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Structural transformation away from agriculture: What role for trade?

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Abstract

An understanding of how and why economies structurally transform away from agriculture as they grow is crucial for developing sensible farm and food policies. Typically, analysts who study this and related structural change issues focus on sectoral shares of gross domestic product (GDP) and employment. This paper draws on trade theory to focus as well on exports. It also notes that the trade costs of some products are too high at early stages of development to make international trade profitable, so a nontradables sector is recognized. The general equilibrium model presented in the theory section provides hypotheses about structural change in differently endowed economies as they grow. Those hypotheses are tested econometrically with a new annual endowments dataset covering 1995 to 2018 for more than 130 countries, a period when trade restrictions were at their lowest for at least a century. The results are consistent with long run de-agriculturalization in terms of sectoral shares of GDP and employment in the course of national economic growth. But a decline in agriculture's share of exports in every country is not inevitable. Moreover, policies can be designed to support growth-enhancing and welfare-improving structural transformation without harming agricultural exporters and distorting world trade in farm products.

Keywords: patterns of structural change, de-agriculturalization, comparative advantage, farm productivity growth

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

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1. INTRODUCTION

Thirty-five years ago, an article in this journal sought to explain agriculture's relative decline in the course of economic growth (Anderson 1987). The world economy has changed dramatically since then, with developing countries industrializing and converging on the living standards of high-income countries as their population growth slows, and with globalization and retreats from protectionism being manifested in rapid rises in the share of production being traded internationally. This article re-visits the issue of de-agriculturalization with new data covering the current globalization wave, and with an open-economy framework so as to focus particularly on the role of exports and trade specialization.

While countries typically began the process of economic growth with most of the population engaged in producing staple food, an ever-increasing number of countries since the early 1800s have seen workers attracted to manufacturing and service activities as non-farm labor productivity improved with industrial capital accumulation or importation. Lewis (1954) assumed that labor was more productive in what he called the modern sector than in the traditional (mainly subsistence agriculture) sector, hence the expectation that the share of the population employed in agriculture would decrease (Gollin 2014). Later in the development process, the manufacturing sector's share of employment has declined as well (Herrendorf, Rogerson, and Valentinyi 2014; Fort, Pierce, and Schott 2018). Those countries fortunate enough to be well-endowed per capita in minerals and energy raw materials or in natural forests find that mining (including the felling of native trees) employs some workers, but that its share of total employment tend to be quite small and also to decline in the course of a nation's economic development.

Shares of gross domestic product (GDP) follow a similar pattern to employment shares. However, agriculture's employment share typically exceeds its GDP share (Timmer 2009). By contrast, the GDP shares of mining and manufacturing often exceed their employment shares. This implies labor productivity is often lower in agriculture than in the rest of the economy. Such labor productivity differences mean that, at the margin, migration of labor from traditional agriculture to industrial activities is likely to speed up economic growth. Meanwhile, the GDP share of services has tended to grow less rapidly than its employment share because (like traditional agriculture) many service activities are relatively labor intensive. Furthermore, the service sector has experienced relatively slow productivity growth, although that is beginning to change for some services thanks in part to the information and communication technology (ICT) revolution (Duernecker, Herrendorf, and Valentinyi 2017).

Development economists have been tracing these patterns of structural transformation in the course of national economic growth for many decades (Clark 1938, 1940; Fisher 1939; Kuznets 1966; Syrquin and Chenery 1989; Timmer 2009; Timmer, de Vries, and de Vries 2015). The pace of change has varied widely across countries, however, and not only because of their different rates of economic growth (*Nickell, Redding,* and *Swaffield 2008). Also,* over time, the peaks in the shares of manufacturing in national GDP and employment have gradually fallen in recent decades, and these peaks are being reached at ever-lower real per capita national income levels. Moreover, in some African developing countries, urbanization is occurring without much industrialization (Rodrik 2016; Gollin, Jedwab, and Vollrath 2016), or with manufacturing being limited mostly to capital-intensive large firms that may provide few jobs for former farmers (McMillan and Zeufack 2022; but see also Mendola, Prarolo, and Sonno 2022).

Developments in the sectoral shares of national exports, however, are far more varied across countries. 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.[1] With the current wave of globalization, numerous trade costs and government restrictions on trade are falling. Indeed a new empirical study finds the trade restrictiveness of both high-income and developing countries since the mid-1990s has been at its lowest since 1950 (Rose et al. 2022), and hence probably since 1913. That is stimulating global value chains and the fragmentation of production processes such that an ever-higher proportion of goods and services have become internationally tradable. As a result, changes in comparative advantage are becoming less predictable (Baldwin 2016, 2019). But restrictions on agricultural trade have been declining slower than, and are well above, those for non-agricultural goods, including in developing

[1] Of the world's top 30 countries in terms of 'revealed' comparative advantage in services, more than 20 are small island developing countries typically exporting inbound tourism services (Anderson 2021). Unfortunately almost none of those countries had data for the full set of variables needed for including them in our empirical testing of hypotheses,

countries.[2] The extent of those price-distorting policies also vary considerably across farm products within each country (OECD 2021), adding to the distortions to global farm trade flows (Anderson 2009). As a result, agriculture's measured share of national exports typically will be less predictable than that for mining or manufacturing, and certainly smaller than it would be in the absence of anti-trade farm policies.

There are numerous explanations for the differences in structural transformation patterns across countries. Commonly included in these explanations are differences in rates of change in relative factor endowments (since factor intensities of production vary across sectors), and differences in rates of technological improvements (since multifactor productivity growth rates differ across sectors and in their factor-saving biases). Demand considerations are less commonly considered, but changes in international terms of trade can matter because countries differ in their comparative advantages. Differential growth in per capita incomes matter too because income and price elasticities of demand for products differ across sectors and tend to decline for food as countries become more affluent.

Recent empirical attempts to explain observed structural changes have tended to focus on employment and/or GDP shares and to ignore the trade dimension (as pointed out by Matsuyama 2009). Perhaps that is because changes in sectoral export shares may reflect not just changes in a country's comparative advantages but also in policies affecting its trade specialization. A consequence is that many such studies do not take into account relative factor endowments, which are prime determinants of comparative advantage, or trade-distorting policies.

The purpose of this paper is to explore the contributions of changes in per capita incomes, relative factor endowments, and sectoral productivity growth on agriculture's shares of GDP, employment, and exports since 1995. We chose this limited time period so as to ensure a large sample of countries (more than 130, depending on the variables available) covering the full spectrum of per capita incomes and with new annual estimates of factor endowments that begin in 1995 (World Bank 2021b).[3] For a smaller sample of countries we are also able to include, as an additional explanatory variable, an estimate of the distortions to agricultural incentives and hence trade.

[2] Average import tariffs fell between 1995 and 2019, but for manufacturing they fell from 5% to 2% for high-income countries and from 13% to 6% for developing countries whereas for agriculture they fell from 11% to 7% for high-income countries and from 16% to 14% for developing countries (WTO 2021).

[3] This is a fuller sample than was available for an earlier structural transformation study that focused on manufacturing and services (Anderson and Ponnusamy 2019). That earlier study also had a more limited endowment dataset than the present study, and did not try to include any policy variables.

The paper begins by summarizing standard theory that is consistent with the above trends and stylized facts regarding structural changes in an economy as it grows. We then take that theory to a panel of annual data for 130+ countries over the 24 years until 2018, to show the extent to which changes in the relative importance of agriculture in GDP, employment, and exports are explained by changes in per capita income, relative factor endowments, sectoral productivity growth and price-distorting policies. Comparable equations are also estimated to examine the changing relative importance of manufacturing over time.

The results are unsurprising for GDP and employment shares, whose decline from the outset in agricultural production, and eventually for advanced economies also in manufacturing, can be viewed as symptoms of successful economic growth. However, sectoral export shares, and thus indexes of "revealed" comparative advantage and trade specialization, are far more varied across the spectrum of per capita incomes. This makes clear that it is not inevitable that a growing economy will pass from export specialization in farm products to manufactures: some will skip manufacturing to become exporters of services while others will grow rich (and have a relatively large nontradables sector) and yet remain specialized in exports of primary products.

The structure of this paper is as follows. Section 2 summarizes what trade and development theory would lead one to expect about structural transformation first in a closed economy and then in a small open economy as it grows. Section 3 outline the sources of data to be used to test several hypotheses derived from that theory. Regression results are then presented in Section 4 to show the extent to which sectoral share changes are explained by changes in per capita income, relative factor endowments, price-distorting policies and, in the case of agriculture, productivity growth in that sector. The final section draws out implications for agricultural policy reform options and economic growth strategies of both high-income and emerging economies.

2. THEORY

We begin by first considering a closed economy, and then an open that also includes a sector producing nontradable products. To keep the analysis as simple as possible, we assume that there are no intermediate inputs and all markets are perfectly competitive and free of government interventions so that there is full employment of all factors of production. Growth is assumed initially to come exogenously from improvements in total factor productivity (TFP), before changes in factor endowments are also considered.

2.1 GDP in 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. However, the demand curve shifts out less for agricultural goods than for other products after productivity-improving income growth. Thus, outputs of both sectors rise but less so for agriculture, and the price of farm products falls relative to the price of non-farm products—and more so the more price inelastic is the demand for food. The GDP share of agriculture would fall even more over time in that growing economy as and when income and price elasticities of demand for food fall further below one as per capita income rises (Engel 1857). Were there to be 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), agriculture's GDP share would fall even further.

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

2.2 GDP in a small open economy

What about a small open economy that can export any share of its production or import any share of its consumption of both farm and nonfarm products at the prevailing international terms of trade? Such an economy would have a larger (smaller) share of its GDP coming from agriculture if it had a comparative advantage (disadvantage) in farm products.

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 national growth was biased toward farm or nonfarm production. If economic growth at home and abroad was unbiased, it would lower the relative price of farm products for reasons mentioned above, in which case this small economy's international terms of trade would deteriorate as would its GDP share from agriculture. That is, 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 change in quantity to more than offset its terms of trade deterioration.[4]

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

If one were to combine the two tradable sectors into one "super sector" of tradables, then the above closed economy conclusion, that agriculture's share of GDP is likely to decline over time, will be stronger if the share of tradables in GDP declines in this growing economy. 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. If productivity growth is equally rapid for nontradables as for tradables, while demand grows faster for nontradables than for tradables, both the price and quantity and hence the value of nontradables will increase relative to that of tradables. But if productivity growth is faster in tradables than in nontradables, it is even more likely that the share of nontradables in GDP would rise and the real exchange rate (the price of nontradables relative to tradables) would appreciate. In that case the share of tradables in GDP would fall.

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

As for mining, domestic demand for ores, minerals, and energy raw materials rise as a country begins to industrialize, build more infrastructure, and become more affluent. But domestic production tends to fall as high-tech manufacturing and services increasingly dominate non-primary production, although improvements in technology could alter this inverted U-shaped relationship with real GDP per capita, as could the discovery of new

[4] 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).

reserves—which, with the help of mining-specific foreign capital inflows, could be exploited even in low-income countries.

2.3 Employment shares

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

Historically, out-migration from agriculture has been sluggish because it typically requires a physical, social, and cultural move from living on or near a farm to a town or city—something that is far less likely to be necessary for an urban worker moving to a new manufacturing or service sector job. Thus the decline in the share of employment in agriculture may lag the decline in agriculture's share of GDP.

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

Productivity impacts on sectoral employment can be positive or negative.[5] On the one hand, the adoption by one sector of labor-saving technologies can raise its output and perhaps exports but reduce its employment, thereby *pushing* labor to other sectors (Gollin, Parente, and Rogerson 2002, 2007). On the other hand, labor could be *pulled out* of a sector due to new job prospects in another sector that is enjoying faster total factor productivity growth and/or faster demand growth associated with spending higher incomes (Lucas 2004; Gollin, Parente, and Rogerson 2007). The push element has always been present for farmers and, more recently, for factory workers where robotics and digitalization are the latest influences.

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

Artificial intelligence will replace some workers, but the income growth it generates will lead to the creation of new jobs (Acemoglu and Restrepo 2018; Baldwin 2019). The net effect of the latter pull factor on sectoral employment is uncertain, but if it favors nontradable services that would be a further reason to expect declines in employment in the various tradable goods sectors, including agriculture.

2.4 What if factor endowments change?

So far we have assumed that national income growth comes from exogenous technological change. Growth also results from investments in innovation, or importation and adaptation of technologies from more advanced economies. Income growth can also result from net factor accumulation over and above depreciation. Natural resource capital can be discovered through mining exploration or improved through investment (e.g., clearing and fencing farmable land). Produced capital can be enhanced as well through domestic investment or by importing capital from abroad. And the stock of labor can change through births exceeding deaths, changes in labor force participation (e.g., more women choosing paid work), population aging, and immigration net of emigration.

Any of these changes alters the per worker endowments of natural resources and produced capital and hence the country's comparative advantages. According to Rybczynski (1955), growth in the aggregate stock of capital per worker can have the effect, at constant relative product prices, of expanding the output of the most capital-intensive industries and shrinking that of the most labor-intensive industries. In developing countries where agriculture is among the most labor-intensive industries, this can be another source of relative decline in that sector of growing economies (Martin and Warr 1994).

2.5 Export shares

Sectoral export shares depend on the country's comparative advantage and on how rapidly the tradability of each sector's output increases as technical changes or infrastructure investments lower trade costs. For example, if a small economy's trade costs fall relative to those of the rest of the world, its comparative advantages will alter and it would become internationally competitive in a larger number of products (Venables 2004). Should its farm products gain more from the decline of trade costs than its nonfarm products, the country would see its comparative advantage in agriculture strengthen, other things being equal.

The two key workhorse theories of comparative advantage developed in the 20th century were 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. These two models have been blended to account for primary sectors that use specific natural resource capital (farmland and mineral deposits) in addition to intersectorally mobile labor and produced capital (Krueger 1977, Deardorff 1984). This blended model suggests we should expect primary products to be exported from relatively lightly populated economies that are well-endowed with agricultural land and/or mineral resources to those economies that are densely populated with few natural resources per worker.

Leamer (1987) developed this Krueger/Deardorff blended model further and related it to paths of economic development. If the stock of natural resource capital is unchanged, rapid growth of produced capital (physical capital plus human skills and technological knowledge) per hour of available labor tends to strengthen comparative advantage in 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, other things being equal. 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.

If a resource-rich economy directs some of its capital investment to forms that are specific to primary production, it would not develop a comparative advantage in manufacturing or services until a later stage of development. This is all the more likely if, as real wages rise, new technologies developed for the primary sector become increasingly labor-saving—leading potentially to what are known as factor intensity reversals. This happens when a primary industry in a high-wage country retains competitiveness against low-wage countries by that industry becoming more capital intensive. The primary sector's share of GDP would decline more slowly the faster its productivity growth compared to the average global rate, both relative to that of other sectors.

2.6 Impact of market-disrupting policies

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

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

Specifically, developing country governments tend to depress agricultural relative to manufacturing incentives facing producers, but they gradually change to the opposite sectoral bias as the country passes through the upper middle-income stage. This has the initial effect of artificially boosting initial shares of manufacturing in GDP and employment, but then slowing the relative decline of agriculture as the economy becomes affluent, for reasons explained in Anderson, Rausser, and Swinnen (2013). Since these sectoral support policies typically have a strong anti-trade bias, they reduce the ratio of trade to GDP, reduce the number of products in which the country is internationally competitive, and in particular reduce agriculture's share of exports of low-income countries and its share of imports of high-income countries. The commonly observed anti-trade bias in assistance to agriculture would help the import-competing part of agriculture but at the expense of the more-competitive export-oriented part of the farm sector, so the net effect may not be strong enough for the agricultural share of exports to be boosted by those policies.

Meanwhile, new technologies can alter trade specializations. The Green Revolution that resulted from investments in agricultural research provided a boom to wheat, rice and maize production from the 1960s in India and other countries for which those crops were 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 those crops' prices and hence the output and net exports of GM-free substitutes in countries that have chosen to not allow the production or use of GM crops. The higher a country's agricultural productivity growth, the more it would boost its farm product exports net of imports. That would apply as much to countries that are net importers of farm products as it would to those that are net exporters. Hence one should expect relatively rapid farm productivity growth in a country to boost its agricultural shares of GDP and employment but not necessarily its share of exports—although it should boost its farm trade specialization index (TSI), defined as ((X-M)/(X+M)) where X and M are the country's value of exports and imports of agricultural products.

2.7 Testable hypotheses

The following hypotheses suggested by the above theory are to be tested empirically:

(i) A nation's shares of agriculture in GDP and employment will fall as its per capita income rises, while the manufacturing sector's shares will initially rise and then eventually fall after the country reaches a high per capita income;

(ii) Countries with a relatively large endowment of farm land per capita will have a relatively high share of exports from their agricultural sector, and hence also higher GDP and employment shares;

(iii) Manufacturing shares of GDP, employment and especially exports will be relatively large in countries with a large per capita endowment of non-farm capital relative to natural resource (farm land or mineral resources);

(iv) Agriculture's shares of a nation's GDP and employment, and its TSI but not necessarily its share of exports, will be higher the higher that country's rate of agricultural productivity growth; and

(v) Agriculture's three shares will be greater the higher the rate of assistance to agriculture relative to that for other tradable sectors, but least so for the export share.

3. DATA SOURCES

In order to test the above hypotheses, we have assembled annual data from 1995 to 2018 for more than 160 countries. An earlier start year is not possible without having to shrink the sample size and thereby reduce the spectrum of countries in terms of income per capita. Even then, we had to draw on several sources to get all the desired variables. Ultimately, we were constrained to between 133 and 141 countries (depending on the equation) for a full set of data for all the variables listed below.

Specifically, the three sets of national variables we seek to explain for the agricultural and manufacturing sectors are:

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

(ii) sectoral shares of employment, S_e; and

(iii) sectoral shares of the total value of exports of goods and services, $S_{x.}$

Data sources are as follows: S_v are from the World Bank (2021a); S_e are from the World Bank (2021a) for agriculture and from ILO (2021) for manufacturing; and the export value data in current US dollars to generate S_x are from the World Bank (2021a), which draws from the United Nations (2021) trade data for goods and from the IMF balance of payment data for services.[6]

The explanatory variables used to explain shares and indexes are:

(i) Real income per capita, YPC. This is defined as the natural log of gross domestic product per capita, measured at purchasing power parity (constant 2017 international dollars), from the World Bank (2021a).

(ii) Factor endowments. The data are from World Bank (2021b) expressed in 2018 US dollars for the years 1995 to 2018. We have expressed them per worker, using employment data from the World Bank (2021a) and ILO (2021). Three factor endowment per worker ratios are used:

a. agricultural land, defined as the discounted sum of the future value of crop and pasture land rents;
b. mineral and energy raw material reserves, defined as the discounted sum of the value of rents generated over the lifetime of the reserves; and
c. non-primary produced physical capital plus human capital, where that physical capital excludes the above two forms but includes other machinery, equipment, buildings, and urban land measured at market prices, and all human capital is defined as the discounted value of earnings over each person's lifetime (disaggregated by gender and employment status).

(iii) National total factor productivity (TFP) growth rate estimates for agriculture, available from USDA-ERS (2021). For the methodology involved in generating those growth rates, see Fuglie, Wang, and Ball (2012). To smooth seasonal variations, we use the percentage increase in the average of the current and previous two years' TFP growth rate over that for the average of the preceding five years.

(iv) Relative rate of assistance to agriculture vs non-agriculture (RRA), available from Anderson and Nelgen (2013). RRA is defined as $100*[(100+NRAag^t)/(100+NRAnonag^t)-1]$, where $NRAag^t$ and $NRAnonag^t$, respectively, are the nominal rates of assistance (NRAs) for the tradable segments of the agricultural and non-agricultural goods sectors. The NRA is the percentage by which gross returns to producers in a sector are raised because of government sectoral or trade policies.

[6] The Standard International Trade Classification (SITC) codes for agriculture are SITC 0, 1, 2, except 27, 28, and 4. For mining they are SITC 27, 28, 3, and 68; and all other merchandise items are classified as manufactures (United Nations 2021).

A summary of the per worker endowment and per capita income variables for the key regions of the world are shown for 2018 in Table 1. There is no clear delineation between high-income and developing countries in terms of their agricultural endowments: North America and Australia have 2-3 times the global average, and even the European Union has 16% more, while among developing countries Latin America and China have more than twice the endowments of South Asia, Africa and the Middle East. Mining endowments also are not highly correlated with YPC, unlike non-primary capital endowments.

[insert Table 1 about here]

One indicator of international competitiveness in agricultural (including processed food) products is the 'revealed' comparative advantage index, defined as the share of those goods in national merchandise exports as a ratio of that sector's share of global merchandise exports (Balassa 1965). Figure 1 shows that since the 1970s that index has converged on unity for high-income countries (from below) and for upper-middle income countries (from above). It also shows that, since the 1990s, the index has remained at 1.5 for lower middle-income countries and has risen from 2.0 to 3.0 for low-income countries. That might seem not very consistent with the above theory. However, it needs to be kept in mind that it is an index as revealed by trade data that have been very distorted in various ways by agricultural and trade policies since the 1950s (Anderson 2009). Also, the data include processed foods, and such processing – including for export – has risen dramatically in recent decades in upper-income countries as declining trade costs have enabled the inputs (primary farm products) to become more tradable internationally (Reardon and Minton 2021). Furthermore, this index says nothing about agricultural imports and hence national self-sufficiency in food and other farm products.

[insert Figure 1 about here]

To help overcome the latter two concerns with looking at agricultural and food export data, Table 2 shows trends in the farm trade specialization index over the past six decades (net exports divided by the sum of exports and imports of agricultural goods). It reveals Australia, New Zealand and South America remain very highly specialized in agricultural exports, although the TSI fell somewhat this century for Australia because of a huge China-induced mining boom. North America and Southeast Asia also have retained net-exporter status in farm products, while Japan has remained a strong net importer. The European Union was a net importer in the 1960s and 1970s but that country group's TSI gradually fell to zero over the following decades thanks to strong EU agricultural support policies and their impact in boosting EU farm productivity growth. China was self-sufficient in farm products before it opened up and began to phase out its anti-agricultural and anti-trade policies from the late

1970s, which initially led it to becoming increasingly a net exporter of farm goods before its rapid industrialization caused it to switch increasingly to net-importer status. As for Africa, it was a net agricultural exporter in the 1960s during which time many of the countries of that regions became independent, but by the 1980s it had become a net importer and that tendency has increased each decade since then.

[insert Table 2 about here]

Evidently, specializing in agricultural exports need not be inconsistent with an economy growing to high-income status, just as being internationally competitive in manufactures or services is not confined only to upper-income countries. With these data in mind, we now turn to our regression results, based on more than 130 countries for the 24 years from 1995 to 2018, aimed at showing the importance of per capita income and relative factor endowments in determining the shares of agriculture (and manufacturing) in national GDP, employment and exports.

4. REGRESSION RESULTS

Since the hypothesized relationships between sectoral shares and per capita income are not expected to be linear, we use the natural log of per capita income and the square of that term in our fixed-effects panel regressions, where we control for both year- and country-fixed effects. The other key variables are the three factor endowments, since trade theory suggests they should influence production and especially trade specialization of open economies. These ratios are the value per worker of the stock of agricultural land, of mineral and energy resources, and of non-primary produced physical capital plus human capital. In addition, we test whether agriculture's sectoral shares are impacted by farm productivity growth and the relative rate of assistance to farmers.

Table 3 presents the results aimed at explaining the sectoral shares for agriculture. Both the log of income per capita and its square have significant coefficients and the appropriate signs for a concave decline. The endowment of agricultural land per worker also has a positive and (except for employment) significant coefficient, again consistent with the above trade theory. The coefficients for non-primary capital has the appropriate negative sign for GDP and employment shares but not for export shares. Recall, though, that this variable includes all human capital so is capturing more than physical capital in non-primary sectors. The coefficients for the TFP growth variable is not very significant but is positive for the GDP and employment shares. However, its sign suggests that faster farm TFP growth reduces the sector's share of exports. As explained above, this may be because it reduces net imports of farm products. Ideally this variable should measure agriculture's TFP growth relative to that of other sectors, but unfortunately there are no estimates available for nonagricultural TFP growth during 1995–2018 for the more than 130 countries in our sample. The adjusted R^2 values are high for national agriculture's shares of value added and employment (above 0.7) but, as expected, it is much lower for the export share (only 0.18).

[Insert Table 3 about here]

The results for manufacturing shares are reported in Table 4. Their adjusted R^2 values are much smaller than those in Table 3 for agriculture. The coefficients of the log of income per capita and its square have the hypothesized signs, that is, they are consistent with an inverted U-shaped path as the average national economy moves from primary production to manufacturing and then services in the course of its economics growth. Those coefficients are significant in the employment and export equations. As for the endowment variables, they have the hypothesized signs in the employment and export share equations, and are statistically significant in the export share equation; it is only the GDP share equation that has no explanatory power.

[Insert Table 4 about here]

We also explored the importance of the relative rate of government assistance (for a subset of 67 countries for which RRA estimates are available). However, in both sets of equations it generated the opposite of the hypothesized sign and added nothing to the R^2 values (even when lags in response were included), and so they are not included in Tables 3 and 4. The explanation for this result probably lies in the high correlation between RRA and YPC, as reported in Table 1 of Anderson, Rausser, and Swinnen (2013). Apart from that, these results are generally supportive of the structural transformation hypotheses summarized in Section 2.7 above, even though the statistical significance of some exogenous was not very strong in some cases.

5. POLICY IMPLICATIONS

The above empirical results together with the theory behind them provide clear implications for governments. The most fundamental lesson is that GDP and employment shares for the agricultural sector inevitably will decline in the course of economic growth. Hence, intervening to prevent that decline with supportive policies will require those supports to continue to rise over time as their value gets capitalized into the value of farm land, at ever-greater cost to consumers and/or taxpayers per farm job retained or farm business saved.

Second and less well-known, manufacturing as a whole as a share of the economy will inevitably decline too. In fact in high-income countries its share of employment has been declining even faster than its GDP share (World Bank 2021a), which is opposite to the agricultural experience. Hence policies aimed at slowing deindustrialization, like those aimed at slowing de-agriculturalization, also 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 would accelerate economic growth via dynamic gains from trade. Governments would then have more wherewithal to assist the least-able of those workers and firms exiting those declining sectors to find new opportunities. Fortuitously, there are now far cheaper and easier ways for governments to target income supplements to needy households, thanks to the ICT revolution that has brought financial inclusion to developing countries at an astonishingly fast pace in recent years (Demirgüç-Kunt et al. 2018). This phenomenal advance in access to e-banking is making it possible for conditional cash transfers to be provided electronically as direct government assistance to even remote rural households of low-income countries.

If open countries are still unsatisfied with the contribution of their farmers to national food security, at least as reflected in food self-sufficiency ratios, an alternative to protectionism would be to subsidize investments in agricultural R&D, rural education and health, roads, and other rural infrastructure improvements (Fuglie et al. 2020). If countries currently underinvest in such activities, extra support could also boost national economic growth. The result in Table 4 are supportive: agricultural productivity growth evidently slows the decline in agriculture's shares of GDP and employment. And even though it does not evidently raise agriculture's share of exports, it may reduce agricultural imports and hence boost food self-sufficiency in that way. Furthermore, re-purposing agricultural support payments makes sense for the decades ahead also because governments are coming under increasing pressure to ensure the agricultural sector contributes also to well-being through more environmentally sustainable production methods and improvements in nutrition and human health (World Bank and IFPRI 2022).

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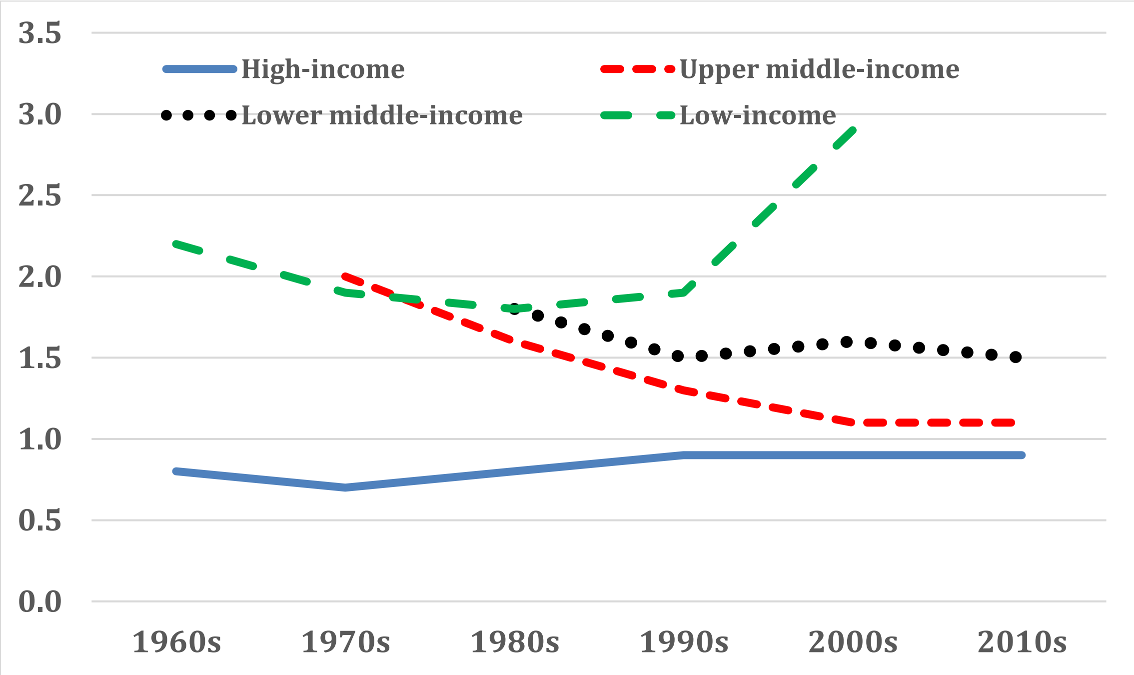
Figure 1: Indexes of 'revealed' comparative advantage[a] in agricultural and food products, 1961 to 2018



[a] The 'revealed' comparative advantage index in agricultural products is the share of agriculture and food in national merchandise exports as a ratio of that sector's share of global merchandise exports, hence 1 for the world (Balassa 1965).

Source: Compiled from data in World Bank (2021a).

Table 1: Regional per worker agricultural land, mineral resources, and other capital[a] endowments, and real income per capita (YPC), relative to the world, 2018

	Agric K	Mining K	Other K[a]	YPC
North America	187	194	545	369
Latin America & Caribbean	123	80	56	96
Europe & Central Asia	119	83	216	131
EU 28 only	*116*	*14*	*260*	*264*
East Asia & Pacific	119	128	129	103
China only	*141*	*46*	*109*	*92*
Australia only	*318*	*1209*	*511*	*288*
South Asia	54	3	17	36
India only	*71*	*16*	*14*	*39*
Sub-Saharan Africa	57	27	11	22
Middle East & North Africa	53	1609	81	208
WORLD	100	100	100	100

[a] 'Other K' refers to non-natural produced capital and all human capital.

Source: Authors' compilation drawing on the World Bank (2021b) for the value of the various capital endowments per worker and World Bank (2021a) for real income per capita (YPC).

Table 2: Indexes of trade specialization in primary agricultural products,[a] by region, 1961 to 2019

	1960s[b]	1970s	1980s	1990s	2000s	2010s
European Union 28	-0.34	-0.21	-0.09	-0.02	-0.01	0.02
United States and Canada	0.14	0.25	0.26	0.22	0.09	0.09
Australia	0.81	0.79	0.77	0.70	0.58	0.47
New Zealand	0.83	0.81	0.80	0.73	0.68	0.67
Japan	-0.88	-0.91	-0.91	-0.92	-0.90	-0.88
China	0.01	0.10	0.09	0.22	-0.11	-0.39
India	-0.13	0.13	0.21	0.36	0.21	0.21
Southeast Asia	0.33	0.28	0.33	0.19	0.22	0.20
South America	0.56	0.56	0.56	0.47	0.57	0.59
Africa	0.41	0.22	-0.12	-0.16	-0.22	-0.25

[a] Agricultural trade specialization index is net exports as a ratio of the sum of exports and imports of agricultural products (so ranging between -1 and +1, positive for net exporters, and the world index is zero). Does not include processed food.

[b] 1960s is 1961–69.

Source: Compiled from FAO (2022).

Table 3: Determinants of agriculture's shares of value added, employment and exports (%), 1995–2018

	GDP (value added)	Employment	Exports
lnYPC	–29.49***	–56.33***	–44.05***
	(–2.96)	(-4.73)	(–2.69)
lnYPC squared	1.39**	2.80***	2.27**
	(2.55)	(4.18)	(2.47)
Agricultural endowment	1.77***	0.59	1.72*
	(3.01)	(1.29)	(1.81)
Non-primary capital endow't	-1.00	-1.95**	0.15
	(-1.52)	(-2.48)	(0.06)
Agricultural TFP growth	0.84	2.43*	–5.91**
	(0.48)	(1.88)	(–2.00)
R-squared (adjusted)	0.723	0.792	0.181
Observations	3,226	3,295	2,704
No. of countries	141	141	133
Country fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes

Note: T-statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Source: Authors' computations.

Table 4: Determinants of manufacturing shares of value added, employment and exports (%), 1995–2018

	GDP (value added)	Employment	Exports
lnYPC	11.81	53.33***	50.85**
	(1.53)	(7.90)	(2.30)
lnYPC squared	–0.64	–2.63***	–3.00**
	(–1.60)	(–7.29)	(–2.46)
Non-primary capital endow’t	–0.13	0.05	5.64***
	(–0.13)	(0.16)	(3.05)
Ag+mineral endowment	0.10	–0.01	–0.55**
	(0.69)	(–0.20)	(–2.02)
R-squared (adjusted)	0.030	0.252	0.070
Observations	3,152	1,955	2,745
No. of countries	138	133	134
Country fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes

Note: T-statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Source: Authors’ computations.