

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

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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. Fortunately, governments now have more efficient and equitable ways of supporting adjustments needed by people who choose or are forced to leave declining industries.

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*JEL codes:* F11, F43, F63, N50, O14

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## 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).<sup>1</sup> 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

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<sup>1</sup>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<sup>a</sup> in Agriculture, Mining, Manufacturing, and Services, 2014

Agriculture		Mining		Manufacturing		Services	
Malawi	8.35	Angola	6.07	Bangladesh <sup>b</sup>	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 <sup>b</sup>	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 <sup>b</sup>	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 <sup>b</sup>	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 <sup>b</sup>	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 <sup>b</sup>	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 <sup>b</sup>	3.54
Senegal	3.54	Australia	3.36	Belgium	1.10	Tonga	3.52
Ukraine	3.15	Peru	3.34	Philippines	1.08	Djibouti <sup>b</sup>	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 <sup>b</sup>	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:

<sup>a</sup>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%.)

<sup>b</sup>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.<sup>2</sup> 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

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<sup>2</sup>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.<sup>3</sup> Growth is assumed initially to come exogenously from improvements in total factor productivity (TFP) with no changes in aggregate factor endowments.<sup>4</sup> The influence of factor endowment changes is considered later in this section.

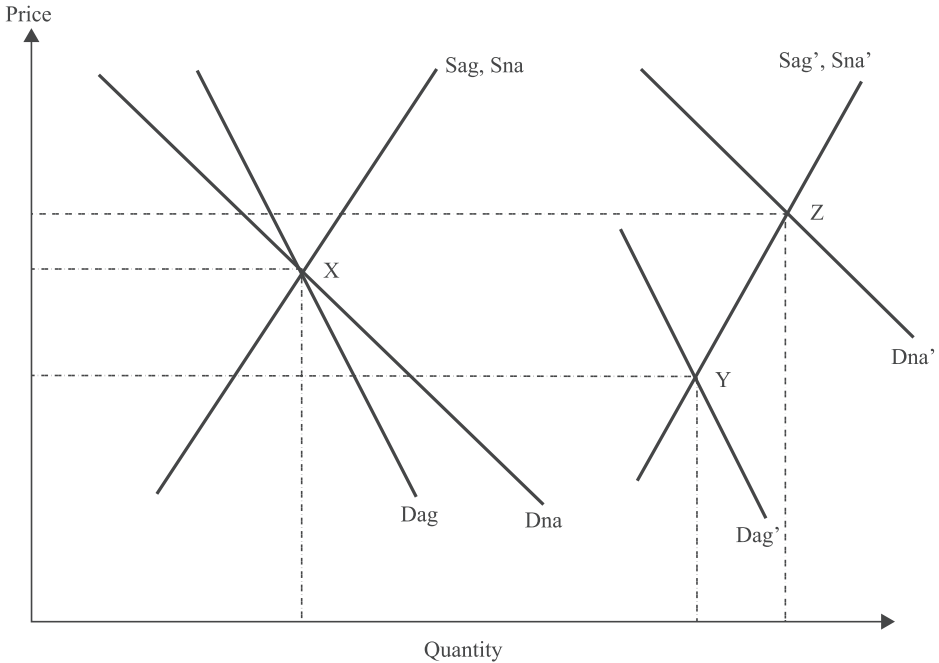
### A. Gross Domestic Product Shares of a Closed Economy

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

<sup>3</sup>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.

<sup>4</sup>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



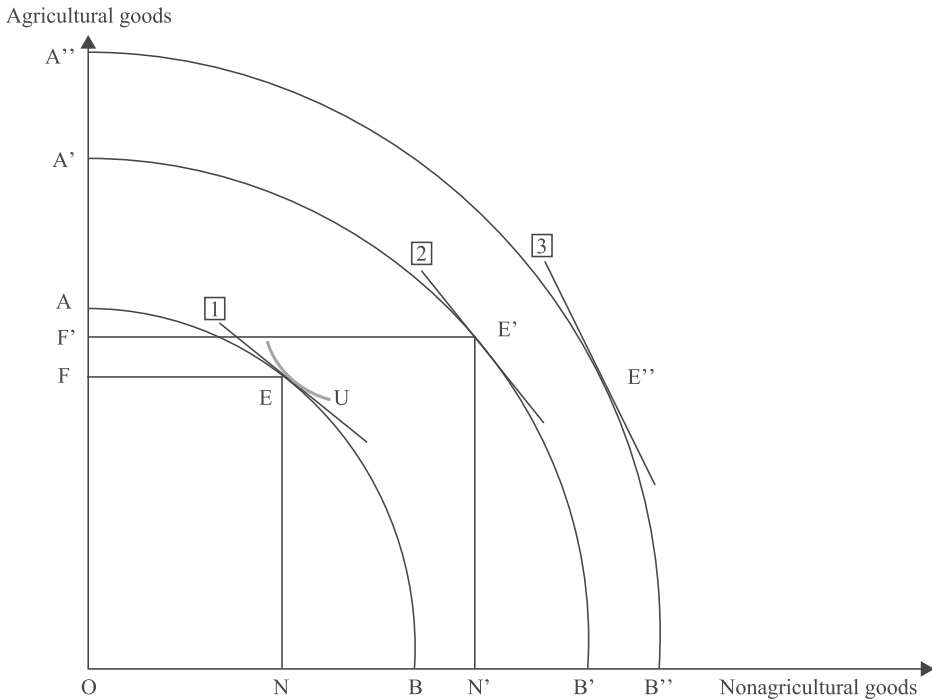
Sag = agricultural supply, Sna = nonagricultural supply, Dag = agricultural demand, Dna = nonagricultural demand. Source: Authors' adaptation from Figure 5.2 of Johnson, D. Gale. 1991. *World Agriculture in Disarray*, revised edition. London: St. Martin's Press.

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.

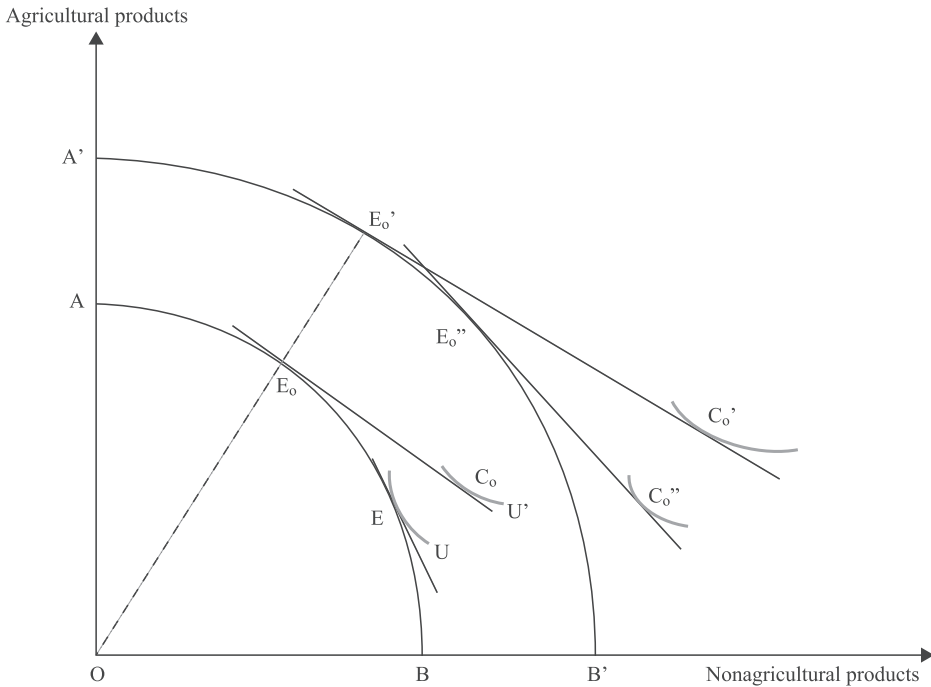
would shift  $AB$  to the northeast to  $A'B'$  if the shift is equiproportionate. The associated growth in per capita income would lead to a new equilibrium at  $E'$ , where the share of income spent on farm products would be lower than at  $E$  (because the income and price elasticities of demand for 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  $E_0$  and consume at point  $C_0$  in Figure 3, where the international terms of trade are given by (the negative of) the slope of  $E_0C_0$ . In that case, this economy's farm sector would have a larger share of GDP at  $E_0$  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  $E_0'$  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  $E_0''$ .

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.<sup>5</sup> 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.<sup>6</sup> 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.

<sup>5</sup>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).

<sup>6</sup>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.<sup>7</sup> 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.

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<sup>7</sup>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.<sup>8</sup> 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

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<sup>8</sup>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.<sup>9</sup> 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.<sup>10</sup>

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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<sup>9</sup>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.

<sup>10</sup>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 <sup>a</sup> 2000–2004	Agricultural Land per Capita <sup>a</sup> 2000–2004	Agricultural Land Value per Capita <sup>b</sup> 2014	Mineral Resources per Capita <sup>b</sup> 2014	Other Capital per Capita <sup>b,c</sup> 2014	GDP per Capita <sup>b</sup> 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
<b>Asia</b>	<b>24</b>	<b>34</b>	<b>102</b>	<b>63</b>	<b>33</b>	<b>37</b>
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:

<sup>a</sup>A percentage of the world average, based on hectares.

<sup>b</sup>A percentage of the world average, based on United States dollars at the market exchange rate.

<sup>c</sup>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.<sup>11</sup>

<sup>11</sup>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

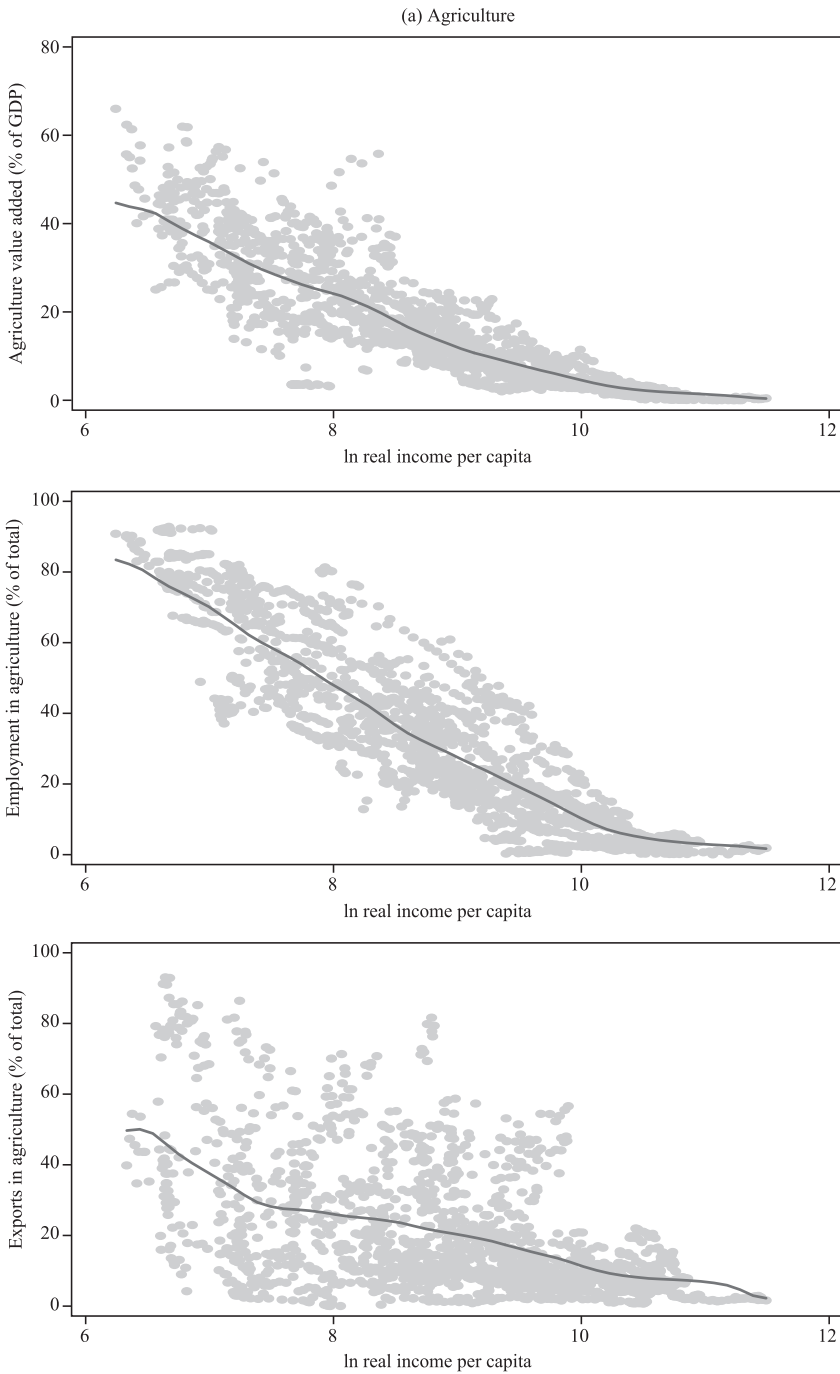
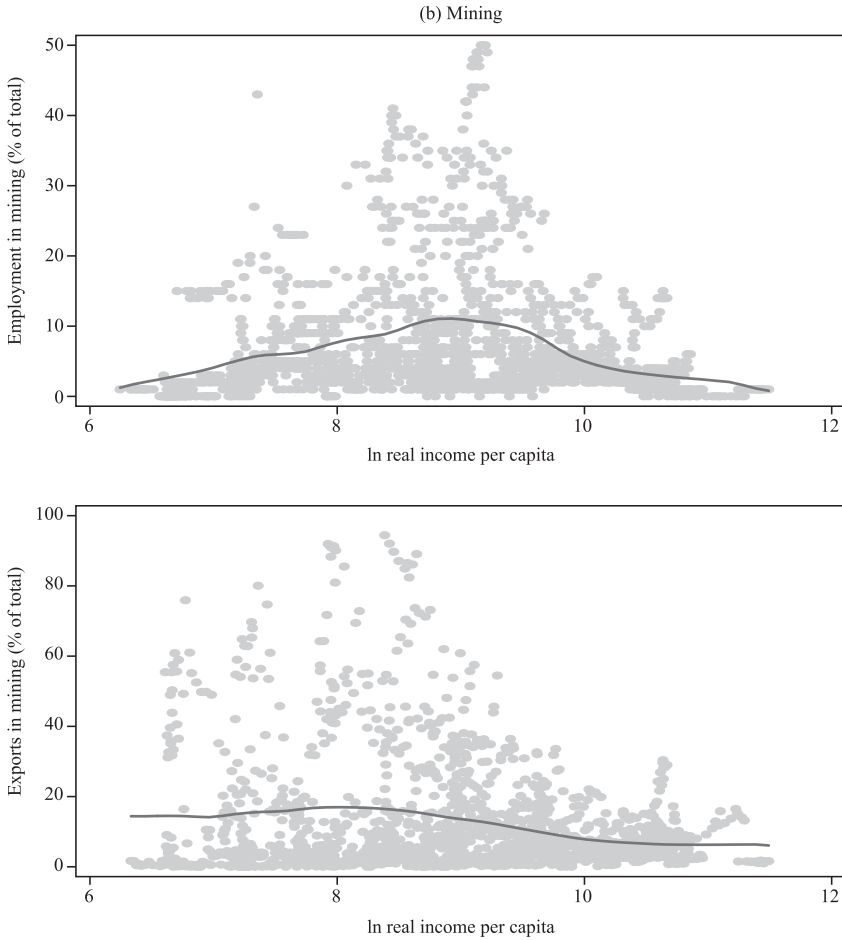


Figure 4. *Continued.*

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.*

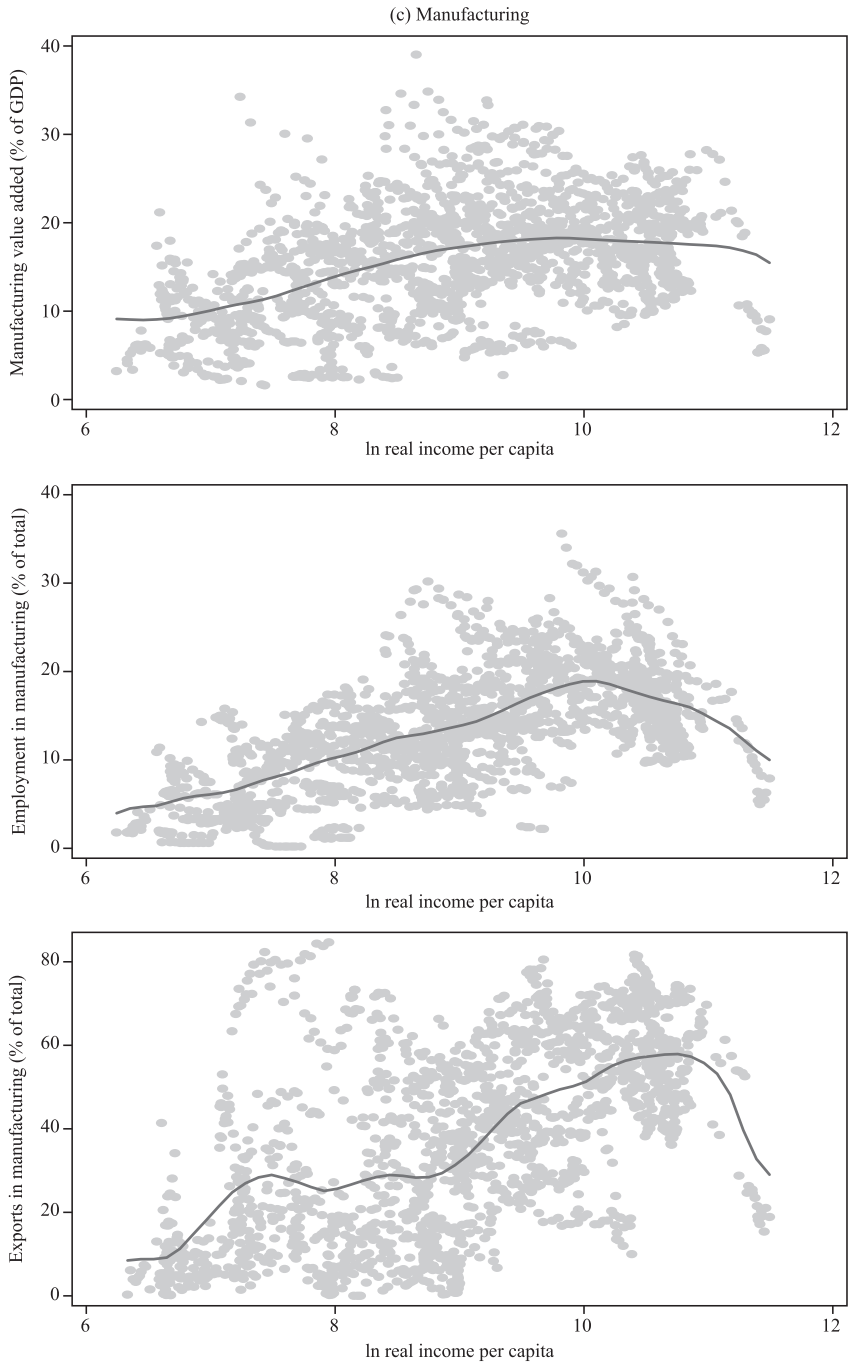
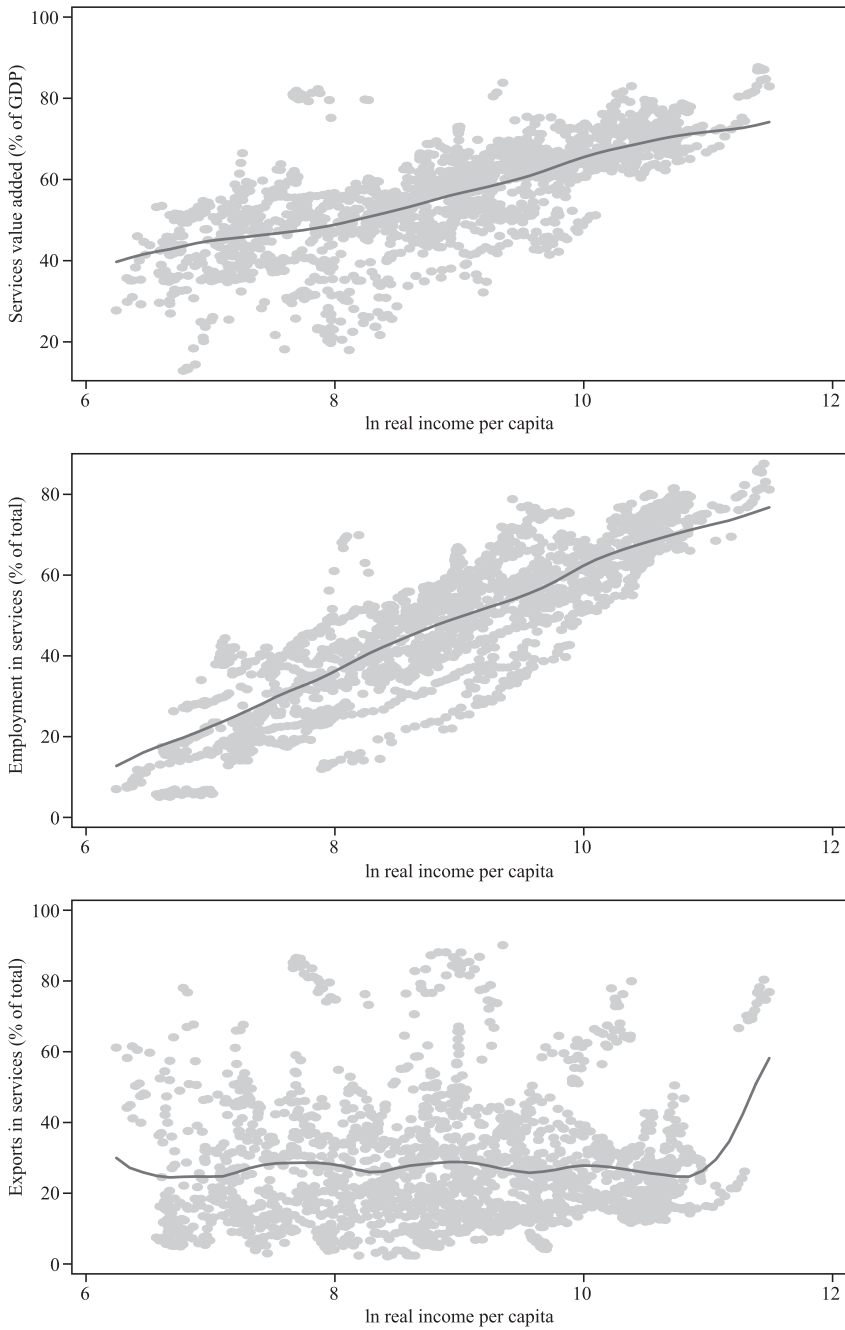




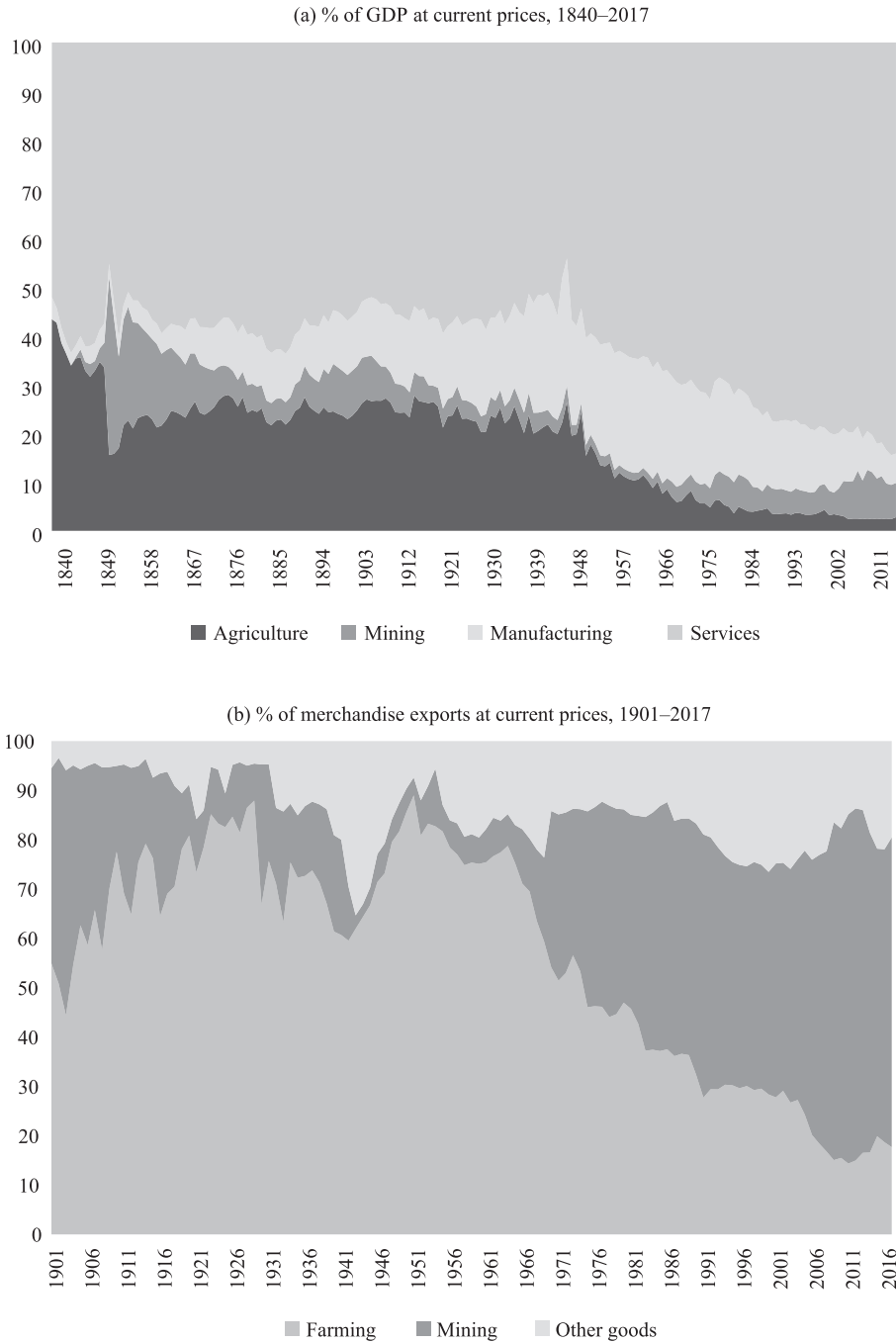
Figure 4. *Continued.*

(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



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.

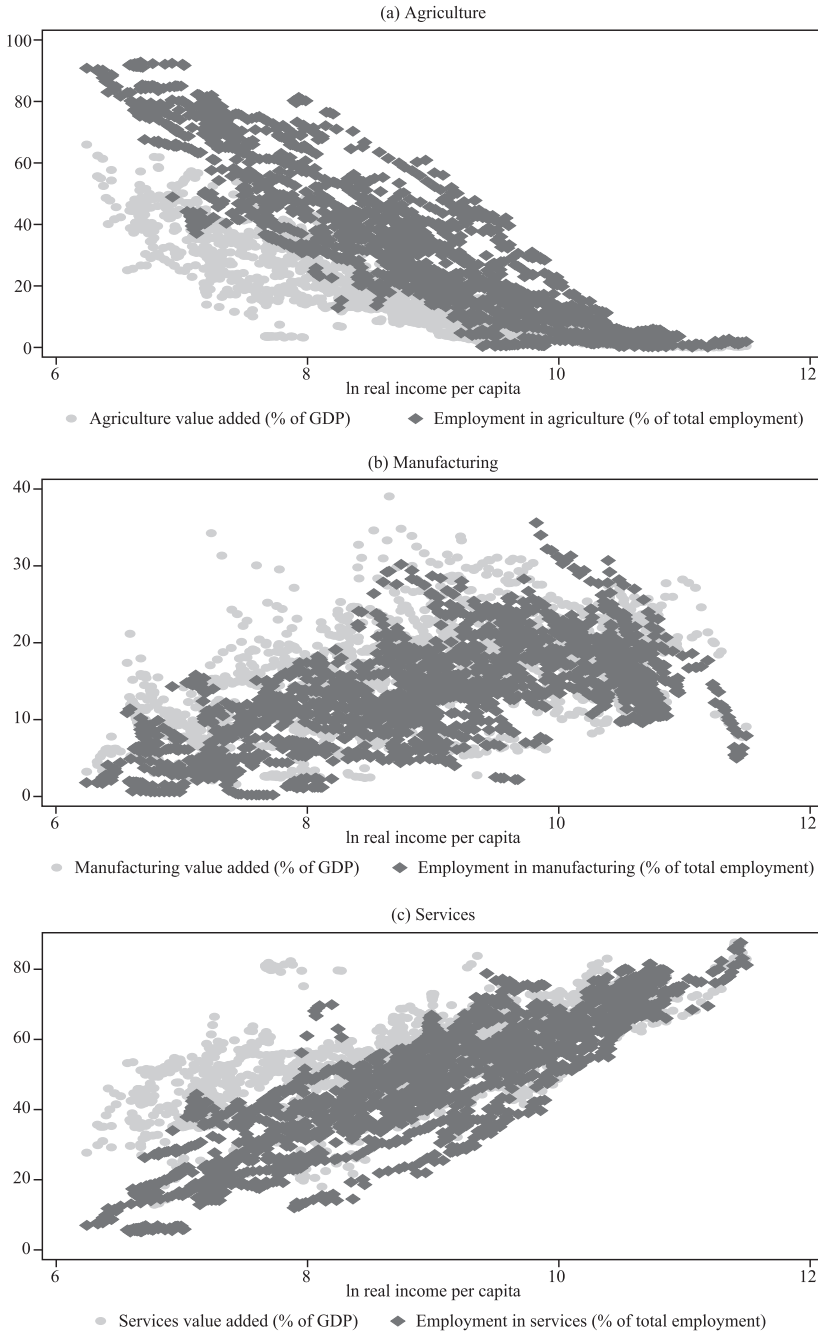
Source: Authors' compilation (see text).

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.

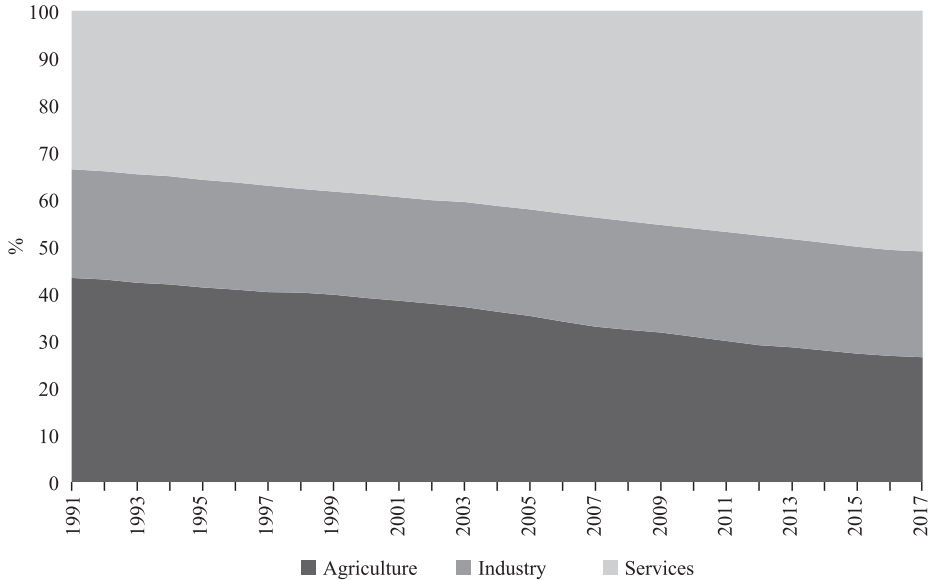
To explore hypothesis 1c, we can examine labor productivity for each sector by comparing the sector's shares of GDP and employment. A GDP share above (below) the employment share suggests that the sector's labor productivity is above (below) the national average. These shares are jointly plotted in Figure 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).

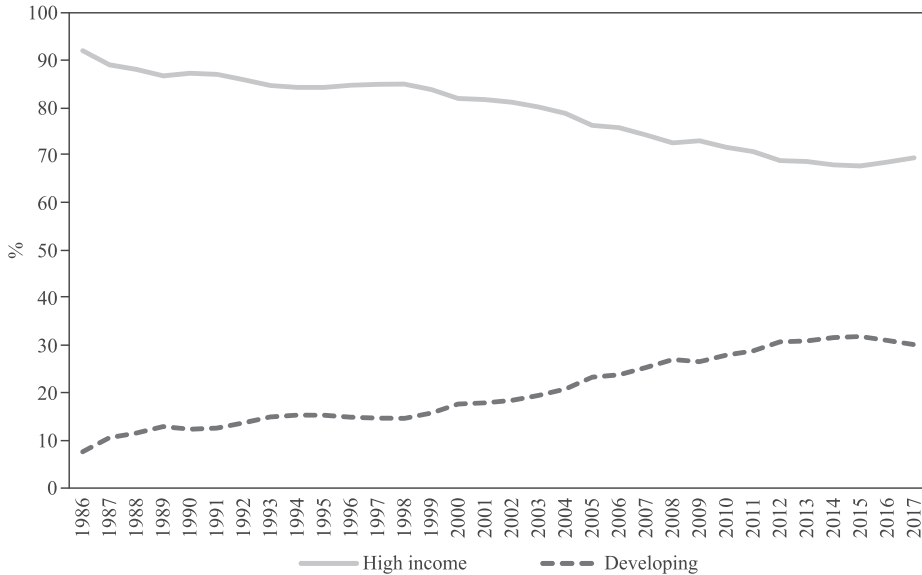
productivity (although it often does because of the very high capital intensity of mining even in low-income countries).

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.<sup>12</sup> 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

<sup>12</sup>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*** (−4.46)	8.828 (1.44)	10.126 (1.01)
ln YPC squared	2.014*** (3.99)	−0.415 (−1.24)	−0.485 (−0.84)
Agricultural endowment	2.071* (1.82)		
Capital endowment		−1.858 (−1.10)	4.064 (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).<sup>13</sup> 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

<sup>13</sup>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
In YPC	-46.42*** (-4.46)	1.994*** (2.68)	32.846*** (6.34)	1.614+++ (0.25)
In YPC squared	1.934*** (2.95)	-0.129*** (-2.89)	-1.901*** (-6.63)	0.453+++ (1.16)
Agricultural endowment	1.189 (1.26)			
Mineral endowment		0.025 (1.42)		
Capital endowment			-0.285 (-0.37)	0.045 (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

In = 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
In YPC	-51.343*** (-2.42)	-10.631 (-0.71)	64.43*** (2.82)	17.49++ (1.28)	15.661 (0.60)
In YPC squared	3.241*** (2.71)	0.560 (0.64)	-3.443*** (-2.76)	-1.232++ (-1.63)	-0.872 (-0.63)
Agricultural endowment	2.779 (1.44)				
Mineral endowment		0.258 (0.76)			
Capital endowment			-0.980 (0.25)	-1.523 (-0.82)	4.042 (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, In = 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*** (−3.77)	−38.806*** (−3.56)	−48.918* (−1.87)
ln YPC squared	2.201** (3.23)	1.522** (2.39)	3.123** (2.18)
Agricultural endowment	1.539 (1.48)	2.218** (2.07)	3.159 (1.52)
Agricultural TFP growth	2.811 (0.99)	−0.225 (−0.18)	8.071** (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

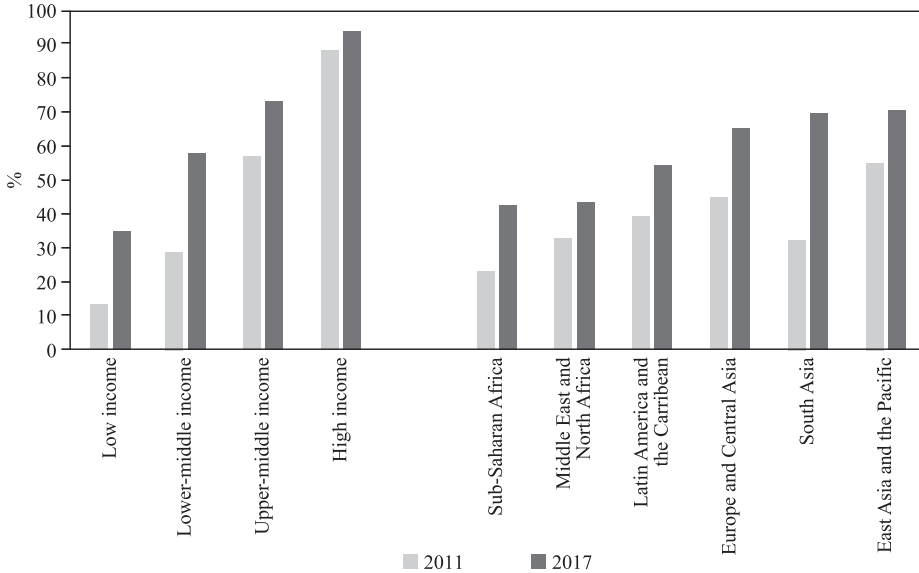
The theory outlined earlier, and the above empirical results provide clear lessons for governments. The most fundamental lesson is that the agriculture sector inevitably will eventually decline in the course of economic growth. Hence, intervening to prevent that decline with price-supportive policies 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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