Impacts of Agricultural Investments on Growth and Poverty: A Review of Literature

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Technical Paper 1

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ACRONYMS AND ABBREVIATIONS

BC	Benefit Cost Ratio
GDP	Gross Domestic Product
IRR	Internal Rate of Return
TFP	Total Factor Productivity

EXECUTIVE SUMMARY

Agricultural development is crucial in developing countries, and particularly in the poorest countries where it accounts for large shares of employment and income and whose poverty is due simply to having a large share of the workforce in low-productivity agriculture. Raising productivity in agriculture is critically important for development, as is smoothly moving workers out of agriculture into more productive employment in other sectors.

Raising agricultural productivity helps both to raise incomes and to reduce poverty—both by raising the incomes of poor people working in agriculture and by lowering the prices of foods that make up a disproportionately large share of the expenditures of poor people. In small and open economies, the increase in profitability of agriculture following improvements in productivity might tend to retain or even attract workers into agriculture. By contrast, at a global level, or at national level when policy focusses on self-sufficiency, improvements in agricultural productivity will free up labor for employment in other sectors.

Incomes are generally much higher in non-agricultural work in developing countries—more than double those in agriculture after careful adjustment for key differences. This raises the possibility of a double dividend from structural transformation as workers move into higher-productivity activities. A key question for development policy is whether it is enough to simply evaluate the gains from higher productivity within agriculture, or whether potential benefits from structural change be included as well.

This paper examines the arguments on this question. It concludes that these dividends may be substantial—but whether they are or not depends on the source of the initial differences in productivity and on the direction of movement when agricultural productivity rises. If it results from policy barriers such as restrictions on the transfer of farmland or requirements for residence permits in urban areas, there are likely to be substantial welfare gains when labor moves out of agriculture. They may also be substantial if urban wages are artificially high and attract substantial numbers of job-waiters into unemployment. However, these gains may be illusory if the income gaps arise primarily from differences in skills or from reluctance to move created by asset fixity.

Another important question is whether investing in agriculture might shift the economy onto a lower growth path because of slow productivity growth in agriculture. In fact, productivity growth measures—whether from studies of total factor productivity growth or from simple comparisons of labor productivity growth—generally find more rapid growth in agriculture.

The shares of agriculture in both the economy and in the workforce are much higher in the poorest countries than in middle- and high-income countries. This makes agricultural development much more effective at raising incomes in the poorest countries. Agricultural growth also appears to be much more potent as a force for poverty reduction than non-agricultural growth, although its effectiveness declines as countries grow richer and the share of agriculture in their economies declines.

Many market failures hinder the growth of agriculture in developing countries. There is strong evidence that interventions to promote agriculture should focus on rectifying or alleviating these market failures, rather than on providing subsidies for specific activities. Private investors under-invest in research for agricultural innovation because—in the absence of intellectual property rights—it is very difficult to justify investments in innovation. In this context, the overwhelming empirical evidence suggests that the returns to government investments in research and development are generally very high, with benefit-cost ratios of 10 or higher.

By contrast, the returns on interventions to subsidize or tax market prices in agriculture typically have negative returns. Even “smart” subsidies targeted strongly to individuals or actions tend to have benefit-cost ratios of one or less.

Transport and related infrastructure has strong public good elements and research suggests that investments in this area frequently have very high rates of return, although not usually quite as stratospheric as those observed for research and development. Land tenure is a classic area of responsibility for governments and can have substantial returns—such as 70 percent increases in productivity—if land rights are initially poorly developed and can be improved.

Provision of information is another central role for government. Key areas include information about market prices and about product quality—with problems of information asymmetry and fake inputs a particular problem in parts of Africa. Solutions to these problems are sometimes indirect, as in the case of information about fish catches in Kerala, for which the solution was making available cell phones service.

Irrigation is another important area for government intervention, with the best solutions frequently involving combinations of government and private information. The returns to surface irrigation schemes vary enormously, with the best projects frequently having benefit-cost ratios of 8 or higher while the worst have negative net returns. The key role for government in groundwater is in establishing a management regime suited to the circumstances of the aquifer and the demand for water. Well formulated regulations in this area have low costs and substantial benefits by improving water use efficiency and avoiding competitive races to the bottom of the well.

Risk and uncertainty is a huge problem in developing country agriculture, with concerns about risk frequently leading producers remaining trapped in low-productivity traditional agriculture. Unfortunately, few traditional insurance programs have managed to overcome the problems of moral hazard, adverse selection and high administrative costs that plague these schemes. New, index-based, that use modern communications show some potential for overcoming these problems.

As incomes grow, agricultural markets need to be developed to handle a much wider range of products than traditional staples. Value chain development to allow producers to take advantage of these opportunities can substantially raise incomes and provide opportunities for diversification into products with greater growth potential than traditional staples.

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1 INTRODUCTION

Perhaps the most fundamental development problem for poor countries is that large shares of their workforces are employed in low-productivity agriculture. The key question for agricultural development and for economic development and poverty reduction more generally is what might be done to solve this problem? One key policy question is whether the focus should be on raising productivity in agriculture or on transferring people into other sectors where productivity is higher and/or might grow more rapidly? And the key question for both these approaches is how best to bring them about.

Some argue that raising productivity within agriculture is too hard and slow and that the only viable model for development is to focus on moving people out of agriculture into higher-productivity sectors. Others argue that successful development involves a sharp reduction in the share of farmers in the economy—so that what is needed is a focus on raising productivity outside agriculture and moving people out of agriculture. The empirical evidence is perhaps even more challenging. The arguments involved are complex and subtle and have engaged some of the best minds working in development economics over the past 80 years. Understanding both theory and evidence is vitally important since they determine what model of change is relevant for policy and, in turn, what economic variables need to be measured and the relevance of the resulting quantitative estimates.

The primary focus of this literature survey is on the insights from quantitative studies undertaken in recent years to shed light on the problem at hand. Of course, what is measured depends a great deal on the model used to understand the change under consideration, and the interpretation of those measures also depends on the model. If the model turns out to be wrong and is replaced by an alternative model, then what needs to be measured will likely change, and the interpretation of the results will also change. This makes it important to understand the models used to interpret the process.

Fortunately, this survey can build on a great deal of earlier research, including surveys such as Dethier and Effenburger (2012), Timmer (1988), the World Development Report of 2008 (World Bank 2008) and a range of Handbook chapters. It also covers a wealth of studies on various aspects of agriculture and growth, structural transformation and policy reform and investments in agricultural development.

The relevant models cover more than just the two questions of whether to focus on raising agricultural productivity or on encouraging movement of labor out of agriculture. They must also answer the important subsidiary questions such as: (i) why is productivity low in traditional agriculture? and (ii) how might movement out of agriculture into more other sectors be brought about? Past research has also made clear that the role of agriculture varies substantially with stage of development. Finally, of course, the key question is what the literature has to tell us about the likely impacts of particular interventions on outcomes for agriculture and for economic development and poverty reduction.

The next section of this paper looks at the evolution of models of the development process and the gaps that remain in our understanding of that process. The third section looks at how the role of agriculture changes with each country's stage of development. The fourth section looks at the impacts of increases in agricultural productivity growth on poverty, as distinct from economic growth. The fifth section look at the evidence on the impacts of particular types of intervention.

2 THEORIES OF ECONOMIC DEVELOPMENT

An early, and still influential, theory of development for poor, agrarian societies was provided by Lewis (1954). Lewis' model built on those of classical economists such as Smith and Marx. He argued that traditional agriculture had low productivity, and that the path to development was through the accumulation of capital needed for a modern, and more productive, industrial sector. His model assumed that agricultural productivity was so low that farmers could not survive if paid the marginal product of their labor and, instead, received the average product of their labor. In this model, low, or even zero, marginal productivity of labor meant that labor could be withdrawn from agriculture with very little impact on agricultural output. Thus, the key to development was to accumulate and invest the capital needed for the modern industrial sector so that workers could be induced to move out of traditional agriculture. Since this movement of labor would reduce agricultural output only marginally, it would not significantly impact the availability of food.

Because most employment and output were in agriculture in poor countries at the time Lewis wrote, the only logical source of funds for investment was the agricultural sector. This contributed to a view that agriculture should be taxed to finance the accumulation of capital needed for industrialization. Since agricultural output was assumed inelastic, this would also have little impact on the supply of food. Since it was assumed that developing countries could not compete in markets for industrial products, manufacturing output for the domestic market should be encouraged by protection—protection that, by Lerner Symmetry (Lerner 1936), acted as an addition tax on tradeable agriculture. This indirect taxation arises both from increases in the cost of intermediate inputs, and from increases in the price of nontraded goods that is often described as a real exchange rate appreciation.

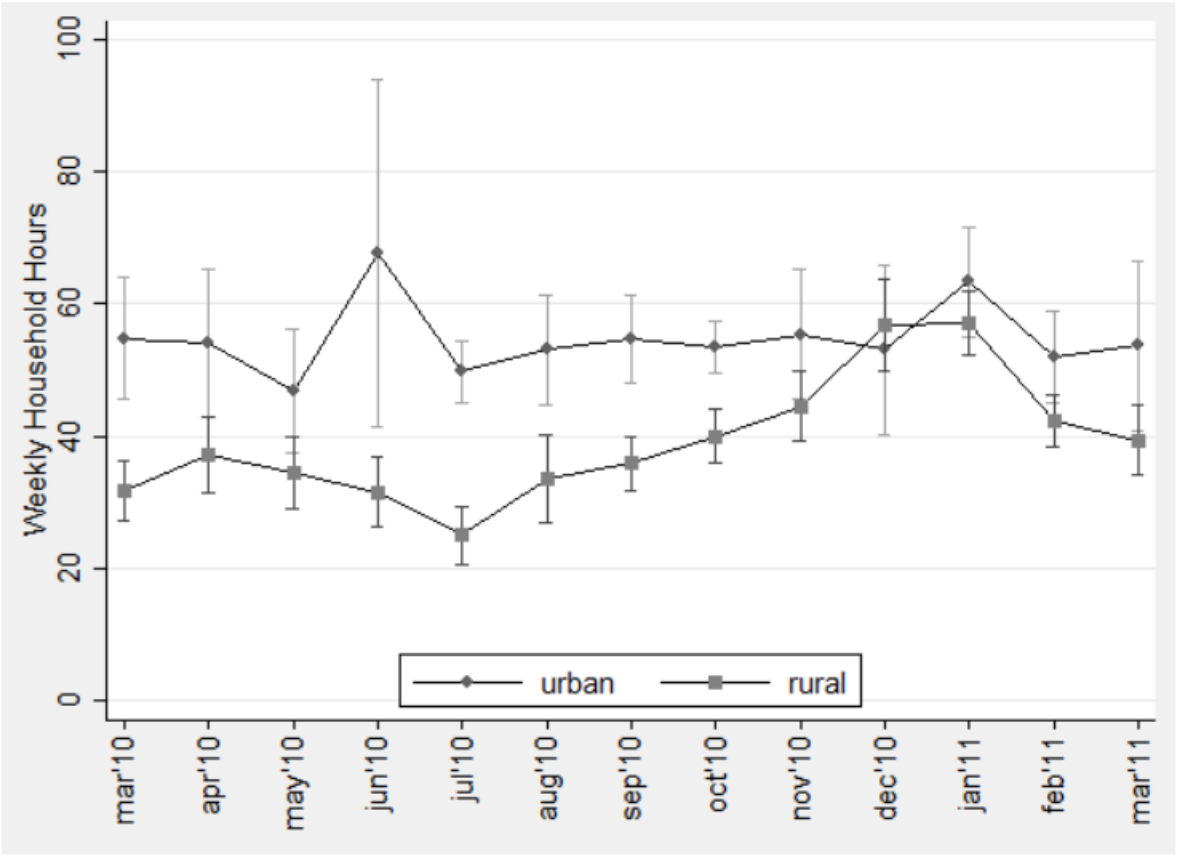
Johnston and Mellor (1961) dissented from the view that agriculture is a stagnant sector. They pointed out that investments in developing modern varieties, and other investments that raised agricultural productivity were possible and could generate important economic benefits. While accepting—or at least not strongly dissenting from—the view that agriculture should be taxed to finance development—they argued that increases in agricultural productivity could solve the "food problem" created by rising population and increases in per capita food demand, promote exports, and contribute to investment in manufactures and creating markets for these goods.

Schultz (1964) disagreed with the view that agriculture was characterized by "surplus" labor, that could be taxed without substantial loss of output. In this view, farmers in poor countries are "poor but efficient" optimizing subject to the constraints imposed by the low-productivity technology available to them. The key to raising agricultural productivity was to improve the technologies available to producers. Taxes on agriculture would reduce output and contribute to the emergence of a food problem. He used historical examples to argue that farmers would adopt new technologies as long as they were cost-effective and to bolster his case that output would fall if labor were removed from agriculture.

Mellor (1976) emphasized two types of linkage between agricultural productivity growth and economy-wide growth—the backward linkages resulting from increased demand for intermediate inputs and the forward linkages resulting from increased final demand from farmers whose incomes had risen. This generated a great deal of research attempting to measure these linkages. Using input-output techniques, Bell and Hazell (1980) concluded—in line with Mellor's view—that forward linkages of this type were more important because of the low share of purchased inputs in most agricultural projects. As more complete models became available, the focus moved away from these demand linkages. Later contributions to this literature, such as Delgado, Hopkins and Kelly (1998) focused primarily on very poor countries in which

remoteness from urban opportunities meant that farm households were under-employed for a substantial part of the year. This phenomenon is still evident in countries such as Malawi, as shown in Figure 1, where hours worked in rural areas approximate those in urban centers during peak periods for agricultural labor demand but fall substantially below in the remainder of the year. But the recognition that the issue of forward and backward linkages is important only in a subset of cases, with farms in isolated areas, considerably diminishes the force of the original argument that these linkages are important for policy.

Figure 1: Hours worked per week in urban and rural areas



Source: de Janvry, Duquennois and Sadoulet (2018)

The policy case provided by Lewis (1954) that agriculture should be taxed to finance industrial development, had much in common with the industrialization process in the Soviet Union and China during the era of central planning. This approach frequently resulted in use of export taxation, particularly on exportable cash crops such as cocoa and coffee. Other motivations for this taxation were the need to finance public expenditures both for development and general government activities and the relative ease of taxing at the border. This taxation frequently had the undesirable consequence of taxing relatively poor farmers.

This direct taxation of agriculture was often accompanied by protection to import-competing industries, provided by combinations of high tariffs and quantitative restrictions such as quotas and licenses. Because many believed that developing countries could not compete in export-oriented manufacturing, the goal was to develop manufacturing initially by import substitution. This protection to the manufacturing sector increased the burden on all traded goods via exchange rate overvaluation as well as through direct increases in input costs.

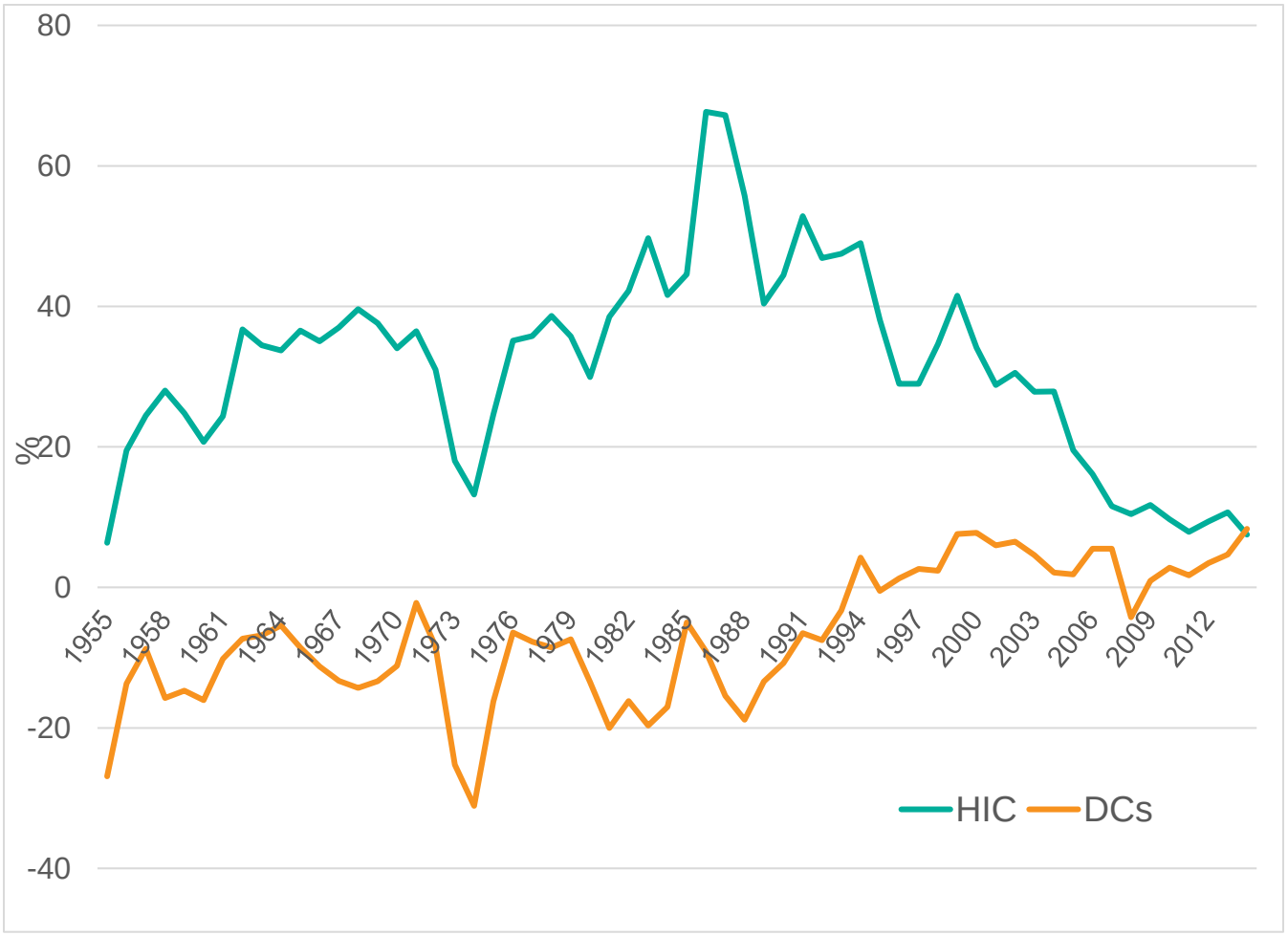
The development case for using trade taxes to finance domestically-oriented manufacturing was greatly weakened by the success of the East Asian "tiger" economies in developing vibrant, export-oriented, labor-intensive manufacturing sectors between the 1970s the 1990s. This undercut the widely-held export pessimistic view that developing countries would depend on agricultural exports with low income elasticities of demand should they liberalize (Prebisch 1959; Krueger 1997, p3). The public finance case for such taxes was also weakened by the emergence of the Value-Added Tax (VAT) for raising public revenue. (Bird and Das-Gupta 2012).

The magnitude of the taxation of agriculture in developing countries was highlighted in an important study by Krueger, Schiff and Valdés (1988). This study used Lerner Symmetry to combine the direct impact of explicit export taxation of agriculture with the indirect burden created by protection to manufactures in assessing the full impact of border measures on developing country agriculture. The results pointed to staggeringly high taxation of agriculture, with most of the burden coming indirectly, through the protection provided to the industrial sector. Massive reforms of both agricultural taxation policies and industrial protection during the 1980s and early 1990s, and the rise in support to agriculture associated with economic growth (Anderson 1995) resulted in a dramatic reduction in the policy bias against agriculture.

The reductions in protection to the industrial sector reflected an improved understanding of the impacts of protection and particularly the very high effective rates of protection applied to import-competing manufacturing sectors in many developing countries (Conybeare 1983). Another contributing factor was the by-then demonstrated ability of developing countries to develop export-oriented manufacturing sectors, frequently by providing relief from tariffs on intermediate inputs to reduce the tax otherwise imposed on export activities (Bach, Martin and Stephens 1996). Improvements in communication technology made it much easier to transfer parts of the manufacturing process to developing countries, with inputs transported from the countries in which they were most efficiently produced to the countries where final assembly was conducted. As noted by Baldwin (2016), this fragmentation of the production process made it much easier for developing countries to create modern industrial sectors than under a protectionist regime where the entire interlinked economic structure must be developed at once—something that only Japan fully achieved between the beginning of the industrial revolution and the 1990s (Martin 2019).

The change in the incentive environment was first documented in Anderson (2009) and subsequently updated by a consortium of international organizations involved in measuring agricultural trade barriers. The change in direct support to agriculture is summarized in Figure 2.

Figure 2: Nominal rates of protection in high-income and developing country agriculture, percent



Sources: 1955–2004, Anderson (2009); 2005–2014, Ag Incentives Consortium, www.ag-incentives.org.

The fact that the average rate of assistance to agriculture in developing countries is now modestly positive should not be taken to mean that there are no distortions. Some countries, particularly in Africa, continue to tax some of their agricultural exports, while frequently supporting import-competing industries such as rice or dairy products. Other countries, such as China, have moved more decisively towards supporting agriculture, although taxation of export-oriented agriculture persisted in China until the early 1990s (Huang et al 2009)..

The stance of policy in a particular sector needs to be considered in considering interventions in agriculture. Investing in protected sectors provides smaller economic benefits than a simple financial analysis would suggest, because investing in these sectors reduces the government revenue generated by import duties. The border price rule is a simple approach to assessing the benefits from increases in output resulting from investment in sectors protected or taxed by border measures. Investment in protected sectors may even result in a reduction in national income (Brecher and Diaz-Alejandro 1977).

Domestic taxes and subsidies not included in the trade measures based above may also have important implications. Adamopoulos and Restuccia (2014) identify a wide range of policies that reduce returns to factors in agriculture, such as progressive land taxes and restrictions on land use, and a tendency for

activities produced by larger farms to be taxed. Including the impacts of these on government revenues changes the shadow prices on agricultural output relative to the market prices to which farmers respond. The presence of such distortions increases the return to resources in agriculture once the impacts on government revenues are considered. Using shadow prices that reflect this will increase the desirability of investing in agriculture.

One important structural feature of economic growth is that the share of agriculture in the economy tends to decline as incomes rise. Two major explanations for this phenomenon have been offered in the literature. The first is that the income elasticities of demand for food are low (Chai and Moneta 2010). The second is that rates of productivity growth differ between sectors. A third and less-widely discussed explanation is that factor intensities and rates of factor accumulation may differ (Acemoglu and Guerrieri 2002), with agriculture being relatively labor intensive in poor countries and rapid accumulation of capital pulling resources out of agriculture according to the Rybczynski theorem (Martin and Warr 1993). Porzio et al (2021) focus on the role of increased education in transferring labor out of agriculture. All these explanations interact with differences in the degree to which products are tradable to produce a range of outcomes.

While there is unanimous agreement about the low income elasticities of demand for food, this does not explain why agriculture declines in individual high-growth economies. If goods are traded, demand may grow slowly relative to supply, with the difference made up by increased exports, or reduced imports, so low income elasticities alone need not result in slow production growth. If goods are not traded, the low income elasticities of demand will translate into declines in the prices of low income elasticity goods that will, in turn, reduce the share of agriculture in the economy.

Differential rates of productivity growth will certainly change the structure of the economy, but the impact of these rates will depend on the tradability of the goods as emphasized by Matsuyama (1992). If goods are freely tradable, then high sectoral productivity growth in a small economy would be expected to increase that sector's share of output. Not only does output increase at any given input level because of the technological improvement, but production of the good becomes more profitable and draws in more inputs and factors. But, if the goods are nontradable, these outcomes may be reversed, either because of their nature or because of self sufficiency policies, technological progress will likely reduce the quantity of resources needed, with a fall in domestic prices causing a reduction in resource use.

The third, factor endowment based explanation interacts with non-tradability in the same way as the technical change-based model. If the economy is open, then output of the good intensive in the factor whose supply is growing will expand. If the economy is closed and the elasticity of demand for the good is low, inputs will be released from the sector benefiting from factor growth. A potentially important difference is that the endowment-based explanations involve new sectors pulling resources out of agriculture, rather than productivity or price changes within agriculture. If additional capital or human capital cause more capital or knowledge intensive sectors than agriculture to grow and to pull labor out of agriculture, the critical question is the tradability of outputs from the expanding sectors, rather than from agriculture.

2.1 Income Gaps between Agriculture and Other Sectors

There appear to be substantial income gaps between returns to labor in agriculture and in other sectors of developing countries. These have potentially very important implications for the impact of interventions that cause transfers of labor from agriculture to non-agriculture. If there are no productivity gaps resulting from labor market or related distortions, then the welfare impact of an increase in agricultural

productivity on national income will depend only on the share of agriculture in the economy and any shadow pricing needed to account for product market distortions (Anderson and Martin 2011). If there are productivity gaps resulting from distortions, the welfare impacts of structural change resulting from increases in agricultural productivity may include both the increase in income resulting from the increase in productivity and the effect on economic welfare of the change in the allocation of labor—a contribution to growth frequently known as a structural change effect as distinct from the effects of productivity growth within sectors.

That there are large differences in productivity between agriculture and other sectors in developing countries is not in doubt. Caselli (2005) argues that almost all the variation in agricultural incomes across countries comes from differences in agricultural total factor productivity, which varies much more than TFP in the non-agricultural sector, and that this variation in agricultural productivity is a critical determinant of differences in GDP per person. Restuccia, Yang and Zhu (2008) show that the ratio of agricultural to non-agricultural productivity falls with increasing real GDP, although Young (2013) argues that this relationship disappears for low-income countries when an Africa dummy variable is included. Such differences in productivity would, however, not result in in differences in labor returns if labor were fully mobile.

Both the size of the gap in productivity between sectors and the direction of movement can have very large potential impacts on national welfare outcomes (McMillan, Rodrik and Verduzco-Gallo 2014). Vollrath (2009) suggests that misallocations due to large quantities of factors being employed in low-return activities account for 80 percent of the variations across countries in total factor productivity, and 30-40 percent of variation in income per capita. It is certainly the case that it can make a large difference to measured growth rates. McMillan and Rodrik (2011, Figure 8) conclude that structural change contributed around half of the impressive measured growth in Latin America between 1950 and 1975. Diao, McMillan and Rodrik (2019) saw it contributing around half of the measured growth in Africa and India during their recent economic growth booms.

This section of the paper follows Matsuyama (1992) in assuming that an increase in agricultural productivity will increase resource use in agriculture in a small, open economy. An increase in productivity reduces the quantity of resources needed to produce a given amount of output but, by raising profitability, draws additional resources into the sector (see Martin and Alston 1997 for a more detailed discussion). If, however, policy makers insist on self-sufficiency in agriculture, or if the productivity increase is global, the outcome is different. Higher productivity increases output at initial prices, but prices fall sharply because price elasticities of demand in agriculture are low. The end result is a reduction in the amount of resources—and particularly labor—employed in agriculture. This hypothesis is examined in subsequent sections.

Three important questions arise in this context: (i) how big are the gaps in returns? (ii) what causes the gaps? (iii) what is the direction of movement in response to interventions? and (iv) what are their implications for the impacts of investments in agriculture or interventions that raise agricultural productivity?

2.1.1 How big are the gaps in returns?

Gollin, Lagakos and Waugh (2014) directly address this question. To answer it, they carefully adjust for a wide range of potential measurement errors, such as those arising from undercounting of subsistence production, and for differences between agricultural and nonagricultural workers—including in hours worked, education levels and human capital—that might inflate the measured gap in incomes between agricultural and non-agricultural workers. They find that the crude ratio of non-agricultural to agricultural

labor productivity averages for 150 countries averages 3.5. Adjusting for measurement errors and for tangible differences in hours, education and human capital lowers this to 2.2, which is still a large difference, equivalent to an annual tax of 120 percent on movement of labor out of agriculture.

2.1.2 Gaps in returns and their implications

At least eight different reasons for gaps in returns have been offered in the literature and the reason for these differences may have important implications. The reasons offered include: (i) income sharing of the type suggested by Lewis (1954); (ii) Harris-Todaro institutional wages (iii) policy barriers to mobility, (iv) selection and differences in the distributions of returns, (v) differences in hours worked, (vi) asset fixity, (vii) differences between urban and rural areas in costs of living and amenities, and (vii) differences in education and skills. These have quite markedly different implications of increases in agricultural productivity, and these implications frequently depend not just on the cause of the gaps in returns, but also on whether the economy is closed or open. Bertrand and Squire (1980) consider (i) and (ii) as variants of the dual economy model. They are considered first because of their extensive treatment in the literature.

(i) The Lewis Income-Sharing Case

In the Lewis (1954) model, the marginal return on labor in agriculture is below the observed wage. Because the marginal product of agricultural labor is below subsistence returns, the only way workers can survive is by sharing returns from other factors, such as land. The return to labor in the modern sector is, by contrast, based on its marginal return, and hence above the marginal return in agriculture. Accumulation of the capital needed to generate employment and/or increases in productivity in non-agriculture have return greater returns than suggested by simple evaluation of returns at market prices because they allow workers to move from agriculture to non-agriculture, where they earn higher marginal returns.

In a small, open economy, increases in agricultural productivity initially reduce the gap between marginal returns in agriculture and in non-agriculture without necessarily increasing wages paid in agriculture, which are assumed to be determined by subsistence requirements. Opportunity cost of farm labor in this situation is not the agricultural wage but the lower marginal product of labor. Only when productivity rises enough to eliminate the gap in marginal productivities between agriculture and non-agriculture does labor begin to flow into agriculture but, by that time, wages will equal the marginal value product of labor in both sectors so standard evaluation approaches are adequate. Bertrand and Squire (1980) provide a general formula for the shadow wage relevant to decision making when, for instance, labor is in surplus in agriculture so that increases in non-agricultural employment do not reduce employment in agriculture one for one.

If the agricultural economy is closed, the fall in agricultural prices resulting from higher agricultural productivity lowers the marginal value product of labor in agriculture by lowering agricultural prices, tending to increase the gap in marginal value products between agriculture and non-agriculture without causing any movement between sectors.

(ii) *Harris-Todaro Institutional Wages*

Harris and Todaro (1970) provided an alternative explanation for a gap in returns, with an institutionally determined wage in the modern sector, and jobs allocated randomly to job-seekers located in urban areas. Under this model, job seekers are attracted to urban areas by the chance to participate in a job

"lottery", with an expected payoff based on the probability of high-wage employment. This model generates economic inefficiency, with a mass of job-seekers facing zero earnings while they wait, hoping for a job. Its implications for welfare may be quite different from those of a barrier to mobility such as a residence permit or legal obstacles to the sale of land. A change such as increased investment in the high wage sector would generate real income gains from the higher wages paid in that sector, but these gains in national income would be offset by attracting a larger share of the workforce into the pool of job-waiting hopefuls whose low incomes drag down national income.

The Harris-Todaro model seems more appropriate for resource-rich countries where some of the resource rents are used to fund government employment than to countries with substantial private sector employment in the non-agricultural sector. Bertrand and Squire (1980) used data on employment, turnover and wage rates to assess the relevance of both these dual-economy models and concluded that neither fitted the reality of Thailand's labor market in the 1970s.

Where this model is relevant, investments that increase agricultural productivity will yield higher returns when agricultural prices are fixed, as in a small, open economy. Higher returns to labor in agriculture reduce the incentive to move to join the urban job-seeker queue, thus lowering the deadweight costs associated with this economic structure. Harris and Todaro (1970) point out that, with this type of model, it is possible to increase agricultural output without reducing manufacturing output. Heady (1981) suggests that the wage in the formal sector, and not a lower wage based on the marginal product of labor in agriculture, is the appropriate shadow price when evaluating industrial projects. It seems likely that this would be the appropriate shadow price to use in evaluating interventions that raise the productivity of labor in agriculture.

If, however, trade policy is designed to achieve self-sufficiency, or agricultural output is nontraded, higher productivity would lower agricultural prices and labor returns enough to increase the incentive to join the job-seeker queue. In this case, the returns to increases in agricultural productivity would fall below what would be suggested by returns at initial wage rates because the increasing gap between agricultural and non-agricultural wages would increase the incentive to join the job-seeker queue.

(iii) Policy Barriers to Mobility

Institutionally determined barriers to mobility can have important implications for investments in agriculture. Barriers that inhibit the movement of rural people to urban areas, such as those resulting from the *hukou* system in China, generate a cost akin to a tax that can be incorporated in models of reform (see Ianchovichina and Martin 2003 for an example). Other institutionally determined barriers arise from resistances to movement such as land tenure conditions that involve loss of land rights when the holder ceases to farm that land. Measures of this type retain too much labor in agriculture. Interventions that reduce this level of employment by, for example, reducing the amount of labor needed to produce a fixed amount of food, will have a benefit that exceeds the conventionally measured gain. An additional unit of labor moved to non-agricultural employment will earn a return equal to the higher wage rate in that activity, which would equal the agricultural wage plus the tax on employment in non-agriculture.

Under an open trade regime for agricultural products increases in agricultural productivity will attract more resources into agriculture. This reduces the return to investments in agriculture relative to the standard case. This shift from the sector with higher returns to the one with lower returns is a structural change with adverse impacts on welfare, as pointed out by McMillan, Rodrik, and Verduzco-Gallo (2014). If there are trade as well as wage distortions, the impacts of agricultural productivity growth should take both distortions into account.

In a closed economy, higher agricultural productivity will raise output for any given commitment of resources but cause domestic agricultural prices to fall and resources to move out of agriculture into higher-return sectors. Starting from zero trade distortions, an increase in agricultural productivity will have a higher return than suggested by valuing its output at market prices because of the move of labor into higher-return sectors. If an increase in labor productivity in agriculture displaces labor out of agriculture one for one with the increase in productivity, the increase in returns to labor should be based on the higher return in the non-agricultural sector. But as the trade distortions become larger, the deadweight costs of increasing these distortions will weigh against the benefits from reallocation of labor to higher productivity sectors.

(iv) Selection and differences in the distributions of returns

Selection by skill into sectors of employment might, at first sight, not seem to provide a basis for policy intervention. After all, a key feature of this model (Roy 1951) is that people select their occupations until the marginal worker in each industry earns the same wage. This intuition is correct when external prices are fixed. However, it need not be the case when the prices facing each sector are not fixed.

Lagakos and Waugh (2014) develop a model in which the returns to labor in agriculture have a much narrower dispersion than in non-agriculture, just as hunting has a narrower dispersion of returns than fishing in the original Roy (1951) model. If food demand must be met from domestic production, then the larger share of food in total demand in poor countries requires that a larger share of the workforce in agriculture, reducing national income. This will not result in gaps in income between workers at the margin because it is the rise in the autarchy wage rate that causes workers to select into agriculture. Thus, the outcome in this model is more a function of the choice of trade policy than of selection.

Only if the evaluation is done at world prices would the lower productivity of labor in agriculture be apparent. With the self-sufficiency imperative in place, increases in agricultural productivity may have super-normal returns by allowing workers to move into higher productivity non-agricultural employment and to reducing the trade barriers needed to maintain self-sufficiency. This will continue to be the case until the value of output at world prices is equal for marginal workers.

For a small country, the best solution to this problem is to remove the trade policy distortions that created the incentive to draw workers into low-productivity agriculture. If these distortions cannot be removed, increases in agricultural productivity will have a higher second-best return than suggested by benefits at market wages because they free labor to move into higher-return activities. Large countries whose liberalization would raise the price of imported foods also need to take this terms of trade effect into account.

(v) Differences in Hours Worked

The difference in hours worked in agriculture and non-agriculture requires special attention. To the extent that this reflects voluntary choices, it has no policy significance. If workers would like to work longer hours but can't because of limited or highly seasonal demands for labor where they are located, the problem is similar to the case (iii) where there are barriers to movement of labor. As in case (iii) a great deal depends on whether agricultural output can be transported. If there is market access for agricultural output, farm incomes will rise when agricultural productivity increases. The rise in agricultural incomes will then increase demand for nontraded services and help diversify employment. If there is no market access for additional agricultural output, then agricultural prices will fall, likely reducing incomes from agriculture. The lower wages in isolated agricultural areas do not appear to constitute a market

failure for which intervention is justified, other than to take action to reduce the costs of isolation. This case differs from the case of policy barriers to mobility in that, in this case, there are true costs of mobility, as distinct from policy barriers that do not involve actual costs of mobility.

(vi) Asset Fixity

Another potential explanation for lower returns in agriculture relative to the remainder of the economy is provided by asset fixity—an explanation widely used to explain low returns to agriculture in today's rich countries during the period of rapid movement of labor out of agriculture (Johnson and Quance 1972). If farm households invest in agriculture-specific capital and/or skills and the demand for these skills unexpectedly declines, then they are less likely to leave the agricultural sector than if they were able to dispose of these assets at something near their acquisition costs. As noted by Hsu and Chang (1990), this theory can be interpreted as incorporating an adjustment cost to movement out of agriculture. These adjustment costs would include the losses on agriculture-specific investments emphasized in the original Johnson and Quance (1972) formulation; losses of social capital associated with the home social network and costs associated with movement to urban areas where this is needed to move out of agricultural employment. All these losses are likely to be smallest for young out-migrants, and much higher if the rapidity of change also requires out-migration of older farmers. It also seems likely that improved communications and transport would, by increasing opportunities to remain connected to family members at home, have reduced the severity of loss of social networks for out-migrants. The increasing importance of outmigration to secondary cities (see Christiaensen and Kanbur 2018) might also have reduced the costs associated with physical movement.

The asset-fixity/adjustment cost model would suggest a large gap between agricultural and non-agricultural returns during the period of most rapid out-migration from agriculture—with a smaller gap before the process of rapid movement begins and as it nears completion. Such a pattern is evident in McMillan, Rodrik and Verduzco-Gallo (2011) for African countries and for a composite of India, Peru and France at different stages of the transition.

(vii) Differences in costs of living

Differences in costs of living between urban and rural areas are frequently invoked as an explanation for higher incomes in urban than in rural areas. Munshi and Rosenzweig (2016), for example, found persistent gaps in wages after allowing for cost of living adjustments—perhaps due to some of the other factors considered here. Ravallion and van der Walle (1991) found cost of living differences in Indonesia to be closer to 10 percent than to the widely quoted 66 percent once allowance is made for differences in housing quality. Ravallion, Chen and Sangraula (2007) provided a more comprehensive set of differences across all world regions that are, on average, 29 percent higher in urban areas. They also point out that part of this difference reflects differences in the quality of services available to residents suggesting that 29 percent might be an over-estimate of the relevant cost difference.

The compensating differentials needed to cover higher costs of living in urban areas are simply a fact of economic life and do not justify adjustments to returns when assessing the impacts of interventions to increase agricultural productivity or returns.

(viii) Differences in education and skills

Where the differences in returns across sectors depend on differences in skills, movement of labor will not create static welfare gains. Even in this situation there may be substantial economic inefficiencies if the differences in skills reflect differences in access to education. There may be substantial inefficiency

if, for instance, rural children have less access to education than similarly capable urban children. Where this is the case, the most direct policy solution lies in increasing educational opportunities for rural children, rather than in seeking to directly move workers from agriculture to other activities.

Summary and Conclusions

The evaluation and explanation of income gaps between agriculture and non-agriculture has absorbed an enormous amount of research effort. One clear conclusion from this literature is surely that the policy relevant part of these gaps are generally much smaller than the large observed gaps. Another is that the impacts of interventions frequently depend heavily on the trade regime, as well as the gaps between returns.

The Lewis (1954) model requires use of the marginal, rather than the average, product of labor to assess the benefits of productivity increases. This reduces the opportunity cost of labor to non-agricultural sector, but agricultural trade policy differences play a limited role in this model. Both wage and trade policies are clearly in play with the Harris-Todaro (1970) dual economy model. In a small, open economy, higher agricultural productivity reduces the gap in returns between agriculture and the high wage sector, reducing the costs associated with joining the formal sector job queue and raising the social returns to investment in agriculture. By contrast, if an agricultural self-sufficiency policy is in effect, higher agricultural productivity will increase the gaps in wages and increase queueing for formal sector jobs.

When there are policy barriers to movement of labor from agriculture to non-agriculture, there are benefits to policies that encourage movement of labor out of agriculture. When trade policy focusses on self-sufficiency, investments in raising agricultural productivity encourage movement of labor out of agriculture and can generate second best welfare gains. In a small, open economy, higher productivity will increase the demand for labor in agriculture and may result in welfare reducing transformation as workers move from non-agriculture to agriculture.

The Roy (1951) selection model only leads to lower marginal productivity at the margin if a self-sufficiency policy is in effect. The same result—a large concentration of labor in low-productivity agriculture will result even without selection if average productivity in agriculture is relatively low and policy makers insist on food self-sufficiency. The first best policy response is to move to a less restrictive trade policy. There is a second-best case for favoring policies that increase agricultural productivity and hence reduce the distortions created by the self-sufficiency policy. In a small, open economy, there is no reason to adjust the shadow price of agricultural labor or goods.

None of the remaining four causes of gaps between returns in agriculture and non-agriculture—differences in hours worked; asset fixity; differences in costs of living; differences in education and skills—provide an efficiency justification for adjustments in the procedure used to evaluate the returns on investments in agriculture.

2.2 Impacts of Agricultural Innovations on Output and Resource Use

Much of the literature on agricultural development places agriculture in a closed-economy context. In this case, agricultural innovations or investments that increase productivity result in sharp declines in prices, and reductions in the resources used in agriculture (Matsuyama 1992). If there are large gaps in income between agriculture and the rest of the economy maintained by policy measures, then increases in agricultural productivity can result in very large income gains, as exemplified by the results in

Gollin, Parente and Rogerson (2007), with increases in agricultural productivity freeing up labor to move from agriculture to higher-productivity non-agricultural sectors.

In this situation, a critical question is whether developing countries are typically nearer the closed or open economy cases. Much of the earlier theoretical literature focused on the closed-economy case because of its focus on large economies such as India where both sheer size and policy-makers' aversion to depending on imports make this appear a reasonably appropriate model. But, does it make sense in Africa, where most developing countries are relatively small and at least the countries with access to the sea have access to food at prices not affected by their decisions on import or export levels?

One plausible intermediate position is that large parts of the agricultural sector in many countries face substantial resistances to trade resulting from their high internal trade costs. In geographically large economies like Zambia, where production regions are relatively remote and frequently face trade barriers either in neighboring countries or imposed by their own government in pursuit of self-sufficiency goals (Koo, Mamun and Martin 2021), perhaps the closed economy model is more appropriate even though they could generally buy or sell as much as they wished without greatly affecting external prices. This is particularly the case where the primary staples are root crops such as cassava, which are close to non-tradable because of high transport costs.

2.3 Evidence on the Impact of Agricultural Growth on GDP

One potential path to identifying whether there are high returns to investments in agricultural productivity growth is to estimate the impacts of higher agricultural growth on non-agricultural output or productivity. Timmer (2002, p496) finds a positive impact of agricultural growth on the non-agricultural sector for a panel of 65 developing countries over the 1960 to 1985 period, with one percent growth in agriculture raising non-agricultural growth by 0.2 percent. A problem in this type of analysis is reverse causality where, for instance, growth in non-agricultural productivity lowers input prices to agriculture but a regression of non-agricultural growth on agricultural growth finds a positive coefficient. To mitigate this problem, Timmer used agricultural growth over the previous five years and found a coefficient of 0.14 on non-agricultural output.

Bravo-Ortega and Lederman (2005) with results reported in de Ferranti et al (2005, p72) find—using estimators designed to deal with causality problems—that an increase in agricultural output of 1 percent caused an increase of 0.15 percent in non-agricultural output. While these studies are not specific about the mechanisms whereby agricultural growth occurs and how it stimulates growth in other sectors, they are consistent with a closed-economy model, where agricultural growth frees up resources for growth in the non-agricultural sector. They could also be consistent with a model where agricultural growth stimulates employment in other sectors via multipliers but, as we have seen, this model is consistent only with situations where labor in rural areas is otherwise underemployed.

Gollin, Hansen and Wingender (2021) use the yield impact of Green Revolution varieties as their explanatory variables, rather than increases in agricultural GDP. They find very large impacts of high yielding varieties on GDP growth—more than twice the direct impacts through increases in agricultural productivity—with a one percent increase in yields due to the introduction of high-yielding varieties resulting in a one percent increase in GDP. Their reduced-form estimate of the structural transformation benefit reflects a combination of a large productivity gap between agriculture and non-agriculture and a substantial shift of resources from agriculture to non-agriculture. They also find the impact of higher-

yielding varieties on GDP to be much higher in countries with larger shares of the labor force in agriculture than in countries with smaller shares. As regards openness, the income effect of high-yielding varieties is smaller in countries that are initially less open.

An unpublished paper by Moscona (2019), uses a somewhat different identification strategy, using yield potential from the GAEZ database as an instrument for both the incentive to adopt and the yield impact of new varieties. He presents results both for states within India and across countries. In both cases, he finds that agricultural total factor productivity (TFP) growth transfers resources out of the non-agricultural sector and reduces the rate of economic growth. Only in the 25 percent of economies that are least open does he find a positive effect of agricultural productivity growth on income. He attributes the slowdown in economic growth associated with the movement of resources away from agriculture to the loss of learning-by-doing gains that he assumes are achievable in the non-agricultural sector, but not in the agricultural sector. This assumption seems questionable given the evidence that TFP growth has been more rapid in agriculture than in non-agriculture for both industrial and developing countries in recent years (see, for example, Bernard and Jones (1995) and Martin and Mitra (2001)).

Updated estimates of these TFP comparisons do not appear to be available, but a simple comparison of partial productivity estimates from the World Development Indicators given in Table 1 reveals that average growth rates of labor productivity have been substantially higher in agriculture than in industry or services in almost all regions and income groups, with the important exceptions of East and South Asia. For the world, agriculture grew one percentage point per year faster than industry, and 1.6 percentage points faster than services. There were a few exceptions at the regional level, with labor productivity in industry growing 1.2 percentage points per year faster than in agriculture in the developing countries of East Asia, and services by 1.3 percentage points in South Asia. In Sub-Saharan Africa and in Latin America and the Caribbean, productivity growth in agriculture was below the world average, and its outperformance in these regions was relative to productivity declines in Industry. The performance of the Low Income group in all sectors is biased downwards by the final-year nature of the sample selection, with some high-growth countries originally in this group moving out and some low-growth countries originally above this group falling in to it during this 26 year period.

Table 1: Labor Productivity Growth by Sector, 1991-2017 %

	Agriculture	Industry	Services
East Asia & Pacific	5.3	6.5	4.7
Europe & Central Asia	2.5	1.3	0.7
Latin America & Caribbean	2.4	-0.4	0.0
Least developed countries	1.9	1.4	0.7
Low & middle income	3.3	2.4	1.5
Low income	1.2	na	0.7
Lower middle income	2.7	1.2	2.3

Middle East & North Africa	2.2	0.9	na
Middle income	3.7	2.5	1.6
South Asia	2.5	2.8	3.8
Sub-Saharan Africa	2.0	-0.7	0.6
Upper middle income	5.0	3.2	1.4
World	3.4	2.4	1.8

Notes: Simple averages of changes in logarithms at annual rate. World Bank definitions of regions and income groups, with regional groups excluding high income countries. Based on 113 countries for which data on value added in constant 2010 US dollars were available. Data extracted from World Development Indicators on 28 September 2019.

The higher growth rates of productivity in agriculture over this period have not come near to removing the income gap between agriculture and the other broad sectors. At the global level, average value added per worker in agriculture was $3,333, as against $29,794 in industry and $31,771 in services. In only five countries did the level of agricultural value added per worker exceed that in industry. However, in 67 percent of the countries with available data, agricultural productivity grew more rapidly than productivity in industry. In 72 percent, it grew more rapidly than in services. The idea that productivity in agriculture inherently grows more slowly than in other sectors seems to be based on outdated perceptions, rather than on recent facts.

3 AGRICULTURE IN DIFFERENT STAGES OF DEVELOPMENT

Much of the macroeconomic literature on the impact of agricultural growth on overall economic growth focusses on the case of very poor countries, where the share of agriculture in both employment and in GDP are large. This may have been a reasonable characterization of developing countries in the 1950s, but it is far from the case now. The World Bank's (2008) World Development Report on Agriculture identified three different groups of developing countries, in which the roles of agriculture differed substantially:

1. Agriculture-based
2. Transforming, and
3. Urbanizing

Key economic features of these three, roughly-equal-sized, groups of countries are summarized in Table 1. The Agriculture-based economies, which were and remain mostly in Sub-Saharan Africa, have very low per capita incomes, employ large shares of their workforces in agriculture, and generate a large share of GDP in this sector. Clearly, productivity growth in these countries can do a great deal to promote economic growth. The Transforming economies still had 57 percent of their workforces in agriculture but generated only 13 percent of GDP from that sector. In the urbanized economies, average incomes were almost $3500 per person, the share of labor in agriculture in the economy had fallen to 18 percent and its share of GDP to only 5 percent. In the agriculture-based economies, agricultural growth had been an important driving force in overall economic growth over the 1990 to 2005 period,

while it had contributed less than 20 percent of overall growth in almost all the transforming and urbanized economies. The sharp decline in the income share of agriculture relative to its labor force share between the three groups is consistent with the widening gaps in incomes with economic growth observed by McMillan, Rodrik and Verduzco-Gallo (2014).

Table 2: The Role of Agriculture in Three Groups of Developing Countries

	Average Income per person	Share of Workforce in Agriculture, %	Share of Agriculture in GDP, %
Agriculture-Based	379	65	29
Transforming	1068	57	13
Urbanized	3489	18	5

Note. Incomes in 2000 $US. Source. World Bank (2008, p31).

Clearly, the sharp differences in the situation of these three groups call for different policy approaches in these countries. In the agriculture-based economies, agricultural growth remains important both for economic growth and poverty reduction. By the time countries reach the transforming stage, increases in agricultural productivity have little scope for increasing overall incomes unless they are associated with a substantial move of labor from low-income agriculture to high-income non-agricultural employment. Improvements in agricultural productivity or income-increasing labor movements may, however, contribute strongly to poverty reduction. By the time countries reach the urbanized stage, there is much less scope for agricultural productivity growth to contribute strongly to overall income increases

As noted by Collier and Dercon (2014), much of the focus in development is on smallholder agriculture in the poorest countries. This is because, as we have seen, agriculture is an important share of the economy and employment in these countries. It is also because smallholder agriculture is seen as being efficient with the available technology, as argued by Schultz (1964), but needing improved technologies and access to inputs if productivity is to improve. While the smallholder-focused approach was also highly successful during the Asian green revolution, the benefits have been slower to emerge in Africa (Pingali 2012).

Collier and Dercon (2014) are concerned that: (i) it may be difficult to achieve the desired rate of increase in productivity with a focus on smallholder agriculture, and (ii) expanding the lowest-productivity sector may make it difficult to achieve structural transformation. In response, they suggest broadening the focus purely from smallholders to a wider range of family farms that might have higher productivity and greater potential for productivity growth. Clearly, raising productivity growth in Africa has been more difficult than in Asia, although many, such as Otsuka and Larson (2012) and Pingali (2012), are optimistic that current and past investments will bring about the desired increase in productivity in Africa. The emergence of middle-sized farms fueled by urban investors (Jayne et al 2016) is perhaps not what Collier and Dercon had in mind, but may help stimulate productivity growth. The second concern, about expanding a low productivity sector, arises only if there are large, distortion-driven gaps in productivity between sectors, something that further measurement and analysis suggests are smaller than previously thought (Fuglie et al 2019).

4 IMPACTS OF AGRICULTURAL GROWTH ON POVERTY

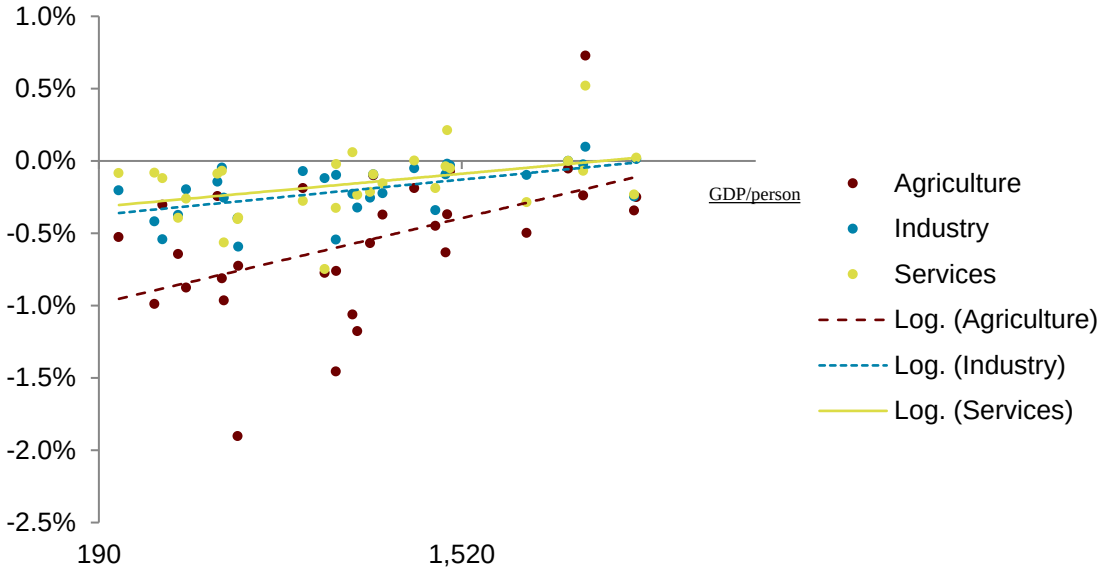
The discussion to date has focused heavily on the impacts of agricultural growth on overall incomes. Another reason for a strong focus on agriculture is its potential impacts on poverty, for which there is strong evidence that it may have disproportionately strong impacts. Many studies (such as Ravallion and Datt, 1996) have found growth in agriculture to be associated with much more rapid reduction in poverty than economic growth in in non-agriculture This seems plausible given the generally much higher poverty rates in rural than in urban areas. However, if it is to be used as a basis for policy, it is important to understand the channels of effect so that policies can most effectively be targeted to promoting growth and poverty reduction.

Loayza and Raddatz (2010) make an important contribution by showing that the impact on poverty depends importantly upon the labor intensity of different sectors (e.g. agriculture, construction and services). In addition to this supply-side linkage, other studies have noted that widespread agricultural productivity growth may have important impacts by reducing the cost of food to poor consumers in closed economies or for the world as a whole (eg Dercon, 2009). On the other hand, Christiaensen, Demery and Kuhl (2011) and Himanshu, Lanjouw, Murgai and Stern (2013) have concluded that the role of the non-agricultural sector in poverty reduction has increased, raising important questions about whether agriculture retains its central importance for poverty reduction.

A recent set of eight studies in World Economy (summarized in Christiaensen and Martin 2018) confirms that, in general, growth in agriculture is generally two to three times as effective in reducing poverty as the same amount of GDP growth generated outside the sector—a result supported by both econometric and economy-wide modelling. This effect diminishes as countries become richer, and essentially disappears at high levels of average income.

Figure 3, drawn from Ivanic and Martin (2018), shows the relationship between growth of 1 percent of GDP in agriculture, industry and services and poverty reduction based on a sample of 315,000 households from 31 countries. This relationship is based on results for an experiment in which productivity was increased in one country at a time.

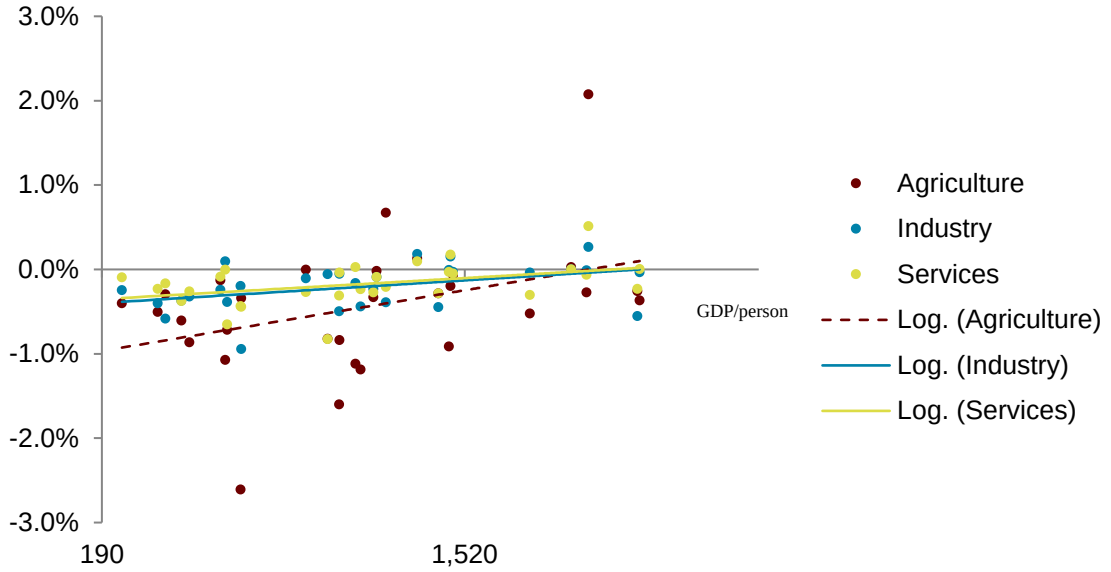
Figure 3: Relationship between per capita GDP and poverty change from a productivity increase of 1% of GDP



Note: Based on analyses for individual countries.

The Ivanic and Martin (2018) paper also considers the case where all countries increase their productivity in the relevant sector at the same time, as would be the case for an innovation that was immediately disseminated worldwide. These simulations, presented in Figure 4, involved much larger declines in output and larger declines in prices of the products concerned, but resulted in similar declines in poverty and a similar degree of outperformance of agricultural productivity growth relative to industry and services. While nominal agricultural incomes decline, the effect of this decline on the poor is muted by the fact that many poor farmers are either small net sellers of agricultural products or even net buyers of these products. Of course, the precise beneficiaries will differ between these two scenarios, with net buyers of food gaining relative to net sellers under the global productivity growth scenario. The robustness of the poverty reduction regardless of whether the innovations are national or global raises questions about the Dercon (2009) argument that raising agricultural productivity is a priority only in landlocked countries.

Figure 4: Relationship between per capita GDP and poverty change coming from productivity change of 1% of GDP



Note: Based on global simulations.

Improvements in agricultural productivity across the developing world have enormous potential for poverty reduction. A recent assessment of the impact of research by the CGIAR network of research agencies on global poverty finds that it has been able to bring about a massive reduction in poverty, lifting around 70 million people out of poverty (Laborde et al 2019), with the largest reductions in South Asia and Africa South of the Sahara.

There is considerable heterogeneity in the poverty impacts of productivity growth by sub-sector. Dorosh and Thurlow (2018) find that some non-agricultural sectors have relatively high poverty reduction impacts. These include productivity improvements in trade and transport services, which can raise agricultural output prices and lower input and living costs for remote farming households, and agro-processing which can help raise output prices for poor farmers. Another poverty reduction benefit can arise through increases in the demand for unskilled labor in these subsectors. Adam, Bevan and Gollin (2018) also find sizeable benefits from lowering transport costs in Tanzania, particularly if this lowering comes about by eliminating monopoly profits in the transport sector. They also highlight the importance of the way in which public investments are financed—showing that infrastructure financed by an import tariff may increase poverty where a similar investment financed by a consumption tax that bears more heavily on urban consumers would result in a poverty reduction.

Productivity increases within agriculture have similarly heterogenous impacts on poverty, depending upon which households are engaged in the production of goods, whether the economy is open or closed, which households consume the good (if it is closed), and the impact of the productivity increase on wages for unskilled workers. In a study focused on prioritizing research resources in Rwanda, Apell et al (2019) find wide variations in the poverty impact of productivity increases by commodity. Productivity increases for goods such as beans that are produced by large numbers of poor farmers generated large reductions in poverty. On the other hand, productivity increases for commodities such as coffee yield very small reductions in poverty. Farmers that can afford to wait several years from planting to harvest tend to have higher incomes.

5 INTERVENTIONS AND THEIR IMPACTS

To this point, this paper has focused on high level impacts, such as the effects of increases in productivity or changes in product prices and wages on national income and on poverty. But policy makers cannot directly affect productivity or prices, and must use policies that affect the agricultural sector, and the economy at large, less directly. Some of the key policy instruments for improving outcomes deal with:

1. Research, development and adoption
2. Product and input price interventions
3. Market access and transportation
4. Land tenure
5. Information
6. Irrigation
7. Risk and uncertainty, and
8. Value chain development

Many of these interventions are intended to deal with market failures. Research and development are typically massively underprovided by markets because of the public good nature of many innovations resulting from research. If a farmer develops a superior variety, many others may benefit, but it is hard for the developer to gain a substantial share of these benefits (See Varian (1992) for a definition of a public good). In this situation, research is under-provided. Transport infrastructure involves many public-good aspects since it is challenging to exclude users from many roads and, as long as they do not reach capacity, use is non-rival. Other interventions in the list, such as irrigation and drainage, require public intervention, whether to allocate usage rights or to provide infrastructure such as dams. Each has specific features so it pays to examine them in turn.

5.1 Research, Development and Adoption

As noted above, research and development suffer from potentially serious market failures. Where it is not possible to exclude free riders from the innovation, potential researchers have inadequate incentive to invest. Mechanisms such as patents can mitigate this problem, but at the expense of reducing access to the innovation. If a patent holder raises the price of the good, its use will be restrained below the optimal level. In response to this problem, governments in higher-income countries have, since the mid nineteenth century, begun to invest in programs to stimulate investments in research on improved varieties and to encourage improved marketing practices (OTA 1982). In developing countries, progress occurred somewhat later, with research agencies established in many African colonies in the 1920s (Eicher and Baker 1991, p98), a Council of Agricultural Research in India in 1929 (Borthakur and Singh 2013) and centralized organization of field experiments in Java in the late 1920s (Maat 2011, p191). Much of the early research in colonial research agencies focused on cash crops for export to the colonizing countries (Lewis 1981).

Fuglie et al (2019) report a set of estimates for internal rates of return sourced from Alston et al. (2000). As is clear from Table 3, these results are extraordinarily high, far higher than the returns available from alternative investments. It appears that governments heavily under-invest in agricultural research and development. If they were to invest optimally, they would continue investing until the marginal returns were much lower.

Table 3: Rates of Return on Investments in Agricultural R&D, %

Geographic or commodity area	Median internal rate of return (%)	Number of estimates
Developed countries	46.0	990
Developing countries	43.3	683
Asia-Pacific	49.5	222
Latin America and Caribbean	42.9	262
West Asia and North Africa	36.0	11
Sub-Saharan Africa	34.3	188
CGIAR & other international agricultural research	40.0	62
All agriculture	44.0	342
Annual crops	43.6	916
Tree crops	33.3	108
Livestock	53.0	233
Natural resource management	16.5	78
Forestry	13.6	60

Source: Fuglie et al (2019) based on Alston et al (2000).

Alston et al (2000) provide a formula that allows comparison of these internal rates of return (IRRs) with the Benefit-Cost (B/C) ratios that are widely reported for other investments. This is:

1. BC = $\frac{IRR}{i}$

Where i is the discount rate used to evaluate the present value of future returns. If we choose a discount rate at the high (conservative) end of the 2 to 5 percent range suggested by Alston et al (2000, p24), then the IRR of 43.3 percent reported for developing countries translates into a Benefit-Cost ratio of 866 and the 34.3 percent IRR for Sub-Saharan Africa into a BC ratio of 686. These benefit-cost ratios bring out—even more clearly than the IRR estimates—the extraordinarily high returns available from research and development at current levels, and the desirability of expanding investments in this area.

5.2 Output and Input Price Interventions

Interventions that affect the prices of agricultural outputs and inputs are by far the largest component of total support to agriculture. These measures are frequently justified on the grounds of meeting the

needs of producers and consumers. But, in reality, these interventions are generally designed to build political support, with more influential interest groups receiving more support than others. The balance between interest groups changes as countries develop, with a general tendency for poor countries to tax their agricultural sectors while rich countries provide support (Anderson 1995). The 54 countries monitored by the OECD provided an average of $436 billion in support through measures such as subsidies and market access barriers between 2018 and 2020, relative to the $102 billion they disbursed on services such as agricultural innovation, infrastructure and stockholding (OECD 2021, p110).

The other major motivation for price interventions is food self-sufficiency, which is frequently confused with food security, although the official FAO definition of food security recognizes it as a goal attainable at the individual, rather than national, level and requiring food availability, access to food, the ability to utilize food and a manageable degree of volatility (FAO 1996). While the concerns of policy makers about risks of relying on food imports are understandable, many of the policies designed to achieve food self-sufficiency create food insecurity at the household level, as graphically depicted by Sen (1981). The use of quantitative restrictions, such as export bans, is particularly problematic because it results in heightened volatility by blocking the ability of positive output shocks to result in additional exports or reduced imports and the ability of negative output shocks to result in reduced exports or increased imports. By lowering domestic prices, export bans reduce the real income of net selling households and can, in cases such as Zambia, result in increases in poverty—compounding the adverse impacts of adverse weather conditions that triggered imposition of the export ban (Koo, Mamun and Martin 2021). Variable levies and/or subsidies can offset the impacts of food price volatility for an individual country but do this at the expense of increasing the volatility of world markets (Martin and Anderson 2012).

The combined set of price interventions in world markets results not in an increase in global efficiency, but in serious global economic losses. Laborde, Martin and van der Mensbrugghe (2011, p265) estimate the gains from elimination of these barriers worldwide at $725 billion per year, with $369 billion of that gain accruing to countries self-designated as developing at the WTO.

Some argue that many of the problems of traditional price interventions can be overcome by using “smart” subsidies administered to targeted producers. Certainly, these policies can avoid some of the problems associated with traditional, unrestricted subsidies. But these measures suffer from many of the problems of traditional subsidies, including high budget costs and, if inputs are provided by government, unreliable delivery and diminution of the role of private suppliers (Minot and Benson 2009). Dorward et al (2008) conclude that the Benefit-Cost ratio for ‘smart’ subsidies in Malawi varied from 0.7 to 1.36, very far from the astounding ratios available from investments in research and development.

5.3 Market Access and Transportation

Improvements in market access that lower transport costs are triply beneficial to people in remote areas. They lower the costs of sending output to markets, resulting in higher realized prices for output. The reduce the costs of obtaining inputs and consumer goods. And they allow agricultural producers to shift their production patterns away from a focus on local needs towards specialization in the commodities that yield the highest returns. Allowing food to be imported in poor seasons reduces the risk of food insecurity, while allowing products to be exported in good seasons can help avoid excessively low returns to producers.

Evaluating these benefits is challenging because of two-way linkages between infrastructure and economic growth—infrastructure can promote economic growth (Aschauer 1989), but economic growth may facilitate investment both by stimulating demand and by reducing financing constraints.

New research allows much better estimation of the benefits of transport infrastructure, and particularly its implications for agriculture. These models use advances in estimation of gravity models to take into account the impacts of improved infrastructure on transport costs, and sidestepping the problems of reverse causality that plagued earlier work evaluating the economic impacts of infrastructure investments. Donaldson (2018) used this approach to evaluate the impacts of the railway network in British colonial India and concluded that the gains from increases in agricultural income were around 16 percent, substantially more than estimated using earlier approaches to infrastructure evaluation. Costinot and Donaldson (2016) used a similar approach, with more details on differences in productivity of different crops in finely defined agroecological zones, to assess the impacts of improvements in transportation infrastructure on agricultural incomes in the United States. They conclude that the income gains from lower transport costs were comparable in magnitude to the enormous productivity gains experienced over the 1880 to 1997 period.

While it is important for future work to account for the potential problems of reverse causality in estimating the impacts of infrastructure, the work of Zhang and Fan (2004) suggests that the resulting bias may be relatively small, and certainly much smaller than the downward bias created by first differencing, one of the proposed solutions to the problem. If we, in this light, accept the broad results of studies such as Fan, Gulati and Thorat (2008), that the resulting benefit cost ratios for rural roads are in the order of 8 to 20, for education 5 to 15 and for irrigation investment 4 to 8, then the massive investments in these sectors by developing country governments in recent years would have contributed substantially to the boom in economic growth that is of central interest to this paper.

Burgess and Donaldson (2010) analyze the impact on food security of connecting a location to the Indian railway network. Prior to connection to the rail network, they found that the risk of famine in a district was strongly related to local rainfall. After connection to this network, the risk of famine was no longer significantly related to rainfall. Burgess and Donaldson (2012) show that famines essentially disappeared after regions of India were linked to the rail network, and that this resulted in a substantial drop in death rates. This empirical research provides a resoundingly clear answer to important question on which theory alone provides no guidance—will opening to trade increase food security?

5.4 Land Tenure Interventions

Improvements in land tenure can have very large impacts on agricultural (and urban) outcomes. In the worst cases of poor land tenure—such as during wartime or in the presence of roving bandits—it does not pay producers even to make the short-term investments in seeds or other inputs required for crop production. Moving from less extreme situations, improvements in land tenure can be expected to: (i) increase incentives to invest in land improvement, (ii) improve access to credit through be able to use land as collateral, (iii) make it easier to transfer land to higher productivity producers, whether through sale or rental, and (iv) reduce the risk of conflicts over land (Fuglie et al 2019).

While there are many studies of projects that enhance land tenure security, relatively few of these appear to provide benefit-cost ratios for these interventions. A comprehensive survey by Lawry et al (2014, p46) provides estimate of the percentage increases in land value associated with reforms, but

not on the costs of the interventions, for six studies. The increases in land value ranged up from 6 percent for the Jacoby and Minten (2007) study in Madagascar to around 75 percent, with an average of around 30 percent. Jacoby and Minten (2007) concluded that the 6 percent increase was insufficient to cover the costs of the program and suggested that it not be extended nationwide. IFAD (2014) analyzes a project in Kyrgyzstan and finds an Internal Rate of Return of 80 percent and a benefit-cost ratio of 14.6. A study by Bolhuis, Rachapalli and Restuccia (2021) of restrictions on land leasing in India finds gains in agricultural productivity of 50 percent if land rental markets are highly distorted.

A key lesson from the Jacoby and Minten (2007) study is that it is important to identify areas where initial tenure uncertainty is high, and this uncertainty can be alleviated through the tenure program. Bellemare (2013) finds a similar result to Jacoby and Minten (2007) for Madagascar but finds large differences between types of informal tenure and their effects on land productivity. Jacoby and Minten (2007) also emphasize the importance of making land titling programs low cost in order to allow the benefits to exceed the costs even in cases where plots are small.

The general lesson from this section appears to be that there are likely many situations where land titling can generate large positive returns, but that these projects must be chosen carefully and performed at relatively low cost if they are to assuredly result in high benefit-cost ratios.

5.5 Information

Information has strong public-good elements in that it is non-rival in consumption. By contrast with a pure public good, however, it is potentially excludable, and farmers are often at a disadvantage relative to other market participants who have an incentive not to share information about, for example, developments in market prices. There is a strong case for governments to help avoid such information asymmetries, which can lead to outcomes that are both inefficient and inequitable. Provision of market information has been shown to lead to outcomes that are more efficient and more equitable to less informed market participants such as small farmers (Goyal 2010).

Similar information asymmetries arise with the quality of purchased inputs, with fake inputs being prevalent in Sub-Saharan Africa (Bold et al 2017). In this case, the problem is not just with reduced quality of the inputs. If producers are unsure about the quality of inputs that they purchase, they are much less likely to adopt new technologies. Enforcement of product brands and quality raises similar problems to those involved with assuring the reliability of weights and measures, although these problems are more complex given the challenges in measuring the quality dimensions of agricultural inputs.

Governments also have an important role in facilitating the rollout of new technologies. Jensen (2007) illustrates the value to producers and consumers of improved information with an event study of the introduction of mobile phone service in Kerala. Following this change, the volatility of fish prices fell, waste was eliminated and producer and consumer welfare increased. While governments do not need to be directly involved in the provision of mobile telephony, they do need to change regulatory frameworks from the traditional monopoly provider model to one that encourages both innovation and competitive pricing. Where this move has been delayed and traditional systems are in effect, there are potentially large benefits with small implementation costs from regulatory reform.

5.6 Irrigation

Irrigation may seem an unpromising area for government intervention. Water, after all, is far from a public good, being potentially excludable from users and strongly rival in consumption—if another person drinks a glass of water, I cannot immediately do so. However, there are frequently challenges involved in making access to water excludable. And there are many co-ordination problems involved in capturing and storing water —especially surface water—for use in irrigation. These challenges have a long history in economics. In the very first issue of the American Economic Review, Coman (1911) laid out the need for thoughtful government intervention in this area. Legal mechanisms that might work in one context, such as riparian rights to water in the humid eastern states of the United States, were profoundly unsuited to the much drier conditions prevailing in the west. Rigid ideologies of the left or the right, such as that government should be exclusively responsible for development of irrigation projects, or that their development should be left solely to the market, both proved unsuited to the challenges faced in the drier western states. Government action is likely to be needed in all cases to provide suitable property rights for water and, in some cases, to coordinate development of water projects.

Returns to irrigation investment are highly idiosyncratic, with the costs of surface irrigation projects depending heavily upon geographic and rainfall conditions. It seems reasonable that the most favored sites would be developed first, leaving higher-cost projects for subsequent development. In line with this, Fan, Gulati and Thorat (2008, p168) found much higher returns to irrigation projects in India during the 1960s and 1970s (Benefit-cost ratios of 8) than in the 1980s and 1990s (Benefit-cost ratios of 4 to 5). Even in the 1970s, however, Cline (1974) found generally low cost-benefit ratios for irrigation projects in North-East Brazil—with the best proposals having ratios below 4 and the worst yielding negative net returns. While these returns are substantially below those for research and development, there is frequently a strong complementarity between the availability of irrigation and adoption of improved varieties.

A concern with large scale surface irrigation project is that it is typically not politically possible for governments to recoup the full costs of the water they supply from their users. This raises the budget costs of projects to governments substantially, and results in a higher hurdle for projects once the costs of raising these budget revenues are taken into account through measures such as the Marginal Cost of Funds (Anderson and Martin 2011).

Groundwater is a hugely important resource for irrigation in many contexts. In India, for instance, it overtook surface irrigation in importance by the 1970s (Ananda and Aheeyar 2019). The key challenge for government in groundwater management is the establishment of a management regime suited to the circumstances. In areas where groundwater is and will remain abundant, then tying property rights to water to the ownership of land—the groundwater equivalent of riparian rights for water extracted from streams—is likely to work satisfactorily. Once there is more demand for water, the common-property nature of water in an aquifer is likely to lead to problems of over-extraction, increasing depth of wells and, potentially, depletion of the aquifer.

Many different approaches to managing this problem have been tried. Some, such as providing electricity subsidies to compensate for the rising cost of extraction, exacerbate the underlying common-property right problem. One approach to the problem would be to define and allocate property rights to water in a manner similar to the allocation of land rights. Unfortunately, such an allocation is particularly difficult because of the existence of prior rights for landholders, and uncertainty about the quantities of

water available. However, considerable progress has been made in developing approaches to managing these problems through group groundwater sharing schemes and the removal of distortionary subsidies (Ananda and Aheeyar 2019).

5.7 Risk and Uncertainty

The environment facing small, poor farmers is extraordinarily risky. Agriculture is much more exposed to weather risks than many other sectors, and subsistence-oriented farmers—particularly those in dryland environments —are seriously exposed to a wide range of weather-related shocks. One response to this problem is to diversify production to mitigate risks, and another to use simple technologies that minimize the up-front investments that could generate negative returns if weather shocks eliminate either crop production or, worse, destroy stocks such as inventories of livestock. Risk is a particular concern when seeking to encourage adoption of newer and more productive technologies. Even if these have much higher expected returns, producers might be reluctant to try them given exposure to risk, particularly if they involve higher up-front costs that may increase exposure to the risk of negative outcomes should the harvest fail.

One potentially logical response to these problems is for governments to provide insurance against production and/or price risk as a way both to reduce risk exposure and to facilitate adoption of improved technologies. There are, however, three problems with conventional crop insurance programs. The first is that their administrative costs are typically very high because of the difficulty of monitoring numerous geographically dispersed plots. The second is adverse selection. Producers with minimal exposure to the covered risks are likely to select out of the program, leaving it with those in more-risky environments and, hence, raising costs. As program costs rise, more of the less-risk-exposed participants will leave, shifting the insured pool to higher and higher cost participants. The third problem is moral hazard, where farmers who are covered for losses feel less need to take risk-reduction measures. These problems have resulted in a situation where few agricultural risk insurance programs succeed unless they are, for some reason, heavily supported by governments (Hazell 1992). Without subsidies, firms quickly tend to be forced out of this activity.

A potential response to this problem is weather-index insurance, in which benefits are paid when an index—such as rainfall at a specified weather station— crosses a limit. This approach reduces administrative costs by avoiding the need for claims officers to evaluate each claimed loss. It also avoids the problem of adverse selection. If a payout is triggered when an index crosses a limit, then the farmer has every incentive to anticipate and prevent damage to the greatest possible extent. The problem of adverse selection remains and a new one emerges with the risk that the index may not accurately predict the risk of loss to the farmer. The success of index insurance schemes to date appears to be mixed.

Carter, Cheng and Sarris (2016) examine when and how index insurance might be used to encourage adoption of improved agricultural technologies. They show that it is likely to be highly successful where risk is large and strongly correlated with the index. They also show that it is likely to be successful in low collateral environments if it is explicitly linked with credit contracts, because this interlinkage reduces risk to the lender by reducing its risk of highly correlated clients. An innovative approach to reducing administrative costs and basis risk is picture-based insurance, in which farmers provide both baseline pictures of insured plots and after-damage photos following adverse covered events (Ceballos, Kramer and Robles 2019).

5.8 Value Chain Development

Value chain development encompasses a wide range of activities in which farmers produce for the market rather than for their own subsistence needs. It frequently requires an active government role—perhaps by providing a legal framework under which producers and marketing firms can confidently enter production contracts—and frequently also needs governments to refrain from activities that hinder market development. A great deal of evidence on the impacts of value chains on market outcomes—and particularly outcomes for the poor—is surveyed in Devaux et al (2016).

At minimum, value chain development requires a well-defined set of property rights to products. Frequently, value chains are much more ambitious, such as those value chains in which contract farming arrangements are established to provide producers with confidence about the prices at which their products will be sold, and inputs are provided (Minot and Sawyer 2016). In these situations, the legal framework needs to be much more developed than in cases where products are simply sold in the spot market. How, for instance, should courts deal with a situation where a producer supplied with free inputs and contracted to deliver her output at a fixed price instead sells her output at a (temporarily) higher price in the spot market?

Another challenge for value chains is the risk that government policies will make one link in the chain unprofitable or excessively profitable, with potentially damaging implications for other participants. Consider a case where a processor uses an intermediate input that is subject to a high import duty, making that processing stage unprofitable and potentially prejudicing the existing of the entire chain. Or a case where a transport oligopoly sets high transport charges that make production for the market unprofitable? Or a case where a requirement to process a primary commodity domestically sharply reduces returns to producers? The effective rate of protection (Corden 1966) is an important analytical concept for value chains because it highlights the impact on value added at each stage and potentially indicates whether particular links in the chain are vulnerable to elimination or to excess profitability at the expends of other market participants.

While developing new value chain opportunities for farmers might seem likely to be uncontroversial, it sometimes needs to be designed carefully if it is to be accepted. The recent controversy about proposals for new agricultural marketing arrangements in India highlights the need for care in the design of new marketing arrangements. Narayanan (2020) sees a need for reform in India, but is concerned about a possible lack of transparency in transactions outside the traditional marketing system. Done right, taking advantage of opportunities created by new marketing channels can raise farmer welfare substantially (Minten, Randrianarison and Swinnen 2009).

6 CONCLUSIONS

The literature on the role of agriculture in economic development makes clear that agriculture can play a particularly important role in economic development, particularly in the poorest countries. In very poor countries, a large share of the workforce typically works in low-productivity subsistence agriculture. Under these circumstances, the only paths to economic development and poverty reduction involve either raising the productivity of workers in agriculture or transferring large numbers out of agriculture and into higher- productivity employment.

Much of the literature has argued that raising agricultural productivity will bring about both these goals—directly raising productivity and helping transfer labor out of agriculture into higher-productivity

occupations. With the apparent productivity gap between agriculture and other sectors frequently in the order of 3 to 1 or higher, such a transfer could generate income gains greater than the direct impact of higher productivity on national income. The case for an agriculture-first approach to development is strengthened by the fact that such growth is likely heavily biased towards the poor. The direct effect alone is helpful for the poor because a very large share of the world's poor work in agriculture, partly because it is likely to raise wages for unskilled labor and partly because any resulting decline in food prices is likely to have its biggest impact on the poor given that they spend a large share of their incomes on the poor. If the increase in agricultural productivity helps to reduce food prices, this is particularly likely to benefit the poor because they spend the largest share of their incomes on food.

Matsuyama (1992) questioned the assumption that raising agricultural productivity would move workers out of agriculture into the rest of the economy. He pointed out that this was clearly the case in a closed economy, but that, in a small, open economy it was more likely that an increase in productivity would draw additional resources into agriculture. If the gap in productivity between sectors were sufficiently large, this could mean that an increase in agricultural productivity actually lowered national income. Most of the empirical literatures on this issue suggests that the national income impacts of an increase in agricultural productivity will shift labor out of the sector (and generate welfare gains by transferring workers). However, an unpublished study by Moscona (2019) points in the opposite direction. Further evidence to clarify this essential point is urgently needed. This paper examines another Matsuyama (1992) assumption—that agriculture is less dynamic than industry and services—and concludes that agricultural productivity growth has been much higher, on average, than in the other two main sectors.

While the general characterization of developing countries as having large shares of their workforce in agriculture was probably a reasonable model in the early 1950s when Lewis (1954) wrote his influential, original paper, this situation has changed drastically since that time. The World Bank's (2008) World Development Report pointed out that the role of agriculture in development was very sensitive to the share of agriculture in the economy and in the labor force. It argued that traditional models applied only to agriculture-based economies, where a large share of the workforce remained in agriculture. In transition economies, the share of GDP in agriculture had fallen enough that agricultural productivity had little impact on economy-wide growth, although it could still have a strong impact on poverty.

A brief examination of the literature on the direct impact of interventions provides a useful guide to the potential ex ante impacts of this range of measures. This concludes that there is strong evidence that R&D investments have particularly high returns. Price interventions in input and output markets are large and primarily driven by political economy considerations, making them inimical to development in most cases. Their reform could—if political-economy concerns can be overcome—both free up resources for other purposes, such as provision of public goods such as increases in research and development, that would yield large positive gains.

The final section of this paper examined the potential for growth and poverty reduction from several specific types of intervention. The evidence is very strong that increases in research, development and extensions could substantially increase income growth and reduce poverty. Well-designed improvements in market access and transportation appear to have quite high rates of return, although lower than those for research and development. In most cases, land tenure enhancements tend to have quite low benefit-cost ratios, perhaps because they are frequently introduced in situations where dispossession is seen to be unlikely. Improvements in market information are seen as generating substantial gains, although we have not been able to obtain reliable estimates of benefit-cost ratios. Irrigation frequently has quite high returns, although generally well below those from R&D. Risk and uncertainty is

typically regarded as a major challenge for small, poor producers, and a potentially strong disincentive to investment in new, high productivity production systems. Despite that there is little evidence of high rates of return from investment in insurance programs. Finally, value chain development encompasses a wide range of interventions from development of new land tenure provision to reform of measures that create missing links in potentially important value chains.

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