Australian National University

Working Papers in Trade and Development

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

Kym Anderson

and

Sundar Ponnusamy

November 2018
Working Paper No. 2018/26

Arndt-Corden Department of Economics
Crawford School of Public Policy
ANU College of Asia and the Pacific

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

Kym Anderson
University of Adelaide and Australian National University
kym.anderson@adelaide.edu.au

and

Sundar Ponnusamy
University of Adelaide
sundar.ponnusamy@adelaide.edu.au

Understanding how and why economies structurally transform as they grow is crucial for sound national policy making. Typically analysts of this issue focus on sectoral shares of GDP and employment. This paper extends that to include exports, including of services. It also considers mining in addition to agriculture and manufacturing, and recognizes some of the products of those four sectors are nontradable. The theory section's general equilibrium model provides hypotheses about structural change in different types of economies as they grow, and tests them econometrically with annual data for a sample of 117 countries for the period 1991-2014. The results point to the futility of adopting protective policies aimed at slowing de-agriculturalization and subsequent de-industrialization in terms of sectoral shares, since those trends inevitably will accompany economic growth. Fortuitously governments now have far more efficient and equitable ways of supporting the adjustments needed by people choosing or being pushed to leave declining industries.

Keywords: patterns of structural change; comparative advantage; productivity growth; declining sectors.

JEL Classifications: D51; E23; F11; F43; F63; N50; N60; O13; O14

Structural Transformation to Manufacturing and Services: What Role for Trade?[1]

Most countries begin the process of economic growth with the vast majority of people engaged in producing staple food. As labour 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, within which he assumed labour was more productive than in the traditional (mainly subsistence agriculture) sector (Gollin 2014). This causes a lowering of the share of the population employed in agriculture and eventually of the absolute number employed on farms. Later in the development process the manufacturing sector's share of employment declines as well, and eventually also the number of workers in manufacturing (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 natural forests find mining (including de-forestation) also employs some workers, but that share of total employment tends to be quite small and also declines in the course of a nation's economic development.

GDP shares follow a similar pattern to employment shares. However, the GDP share of agriculture often declines faster than its employment share. By contrast, the GDP shares of mining and manufacturing often decline slower than their employment shares, implying labour productivity in those two sectors grows faster than the national average. Such labour productivity differences mean that, at the margin, migration of labour from traditional agriculture to manufacturing is likely to speed economic growth. The GDP share of services has tended to grow slower than its employment share because it (like traditional agriculture) is relatively labour 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, see Duernecker, Herrendorf and Valentinyi 2017).

[1] Revision of a paper prepared for an ADB conference on New Perspectives on Asian Development, Bangkok, 19-20 July 2018, and the Agricultural and Applied Economics Association Annual Meetings, Washington DC, 5-7 August 2018. Thanks are due to conference participants and journal referees for helpful comments. Forthcoming in *Asian Development Review* 36(2), September 2019.

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).[2] Also, over time, the peak shares of manufacturing in total GDP and employment have gradually fallen, and have been occurring at earlier real per capita income levels; and, in some developing countries, urbanization is occurring without much industrialization (Rodrik 2016; Gollin, Jedwab and Vollrath 2016; Felipe, Mehta and Rhee 2017; Nayyar, 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 highest-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, the further lowering of trade costs and governmental restrictions on trade is accelerating the fragmenting 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; 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: the international terms of trade for such countries have faced a long-term decline and are more volatile than those for other countries;[3] and the tradables sectors of high-income countries typically are 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

[2] 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 and households.

[3] See, e.g., Spraos (1980) and Pfaffenzeller, Newbolt 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.

long-run economic growth, led resource-rich developing economies – and Australia and New Zealand – to grow slower than others until they belatedly opened their economies (Anderson 98). 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 necessarily have to be produced domestically.

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

Recent empirical attempts to explain observed structural changes have tended to focus on one or a subset of countries, or sectors (normally ignoring mining), or contributors (particularly labour productivity); and they have tended to 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 the present 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/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 at the terms of trade faced at that country's border. The differences between the closed and open economy are small for

sectoral shares of GDP and employment, but can be large for sectoral shares of exports. It then takes that theory to a panel of annual data for 117 countries over the 25 years to 2014, to show the extent to which declines in the relative importance of primary and then manufacturing sectors in GDP, employment and exports are explained by changes in per capita income, relative factor endowments and, in the case of agriculture, the sector's own productivity growth.

The results are unsurprising for GDP and employment shares, whose decline for 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 export specialization in a few primary products is retained for those high-income countries relatively well endowed in agricultural land or mineral reserves per worker. 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) while remaining specialized in exports of primary products (Gill et al. 2014).

The structure of the paper is as follows. The first section summarizes what trade and development theory would lead one to expect about structural transformation as economies grow. The 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. Then regression results are tabled 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.

Theory

It is helpful to begin by 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, it is assumed there are no intermediate inputs and all markets are perfectly competitive and free of government interventions[4] so that there is full employment of all factors of production. Growth is assumed initially to come exogenously from improvements in total factor productivity (TFP), with no changes in aggregate factor endowments;[5] but later in this section the influence of factor endowment changes also is considered.

GDP shares of a closed economy

Consider first a closed economy with only two sectors: agriculture and non-agriculture. 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 the two sectors' supply curves coincide initially and hence also subsequent to productivity growth that lowered 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 income on food as their incomes rise, the demand curve shifts out less for agricultural goods than for other products in the wake of productivity-improving income growth. Thus output of both sectors rise but less so for agriculture, and the price of farm products falls relative to the price of non-farm products – and more so the more price inelastic is the demand for food. The GDP share of agriculture (non-agriculture) is below (above) 50% at the new equilibrium points Y and Z. It would fall even more over time in that growing economy the more the income and price elasticities of demand for food fall further below one 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 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 the ratio of the international prices of agricultural products to

[4] Changes in taxes, subsidies or quantitative restrictions on production, consumption or trade in products or the factors used to produce them also affect the structural transformation of an economy, but are ignored here.
[5] The emphasis on technical change as the key source of economic growth that is inducing structural transformation is consistent with the recent empirical literature (Herrendorf, Rogerson and Valentinyi 2014).

other products will decline over time as global per capita income grows. This is consistent with what happened over the 20th century (Pfaffenzeller, Newbolt and Rayner 2007).

The effects of these tendencies in a closed economy can be seen also 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 non-farm 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 of) the 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, would shift AB to the northeast, to A'B' if equi-proportionate. 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 (due to the income and price elasticities of demand for food being less than one). 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 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, as in a move from E to E" where price line 3 is even steeper than price line 2.

GDP 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 non-farm products at the prevailing international terms of trade? Then instead of its initial equilibrium being at point E in Figures 1 and 2, 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 minus 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 was biased toward farm or non-farm production. If that growth was sectorally unbiased, agriculture's share would remain unchanged, at E_0' in Figure 3. If economic growth abroad was similarly unbiased, it would have lowered the relative price of

farm products for reasons mentioned above, in which case this small economy's international terms of trade would have deteriorated 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 towards agriculture for the quantity change to more than offset its terms of trade deterioration.[6] The agricultural growth bias would have to be even stronger in a *large* farm-exporting economy since its growth would depress the country's international terms of trade further.

Adding a nontradables sector

In reality, a large part of each economy involves the production and consumption of nontradable goods and services, because of those products' prohibitively high trade costs. The prices of such products 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 is strengthened if the share of tradables in GDP is likely to decline 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 value of nontradables will increase relative to that of tradables. This is illustrated in Figures 1 and 2 if the axes are re-labelled 'tradables' and 'nontradables' in place of 'agricultural goods' and 'non-agricultural 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

[6] 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).

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 1 and 2 above showed it did for agriculture. While that elasticity may be above one in low-income countries, it falls increasingly below one as countries become more affluent.[7] Hence the manufacturing sector also is 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.

Allowing for mining

To be relevant also to resource-rich economies, assume now that the natural resource-based tradables sector involves mining as well as agriculture. Domestic demands for ores, minerals and energy raw materials rise as a country begins to industrialize, build more infrastructure and become more affluent, but then tend to fall as high-tech manufacturing and services increasingly dominate non-primary 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, though, 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.

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. By 2014 services accounted for at least 40% of national export earnings for around one-third of all countries (when the global average was 21%). Some of those tradable services are based on natural resources (e.g., tourism in conservation parks and at beaches and ski resorts; gas pipeline or transport transit), others take advantage of low wages (telephone call centres) or sophisticated financial sectors (international banking and

[7] Empirical estimates for the UK and US is supportive of 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).

insurance). To accommodate that, the resource-based services can be included with agriculture and mining in the natural resources sector and the rest can be included along with 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 relate to products that are nontradable. One can think of the services shares as being 'nontradables' if it were the case that the number of services jobs or GDP value related to tradables were equivalent to those for goods that are nontradable.

Employment shares

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

Historically, out-migration from agriculture has been sluggish because typically it also 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 with a move for an urban worker 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 occupation 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 because of its seasonality (McCulloch 2017).

The share of mining in employment, by contrast, typically is 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 sub-soil or sub-seabed reserves, can be a significant source of both mining sector GDP growth and structural transformation, but not necessary of

more local jobs in that sector if local workers lack the skills required for those tasks. This contrasts with mining booms pre-World War I which attracted immigrants for such labour-intensive tasks as panning for gold.

As for productivity impacts on sectoral employment, they can have either sign.[8] On the one hand, the adoption by one sector of labour-saving technologies can raise its output and perhaps exports but reduce its employment, thereby *pushing* labour to other sectors (Gollin, Parente and Rogerson 2002, 2007). On the other hand, labour could be *pulled out* of a sector due to new job prospects in another sector that is enjoying faster total factor productivity growth and/or faster demand growth associated with the spending of the 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). The net effect of the latter 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.

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 the various sectors unevenly. Growth also results from investments in innovation or in importation and adaptation of technologies from more-advanced economies. Income growth also can result from net factor accumulation over and above depreciation.[9] Natural resource capital, for example, can be discovered through mining exploration or improved through investment (e.g., clearing and fencing farmable land). Produced capital also can be enhanced through domestic investment or by importing it from abroad; and the stock of labour changes through births exceeding deaths, altered labour force participation (e.g., more women choosing paid work), population aging, and immigration net of emigration.

[8] According to the induced innovation hypothesis, productivity growth will be biased in favor of saving the scarcest factor of production most (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.

[9] 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 labelled as ‘technological change’.

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 outputs of the most capital-intensive industries and shrinking that of the most labour-intensive industries. In developing countries where agriculture is among the most labour-intensive industries, along with such industries and clothing and footwear, this can be another source of relative decline in those sectors of growing economies. Martin and Warr (1993, 1994) found this has been the case for agriculture in Indonesia and Thailand.

Export shares: less clear-cut

What about sectoral export shares? They 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, it 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 non-farm products, for example, the country would see a strengthening of its agricultural comparative advantage.

The two key workhorse theories of comparative advantage developed in the twentieth 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 specific to each sector. Those two models have been blended to account for primary sectors that use specific natural resource capital (farmland, mineral deposits) in addition to intersectorally mobile labour and produced capital (Krueger 1977, Deardorff 1984). That 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 plus human skills and technological knowledge) per hour of available labour tends to strengthen comparative advantage in non-primary 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, *ceteris paribus*.[10] 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 typically is agrarian, with most GDP and employment in the agricultural 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, labour rewards will be low. It may be autarkic initially, but as its trade costs fall or governmental trade restrictions are removed, it will develop a comparative advantage in unskilled labour-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.[11]

In the standard Heckscher-Ohlin model of international trade, in which factors of production are perfectly mobile intersectorally, international trade in 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). That is not so in the specific-factor or blended trade models, however, where rewards to intersectorally mobile labour will tend to be above (below) the global average in countries that are lightly (densely) populated. That wage difference may be sufficient to induce international labour movements.

Specifically, natural resource-abundant economies may attract migrants from more-densely populated countries, 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 slower than in economies that are growing equally rapidly but are less

[10] Columns 3 to 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 within 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 is likely to be that country's comparative advantage in resource-based products.

[11] The above theory of sectoral changes and evolving comparative advantages has been used successfully to explain the twentieth century 'flying geese' pattern of comparative advantage and then disadvantage in unskilled labour-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 of production processes and the lengthening of regional and global value chains (Baldwin 2016; Constantinescu, Mattoo and Ruta 2018; Rodrik 2018).

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 non-primary sectors would be relatively capital intensive. This is all the more likely if new technologies developed for the primary sector become increasingly labour-saving as real wages rise – leading potentially to what are known as factor intensity reversals, whereby a primary industry in a high-wage country can retain competitiveness against low-wage countries by that industry becoming more capital intensive. The primary sector's share of GDP would decline slower the more its productivity grew faster than the average global rate, both relative to that of other sectors.

Around the above long-run trends there tend to be cycles in the international prices of some commodities. As well, 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. That, in turn, draws resources to that sector, and to the sectors producing nontradables such as services, and thus away from other sectors producing tradables, *ceteris paribus*. It also raises national income and so boosts the domestic demand for both locally produced and imported products. Together those forces reduce the volume of exports from non-booming 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 so 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 that comes 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) also are 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) one, and that elasticity declines toward zero (one) as incomes grow. Within the food bundle, demand elasticities for staples fall much earlier than for non-staples 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 one in low-income countries, falls increasingly below one as countries become affluent. Because production of income-elastic goods tends to use skilled labour 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. One 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 that are near high-income countries with fewer such assets. Another example relates to transit services. Landlocked countries, especially smaller ones with large neighbours, have a comparative advantage in providing transit services such as underground pipelines or access to roads, rail and rivers. Yet another is call centre and information technology services requiring English-language capability: the ICT revolution has strengthened the comparative advantage in such labour-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.

Impact of market-distorting policies

Changes in taxes, subsidies or quantitative restrictions on production, consumption or trade in products or the factors or intermediate inputs used to produce them also can be and are used to 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, for food and energy security, for food safety, and for environmental degradation. That has contributed to systematic differences in the use of trade and other price-distorting policies in responding to those concerns. Differing perceptions of risk also have led to different policies toward new technologies.

Specifically, developing country governments tend to depress agricultural relative to manufacturing incentives facing producers but to gradually change to the opposite sectoral bias as the country passes through the upper middle-income stage, thereby artificially boosting the 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 (2011). Since these sectoral support policies typically have a strong anti-trade 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 have raised or lowered 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 they become more affluent, however, emerging economies 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 mining's share of exports is initially lowered but less so as income growth proceeds – and may be inflated eventually 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 re-location of fossil fuel-intensive industries to less-regulated poorer countries.

As well as these long-run trends in sectoral policies, in some natural resource-rich countries governments assist tradable sectors that lag 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, the 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 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 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.

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 initially will rise and then eventually fall after countries reach a high per capita income. However:
   1.1 in lightly populated settler economies, the agricultural (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;
   1.2 the share of exports of labour-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;
   1.3 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 labour productivity will become relatively low;
   1.4 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
   1.5 the shares of services may be high, especially in exports, for developing countries with a strong comparative advantage in tourism, transit, call centre 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 mining labour 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

3.1 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

4.1 except in those developing countries with a strong comparative advantage in such services as tourism, transit, call centre or information technology services.

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 total factor productivity growth in that sector relative to that of the rest of the economy

6.1 and in particular those shares will be higher for countries that have adopted high-yielding green revolution or GM crop varieties.

Data for pertinent variables

In order to test the above hypotheses, we have assembled annual data for more than 160 countries and for the years 1990 to 2016. 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 to 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 four sectors (agriculture, mining, manufacturing and services) are:

- Sectoral shares of GDP (value added), S_v
- Sectoral shares of employment, S_e and
- Sectoral shares of exports of goods and services, S_x

Data sources are as follows: S_v are from World Bank (2018a); S_e are from World Bank (2018a) except for manufacturing shares which are from ILO (2018); and the export value data in current US dollars, to generate S_x, are from World Bank (2018a) which draws from United Nations (2018) trade data for goods[12] and from IMF balance of payment data for services.

The explanatory variables to be used to explain those sectoral shares and indexes are:

- Real income per capita, defined as the natural log of GDP per capita, PPP (constant 2011 international $), are from World Bank (2018a);
- Factor endowments 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 (2018a), interpolating linearly for the years in between, and extrapolating back to 1990 using the same rate of change as between 1995 and 2000 and forward to 2016 using the same rate of change as between 2010 and 2014. Three per worker ratios are used:
    - Agricultural land, defined as the discounted sum of the future value of crop and pasture land rents,
    - Mineral and energy raw material reserves, defined as the discounted sum of the value of rents generated over the lifetime of the reserves, and
    - 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 (with persons being disaggregated by gender and employment status).
- National total factor productivity growth rate estimates for agriculture, TFP, are available to 2012 from Fuglie, Wang and Ball (2012).

Evidence of structural transformation as per capita incomes grow

Before turning to regression results in the next section, this section looks at just the relationship between per capita income and sectoral shares. In Figures 4(a) to 4(d), the four

[12] The Standard International Trade Classification codes for agriculture are SITC 0, 1, 2 except 27 and 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 labour-intensive manufactures such as textiles, clothing and footwear (SITC 65, 84 and 85).

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, 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.

Exceptions to this hypothesis can be found of course. A particularly striking one is agriculture's GDP share in Australia: for the 10 decades to 1950, that share remained within the 20-30% range (Figure 5(a)) – 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 labour-saving farm technologies, as well as rapid immigration (Anderson 2017). This is consistent with hypothesis 1.1. Also clear from Figure 5(a), and supportive of hypothesis 1, is the rise and then 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 removal of import quotas in the 1960s and the lowering of tariffs from 1972, that sector's share fell exceptionally rapidly. By 2016 it was just 6%, compared with an average of 14% in other high-income countries (World Bank 2018). Figure 5 also is strongly supportive of 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 1.2, we separated out exports of labour-intensive manufactures (defined simply as textiles, clothing and footwear, SITC 65, 84 and 85) from other manufactures, and plotted the share of this sub-sector of exports against real per capita income. Figure 6 shows strong support for that hypothesis: the share of exports of labour-intensive manufactures in total exports initially rises but then declines as per capita incomes rise.

To explore hypothesis 1.3, we can examine labour productivity for each sector by comparing the sector's shares of GDP and employment. If the GDP share is above (below) the employment share, it suggests that sector's labour 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 labour productivity is relatively low. Figure 7 also

reveals that it is manufacturing rather than services that tends to have above-average labour 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 labour productivity (although it often does because of the very high capital intensity of mining even in low-income countries).

Hypothesis 1.4 concerns shares of global employment. Figure 8 shows that indeed the share of agriculture (services) in global employment has been declining (rising), while employment in industry[13] has maintained its share at 22-23% -- consistent with the finding of little trend in the estimated global share of manufacturing by Felipe and Mehta (2016). With the slower growth and greater capital intensity of industry in high-income countries than developing countries, the share of industry jobs that are in the high-income country group 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 on the share from high-income countries (Figure 9).

As for hypothesis 1.5 and 3.1, Table 1 reveals that the 30 countries with the highest shares of services in their exports are mostly small (often tropical tourist island) developing countries, and there is only one high-income country 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, Canada, 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.

Regression results

We turn now to fixed effects panel regression results. Since the hypothesized relationships between sectoral shares and per capita income are not linear, we use the natural log of per

[13] 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 (2018a).

capita income and also 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 at least open economies. They are the value of the stocks per worker of agricultural land, of mineral and energy resources, and of produced (physical plus human) capital. As well, 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 value added (that is, of GDP).[14] Consistent with the convex line in Figure 4(a), for agriculture both the log of income per capita and its square have significant coefficients. So too does the endowment of agricultural land per worker and – consistent with trade theory – its sign is positive. The income coefficients for manufacturing also have the expected signs and are consistent with the inverted U line in Figure 4(c). 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, consistent with Figure 4(d), their values suggest that sector's share of GDP rises almost linearly with income. 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. For agriculture and manufacturing they have the same signs as in the value added equations; for mining they are consistent with the inverted U-shape in Figure 4(b); 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 (consistent with the wide income range of countries with a comparative advantage in mining), but for other sectors they range from 0.40 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 the expected signs. Likewise 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 as expected, given the wide range of comparative advantages of countries at each income level.

[14] Mining is missing because we had insufficient countries' data on its share of GDP.

The agricultural equations are repeated in Table 6 but with another explanatory variable added: TFP, the rate of total factor productivity growth in agriculture. Its coefficients are not very significant, but their signs suggest faster farm TFP growth adds to the sector's shares of GDP and exports but reduces its employment share (perhaps because of its labour-saving bias). Ideally this TFP variable should be for agriculture relative to other sectors, but unfortunately there are no estimates available for non-agricultural TFP growth over the 1991-2014 period for these 95+ countries.

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

- The 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 as countries approach high-income status.
- The share of exports of labour-intensive manufactures in total exports decline as per capita income expands.
- The decline in the share of employment in agriculture lags the decline in agriculture's share of GDP.
- Countries well-endowed with farm land (mineral or energy resources) per worker have a larger share of their exports from the farm (mining) sector.
- Exports of manufactures are more labour intensive, the smaller a country's per worker endowment of capital.
- Agriculture's shares of GDP and exports are higher, and of employment are lower, the higher the rate of total factor productivity 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.

Policy implications

The theory outlined earlier and the above empirical results provide clear lessons for governments. The most fundamental is that the agricultural sector will inevitably decline in the course of economic growth nationally, or even just in the rest of the world. Hence intervening to prevent that 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 manufacturing and exporting of products that are intensive in the use of unskilled labour are likely to expand initially in densely populated, natural resource-poor countries, but such industries also will inevitably decline as a share of growing economies as national real wages rise. Hence protecting jobs and factories in such industries from import competition also will become ever-more expensive over time.

Third, and less well-known, manufacturing as a whole will inevitably decline as a share of GDP, and in high-income countries its share of employment has been declining even faster than its GDP share (Figure 4(c)). Hence policies aimed at slowing de-industrialization, like those aimed at slowing de-agriculturalization, 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 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 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 six 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, where financial services penetration is only 2.5 and 5 percentage points, respectively, below the national average.

If open countries are still unsatisfied with the contribution of their farmers to national food security, as reflected in food self-sufficiency ratios, alternatives to protectionism include subsidizing investments in agricultural R&D, in rural education and health, and in roads and

other rural infrastructure improvements. If such activities are currently under-invested in, 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 has been exceptionally high (Michaels 2011). Together with general evidence that opening up contributes to economic growth (e.g. Lucas 2009), this 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 sounder 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.

References

Acemoglu, D. and P. Respetto (2018), "The Race between Man and Machine: Implications of Technology for Growth, Factor Shares, and Employment", *American Economic Review* 108(6): 1488–1542.

Anderson, K. (1987), "On Why Agriculture Declines With Economic Growth", *Agricultural Economics* 1(3): 195-207, October.

Anderson, K. (1998), "Are Resource-Abundant Economies Disadvantaged?" *Australian Journal of Agricultural and Resource Economics* 42(1): 1-23, March.

Anderson, K. (ed.) (2009), *Distortions to Agricultural Incentives: A Global Perspective, 1955-2007,* London: Palgrave Macmillan and Washington DC: World Bank.

Anderson, K. (2017), "Sectoral Trends and Shocks in Australia's Economic Growth", *Australian Economic History Review* 57(1): 2-21, March.

Anderson, K. and S. Nelgen (2013), *Updated National and Global Estimates of Distortions to Agricultural Incentives, 1955 to 2011,* World Bank, Washington DC, accessed at www.worldbank.org/agdistortions.

Anderson, K., G. Rausser and J.F.M. Swinnen (2013), "Political Economy of Public Policies: Insights from Distortions to Agricultural and Food Markets", *Journal of Economic Literature* 51(2): 423-477, June.

Anderson, K. and B. Smith (1981), "Changing Economic Relations Between Asian ADEs and Resource-Exporting Developed Countries", pp. 293-338 in *Trade and Growth in the Advanced Developing Countries,* edited by W. Hong and L. Krause, Seoul: Korea Development Institute Press.

Anderson, K., and A. Strutt (2016), "Impacts of Asia's Rise on African and Latin American Trade: Projections to 2030", *The World Economy* 39(2): 172-94, February.

Balassa, B. (1965), "Trade Liberalization and Revealed Comparative Advantage", *Manchester School of Economic and Social Studies* 33(2): 99–124.

Baldwin, R. (2016), *The Great Convergence: Information Technology and the New Globalization*, Cambridge MA and London: Harvard University Press.

Bennett, M.K. (1936), "World Wheat Utilization Since 1885-86", *Wheat Studies of the Food Research Institute* 8: 339-404, June.

Bennett, M.K. (1941), "Wheat in National Diets", *Wheat Studies of the Food Research Institute* 18(2): 35–76, October.

Boppart, T. (2014), "Structural Change and the Kaldor Facts in a Growth Model with Relative Price Effects and Non-Gorman Preferences", *Econometrica* 82(6): 2167–96.

Caron, J., T. Fally, and J.R. Markusen (2014), "International Trade Puzzles: A Solution Linking Production and Preferences", *Quarterly Journal of Economics* 129(3): 1501-52.

Clark, C. (1957), *The Conditions of Economic Progress*, 3rd edition, London: Macmillan.

Coady, D., I. Parry, L. Sears and B. Shang (2017), "How Large Are Global Energy Subsidies?", *World Development* 91(1): 11-21.

Constantinescu, C., A. Mattoo and M. Ruta (2018), "Trade in Developing East Asia: How It Has Changed and Why It Matters", Policy Research Working Paper 8533, World Bank, Washington DC, July.

Corden, W.M. (1984), "Booming Sector and Dutch Disease Economics: Survey and Consolidation", *Oxford Economic Papers* 36(3): 359-80, November.

Crowson, P. (2018), "Intensity of Use Re-examined", *Mineral Economics* 31 (1-2): 61-70, May.

Deardorff, A.V. (1984), "An Exposition and Exploration of Krueger's Trade Model", *Canadian Journal of Economics* 5(4): 731-46.

Demirgüç-Kunt, A., L. Klapper, D. Singer, S. Ansar and J. 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

Duernecker, G., B. Herrendorf and A. Valentinyi (2017), "Structural Change Within the Service Sector and the Future of Baumol's Disease", CEPR Discussion Paper 12467, London, November.

Engel, E. (1857), "Die Productions und Consumtionsverhältnisse des Königreichs Sachsen", *Zeitschrift des statistischen Bureaus des Königlich Sächsischen Ministerium des Inneren* 8–9: 28–29.

Felipe, J. and A. Mehta (2016), "Deindustrialization? A Global Perspective", *Economics Letters* 149: 148-51.

Felipe, J., A. Mehta and C. Rhee (2017), "Manufacturing Matters…But it's the Jobs That Count", mimeo, University of California, Santa Barbara, November.

Fort, T.C., J.R. Piercet and P.K. Schott (2018), "New Perspectives on the Decline of US Manufacturing Employment", NBER Working Paper 24490, Cambridge MA, April.

Frankel, J.A. (2012), "The Natural Resource Curse: A Survey," Ch. 1 (pp. 17-57) in *Beyond the Resource Curse*, edited by B. Shaffer, Philadelphia PA: University of Pennsylvania Press.

Freebairn, J. (2015), "Mining Booms and the Exchange Rate", *Australian Journal of Agricultural and Resource Economics* 59(4): 533-48.

Fuglie, K.O., S.L. Wang and V.E. Ball (eds.) (2012), *Productivity Growth in Agriculture: An International Perspective*. London: CABI. National agricultural productivity estimates are accessible for 1961 to 2012 at http://www.ers.usda.gov/data-products/international-agricultural-productivity.aspx

Gill, I.S., I. Izvorski, W. van Eeghen and D. de Rosa (2014), *Diversified Development: Making the Most of Natural Resources in Eurasia,* Washington DC: World Bank.

Gollin, D. (2014), "The Lewis Model: A 60-year Retrospective", *Journal of Economic Perspectives* 28(3): 71-88, Summer.

Gollin, D., R. Jedwab and D. Vollrath (2016), "Urbanization With and Without Industrialization", *Journal of Economic Growth* 21(1): 35-70, March.

Gollin, D., S.L. Parente and R. Rogerson (2002), "The Role of Agriculture in Development", *American Economic Review* 92(2): 160-64, May.

Gollin, D., S.L. Parente and R. Rogerson (2007), "The Food Problem and the Evolution of International Income Levels", *Journal of Monetary Economics* 54(4): 1230–55, May.

Hayami, Y. and V. Ruttan (1985), *Agricultural Development: An International Perspective*, revised edition, Baltimore MD: Johns Hopkins University Press.

Herrendorf, B., C. Herrington and Á. Valentinyi (2015), "Sectoral Technology and Structural Transformation", *American Economic Journal: Macroeconomics* 7(4): 104-133, October.

Herrendorf, B., R. Rogerson and Á. Valentinyi (2013), "Two Perspectives on Preferences and Structural Transformation", *American Economic Review* 103(7): 2752-89, December.

Herrendorf, B., R. Rogerson and Á. Valentinyi (2014), "Growth and Structural Transformation", Ch. 6 (pp. 855-941) in *Handbook of Economic Growth, Volume 2B, edited by* P. Aghion and S.N. Durlauf, Amsterdam: Elsevier.

Hicks, J.R. (1963), *The Theory of Wages*, 2nd edition, London: Macmillan.

Johnson, D.G. (1991), *World Agriculture in Disarray*, revised edition, London: St Martin's Press.

Jorgenson**,** D. and Z. Griliches (1967), "The Explanation of Productivity Change", *Review of Economic Studies* 34(99): 249-80.

Kravis, L.B., W. Heston and R. Summers (1983), "The Share of Services in Economic Growth", in *Global Econometrics*, edited by F.G. Adams and B.G. Hickman, Cambridge MA: MIT Press.

Krueger, A.O. (1977), *Growth, Distortions and Patterns of Trade Among Many Countries*, Princeton NJ: International Finance Section.

Kuznets, S. (1966), *Modern Economic Growth: Rate, Structure and Spread*, New Haven: Yale University Press.

Laborde, D., T. Lallemant, K. McDougal, C. Smaller and F. Traore (2018), *Transforming Agriculture in Africa and Asia: What Are the Priorities?* Geneva: International Institute for Sustainable Development and Washington DC: International Food Policy Research Institute, September.

Lange, G.-M., Q. Wodon and K. Carey (eds.) (2018), *The Changing Wealth of Nations 2018: Building a Sustainable Future*, Washington DC: World Bank. Data for 1995-2014 and methods used are at https://datacatalog.worldbank.org/dataset/wealth-accounting

Lawrence, R.Z. (2018), "Recent US Manufacturing Employment: The Exception that Proves the Rule", Research Working Paper 18-002, Harvard Kennedy School, January.

Leamer, E.E. (1987), "Paths of Development in the Three-Factor, n-Good General Equilibrium Model", *Journal of Political Economy* 95(5): 961-99.

Lewis, W.A. (1954), "Economic Development with Unlimited Supplies of Labour", *The Manchester School of Economic and Social Studies* 22: 139–91.

Liu, X., A. Mattoo, Z. Wang and S.-J Wei (2018), "Services Development and Comparative Advantage in Manufacturing", Policy Research Working Paper 8450, World Bank, Washington DC.

Lluch, C., A.A. Powell and R.A. Williams (1977), *Patterns in Household Demand and Savings*, London and New York: Oxford University Press.

Lucas, R.E. (2004), "Life Earnings and Rural-urban Migration", *Journal of Political Economy* 112(1, part 2): S29–S59, February.

Lucas, R.E. (2009), "Trade and the diffusion of the industrial revolution", *American Economic Journal: Macroeconomics* 1(1): 1–25, January.

Markusen, J.R. (2013), "Putting Per-capita Income back into Trade Theory", *Journal of International Economics* 90(2): 255-65, July.

Martin, W. and D. Mitra (2001), "Productivity Growth and Convergence in Agriculture and Manufacturing", *Economic Development and Cultural Change* 49(2): 403-23, January.

Martin, W. and P. Warr (1993), "Explaining Agriculture's Relative Decline: A Supply Side Analysis for Indonesia", *World Bank Economic Review* 7(3): 381-401, September.

Martin, W. and P. Warr (1994), "Determinants of Agriculture's Relative Decline: Thailand", *Agricultural Economics* 11: 219-35.

Matsuyama, K. (1992), "Agricultural Productivity, Comparative Advantage, and Economic Growth", *Journal of Economic Theory* 58(2): 317-33, December.

Matsuyama, K. (2009), "Structural Change in an Interdependent World: A Global View of Manufacturing Decline", *Journal of the European Economic Association* 7(2–3): 478–86, April–May.

McCullough, E. (2017), "Labour Productivity and Employment Gaps in Sub-Saharan Africa", *Food Policy* 67: 133–52.

Michaels, G. (2011), "The Long Term Consequences of Resource-Based Specialisation", *Economic Journal* 121(551), 31–57, March.

Nayyar, G., M. Cruz and L. Zhu (2018), "Does Premature Deindustrialization Matter? The Role of Manufacturing versus Services in Development", Policy Research Working Paper 8596, World Bank, Washington DC, September.

Nickell, S., S. Redding and J. Swaffield (2008), "The Uneven Pace of Deindustrialization in the OECD", *The World Economy* 31(9): 1154-84.

OECD (2015), *OECD Companion to the Inventory of Support Measures for Fossil Fuels 2015*, Paris: OECD.

Otsuka, K., J.P. Estudillo and Y. Sawada (eds.) (2009), *Rural Poverty and Income Dynamics in Asia and Africa,* London and New York: Routledge.

Ozawa, T. (2009), *The Rise of Asia: The 'Flying-Geese' Theory of Tandem Growth and Regional Agglomeration,* Cheltenham: Edward Elgar.

Pfaffenzeller, S., P. Newbolt and A. Rayner (2007), "A Short Note on Updating the Grilli and Yang Commodity Price Index", *World Bank Economic Review* 21: 151–63.

Prebisch, R. (1950), *The Economic Development of Latin America and Its Principal Problems*, UN document no. E/CN.12/89/Rev.1., New York: United Nations.

Prebisch, R. (1959), "Commercial Policy in Under-developed Countries", *American Economic Review* 492(2): 251–73, May.

Radetzki, M. and J. Tilton (1990), "Developing Countries: The New Growth Markets", in *World Metal Demand: Trends and Prospects*, edited by J. Tilton, Washington DC: Resources for the Future.

Rodrik, D. (2016), "Premature Deindustrialization", *Journal of Economic Growth* 21(1): 1-33, March.

Rodrik, D. (2018), "New Technologies, Global Value Chains, and Developing Countries", NBER Working Paper 25164, Cambridge MA, October.

Rybczynski, T.M. (1955), "Factor Endowments and Relative Commodity Prices", *Economica* 22(4): 336-41.

Sandri, D., E. Valenzuela and K. Anderson (2006), "Compendium of National Economic and Trade Indicators by Region, 1960 to 2004", Agricultural Distortions Research Project

Working Paper 01, World Bank, Washington DC, October. Posted at www.worldbank.org/agdistortions

Singer, H. (1950), "The Distribution of Gains between Investing and Borrowing Countries", *American Economic Review* 40(2): 473-85, May.

Spraos, J. (1980), "The Statistical Debate on the Net Barter Terms of Trade between Primary Commodities and Manufactures", *Economic Journal* 90:107–28.

Syrquin, M. (1988), "Patterns of Structural Change", pp. 203-73 in *Handbook of Development Economics, Volume 1*, edited by H. Chenery and T.N. Srinivasan, Amsterdam: North-Holland.

Syrquin, M. and H. Chenery (1989), "Three Decades of Industrialization", *World Bank Economic Review* 3(1): 145-81.

Theil, H. and K.W. Clements (1987), *Applied Demand Analysis: Results from System-Wide Approaches*, Cambridge MA: Ballinger.

Timmer, M., G. de Vries and K. de Vries (2015), "Patterns of Structural Change in Developing Countries", pp. 65-83 in *Routledge Handbook of Industry and Development*, edited by J. Weiss and M. Tribe, London: Routledge.

United Nations (2018), COMTRADE, international trade data accessed in May 2018 at https://comtrade.un.org

van der Ploeg, F. (2011), "Natural Resources: Curse or Blessing?", *Journal of Economic Literature* 49(2): 366–420, June.

Venables, A.J. (2004), "Small, Remote and Poor", *World Trade Review* 3(3): 453-57, November.

Williamson, J.G. (2012), "Commodity Prices over Two Centuries: Trends, Volatility and Impact," *Annual Review of Resource Economics* 4: 185-207.

World Bank (2018a), *World Development Indicators*, World Bank, Washington DC, accessed in May 2018 at https://data.worldbank.org/products/wdi

World Bank (2018b), *Commodity Market Outlook*, World Bank, Washington DC, annual historical time series (Pink Sheet) data accessed in May 2018 at http://www.worldbank.org/en/research/commodity-markets#3

Table 1: Top 30 countries in terms of their 'revealed' comparative advantage[1] in agriculture, mining, manufacturing and services, 2014

Agriculture		**Mining**		**Manufacturing**		**Services**	
Malawi	8.35	Angola	6.07	Bangladesh[2]	1.65	Bermuda	4.60
Guyana	7.90	Algeria	5.76	China	1.65	Macao	4.55
Benin	7.81	Kuwait	5.70	Botswana	1.55	Grenada[2]	4.36
Paraguay	7.49	Nigeria	5.67	Slovak Rep.	1.53	Palau	4.32
Burkina Faso	7.18	Brunei Dar.	5.58	Czech Rep.	1.50	Maldives	4.25
Cote d'Ivoire	7.02	Saudi Arabia	5.24	Mexico	1.44	Antigua&Barbuda	4.23
New Zealand	6.65	Oman	5.20	Korea, Rep.	1.40	St. Kitts&Nevis	4.19
Uruguay	6.14	Mongolia	5.17	Japan	1.37	Sint Maarten	4.18
Ethiopia	5.98	Azerbaijan	5.13	Vietnam	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[2]	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[2]	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	Russia	4.18	Thailand	1.18	Timor-Leste[2]	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&Gre.[2]	3.77
Guatemala	4.44	Congo, Rep.	3.67	Tunisia	1.15	Sao Tome&Princ.	3.75
Tanzania	4.38	Yemen, Rep.	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&Tob	3.47	Cambodia	1.12	Montenegro[2]	3.54
Senegal	3.54	Australia	3.36	Belgium	1.10	Tonga	3.52
Ukraine	3.15	Peru	3.34	Philippines	1.08	Djibouti[2]	3.49
Chile	3.13	Norway	3.33	Hong Kong	1.06	Afghanistan	3.29
Iceland	2.98	Ecuador	3.15	France	1.02	Curacao[2]	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

[1] Index of 'Revealed' Comparative Advantage (RCA) is the share of a sector in a country's total goods and services 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, from 96% to 41% for mining, from 86% to 52% for manufacturing, and from 98% to 61% for services. (There are well over 30 more countries whose services share of exports exceeds twice the global average of 21%.)

[2] Due to insufficient data for some other variables, these countries are not included in Figures 4, 6 and 7, nor in the regressions reported in subsequent tables.

Source: Authors' compilation based on United Nations (2018) export value data for goods and IMF balance of payments data for services as tabled in World Bank (2018a)

Table 2: National GDP and agricultural land, mineral resources and other capital endowments, per capita, Asian and other countries relative to the world, 2000-04 and 2014

	Total land per worker,[a] 2000-04	**Agric. land per capita,[a] 2000-04**	**Ag. land value per capita,[b] 2014**	**Mineral resources per cap.,[b] 2014**	**Other capital per cap.[b,c] 2014**	**GDP per capita,[b] 2014**
Bangladesh	4	8	36	1	6	10
Taiwan	8	5	low	1	high	208
Korea, Rep.	9	5	48	1	273	256
Japan	12	5	25	1	355	350
India	15	22	59	15	9	14
Vietnam	18	14	104	35	13	18
Philippines	21	19	65	8	17	26
China	28	54	156	63	60	71
Thailand	32	39	131	9	35	54
Indonesia	40	27	78	43	25	32
Myanmar	59	42	na	low	low	12
Cambodia	65	49	82	0	6	10
Malaysia	74	41	143	109	136	103
Lao PDR	151	42	135	51	12	20
All developing 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
ME+N Africa	280	91	83	2287	19	108
New Zealand	326	550	366	na	high	409
Australia	1799	2856	202	1584	500	571
World	100	100	100	100	100	100

[a] A percentage of the world average, based on hectares.
[b] A percentage of the world average, based on US dollars at market exchange rate.
[c] Other capital refers to non-natural produced (including human) capital.

Source: Authors' compilation drawing on 2000-04 WDI data assembled in Sandri et al. (2007) and 2014 World Bank data in Lange, Wodon and Carey (2018).

Table 3: Determinants of sectoral shares of valued added (% of GDP), 1991-2014

	Agriculture	Manufacturing	Services
lnYPC	-41.909***	8.828	10.126
	(-4.46)	(1.44)	(1.01)
lnYPC 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	2504	2409	2500
No. of countries	117	116	117
Country fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes

t-statistics in parenthesis. * p < 0:1, ** p < 0:05,*** p < 0:01

Source: Authors' computations.

Table 4: Determinants of sectoral shares of employment (% of total employment), 1991-2014

	Agriculture	Mining	Manufacturing	Services
lnYPC	-46.42***	1.994***	32.846***	1.614+++
	(-4.46)	(2.68)	(6.34)	(0.25)
lnYPC 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	2599	2303	2598	2599
No. of countries	113	104	113	113
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes

t-statistics in parenthesis. * p < 0:1, ** p < 0:05,*** p < 0:01

F-statistics in parenthesis.+ p(F) < 0:1, ++ p(F) < 0:05, +++ p(F) < 0:01

Source: Authors' computations.

Table 5: Determinants of sectoral shares of exports (% of all merchandise + services exports), 1991-2014

	Agriculture	Mining	Manufacturing	LI man.[a]	Services
lnYPC	-51.343***	-10.631	64.43***	17.49++	15.661
	(-2.42)	(-0.71)	(2.82)	(1.28)	(0.60)
lnYPC 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	2063	1837	2061	2049	2369
No. of countries	109	100	109	108	112
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes

t-statistics in parenthesis. * p < 0:1, ** p < 0:05,*** p < 0:01

F-statistics in parenthesis.+ p(F) < 0:1, ++ p(F) < 0:05, +++ p(F) < 0:01

[a] Labour-intensive manufactures (textiles, clothing and footwear)

Source: Authors' computations.

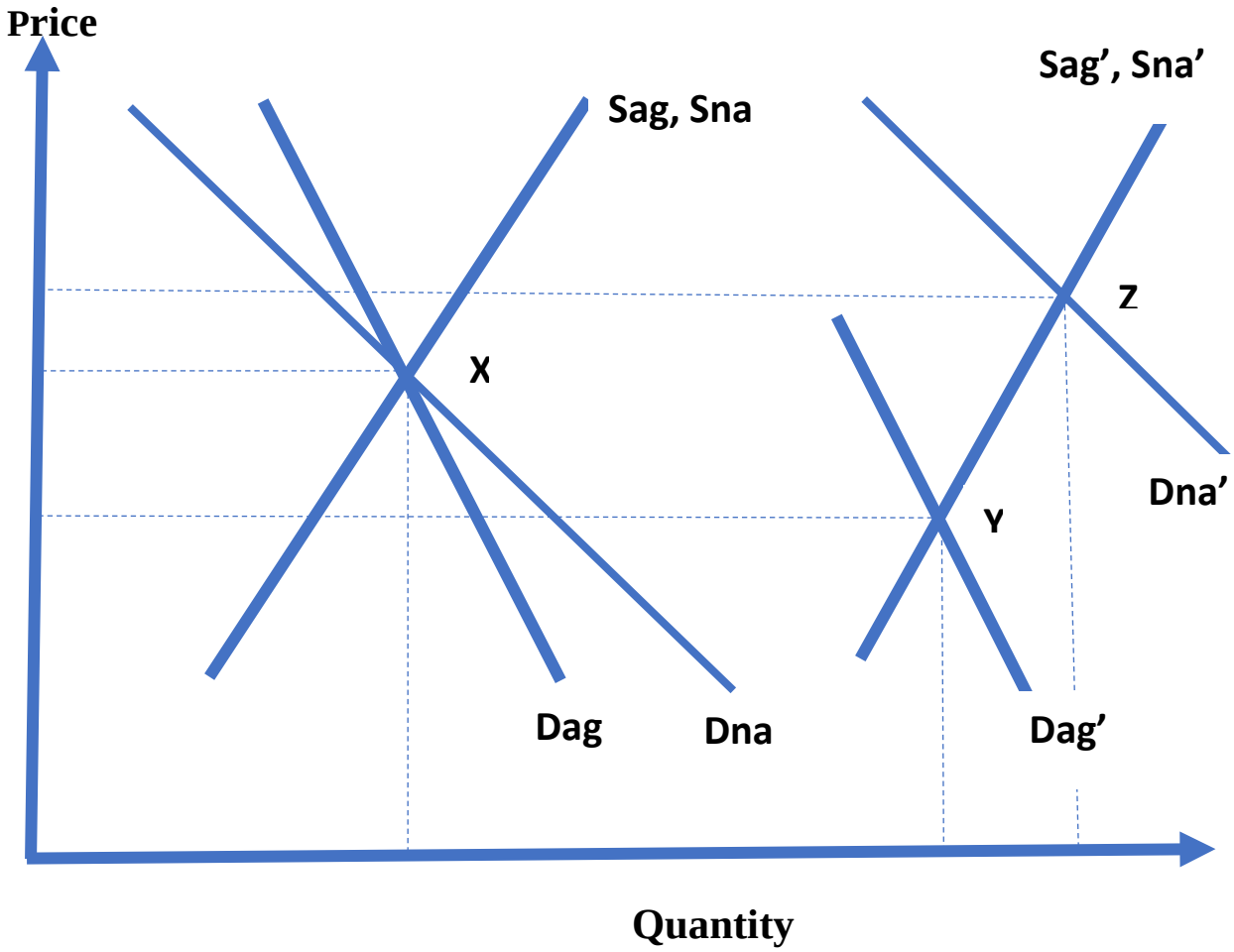
Table 6: Determinants of agriculture's shares of value added, employment and exports, 1991-2014 (%)

	Value added	Employment	Exports
lnYPC	-46.855***	-38.806***	-48.918*
	(-3.77)	(-3.56)	(-1.87)
lnYPC 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	1995	2088	1669
No. of countries	99	98	95
Country fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes

t-statistics in parenthesis. * p < 0:1, ** p < 0:05,*** p < 0:01

Source: Authors' computations.

Figure 1: Shifts in demand and supply curves for agricultural and non-agricultural products in a closed growing economy



Source: Authors' adaptation from Johnson (1991, Figure 5.2).

Figure 2: Effects of productivity growth in agricultural and non-agricultural sectors in a closed growing economy

Source: Authors' adaptation from Anderson (1987).

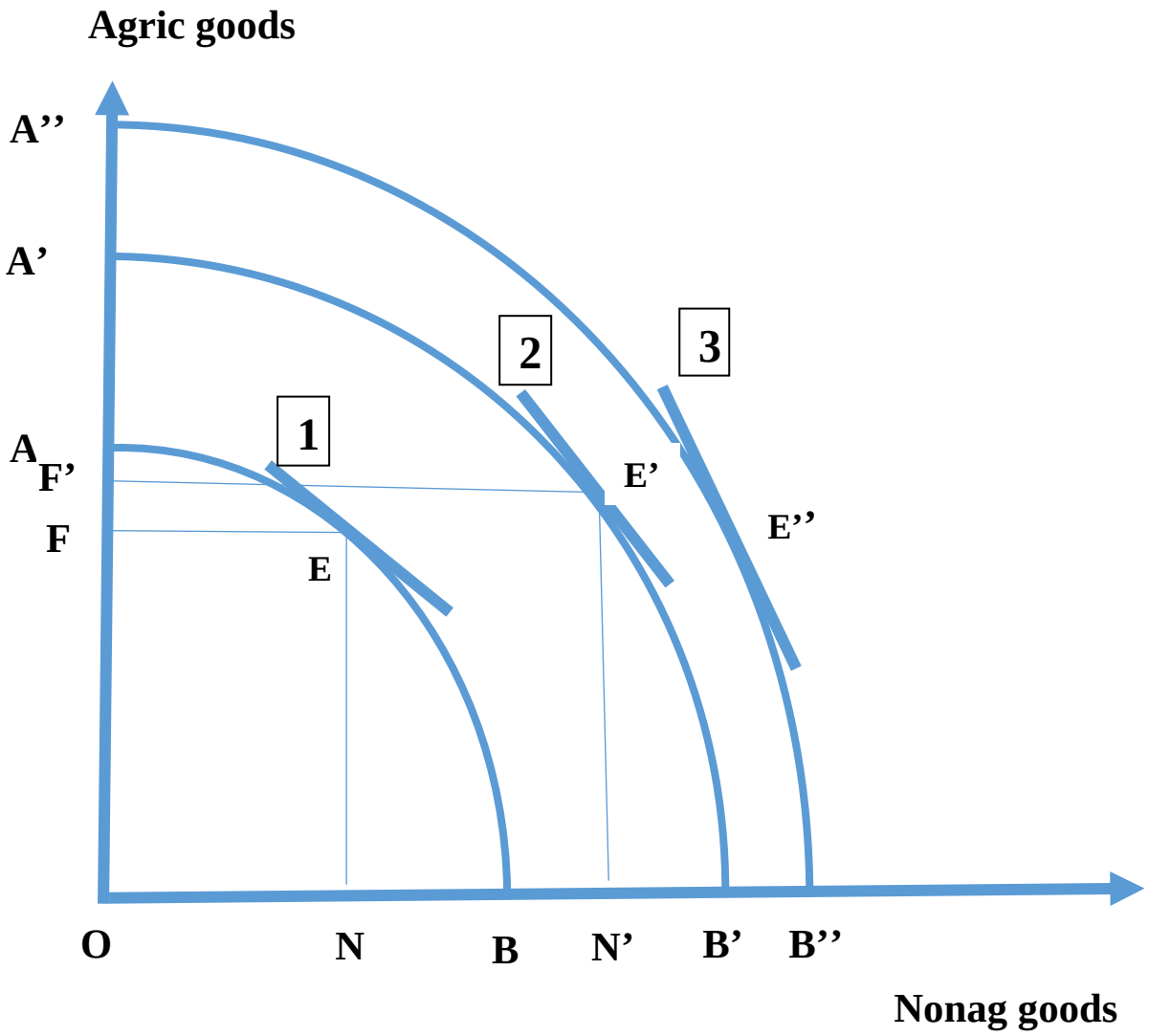


Figure 3: Effects of productivity growth in agricultural and non-agricultural sectors in an open growing economy

Source: Authors' adaptation from Anderson (1987).

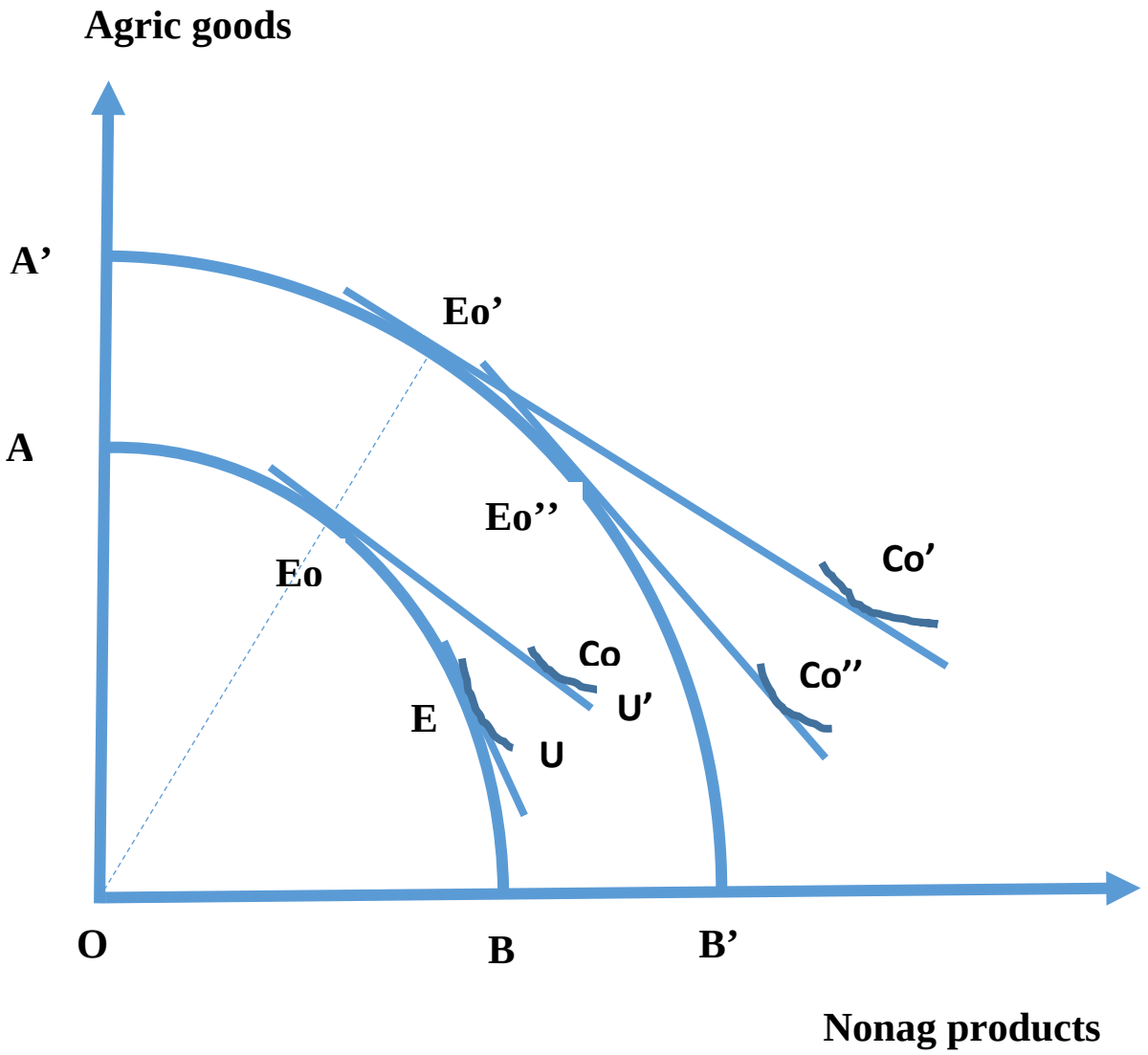


Figure 4: Sectoral shares of GDP (value added), employment and exports as real per capita incomes rise, 1990 to 2016 (%) Source: Authors' compilation (see text).

(a) Agriculture

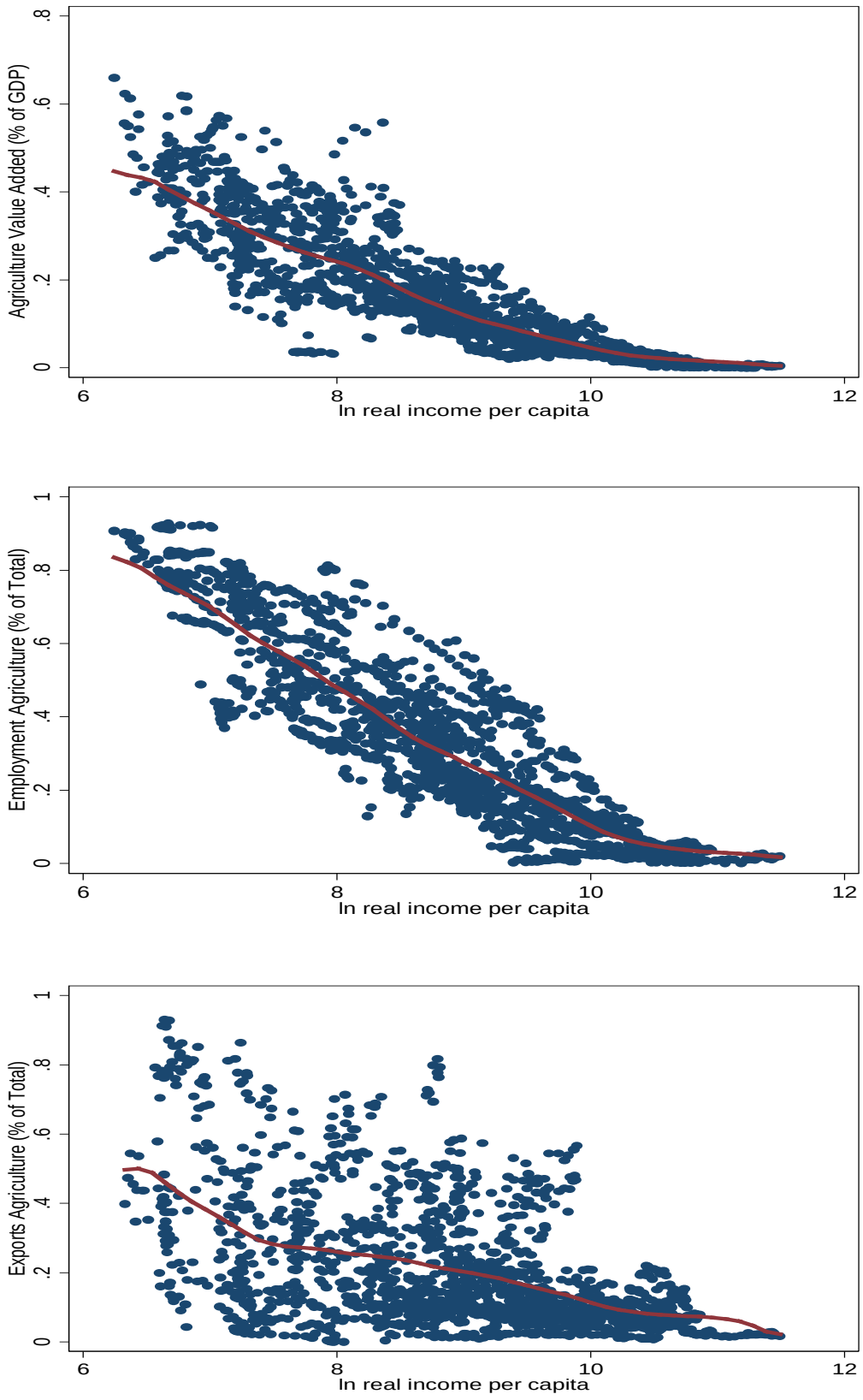
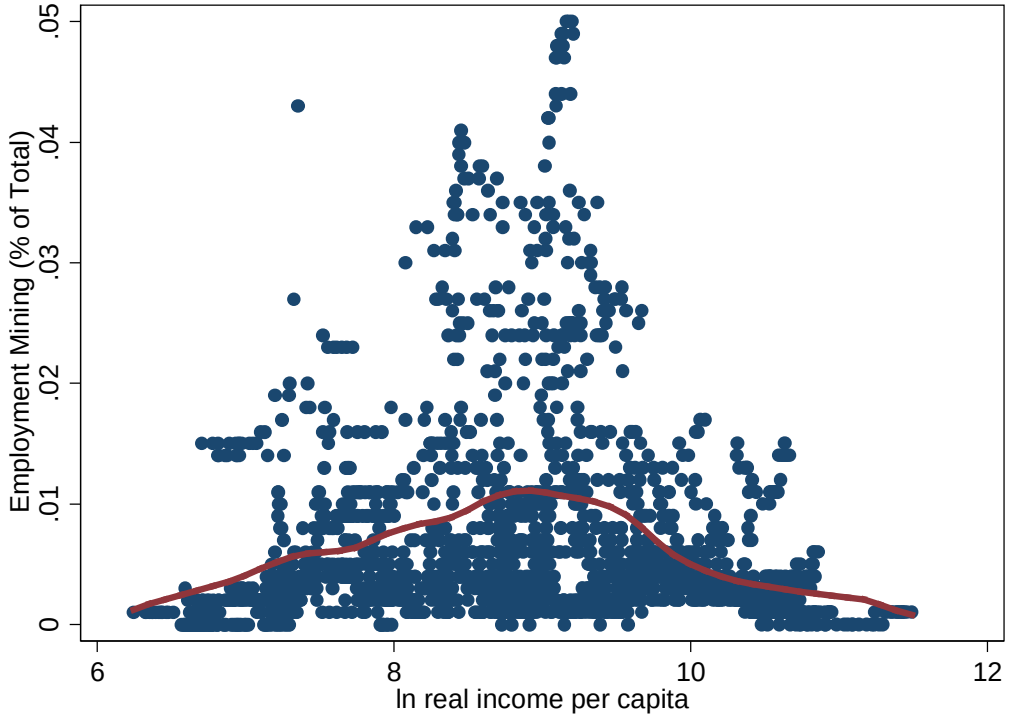


Figure 4 (continued): Sectoral shares of GDP, employment and exports as real per capita incomes rise, 1990 to 2016 (%) Source: Authors' compilation (see text).

(b) Mining



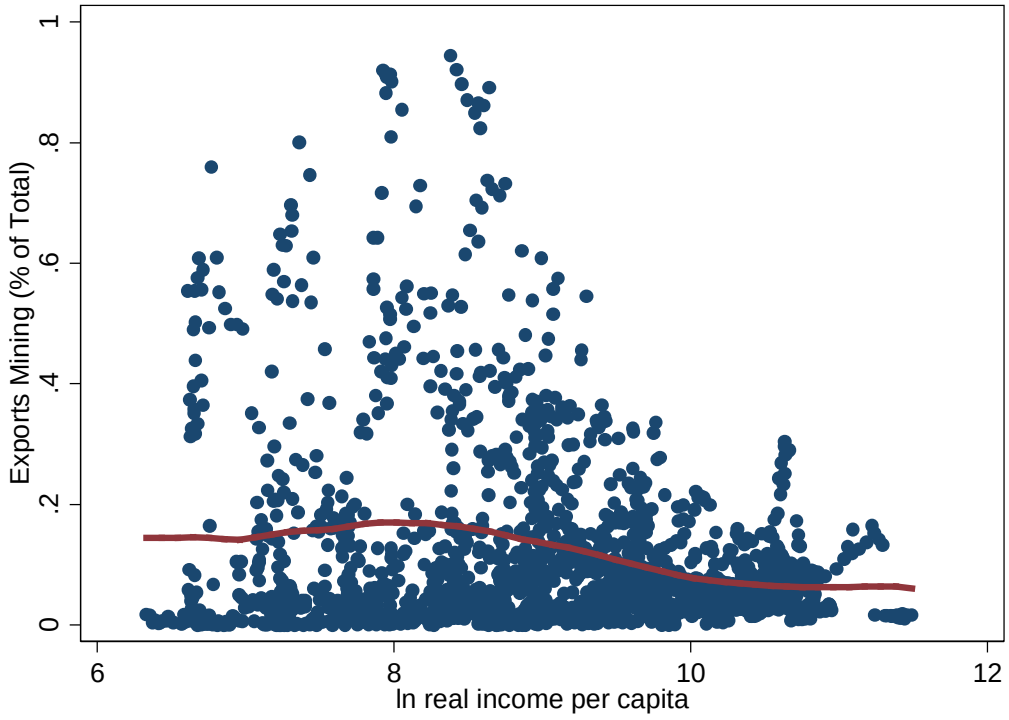
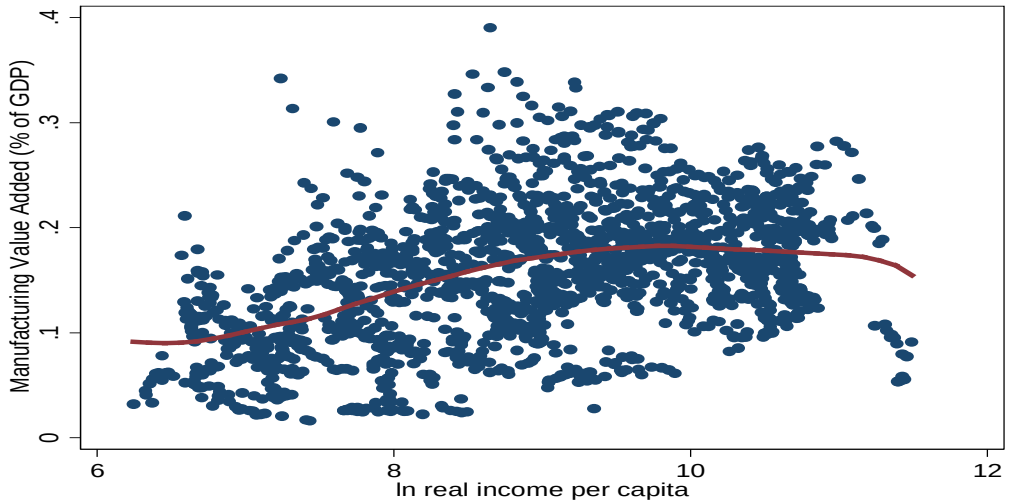
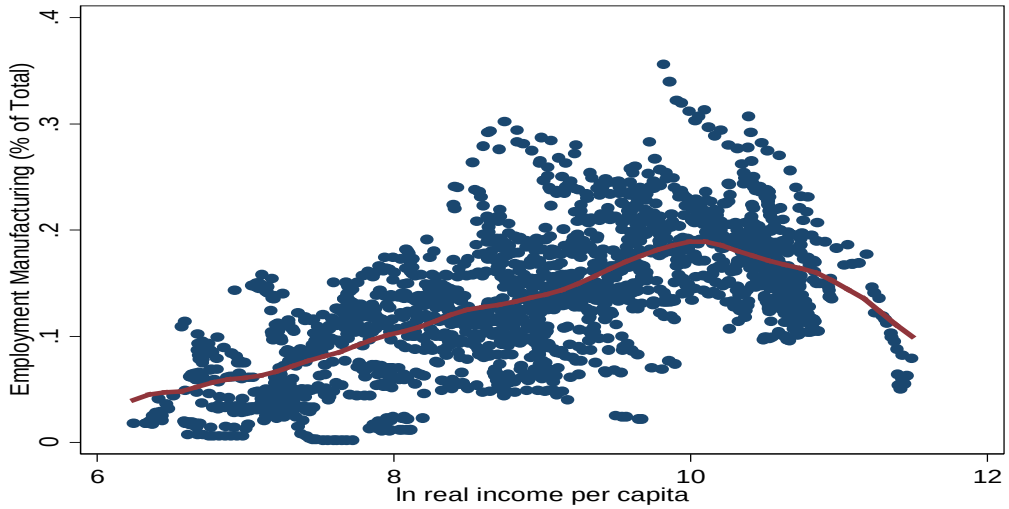


Figure 4 (continued): Sectoral shares of GDP, employment and exports as real per capita incomes rise, 1990 to 2016 (%) Source: Authors' compilation (see text).

(c) Manufacturing





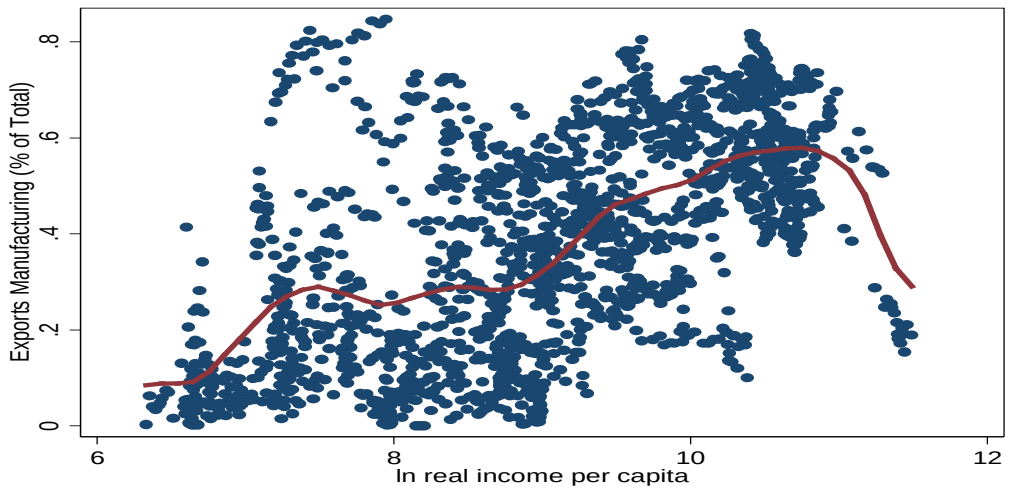
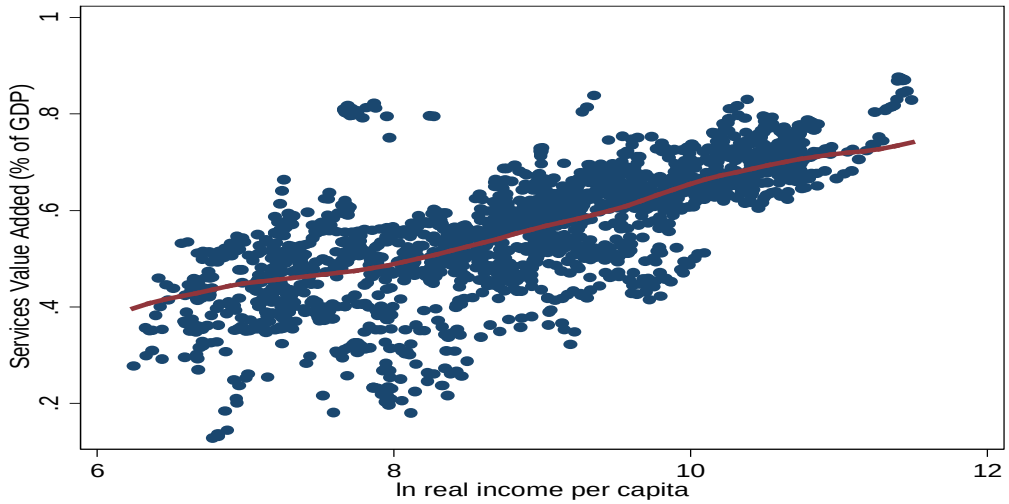
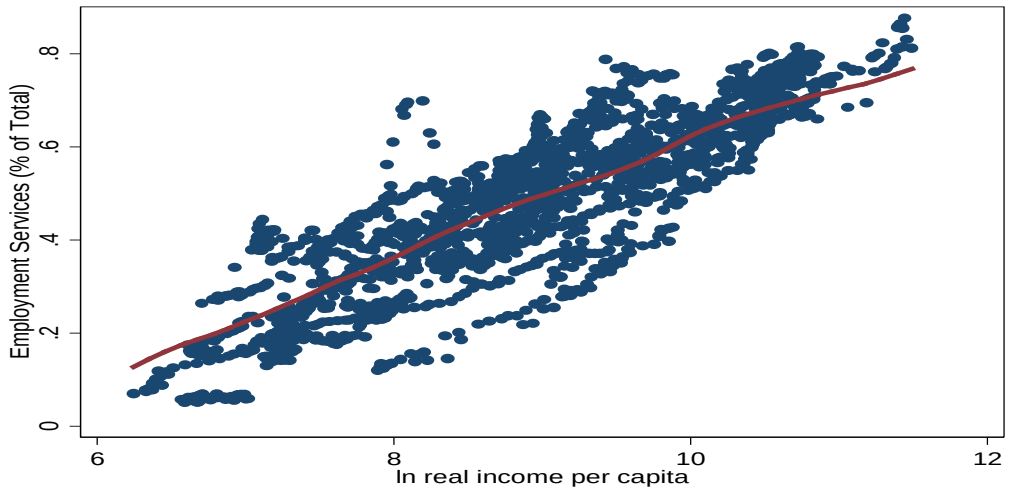


Figure 4 (continued): Sectoral shares of GDP, employment and exports as real per capita incomes rise, 1990 to 2016 (%) Source: Authors' compilation (see text).

(d) Services





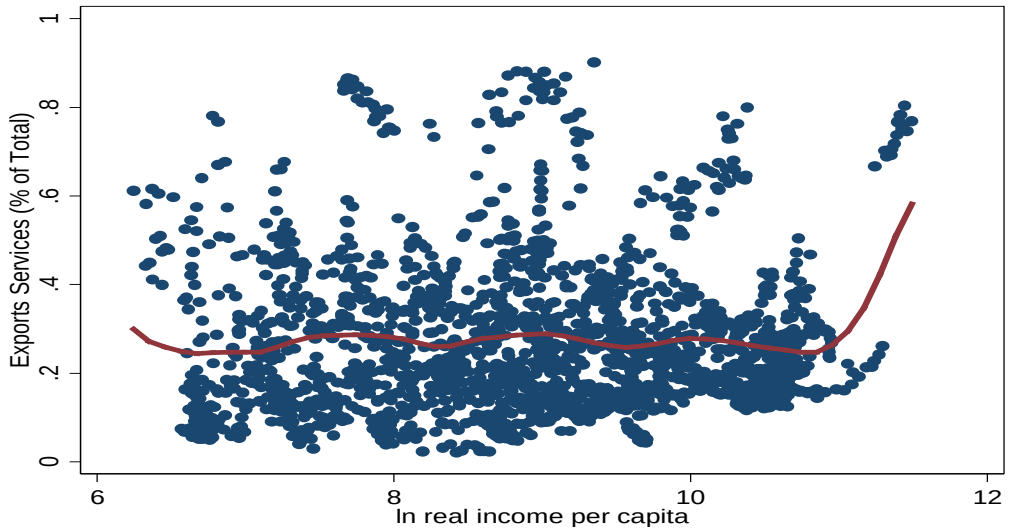
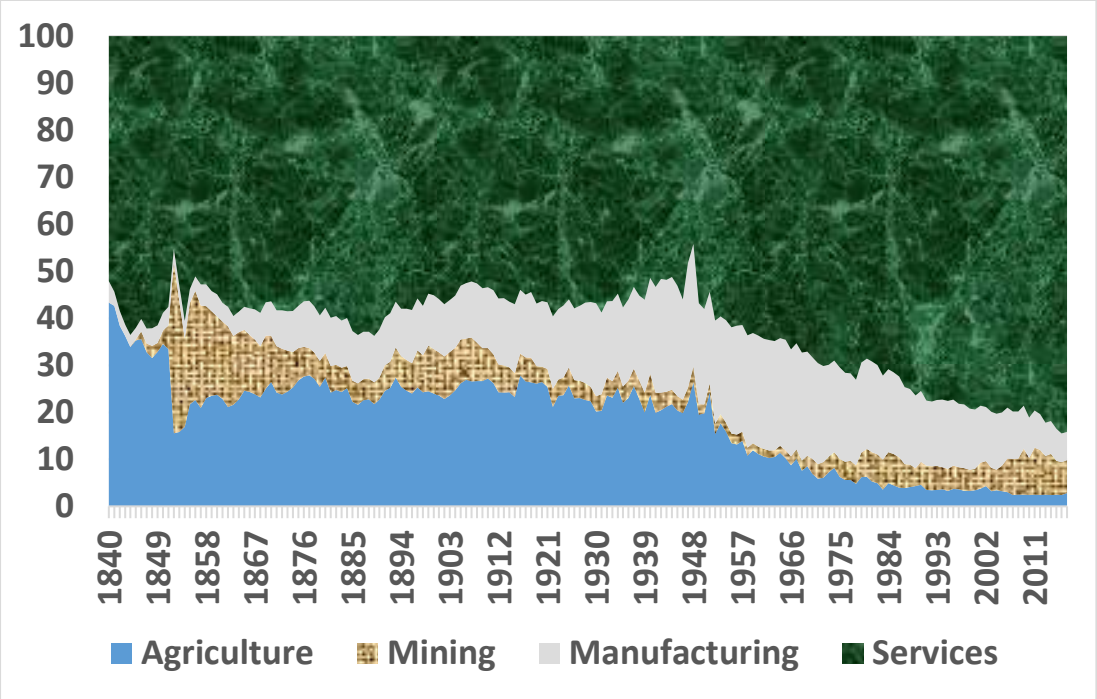
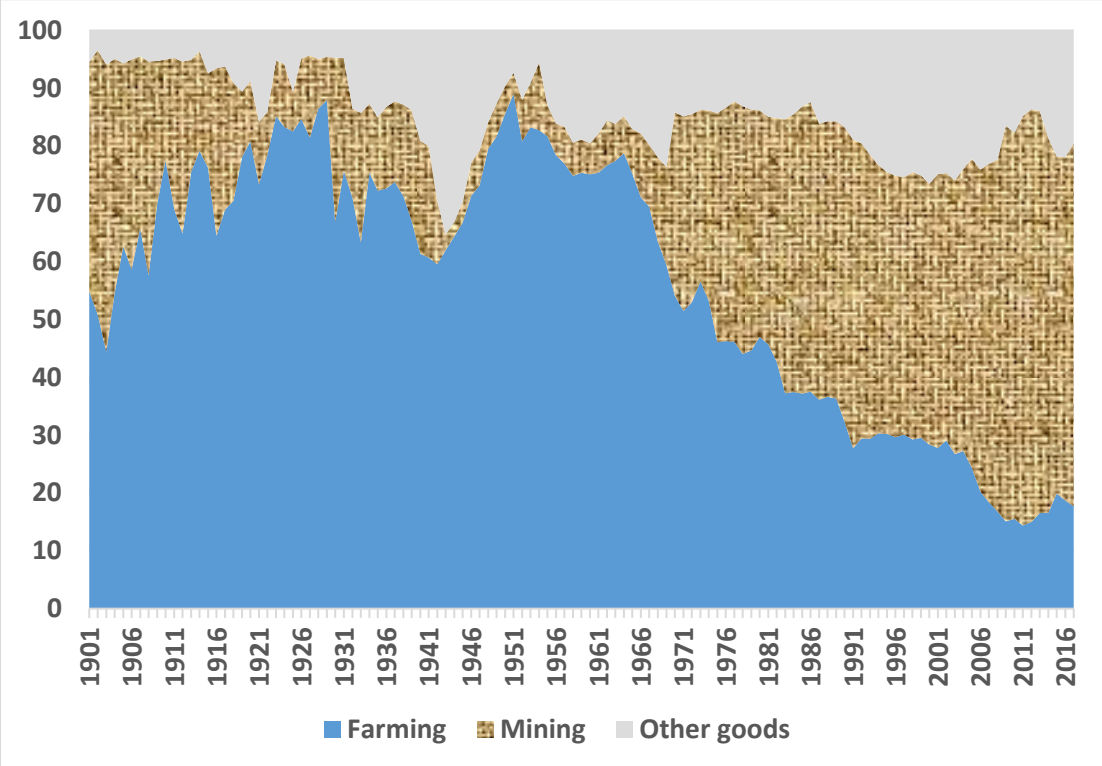


Figure 5: Sectoral shares of GDP and exports, Australia, 1840 to 2017 (%)

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

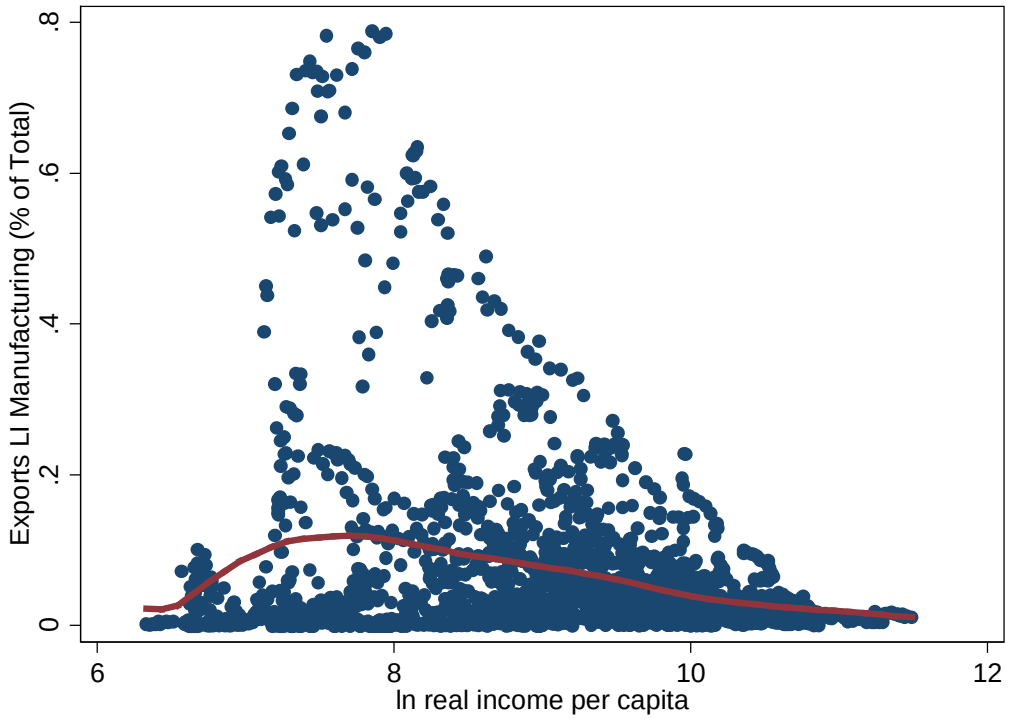


(b) % of merchandise exports at current prices, 1901 to 2017



Source: Anderson (2017), updated and backdated by the author.

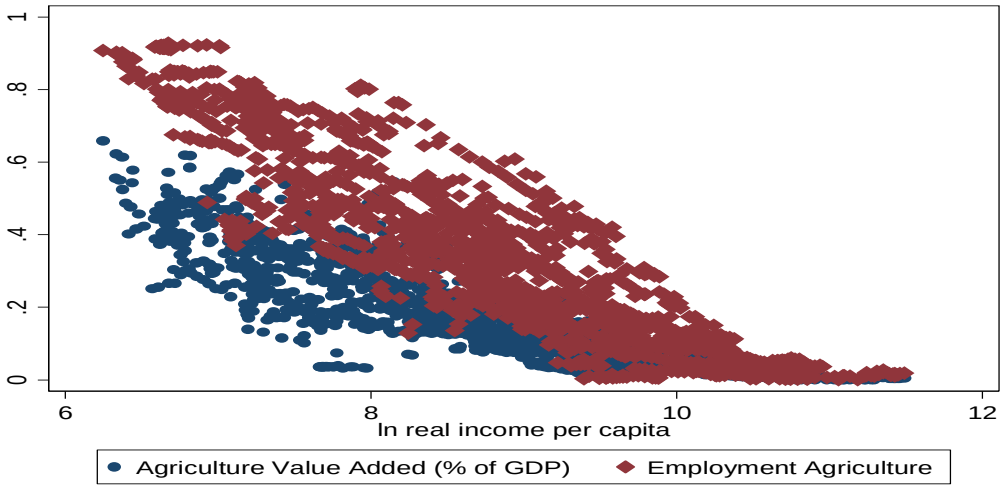
Figure 6: Shares of exports of labour-intensive manufactures in total exports as real per capita incomes rise, 1990 to 2016 (%)



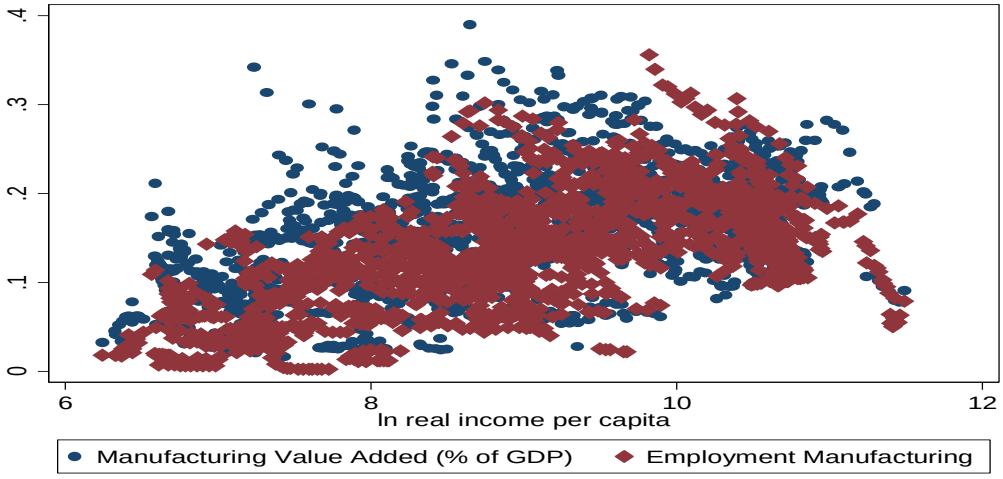
Source: Authors' compilation (see text).

Figure 7: Sectoral proportions of GDP and employment as real per capita incomes rise, 1990 to 2016
Source: Authors' compilation (see text).

(a) Agriculture



(b) Manufacturing



(c) Services

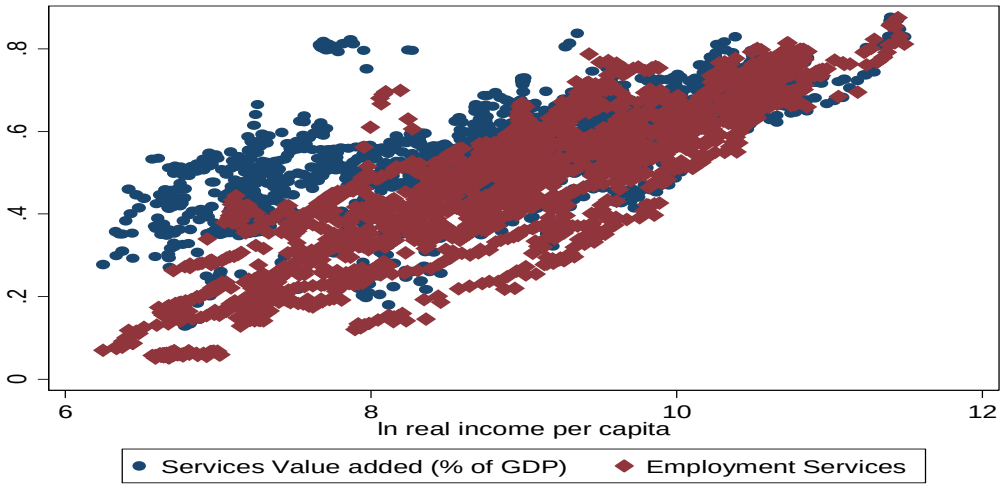
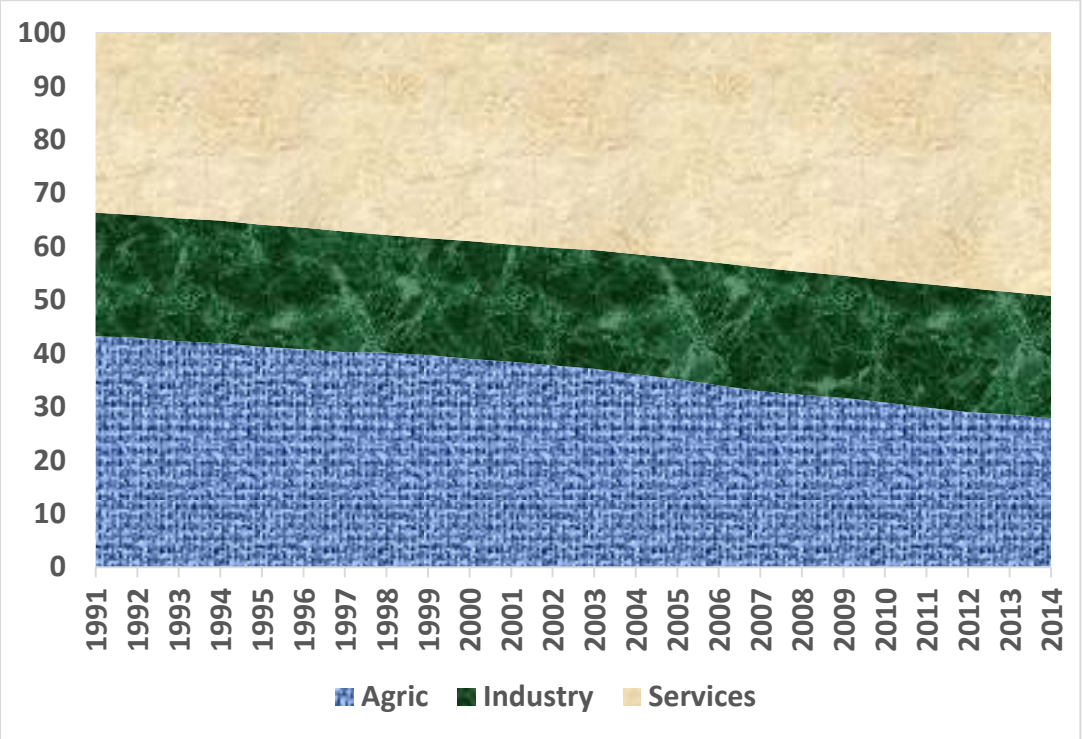
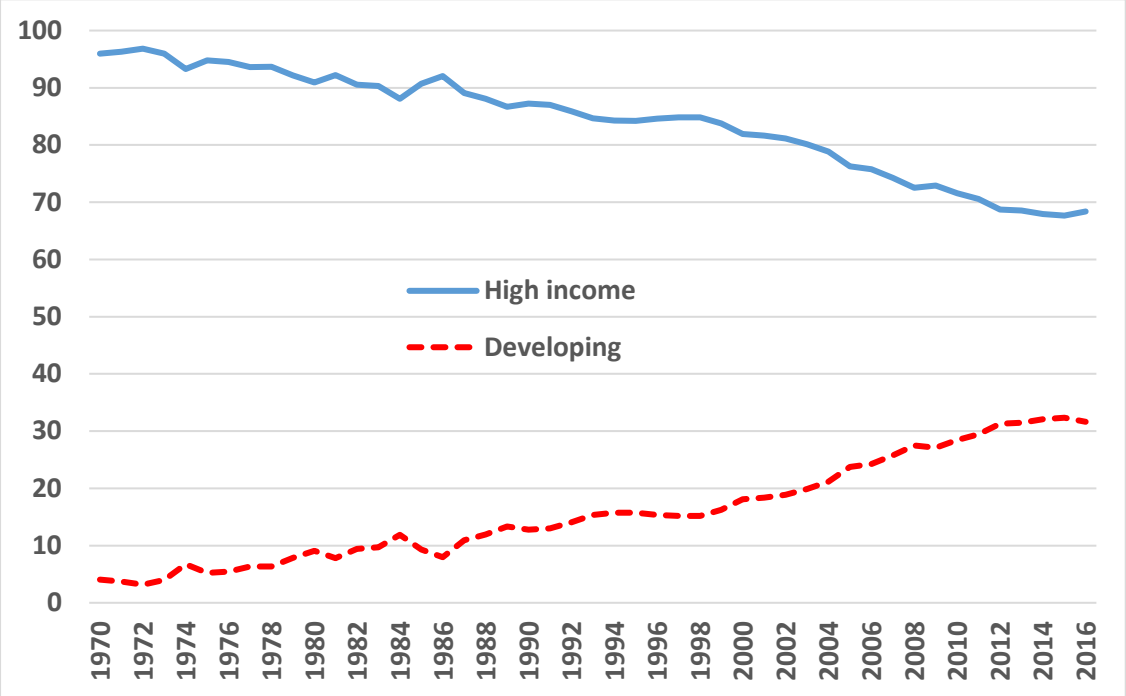


Figure 8: Share of global employment by sector, 1991 to 2014 (%)



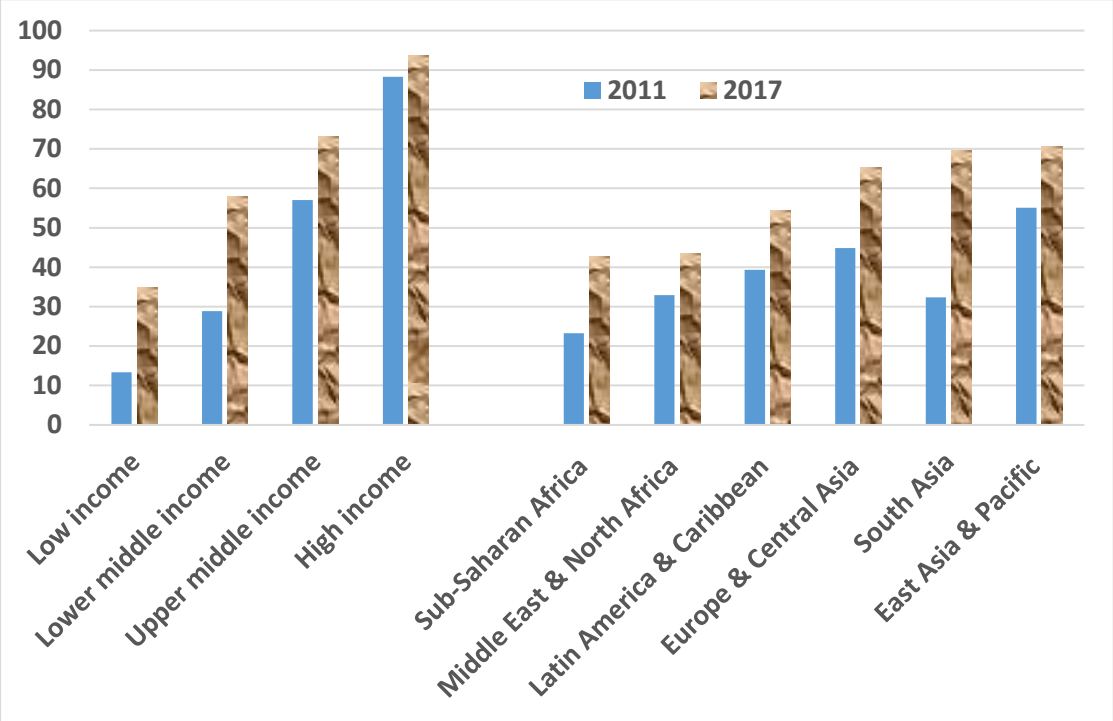
Source: Compiled by authors from data in World Bank (2018a)

Figure 9: Share of global exports of manufactured goods, high-income and developing countries, 1970 to 2016 (%)



Source: Compiled by the author from World Bank (2018).

Figure 10: Share of adults with a bank or mobile-money account or equivalent, developing economy regions and high-income countries, 2011 and 2017 (%)



Source: Demirgüç-Kunt et al. (2018).