seeking Inpatient Health Care**



D. District-Level Health Costs of Floods and Droughts

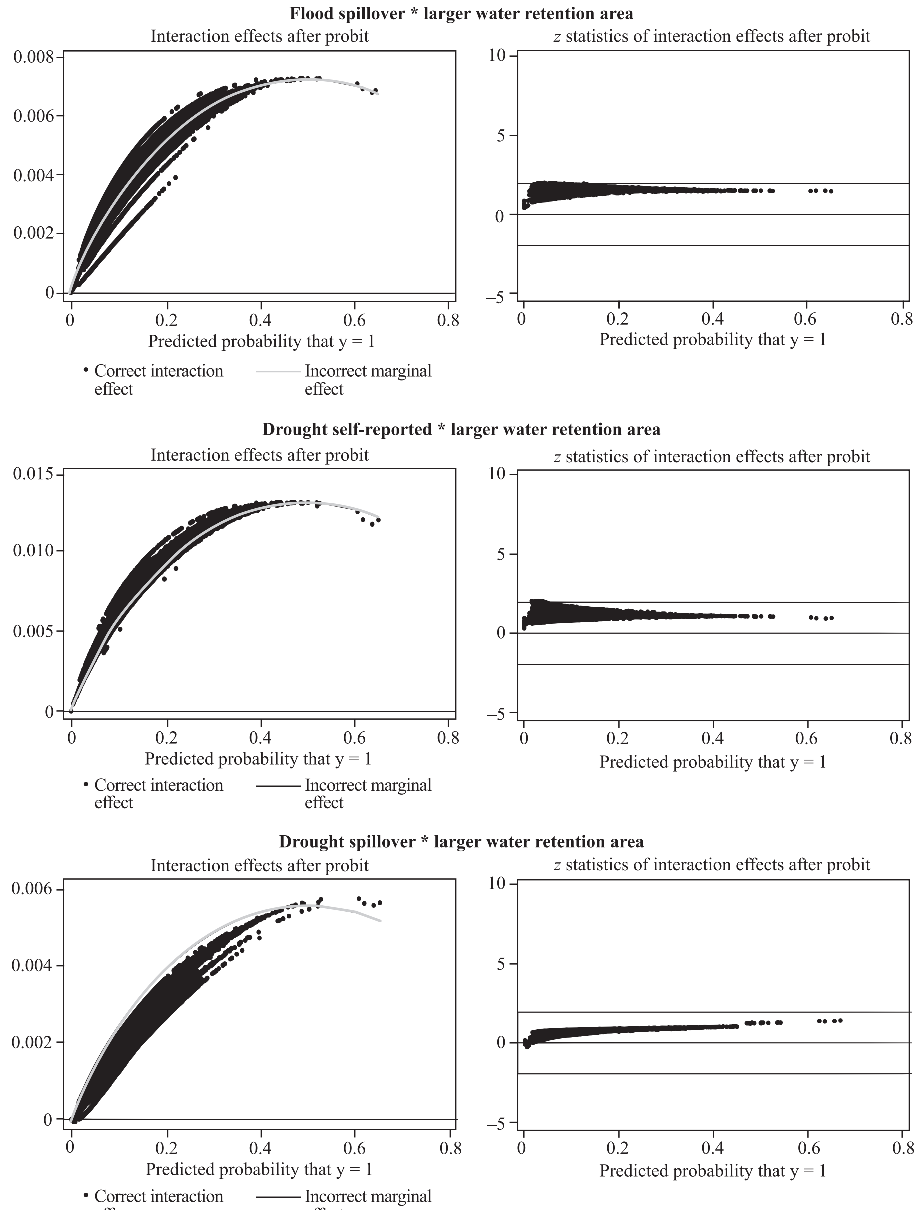
Table 5 provides information about the estimation specification described in equation (3). In these specifications, we estimate the average increase in health

Figure 1. *Continued.*



expenditures at the household level associated with an episode of inpatient or outpatient health service utilization. Not very surprisingly, we note that inpatient care is on average about 3 times as costly for a household as it is for outpatient care (column [iii]). Other interesting observations that arise out of these estimates

Figure 1. *Continued.*



Source: Authors' estimates.

is that the expenditure associated with males and older patients are on average higher. Households with higher socioeconomic status (better educated, belong to the Sinhalese majority, have higher income, and live in an urban area) are all associated

Table 5. **Private Health-Care Costs (per month, for inpatient and outpatient services)**

Variables	(i)		(ii)		(iii)	
Inpatient (at least once last year)			**1,720.18*****	(166.900)	**1,602.20*****	(176.430)
Outpatient (at least once last month)	**709.30*****	(111.000)			**502.40*****	(113.030)
Male or female (dummy)	180.70*	(104.100)	171.33*	(104.030)	169.90*	(103.980)
Age (years)	10.92***	(2.550)	10.82***	(2.530)	8.47***	(2.560)
Education (years)	64.71***	(11.420)	58.54***	(11.340)	63.16***	(11.420)
Sinhalese (dummy)	449.64	(753.520)	469.45	(750.890)	467.38	(753.470)
Tamil (dummy)	227.57	(753.580)	170.25	(753.200)	543.61	(760.990)
Employed (dummy)	−486.24***	(131.590)	−509.70***	(131.130)	−458.47***	(131.570)
Employer (dummy)	−564.42	(607.370)	−553.99	(607.110)	−5,484.53	(606.810)
Own family worker (dummy)	−710.62***	(163.470)	−716.05***	(163.220)	−546.22***	(164.440)
Rural sector (dummy)	−290.97**	(121.340)	−305.15***	(121.310)	−179.87***	(127.300)
Estate sector (dummy)	−778.76***	(197.290)	−755.90***	(197.150)	−672.13***	(224.020)
Total income (Sri Lanka rupees)	0.02***	(0.002)	0.02***	(0.001)	0.02***	(0.001)
Time to hospital	−29.90***	(7.770)	−30.72***	(7.760)	−26.81	(8.030)
Constant	31.31	(760.310)	49.19	(758.890)	−1,149.43	(890.560)
Observations	79,381		79,381		79,381	
R-squared	0.005		0.006		0.01	
F-statistic	32.85		37.32		36.26	
Degrees of freedom	13		13		14	

Notes: Robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.
Source: Authors' estimates.

with more health expenditures. Low expenditures are especially associated with the estate (plantation) sector and, maybe obviously, those that live in communities that are more distant from hospitals. We note that while all of these results are statistically significant, the overall explanatory power of the model is quite minimal.

In order to assess the overall costs associated with health services provided to a hazard-impacted population, we need to measure the population's vulnerability to flood- and drought-related utilization of health services across districts. The estimates provided in Table 6 are calculated by multiplying the district population and the point estimates of the disaster shock variable (marginal effect of floods and droughts on health services utilization) as estimated in the regressions detailed above.

Table 7 shows the total cost estimates due to droughts and floods, separated for the costs associated with the private and public sectors. The estimates are based

Table 6. **District-Level Population Vulnerability to Flood- and Drought-Related Health Risks**

		Flood-Associated Inpatient Care Cost per Year					Drought-Associated Outpatient Care Cost per Month			
Province	**District**	**Inpatients if total population is directly affected**	**Public sector inpatient care cost ($)**	**Private sector inpatient care cost ($)**	**Inpatients if each district experiences a flood**	**Public sector inpatient care cost ($)**	**Private sector inpatient care cost ($)**	**Outpatients if total population is affected by drought**	**Public sector outpatient care cost ($)**	**Private sector outpatient care cost ($)**
Western	Colombo	46,196	956,918	569,277	23,098	478,459	284,638	69,294	148,716	267,581
	Gampaha	45,892	353,577	565,531	22,946	176,788	282,765	68,838	54,949	265,821
	Kalutara	24,346	471,327	300,018	12,173	235,664	150,009	36,519	73,246	141,020
Central	Kandy	27,398	530,413	337,628	13,699	265,206	168,814	41,097	82,428	158,698
	Matale	9,644	99,528	118,844	4,822	49,764	59,422	14,466	15,467	55,861
	Nuwaraeliya	14,132	113,305	174,150	7,066	56,652	87,075	21,198	17,609	81,857
Southern	Galle	21,176	326,363	260,953	10,588	163,181	130,477	31,764	50,720	122,658
	Matara	16,186	165,384	199,461	8,093	82,692	99,731	24,279	25,702	93,754
	Hambantota	11,932	130,408	147,039	5,966	65,204	73,519	17,898	20,266	69,114
Northern	Jaffna	11,660	188,497	143,687	5,830	94,249	71,844	17,490	29,293	67,538
	Mannar	1,982	33,728	24,424	991	16,864	12,212	2,973	5,242	11,480
	Vavuniya	3,430	47,298	42,268	1,715	23,649	21,134	5,145	7,351	19,868
	Mulativu	1,838	33,815	22,650	919	16,907	11,325	2,757	5,255	10,646
	Kilinochchi	2,258	20,366	27,826	1,129	10,183	13,913	3,387	3,165	13,079
Eastern	Batticaloa	10,502	148,435	129,417	5,251	74,218	64,708	15,753	23,067	60,831
	Ampara	12,962	182,688	159,732	6,481	91,344	79,866	19,443	28,391	75,080
	Trincomalee	7,564	80,236	93,212	3,782	40,118	46,606	11,346	12,469	43,813
North Western	Kurunegala	32,206	391,127	396,877	16,103	195,564	198,439	48,309	60,784	186,547
	Puttlam	15,196	131,870	187,261	7,598	65,935	93,631	22,794	20,494	88,020
North Central	Anuradhapura	17,124	255,677	211,020	8,562	127,839	105,510	25,686	39,734	99,187
	Polonnaruwa	8,066	114,533	99,398	4,033	57,266	49,699	12,099	17,799	46,721
Uva	Badulla	16,236	268,250	200,077	8,118	134,125	100,039	24,354	41,688	94,044
	Moneragala	8,962	112,079	110,439	4,481	56,039	55,220	13,443	17,418	51,911
Sabaragamuwa	Ratnapura	21,646	251,114	266,745	10,823	125,557	133,373	32,469	39,025	125,380
	Kegalle	16,732	171,248	206,190	8,366	85,624	103,095	25,098	26,614	96,917

Source: Authors' estimates.

Table 7. **Public Health Cost of Floods and Droughts** ($)

Province	Flood-Associated Inpatient Care Cost per Year: If the total population in each district is directly affected by a flood				Flood-Associated Inpatient Care Cost per Year: Health spillovers if all districts experience a flood				Drought-Associated Outpatient Care Cost per Month: If all districts experience a drought				Total Cost per Capita
	Public sector inpatient care cost	Private sector inpatient care cost	Private and public sector cost	Per capita cost	Public sector inpatient care cost	Private sector inpatient care cost	Private and public sector cost	Per capita cost	Public sector outpatient care cost	Private sector outpatient care cost	Private and public sector cost	Per capita cost	
Western	1,781,822	1,434,825	3,216,647	0.60	890,911	717,413	1,608,324	0.30	276,910	674,422	951,332	0.20	1.0
Central	743,245	630,621	1,373,866	0.50	371,623	315,311	686,933	0.30	115,504	296,416	411,920	0.20	1.0
Southern	622,154	607,454	1,229,608	0.50	311,077	303,727	614,804	0.20	96,688	285,526	382,214	0.20	0.9
Northern	323,704	260,855	584,559	0.60	161,852	130,427	292,280	0.30	50,305	122,612	172,917	0.20	1.0
Eastern	411,360	382,360	793,720	0.50	205,680	191,180	396,860	0.30	63,928	179,724	243,651	0.20	0.9
North Western	522,997	584,138	1,107,135	0.50	261,498	292,069	553,568	0.20	81,277	274,567	355,844	0.20	0.9
North Central	370,210	310,418	680,628	0.50	185,105	155,209	340,314	0.30	57,533	145,908	203,441	0.20	1.0
Uva	380,329	310,517	690,846	0.50	190,164	155,258	345,423	0.30	59,106	145,955	205,061	0.20	1.0
Sabaragamuwa	422,362	472,935	895,297	0.50	211,181	236,468	447,648	0.20	65,639	222,297	287,936	0.20	0.8
Total	5,578,183	4,994,124	10,572,307	0.50	2,789,091	2,497,062	5,286,153	0.30	866,891	234,7425	3,214,317	0.20	0.9

Notes: Currency conversion is $1 = SLRs130, which was the average exchange rate in 2013.
Source: Authors' estimates.

on Sri Lanka's population census of 2012. Public health costs are based on the reported district-level per capita health expenditure, while the private costs were estimated in Table 5. The estimated realization of the district-level health burden is derived from the population in each district in each year and from whether districts were actually exposed to a flood or drought in the same year. Finally, the online Appendix also presents the same results on a map of Sri Lanka, identifying the costs associated with both inpatient and outpatient care at the district level and in per capita terms.

VI. Robustness

The self-reported binary treatment variable we use does not provide detailed information on the severity of the treatment. It is also possible that self-reported treatment is motivated by factors other than the damage intensity, such as the hope of becoming eligible for disaster relief, and therefore might be inaccurate.[11] When examined against district-level administrative data on disasters, the self-reported treatment indicator matches well—all affected districts reported were also locations where people self-reported as affected.[12] Certain self-reported households, however, were in districts that were not reported as affected by a disaster in the administrative data. This is not necessarily an indication of any misreporting as the aggregate datasets are frequently criticized for not reporting on local events that were destructive in a very limited geographic area and therefore did not cause that much damage in the aggregate (even if the loss for affected households was very high).

The district-level flood and drought impact reported in the administrative data is reasonably matched with the district-level rainfall data and, accordingly, provides further evidence that the treatment variable we use is not overtly biased. We also include specifications in the online Appendix that use measured rainfall data; the results of these specifications (when treatment is identified by district-measured rainfall) are very similar.

Similarly, there may be problems with the self-reported health outcome variable used in the analysis. This variable provides only limited information, because it reports only on whether there was an inpatient or outpatient visit at least once in the past year (or month), even though more than one visit could have occurred within that year (or month). This can cause an underestimation of the health risk due to disasters in our analysis—estimates reveal only the association of exposure to extreme weather and the likelihood of seeking inpatient and outpatient health care at least once in the past year (or month). The estimated costs of health

[11] In reality, of course, the survey and the disaster relief program are completely independent from each other. The two programs are implemented by different administrative authorities reporting to different ministries.

[12] This conclusion is in contrast with a finding from Bangladesh, where the congruence between self-reports and objective observations is less reassuring (Guiteras, Jina, and Mobarak 2015).

care after a disaster may still be biased if frequently affected households take (costly) adaptation measures or if frequent disasters cause people to relocate to other areas. If adaptation is similar at the district level, the district fixed effects in our model control for any district-level adaptations.

VII. Conclusions, Caveats, and Climate Change

This study's objective was to determine the economic costs associated with extreme weather impacts on health care. The most obvious finding emerging from our analysis is that frequently occurring local floods and droughts appear to impose a significant health risk when individuals are directly exposed to these hazards, and that this exposure sometimes requires even higher hospitalization rates. Our observations are not surprising given that Sri Lanka experiences a high incidence of several infectious diseases (e.g., large numbers of leptospirosis and dengue cases) that are related to floods and droughts and that require affected people to seek health-care services (see online Appendix 1). Those impacts, and especially the indirect spillover effects to households that are not directly affected by the hazard, are at least partly associated with land use in the affected environs of the hazard and with the household's access to sanitation and hygiene. Why sanitation and hygiene are important in mediating the impact of floods and droughts probably does not need explaining. The most likely causal story behind our observations about land use interacting with both floods and droughts is that both disasters lead to a higher likelihood of contaminants and infections being transmitted (most likely orally or through contact) when artificial reservoirs are prevalent in the affected area as they interact with the water available for human consumption.[13]

The health spillovers we identified almost always appear to be associated with household sanitation and hygienic conditions. Health spillovers due to floods are associated with households using unsafe drinking water sources (wells and other unsafe sources). It seems that flooding increases the likelihood of contamination of public water sources. Other possible epidemiological explanations for our spillover finding is the increased presence of disease- transmitting vectors (e.g., mosquitos) in the aftermath of floods, an increase that also affects households that were not directly damaged by the event.

Finally, both direct and indirect risks of floods and droughts on individual health have an economic cost and, consequently, a welfare loss associated with it. Overall, our estimates suggest that Sri Lanka spends at least $19 million per year on health-care costs associated with floods and droughts. This cost is divided almost equally between the public and household sectors, with 83% of it spent on flood-related health care and the rest on drought-related health care. Worryingly, our calculations show that the health burden is distributed spatially so that the highest

[13] It is important to note that Sri Lanka has many artificial reservoirs, some dating back many centuries.

health burden due to floods and droughts is borne by the Western and Central provinces followed by the Southern and North Western provinces. The total per capita burden is almost equal across all regions. The Western province is the richest region in the country—it has nearly double the monthly per capita income when compared to the poorest one, and it also bears the highest health burden associated with floods and droughts (online Appendix 16).

It is worth noting that the estimated health expenditure burden quantified in this paper is only a part of the full economic cost of this health burden. The cost in this paper is estimated in terms of direct public and household expenditure on disease treatment, not the full accounting of costs. Underestimation of actual costs is likely since household members presumably experience reduced productivity and reduced ability to generate income during their treatment. Equally, the opportunity cost of government spending resources on these health costs is probably substantial, as the opportunities for more productive fiscal expenditures are more numerous in countries with a low capital base and one that is rapidly developing (as is the case in Sri Lanka). Our estimated drought effect may also be underestimated since droughts cause longer-term effects beyond 1 year, while our estimates focus only on same-year health expenditures.

Finally, regional climate model projections for future temperatures predict increases for Sri Lanka: 1°C–1.1°C by 2030, and 2.3°C–3.6°C by 2080. Accordingly, precipitation is likely to increase by 3.6%–11% by 2030, and 31.3%–39.6% by 2080 (Ahmed and Suphachalasai 2014). Studies also predict higher frequencies of high intensity rainfall events causing floods and dry periods generating drought conditions (Ministry of Environment 2010). In short, both the frequency and the intensity of droughts and floods are projected to increase because of climatic change, though the magnitude of these increases is as yet unknown. Consequently, the health burden of these events is only likely to increase, further demanding precious resources that are required elsewhere in a rapidly growing but still relatively poor country.

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List of Additional Tables Available in Online Appendix

The online Appendix is posted at: https://sites.google.com/site/noyeconomics/research/natural-disasters.

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Providing a Safe Working Environment: Do Firm Ownership and Exporting Status Matter?

Zara Liaqat*

This paper hypothesizes that there exists a relationship between the exporting and ownership characteristics of firms and the incidence of accidents at work, using a detailed dataset of manufacturing firms in Viet Nam. There appears to be a positive and highly significant effect of both exporting and foreign ownership on the frequency of accidents. The results obtained are robust across various specifications as well as alternative measures of exporting status and the severity of accidents. The study highlights a greater need for the implementation of labor standards in countries that are becoming increasingly reliant on globalization as a source of economic growth.

Keywords: foreign direct investment, international trade, labor standards, working conditions
JEL codes: F14, F16, J28, J81, O53

I. Introduction

The rapid growth of international trade and foreign direct investment (FDI) since the 1990s has produced a large number of studies evaluating the effects of globalization on national welfare as well as on the economic conditions of firms, consumers, and workers in open economies. Although a majority of the existing literature hypothesizes, both theoretically and empirically, that international trade leads to an overall gain in welfare, some of the recent evidence has intensified apprehensions over globalization. One of these concerns is that in the race to employ the cheapest methods of producing goods, firms often use production processes that compromise on the working conditions they provide to their workers. The increasing pressures of globalization often come at the expense of deteriorating labor standards at workplaces merely to keep the unit cost of production lower than that of other firms in the same country or compared with average costs in other countries (Liaqat

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2017). In the absence of appropriate labor regulations, increased world trade may, therefore, result in inferior working conditions and a rise in accidents at work.

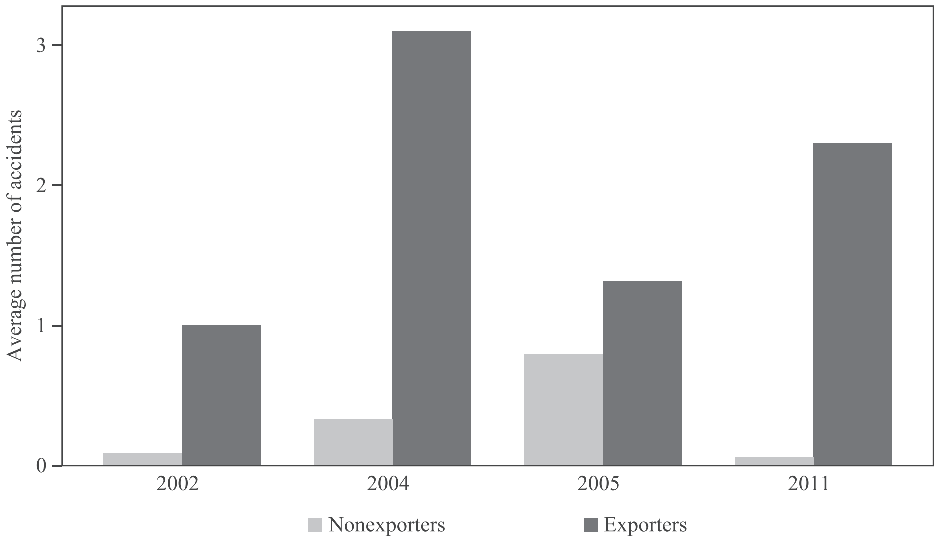
The inability of earlier theoretical analyses to yield unambiguous predictions about the effects of globalization on worker conditions provided by firms has led to numerous empirical studies on wage and nonwage working conditions in relation to globalization.[1] Nevertheless, there are still relatively few quantitative studies of the effects in large samples, as well as several unresolved issues, particularly on how best to link exporting and the ownership status of a firm to the nonwage working conditions provided to its workers. In this paper, I aim to offer evidence of this association by estimating a relationship between the exporting and foreign ownership characteristics of firms and the occurrence of accidents at work. I utilize detailed data of manufacturing sector firms in Viet Nam. The most important finding of this study is that there appears to be a positive and highly significant effect of exporting behavior and foreign ownership on the incidence of accidents at manufacturing firms in Viet Nam. The identification approach used attempts to exogenously determine the effects of exporting and the ownership characteristics of firms in the dataset by controlling for a comprehensive set of firm, province, and industry attributes, as well as with the use of appropriate robustness checks. The results obtained in the paper point toward the need for adequate enforcement of labor standards, especially in countries becoming increasingly dependent on globalization as a source of economic growth and development.

Figure 1 reveals the disparity between exporting and nonexporting firms in terms of the average number of accidents occurring at work in 2002, 2004, 2005, and 2011. The sample used in the study is from data provided by the General Statistics Office of Viet Nam. There seems to be a noticeable difference across the two groups of firms. Exporting firms, on average, incurred a greater number of accidents than nonexporting firms in all 4 years. In Figure 2, this comparison is carried out across foreign and domestically owned firms. Once again, the mean number of accidents differs considerably across the two categories of firms. Fewer accidents arose on average at firms that are domestically owned as opposed to those having foreign owners. Both snapshots of the data used in this study pose a relevant question about the nonwage working environment provided by manufacturing firms in Viet Nam: is there a systematic relationship between these two essential traits of firms and the workplace safety that they offer to their workers?

Whether or not globalization has a positive impact on workers and working conditions has been unclear so far. Trade liberalization increases labor demand in exporting sectors, thereby leading to higher wages for workers employed in those sectors. However, by decreasing the demand for workers, it can lead to a loss of

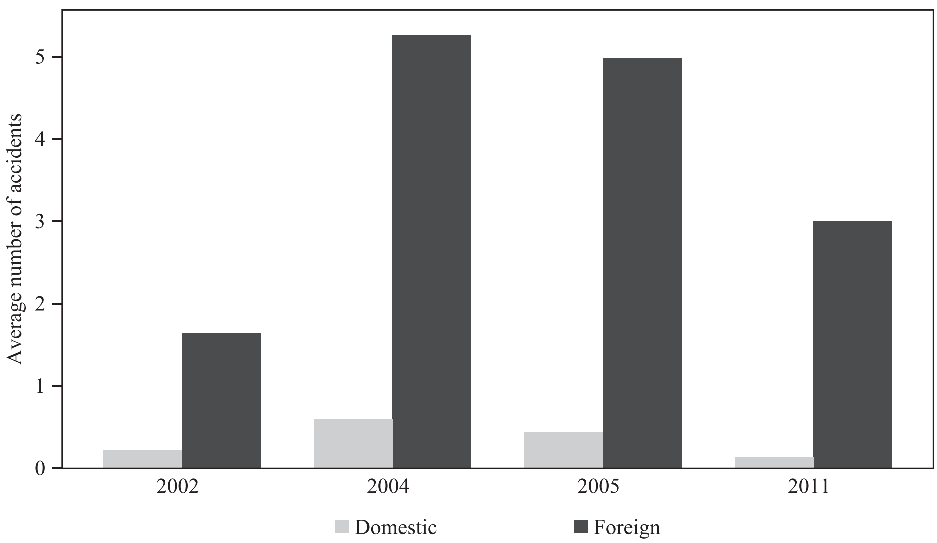
[1]While the term "globalization" is broadly used to refer to the growing volume of world trade, FDI, and to denote the movement of capital and labor across national borders, this paper refers to globalization as an expansion of trade and foreign ownership of domestic firms.

Figure 1. **Accidents at Work by Exporting Status**



Source: General Statistics Office, Viet Nam.

Figure 2. **Accidents at Work by Ownership Status**



Source: General Statistics Office, Viet Nam.

jobs in the import-competing sectors, and in some cases, it can force firms to attempt to reduce costs through deteriorating working conditions. Even if trade creates jobs in the exporting industries, growing pressures to remain competitive in a highly integrated global market may also compel firms to cut unit costs by worsening working conditions. The same is true as far as the effects of FDI on working conditions is concerned. The argument for a race to the bottom is founded on the assumption that capital moves from countries with better working conditions to countries with poorer working conditions or unenforced labor standards because firms find it profitable to do so. On the other hand, if foreign firms decide to maintain working conditions between the domestic level and those in the origin country, the average level of working conditions may rise. This may even induce domestic firms to improve working conditions (Jayasuriya 2008).

An Employment Policy Primer published by the World Bank provides a summary of various research assessments carried out on the topic of globalization and its impact on working conditions (Jayasuriya 2008). By referring to the results from five countries (Cambodia, El Salvador, Honduras, Indonesia, and Madagascar), it outlines an approach for a systematic cross-country comparison of the relationship between globalization and working conditions. The note highlights the significance of accounting for each country's unique history, trade reforms, and economic conditions. Secondly, it proposes paying close attention to the evolution of labor standards in the country, in general, and to select the most appropriate measures of working conditions specifically. One way to investigate the effects of globalization on working conditions between industries is by inspecting the wage differentials between industries after controlling for worker characteristics (e.g., gender, age, education, and other factors). The note also lists a set of nonwage working conditions that may be included in the regression analysis: health and safety, hours, security, benefits, union representation, and details about the working environment of industries directly affected by globalization.

A difficulty that complicates the analysis at hand is the quantification of working conditions. In several existing studies, wage rates have been used to denote working conditions, principally because wage data are often more complete than data on individual characteristics of working conditions. Yet, many studies do focus on nonwage working conditions as well. These conditions may include number of hours worked, overtime hours worked, health and safety, job security, benefits, union representation, working environment, and so forth. In most cases, the necessary data are acquired from household or labor force surveys. A study that relies on data for the number of accidents at a workplace to denote working conditions is that by Neak and Robertson (2009). It provides both qualitative and quantitative analyses of the link between globalization and working conditions, and it pays close attention to the role of international organizations and monitoring in Cambodia's globalization experience using data originated from labor market surveys. Their evaluation is derived from two measures of working conditions: the interindustry wage differential and the number of accidents. The results propose that wages and working conditions tend to be positively related and are better in sectors receiving FDI. The study reveals that wages and working conditions in the garment sector are above the industry average by providing evidence of relatively fewer accidents in the clothing industry. Given that trade and investment in Cambodia seem to be largely focused in the garment sector and that employment in this sector has drastically increased due to advances in globalization, the results offer meaningful insights into the relationship between export growth and working conditions.

Workplace environment has been the subject of numerous recent studies. Although not directly linked with the assessment of globalization, a recent paper by Blattman and Dercon (2018) uses experimental evidence from Ethiopian industrial firms to examine the long-run impact of occupational choices faced by local workers. They show that industrial jobs offered more working hours than informal job opportunities, had little impact on incomes because of lower wages, were riskier in nature, and thus were often associated with serious health problems. A study more closely related to this paper is that of Hummels, Munch, and Xiang (2016). It combines Danish data on individuals' health with Danish matched worker-firm data to determine how increases in exports by firms affect their employees' job injuries and sickness. They find that rising exports indeed lead to higher rates of injury and sickness, including severe depression, use of antithrombotic drugs, and hospitalizations due to heart attacks or strokes. They use external shocks to Denmark's trading environment—such as weighted averages of world import demand, world export supply, and transport costs—to construct instruments for exports. Another study inspecting data on injuries at manufacturers in the United States (US)—adapting from recent work by Autor, Dorn, and Hanson (2013)—uses Chinese import growth during 1996–2007 as a shock to competition. McManus and Schaur (2016) show that injury rates in competing US industries increase over the short to medium run, particularly at smaller establishments. Following Autor, Dorn, and Hanson (2013), they too instrument for Chinese import growth in the US with Chinese import growth in a set of other Organisation for Economic Co-operation and Development countries. To my knowledge, the relationship between greater exposure to international competition and worker health and workplace conditions in emerging or developing economies has not yet been thoroughly investigated. Accordingly, in this study, I attempt to provide a comprehensive analysis of the potential association between trade openness as well as foreign ownership and the incidence of workplace accidents using enterprise-level data from Viet Nam.

A relatively larger body of literature attempts to analyze the impact of FDI and multinational production on the recipient country's labor market outcomes. Foreign-owned firms are often associated with the provision of on-the-job training and tend to offer higher wages compared to their domestic counterparts (see, for example, Javorcik 2015). The study by Brown, Deardorff, and Stern (2004) evaluates the empirical evidence on the effects of multinational production on wages and working conditions in developing countries. Their paper recognizes that attempts to define and measure the living wage are fraught with insuperable difficulties. Nonetheless, there is a large body of empirical evidence showing that foreign ownership results in increasing productivity and wages by expanding the scale of production. A valuable summary of some of the evidence is offered by Lim (2000), demonstrating that foreign-owned and subcontracting firms in manufacturing industries have a propensity to pay higher wages than domestic firms. Foreign-owned firms are more likely to make use of labor organizations and democratic institutions that advance the efficiency of their factory operations, thus improving the conditions of work. The Organisation for Economic Co-operation and Development (2000) discovered that FDI was positively correlated with the protection of union members and the right to establish free unions, strike, and bargain collectively. However, several problems have been cited with the use of ratification of International Labour Organization (ILO) conventions and the Freedom House indicators of democracy as measures of worker rights and labor costs (Martin and Maskus 2001).

The discussion section of this paper briefly examines the usefulness of linking labor standards with trade reforms. Mounting global pressures to improve labor standards have not always produced the desired outcomes. Berik and Rodgers (2009) examine the status and enforcement of labor standards in two Asian economies, Cambodia and Bangladesh, that have lately experienced intense pressure to enhance the price competitiveness of their textile and clothing exports. While compliance with basic labor standards improved in Cambodia following a trade agreement with the US, the empirical evidence pointed toward opposing results in Bangladesh. The divergent experiences indicate that trade-linked schemes may at times achieve improvements in labor standards without deterring export or job growth.

The remainder of the paper is organized as follows. Section II provides an overview of trade and FDI reforms introduced in Viet Nam. Section III summarizes relevant findings from recent studies specific to Viet Nam and sets the stage for the empirical analysis. Section IV discusses data sources and descriptive statistics, and identifies the empirical model used in this paper. Section V presents the results. Finally, section VI offers some policy implications and concludes.

II. Overview of Trade Reforms and Foreign Direct Investment in Viet Nam

Viet Nam has undergone extraordinary rates of economic growth in the last 2 decades. Gross domestic product (GDP) per capita in purchasing power parity terms almost tripled between 1986 and 2010. As discussed in McCaig and Pavcnik (2013), over a third of Viet Nam's growth can be attributed to structural change triggered by movements of labor from low-productivity agriculture toward more productive manufacturing and services. In 1986, Viet Nam introduced a series of reforms, commonly known as Doi Moi, as an attempt to transform the economy from central planning to a regulated market economy. The exceptional rate of economic expansion was coupled with a significant shift in the composition of its

GDP in the form of economic activities shifting away from agriculture and toward the manufacturing and service sectors (McCaig and Pavcnik 2013).

It is widely accepted that the Communist Party executed the reforms as a result of poor economic conditions in Viet Nam during the 1980s (World Bank 2011). Viet Nam was an agrarian country at the start of the reforms and witnessed low growth rates. State-owned enterprises (SOEs) were the leading means of production and employment in the nonagriculture sector. Furthermore, the US had imposed a trade embargo on Vietnamese exports that was only lifted in 1994. Prior to the reforms, Viet Nam was very much a closed economy with very few exports. Exports and imports were limited by the imposition of export duties, quotas and licenses, and an overvalued exchange rate.

As a part of the Doi Moi reforms, there was massive decentralization and the provision of enterprise autonomy over production and pricing, along with the implementation of policies that tremendously encouraged competition. The Foreign Investment Law of 1987 allowed foreign enterprise activities by offering tax concessions and duty exemptions (Dodsworth et al. 1996). Several export processing zones and industrial parks were created, which provided firms favorable tax rates and import and export duties. The SOEs received autonomy over price-setting and production processes. Although by 2010, only 3,364 of them remained in operation, SOEs remained a crucial sector in terms of production and manufacturing output, contributing 36.1% to GDP during 2006–2009 (Minh et al. 2010).

Viet Nam experienced a huge inflow of FDI in the 1990s and 2000s. There was also a significant rise in the relative share of output produced by the FDI sector, which was close to 18% during 2006–2009. The Enterprise Law of 2000 made it easier for private household enterprises to register and operate by decreasing the time required to register (World Bank 2002). The enterprise reforms led to noteworthy improvements in many business environment characteristics that significantly contributed to the growth of foreign ownership and international trade.

Domestic trade reforms and the signing of a number of free trade agreements led to the rapid growth of Viet Nam's international trade. Doi Moi reforms helped allow private enterprises to engage in international trade by removing numerous import and export quotas, budget subsidies for exports, and import permit requirements; lowering or eliminating export duties; and simplifying licensing procedures (Dodsworth et al. 1996). These reforms were accompanied by a devaluation of the exchange rate in 1989. Viet Nam signed a preferential trade agreement with the European Economic Community in 1992 (Glewwe 2004). It became a member of the Association of Southeast Asian Nations Free Trade Area in 1995. The US–Viet Nam Bilateral Trade Agreement was signed in 2001, and in 2007, Viet Nam became a member of the World Trade Organization (World Bank

2011). There was also an improvement in the ability of firms to export and import, indicated by an overall rise in the ease of doing business in Viet Nam (World Bank 2013).

Between 1986 and 2011, there was a remarkable increase in Viet Nam's aggregate exports and imports. Imports and exports averaged only about 15% and 5% of GDP, respectively, in the middle of the 1980s before rising to about 88% and 78% of GDP by 2010 (McCaig and Pavcnik 2013). At the same time, there were major changes in the composition of trade, with a decline in exports of agricultural and aquaculture products, and a sharp rise in the exports of relatively unskilled, labor-intensive manufactured goods. There was a drop in the share of clothing and footwear imports and an increase in that of nonferrous metals. As noted in the empirical sections of this paper, there was an important interaction between the liberalization of trade and foreign investment in Viet Nam. By 2010, foreign-owned firms had captured over half of all exports and about 44% of imports.

III. Globalization and Labor Standards in Viet Nam

The consequences of the rapid expansion in international trade and FDI in Viet Nam, as discussed in the previous section, have been the subject of numerous empirical studies and reports. McCaig and Pavcnik (2014) study the effects of a rise in exports on labor allocation across businesses in Viet Nam. They learn that workers reallocate from household businesses to employers in the formal enterprise sector; the reallocation seems to be more apparent in industries that experience larger cuts in tariffs. Glewwe (2000) examines the status of workers in Viet Nam employed by businesses that have foreign owners or are in joint ventures with foreign investors—vis-à-vis the average Vietnamese worker—by comparing wages, the consumption expenditure levels of the households to which these workers belong, and whether workers in foreign-owned ventures were officially declared poor. In almost all the cases, the evidence confirmed that workers in foreign-owned businesses were better off than the average Vietnamese worker.

Another paper centered on Vietnamese data considers the impact of liberalized trade policy on the incidence of child labor. Edmonds and Pavcnik (2002) exploit the variation in the real price of rice to study the link between price movements of an exported commodity and economic activities of children using a panel of household data. They find that rice price increases can account for almost half of the decline in child labor that occurred in Viet Nam in the 1990s. This outcome is especially remarkable as it suggests that the use of trade sanctions on exports from developing countries to eradicate child labor is unlikely to produce the desired outcome.

Nevertheless, a large body of anecdotal evidence tends to imply a less optimistic outcome associated with the expansion of international trade in Viet Nam. O'Rourke (1997) conducted research on over 50 Vietnamese factories, including the Tae Kwang Vina factory, a Nike subcontractor in the Dong Nai province of Viet Nam. This factory was the subject of an earlier audit report conducted by Ernst & Young, which revealed a number of striking conclusions about the working conditions inside the factory (Ernst & Young 1997). Below are some of the points raised in the Ernst & Young audit:

(i) In 48 out of 50 cases, workers were required to work more than the maximum working hours.

(ii) Only 15 out of 50 workers were not satisfied with their working conditions (e.g., "hot, stuffy").

(iii) Personal protective equipment (e.g., gloves, masks) was not provided on a daily basis.

(iv) Workers did not wear protective equipment, "even in highly-hazardous places where the concentration of chemical dust and fumes exceeded the standard frequently."

(v) From a sample of 165 employees from the mixing and roller sections, 128 employees (77.6%) contracted respiratory disease.

Despite the issues identified, the key conclusion of the report was that Tae Kwang Vina was in compliance with the Nike codes of conduct. Even so, O'Rourke (1997) performed walk-through audits of environmental and working conditions in the factory and interviewed management personnel as well as representatives of Nike in Viet Nam. Owing to his confidential interviews with workers, O'Rourke's (1997) assessment lead to remarkably contradictory results. In particular, the audit neglected information regarding occupational health and safety, environmental, and general working conditions, and the methodology employed ignored conventional standards of labor and environmental auditing. O'Rourke (1997) suggested that a truly independent audit of labor and environmental practices should involve a more comprehensive analysis of the system within the factory that affects working conditions, health and safety, and the environment. Moreover, he presented a persuasive argument against accounting firms being retained by manufacturers conducting audits of labor and environmental conditions.

According to official government reports, Viet Nam lacks mechanisms and incentives for investments in improving working conditions and in using clean and advanced technologies to minimize workplace environmental pollution and protect workers (Ministry of Labour, Invalids and Social Affairs and International Labour Organization 2006). The standards on occupational safety and health (OSH) and fire-explosion prevention are rather insufficient, particularly those on the management of new equipment and technologies. The report also emphasizes that compliance with OSH regulations in many branches, localities, and enterprises is not taken seriously. Moreover, workers are not aware of their rights to protect themselves from risks of occupational accidents, sickness, and diseases, while employers do not understand, or perhaps ignore, their responsibilities. A briefing paper for the Worker Rights Consortium (2013) concludes that Vietnamese workers faced severe safety and health hazards on the job. It cites several interviews with employees in various factories near Ho Chi Minh City—including Nike suppliers Tae Kwang Vina and Yupoong Viet Nam; All Super Enterprise, a supplier to J.C. Penney and Lacoste; and Scavi Viet Nam, a supplier to Puma and VF. In many cases, it was found that working hours exceeded the legal limit. Furthermore, factory workers were often at risk from hazards such as locked fire exits and failure to provide protective equipment. A 2011 survey by the Vietnam General Confederation of Labour indicated that over 90% of the safety gear supplied to employees failed to meet applicable industrial standards. Strike organizers faced dismissal, blacklisting, prosecution by employers, and imprisonment by government authorities (Vietnam General Confederation of Labour 2011). Not only were the nonwage working conditions worse, the confederation described the wages paid by foreign-invested factories as “shockingly low.”

IV. Data and Empirical Methodology

A. Description of Data

I use data from the enterprise surveys conducted by the General Statistics Office of Viet Nam since 2000. The dataset covers firms from the manufacturing sector in Viet Nam. The annual survey dataset records responses from all formally registered enterprises in the country and contains basic information pertaining to each registered enterprise. This includes information about the type of firm (e.g., central government, local government, or foreign); industry; total turnover and profits; as well as information about employment.[2] Along with the basic characteristics of the enterprise, there are also questions about firm-provided training, investment in research and development, and taxation.[3] Results from these enterprise surveys are published but the datasets are not publicly available. Access to the datasets and permission to use them were granted by the General Statistics Office.

Even though, generally, there is consistency in the topics covered in the annual surveys, in some cases (especially during more recent years), there have been a few disparities in the questionnaires. Although the survey responses were

[2] In case a firm produces multiple products, I use the primary industry of the firm for classification purposes.

[3] The survey includes a supplementary set of questions for enterprises in the service sector.

collected annually from 2000 to 2015, the question about the number of labor accidents that occurred during the year was included only in four annual surveys: 2002, 2004, 2005, and 2011. I am, consequently, restricted to utilize data only from these years. Nonetheless, because the dataset covers a broad sample of manufacturing firms and is reasonably spread over almost a decade, it allows for extensive analysis using advanced econometric techniques.

Each of the questionnaires for 2002, 2004, 2005, and 2011 inquires the firm about the number of labor accidents that occurred during the year and how many of those accidents were fatal. The second part of the question asks about the number of victims of these accidents and the resulting number of deaths, if any. The final part of the question pertains to the total cost (in millions of Vietnamese dong) of damages caused by these accidents. The baseline regression utilizes the first part of the questions related to labor accidents. Notwithstanding, as explained in the following section, I also use several measures of the severity of accidents as a robustness check.[4]

In terms of the representativeness of various subjects, the coverage is rather uneven. This can be seen by comparing the summary statistics across the 4 years included in Table 1. These differences owe to the variation across questionnaires, with the most recent questionnaire in 2011 being more detailed in terms of the information about the firm's workforce and exporting behavior. The questionnaires for 2002, 2004, and 2005 simply ask the firm whether it engaged in any exporting activities.[5] Therefore, exports is modeled as a binary variable that takes the value of 1 if a firm exports and 0 otherwise in a majority of regressions reported in the paper. For the year 2011, however, I have specific information about the fraction of total sales that are exported, and thus obtain a more refined measure of exporting status. For this reason and as explained later in the section containing econometric specifications, I run separate cross-sectional regressions for the year 2011, hoping

[4] The accidents data depicted in Table 1 were compared with the totals reported by various issues of official national reports such as the National Profile on Occupational Safety and Health and Fire-Explosion Prevention in Viet Nam (Ministry of Labour, Invalids and Social Affairs and International Labour Organization 2006, 2010). The number of accidents, victims, deadly accidents, and fatalities are all stated to be much higher according to the enterprise survey dataset used in this paper. For example, the number of accidents, victims, deadly accidents, and deaths in 2005, according to the report, are 4,050; 4,164; 443; and 473, respectively. One possible reason for this inconsistency is the difference in sources and coverage of the data compiled under the Ministry of Labour, Invalids and Social Affairs, which is the primary data source for the ILO national reports. The data collected are based on the reporting system from enterprises to local labor inspectors and to the Labour Inspectorate of the Ministry of Labour, Invalids and Social Affairs. The report itself warns that not all enterprises reported their annual occupational accidents, resulting in the data that reflect annual occupational injuries not to be precise. Furthermore, data on occupational injuries by provinces, types of industries, ages, and sex are not available in these national reports.

[5] There is no consistent change in the share of either exporting or foreign-owned firms over the years. However, the share of exporting firms in 2005 is reported to be much smaller than that for other years. This is because the questionnaire for 2005 enquires whether the firm exported services, while the other three questionnaires queried specifically about the export of goods. Thus, as expected, the reported exporter share in 2005 is only 0.5% as opposed to 24.4%, 18.9%, and 10.8% in 2002, 2004, and 2011, respectively. Due to the discrepancy in the definition of exports, I also estimate the model excluding data for 2005, as discussed later in the paper.

Table 1. **Descriptive Statistics**

	2002		2004		2005		2011	
Variables	**N**	**Mean**	**N**	**Mean**	**N**	**Mean**	**N**	**Mean**
Fixed assets	18,476	10,677	11,851	583.3	14,466	773.5	64,527	25,007
Foreign	18,966	0.0701	23,934	0.0812	27,620	0.0827	70,160	0.0693
Joint	18,966	0.0221	23,934	0.0191	27,620	0.0165	70,160	0.00795
SOE	18,966	0.112	23,934	0.0655	27,620	0.0450	70,160	0.00244
Export	18,045	0.244	23,934	0.189	25,767	0.00516	70,160	0.108
Import	18,966	0.268	23,934	0.171	27,620	0.468	70,160	0.111
Size	18,944	136.5	23,922	134.3	27,596	126.6	70,157	81.67
Female workers (No.)	16,187	87.27	22,355	80.05	26,240	73.40	57,483	10.56
Age	18,956	7.487	22,145	7.135	26,675	6.768	15,316	13.26
Average wage	18,819	9.238	23,895	11.78	27,561	13.10	69,017	33.21
Accidents (No.)	16,366	0.311	6,635	1.122	7,741	0.901	33,593	0.307
Deadly accidents (No.)	15,900	0.00698	5,558	0.0202	6,995	0.0134	28,367	0.00338
Victims (No.)	16,360	0.372	6,015	1.242	7,321	1.139	28,985	0.356
Deaths (No.)	15,893	0.00799	5,549	0.0216	6,978	0.0153	28,333	0.00416
Cost of damages	16,191	66.64	5,809	12.10	7,173	43.14	28,890	278.7
Training expenditure	16,784	1.925	4,222	3.608	24	790.8	24	680.1
Capital intensity	18,470	76.70	11,844	10.27	14,448	11.73	64,446	208.2
R&D intensity	3,896	0.0421	5,018	0.229			288	7.202
Environmental expenditure	5,461	114.2	6,899	71.04	7,313	635.7		
Workers hired (No.)	10,332	66.74	17,122	55.34	20,119	54.32		
Workers fired (No.)	8,340	41.91	14,509	45.23	18,045	47.82		
Intermediate inputs					3,571	121,159		
Export intensity							24,224	0.949
Industrial zone							68,856	0.0852
Workers (No., 15–34 years)							64,309	61.47
Workers (No., 35–55 years)							67,885	24.56
Workers (No., 56–60 years)							41,246	2.372
Workers (No., over 60 years)							32,921	0.346
Unskilled labor (No.)							33,648	57.61
Skilled labor (No.)							28,615	31.02

R&D = research and development, SOE = state-owned enterprise.

Notes: Fixed assets, average wage, cost of damages, training expenditure, cost of damages, environmental expenditure, and intermediate inputs are values in million dong. Capital intensity is fixed assets per worker. R&D intensity is spending on research and development expressed as a percentage of total sales. Export intensity is measured by the fraction of sales exported.

Source: Author's calculations based on annual enterprise surveys (various years) obtained from the Government of Viet Nam, General Statistics Office.

to perceive a more robust relationship between the exporting propensity of the firm and the working conditions that it offers.

The ownership variables (foreign, SOE, or joint ownership) also take the form of dummy variables. Firm size is measured using the total number of workers, and capital intensity is measured as fixed assets per worker. I also control for the number of female employees in the regression models. Age is computed as the difference between the survey year and the year the firm started operations. The average wage is calculated by dividing the total compensation paid to employees by the number of full-time employees of the firm.[6]

As shown in Table 1, I also report some of the human capital measures for the 2011 dataset, which provides the numbers of employees with high school diplomas and college or university degrees. These figures are used to compute the fractions of skilled and unskilled workers in each firm. Other supplementary data available only for 2011 include location in an industrial zone, workers by age group, and export and import status. Lastly, the variables with uneven coverage across years are spending on environmental protection, value of intermediate inputs, research and development (R&D) intensity, and number of workers hired and fired during the year.[7]

Table 2 shows the sample representativeness by exporting and ownership status of the firm and indicates the dissimilarity across subsamples. The mean values of foreign-owned exporters and foreign-owned firms that export in the dataset are both quite high at 34.9% and 56.6%, respectively. Foreign-owned and exporting firms possess more capital, higher export intensity, more fixed assets, and a greater likelihood to import; they are relatively bigger as measured by the number of workers (total size as well as by age groups, skill intensity, and gender). They also both hire and fire more workers compared to nonexporters and domestically owned enterprises. A greater share of exporters and foreign-owned firms are located in industrial zones (40% and 61.3%, respectively) than are nonexporters and domestically owned enterprises (both at 4.6%). As frequently assessed in the trade literature, a typical exporting and foreign firm in Viet Nam pays a higher average wage than firms that do not export or those with domestic owners.

On the other hand, unlike the findings of Javorcik (2015), the average spending on training and environmental protection is lower for the foreign firms than for domestic firms. As far as the proxies of nonwage working conditions are concerned, exporters and foreign-owned firms tend to do worse in virtually all cases; with higher averages for number of accidents, number of victims of accidents, and cost of damages as a result of accidents, it appears that nonexporters and domestically owned enterprises deliver superior nonwage working conditions. Since

[6]The total compensation includes wages, salaries, bonuses, gratuities, social security contributions, as well as other compensation out of production costs.

[7]R&D intensity is defined as the spending on R&D expressed as a percentage of total sales.

Table 2. **Descriptive Statistics by Exporting and Ownership Status**

	Nonexporter		Exporter		Domestic		Foreign	
Variables	**N**	**Mean**	**N**	**Mean**	**N**	**Mean**	**N**	**Mean**
Export	–	–	–	–	127,665	0.0846	10,241	0.566
Import	121,302	0.154	16,604	0.385	130,261	0.174	10,419	0.693
Foreign	121,302	0.0366	16,604	0.349	–	–	–	–
Fixed assets	93,296	8,953	14,145	69,781	101,628	13,522	7,692	59,123
Joint	121,302	0.00838	16,604	0.0511	130,261	0.0145	10,419	0
SOE	121,302	0.0320	16,604	0.0575	130,261	0.0393	10,419	0
Size	121,250	62.82	16,604	427.3	130,203	80.81	10,416	432.0
Female workers (No.)	103,929	27.58	15,845	170.8	112,401	34.82	9,864	184.7
Age	68,846	8.070	12,175	9.292	76,010	8.388	7,082	6.489
Accidents (No.)	54,136	0.196	9,550	1.919	59,530	0.230	4,805	3.350
Deadly accidents (No.)	48,114	0.00584	8,094	0.0149	53,052	0.00675	3,768	0.0146
Victims (No.)	49,037	0.223	9,015	2.131	54,229	0.260	4,452	4.064
Deaths (No.)	48,070	0.00655	8,073	0.0181	53,002	0.00766	3,751	0.0176
Cost of damages	48,714	32.87	8,733	889.8	53,838	151.1	4,225	326.2
Training expenditure	15,109	2.580	5,340	8.135	19,408	4.075	1,646	2.275
Environmental expenditure	15,289	286.9	4,260	204.3	17,322	299.9	2,351	241.5
Average wage	120,035	21.21	16,590	32.08	128,974	20.99	10,318	38.89
Capital intensity	93,191	132.5	14,144	190.2	101,597	123.3	7,611	340.7
R&D intensity	5,941	0.557	3,256	0.0244	8,196	0.170	1,006	1.981
Workers hired (No.)	38,323	37.02	7,546	163.1	42,544	38.82	5,029	214.4
Workers fired (No.)	32,718	31.71	6,708	114.8	36,508	33.32	4,386	148.7
Intermediate inputs	3,332	120,141	34	89,090	2,958	113,250	613	159,321
Export intensity	23,432	0	792	29.01	23,466	0.687	758	9.061
Industrial zone	61,311	0.0464	7,545	0.400	64,058	0.0457	4,798	0.613
Workers (No., 15–34 years)	56,829	24.29	7,480	344.0	59,500	36.96	4,809	364.7
Workers (No., 35–55 years)	60,409	14.18	7,476	108.4	63,102	20.25	4,783	81.43
Workers (No., 56–60 years)	36,348	1.715	4,898	7.249	38,418	2.228	2,828	4.337
Workers (No., over 60 years)	29,315	0.301	3,606	0.716	30,812	0.323	2,109	0.691
Unskilled labor	30,179	24.16	3,469	348.6	31,778	38.87	1,870	375.9
Skilled labor	25,689	15.39	2,926	168.2	27,047	24.56	1,568	142.5

R&D = research and development, SOE = state-owned enterprise.

Notes: Fixed assets, average wage, cost of damages, training expenditure, cost of damages, environmental expenditure, and intermediate inputs are values in million dong. Capital intensity is fixed assets per worker. R&D intensity is spending on research and development expressed as a percentage of total sales. Export intensity is measured by the fraction of sales exported.

Source: Author's calculations based on annual enterprise surveys (various years) obtained from the Government of Viet Nam, General Statistics Office.

the figures displayed so far are purely descriptive, I now turn to the quantitative analysis of a comparison of these two types of firms in Viet Nam.

B. Econometric Framework

I have established that the firm-level empirical evidence on the relationship between exporting behavior and working conditions is insufficient and ambiguous. I now turn to the primary goal of this paper. In this section, I explain the econometric approach used to gauge the impact of a firm's exporting status on the number of workplace accidents using enterprise survey data from Viet Nam. Identifying the causes of workplace accidents is challenging due to a number of factors. On one hand, a higher number of accidents may be brought about by an inferior state of the working environment (e.g., the condition of the plant or factory), while it is also equally likely that inadequate implementation or enforcement of labor standards in a particular region or industry leads to a greater incidence of accidents at the plant. In other words, the reasons for the occurrence of workplace accidents can be manifold. Because the principal goal is to identify the role of exporting and ownership status in determining the number of accidents, it is of utmost importance to control for a range of potentially significant causes of accidents at the factory. Unfortunately, due to data limitations and the resulting omitted variable bias, it is impossible to account for all the potential determinants of workplace accidents. In addition, a simple regression of the number of accidents on exporting status is expected to yield biased results because exports are likely to be endogenous; a firm providing a safer working environment is also likely to be more productive by means of either using better technology or by employing healthier, more efficient workers, and is thus expected to be exporting a part or all of its superior quality output. Consequently, exporting behavior itself may be associated with a number of firm-, industry-, or region-specific characteristics that will need to be controlled for in the specification in order to obtain any meaningful relationship between exporting propensity and accidents at work.

In order to measure this association, I define the following linear model:

$$A_{ijt} = \alpha_0 + \alpha_1 E_{ijt} + \alpha_2 x_{it} + \mu_{j,t} + \mu_p + \varepsilon_{ijt} \tag{1}$$

where A_{ijt} is the number of accidents that took place in the survey year t at firm i in industry j for every thousand workers in firm i. As noted above, both exporting and foreign firms are much larger than nonexporting or domestic firms, and therefore may be more likely to have accidents simply because they are larger in size. In order to adjust for size differences and obtain estimates that can be easily interpreted, I use accidents per thousand workers as a dependent variable instead of the total number of accidents or number of accidents per worker. I do not log transform A_{ijt} because there are a considerable number of zeros in the dataset, indicating that many firms did not experience any serious accidents during the course of the year.

E_{ijt} is the observed binary export variable that takes a value of 1 if firm i is an exporting firm. x_{it} denotes the vector of time-varying firm characteristics, including its status of ownership (foreign or SOE), size, capital intensity, number of female employees, and age of the firm. The choice of firm characteristics to be included in x_{it} is explained below. Since the number of accidents occurring in a firm is expected to vary across different types of manufacturing industries overtime, I include the three-digit ISIC industry-by-time fixed effects, given by $\mu_{j,t}$. Industry-year fixed effects allow for industry-specific trends in accidents and control for shocks that affect all firms in a given industry in a certain year. Lastly, μ_p represents province fixed effects.

The foremost threat to the identification of equation (1) is that the estimates may be driven by unobserved factors related to both the exporting status of a firm as well as the number of workplace accidents, such as demand shocks. In order to exogenously identify different shocks, I also provide an alternative estimation of the model by replacing the industry-year and province fixed effects by an interaction of industry, time, and province fixed effects. By controlling for a rigorous set of time-invariant local sectoral determinants of accidents, I ensure that no systematic information is shifted into the error term that is correlated with the independent variables, or which creates an endogeneity bias for the variables that I treat as exogenous.

As discussed above, it is imperative to control for a variety of firm and industry characteristics in order to obtain any meaningful estimates of the effect of exporting behavior on workplace accidents. A fundamental concern for the estimating strategy is that exports, E_{ijt}, are likely to be correlated with the error term, ε_{ijt}, and therefore cause an omitted variable bias in the estimated results. Although I am unable to include some of these factors in the estimation of equation (1) above because of the lack of available data, it is nevertheless possible to make use of adequate proxies to incorporate numerous variables missing in the dataset.[8] More importantly, the inclusion of industry-year and province fixed effects can help wipe out the time-invariant industry and/or province-specific factors that might affect working conditions. For example, it is expected that the working conditions provided by a given firm are likely to be associated with the overall firm competitiveness along with its other key characteristics. Accidents at work may also be connected with local and world demand for the finished product, which in turn is affected by the industrial competitiveness of local firms. By capturing the industry-specific trends in the regression estimates, I am able to pick up the influence of worldwide industrial demand shocks.

[8]As explained in this section, I control for various seemingly unrelated variables in all the regressions, such as R&D spending by the firm and expenditure on environmental factors, that can potentially serve as proxies for firm productivity and thereby be classified as determinants of the number of accidents that take place.

Another essential aspect in influencing the state of the work environment offered is the effectiveness of the implementation of labor standards in a given industry or region. The existing literature points to the significance of various firm and industry characteristics that are likely to be related to the enforcement of labor regulations (Liaqat and Nugent 2016). The existence of satisfactory labor standards per se is not sufficient to encourage employers to improve working conditions. A more effective implementation is likely to be related to a number of individual firm attributes and not just to the existence of complementary institutions. Larger firms, for example, are more likely to implement labor laws in their workplaces because they are more noticeable to regulatory officials. The same is true if a firm is located in a capital city or in an industrial or exporting zone. The inclusion of province fixed effects sweeps out the differences across firms in terms of the implementation of existing labor regulations in Viet Nam and to some extent tackles the concern over lack of data availability about the state of the factory (e.g., use of obsolete equipment, suitable safety measures introduced, and amount of overtime hours). Since some of the province fixed effects may be varying over time, I use a combination of either industry-year and province fixed effects, or industry-year-province effects, which enables controlling for the inherent endogeneity bias arising from the unobserved influences on both the exporting status and ownership status of a firm, and on the number of accidents at work. As seen below, the fundamental results remain robust across all of these specifications.

Another complexity pertaining to the empirical technique is that the dependent variable, the number of accidents (accidents per thousand workers), is a much-skewed variable. Many firms do not respond to the question about accidents, and a large number of manufacturing firms that do respond report no accidents at all.[9] A comparison of the descriptive statistics of accidents data derived from the enterprise surveys with the official national reports illustrates that, despite concerns about underreporting, the enterprise surveys yield greater totals for all the different variables used in the study pertaining to accidents.[10] Yet, in terms of selection into responding, I would be interested in detecting why any given firm would not respond to the question about labor accidents.[11]

To observe how much variation in responding is related to observed firm characteristics, I estimate a logistic probability model with an indicator for responding to the question as the dependent variable and control for a range of firm

[9] As far as the presence of a large number of zero observations is concerned, a linear model appears to be sufficient, at least theoretically. It is not a requirement that the dependent variable be normally distributed or approximately normally distributed for least squares regressions to work. Furthermore, the calculation of robust standard errors can control for heteroscedasticity in the error terms.

[10] Please refer to footnote 6 for a detailed explanation.

[11] Nonresponse could reflect either a desire to hide something or simply a lack of information by the person filling out the form. For example, small and poorly funded firms are more likely to not respond. Presumably, this should affect some of the other variables as well and not just accidents. Similarly, nonresponse is probable if the survey is handed to someone who cannot fully comprehend the survey questions.

characteristics as potential explanatory factors. The list of explanatory variables is wide ranging; as a first step, I incorporate as many controls as the dataset permits, while ensuring there is no multicollinearity in the selected controls—ranging from information about employment, ownership, fixed assets owned by the firm, exporting as well as importing behavior, type of industry, and the firm's location, to also including apparently less relevant characteristics such as R&D and environmental protection spending carried out by the firm in a given year. This exercise enables us to identify the significant determinants of (non)response, which can then be controlled for in equation (1) within x_{it}. I report the logistic probability estimates, which form the basis of the choice of firm characteristics included in x_{it}, in the Appendix. Although the magnitude of the coefficient of ownership status is relatively large, the effects of exporting and foreign ownership on the probability of not responding to the questions about labor accidents are both statistically insignificant.[12] The variables that do turn out to have a significant impact on response include importing status, fixed assets, R&D intensity, and spending on environmental protection. Therefore, I control for all of these variables in the regressions, along with the other firm characteristics expected to have an influence on working conditions.

The earlier overview of trade reforms and FDI in Viet Nam shows that there was a key interaction between trade openness and foreign investment in Viet Nam, especially during 1986–2011. Foreign-owned firms had captured over half of all exports by 2010. Table 2 also shows that a major proportion of exporting firms were foreign owned and vice versa. Therefore, I extend the empirical model specified in equation (1) to test whether foreign-owned exporters incur a higher number of workplace accidents than domestically owned exporting firms:

$$A_{ijt} = \beta_0 + \beta_1 E_{ijt} + \beta_2 F_{ijt} + \beta_3 (E_{ijt} * F_{ijt}) + \beta_4 x_{it} + \mu_{j,t} + \mu_p + \varepsilon_{ijt} \tag{2}$$

By estimating the model in levels (with the exception of x_{it}), I can account for zero accident observations, which would have to be dropped in the log-linear model. I once again control for industry-by-time and province fixed effects, as well as industry-province-year effects in separate regressions.

Up to now, I have used a binary measure of the exporting status of a firm to disclose any potential relationship between accidents and exports. A more refined independent variable for quantifying exporting status is perhaps the fraction of total sales revenue that is exported. As noted above, the questionnaires for the years 2002, 2004, and 2005 only question the firm about whether or not it exported any of its output. On the other hand, the longer and more comprehensive questionnaire for

[12]The sample selection bias is expected to be mitigated if both exporters and foreign-owned firms are not systematically underreporting the number of accidents.

2011 consists of information about the percentage of total turnover attributable to exports. In order to check if the results are sensitive to the proxy of exporting status and to more accurately capture the link between export propensity and the number of workplace accidents, I replace the exporting dummy variable by the logarithm of fraction of sales exported in equation (2) and run the model separately only for the year 2011. I also utilize the additional information provided in the 2011 survey by extending the firm characteristics, x_{it}, to include a range of other controls, including a dummy variable for the firm's location in an industrial zone. The results based on the cross-sectional estimation are displayed in Table 5.

C. Alternative Measures of Working Conditions

In the estimation methodology, I try to address the likely bias arising due to sample selection. The primary cause of sample selection in the data is not reporting or misreporting information about accidents at work. Many manufacturing firms did not respond to the questions about labor accidents and this lack of response is unlikely to be random. It may be the case that larger firms or those located in more heavily populated provinces or industrial zones are more likely to report accidents simply because they are more noticeable to regulators. Despite controlling for some of these potential sources of bias in x_{it}, I perform a robustness check using more serious deadly accidents and the resulting rate of fatalities, under the proposition that these accidents are difficult to hide and less prone to misreporting. I utilize a number of other proxies of working conditions available in the enterprise surveys' dataset: the number of victims of accidents, the number of deadly accidents, and the total number of deaths caused by these deadly accidents. Additionally, all of these variables take into consideration the severity of workplace accidents modeled earlier, and hence can be perceived to be superior measures of unsafe working conditions. The estimation results generated based on the alternative measures of working conditions are reported in Tables 6 and 7.

Another cause of concern is the existence of outliers in the reported accidents data. A few firms with a very large number of accidents could heavily influence the regression results. I check for the influence of outliers by excluding the firms reporting very large numbers of accidents (e.g., over 50, over 100, or more) and limiting the estimating samples. Nonetheless, the results are consistent across various samples and are not driven by a handful of firms. In addition to controlling for some of the potential sources of bias arising due to sample selection, a robustness check using more serious deadly accidents and the resulting rate of fatalities is also performed, as explained above.

Lastly, a threat to the representativeness of the estimates derived in this paper is that the yearly samples only target formal manufacturing enterprises in Viet Nam, which are not representative of the full population. A large number of workers in the manufacturing sector are employed in informal plants. The sample is therefore biased toward excluding labor accidents that occur outside the universe of firms covered in this analysis. Ideally, I would like to extend the sample to include informal manufacturing firms, but that is not possible with the data source. Even so, to the best of my knowledge, there is no compelling evidence on accidents among informal firms in Viet Nam. As a result, I will focus on labor accidents in the formal sector alone. The results reported here do not necessarily imply an overall increase in accidents in manufacturing.

To summarize, the baseline estimation regresses the number of accidents for every thousand workers on exporting and ownership characteristics of firms, while controlling for a comprehensive set of firm, industry, and provincial determinants of the type of workplace environment provided by a given firm. As a robustness check, I test the model using alternative measures of working conditions.

V. Results

A. Estimation Results

The results of the baseline regressions are depicted in Table 3. Column (1) controls for industry-year fixed effects, while column (2) adds provincial controls to the initial specification. Column (3), on the other hand, includes a different combination of fixed effects, allowing for variation in the level of accidents after controlling for industry- and province-specific trends for the reasons discussed above. Columns (5)–(6) control for the complete set of time-varying firm characteristics, denoted by x_{it}, while column (4) repeats the estimation under column (3) but restricts the sample to include only the observations used in columns (5)–(6).[13] As denoted by the positive and significant coefficients of Export in all columns of Table 3, there appears to be on average a positive relationship between the number of accidents and the exporting status of a firm; firms exporting a part or all of their output experience an average of 3.26 more accidents per thousand workers than their nonexporting counterparts, for whom the average number of accidents is 0.92 for every thousand workers employed. The positive association between exporting status and the number of accidents persists upon the inclusion of a range of firm, industry, and provincial characteristics and trends, although there is a large decline in the number of observations in columns (4)–(6), along with a slight reduction in the magnitude of the coefficient of Export. While controlling for various firm attributes reduces the sample size, there is no drastic change in either the size or significance of the coefficient of interest.

[13]This intermediate step, whereby I run the same regression as in column (3) but limit the observations to those included in columns (5)–(6), checks whether the coefficient of the variable of interest changes due to the change in the sample or because of the addition of control variables, or both.

Table 3. **Baseline Ordinary Least Squares Estimation Results**

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Export	3.257***	2.144***	1.735***	2.116***	1.030***	1.051***
					(0.142)	(0.144)
Log (Capital intensity)					0.202*	0.194
					(0.119)	(0.119)
Log (Age)					0.461***	0.471***
					(0.157)	(0.152)
SOE					−1.502**	−1.208*
					(0.683)	(0.704)
Import					0.494*	0.567
					(0.295)	(0.346)
Log (R&D intensity)					−0.998	−0.341
					(0.995)	(0.594)
Log (Environmental expenditure)					0.584**	0.607**
					(0.246)	(0.266)
Constant	0.921***	−0.005	1.150***	0.204	−1.238	−1.966**
	(0.084)	(0.203)	(0.033)	(0.239)	(2.260)	(0.793)
Observations	63,584	63,584	63,584	8,051	8,051	8,051
R-squared	0.021	0.050	0.252	0.062	0.055	0.074
Industry-year effects	Yes	Yes	No	No	Yes	No
Province effects	No	Yes	No	No	Yes	No
Industry-province-year effects	No	No	Yes	Yes	No	Yes

R&D = research and development, SOE = state-owned enterprise.

Notes: Robust standard errors are given in parentheses. The dependent variable is the number of accidents per thousand workers. *** = significant at 1%, ** = significant at 5%, and * = significant at 10%.

Source: Author's calculations based on annual enterprise surveys (various years) obtained from the Government of Viet Nam, General Statistics Office.

Let us examine the estimates attained for other control variables. As one would have thought, older firms are expected to encounter more accidents for every thousand workers. The coefficient of capital intensity always takes a positive value in these regressions, but the estimates are lower in magnitude and significance. Interestingly, firms importing a part of their intermediate inputs are also likely to be associated with a larger number of accidents. The coefficient of SOEs yields a negative and significant influence. Higher spending on environmental protection, surprisingly, is linked with more accidents, on average. However, the effect of R&D intensity appears to be insignificant in Table 3. As mentioned earlier, the choice of firm characteristics to be controlled for stems from the results of the logistic probability model, through which I attempt to account for the various firm characteristics linked with missing or unreported information about accidents at the factory.

I have shown that the exporting status of an average firm in Viet Nam tends to be highly associated with a larger number of accidents. The descriptive statistics depicted in Table 2 indicated that a significantly large proportion of exporting firms are foreign owned, and an even larger fraction of foreign-owned firms generate at

Table 4. **Baseline Ordinary Least Squares Estimation Results—Interaction of Exporting Status and Foreign Ownership**

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Export	1.858***	1.380***	1.141***	1.458***	0.632***	0.666***
	(0.380)	(0.213)	(0.178)	(0.345)	(0.196)	(0.202)
Foreign	5.084***	3.993***	2.617**	2.284**	1.842*	1.854*
	(1.334)	(1.145)	(1.025)	(1.007)	(0.990)	(1.019)
Export × Foreign	−0.067	−0.705	−0.083	0.563	0.695	0.629
	(0.753)	(0.727)	(0.757)	(1.976)	(1.910)	(1.943)
Log (Female)					0.260**	0.249**
					(0.111)	(0.113)
Log (Capital intensity)					0.154	0.148
					(0.121)	(0.122)
Log (Age)					0.532***	0.540***
					(0.169)	(0.164)
SOE					−1.009*	−0.704
					(0.514)	(0.549)
Import					0.249	0.309
					(0.298)	(0.349)
Log (R&D intensity)					−0.954	−0.259
					(0.948)	(0.517)
Log (Environmental expenditure)					0.585**	0.606**
					(0.238)	(0.255)
Constant	0.761***	−0.062	1.050***	0.126	−1.019	−1.712**
	(0.114)	(0.212)	(0.061)	(0.224)	(2.157)	(0.698)
Observations	63,584	63,584	63,584	8,051	8,051	8,051
R-squared	0.029	0.054	0.254	0.070	0.061	0.079
Industry-year effects	Yes	Yes	No	No	Yes	No
Province effects	No	Yes	No	No	Yes	No
Industry-province-year effects	No	No	Yes	Yes	No	Yes

R&D = research and development, SOE = state-owned enterprise.
Notes: Robust standard errors are given in parentheses. The dependent variable is the number of accidents per thousand workers. *** = significant at 1%, ** = significant at 5%, and * = significant at 10%.
Source: Author's calculations based on annual enterprise surveys (various years) obtained from the Government of Viet Nam, General Statistics Office.

least a part of their sales revenue from outside Viet Nam. In order to ascertain the connection between these two comparable characteristics of firms, equation (2) is estimated, which includes an interaction term (Export × Foreign). The results are illustrated in Table 4. Across all the columns and with the inclusion of various fixed effects, the coefficients of both Export and Foreign are positive and significant; it appears to be the case that foreign ownership is also associated with having more accidents. Furthermore, the average number of accidents occurring in a foreign-owned firm is much higher in magnitude in comparison to not only domestically owned firms but also exporting firms (5.11 accidents per thousand workers as opposed to 1.89 accidents). Although the interaction term (Export × Foreign) coefficient is always insignificant, it remains positive in columns (4)–(6). The significance of other control variables in Table 4 is largely comparable to those discussed earlier in Table 3, with the exception of Capital Intensity and Import, the coefficients of which now become insignificant.[14]

The empirical findings somewhat offer support to the argument for a race to the bottom and, especially in the context of a developing country, to the postulation that capital is likely to move toward countries with poorer working conditions simply because firms find it profitable to do so. As seen in Table 2, foreign firms do tend to pay a higher wage on average but, coupled with the estimates derived pertaining to the nonwage working conditions, the overall effect on worker welfare is unlikely to be distinctly positive. If foreign firms, however, choose to retain working conditions between the domestic level and those in the origin country, the average level of working conditions may improve with domestic firms being prompted to improve their working conditions (Jayasuriya 2008). This does not seem to be true in the case of Viet Nam, where foreign ownership is evidently associated with a greater number of accidents at work. On the other hand, it is also probable that foreign firms report information about accident occurrence more accurately compared to domestically owned firms because they are likely to be under greater scrutiny by regulatory officials, whereas the domestic firms may deliberately misreport or understate the number of workplace accidents. While I do extend the analysis to test the validity of the information reported by accounting for more severe accidents that are rather difficult to hide, it is equally likely that workers in foreign firms are indeed exposed to hazardous working conditions. As described in O'Rourke's (1997) assessment discussed earlier, compliance with OSH regulations in many enterprises (domestic and foreign owned) and regions in Viet Nam is often not taken seriously. This perception is corroborated by the audits of several multinational firms, which knowingly neglected information about OSH and general working conditions.

The regression results presented so far quantify the exporting status of a firm as an indicator variable, assuming the value of 1 if the firm exports a part of its sales revenue abroad and 0 otherwise. If there is a large degree of variation across firms in the fraction of total revenue generated from foreign sales, or the majority of firms export only a small percentage of sales, the use of a binary variable may fail to accurately capture the link between export intensity and the number of accidents at work. The descriptive statistics illustrated in Table 2 indicate that an average exporting firm earned only 29% of sales revenue from exports. It is, therefore, imperative to test whether the results stand if I measure exporting status by the fraction of total sales exported instead of using a dummy variable. This information is available in the 2011 dataset.

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[14] As noted in footnote 6, the questionnaire for 2005 uses a different definition of exporting by asking firms about the export of services rather than goods. In order to take into account the inconsistency in these definitions, I repeat the estimation of equations (1) and (2) excluding data for 2005 and confining the sample to the years 2002, 2004, and 2011. The results, which are available in the Appendix, are very similar to those illustrated in Tables 3 and 4.

Table 5. **Estimation Results after Controlling for Export Intensity, 2011**

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Log (Export intensity)	0.253**	0.246**	−0.060	0.067	0.054	0.023
	(0.106)	(0.106)	(0.129)	(0.096)	(0.103)	(0.103)
Foreign	1.287**	1.282**	1.015*	0.801*	0.932*	0.442
	(0.582)	(0.590)	(0.511)	(0.452)	(0.504)	(0.473)
Export intensity × Foreign	1.432***	1.439***	0.109	0.512	1.547***	1.296**
	(0.508)	(0.507)	(0.526)	(0.411)	(0.496)	(0.502)
Log (Female)					0.086**	0.016
					(0.038)	(0.036)
Log (Capital intensity)					0.036**	0.016
					(0.014)	(0.011)
SOE					−0.725***	−0.452**
					(0.153)	(0.189)
Import					0.621**	0.388
					(0.229)	(0.259)
Log (15<Age<34)						0.056
						(0.053)
Industrial zone						1.614***
						(0.448)
Constant	0.327***	−0.001	−0.233**	0.360***	0.128	−0.134
	(0.080)	(0.003)	(0.091)	(0.010)	(0.106)	(0.079)
Observations	23,747	23,747	23,747	23,747	23,462	23,461
R-squared	0.002	0.003	0.009	0.021	0.003	0.004
Industry effects	No	Yes	Yes	No	No	Yes
Province effects	No	No	Yes	No	No	No
Industry-province effects	No	No	No	Yes	No	No

R&D = research and development, SOE = state-owned enterprise.
Notes: Robust standard errors are given in parentheses. The dependent variable is the number of accidents per thousand workers. All columns use a single year of data (2011). Export intensity is measured by the fraction of sales exported *** = significant at 1%, ** = significant at 5%, and * = significant at 10%.
Source: Author's calculations based on annual enterprise surveys (various years) obtained from the Government of Viet Nam, General Statistics Office.

The estimated results obtained by running equation (2) using export intensity instead of exporting dummy variable are exhibited in Table 5.[15] Once again, the effect of percentage of sales exported on the number of accidents is consistently positive across all specifications, both with and without industry fixed effects. The only exception is column (3), which includes industry and province fixed effects. The coefficient of Foreign is almost always positive and statistically significant. Moreover, the coefficient of the interaction term (Export Intensity × Foreign) is now significant and much higher in magnitude than those reported in Table 4 in a majority of cases. This result corroborates the earlier finding that foreign-owned exporting firms in Viet Nam experienced a greater number of workplace accidents in 2011 than their domestically owned, nonexporting counterparts due to the very

[15]Since I use only the 2011 dataset in this case, yearly effects are not included.

reasons hypothesized above. The coefficients of Capital Intensity and Import are both positive and greater in significance compared with those displayed in Table 4. The estimates for the number of female workers and SOE are also comparable in size and significance with those reported in Table 4. Table 5 reports the results generated upon the inclusion of the number of employees by age group. A higher number of workers in the age group of 15–34 years, on average, is linked with a greater number of workplace accidents, but the estimates are not statistically significant. Column (6) controls for a firm's location in an industrial zone, and the estimated coefficient is sizable and significantly positive.

B. Robustness Check: Alternative Measures of Working Conditions

Based on the results depicted in Tables 3–5, I have shown that both the exporting status and foreign ownership status of firms are positively associated with the number of accidents occurring in manufacturing firms in Viet Nam. The results discussed above are robust across various specifications and, more importantly, based on different methods of quantifying exports. But are these results sensitive to the measure of nonwage working conditions? The focus so far has been on only one specific measure, the number of accidents. Accidents at manufacturing plants may vary in their severity in terms of the number of workers affected by the accident. Next, I check whether this association holds for related but distinct measures of working conditions: number of victims of accidents, number of deaths caused by accidents, and number of deadly accidents. The regression results are revealed in Tables 6 and 7 for the complete sample set and the year 2011 only, respectively.

I notice that the coefficient of the interaction term remains positive and significant for the first of the three proxies of working conditions: the number of victims of accidents that occurred in the firm; exporters that have foreign ownership are likely to incur a larger number of victims from workplace accidents, even after controlling for industry-year-province fixed effects as well as numerous firm characteristics (Table 6). I find these results to be stronger for exporting firms whereby the estimates obtained are positive and highly significant across all three proxies of working conditions. Yet, the coefficient of Foreign assumes a negative value in columns (3) and (5), but in both of these cases, the much larger positive coefficient of the interaction term outweighs the negative coefficient for foreign ownership alone.[16] Nonetheless, there occurs a large drop in the number of observations upon the inclusion of firm characteristics. An interesting finding is that importing firms are less likely to witness serious (deadly) accidents than firms in other industries. In Table 7, which reports cross-sectional results attained by using 2011 data only, yet again a positive and significant association between exporting

[16]For example, in Table 6 column (3) the coefficient of Foreign is –0.00041, but the coefficient of Export × Foreign is 0.00716.

Table 6. **Estimation Results for Alternative Measures of Working Conditions**

Variables	(1) Number of Victims	(2) Number of Victims	(3) Number of Deaths	(4) Number of Deaths	(5) Number of Deadly Accidents	(6) Number of Deadly Accidents
Export	0.86166***	0.00516	0.01283***	0.00077	0.01053***	−0.00169
	(0.138)	(0.148)	(0.004)	(0.003)	(0.003)	(0.002)
Foreign	1.46143***	0.28419	−0.00041	0.00134	−0.00144	0.00127
	(0.410)	(0.331)	(0.002)	(0.006)	(0.002)	(0.006)
Export × Foreign	1.16173*	1.76151**	0.00716	0.00208	0.00717	0.00284
	(0.656)	(0.723)	(0.007)	(0.007)	(0.006)	(0.006)
Log (Female)		0.46173***		0.00159*		0.00185**
		(0.106)		(0.001)		(0.001)
Log (Capital intensity)		−0.00409		0.00009		0.00028
		(0.014)		(0.000)		(0.000)
SOE		0.20434		−0.00330		−0.00464
		(0.294)		(0.003)		(0.003)
Import				−0.00394**		−0.00348**
				(0.002)		(0.001)
Log (R&D intensity)				0.00271		0.00274
				(0.004)		(0.004)
Log (Environmental expenditure)				0.00078		0.00124
				(0.001)		(0.001)
Constant	−0.16292*	−0.47071**	−0.00470	0.00193	−0.00339	0.00030
	(0.087)	(0.182)	(0.003)	(0.002)	(0.002)	(0.002)
Observations	58,052	54,430	56,143	8,334	56,208	8,335
R-squared	0.086	0.172	0.173	0.705	0.195	0.550
Industry-year effects	Yes	No	Yes	No	Yes	No
Province effects	Yes	No	Yes	No	Yes	No
Industry-province-year effects	No	Yes	No	Yes	No	Yes

R&D = research and development, SOE = state-owned enterprise.

Notes: Robust standard errors are clustered by industry and given in parentheses. The dependent variables are number of victims of accidents, number of deaths, and number of deadly accidents. Export intensity is measured by the fraction of sales exported. *** = significant at 1%, ** = significant at 5%, and * = significant at 10%.

Source: Author's calculations based on annual enterprise surveys (various years) obtained from the Government of Viet Nam, General Statistics Office.

intensity and the number of victims of accidents continues to hold. However, no significant relationship between exporting and foreign ownership and the number of deadly accidents or fatalities can be detected. Yet, compared to Export and Foreign, the coefficients of other controls yield results unmistakably better and consistent with the earlier findings.

In short, the overall effect of exporting behavior and foreign ownership continues to be undesirable only when workplace hazards are measured in terms of the number of workers affected by these accidents. With the use of deadly accidents and the subsequent fatalities as measurements, the results are generally less supportive of the main proposition with regard to foreign ownership compared with those results discussed earlier.

Table 7. **Alternative Measures of Working Conditions, 2011**

Variables	**(1)**	**(2) Number of Victims**	**(3)**	**(4)**	**(5) Number of Deaths**	**(6)**	**(7)**	**(8) Number of Deadly Accidents**	**(9)**
Log (Export intensity)	0.16530***	0.07479**	0.02337	0.00292	0.00187	0.00069	0.00291	0.00132	0.00068
	(0.044)	(0.030)	(0.028)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)
Foreign	0.28769*	0.16996	0.15202	0.00089	−0.00047	0.00068	0.00906	0.00610	0.00068
	(0.151)	(0.145)	(0.156)	(0.002)	(0.002)	(0.002)	(0.009)	(0.007)	(0.002)
Export intensity × Foreign	0.43791**	0.37976***	0.08027	0.00392	0.00452	−0.00191	0.01681	0.01785	−0.00190
	(0.166)	(0.123)	(0.135)	(0.007)	(0.007)	(0.002)	(0.014)	(0.014)	(0.002)
Log (15<Age<34)		0.03652***	0.03282***		0.00046	0.00038		0.00006	0.00038
		(0.010)	(0.009)		(0.000)	(0.000)		(0.000)	(0.000)
Log (Female)		0.04643***	0.02955***		0.00141*	0.00098		0.00213*	0.00098
		(0.009)	(0.009)		(0.001)	(0.001)		(0.001)	(0.001)
Log (Capital intensity)		−0.00228	0.00013		0.00005	0.00005		0.00009	0.00005
		(0.001)	(0.001)		(0.000)	(0.000)		(0.000)	(0.000)
Industrial zone		0.09616**	0.04296		−0.00142	−0.00086		0.00257	−0.00086
		(0.037)	(0.041)		(0.001)	(0.001)		(0.004)	(0.001)
SOE		−0.11371	−0.13902**		−0.00557	−0.00382		−0.00678*	−0.00381
		(0.112)	(0.063)		(0.003)	(0.003)		(0.004)	(0.003)
Import		0.04749	0.01901		0.00068	−0.00023		0.00192	−0.00023
		(0.036)	(0.038)		(0.001)	(0.001)		(0.002)	(0.001)
Constant	0.01995***	−0.09136***	−0.06559***	0.00038**	−0.00180	−0.00116	0.00038**	−0.00184	−0.00086
	(0.004)	(0.021)	(0.023)	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
Observations	23,693	23,417	23,417	23,649	23,375	23,375	23,652	23,378	23,378
R-squared	0.039	0.049	0.253	0.003	0.007	0.268	0.005	0.007	0.796
Industry-province effects	No	No	Yes	No	No	Yes	No	No	Yes

R&D = research and development, SOE = state-owned enterprise.

Notes: Robust standard errors are clustered by industry and given in parentheses. The dependent variables are number of victims of accidents number of deaths, and number of deadly accidents. All columns use a single year of data (2011). Export intensity is measured by the fraction of sales exported. *** = significant at 1%, ** = significant at 5%, and * = significant at 10%.

Source: Author's calculations based on annual enterprise surveys (various years) obtained from the Government of Viet Nam, General Statistics Office.

VI. Conclusion and Policy Discussion

Apart from anecdotal evidence, there is no comprehensive study presenting evidence to test whether foreign-owned or exporting firms in developing countries suppress worker rights by worsening their nonwage working conditions. The popular press is filled with claims of multinational firms paying awfully low wages to domestic workers in low-income countries and forcing them to work under horrific conditions. The objective of this paper is to offer evidence of this association by estimating a relationship between exporting and foreign ownership characteristics of firms and the occurrence of accidents at work. The results generated are based on a comprehensive database of manufacturing sector firms in Viet Nam, a country that experienced a remarkable increase in aggregate exports, imports, and FDI from 1986 to 2011.

The empirical specification is built on the premise that, after controlling for various firm characteristics and unobserved cross-sectoral differences, there is a significant disparity in the number of accidents at work occurring in exporting as opposed to nonexporting firms. The most imperative outcome of this study is that there appears to be a positive and highly significant effect of exporting behavior and foreign ownership on the incidence of accidents in Vietnamese manufacturing firms. This result is robust to the inclusion of numerous firm and industry characteristics, and across alternative measures of nonwage working conditions and different quantifications of exporting status. Some other relevant findings pertain to these very firm characteristics: (i) older enterprises experience more accidents at work; (ii) SOEs are predicted to incur fewer accidents; (iii) firms with a greater degree of capital intensity experience a higher number of accidents than other manufacturing firms; (iv) a larger share of female employees is, on average, associated with incurring more accidents; and (v) a firm's location in an industrial zone is generally linked with a greater volume of accidents compared with firms located outside of industrial zones.

There is no doubt that international trade and FDI have helped provide improved job opportunities for Vietnamese workers. At the same time, the government deems it necessary that workers' rights be legally mandated and properly enforced, especially so in export processing zones and other industrial locations. A higher number of accidents may possibly be linked with excessive amounts of overtime hours. Several studies have reported disproportionate overtime hours in Vietnamese firms.[17] Milberg and Amengual (2008) point out that reducing overtime necessitates paying workers a sufficient salary to diminish the need for extra hours as well as adjusting production processes, as has been demonstrated by the ILO's Factory Improvement Programmes in Viet Nam and Sri Lanka. Increasing

[17] See, for instance, Wang (2005) and Barrientos and Smith (2006).

consumer demand for products produced under decent labor conditions can also prove to be effective (Harrison and Scorse 2010). An anti-sweatshop campaign can harm the reputation of a multinational company and encourage it to foster voluntary workplace codes of conduct as well as to comply with labor standard norms.

Certainly, more qualitative and quantitative research into the effects of trade agreements on labor standards would be useful, particularly if it could identify the most effective mix of enforcement mechanisms. It is imperative to analyze additional measures of nonwage working conditions including the health and safety of workers, number of hours worked, security and other benefits, details about the working environment, and age of the factory or plant, among others. It is hoped that given the significance of firm-supplied safer working conditions to continued growth and development in developing countries, the results generated in the paper may contribute to the design of more appropriate labor safety standards.

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Appendix

Table A.1. **Logistic Probability Model Estimation Results**

Variables	**(1)**	**(2)**	**(3)**
Log (Female)	0.091	0.063	0.117
	(0.215)	(0.272)	(0.276)
Log (Age)	−0.212	−0.209	−0.231
	(0.236)	(0.255)	(0.256)
Log (Size)	0.130	0.211	0.100
	(0.271)	(0.323)	(0.331)
SOE	0.161	0.248	0.400
	(0.471)	(0.489)	(0.496)
Export	−0.126	−0.171	−0.164
	(0.353)	(0.394)	(0.395)
Import	-1.218^{***}	-1.431^{***}	-1.295^{***}
	(0.338)	(0.361)	(0.370)
Foreign	0.232	0.390	0.432
	(0.472)	(0.510)	(0.514)
Log (Fixed assets)	0.157^{***}	0.155^{***}	0.222^{***}
	(0.044)	(0.047)	(0.061)
Log (R&D intensity)	1.151^{***}	1.247^{**}	1.246^{**}
	(0.395)	(0.491)	(0.490)
Log (Environmental expenditure)	0.475^{***}	0.471^{***}	0.479^{***}
	(0.068)	(0.076)	(0.075)
Constant	-6.333^{***}	-6.228^{***}	-6.751^{***}
	(0.635)	(1.217)	(1.248)
Observations	8,106	6,711	6,711
Year effects	No	No	Yes
Industry effects	No	Yes	Yes

R&D = research and development, SOE = state-owned enterprise.
Notes: Standard errors are given in parentheses. The dependent variable is a dummy variable that is equal to 1 if the firm does not respond to the question about labor accidents at work and 0 otherwise. The sample size is reduced upon the inclusion of industry fixed effects in the logistic probability regression, i.e., going from column (1) to (2) to (3). This is because, unlike an ordinary least squares estimation, the use of logit drops observations whose contribution to the log-likelihood function is 0 for given values of the parameters. *** = significant at 1%, ** = significant at 5%, and * = significant at 10%.
Source: Author's calculations based on annual enterprise surveys (various years) obtained from the Government of Viet Nam, General Statistics Office.

Table A.2. **Baseline Ordinary Least Squares Estimation Results—2002, 2004, and 2011**

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Export	3.290***	2.299***	1.751***	2.116***	1.030***	1.051***
	(0.565)	(0.303)	(0.222)	(0.672)	(0.367)	(0.374)
Log (Female)					0.369**	0.358**
					(0.142)	(0.144)
Log (Capital intensity)					0.202*	0.194
					(0.119)	(0.119)
Log (Age)					0.461***	0.471***
					(0.157)	(0.152)
SOE					−1.502**	−1.208*
					(0.683)	(0.704)
Import					0.494*	0.567
					(0.295)	(0.346)
Log (R&D intensity)					−0.998	−0.341
					(0.995)	(0.594)
Log (Environmental expenditure)					0.584**	0.607**
					(0.246)	(0.266)
Constant	0.760***	−0.238	1.021***	0.204	−1.238	−1.966**
	(0.096)	(0.205)	(0.038)	(0.239)	(2.260)	(0.793)
Observations	55,919	55,919	55,919	8,051	8,051	8,051
R-squared	0.018	0.045	0.232	0.062	0.055	0.074
Industry-year effects	Yes	Yes	No	No	Yes	No
Province effects	No	Yes	No	No	Yes	No
Industry-province-year effects	No	No	Yes	Yes	No	Yes

R&D = research and development, SOE = state-owned enterprise.
Notes: Robust standard errors are given in parentheses. The dependent variable is the number of accidents per thousand workers. *** = significant at 1%, ** = significant at 5%, and * = significant at 10%.
Source: Author's calculations based on annual enterprise surveys (various years) obtained from the Government of Viet Nam, General Statistics Office.

Table A.3. **Baseline Ordinary Least Squares Estimation Results: Interaction of Exporting Status and Foreign Ownership—2002, 2004, and 2011**

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Export	1.854***	1.423***	1.138***	1.458***	0.632***	0.666***
	(0.378)	(0.229)	(0.181)	(0.345)	(0.196)	(0.202)
Foreign	4.006***	3.041**	2.100**	2.284**	1.842*	1.854*
	(1.455)	(1.316)	(1.039)	(1.007)	(0.990)	(1.019)
Export × Foreign	1.007	0.448	0.411	0.563	0.695	0.629
	(1.093)	(1.040)	(0.841)	(1.976)	(1.910)	(1.943)
Log (Female)					0.260**	0.249**
					(0.111)	(0.113)
Log (Capital intensity)					0.154	0.148
					(0.121)	(0.122)
Log (Age)					0.532***	0.540***
					(0.169)	(0.164)

Continued.

Table A.3. *Continued.*

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
SOE					−1.009*	−0.704
					(0.514)	(0.549)
Import					0.249	0.309
					(0.298)	(0.349)
Log (R&D intensity)					−0.954	−0.259
					(0.948)	(0.517)
Log (Environmental expenditure)					0.585**	0.606**
					(0.238)	(0.255)
Constant	0.671***	−0.242	0.957***	0.126	−1.019	−1.712**
	(0.111)	(0.212)	(0.057)	(0.224)	(2.157)	(0.698)
Observations	55,919	55,919	55,919	8,051	8,051	8,051
R-squared	0.025	0.048	0.234	0.070	0.061	0.079
Industry-year effects	Yes	Yes	No	No	Yes	No
Province effects	No	Yes	No	No	Yes	No
Industry-province-year effects	No	No	Yes	Yes	No	Yes

R&D = research and development, SOE = state-owned enterprise.

Notes: Robust standard errors are given in parentheses. The dependent variable is the number of accidents per thousand workers. *** = significant at 1%, ** = significant at 5%, and * = significant at 10%.

Source: Author's calculations based on annual enterprise surveys (various years) obtained from the Government of Viet Nam, General Statistics Office.

Erratum

The author of the article on "An Economic Evaluation of the Health Effects of Reducing Fine Particulate Pollution in Chinese Cities" published in Volume 35, Issue Number 2 of the Asian Development Review pointed out the following details for correction.

1. Co-author's name on the cover and in the table of contents is mispelled. Shiqui Zhang should be Shiqiu Zhang.

2. Equation 5 on page 67: Y_i should be the numerator.

$$VSL_i = VSL_{Beijing,\ air\ pollution} * \left(\frac{Y_{Beijing}}{Y_i}\right)^e$$

$$\Downarrow$$

$$VSL_i = VSL_{Beijing,\ air\ pollution} * \left(\frac{Y_i}{Y_{Beijing}}\right)^e$$

3. Equation 7 on page 68: Y_i should be the numerator.

$$TC_i(c_i) = VSL_{Beijing,\ air\ pollution} * \left(\frac{Y_{Beijing}}{Y_i}\right)^e * P_i \sum_k \left\{ I_{ki} * \frac{RR_k(c_i) - 1}{RR_k(c_i)} \right\}$$

$$\Downarrow$$

$$TC_i(c_i) = VSL_{Beijing,\ air\ pollution} * \left(\frac{Y_i}{Y_{Beijing}}\right)^e * P_i \sum_k \left\{ I_{ki} * \frac{RR_k(c_i) - 1}{RR_k(c_i)} \right\}$$

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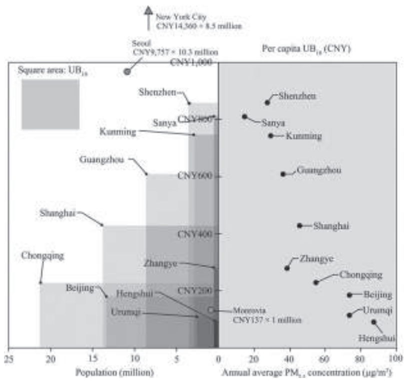
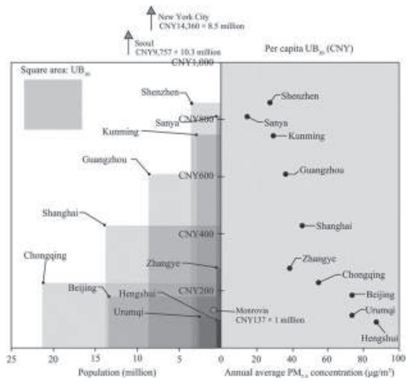
https://doi.org/10.1162/adev_x_00129

4. Figure 9 on page 79: There should be no dot indicating Seoul and there should be an arrow pointing up.





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