CHAPTER 73

Agricultural Productivity and Economic Growth

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Abstract

In most poor countries, large majorities of the population live in rural areas and earn their livelihoods primarily from agriculture. Many rural people in the developing world are poor, and conversely, most of the world's poor people inhabit rural areas. Agriculture also accounts for a significant fraction of the economic activity in the developing world, with some 25% of value added in poor countries coming from this sector. The sheer size of the agricultural sector implies that changes affecting agriculture have large aggregate effects. Thus, it seems reasonable that agricultural productivity growth should have significant effects on macro variables, including economic growth.

But these effects can be complicated. The large size of the agricultural sector does not necessarily imply that it must be a leading sector for economic growth. In fact, agriculture in most developing countries has very low productivity relative to the rest of the economy. Expanding a low-productivity sector might not be unambiguously good for growth. Moreover, there are issues of reverse causation. Economies that experience growth in aggregate output could be the beneficiaries of good institutions or good fortune that also helps the agricultural sector. Thus, even after 50 years of research on agricultural development, there is abundant evidence for correlations between agricultural productivity increases and economic growth but little definitive evidence for a causal connection.

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This chapter reviews theoretical arguments and empirical evidence for the hypothesis that agricultural productivity improvements lead to economic growth in developing countries. For countries with large interior populations and limited access to international markets, agricultural development is essential for economic growth. For other countries, the importance of agriculture-led growth will depend on the relative feasibility and cost of importing food.
JEL classifications: O11, O13, O41, O47, Q1

Keywords

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structural transformation
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1. INTRODUCTION

In most poor countries, large majorities of the population live in rural areas and earn their livelihoods primarily from agriculture. In sub-Saharan Africa and some parts of Asia, as much as 60% of the economically active population works primarily in agriculture, and approximately the same fraction resides in rural areas. Many of the people living in the rural areas of the developing world are poor, and conversely, most of the world's poor people inhabit rural areas—as much as 70–75%, according to Ravallion et al. (2007).

Agriculture also accounts for a significant fraction of the economic activity in the developing world, with some 25% of value added in poor countries coming from this sector (World Development Indicators, 2009). Agriculture also makes up a large fraction of the exports of developing countries, with both food and nonfood crops playing important roles. In a few countries, exports of raw agricultural commodities total 15–30% of GDP.

The sheer size of the agricultural sector implies that changes affecting agriculture have large aggregate effects. But these effects might be complicated. The large size of the agricultural sector does not necessarily imply that it must be a leading sector for economic growth. In fact, the agricultural sector in most developing countries has very low productivity relative to the rest of the economy. Expanding a low-productivity sector might not be unambiguously good for growth. In fact, a skeptical line of thought in development economics has long argued that the agricultural sector is at best a limited source of growth; this "agro-pessimist" viewpoint, expressed in recent writings such as Dercon (2009), is discussed here.

Economic theories and models dating back to the work of Mellor, Gardner, and Johnston in the 1960s offer insights into the mechanisms through which agricultural productivity growth might drive overall economic growth, but the assumptions

invoked by some models are strong. Under alternative assumptions, some researchers (e.g., Matsuyama, 1992) find exactly the opposite: that agricultural productivity gains may be negatively related to economic growth.

Many empirical analyses have also attempted to use time series or cross-country studies to demonstrate a causal link from agricultural productivity levels or growth rates to the broader economy. But although this work draws on a plethora of different methodological approaches and data types, there is little that meets contemporary standards of econometric identification. As a result, the correlations between agricultural productivity growth and economic growth are empirically well demonstrated, but the causal relationships are less clear.

This chapter selectively reviews the literature on agricultural productivity and its contributions to economic growth. It argues that agricultural productivity growth is neither a necessary nor sufficient condition for economic growth—but that in many developing countries, agricultural productivity growth is nevertheless the first and most important source of economic growth. Recent research has offered a vast amount of evidence documenting the links between agricultural development and economic growth (including the World Bank's *World Development Report 2008* and the associated background papers), and recent work in the growth literature has helped clarify agriculture's role. The chapter argues that we now understand fairly clearly the circumstances in which agricultural productivity can and must play a central role in economic growth—as well as those circumstances in which it will not.

Some specific questions addressed here include these:

- How convincing are the empirical claims that increasing agricultural productivity leads to economic growth? What lessons can we draw from historical episodes, and what do recent country experiences tell us?
- What underlying rationales or models support these claims?
- What assumptions are critical to these models? Could alternative models also apply?
- What empirical evidence can allow us to distinguish between models? Under what conditions might one model be more useful than others?

The chapter proceeds as follows: Section 2 sets out some central facts about agricultural productivity and economic growth. Section 3 reviews some of the theories that might provide guidance in thinking about causal mechanisms. Section 4 reviews some of the empirical literature that documents links between agricultural productivity and economic growth. Section 5 considers skeptical views of the relationship between agricultural productivity and growth and concludes by offering a summary and interpretation of the evidence.

The literature in this field is too vast for any review article to be comprehensive or exhaustive. This chapter instead tries to cover a somewhat representative assortment of the literature, focusing in particular on some writings from the growth field that might be unfamiliar to many agricultural economists. Readers in search of other

recent literature reviews might want to consult such previous efforts as Byerlee et al. (2009), Diao et al. (2004), Irz et al. (2001), Mellor (1999), Mundlak (2000), Staatz and Dembélé (2007), Thirtle et al. (2001), Timmer (2003), and of course, the comprehensive effort represented by the World Bank's *World Development Report 2008*. In addition, no fewer than three previous chapters in various *Handbook* volumes have addressed similar questions: Timmer's piece on "The Agricultural Transformation" in the *Handbook of Development Economics* (1988); Timmer's piece on "Agriculture and Economic Development" in the *Handbook of Agricultural Economics* (2002); and Foster and Rosenzweig's article on "Economic Development and the Decline of Agricultural Employment" in the *Handbook of Development Economics* (2008). Many of the issues addressed in the current chapter have been covered previously in these excellent surveys, among others.

2. BACKGROUND: WHY FOCUS ON AGRICULTURE?

As noted, a large fraction of the developing world's labor force works in agriculture. For the world as a whole, about 40% of workers earn their living primarily from agriculture. For the poorest countries in the world, the fraction is much higher: In those countries classified by the United Nations as least developed, 65% of the labor force is employed in agriculture. More than a dozen countries have agriculture shares of employment that exceed 75%, and the East African region as a whole approaches this level. Table 1 offers a breakdown for a number of regional aggregates; Figure 1 shows a scatter plot of the data for individual countries.

These numbers are necessarily imprecise. In principle, the data report the share of individuals who earn their living primarily from agriculture, but this could overstate the actual fraction of hours worked in agriculture. Many people who are counted as working in agriculture also supply labor for other market and nonmarket activities. The numbers understate, however, the fraction of individuals whose livelihoods are linked closely to the agricultural sector, such as those employed in transporting or processing agricultural goods. One crude way to measure the number of people in this category is to look at rural populations. For the world as a whole, the UN Food and Agriculture Organization (FAO) reports that approximately half of the world's people live in rural areas, and in the least developed countries, the figure is about three fourths (see Table 2).

Agriculture also accounts for large fractions of economic activity, measured in value terms. In many developing countries, 25–30% of GDP comes from agriculture; in a few poor countries, primarily in Africa and Southern Asia, agriculture's share of output exceeds 40%. (See Table 3 for regional aggregates.) In general, there is a strong and negative relationship between a country's level of income per capita and the fraction of agriculture in output. This relationship, one of the oldest stylized facts in the growth

Table 1 Agricultural population and economically active population, as share of total, 2010

Region	Total Population	Agricultural Population as Fraction of Total	Total Economically Active Population (1000)	Fraction of Economically Active Population in Agriculture
Africa	1,032,014	0.508	459,461	0.524
–Eastern Africa	332,106	0.732	160,585	0.744
–Middle Africa	129,582	0.569	55,510	0.580
–Northern Africa	206,295	0.314	86,267	0.301
–Southern Africa	56,592	0.138	24,269	0.107
–Western Africa	307,439	0.440	132,830	0.457
Americas				
–Northern America	348,573	0.017	182,535	0.016
–Central America	153,658	0.208	67,758	0.185
–Caribbean	42,300	0.217	19,980	0.208
–South America	397,742	0.138	180,736	0.135
Asia				
–Central Asia	62,061	0.213	30,441	0.206
–Eastern Asia	1,562,575	0.536	937,594	0.544
–Southern Asia	1,715,319	0.481	784,158	0.520
–South-Eastern Asia	594,214	0.434	313,463	0.469
–Western Asia	232,140	0.183	99,233	0.241
Europe	719,955	0.058	365,121	0.060
Australia and New Zealand	25,647	0.045	13,197	0.046
Other Oceania	9,842	0.606	4,699	0.588
Least Developed Countries	862,829	0.645	414,307	0.650
World	6,896,040	0.384	3,458,376	0.406

Source: FAOSTAT 2009.

literature, is illustrated in Figure 2, which uses PPP measures of real per capita income from the Penn World Tables (Heston et al., 2006) for the year 2005.

The cross-section data on agriculture's share of employment and output echo the time-series data for countries that are currently rich. Figures 3 and 4 show agriculture's share of employment and output for 15 of today's industrial countries at moments in

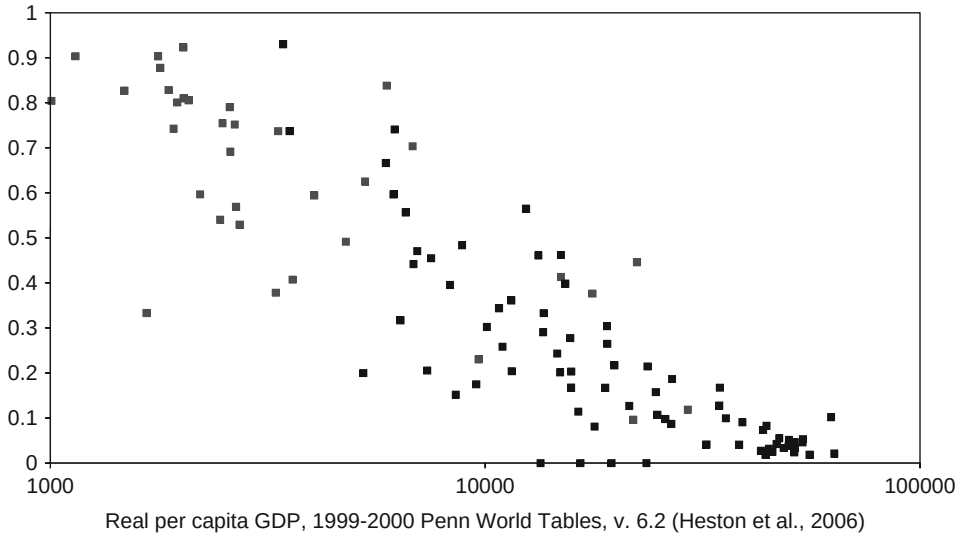

Figure 1 Agriculture Share of Workforce, Cross-Section Data, 2000.

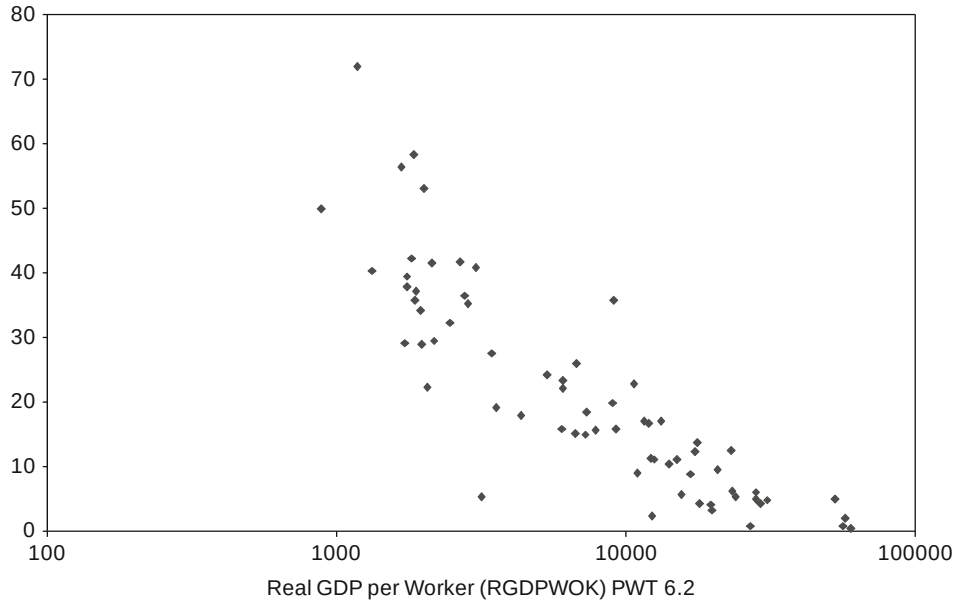

Figure 2 Agriculture's Share of GDP, Cross-Section Data. Sources: Data on Real GDP per Worker are taken from Penn World Tables, v. 6.2 (series RGDPWOK) for 2000; data on agriculture's share of GDP are from the World Bank's *World Development Indicators* accessed April 2009.

Table 2 Total population and fraction rural, 1950-2010

Region	1950		1960		1970		1980		1990		2000	
	Total	Rural	Total	Rural	Total	Rural	Total	Rural	Total	Rural	Total	Rural
Africa	224,203	0.855	282,238	0.813	364,135	0.764	479,786	0.721	637,420	0.680	820,960	0.641
–Eastern Africa	65,071	0.947	82,758	0.926	109,021	0.896	145,950	0.853	197,244	0.821	257,293	0.793
–Middle Africa	26,104	0.860	32,173	0.823	41,289	0.751	54,715	0.710	73,632	0.675	97,765	0.628
–Northern Africa	53,303	0.752	67,308	0.696	85,939	0.637	111,364	0.597	143,965	0.553	174,436	0.516
–Southern Africa	15,591	0.624	19,731	0.581	25,462	0.563	32,974	0.553	41,827	0.512	51,950	0.461
–Western Africa	64,134	0.901	80,268	0.848	102,424	0.786	134,783	0.727	180,752	0.668	239,516	0.612
Americas	339,241	0.472	424,319	0.410	519,473	0.355	619,924	0.314	728,198	0.275	838,719	0.232
–Northern America	171,615	0.361	204,150	0.301	231,931	0.262	255,545	0.261	283,921	0.246	315,671	0.209
–Central America	37,515	0.608	50,916	0.536	69,581	0.462	92,254	0.397	112,725	0.350	135,587	0.313
–Caribbean	17,132	0.632	20,773	0.599	25,421	0.545	29,855	0.483	34,356	0.440	38,616	0.384
–South America	112,979	0.573	148,480	0.490	192,540	0.403	242,270	0.317	297,196	0.255	348,845	0.205
Asia	1,384,367	0.836	1,668,862	0.806	2,092,096	0.778	2,578,620	0.742	3,112,431	0.685	3,704,836	0.629
–Eastern Asia	669,906	0.835	791,743	0.798	986,627	0.772	1,178,001	0.743	1,343,911	0.670	1,476,295	0.596
–Southern Asia	493,949	0.842	597,904	0.828	744,255	0.806	940,609	0.766	1,192,559	0.735	1,460,856	0.710
–South-Eastern Asia	178,149	0.846	223,127	0.815	286,762	0.786	359,107	0.745	440,574	0.684	519,997	0.603
–Western Asia	42,363	0.737	56,088	0.659	74,452	0.566	100,903	0.488	135,387	0.386	192,389	0.363
Europe	566,339	0.491	631,477	0.436	693,553	0.381	739,288	0.332	777,792	0.312	717,700	0.290
Australia/New Zealand	10,127	0.238	12,648	0.195	15,548	0.155	17,751	0.146	20,284	0.147	22,993	0.131
Other Oceania	2,680	0.915	3,234	0.878	4,089	0.813	5,102	0.776	6,449	0.756	8,112	0.764
Least Developed	200,175	0.927	247,118	0.905	315,603	0.869	405,528	0.827	525,118	0.790	678,997	0.752
World	2,526,957	0.709	3,022,778	0.671	3,688,894	0.640	4,440,471	0.609	5,282,574	0.571	6,113,320	0.535

Source: FAOSTAT 2009.

Table 3 Agriculture's share of GDP (%), selected regional aggregates

Region	1965	1970	1980	1990	2000	2006
High income	..	..	4.0	2.8	1.9	1.4
Middle income	27.0	25.0	20.1	16.8	10.8	9.2
Low income	..	..	..	34.2	30.4	25.9
East Asia & Pacific	37.8	34.6	28.6	25.0	14.6	11.8
Europe & Central Asia	..	..	..	15.4	9.5	7.4
Latin America & Caribbean	16.1	12.9	10.1	8.9	5.9	5.9
Middle East & North Africa	..	..	15.6	18.1	12.6	11.7
South Asia	41.0	41.5	34.7	29.1	23.9	18.5
Sub-Saharan Africa	21.9	19.6	18.5	18.8	16.5	16.3
World	..	..	6.6	5.4	3.6	3.0

Source: World Bank, World Development Indicators, accessed 4-30-09.

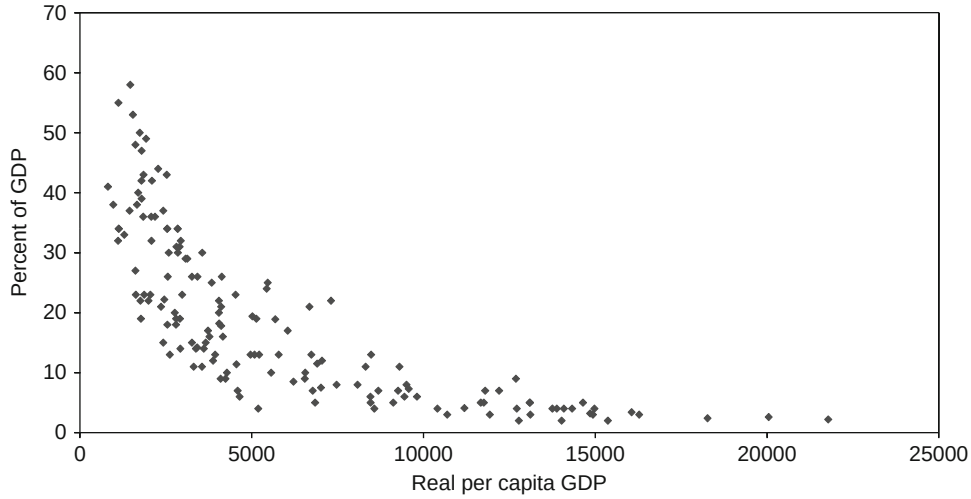

Figure 3 Share of agriculture in GDP, based on time series data for 15 industrial countries. Sources: Mitchell 1992, pp. 912-917; Kurian 1994, p. 93-94; Mitchell 1993, pp. 775-77; Mitchell 1995, pp. 1027-31. Data on real per capita GDP are taken from Penn World Tables, v. 5.6, for the available years of coverage; historical data are taken from Maddison 1995, pp. 194-206.

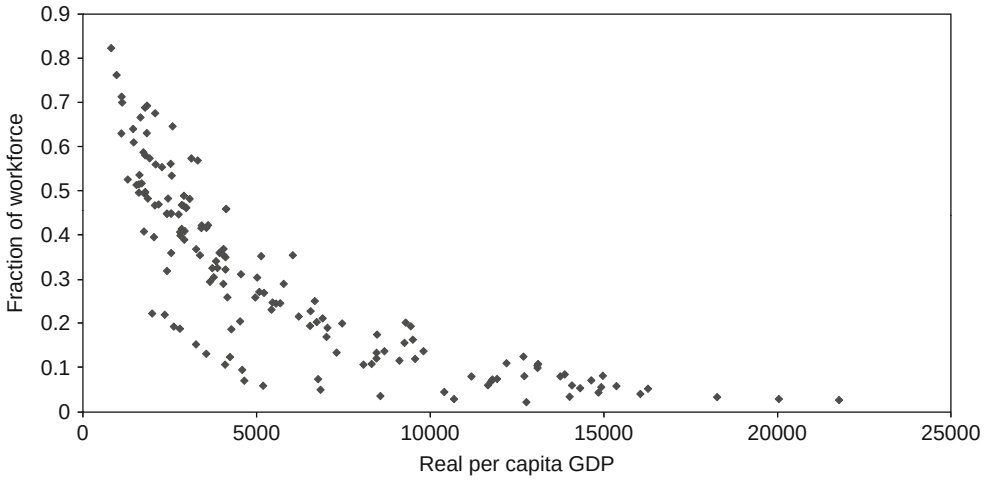

Figure 4 Employment in agriculture as share of total employment, based on time series data for 15 industrial countries. Sources: Mitchell 1992, pp. 141-58; Kurian 1994, p. 78; Mitchell 1993, pp. 99-103; Mitchell 1995, pp. 95-103. Data on real per capita GDP are taken from Penn World Tables, v. 5.6, for the available years of coverage; historical data are taken from Maddison 1995, pp. 194-206.

the historical past when they were relatively poor. It is striking that the historical data display the same patterns as the cross-section data.

As the preceding paragraphs make clear, agriculture's shares in both employment and output are higher in poor countries than in rich ones; but the employment shares are substantially higher than the output shares in most developing countries. This fact is somewhat underappreciated, but it has important implications. As an arithmetic matter, if agriculture accounts for a higher share of employment than of value added, output per worker in agriculture must be lower than in nonagriculture. In fact, the implied differences in output per worker are large.

Table 4 reports calculations of output per worker in agriculture and nonagriculture for a relatively small set of countries. These are calculated somewhat crudely from the aggregate data on agriculture's shares of value added and employment. As such, they should not be taken as careful micro estimates of differences in labor productivity. For that purpose, ideally, we would have firm-level data or wage data from competitive labor markets. Nevertheless, the productivity differences suggested by these calculations are striking. They point to a sharp difference in average labor productivity between sectors. To the extent that average products may be indicative of marginal products or wages, the data offer a clear suggestion that rural areas are poor and that agricultural labor offers low returns.

Table 4 offers additional information on rural poverty. If we take these numbers literally, a number of developing countries have *average* agricultural output per worker that is less than $1000. With the dependency ratios typical in most developing countries, this corresponds to levels of income per capita substantially below $1/day. For many countries, agricultural output per capita is less than $2/day. By contrast, very few countries in the data have nonagricultural output per capita of less than $2/day.[1]

Using a different data set and different PPP exchange rates, the World Bank reports its own data on output per worker in agriculture. In their data, for those countries designated as low income, agricultural value added per worker in 2005 averaged $330, below the $1/day poverty line. For the least developed countries, the corresponding figure was $254. Although we cannot rely too much on these aggregate data for measures of poverty, the data point strongly toward the conclusion that the problem of poverty in the developing world is, at least in a proximate sense, related to a problem of low productivity in agriculture.

There are many possible reasons for the productivity differences across sectors. One possibility is that the sectoral disparity is simply an illusion—an artifact of measurement problems with both labor and output. The labor figures used here do not measure hours worked in agriculture; they instead represent the fraction of the economically active population who report that agriculture is their primary source of income. To the extent that rural people are counted, by default, as working in agriculture, we may overestimate the labor used in agriculture.[2] Similarly, the data might do a poor job of accounting for the value of agricultural output. National income and product accounts in principle include home-consumed agricultural goods, so the problem is

not one of theory. Implementation, however, can be tricky. Sectoral output is usually estimated from area and yield data rather than from market sales, but it is not always straightforward to quantify the volume of output, nor is it obvious what prices should be used for valuing agricultural production.

Ultimately, however, it seems difficult to make the case that the sectoral differences are primarily due to mismeasurement. Living standards in rural areas are visibly lower in much of the developing world; this is borne out in household survey data, anthropometric studies, and other empirical research.[3] Although measurement problems might be real, it is simply implausible to argue that the sectoral gap does not have a real origin.

Among other possible explanations, it might be the case that agricultural labor is disproportionately low-skilled or that agricultural firms are poorly managed. Perhaps many poor countries are simply and irremediably very poor at agriculture—a result, possibly, of adverse climate and geography. Technologies (such as crop varieties and agronomic practices) could be less well developed in the tropics than in other regions (as argued, for example, by Gallup and Sachs 2000 or Masters and McMillan 2001). Any or all of these explanations might help to account for the low measured productivity levels in developing countries' agriculture.

Beyond productivity and agriculture's role as a productive sector, there are other reasons to focus on agriculture as a sector that has important economywide impacts on growth. One particularly important issue is the sector's central role in providing food for poor populations. The relationship between agricultural production and food consumption is too obvious to require any elaboration. Clearly, agriculture produces nonfood goods, but in most developing countries, a large fraction of agricultural land is devoted to food production.

The converse is also true. Although some middle-income countries rely on food imports, much of the food consumed in low-income countries is produced domestically. Few developing countries import more than 10% of their calorie consumption. In sub-Saharan Africa, for example, approximately 90% of all calories consumed as food are produced within the region; most food is in fact produced within the countries where it is consumed. A few coastal cities import significant quantities of grain and meat, but much of the continent consumes virtually no imported food. Many interior countries are almost entirely self-sufficient, except for a few luxury goods consumed by urban elites. Uganda, for example, imports less than 2% of its total calorie consumption.

With low productivity in agriculture, relatively few imports, and low incomes, people in developing countries face high food costs relative to incomes. An equivalent statement is that the real wage is low. In many developing countries, it is common for households to spend half of their incomes on food. In a number of surveys, food accounts for two thirds, three quarters, or even 80% of household expenditure, with higher numbers in rural areas than in urban areas. Numbers like these almost necessarily imply deep poverty, closely related to low agricultural income and output.

Food production thus has importance in the developing world because of its impacts on the poor. It also has particular significance because of its importance for

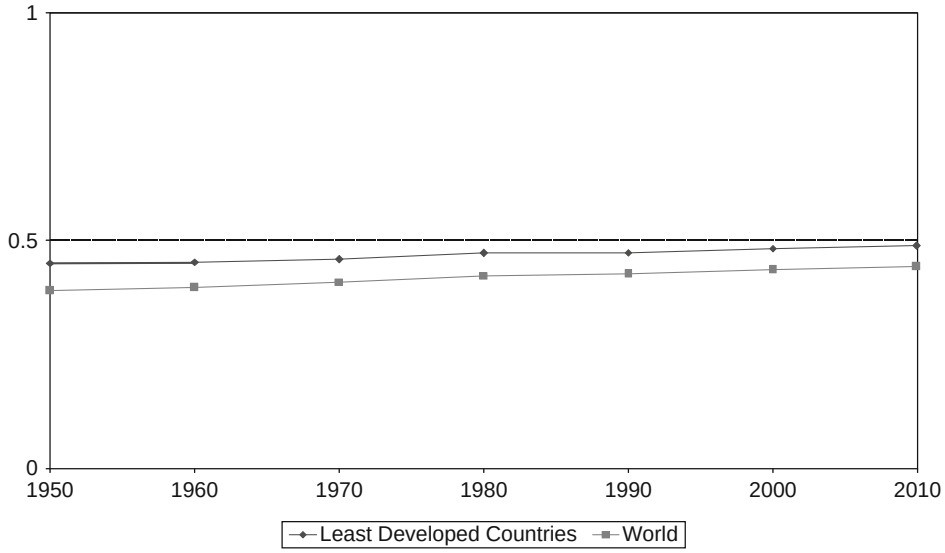

Figure 5 Women as a fraction of agricultural workforce, 1950-2010. Source: FAOSTAT 2009.

women. For the world as a whole, women make up about 45% of the agricultural workforce; in the least developed countries, the fraction is very nearly half (see Figure 5). Perhaps more strikingly, of the world's economically active women, approximately half work in agriculture—a significantly higher fraction than for men. This is particularly true in the least developed countries, where 73% of economically active women work in agriculture, compared with 59% of economically active men. Thus, where women are economically active, especially in the poorest countries, they work in farming. Although this fraction is falling as economies move out of agriculture and opportunities open up for women in other sectors, Figure 6 shows that the transition has not been rapid. These data suggest that, since women disproportionately work in agriculture and since women tend to be disproportionately represented among the poor, agricultural development could have particular relevance from a gender perspective.

Taken together, the facts presented here suggest that if our goal is to understand economic growth in the developing world, we should begin with a careful examination of the agricultural sector. In a proximate sense, it is clear that a major cause of low incomes and slow growth in the developing world is the low level and the slow growth of agricultural productivity. This does not necessarily imply that agriculture should be targeted for remedial investments; after all, perhaps a better strategy is to import larger quantities of food or even to provide food aid on a more systematic basis. But it appears essential to look at developing economies in ways that disaggregate by sector.

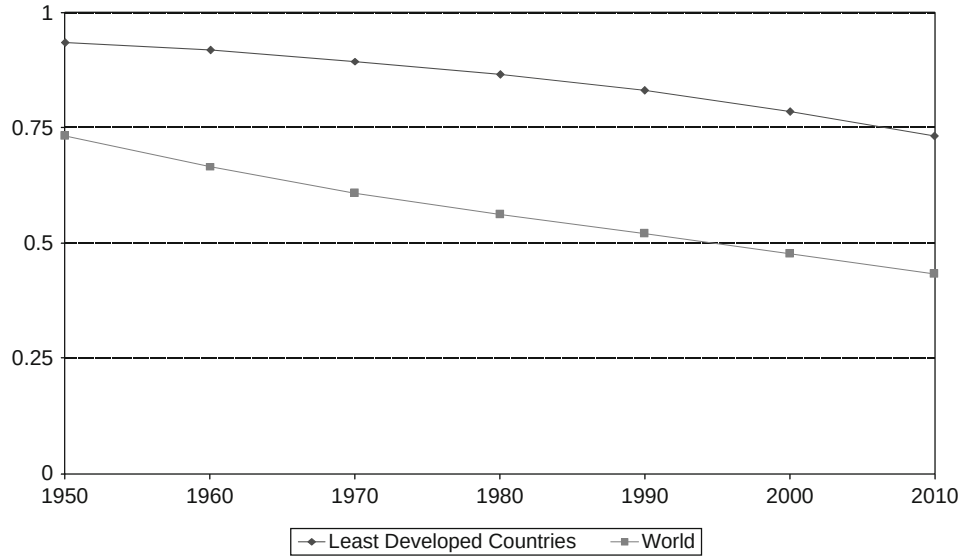

Figure 6 Fraction of economically active women who work in agriculture, 1950-2010. Source: FAOSTAT 2009.

The agricultural situation described here raises a number of questions. Why are so many people in the developing world "stuck" in the subsistence agricultural sector, using little improved technology and essentially unable to benefit from the division of labor? Given the income and productivity differences across sectors, why do we not observe more people migrating out of subsistence agriculture and moving to cities? To address these questions, it is useful to look at previous theories and empirical studies.

3. THEORIES OF STRUCTURAL TRANSFORMATION

As early as Adam Smith, economists recognized that economic growth is accompanied by a sectoral transformation that leads to the movement of labor and other resources out of agriculture and into other activities.[4] The nature of this transition—and the direction of causation—have attracted much discussion and generated a surprising degree of controversy. For example, economic historians have debated whether or not agricultural productivity improvements preceded the Industrial Revolution, and development economists have argued over whether foreign assistance should give priority to agricultural development or industrial development. The stylized facts, however, are not in dispute. Kuznets (1966) initially documented the nature of the structural transformation in both time-series and cross-section data; other early empirical work includes Chenery and Syrquin (1975), Syrquin (1988), and similar studies that documented patterns of sectoral change within and across countries.

The structural transformation—the movement of workers and other resources out of agriculture and into other sectors—has important implications for income levels and growth rates. Since there are large differences in output per worker between agriculture and nonagriculture in the developing world, the movement of workers out of agriculture is, on average, an important source of growth. To see this, consider again the data in Table 4. The right-hand column for each country shows the ratio of labor productivity in nonagriculture relative to agriculture. For a number of countries in the data, nonagricultural labor productivity is far higher than agricultural labor productivity, with tenfold and twentyfold differences not infrequent. In these countries, a marginal worker who moves from agriculture into the nonagricultural sector will drive up the average product of labor for the economy as a whole. Looking back over the past 50 years, the sectoral reallocation of labor has been an important source of income growth in many countries.

Table 5 shows a decomposition of growth in output per worker for those developing countries with available data. The first column in this table shows the average annual compound growth rate for output per worker, as reported in the PWT 6.2 data (Heston et al., 2006). Country observations are sorted in descending order by this variable. The next two columns show the contributions to overall growth in output per worker that come from productivity growth within agriculture and nonagriculture. Figure 7 shows a scatter plot of growth in output per worker in agriculture and for the aggregate economy. To derive these numbers, the growth rates of agricultural output per worker and nonagricultural output per worker are calculated, based on analysis comparable to that in Table 4 but going back to previous years. Growth rates within each sector are then weighted by the share of each sector in output in 1980 (approximately the midpoint of the data). The weighted sector growth rates are shown in the second and third columns of Table 5. The residual unexplained growth in output per worker is then due to sectoral reallocation, and it is shown in the rightmost column of the table.

A striking result is that for many of the countries in the data, sectoral reallocation is a major source of growth in output per worker. China, which is the country in the data with the most rapid growth in output per worker, appears to have gotten almost all of its growth from the reallocation of workers out of agriculture. Other countries with large fractions of their growth coming from sectoral reallocation include Egypt, Turkey, Brazil, Mexico, and Kenya. In total, about 30 of the countries in the data received more of their growth from sectoral reallocation than from productivity growth within either sector.

Another striking result is that for almost 30 countries, average labor productivity grew faster in agriculture than in nonagriculture. This of course reflects changes in inputs as well as in technology; it is not a measure of TFP growth. For many countries, agricultural labor productivity rises at least in part because of the severe diminishing marginal returns to labor in agriculture. Where marginal product is low, the movement

Table 4 Sectoral labor productivity, agriculture and non-agriculture, 1999-2000

Country	Real per capita GDP per worker (PWT 6.2)	Agricultural output per worker	Non-agricultural output per worker	Ratio	Country	Real per capita GDP per worker (PWT 6.2)	Agricultural output per worker	Non-agricultural output per worker	Ratio
Liberia	1,174	1,250	1,016	0.81	Suriname	12,453	7,310	13,661	1.87
Congo, DR	885	699	1,205	1.72	Egypt	11,940	5,972	14,941	2.50
Sierra Leone	1,846	1,734	2,030	1.17	Guatemala	10,609	5,341	14,977	2.80
Togo	1,947	1,116	3,180	2.85	Colombia	14,054	7,139	15,825	2.22
Central African Rep.	2,005	1,467	3,438	2.34	Fiji	11,482	4,897	15,871	3.24
Benin	2,769	1,874	3,819	2.04	Zimbabwe	7,302	2,152	15,978	7.43
Sudan	2,669	1,822	3,996	2.19	Dominican Republic	15,009	10,029	16,001	1.60
Chad	1,810	1,018	4,211	4.13	Paraguay	13,150	6,493	16,649	2.56
Guinea-Bissau	1,667	1,135	4,236	3.73	China	6,689	1,512	17,018	11.25
Ghana	2,827	1,750	4,252	2.43	Brazil	15,470	5,196	17,527	3.37
Madagascar	1,722	677	4,733	6.99	Burkina Faso	1,962	617	17,931	29.07
Congo, Rep.	3,150	413	5,011	12.14	Venezuela	17,913	9,306	18,672	2.01
Zambia	2,051	661	5,184	7.84	Algeria	16,661	6,058	20,087	3.32
Mauritania	3,436	1,800	5,266	2.93	Tunisia	17,289	8,658	20,111	2.32
Gambia	1,859	845	5,620	6.65	Turkey	12,205	2,986	20,132	6.74
Lesotho	4,317	1,976	5,824	2.95	Iran	17,595	9,081	20,679	2.28
Malawi	1,742	831	6,166	7.42	South Africa	19,760	6,761	21,136	3.13
Mali	2,138	1,097	6,587	6.01	Papua New Guinea	9,055	4,355	22,702	5.21
Kenya	2,458	1,054	6,775	6.43	Thailand	10,876	1,738	22,724	13.07
Honduras	5,976	3,008	7,343	2.44	Costa Rica	20,596	9,678	23,347	2.41
Uganda	2,163	798	7,664	9.60	Mexico	19,621	3,810	23,943	6.28

Continued

Table 4 Sectoral labor productivity, agriculture and non-agriculture, 1999-2000—Cont'd

Country	Real per capita GDP per worker (PWT 6.2)	Agricultural output per worker	Non-agricultural output per worker	Ratio	Country	Real per capita GDP per worker (PWT 6.2)	Agricultural output per worker	Non-agricultural output per worker	Ratio
Côte d'Ivoire	5,325	2,622	7,940	3.03	Hungary	23,789	11,958	25,202	2.11
Burundi	1,328	594	8,256	13.91	Nepal	3,012	1,319	26,132	19.81
Niger	1,749	755	8,841	11.72	Barbados	29,178	29,165	29,179	1.00
Pakistan	6,719	3,701	9,401	2.54	Argentina	27,980	14,289	29,457	2.06
Senegal	3,542	920	10,884	11.83	Swaziland	23,044	8,456	30,544	3.61
Bolivia	7,195	2,445	10,953	4.48	Chile	27,995	10,870	31,194	2.87
India	6,033	2,363	11,456	4.85	Korea, Rep.	30,621	14,971	32,352	2.16
Cameroon	6,023	2,244	11,552	5.15	Malaysia	26,868	1,235	32,766	26.53
Rwanda	1,874	768	12,629	16.43	Gabon	23,141	3,809	34,864	9.15
Indonesia	7,800	2,516	12,748	5.07	Saudi Arabia	52,825	26,304	55,752	2.12
Philippines	9,229	3,680	12,857	3.49	Puerto Rico	55,981	21,074	56,800	2.70
Sri Lanka	8,967	3,920	13,182	3.36	Kuwait	59,647	19,607	60,085	3.06
Jordan	12,239	2,489	13,511	5.43	Oman	57,038	3,018	88,695	29.39

Source: Author's calculations from PWT 6.2 (Heston et al., 2006) and FAOSTAT.

Table 5 Growth Decomposition, 1960-2000 unless otherwise indicated

Country	Growth of Output per Worker (PWT v. 6.2)	Growth from Agriculture	Growth from Non-Agriculture	Growth from Sectoral Shifts	Remarks
China	0.053	0.014	-0.015	0.054	
Korea, Rep.	0.051	0.007	0.030	0.014	
Thailand	0.043	0.004	0.007	0.032	
Malaysia	0.042	-0.002	0.030	0.014	
Swaziland	0.038	0.005	0.117	-0.084	1970-2000
Sri Lanka	0.034	0.008	0.021	0.005	
Lesotho	0.032	-0.001	0.075	-0.042	
Pakistan	0.030	0.007	0.005	0.018	
Indonesia	0.028	0.001	-0.001	0.027	
India	0.028	0.006	-0.014	0.036	
Egypt	0.028	0.006	-0.011	0.032	1970-2000
Hungary	0.026	0.002	0.038	-0.014	1970-2000
Turkey	0.026	-0.003	-0.009	0.037	1970-2000
Ghana	0.025	0.014	0.007	0.004	
Puerto Rico	0.022	0.001	0.132	-0.110	1970-2000
Papua New Guinea	0.022	0.008	0.026	-0.012	1970-2000
Tunisia	0.021	0.005	0.055	-0.039	1970-2000
Dominican Rep.	0.019	0.005	0.048	-0.034	1970-2000
Malawi	0.019	0.007	-0.006	0.018	
Oman	0.018	-0.001	0.180	-0.161	1970-2000
Nepal	0.018	0.003	-0.002	0.018	1970-2000
Paraguay	0.017	0.003	0.027	-0.013	
Brazil	0.017	0.002	-0.005	0.021	
Congo, Rep.	0.015	-0.001	0.017	-0.002	
Côte d'Ivoire	0.014	0.004	0.000	0.010	
Gabon	0.014	-0.001	0.028	-0.013	
Philippines	0.013	0.003	-0.003	0.013	
Cameroon	0.013	0.003	-0.003	0.013	1970-2000
Burkina Faso	0.013	0.002	0.006	0.006	
Chile	0.012	0.002	0.025	-0.015	
Colombia	0.011	0.001	0.011	-0.001	1970-2000
Benin	0.011	0.006	-0.007	0.012	
Guinea-Bissau	0.011	0.009	0.017	-0.015	1970-2000
Zimbabwe	0.011	0.002	0.015	-0.007	1970-2000
Mali	0.010	0.003	-0.010	0.017	1970-2000
Mexico	0.010	-0.001	-0.002	0.013	1970-2000
Mauritania	0.010	0.007	0.013	-0.010	1970-2000

Continued

Table 5 Growth Decomposition, 1960-2000 unless otherwise indicated—Cont'd

Country	Growth of Output per Worker (PWT v. 6.2)	Growth from Agriculture	Growth from Non-Agriculture	Growth from Sectoral Shifts	Remarks
Barbados	0.010	0.002	0.061	-0.053	
South Africa	0.009	0.001	0.009	0.000	
Iran	0.009	0.001	0.007	0.001	1970-2000
Guatemala	0.009	0.002	0.032	-0.025	1970-2000
Gambia	0.008	0.002	0.031	-0.026	1970-2000
Algeria	0.007	0.003	0.027	-0.022	1970-2000
Costa Rica	0.006	0.000	0.028	-0.022	
Honduras	0.006	0.002	0.005	-0.001	
Argentina	0.005	0.000	0.028	-0.022	1970-2000
Burundi	0.005	-0.011	0.000	0.016	1970-2000
Kenya	0.003	0.001	-0.014	0.016	
Bolivia	0.003	-0.001	0.031	-0.028	1970-2000
Fiji	0.003	-0.001	0.106	-0.102	1970-2000
Uganda	0.003	-0.003	-0.007	0.013	
Central African Rep.	0.000	0.008	-0.013	0.005	1970-2000
Rwanda	0.000	-0.010	0.000	0.010	1970-2000
Zambia	0.000	0.002	-0.014	0.011	1970-2000
Sudan	0.000	0.003	-0.027	0.024	1970-2000
Senegal	0.000	-0.001	-0.005	0.006	
Togo	-0.002	-0.001	0.000	-0.001	
Jordan	-0.004	-0.002	0.088	-0.090	1970-2000
Venezuela	-0.005	0.001	0.008	-0.014	
Chad	-0.005	-0.001	-0.024	0.020	
Niger	-0.006	-0.010	0.000	0.004	
Suriname	-0.006	0.002	0.136	-0.144	1970-2000
Saudi Arabia	-0.007	0.001	0.068	-0.076	1970-2000
Madagascar	-0.011	-0.002	-0.028	0.020	1970-2000
Sierra Leone	-0.018	0.004	-0.012	-0.011	1970-2000
Congo, DR	-0.037	0.001	-0.071	0.033	1970-2000
Kuwait	-0.042	0.000	0.170	-0.212	1970-2000
Liberia	-0.050	-0.001	-0.027	-0.021	1970-2000

Source: Author's calculations from PWT 6.2 (Heston et al., 2006), FAOSTAT, and World Development Indicators.

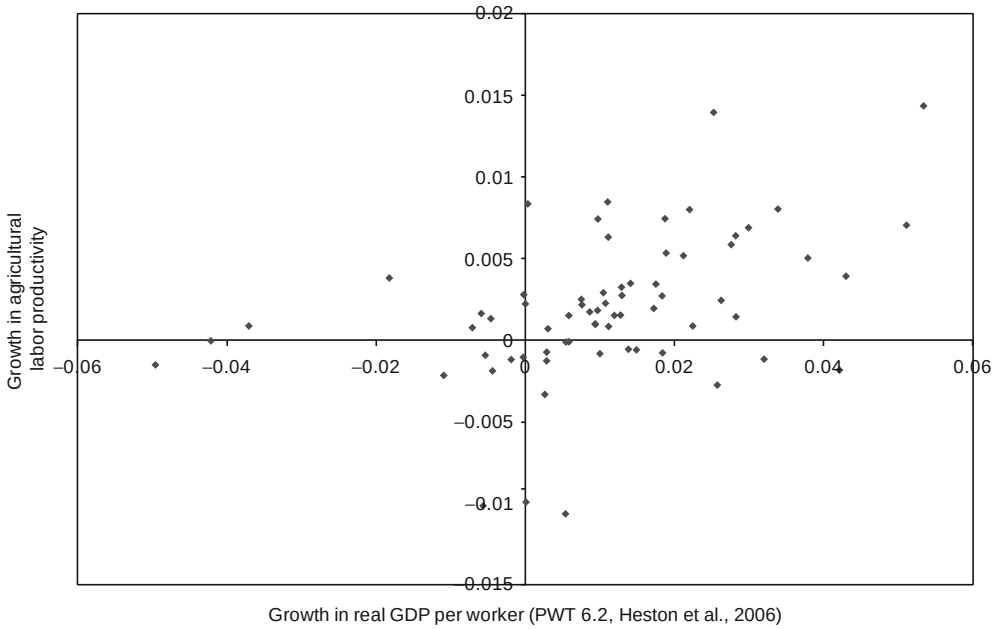

Figure 7 Growth in output per worker and growth in agricultural labor productivity, 1960-2000.

of workers out of agriculture should drive up the average product of the labor that remains. We see this phenomenon in Pakistan, India, and Indonesia—all countries that had relatively strong growth in agricultural TFP over the period 1960–2000.

These empirical observations are consistent with a number of longstanding theories of economic development. The role of structural transformation has been a major theme in the development and growth literature, as will be explored in the following section.

3.1 Theories of agriculture's role

The early development literature offered two different views of the structural transformation—and more generally of the role of agriculture in development. One influential early view was that of Lewis, who, along with influential scholars such as Rosenstein-Rodan (1943) and Rostow (1960), viewed modern economic growth as essentially identifiable with industrialization. These authors, like most of the early growth and development economists, tended to view subsistence agriculture as a default source of employment and as a pool of reserve labor. The challenge of development, in their view, was to create and expand employment in the modern industrial sector. This sector was seen as having high potential for growth, and it was assumed that industry (and, to a lesser extent, services) would gradually absorb workers from agriculture. Lewis

(1955) and Fei and Ranis (1964) viewed the agricultural sector essentially as a pool of surplus labor, with a very low shadow wage.

In many dual-economy models, such as those of Lewis, the labor market dynamics were somewhat ill defined. It was assumed that wage differences could and would arise between the modern sector and the traditional sector, with some kind of efficiency wage story (or, alternatively, a price-distorting minimum wage) accounting for the high wages paid in the modern sector. Harris and Todaro (1970), among others, recognized that incentives would arise for rural-to-urban migration in this model, but they maintained the assumption that the modern sector would provide a limited number of jobs, with wages above the market-clearing level.

An alternative view, also present in the early development literature, was that many poor economies suffered from what T. W. Schultz (1953) characterized as the "food problem." Simply put, Schultz argued that many poor countries are in a situation of "high food drain," in which they have "a level of income so low that a critically large proportion of the income is required for food." Schultz took it as given that countries in this situation must produce the bulk of their own food to satisfy subsistence needs, presumably because imports are prohibitively costly and because these countries have few goods or resources to exchange for food. Until they can meet their subsistence needs, Schultz said, they are unable to begin the process of modern economic growth.

Schultz's view was later echoed in a large literature on development, which held that an agricultural surplus is a necessary condition for a country to begin the development process. The hypothesis was a central argument of Johnston and Mellor (1961), Johnston (1970), Johnston and Kilby (1975), Timmer (1988), and Johnson (1997), and it continued to figure prominently in the later works of Mellor (1995, 1996) and the analyses of many other scholars (e.g., Eswaran and Kotwal, 1993; Mundlak, 2000).

A view that can be characterized as the *Mellor hypothesis* took hold in the agricultural development literature. This hypothesis was typically stated as a narrative model that outlined a set of general equilibrium impacts that were claimed to result from agricultural productivity growth. The Mellor hypothesis held that agricultural productivity growth resulted in a linked set of impacts, including:

- Increases in farm income and profitability, resulting in improved welfare of farmers and the rural poor
- Declining food prices, benefiting poor rural and urban consumers, including small farmers who might be net purchasers of food
- Reductions in the nominal wage, consistent with increases in the real wage, allowing the industrial sector to reduce costs
- Increases in the domestic demand for industrial output
- Increasing competitiveness of both agricultural and industrial exports, with positive impact on hard currency earnings
- Expansion of the domestic industrial sector, pulling labor and investment resources out of agriculture

This framework has been spelled out in various forms in many places (e.g., Mellor, 1995, 1996), but with little effort to model it formally or to test it empirically. Various authors provided empirical support for particular elements of the argument, but there was little effort to test the Mellor hypothesis as a unified theory. In recent years, however, a number of authors have offered explicit two-sector models in which some parts of the Mellor hypothesis can be explored formally.

3.2 Two-sector models

Following a brief flurry of interest in multisector models in the early 1960s (e.g., Uzawa, 1961, 1963), little was written on the subject of structural transformation until perhaps the mid-1990s. Since then, however, a number of researchers have sought to examine the importance of structural change in the growth process. Many recent papers have attempted to offer formal models of structural change, industrialization, and growth. Some have focused on long-run growth processes; others have sought to explain cross-section differences among countries.

One distinction in this literature is whether the models allow for *dualism*, which is often interpreted as simply meaning that markets do not fully clear across sectors or that there are some kinds of barriers or transaction costs that constrain the equilibrium. Dual-economy models are contrasted with fully neoclassical models, in which labor, capital, and goods markets clear across sectors. The distinction has not proven entirely useful, since recent papers have blurred the line by providing various microfoundations for dualism.

Among the first papers in this two-sector literature were some that sought to reproduce the structural transformation. These included Echevarria (1995, 1997); Kogel and Prskawetz (2001); Irz and Roe (2001), and Kongsamut, Rebelo, and Xie (2001). A related set of papers sought to model the structural transformation from a traditional (implicitly agricultural) economy to a modern (largely non-agricultural) economy, focusing primarily on long-run growth issues. Among these papers were King and Rebelo (1993); Goodfriend and McDermott (1998); Laitner (2002); Hansen and Prescott (2002); Ngai (2004); and Ngai and Pissarides (2007).

Several papers have explicitly tried to reproduce the dualism of Harris and Todaro (1970) while bringing a new level of formalism and explicit general equilibrium analysis. For example, Temple (2005), Vollrath (2004), and Vollrath (2008), among others, have explored multisector models in which unemployment or underemployment is possible. In these papers, there may be fixed urban wages or other rigidities that prevent the urban labor market from clearing; other papers (e.g., Caselli and Coleman, 2001) rely on transaction cost wedges that prevent the labor market from equalizing marginal products across sectors. These papers often have the feature that the allocation of resources across sectors is inefficient; the social planner would allocate labor and capital differently.

A stylized implication of this class of models is that policies should focus on removing or reducing the rigidities that lead to inefficient outcomes and overallocation of resources to agriculture.

Another set of growth papers, including Gollin et al. (2002, 2007), follow Schultz in assuming that many poor countries are hindered in their growth processes by the need to tie down large amounts of labor and other resources in food production. These papers show that the transition to modern "Solow"-type growth can be slowed dramatically when countries must feed themselves. Countries that have low agricultural productivity—which could be due to poor technology, geography, or institutions—will trail far behind the leaders, even though in the long run the agricultural sector will be unimportant as a source of cross-country income differences. A stylized policy implication of this line of argument is that efforts to boost agricultural productivity may have a large payoff in terms of growth—a view argued forcefully in Schultz (1964), anticipating much of the subsequent literature. A model based on Gollin et al. (2002) is presented in this chapter.

A key assumption in these papers is that the economies are closed to food imports. If food is essential for consumption and if there is no effective alternative to countries producing this food domestically, development must begin with a focus on agriculture and agricultural productivity—and specifically with food production.

In an open economy world, different results obtain. Matsuyama (1992) offers an example of a model economy in which the importance of the closed economy assumption is made clear. Matsuyama offers a two-sector model with an agricultural sector and a manufacturing sector. In the closed economy version, countries that are good at agricultural production have an advantage in that fewer resources need to be allocated to producing food. However, when the economy is open, a country that has a comparative advantage in agricultural production can become locked into a sector with low levels of technological progress, leaving it doomed to fall farther behind countries that have a comparative advantage in industry. This result is mirrored in a dynamic setting in the one-sector environment explored by Hansen and Prescott (2002). Hansen and Prescott model an economy with a single sector that undergoes a conversion from a Malthusian traditional economy to a modern Solow economy at some point in its development. In this framework, economies that have high productivity levels in the traditional sector will undergo this structural transformation later in history, resulting in lagging long-run levels of output per capita.

In Matsuyama's framework, the availability of imported food allows countries to move resources into the manufacturing sector, where there is more rapid growth. This basic observation, which is echoed to a degree by many more recent critics of agricultural-based development strategies (e.g., Dercon 2009), will be addressed later in this chapter.

Vollrath (2008) offers a different channel through which it could be dynamically disadvantageous for countries to have high agricultural productivity levels. In his model, traditional sector work (which might be assumed to correspond to agriculture) has

production complementarities with fertility and the production of children. Because childrearing is time consuming, countries that experience an increase in the productivity of the traditional sector will see increases in the share of people in the traditional sector, along with rising levels of fertility and increases in population growth rates. Measured output per person will fall, although utility will rise. In this model, agricultural productivity gains will reduce measured output levels but will be efficient from the vantage point of a utility-maximizing social planner. In a sense, this paper is related to Gollin et al. (2004), in which agricultural production has similar complementarities with home production.

Overall, the theoretical literature offers a number of perspectives on the role of agricultural productivity as a source of modern economic growth. The Mellor hypothesis, in which agricultural productivity is necessarily the source of long-run economic growth, does not necessarily hold in all growth models. The hypothesis is most likely to hold in a closed economy in which the agricultural sector is producing food staples that cannot easily be supplanted with imports. Is this the relevant case? Over a number of years, an empirical literature has attempted to ask whether agricultural productivity is linked causally with economic growth. The following section surveys this literature and explains why the literature has struggled to offer cleanly identified causal links.

4. EMPIRICAL EVIDENCE FOR AGRICULTURE'S ROLE

A voluminous literature, dating back to the work of Chinery, Syrquin, and others referenced earlier, has attempted to uncover causation in the (undisputed) correlations between agricultural growth and economic growth. This literature takes a number of different forms. Some studies have sought to use cross-country or cross-section studies that compare agricultural productivity growth rates with GDP growth rates; others have looked at returns to research. Still other papers have used the techniques of growth accounting, or *levels accounting*, to arrive at estimates of agriculture's role in generating economic growth. A recurring problem in the empirical literature is establishing any convincing identification of a causal relationship.

4.1 The difficulty of identification

To understand why identification has been so elusive, consider the following thought experiment: What would be the *ideal* experiment needed to provide clear and unambiguous evidence of the effects of agriculture on overall growth and poverty reduction? For obvious reasons, this can only be a thought experiment rather than a real one. The thought experiment is useful, however: It provides a benchmark against which to measure the other empirical and theoretical evidence that is actually available.

There are many possible variants on the experimental design, but essentially they would all have the following elements. First, take a large number of otherwise identical versions of the world as it currently exists. In each version of the world, identify a single

developing country at random to take part in a "treatment." Other countries will be left unchanged. With enough replicates of the world, we will have a large number of treatment countries; indeed, for each country we will have a large number of treatment experiences and control experiences. For the most effective control, we should also include a number of replicates of the existing world in which no country receives a treatment.

The treatment will consist of a fully funded program that will spur agricultural development, perhaps by achieving a given rate of growth in agricultural productivity. Control countries will receive no development programs, or possibly they will receive comparably sized development programs that target some other sector or sectors. The correct control is unclear.

As part of the experiment, we will observe these economies growing over time. Because the impacts of their development programs could take a long time to come online, we will follow these worlds over a period of several decades at least.

At the conclusion of this time period, we will compare treatment countries with nontreatment versions of themselves and with nontreatment versions of other developing countries. If we collect our data carefully, this comparison will allow us to identify (in a causal sense) the effects of agricultural development programs on growth and poverty reduction. We will be able to infer (with sufficient replications) that differences between the treatment and control versions of the same country are in fact due to the agricultural development treatment.

Obviously this thought experiment is an unattainable ideal. But it serves as a useful benchmark in evaluating the actual comparisons that economists have made in looking at the data. Both supporters and opponents of agriculture-centered approaches to development have tended to focus on the limited cross-country data, either in regression analyses or in more anecdotal accounts and case studies. The usual idea is to look at countries that have implemented a set of policies (e.g., agricultural development policies) and to compare them with those that have not. But these cross-country comparisons are almost certainly flawed because there is no randomness in the "assignment" of countries to treatment or control. Moreover, countries may differ in ways that are correlated with the assignment and that directly affect their outcomes. For example, many of the poorest countries could have weak institutions, low productivity, poor geography, and little access to international markets. These countries are almost certainly agricultural, and many might have pursued agricultural development strategies—which in turn are likely to have proven ineffective.

Supporters of agricultural development generally look at successful countries and argue that they have almost all experienced significant agricultural development. This is a specious argument. Almost by definition, any country that has developed has undergone a structural transformation that involves some growth in the agricultural sector. As a result, these countries appear to show a positive relationship between agricultural development and growth; but this relationship could be spurious.

Opponents of a focus on agriculture, especially in sub-Saharan Africa, tend to argue that previous efforts have achieved little; they infer from this that it would be futile to pursue agricultural development efforts—or at least that it might be more productive to invest in other sectors. But this argument suffers from the opposite fallacy. If African development has been hampered by other barriers (e.g., civil conflict, poor institutions), any development efforts, not just agricultural programs, will have failed. It would be erroneous on this basis to arrive at the conclusion that agricultural development is futile.

We might seek evidence from "before" and "after" comparisons of individual countries that institute pro-agriculture reforms. But these reforms are seldom random in their timing; they typically accompany other policy changes that may have a greater direct effect on outcomes. Any inference about the impact of the agricultural policy changes on outcomes will be "contaminated," in a statistical sense, by the impact of the other reforms.

Essentially the same problem holds with any of the real-world experiences on which we might be tempted to base our analysis. None of these really approximates the benchmark experiment. As a result, we will have great difficulty in interpreting the cross-country or time-series data as offering any conclusive or clear evidence on the impact of agriculture on growth and poverty.

Nevertheless, a number of recent studies have taken aim at the relationship between agricultural growth and economic growth, making use of the best available econometric tools.

4.2 Cross-section and panel studies

A number of recent papers nevertheless have attempted to find relationships between agricultural productivity growth and economic growth using cross-section or panel data, drawing on a variety of econometric techniques.

In a recent paper, Self and Grabowski (2007) report a set of results in which economic growth rates are regressed on a number of right-hand variables, including a variety of direct and indirect measures of agricultural productivity. The results support strong correlations between their productivity measures and growth rates of per capita income. They also find agricultural productivity levels correlated with the growth in the human development index (HDI) achieved by countries. A weakness of their approach, which is acknowledged by the authors, is that the right-hand variables in their regressions could be endogenously determined. The authors admit that their results might not be cleanly identified for this reason, but they note the lack of any obvious instruments that would allow them to bypass this problem.

In an earlier paper along the same lines, Humphries and Knowles (1998) estimate a Solow-type growth model, in the spirit of Mankiw, Romer, and Weil (1992), using as

a right-hand variable the proportion of the labor force working outside the agricultural sector. They interpret the coefficient supporting a positive association between the fraction of the workforce outside agriculture and the growth of income per capita from 1960–1985. Recognizing the possible endogeneity of the labor force variable, the authors also report results based on estimations using instrumental variables. Their preferred instruments are climate variables that are presumed to affect the magnitude of the agricultural sector but not the overall growth rate. They report results that seem consistent with their OLS results.

In an earlier paper, Dowrick and Gemmell (1991) ask how the size of the agricultural sector affects countries' ability to achieve convergent growth. This paper finds that agricultural productivity for the poorest countries in their sample is converging toward the levels of the world leaders, at least after 1973, but it finds that the convergence in agricultural technology is not sufficient to achieve overall convergence in income levels.

A different approach is to ask whether changes in agricultural output (rather than TFP) are causally related to changes in GDP. For example, Tiffin and Irz (2006) use Granger causality tests to argue that the correlation between these two variables takes a form that implies a causal direction from agriculture to the aggregate economy rather than the converse. Bravo-Ortega and Lederman (2005) also rely on Granger causality tests in an attempt to trace causal links from agricultural productivity growth to a variety of aggregate welfare measures.

Perhaps more common in the literature are studies that seek to trace causal links from agricultural productivity to poverty reduction (for example, Datt and Ravallion, 1996; Thirtle et al., 2001; Irz et al., 2002; Fan et al., 2000). Much of this literature argues that agriculture-based growth is more effective than other forms of growth at reducing poverty. Mellor (2000) expressed this view most forcefully, in a view characterized critically by Hasan and Quibria (2004) as "agricultural fundamentalism." Mellor specifically makes the claim: "There has been a tendency to generalize that economic growth reduces poverty when in fact it is the direct and indirect effect of agricultural growth that accounts for virtually all the poverty decline." Because this chapter focuses on the links to economic growth, the literature on agriculture and poverty reduction lies largely beyond our scope.

To sum up, the empirical evidence linking agricultural development to economic growth in the cross-country data is highly suggestive but offers few examples of convincingly identified causal links. Reviewing this literature, Gardner (2003) and Tsakok and Gardner (2007) found little well-identified empirical evidence. Gardner and Tsakok conclude in fact that "this approach is fraught with difficulties that have so far precluded definitive findings" (p. 1145). They add the somewhat damning conclusion that "our view is that economists will simply have to face the fact that econometric studies of country data will not be able to establish causality."

4.2.1 Growth accounting and productivity measurement

As an alternative to running regressions on cross-section or panel data, a number of scholars have turned to other strategies for looking at agriculture's impact on overall economic growth. One alternative strategy is to carry out a sectoral growth accounting exercise, based on methodology introduced initially by Solow (1957). This kind of analysis can indicate whether productivity growth in agriculture has been more rapid than in other sectors; if so, it seems reasonable to argue that the sector plays a key role in generating economic growth.

Growth accounting exercises conducted for the agricultural sector itself can also show the importance of productivity growth—as opposed to intensification of input use—as a source of output increases.

Several papers in this literature argue that productivity growth has been higher in agriculture than in manufacturing. This result was obtained in Jorgenson, Gollop, and Fraumeni for the U.S. time series (1987) and Jorgenson and Gollop (1992); Jorgenson and Stiroh (2000) found a similar result for a more recent data period, with agriculture among the sectors with the highest TFP growth. Mundlak (2005) similarly finds that TFP growth accounts for essentially all of agriculture's productivity growth in the period 1940–90 in the US.

Looking at a broader set of countries, including a number of developing countries, Martin and Mitra (2001) find that TFP growth in agriculture exceeds that in manufacturing. Bernard and Jones (1996) find that agricultural TFP growth is higher than nonagricultural TFP growth in a sample of 14 OECD countries for the period from 1970–1987.

In a recent study focusing on two rapidly growing large economies, Bosworth and Collins (2008) find that agricultural TFP growth has been a major source of economic growth for both India and China during the past 25 years, though not so important as industrial growth in China or growth in services in India. This study also notes the important role that has been played in both countries by sectoral reallocations of labor out of (low productivity) agriculture into higher productivity industry and services. The results of this paper are echoed to a large extent in Gulati et al. (2005), who find that China's growth was heavily influenced by agricultural reforms, with strong accompanying effects on poverty reduction. Gulati and his coauthors argue that China has been more successful than India at reducing the poverty headcount, and they attribute this performance to the agricultural roots of Chinese reforms.[5]

A widely recognized difficulty in the growth accounting literature is that the technique only provides a decomposition of the immediate sources of growth—into inputs and TFP. To the extent that increases in TFP stimulate increased input use (or to the extent that new inputs such as machinery may embody new technologies), the methodology cannot disentangle the underlying causation.

There are also conceptual problems in interpreting comparisons of TFP growth rates across sectors. Theories of structural transformation suggest that growth in other sectors of the economy may pull underutilized resources out of agriculture. We

observe this as increases in agricultural TFP, if output remains constant while inputs are falling. But it would be misleading to infer that agricultural productivity growth is therefore the source of overall economic growth.

An interesting and relevant illustration of the ways in which growth accounting can obscure the underlying causal mechanisms is given by Landon-Lane and Robertson (2003), who show that in a two-sector model, factor accumulation can lead to sectoral reallocations, which in turn lead to increases in aggregate output. Without accounting carefully for these sectoral changes, an observer might treat the sectoral reallocation as a manifestation of TFP growth within the two sectors. Properly speaking, however, it should be viewed as a result of the factor accumulation. Landon-Lane and Robertson show that this channel of impact is quantitatively important in a panel data study of 78 countries. An implication is that growth accounting exercises that find high impact from agricultural TFP growth might be overstating the importance of within-sector changes and understating the importance of across-sector reallocations.

4.3 Development accounting

In recent years, a number of papers have sought to explore a different approach in attempting to assess agriculture's contributions to overall economic growth. These papers have used models to provide an accounting framework with which to analyze the sources of cross-country disparities in income per capita. Characterizing this literature as *development accounting,* or *levels accounting,* these papers follow the techniques explored first by Klenow and Rodríguez-Clare (1997) and Hall and Jones (1999). The goal of papers in this literature is to understand whether the gaps between rich and poor countries are primarily due to differences in accumulated factors of production or to actual differences in efficiency or TFP.

The initial papers using this technique used single-sector models, but a number of recent papers have used multisector models to look at the impact of sectoral issues. Possibly the first of these was Caselli's paper (2005) in the *Handbook of Economic Growth*. In this paper, Caselli finds that efficiency differences *within* the agricultural sector are very important as a source of cross-country income differences. He argues that income differences between poor and rich countries do not simply reflect differences in the sectoral composition of output, with poor countries devoting more resources to a low productivity sector; he suggests that in fact the low levels of efficiency within agriculture are important for the low income levels of developing countries.

A different conclusion emerges from a related paper by Cordoba and Ripoll (2007), in which the authors extend the accounting analysis by adding a measure of human capital in different sectors. They find that a large fraction of the disparity in output per worker within the agricultural sector is traceable to differences in human capital levels between rural and urban workers. This implies that increasing productivity in developing country agriculture might not lead to large increases in national income, since these countries will still lag far behind in human capital in the agricultural sector.

Several other development accounting papers offer insights into the "factors or efficiency" debate. Restuccia et al. (2008) offer another accounting analysis, in a model that incorporates intermediate inputs. They show that agricultural inputs appear to be unusually expensive in poor countries, so they are used in relatively low quantities. This reduces the overall efficiency of the agricultural sector. They also find that the allocation of workers to the agricultural sector appears to be inefficiently high, which they interpret as suggesting that some transaction cost or barrier prevents the intersectoral mobility of labor. In a sense, this paper draws less on the development accounting literature than on the "business cycle accounting" techniques introduced by Chari, Kehoe, and McGrattan (2007).

Related to this work, a number of recent accounting papers consider the impact of factor misallocations. Vollrath (2009) considers misallocations of labor as a possible cause of low efficiency in developing country agriculture. This paper argues that misallocation of factors—which he characterizes as "dual economy" effects—explain a large fraction of the differences in income per capita across countries and an even large fraction of the measured differences in TFP. In this respect, Vollrath echoes a theme emphasized in Chanda and Dalgaard (2008) and Temple (2004, 2005).

The dual-economy versions of the development accounting literature tend to argue that neither technology improvements nor factor accumulation will bring about dramatic output gains in developing country agriculture. These papers collectively suggest that there could be significant allocative inefficiency in developing country agriculture, due either to policy barriers or transaction costs of some kind.

4.4 Other approaches

Several other empirical approaches have been used, to varying degrees, by researchers studying contemporary links between agricultural productivity and economic growth. This chapter does not devote much space to these methods. Some have been adequately (or even exhaustively) covered elsewhere; others have been used less extensively in the literature. Nevertheless, it is worth touching on them briefly here.

4.4.1 CGE models and growth multipliers

One way to assess the growth impacts of agricultural productivity improvements is to use computable general equilibrium models (CGEs) or other structural frameworks in which estimated elasticities are applied in the context of formal models. A related approach involves calculating growth multipliers, as in Block (1999). Because this material has been covered extensively elsewhere in the *Handbook of Agricultural Economics* (Volume 2A, Part 4, contains three chapters on applied macroeconomic analysis of the agricultural sector), the current chapter considers this literature only in passing.

A standard workhorse CGE model with an agricultural sector is presented in detail in Löfgren et al. (2001). This model and its variants have been used in an extensive policy analysis literature that focuses primarily on the impact of trade, price, and policy

reforms. The model also allows for analysis of the effects of agricultural productivity growth, although it offers only a comparative static measure rather than long-run dynamics. For many purposes, however, the simple comparative static measure might be sufficient.

Several other larger-scale models of global agriculture also offer the potential to analyze productivity impacts at the national or global level. These include the IMPACT model at the International Food Policy Research Institute (IFPRI), which is described in Rosegrant et al. (2008), and the GTAP model, described in part in Powell (2007).

A number of analyses of agricultural research impacts, including Evenson et al. 1999 and Evenson and Gollin (2003b), have drawn on the IMPACT and GTAP models for their estimates of impacts.

Models of this kind offer the advantages of clean causal identification—at least relative to the econometric approaches described earlier. However, CGE models depend fundamentally on the underlying elasticity estimates, functional specifications, and coefficients. For this reason, their results are sometimes accused of lacking transparency. Nevertheless, a number of CGE models have been developed that offer the best available estimates of specific productivity improvements—for example, for the introduction of improved sweet potatoes in Uganda. For further discussion of these models and their usefulness in analyzing agricultural productivity changes, see Hertel (2002).

4.4.2 Returns to research

An abundant literature examines the economic returns to agricultural research. This literature often measures internal rates of return or benefit/cost ratios. Some studies report elasticities of various welfare measures to investments in research. A few report growth effects—or economywide benefits—of investments in agricultural research.

This chapter does not devote much space to summarizing the research, since an entire previous section of the *Handbook of Agricultural Economics* addresses issues of invention and innovation (Part 3 of Volume 3, consisting of six chapters). In addition, Evenson's contribution to Volume 1A of the *Handbook* (2001) specifically focused on the economic impacts of agricultural research and extension. A separate and remarkably comprehensive study by Alston et al. (2000) examined nearly the entire literature to that point on the returns to research, casting a skeptical eye on some of the commonly reported claims of impact. Even this critical meta-analysis concluded that rates of return to research are extremely high—although it posed the question of why such high rates of return have not been manifested either in rapid rates of agricultural growth or in massive public investments in research.

The high rates of return do provide evidence, of a limited kind, for agricultural productivity contributions to economic growth. After all, research generates improvements in TFP, which in turn should translate into economic growth. In practice, however, it might be difficult to identify these impacts. In many studies, the research benefits are

narrowly defined to consist of partial equilibrium impacts on producers of a specific crop in a narrowly specified area. Some studies cover larger geographic areas and longer time scales—although typically the econometric identification problems become more acute as the area broadens and the duration lengthens.

The identification problems matter because many of the growth impacts of agricultural research are expected to be diffuse and could involve long time scales. For example, if research contributes to growth of grain yields, the long-term growth impact will most likely not be improved profits or incomes for farmers. Instead, the main impact may be on rates of urbanization and subsequent industrial growth. The impacts of agricultural research on industrial growth will surely be difficult to untangle on a national scale using econometric techniques.

Nevertheless, a number of papers report evidence of research impacts on economic growth and other welfare measures. These include impacts at the global level (e.g., Evenson and Gollin, 2003b); and at the national level (e.g., Fan and Pardey, 1997, for China; Evenson et al., 1999, for India). A recurring finding in this literature is that agricultural research investments are correlated with strong productivity gains in agriculture and improvements in a variety of welfare measures. A potential identification problem arises because research investments are not randomly distributed, either across countries or within them. Research tends systematically to take place in (and therefore to target) countries, states, or regions with effective governance and institutions. If growth and welfare gains occur subsequent to the research investments, we face an attribution problem: How much of the gains are due to research, and how much are due to other institutional characteristics or to changes that are related to the research? This problem makes it difficult to reach convincing conclusions about the relationship between research-induced productivity gains and economic growth.

4.4.3 Lessons from economic history

If the recent cross-country experience offers little cleanly identified evidence for the growth impacts of agricultural productivity, what can we learn from the historical record? A lively debate in the economic history literature concerns the role of agricultural productivity growth in the Industrial Revolution in Europe.

One view is that agricultural productivity gains preceded the Industrial Revolution (e.g., Crafts, 1985). The additional argument is sometimes made that essentially *all* countries experiencing rapid industrial growth have first undergone significant growth in agricultural productivity. Versions of this argument are presented in Huffman and Orazem's chapter (2007) in this *Handbook,* and a number of references are offered in a paper by Bezemer and Headey (2008).

An opposing view holds that agricultural productivity growth was not coincident with the Industrial Revolution in Britain and that agricultural productivity *levels* were higher in other parts of the world than in Britain (begging the question of why the

Industrial Revolution did not happen first elsewhere). This view is summarized in Dercon (2009) and reflects recent work by a number of economic historians, including Allen (1999) and Clark (1998, 2002).

Although this debate focuses on events that took place several centuries ago, the implications for current thinking about agricultural development could be significant. If agricultural productivity growth was not an essential part of the Industrial Revolution, perhaps it is even less necessary for today's developing economies, which after all have access to robust international markets for most agricultural goods.

Interestingly, however, none of the researchers looking at the Industrial Revolution in Britain argues that improvements in agricultural productivity were entirely irrelevant to urbanization and industrial growth. As the Industrial Revolution proceeded and urban populations grew, the farming sector needed to produce most of the food needed in cities. If agricultural productivity growth did not come prior to the Industrial Revolution, it was nevertheless an important concurrent event in most countries. Whether or not it came first, the agricultural revolution seems to have made a significant contribution in determining the pace of modern economic growth.

5. AGRO-PESSIMISM

The previous section suggests that there is no clearly identified empirical evidence that unambiguously demonstrates a channel from agricultural development to economic growth. Some skeptics have gone farther and argued that in fact agriculture plays a trailing role, if any, in the development trajectories of many countries. These "agro-pessimists" argue that development policy has suffered from an overemphasis on agriculture, driven by underlying confusion about the causal relationship between agriculture and development.

Although the agro-pessimists acknowledge that the agricultural sector accounts for large fractions of employment and economic activity in poor countries, they also argue that in some countries it might have relatively low growth potential. The East Asian miracle is viewed by some as evidence that growth does not necessarily require broad agriculture-based development. Instead, many Asian countries appear to have developed through export-oriented manufacturing. For example, Amsden (1989) made the case that Korea industrialized without any preceding agricultural revolution, and a number of scholars have argued that China's recent growth miracle was driven only in its earliest stages by agricultural policy reforms.[6]

Dercon (2009) proposes that causation might in fact run from economic growth to improvements in agricultural productivity. He notes that efforts to support smallholder agriculture could be supporting the least productive activities in the entire economy. Better prospects for reducing rural poverty and stimulating growth might come from

nonagriculture, creating additional opportunities for people to exit farming. A strategy of exporting nonagricultural goods or cash crops and importing food might prove better than a development strategy based on agriculture. To the extent that policies target rural areas, he suggests, the focus should be on health and education investments that make it easier and cheaper for individuals to leave agriculture in due course. In the long run, those who succeed in leaving behind smallhold agriculture are likely to be the best off.

Dercon notes that there is considerable heterogeneity within developing countries, and he acknowledges that agriculture-based growth might be necessary in some landlocked and resource-poor countries. In coastal countries and those with richer endowments of natural resources, however, he argues that countries might do better to export other goods and to import food. In these economies, he says, "agriculture is not the crucial constraint." Some other researchers arrive at similar conclusions. Ellis and Harris (2004) write that policies facilitating rural-to-urban migration could be more sensible than policies to support agriculture.

This view is echoed by a number of influential figures in the development policy arena, such as Paul Collier (2008), who dismisses visions of smallholder agricultural development as a form of "romantic populism," part of the "middle- and upper-class love affair with peasant agriculture" (Collier 2008, p. 71). Collier suggests that "urban dynamism" is the key to solving agriculture's problems.[7] He takes particular issue with the notion that smallholder agriculture must be the target of development efforts. Although the poor do primarily earn their livings from smallholder systems, he notes, there is little evidence that productivity can increase sufficiently within these systems to generate growth. By contrast, a development strategy that focuses on large-scale commercial farms and on the nonagriculture sector could ultimately provide greater benefits for the poor by expanding the livelihood opportunities available to them.

6. RECONCILING COMPETING VIEWS

How can we reconcile the views of the agro-pessimists with the Mellor hypothesis presented earlier? And how can we interpret the vast amounts of not-quite-definitive empirical evidence that agriculture plays a key role in development?

Given the differing views in the literature, it is useful to write down a simple model as a heuristic device for considering the ways in which agricultural development could generate differing impacts under different circumstances.

Consider the following simple static model economy, drawn from Gollin and Rogerson (2009) and similar in spirit to Gollin, Parente, and Rogerson (2007) or, in fact, to Eswaran and Kotwal (1993).

In this model economy, each individual has preferences over two goods, which we label as agriculture (a) and manufacturing (m), given by:

$$u(a - \bar{a}) + v(m + \bar{m}) \tag{1}$$

where u and v are defined for non-negative values. We assume that both functions are increasing and strictly concave. The parameters $\bar{a}$ and $\bar{m}$ are both strictly positive.[8] The key feature of these preferences is the presence of the $\bar{a}$ and $\bar{m}$ terms, which serve to make the income elasticity of the agricultural good less than one and that of the manufactured good greater than one.[9] An extreme version of these preferences is the special case where:

$$u(a - \bar{a}) = \begin{cases} -\infty & \text{if } (a - \bar{a}) < 0 \\ \omega & \text{if } (a - \bar{a}) \geq 0 \end{cases}$$

.

This utility function gives rise to an extreme Engel curve in which utility is flat once the economy has satisfied its food needs. A slight relaxation of this assumption gives the utility function in Gollin, Parente, and Rogerson (2007)—that is,

$$u(a - \bar{a}) = \begin{cases} a & \text{if } (a - \bar{a}) < 0 \\ \bar{a} & \text{if } (a - \bar{a}) \geq 0 \end{cases}$$

The economy is endowed with one unit of land and each individual is endowed with one unit of time.

The technology for producing the manufactured good is given by:

$$m = A_m n_m \tag{2}$$

where n_m is the number of workers that work in the manufacturing sector, and the technology for producing the agricultural good is given by:

$$a = A_a L^{\theta} n_a^{1-\theta} \tag{3}$$

where n_a is the number of workers that work in the agricultural sector and L is land.

Given the extreme version of the preferences used here, we simply assume that the economy is able to produce sufficient amounts of a so as to provide all individuals with at least $\bar{a}$ units of the agricultural good. A sufficient condition for this is that $A_a > \bar{a}$. We assume that land ownership is equally distributed across the population.

The social planner's problem in this model economy is to maximize the utility of a representative household subject to the feasibility constraints. This turns out to be somewhat trivial given the extreme form of preferences that we have assumed. In particular, given that everyone needs to consume exactly $\bar{a}$ units of the agricultural good but receives no benefit from consuming any additional amount, the optimal allocation

is to place enough workers in the agricultural sector so as to produce $\bar{a}$ for each individual in the economy and then to allocate all remaining workers to the manufacturing sector. It follows that the optimal value for n_a is given by:

$$n_a = \left[\frac{\bar{a}}{A_a}\right]^{1/(1-\theta)}. \tag{4}$$

The key implication of this model is that in a closed economy in which food is a necessity, there is a powerful negative relationship between agricultural TFP and employment in agriculture. In particular, a 1% decrease in agricultural TFP A_a will lead to an even larger percentage increase in employment in agriculture, equal to $1/(1-\theta)$.

This basic result holds robustly so long as the economy is closed. The model sharply underscores the somewhat obvious point that in a relatively closed economy in which food is an essential consumption good (and in which food must be produced domestically), agricultural productivity is linked directly to the fraction of the population working in the agricultural sector. If we observe a large number of people in this sector, with low productivity levels, we should not view the result as a paradox; instead, it is a natural implication of a simple model with subsistence food production.

Gollin and Rogerson (2009) show that the same result holds for more general specification of preferences and for situations in which the nonagricultural good is used as an input into agriculture. They also show that high transportation costs can exacerbate the effects of low agricultural productivity. In an economy where it is costly both to produce and to transport food, we should expect to find lots of people living in rural areas and producing their own food.

Although this simple sketch of a model is not intended to be taken as a literal representation of a poor developing economy, the point is that a rudimentary model of this type makes it unsurprising that large fractions of the population in developing countries are engaged in agriculture, even while they have relatively low productivity and live in isolated rural areas. This is a predictable equilibrium outcome, so long as productivity is low and there are few alternative sources of food.

The closed economy assumption is restrictive but also revealing. Countries have a growth advantage if they are in a position to import significant quantities of food in exchange for exports of nonfood goods or services. Trade can be a substitute for the long, slow business of increasing agricultural productivity. But for many countries with large populations in remote areas, it is difficult to see how food imports will plausibly replace domestic production. Although people will continue to move to the coastal cities of the world, these migrations entail significant transaction costs in the short and medium term. As a result, in these countries a trade-based food strategy will be difficult to implement.

In other countries or under different circumstances, however, the link between agricultural productivity and economic growth might be less clear. Increasing the

productivity of nonfood cash crops could be more important for some countries than increasing the productivity of food crops; some countries might be better off relying on nonagricultural production altogether. Agro-pessimism might be warranted in those countries that have the human capital and institutional capability such that they can move into world markets as producers of manufactured goods or other tradables.

7. CONCLUSION

A model in which countries must attain a high degree of food self-sufficiency seems appropriate at present for those parts of the developing world that are landlocked, predominantly rural, and have large fractions of their population living at a considerable distance from coastal cities, where they might have access to inexpensive food imports. This might include, for example, a number of African countries: Uganda, Congo, Mali, Niger, Ethiopia, and Burkina Faso. It might also include a number of countries in South America and Asia: Peru, Bolivia, Mongolia, Cambodia, and others.

Some other countries, however, might be able to rely much more on imported food. Small island economies (e.g., Mauritius or Fiji), along with coastal economies with well-developed port infrastructure and good access to international markets (e.g., South Africa, much of North Africa, and some countries in Central America and the Caribbean), might be able to feed themselves more efficiently from imports than through domestic production.

Recent debates between agro-pessimists and agricultural fundamentalists paint an excessively stark choice between development strategies that focus exclusively on agriculture and those that largely ignore the sector. This is unfortunate. Given that many or most developing countries have at least one quarter of their workforce in agriculture and given the importance of agricultural output in the consumption baskets of the poor, it is hard to imagine that significant growth or poverty reduction will arrive in the absence of agricultural productivity growth.

A few countries might be able to substitute agricultural imports for productivity growth; these countries will be at a considerable advantage relative to their neighbors. But many countries, including some very large and very poor countries, will be unable to feed their populations with imports. A country such as Congo, for example, will continue to depend heavily on domestic production for its food needs.

In the long run, nonagricultural productivity growth will be crucial for the developing world, as it has been in every other region. The nonagricultural sector will eventually become the primary source of employment, and a smaller number of people (presumably operating larger farms) will produce food for urban markets. This general story—told convincingly in the early agricultural development literature—seems in large measure to be right.

What is the role of government and the international community? The structural transformation will take place in today's developing countries—as it did previously in today's rich countries—because of the low income elasticities of agricultural goods combined with improvements in agricultural technologies. Governments have little direct role to play in managing this transformation or hindering it. However, government certainly has a role in supplying public goods that could affect the speed of the transformation.

For example, agricultural research is almost always a public sector activity because the replicability of seeds makes it difficult for private firms to recoup the benefits of genetic improvement research.[10] Transportation infrastructure also has a public good aspect, since private actors are likely to under-provide and under-maintain roads.[11] Governments (or perhaps farmer organizations) also have a role to play in managing quality and setting standards (for domestic as well as export markets). Governments also have a role to play in providing pubic goods for the nonagricultural sector, including a variety of legal and regulatory functions.

Perhaps it is useful in closing to recall Adam Smith's admonition to remember the interdependence of the agricultural sector and the nonagricultural sector (1986; Book III, Chapter 1):

> **The great commerce of every civilised society is that carried on between the inhabitants of the town and those of the country. It consists in the exchange of rude for manufactured produce, either immediately, or by the intervention of money, or of some sort of paper which represents money. The country supplies the town with the means of subsistence and the materials of manufacture. The town repays this supply by sending back a part of the manufactured produce to the inhabitants of the country. The town, in which there neither is nor can be any reproduction of substances, may very properly be said to gain its whole wealth and subsistence from the country. We must not, however, upon this account, imagine that the gain of the town is the loss of the country. The gains of both are mutual and reciprocal, and the division of labour is in this, as in all other cases, advantageous to all the different persons employed in the various occupations into which it is subdivided.**

End Notes

⋆. Much of the content of this chapter reflects the author's long-term collaborations with Robert Evenson and with Richard Rogerson and Stephen Parente. However, the views presented in this chapter are the author's own and do not implicate any of these coauthors. The author has also benefited from many years of discussions about agriculture's role in development—and about development economics in general—with Anand Swamy and especially Cheryl Doss.

1. Note that the table shows levels of output per worker, which is a useful measure of productivity. The data on output per capita can be obtained simply from these data, but for conciseness, they are not presented here.
2. This is not, however, a problem unique to poor countries. In many rich countries, farmers may work in off-farm activities (e.g., holding a steady job "in town"), and it is not clear whether we are likely to overestimate agricultural labor more severely in rich countries or in poor ones.

3. See Ravallion et al. (2007) for a detailed analysis, based on household survey data, of rural versus urban living standards.
4. Smith even seemed to recognize the fact that productivity differences across countries were greater in agriculture than in nonagriculture. He wrote (1986, p. 111), "The most opulent nations, indeed, generally excel all their neighbors in agriculture as well as in manufactures; but they are commonly more distinguished by their superiority in the latter than in the former." He also seemed to argue (p. 483) that agricultural productivity growth would normally precede industrial growth: "According to the natural course of things, therefore, the greater part of the capital of every growing society is, first, directed to agriculture, afterwards to manufactures, and last of all to foreign commerce. This order of things is so very natural that in every society that had any territory it has always, I believe, been in some degree observed.
5. China was also the subject of a related study by Fan et al. (2003) that found similarly high rates of return to investment in rural areas.
6. Amsden's view has been challenged by Kang and Ramachandran (1999), among others.
7. Collier has pressed this argument vociferously in nonacademic forums, including the opinion pages of various newspapers; in a speech before the British All Party Parliamentary Group on Overseas Development, among other places, he has explicitly argued that the agricultural sector is unlikely to play a key role in generating growth or reducing poverty in Africa. He has called instead for more resource-based activities and low-tech manufacturing. (A podcast of his APPGOD speech is available at www.odi.org.uk/events/apgood/Agric_in_Africa_05/apgood_oct17/audio/PCollier.wma.)
8. Although we refer to the nonagricultural good as the manufacturing good, it should be interpreted as representing both the manufacturing and the service sectors.
9. It is sufficient that at least one of $\bar{a}$ or $\bar{m}$ be greater than zero for this property to hold. Having both positive allows for the possibility of a corner solution in which $m = 0$.
10. The few exceptions to this pattern involve hybrid seeds, where heterosis effects make it worthwhile for farmers to purchase fresh seed each season, and a few other crops in countries where intellectual property rights allow breeders to collect rents from their research.
11. The need for public involvement here is somewhat less clear; history provides many examples of privately funded road construction and maintenance, with toll collection offering a mechanism for cost recovery. However, it is telling that most countries have opted for a strong public role in road construction. One concern is that privatized roads are often natural monopolies, so that a public role could be needed from a regulatory standpoint, even if it is not required for construction or maintenance.

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