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Causes of rural economic development

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Abstract

Underlying factors in the growth of agriculture as a sector and of rural incomes in developing countries are investigated, using data from 85 countries during 1960–2001. Hypotheses about growth are derived from both the general growth literature and the empirical literature on past agricultural growth in the United States and other industrial countries. The growth of agriculture as a sector is surprisingly independent of the growth of income per capita for those who work in that sector. Neither is necessary nor sufficient for the other. Agricultural economics is in many circumstances not the key discipline in understanding the economics of rural income and poverty.

JEL classification: O13

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> We can be most helpful in locating the bottlenecks and constraints to growth and suggest means to their alleviation. In this, we sometimes have to operate at the frontier of professional knowledge, and often against the common wisdom of governments, but this is where the progress is to be made.
>
> —Mundlak, 1999, p. 46

1. Introduction

This paper follows Yair Mundlak's recommendation, which concluded his Elmhirst lecture, to identify sources of and constraints upon economic growth in agriculture. The subject matter is approached not from the perspective of research on international agricultural development, but rather as a follow-up to studies of the development of U.S. agriculture. The story of U.S. agriculture serves as a possible source of lessons for countries where sustained growth in the real incomes of rural people has not yet occurred. Moreover, U.S. research bears on the question of how the relatively poorest farm people have fared in the growth process (Gardner, 2000), a topic that fits well with the emphasis of President von Braun's address.

The paper starts by revisiting some fundamentals of agricultural development economics, the literature concerning it, and data measurement issues. In the second major section, empirical evidence is reviewed on the growth of agriculture as an industry. The third section turns to welfare consequences of agricultural growth as measured by real household incomes. The final section discusses conclusions about the causes of sector growth and real income growth.

2. Models of growth

Since World War II, a huge literature has emerged on economic growth, with special attention to agriculture. Since that time most of the poor countries of the world have become less poor, and agriculture in practically all of them has become more productive (in terms of output per worker, output per acre, or multifactor productivity growth). However, the success has varied widely from country to country, from one period to another, and across regions within countries. How well does the accumulated literature further an understanding of these variations, and what might have been done to improve the performance of the

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worst-performing countries? The central analytical task is to identify the causes of growth.

It might be expected that the most helpful writings would be those that cover the complexity and range of the societies being studied, and thus finding a multiplicity of causes, each having different weights in different countries and at different times. However, to date no such comprehensive approach has proven fruitful. Instead, economists' contributions have typically proceeded by over-simplification, either by a model fixing on only a few key causal factors, which are taken to be applicable over a range of countries and circumstances, or by focusing on a single country and dissecting events through an analytical description (as opposed to econometric hypothesis testing).

Many of the key conceptual contributions can be classified according to two polarities of approach: microeconomic versus macroeconomic, and theoretical versus empirical. No economist is purely in any of the four camps that these polarities generate—micro-theoretical, micro-empirical, macro-theoretical, and macro-empirical. Yet many have emphases that place their main contributions in one or another area. The macro-theoretical approach got a big initial boost in the 1950s from growth models treating output in the economy as generated by a neoclassical production function, with capital as an input created by savings. Agriculture as a sector in a general equilibrium context was treated in two-sector models in both comparative static versions (notably Simon, 1947) and the many dual-economy models that followed.[1]

Macro-empirical contributions until recent years have had a case study flavor, accumulating analytical description without a formal model. Mancur Olson (1982) is a good example. More recently the creation of panel data covering countries over time has made possible an econometric macro-empirical research, e.g., Barro and Sala-i-Martin (1995). This literature has austere but fruitful theoretical underpinnings, leading to ideas of "convergence" that have not yet been exploited sufficiently in investigating agricultural growth. An outstanding example of the micro-empirical approach is T. W. Schultz (1964). Many recent papers on household behavior in poor countries are heavier on micro-theory. Yet in both Schultz and, for example Singh et al. (1986), there is an intimate integration of theory and empirical observation.[2]

All the approaches have generated hypotheses about causes of growth that will be discussed below in the context of rural economic development.

2.1. *Measures of growth*

One of the services of the models is to provide a conceptual basis for our choices of variables to measure in quantitative terms and test econometrically. Agricultural output growth is a measure that arises naturally from the estimation of a production function. However, output can grow for reasons that provide little or no support for a rising standard of living—for example, output could rise under population pressure simply because of a larger farm labor force or clearing of additional land. For many purposes a better indicator of growth is agricultural gross domestic product (GDP) (value added) per worker—what the sector generates for each productively engaged person over and above the cost of inputs from outside of agriculture. Agricultural GDP per worker readily translates to a potential living standard measure, namely real income per household. With respect to causes of growth, underlying production theory says that either output or value added per worker can grow for the same two principal reasons: investment (including investment in human capital) and technological progress. The question then becomes why investment and technological progress occur, or fail to occur.

Matters get more interesting analytically as well as better attuned to actual situations when the link between agricultural value added and rural household incomes is broken. Farms produce nonagricultural products and farm household members earn incomes from nonfarm sources. Then the causes of growth may well be different for agricultural growth and rural income growth. Nonetheless, a flourishing agricultural sector can still be important instrumentally as a means of achieving rural income growth. One of the key empirical questions about economic growth in

[1] "Comparative static" models investigate economic change through one-time shocks in exogenous variables, as opposed to dynamic models that investigate time paths of investment or other growth-generating endogenous variables.

[2] Of course, many economists' works don't fall so easily into any of these categories. Hayami and Ruttan (1985), Mundlak (1999), and Timmer (2002), for example, draw on all the approaches.

rural areas is how crucial agricultural sector growth is in the process.

While no measure of either agricultural sector growth or rural income growth is perfect, some useful indicators exist for many countries over a substantial period. The most promising way to learn about the causes of growth is to compare the record of such indicators across countries as associated with variables hypothesized to be causes of growth. In order to carry out such comparisons most meaningfully, uniformly constructed cross-country data are needed. The massive undertaking of constructing such a data set for agriculture has been taken on principally by the Food and Agriculture Organization of the United Nations (FAO). The World Bank's *World Development Indicators* (available on-line) combines the FAO data with other sectoral and macroeconomic information for the years 1961–2001. These data are the main source of statistical information in this paper. Measures of agricultural sector growth include cereal yields, crop and livestock output indexes, and agriculture's contribution to GDP (sectoral value added).

3. Agricultural sector growth

"Getting agriculture moving" is a slogan that encapsulates the problem as it appeared to agricultural economists early in the post–World War II period as population pressures were seen as requiring faster expansion of food production than looked likely to occur in many low-income countries, where traditional agriculture is the rule. Traditional agriculture is characterized by poverty or subsistence-level living standards, with famine an ever-present threat, and hope of transformation to a higher standard of living for the rural population as a whole remote. What has to happen for a country's agriculture to break out of that situation? In the early 1960s, T. W. Schultz formulated his answer, beginning with what is *not* likely to work: improved efficiency within existing resource and technological constraints is not the answer, nor is investing more, given those constraints. Clearing more land is an investment that tends to be too costly for the returns to generate sustained growth and "additional irrigation is on approximately the same footing as land" (Schultz, 1965, p. 45). The high-payoff sources of growth are to be found elsewhere, notably in "improvements in the quality of agricultural inputs," virtually all of which must come from outside of agriculture rather than being generated within it (p. 46). Here Schultz has in mind not only fertilizer, tractors, and improved crop genetics, but also schooling and other means to improve the skills of farm people.[3]

The thinking of all who take an interest in agricultural development has to be influenced by the high returns to agricultural research in many countries, notably in the "Green Revolution." There exist inspiring cases where agriculture has flourished as a result. What is the evidence of success from these developments? Three indicators are: cereal yields, multifactor productivity, and agricultural GDP per worker.[4] Acceleration in yield is an indicator that a technology/investment shock is generating streams of output from given land inputs; but it is partial in that yield increases themselves do not imply improved profits because the land-augmenting inputs may cost too much. Multifactor productivity takes into account all the measured inputs and so is conceptually a better indicator of what a country obtains from a given set of resources committed to agriculture. But despite recent progress, obtaining accurate cross-country comparisons of multifactor productivity over time remains a major problem; and multifactor productivity is still not a sufficient indicator of the returns to farm-origin land, labor, and invested capital that constitute the basis for farm household income growth (because, for example, product buyers may reap the bulk of productivity gains through lower product prices). Agricultural GDP subtracts the costs of purchased inputs from outside agriculture, and indicates the net gains available for the purposes of improved incomes of farm people. Yet the data are sparser and require often-dubious assumptions (e.g., in estimating capital service flows) for multifactor productivity and agricultural GDP.

[3] Education is expected to be productive by improving the basic skills of people, not by changing their outlook to be less traditional or via other cultural changes. Indeed, Timmer attributes to Schultz "the demise in the late 1960s of community-action programs," which focused on cultural/institutional transformation (Timmer, 2002, p. 1516).

[4] For purposes of evaluating investments in research that generate technological change, a more appropriate bottom line is the rate of return to investment. It is estimates of these rates being extraordinarily high that have sealed the case for the benefits of international agricultural research (see Alston et al., 2000 and Evenson, 2001 for comprehensive reviews).

3.1. Cereal yields

Data on growth rates of cereal yields (kilograms per hectare) are available for 86 countries during two time periods, 1961–80 and 1981–2001.[5] The two periods are referred to as "Early Green Revolution" and "Late Green Revolution" by Evenson and Gollin (2003). The yield data are instructive in showing that progress indeed has occurred worldwide. Yields increased during 1961–2001 in all but 9 of the 85 countries covered; 8 of these were in Africa (Angola, Botswana, Chad, Congo, Mozambique, Rwanda, Sierra Leone, and Sudan). The sub-periods show a slowdown in yield growth in recent years, a phenomenon that some have viewed with alarm (see e.g., International Fund for Agricultural Development, 2001, Chapter 4). However, the slowdown is not huge, and does not occur in many countries. Yields in 15 of the 31 African countries, and in 10 of 18 Latin American ones, grew faster in 1981–2001 than in 1961–80. The countries that fit best the notion of yield slowdown were the industrial country (OECD) group.[6]

Countries can be ranked within each regional group by the rate of yield growth in 1961–81. It is notable that countries with the highest yield growth in 1961–81 are typically observed to have slower yield growth in 1981–2001, while the departures from this generalization tended to be countries with lower growth rates in 1961–80. However, the correlation coefficient between the growth rates in the earlier and later periods is only −0.06, not statistically significant, for the whole sample of 85 countries. Figure 1 shows the time series of yield growth for countries that had particularly high or low rates in 1961–80. China and India are examples where yields grew fast and then continued to do so; while yields in Belize and Swaziland grew fast and then stagnated. In Angola and Mozambique yields declined sharply and then rebounded. There are no cases where yields declined at a high rate and then continued to decline. The closest approximation is Haiti, where a 0.4% rate of yield decline in 1961–81 was followed by a 0.7% rate of decline in 1980–2001.

Figure 1 indicates a substantial divergence of yields over time. This is partly a matter of the small sample selected, but when all the 85 countries covered are charted, it also shows divergence of yields over time.[7] This divergence of yields across countries is a surprise from the viewpoint that underlies a lot of recent work in the theory of economic growth. The basic idea is that any economy's output is generated by technology and economic actors following neoclassical principles. The application to crop yields is that with the same technology available everywhere, countries with lower yields will have a higher marginal return to new inputs. Therefore, use of such inputs is expected to increase at a higher rate in lower-yield countries and to increase their yields faster than those of initially high-yield countries. So stated, this idea is unattractive for the historical evolution of most of world agriculture because of differences in climate and other natural resources, and because the same technology is not available everywhere. The issue then arises of the international transfer of technology. On this subject we do have plausible dating of at least one important element of the cross-country story: the international integration of agricultural research under the Consultative Group on International Agricultural Research (CGIAR) in about 1970. Thus, if agricultural research is an important element of the story, there ought to be more convergence in the years following 1970 than before. A more complex version of this story is what Evenson and Gollin (2003, p. 758) call "broader and deeper impacts" of CGIAR research on more crops in more countries after the mid-1970s. Yet the yield data give no indications of yield convergence, even in the 1990s.

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[5] These data are available in Table 1 of the version of the paper delivered at the conference (www.iaae-agecon.org).

[6] The World Bank (2002) states that "the yield growth experienced since the 1970s has slowed sharply in the 1990s due to diminishing returns to further input use, the rising cost of expanding irrigation, a slowdown in investment in infrastructure and research (in part induced by declining commodity prices), and resource and environmental constraints" (p. 47). This story is generally plausible but not supported with evidence, and what seems most fundamentally dubious is the initial claim of a sharp slowdown in yield growth. Of the 31 African countries, 16 had yields that increased more rapidly in the 1990s as compared to the 1980s than in the 1980s compared to the 1970s; and similarly the trend rate of growth during the 1990s was greater than the trend rate during 1970–89 for 16 of the 31. The 11 Asian countries in the sample are similarly split. But China and India, the two biggest, do conform to the idea of a yield slowdown in the 1990s. Nonetheless, we have about as many instances of yields accelerating in the 1990s as of yields decelerating.

[7] See Figure 1(a) in the conference version of the paper (www.iaae-agecon.org).

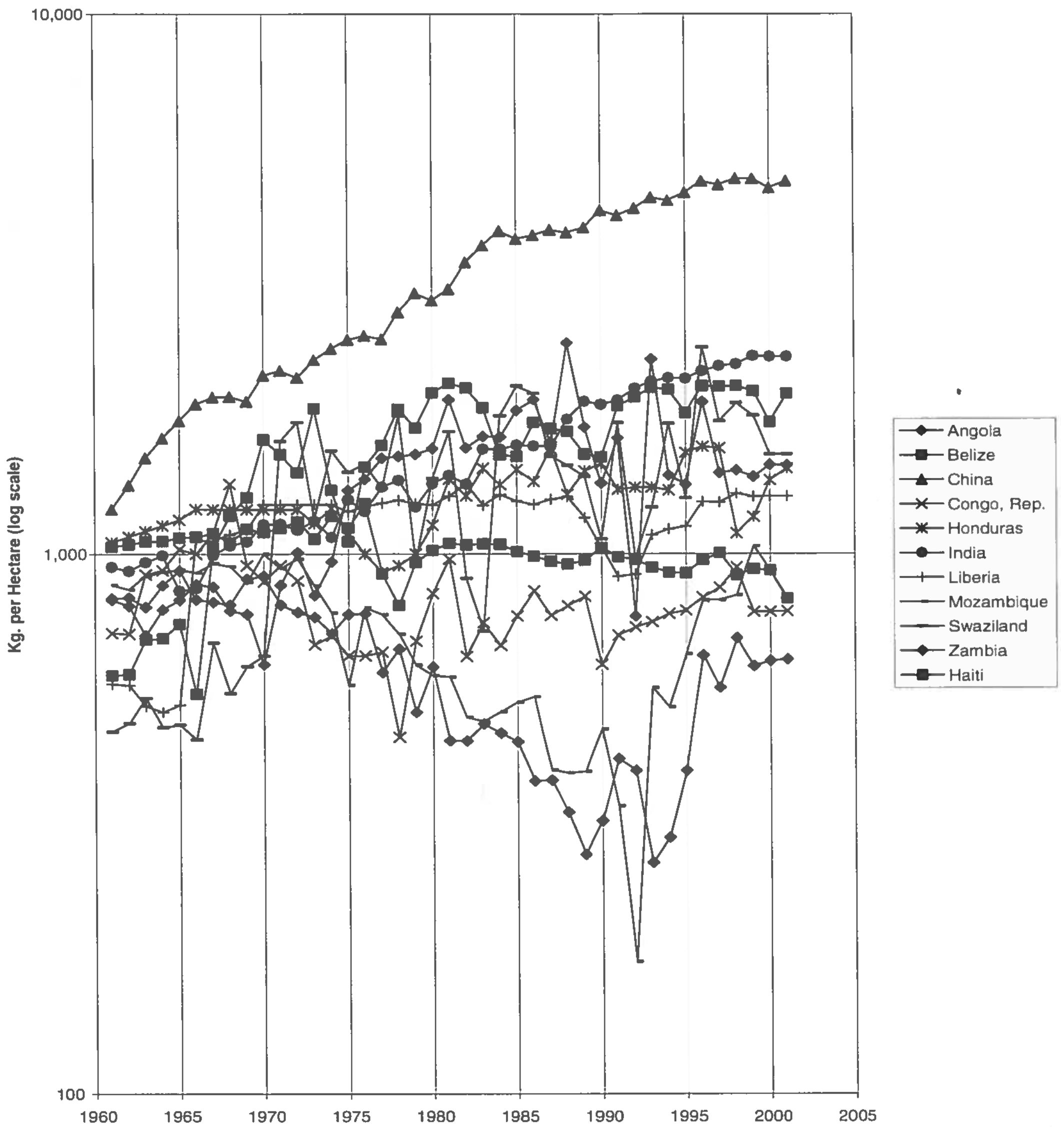

Figure 1. Cereal yields in selected countries.

3.2. Agricultural GDP per worker

The convergence hypothesis might be more likely to apply to real agricultural GDP per worker. The idea is that, at an initial point in time, countries with a lower agricultural GDP per worker will have a higher marginal return to capital investment under the classical laws of production. Therefore, more investment will occur in lower-GDP countries and their agricultures will grow faster than those of initially high-GDP countries. Notwithstanding questions of accurate measurement, the FAO/World Bank indicator series provide a substantial, consistently constructed panel of cross-country comparisons over time. Data on the 1980–2001 growth rates of agricultural GDP per worker for the 79 countries that have sufficient data for this purpose are available.[8] These rates, as was also the case for the cereal yield growth rates discussed above, are not calculated from changes between the 1980 and 2001 endpoints on the grounds that random year-to-year variation makes the calculated rate too sensitive to the choice of endpoint years (and for some countries the data available do not begin until after 1980 and end before 2001). Instead, log-linear trend regressions were estimated and the slope for each country is the "trend growth rate" for that country. The time series for several groups of countries are shown in Figure 2(a)–(d). In none of these charts is convergence evident, nor is there convergence between groups. The African countries started lowest and grew slowest, and the OECD countries started highest and grew fastest. Yet there are substantial differences among the growth experiences of countries within each group and across all groups, and more may be learned about the causes of growth by finding out which "growth-conditioning variables" explain those differences.

The importance of growth-conditioning variables became apparent to scholars of both agricultural and general economic growth as thwarted expectations of technology-led rural prosperity mounted. T. W. Schultz noted that while advances in technology and availability of capital for financing new inputs had become ever more widespread, "it has became increasingly evident that adoption of the research contributions and efficient allocation of the additional capital are being seriously thwarted by the distortion of agricultural incentives" (Schultz, 1978, p. vii). The World Bank (2002, p. 47) summarizes a range of recent opinion about constraints to growth, noting the prevalence of problems created by micro and macro policy discrimination against agriculture, inefficient and uncompetitive marketing institutions, underdeveloped labor and financial markets, weak political and property rights institutions, and world price-depressing policies of the OECD countries.

Which variables are the most important? Are there some that do not matter much in fact even though in principle they might have been expected to? Are there some conditions that are so important that, if they prevail, they are sufficient for real income growth? Two quite different approaches to answering such questions are prominent. The first is econometric, pooling data on similar variables for as many countries as possible and attempting to explain the differences in growth statistically through association with candidate causal variables. The second is qualitative and narrative, essentially the accumulation of case studies by scholars with wide experience in agriculture across a variety of countries.

3.3. *Cross-country regressions*

An econometric approach that has immediate attraction as a method of explaining differences in growth rates among countries is to use time series regressions, pooled across countries, in which changes in candidate variables as causes of growth are correlated with rates of growth in real agricultural GDP per worker, or other variables taken as indicators of growth in agriculture. Hayami and Ruttan (1985, Chapters 5 and 6) and Mundlak (1999, 2000, 2001) have explored in depth the use of cross-country production functions.[9] Hayami and Ruttan (1985, p. 157) explained an agricultural output index as a Cobb–Douglas function of inputs for 43 countries in 1960, 1970, and 1980, and used the results to account for growth in output per worker. They found that output per worker in less-developed countries could effectively be increased by input increases along with education and research, and viewed the findings as "essentially encouraging" because they showed the possibility of progress even in the face of population pressure with limited agricultural land availability. Mundlak (2000) worked with improved data, especially for capital and investment, increased the country coverage to 88, extended the data coverage to 1992, explained agricultural GDP rather than output, and generalized the model to incorporate incentives (prices and risk) and constraints from the economic and physical environment as well as the usual input quantities. He also used country-specific "within" as well as "between" time period estimators to minimize identification problems that plague cross-sectional production function estimates.[10] He found

[8] Table 2 in the conference version of the paper (www.iaae-agecon.org).

[9] Other recent studies similar in approach include Fulginiti and Perrin (1993), Frisvold and Ingram (1995), and Craig et al. (1997). For a summary of findings from earlier such studies, see Hayami and Ruttan (1985), p. 149.

[10] See Deaton (1995, pp. 1824–1827) for a succinct presentation of the problems and remedies.

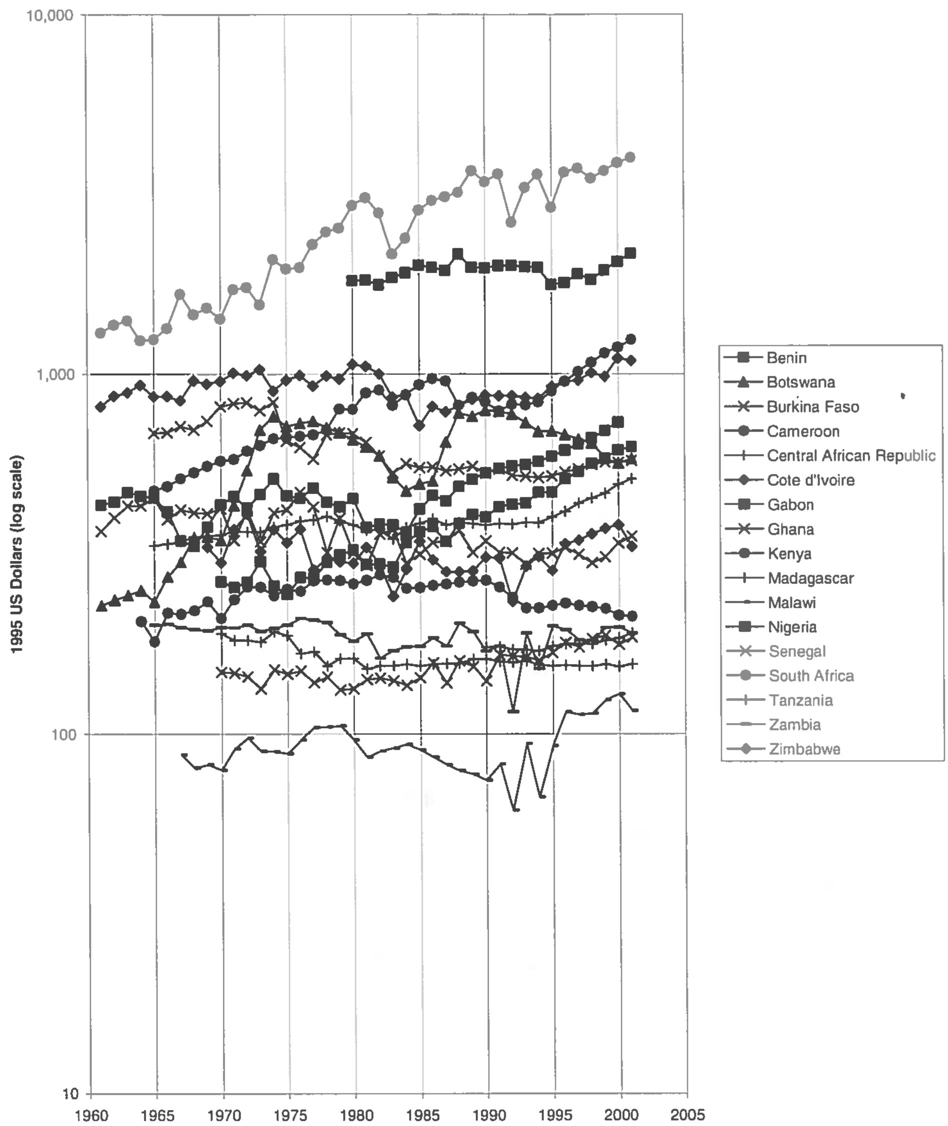

Figure 2(a). Real agricultural GDP per worker, sub-Saharan Africa.

input quantities to be important largely as expected, largely in line with earlier findings, and found increases in capital especially important in generating increased agricultural GDP. Variables over which a country can have some control as a matter of policy, notably agricultural prices and schooling, were estimated to have quite small effects (the schooling results stand in sharp contrast to the findings of Hayami and Ruttan). Yet, as Mundlak (2001) notes, these policy variables may influence investment and adoption of improved inputs, and the regressions already include the input levels. To sort out the full contributions of such variables as causes of growth one needs either a more complete structural model of input and output supply and demand, or else reduced-form equations in which growth is estimated as a function of exogenous or policy variables only.

Attempts to test the convergence hypothesis, such as Barro and Sala-i-Martin (1995), have generated an essentially reduced-form approach that may be

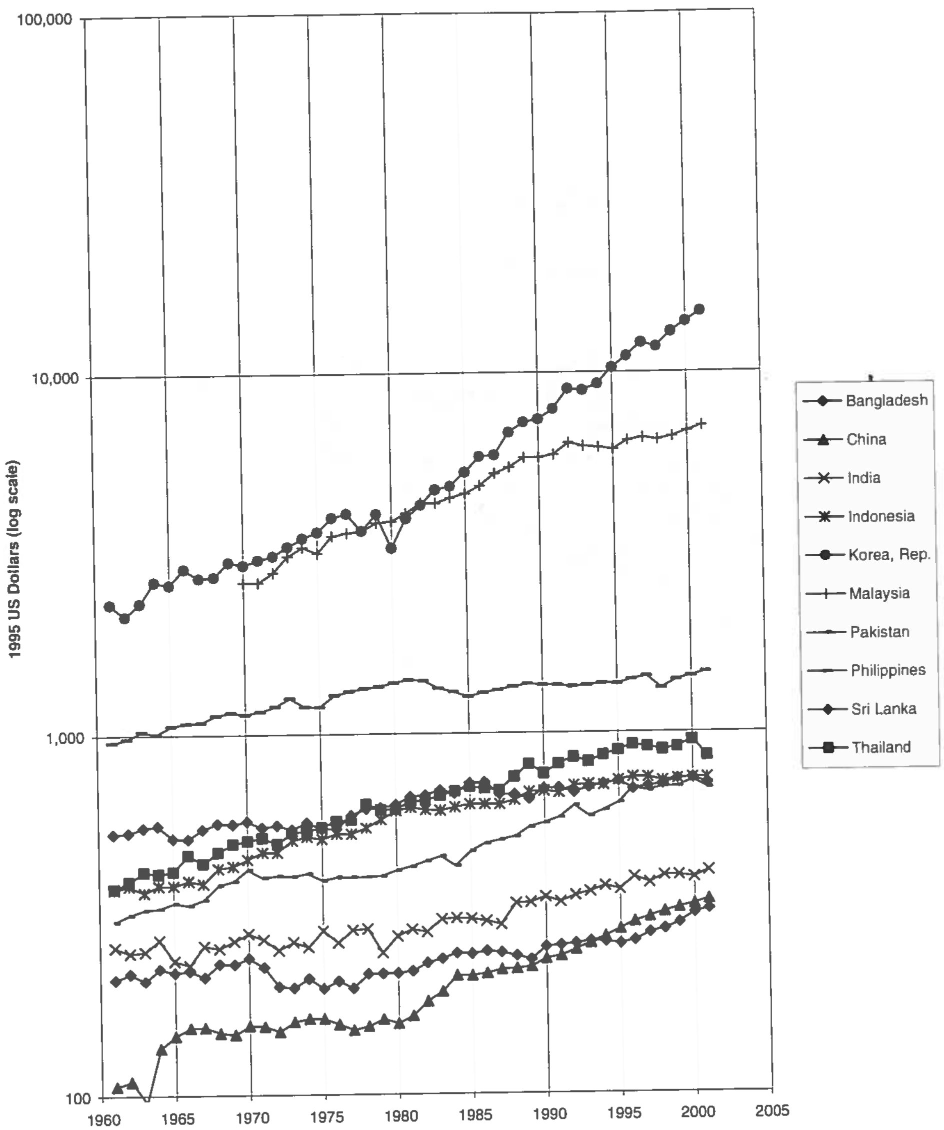

Figure 2(b). Real agricultural GDP per worker, Asia.

helpful. The simplest equation for estimating convergence is

$$G_{t,0} = \alpha + \beta y_0 \tag{1}$$

where $G_{t,0}$ is the rate of growth of agricultural GDP per worker between time 0 and a later time, t; y_0 is the log of the initial level of agricultural GDP per worker; and α and β are parameters to be estimated. The estimate of β indicates change in the growth rate resulting from a 1% higher level of y_0. Analogously, other initial-year levels of other variables hypothesized to influence growth can be added to equation (1). What we give up with this simple approach is the capability to estimate the dynamics of growth—how changes in causal variables affect growth and its timing—and the capability to estimate structural parameters of production or supply relationships. However, the econometric problems of sorting out causal effects from trending time

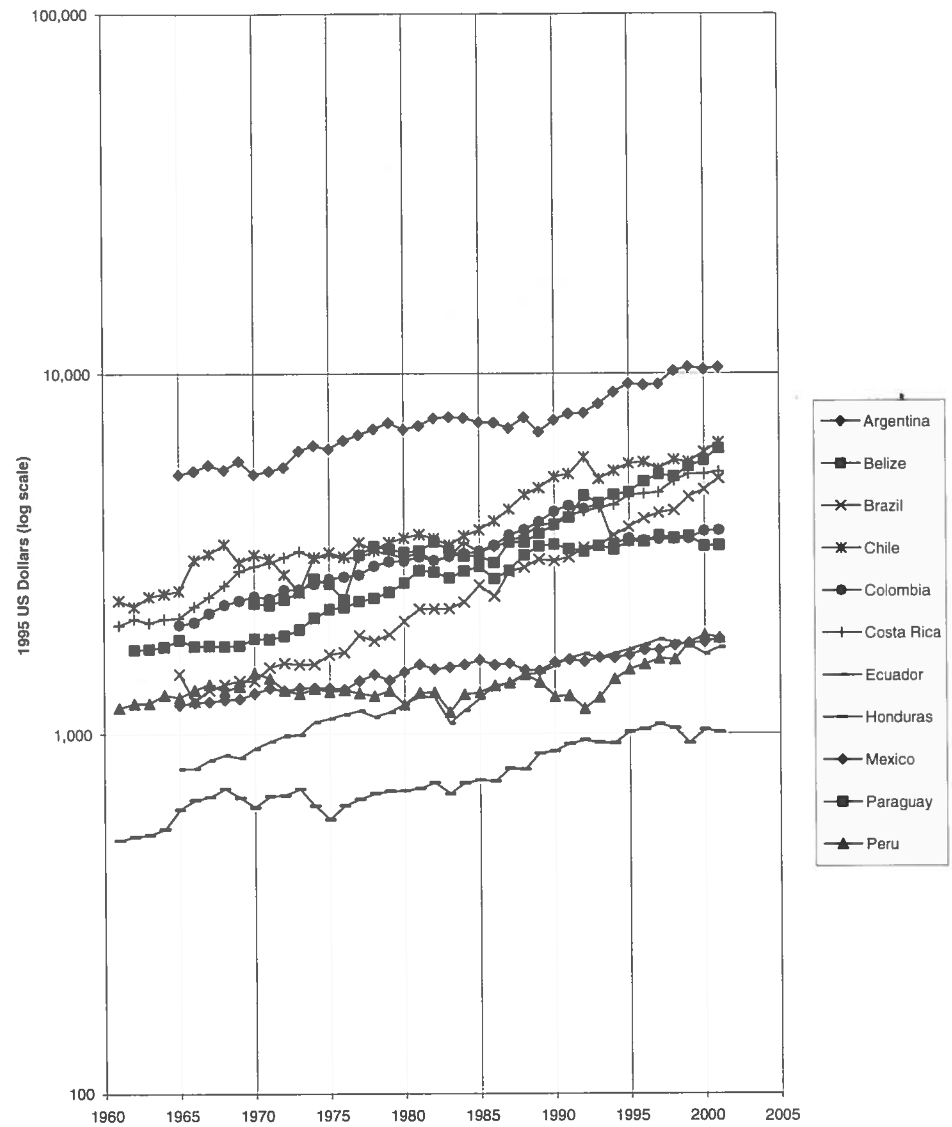

Figure 2(c). Real agricultural GDP per worker, Latin America.

series, and the predominance of measurement errors or other random fluctuations in year-to-year changes, are likely to preclude estimating dynamic relationships anyway.

Econometric objections to equation (1) have been raised.[11] One is the likelihood of bias toward a negative value of the estimated β because initial measured levels are temporarily low or high just by chance, owing to measurement error or transitory single-year events. When this occurs convergence is, according to equation (1), likely to be observed even if in fact no real convergence occurs. A second problem is that if variables omitted from the equation are positively correlated with income growth but negatively correlated with initial income, the estimated β will be biased toward a negative value. To address this criticism,

[11] For details, see Quah (1996) or Nerlove (2000).

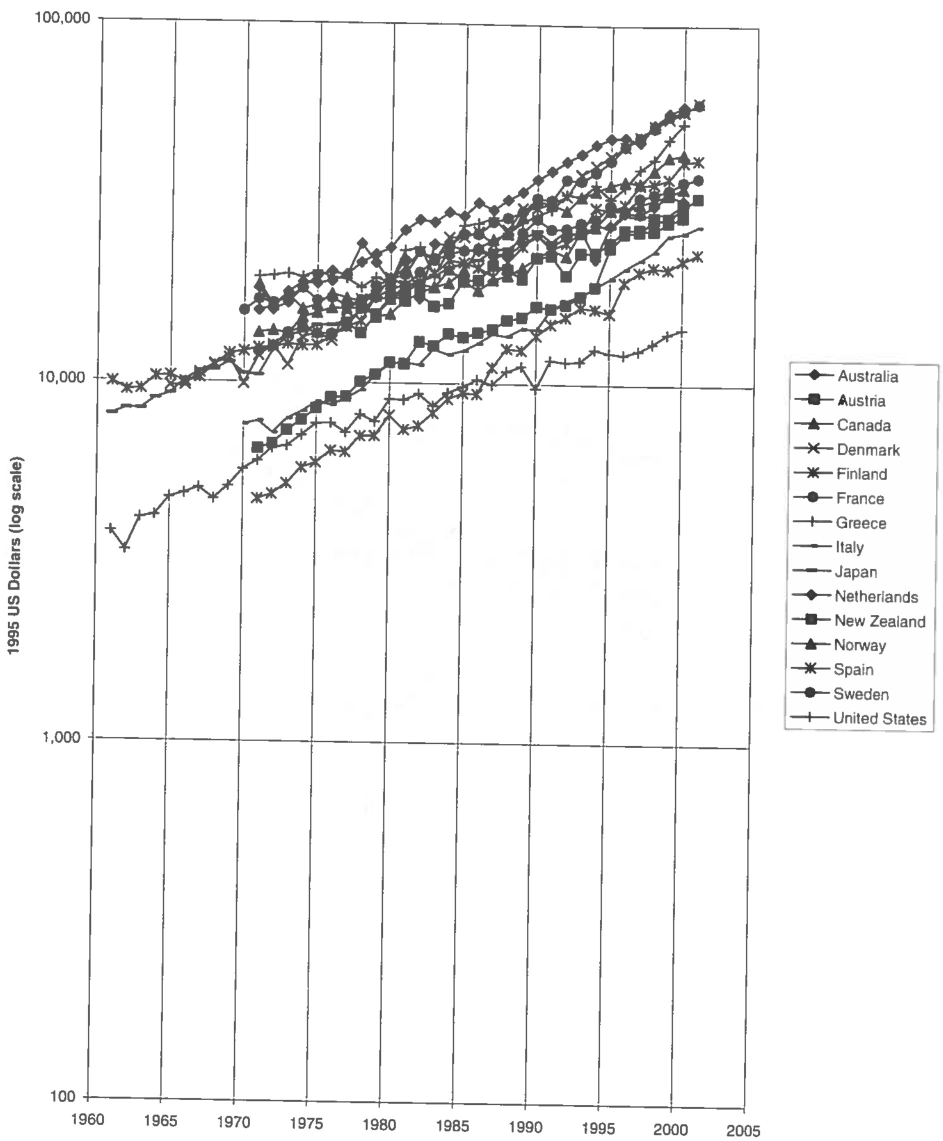

Figure 2(d). Real agricultural GDP per worker, OECD countries.

initial-year values can be added for likely omitted variables, thus estimating "conditional" convergence. This approach is what was suggested above, adding additional variables hypothesized to be causes of growth. The first problem is one that may be intractable given likely measurement error as well as random fluctuation in the agricultural GDP data. It means that there cannot be much confidence in what is really measured by the estimated β.

The general form of the linear regressions to be estimated is

$$G_{t,0} = \alpha + \beta y_0 + \gamma X_0 + \delta \Delta Z_{t,0} + \varepsilon \tag{2}$$

where X_0 is a vector of initial values of hypothesized causal variables that may be endogenous, $\Delta Z_{t,0}$ is a vector of rates of change between 0 and t (changes in natural logs) of hypothesized causal variables that change over time and are exogenous to $G_{t,0}$, ε is an independent and identically distributed error term, and γ and δ are vectors of parameters that provide estimated impacts of the variables on growth. The observations are of a cross section of countries (country subscripts on the variables and error term are suppressed).

Explaining growth in the framework of equation (2) places the emphasis differently than the estimation of cross-country production functions. The key variables in production functions are input quantities and, in the dynamic context, investment in capital. But these are endogenous variables and not appropriate either as X_0 or $\Delta Z_{t,0}$ variables in equation (2). The use of equation (2) is rather to explore quantitatively the influence of factors that the literature on economic development has given attention to, typically in a descriptive or qualitative fashion. For example, a nation's rural infrastructure, human capital, market institutions, and political framework are aspects of the initial conditions that may be conducive or inimical to growth. Policy changes, educational improvements, or world market changes, if they are exogenous, are examples of possible $\Delta Z_{t,0}$ variables.

Attempts to consider multiple routes to growth, and as a result of that consideration narrow the focus to key factors, typically take a case study, analytically descriptive approach for one or a few countries rather than trying to systematically compare many countries in a cross-country regression. Examples of thoughtful studies of this genre include Pearson et al. (1987), Lele (1989), and Eicher (1999), among many others. While such studies have country-specific objectives, they can be helpful in specifying cross-sectional regressions because their findings for particular cases suggest hypotheses that can sometimes be tested in the cross-country context—the main constraint being whether reasonably believable data can be found to embody the hypothesis.

It is striking in such case studies that the factors that end up being the focus of interest are typically governmental actions. The underlying reason is that the countries considered tend to be those in which economic growth has been weak, as is the case in so much of developing country agriculture for most of recorded history. If a country is mired in stagnation and poverty, one has to look for major changes or shocks to the system, and governments (albeit sometimes foreign governments) are the instruments at hand to provide public goods such as research, or to remove public bads such as monopoly, abuse of power, or legal disorganization. Given that, Mundlak's admonition quoted at the beginning of this paper, namely for economists to operate "against the common wisdom of governments" may seem surprising. The problem is that governments are often not willing or able to undertake the recommended policies. After all, governments are not usually entities exogenous to the status quo that can be used to shock the economy, but rather are an integral part of the status quo.

Consider the following conditioning factors for agricultural GDP growth, in all of which government has some role: providing macroeconomic and political stability; establishing reliable property rights and incentives; fostering productivity-enhancing new technology; and enabling access to competitive input markets (including credit) and output markets, without exploitive taxation.

The effects of policies or the institutional situation can be tested by introducing variables in equation (2) for initial-period values of variables representing policies or institutions. Unfortunately, because of lack of data this approach is often infeasible. The World Bank development indicators include estimated annual inflation rates, which were used to construct an indicator of macroeconomic instability, the variability (standard deviation) of the rate of inflation over the 1980–2001 period. With respect to political stability and obstacles to investment, indicators from O'Driscoll et al. (2003), Transparency International, and Freedom House (2003) are used that are intended to measure, respectively, commercial freedom, regulatory propriety (lack of corruption), and the overall state of repression in a country.

Factor market constraints, apart from those that stem from general economic and political conditions of the country, are often country-specific. Factor quantities themselves are used as explanatory variables in analyses like Mundlak's (1999, 2000), but as mentioned earlier what one really wants to know is why factor quantities increase or decrease. Prices of specific factors in each country's agriculture vary across countries but they are endogenous variables, consequences as much as causes of agricultural growth.

Product prices are often good candidates as causal variables, essentially treating agricultural sector growth as a matter of estimating supply functions, but in the present analysis we are explaining a single period of time, with all variation in the observations being cross-sectional, so all countries are, to a first approximation, operating under the same world market conditions. Where countries differ in the product market is in the role of subsidies, trade barriers, or other governmental interventions in the markets. Unfortunately, while there have been major efforts to quantify the support provided to agriculture to permit cross-country comparisons among the OECD countries, such measures hardly exist for most less-developed countries of the world. Product prices in these countries are undoubtedly affected by subsidies of agriculture in the OECD countries, and some countries, because of their product mix or location, are affected differently than others. Adverse effects upon growth would appear most directly in a lower agricultural GDP, or slower growth of agricultural GDP, in the most vulnerable countries. In order to obtain evidence of the importance of differential product price experiences on differences in the rates of agricultural GDP growth, the rate of growth of FAO's crop production index, a quantity indicator, should also be considered.[12] The ranking of countries from high to low growth rates in 1980–2001 is quite similar for the two indicators, and not generally lower for agricultural GDP. Because low or declining prices reduce agricultural GDP directly, they affect crop output only indirectly through supply response; the similarity of the two columns makes it seem unlikely that differential price experience is a dominant force in these rankings—though this hypothesis certainly could use better confirming or disconfirming evidence.

In searching for causes of the transformation of agriculture from economic stagnation to economic growth, it is natural to be drawn to investigation of the experiences of countries where this has happened. This draws attention more to the industrial countries and less to the developing world. Tomich et al. (1995), among others, have drawn lessons from developed countries where agricultural sector growth has occurred. The story economists are most familiar with is as follows: scientists, engineers, and tinkerers, in both the private and public sectors, apply their knowledge to problems of agriculture; extension services and other sources of information place new knowledge in farmers' hands; and with sufficient property rights and price incentives to call forth the necessary investment, farmers adopt new technology and generate more output and income from their resources. Most of the gains may accrue to buyers of farm products rather than their producers, as increased output drives down prices, but nonetheless this is the paradigm of growth.

Historians have unearthed evidence on what was going on during the period when U.S. agriculture entered its period of strong and sustained productivity growth. This evidence, which has been largely neglected by economists, includes facts about farmers' attitudes and preferences, the intellectual and exemplary contributions of visionary individuals, and the establishment of institutions and forms of economic organization conducive to growth. The idea of the farmer as an ignorant, intellectually ossified follower of traditional practice and fearful of change, and constitutionally unable to forgo consumption in order to invest, was an influential view in the first half of the twentieth century. In this context investment in new technology would require a cultural transformation. Nonetheless, Griliches (1957) brilliantly showed that profitability was sufficient to explain the pattern of adoption of hybrid corn. But rural sociologists also staked a claim to cultural/social explanations such as community leadership and informational networks (e.g., Ryan and Gross, 1943; Havens and Rogers, 1961). Danbom (1979) describes the efforts by many promoters of progress in agriculture, notably President Theodore Roosevelt in the first decades of the twentieth century, to instill in farm people a mentality conducive to commercialization of their enterprises, investment, and the adoption of innovative technology. Historians like Clarke (1994) have also given a broader interpretation of agricultural support programs, particularly the New Deal programs of the 1930s, emphasizing how they altered farmers' outlook in ways that promoted investment and adoption of new technology.

Broader modes of thought are of course not new in the theory of development. Hagen (1962) is exemplary of ideas in the 1950s that obstacles to development are largely traditional rural village institutions and/or inside the heads of the villagers. Thus, "economic theory has rather little to offer" and "both the barriers to growth and the causes of growth seem to be largely internal rather than external" (Hagen, quoted in

[12] These data are presented in Table 2 of the conference version of the paper (www.iaae-agecon.org).

Stevens and Jabara, 1988, p. 94). This view is the opposite of Schultz's mentioned earlier, that inputs from outside of agriculture are key, and that, if profitable, they will be adopted. The noneconomic approach lost luster with the perceived failure of community development schemes, and it seems the last nail in its coffin was the Green Revolution. New varieties were adopted along with purchased inputs, apparently without need of cultural or psychological transformation in rural communities.

In order to test these ideas in equation (2) technological and cultural variables are required. The data available on either type of variable have neither the conceptual specificity nor the precise measurement required. There are data that provide plausible indicators of differences in technology between countries. Several studies, such as Evenson and Kislev (1975), use a country's research and/or extension expenditures as a cause of agricultural growth (with long lags). Two of their indicators measured as of the mid-1960s, public research expenditures and agricultural science publications (Evenson and Kislev, 1975, Appendix I), are used here. However, these data are not reported for 24 of the countries discussed in this paper. The CGIAR publishes later data for more countries, of which average public research expenditures in each country during 1976–1980 are used here. These data are used to estimate a research expenditure variable that covers 53 countries with information about spending in the 15 years preceding the 1980–2001 period over which equation (2) is estimated. Because identifying effects of new technology through these variables is far from assured, given the long lags found by most researchers between invention and implementation and the pervasive role of 'spill-ins' from other countries' research and from the CGIAR centers, indirect indicators of technology implementation are also used as X_0 variables. These are initial (1980) estimates of fertilizer per hectare and tractors per hectare. In addition, the rate of growth of cereal yields over the two decades preceding 1980 is used to indicate a preexisting willingness to innovate that may carry over to the 1980–2001 period.

On the cultural side, the most plausible variable about personal characteristics is the extent of illiteracy in a country. High illiteracy plausibly indicates a high prevalence of traditional attitudes that are barriers to growth. Illiteracy may also serve as a proxy for (lack of) schooling, and schooling is an indicator of investment in human capital and improved labor quality that Schultz pioneered as important in agricultural development, and which has been widely accepted by economists as a source of economic growth.

A quite different labor-centered view of agriculture and economic growth stems from the observation of large numbers of poor and seemingly underemployed people in rural areas. The stark labor-surplus ideas of early dual economy models have evolved to more nuanced assessments that still retain the thought that the path to rural development must overcome in some way the insufficiency of remunerative employment where the ratio of workers to other resources is high. Tomich et al. (1995), for example, characterize the economies where development is needed as CARLs (countries with abundant rural labor). The difference made by labor abundance is tested here using rural population density (workers per hectare) as an explanatory variable.

Table 1 reports the results of estimates of several specifications of equation (2) for the set of countries included in this discussion. The results are typical of cross-country regressions in being suggestive but far from definitive in sorting out causes of growth. Regression 1, the simple convergence model, indicates significant divergence—in countries that started out with the highest agricultural GDP per worker in 1980, that variable grew the fastest between 1980 and 2001.[13] The best performers tend to be the OECD countries. Regression 2 explores whether that is the only reason for divergence by including regional dummy variables. It turns out that the OECD dummy is positive but not statistically significant. The dummy for sub-Saharan African countries is, however, significant and negative; agricultural GDP per worker in these countries on average grew at a rate of 1.6% per year slower than countries in Asia, Latin America, and the remaining group (transition economies and Mediterranean countries) that define the intercept. The estimates of β in regressions 2 and 3 are not significantly different from zero. These results are what Figure 2(a)–(d) suggest, and the regressions confirm the lack of convergence, even "conditional" convergence (appearing when other growth-conditioning variables are held constant).

The growth-conditioning variables included in regression 3 of Table 1 have jointly significant effects on the rate of agricultural GDP increase, and many have

[13] Here and later taking significance at the 10 percent level—requiring a 't' statistic of 1.7 or more in absolute value.

Table 1
Regressions explaining growth in agricultural GDP per worker, 71 countries, 1980–2001

Independent variable	Dependent variable: Percent growth in Ag. GDP per worker			
	1	2	3	4
Intercept	−0.303 (−3.34)	0.009 (0.50)	0.077 (2.08)	0.251 (3.20)
Ag. GDP per worker, 1980	0.007 (5.60)	0.002 (0.92)	−0.002 (−0.71)	−0.019 (−2.84)
Africa		−0.016 (−2.25)		
Asia		0.001 (0.13)		
Latin America		−0.006 (−0.81)		
OECD countries		0.011 (1.25)		
Fertilizer per ha., 1980			0.097 (3.31)	0.050 (1.01)
Tractors per ha., 1980			−0.073 (−1.66)	−0.213 (−3.62)
Growth in crops per worker, 1961–1980			0.261 (1.98)	0.599 (2.64)
Illiteracy rate of youth, 1980			0.0007 (0.54)	−0.0002 (−0.06)
Ag. research spending, percent of GDP, 1965–80			−0.0051 (−1.49)	−0.0025 (−0.50)
Std. dev. of inflation rate			0.0007 (1.09)	0.0024 (1.62)
Restraints on economic freedom (Heritage)			−0.008 (−1.21)	−0.028 (−2.86)
Absence of corruption (Transparency International)			0.003 (1.84)	0.002 (1.02)
Restrictions of civil liberties (Freedom House)			−0.006 (−1.61)	−0.030 (−3.29)
Rural population per ha., 1980			−0.014 (−1.34)	0.042 (2.06)
Trade in goods (% of GDP)				0.042 (2.43)
PSE				0.036 (2.96)
$\bar{R}^2$	0.309	0.426	0.532	0.714
Number of countries	71	71	49	27

the expected signs, but none of them emerges individually as a predominant determinant of agricultural growth.

Consider, for example, the illiteracy variable. This is the variable most directly related to human capital and also to ideas about cultural prerequisites to growth. The variable has an unexpected positive sign, indicating that countries with higher illiteracy grew faster. But this sign is not robust—it changes as other right-hand side variables are added or deleted—and the variable is not statistically significant. This lack of significance is not a complete surprise as it parallels the findings in Craig et al. (1997) and Mundlak (1999), who also estimated no significant effects of literacy on productivity or agricultural GDP per worker. However, Hayami and Ruttan (1985, Chapter 6) found education an important cause of productivity growth in agriculture (although their literacy variable alone was often insignificant). So did Antle (1985) and Fulginiti and Perrin (1993).[14] It could be argued that illiteracy data are imperfect both conceptually and practically as measures of human capital or skill, but that still leaves no clear answer about the importance of schooling to growth. Based on empirical findings in the United States from states, counties, and individual farms (Gardner, 2002), it is possible that farmer education as a contributor to agricultural productivity has nothing like the importance that Schultz's ideas about human capital suggested and that early empirical work, notably Welch (1970), found.

The other variable related to labor supply is rural population density (persons per square kilometer) at the beginning of the period, 1980. If abundant labor is a hindrance to growth, this variable should have a negative sign. But the variable is insignificant in Table 1, and in all other specifications of the equation tried. Similar results were obtained for an alternative specification of this variable, namely agricultural workers per hectare of arable land.

Variables intended to indicate the initial presence of technological innovation had mixed performance. The 1980 level of fertilizer use per hectare has a positive sign and is statistically significant in regression 3, but tractors per hectare in 1980 are insignificant. Growth of crop output per worker in the preceding period,

[14] See Huffman (2001) for a thorough review of econometric studies.

1961–1980, has a significantly positive sign, suggesting that countries with a history of productivity improvement have the momentum that carries through to later growth. However, the research variable is insignificant. This result persists whether research spending is measured per dollar of agricultural GDP or as an absolute amount (the latter being appropriate if research is a pure public good within the country). The alternative technology variable from Evenson and Kislev (1975), research publications, has an even lower *t* statistic.

Of the four economic-political environment variables, only the absence of corruption as scored by Transparency International is significant. Its coefficient says that if a country's noncorruption index goes up by four positions on a scale of 1 to 7, that adds 1% annually to the country's rate of growth of agricultural GDP per worker.

Regression 4 adds two variables more explicitly related to a country's economic policies. The first is the value of international trade in goods as a fraction of national GDP. The second is an index of governmental support to agricultural commodity markets, the producer subsidy equivalent (PSE). PSEs have been calculated in a number of ways, and all of those ways have been subject to criticism. The 1985–1989 average PSE as estimated in U.S. Department of Agriculture (1994) is used here. This measure covers the largest number of countries using a consistent calculation method for the same time period. Even so, using this variable reduces the number of countries in the sample to 27, and increases the weight of OECD countries in the sample. The estimated value of goods in international trade in 1980 is also unavailable for many of the 49 countries used in regression 3.

The results are broadly the same as in regression 3, but now rural population density has a significantly positive sign, suggesting that more people per hectare is actually growth-increasing. Also, the two political liberty variables turn out to be significant and with the expected signs in regression 4: the *Heritage Foundation/Wall Street Journal* index of economic freedom has a negative sign as expected (the index is higher the greater the restraints), and it is statistically significant. The same is true of Freedom House's more general index of whether a country is "free" (index value 1), "partly free" (index value 2), or "unfree" (index value 3). However, neither the corruption index nor the economic instability measures (the standard deviation of the rate of inflation) are significant.

The variables added in regression 4, the importance of international trade and the PSE, are both significantly positive. A country can increase its growth of agricultural GDP per worker by trading more and by subsidizing its agriculture. (The national welfare consequences may, of course, be quite different, notably because the PSE boosts agriculture at the cost of taxpayer outlays.) Note that the coefficient means that the PSE would have to increase by 30% of the value of agricultural output in order to boost the rates of agricultural GDP growth by 0.1%.

3.2. Real household income growth

Growth in the agricultural sector is important insofar as it helps achieve growth in real standards of living. But analysis of the relationship between agricultural sector growth and average rural incomes or rural poverty involves several complications to an already complicated set of issues. Note first that the most easily demonstrable gains from productivity growth in agriculture are those of urban consumers of food products who benefit from lower prices. This contribution of agriculture is an important benefit in a whole-economy view but for rural incomes low prices mean less market returns. How can the contribution of agricultural sector growth to rural household incomes be identified?

Consider two views about the causes of real income growth in rural areas: first, agriculture as the engine of growth, with investment in agriculture generating real income growth in rural areas; and second, economy-wide demand for labor as the engine of growth in agriculture, with a growing real wage a sufficient condition for rural household income growth. The reason for drawing this contrast is that in recent work on economic growth in American agriculture (Gardner, 2002), there is more evidence that the second view captures the dominant forces behind the catch-up of farm to urban household incomes levels. Putting aside the Depression, from the "Golden Age of Agriculture" in 1897–1914 through the 1960s, U.S. agriculture was a technologically dynamic magnet for investment, with high and sustained rates of productivity growth after the mid-1930s. Yet the median income of farm households remained low relative to nonfarm incomes. Incomes of farm families rose above 60% of those of the nonfarm population only during 1910–20. The trend, if any, was negative until 1960. Therefore, a vigorous agricultural sector is not a sufficient condition for high incomes or for real income growth in the rural sector (relative to the urban sector).

Later history casts doubt on the necessity of agricultural sector growth for farm household income growth. Although U.S. agricultural productivity (multifactor productivity as estimated by USDA) has continued to grow at about the same rate of 1.5 to 2% annually for the whole 1948–1999 period, since 1980 investment in the sector has turned negative and real agricultural income per farm has declined. Yet this is the very period in which farm household incomes at last caught up to nonfarm household incomes, and indeed by the end of the twentieth century were well ahead (see Gardner, 2002, pp. 78, 84). Therefore, a vigorous agricultural sector is not necessary for high household incomes or income growth in the rural sector.[15]

Even if agricultural growth is neither necessary nor sufficient for household income growth, it could nonetheless be helpful. But in cross-sectional analyses of U.S. states and counties, no significant relationship between sectoral growth and rural household income growth was found, neither at the median-income level nor for relatively low-income groups nor for the incidence of farm poverty (Gardner, 2000). Instead, what matters is the linkage of farm factor markets, particularly the farm labor market, with the nonfarm economy.

Notwithstanding the preceding, it would be premature to dismiss agricultural sector growth as an engine of growth in developing countries, for reasons that have been continually emphasized in the literature on agriculture and development at least since Johnston and Mellor (1961). The most basic is macroeconomic, where agriculture's share of the labor force is large. An increase in real output per worker resulting from agricultural productivity growth increases labor productivity in the whole economy, and hence increases real income per capita. This is the point at which the oft-repeated statistics about a near majority of the developing world's labor force being rural becomes relevant to agriculture as an engine of growth. Similarly, if agriculture generates a large fraction of a country's consumption or export-earning goods, then improved productivity in agriculture directly increases real GDP per capita substantially. If a public investment of $1 billion in a sector of the economy generates an increase in total factor productivity of 2% over the next 20 years in that sector, it is best, other things equal, to carry out the investment in the largest sector available. On those simple grounds, agriculture has a leg up in many economies.

Figure 3 shows the relationship between growth of agricultural GDP per worker and national GDP per capita for 52 developing countries during 1980–2001. The association is positive and significant. But what is the direction of causality? Investigation of lags in the sample of countries during 1961–2001 does not show agriculture as leading.

The prime experience in the developing world that impels consideration of agriculture as an engine of rural income growth is East Asia. This is where both agricultural GDP and overall GDP per capita have generated the most positive long-term record. The World Bank (2002) concludes that in these countries "agricultural development created a dynamism in rural areas, which, in later stages, was combined with rapid industrialization" (p. 47). The reasons for this conclusion are not spelled out, however. Both agricultural and overall GDP growth for South Korea, the outstanding example of rapid and sustained agricultural GDP growth, are shown in Figure 4. No strong message about causality is apparent. National GDP per capita grew faster than agricultural GDP per worker throughout the 1961–2001 period, the latter at the high rate of 4.7% annually and the former at the extraordinary rate of 6.1%, increasing from $1,350 per capita (in 1995 dollars) in 1961 to $13,500 in 2001. Agricultural GDP grew at a faster rate after 1980 than before, suggesting that national GDP led agricultural growth rather than the Bank's asserted causality.

Data are available on the growth rates of agricultural GDP per worker and national GDP per capita for 66 countries.[16] Within each of the regional developing country groupings (Africa, Asia, and Latin America), the countries that grew fastest in national GDP per capita also grew fastest in agricultural GDP per worker, with a few notable exceptions such as Brazil. Yet in the region where the fastest growth occurred, Asia,

[15] To put the point more concretely, if for example the mechanical cotton picker had never been invented, U.S. cotton laborers would not have appreciably higher incomes today, yet there would be a lot more of them (assuming the U.S. remained competitive in world markets).

[16] These are reported in Table 4 of the conference version of this paper (www.iaae-agecon.org).

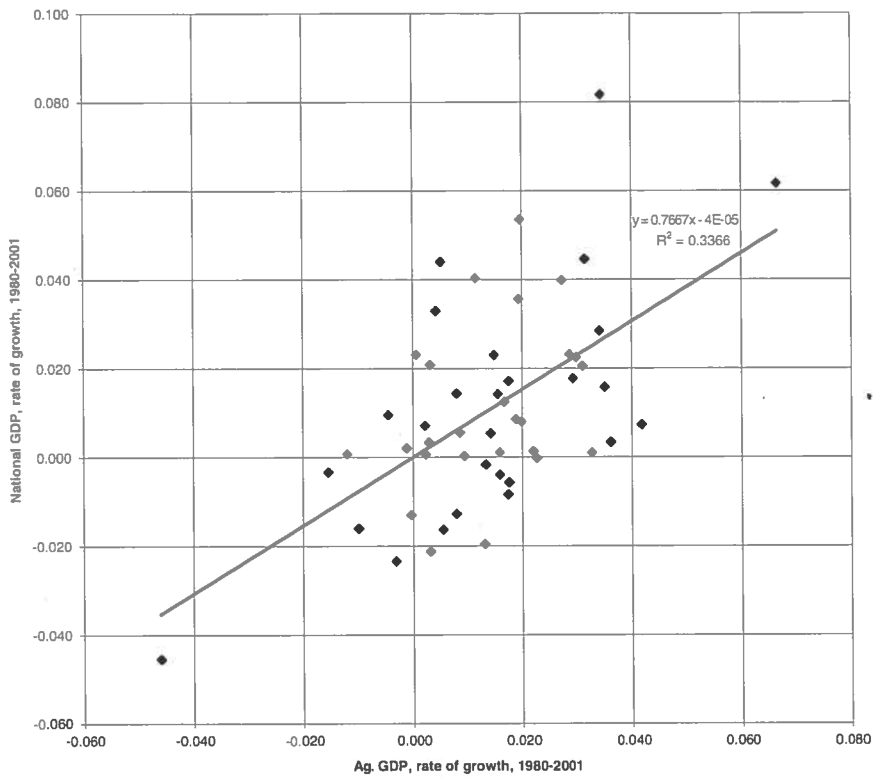

Figure 3. Agricultural GDP per worker and national GDP per capita, 52 developing countries.

agricultural growth lagged behind national growth; while in Africa and Latin America agricultural growth was higher.[17]

Regressions like those whose results are reported in Table 1 were also estimated with the growth of national GDP per capita as the dependent variable. These regressions (not shown in detail) gave results more nearly in accord with expectations. The estimated β coefficient is significantly negative, indicating that the lower-income countries in 1980 grew faster during 1980–2001. Factors causing faster growth in agricultural GDP have positive effects on national GDP growth. The political and economic institutional variables are significant, but the corruption index appears more closely related to GDP growth than to agricultural growth. Because of its prominence in recent literature the hypothesis that countries with access to international waters (oceans or seas connected to them) grow faster than land-locked countries was also tested. Indeed, in this sample the "coastal" countries (75% of the sample) did grow significantly faster during 1980–2001, other things held constant. And, consistent with that finding, greater participation in international trade in the initial period (1980) is significantly related to faster GDP growth in 1980–2001.

However, these results say nothing about rural as compared to urban incomes, as these income differences are not in the data set. One study that carried out an econometric investigation of specifically rural incomes in a developing country context is Estudillo et al. (2001), who worked on wage rates of agricultural workers in the Philippines. Their findings parallel those cited above for the United States—the cause of growth in agricultural wage rates is growth of labor demand in the nonfarm economy. The implications of agricultural

[17] Note that these comparisons do not say anything about agriculture's share of national GDP, which turns on aggregate values. These growth rates are per person, so if the rural population is declining it is quite possible for agricultural GDP per person to rise while aggregate agricultural GDP, and its share in total GDP, decline.

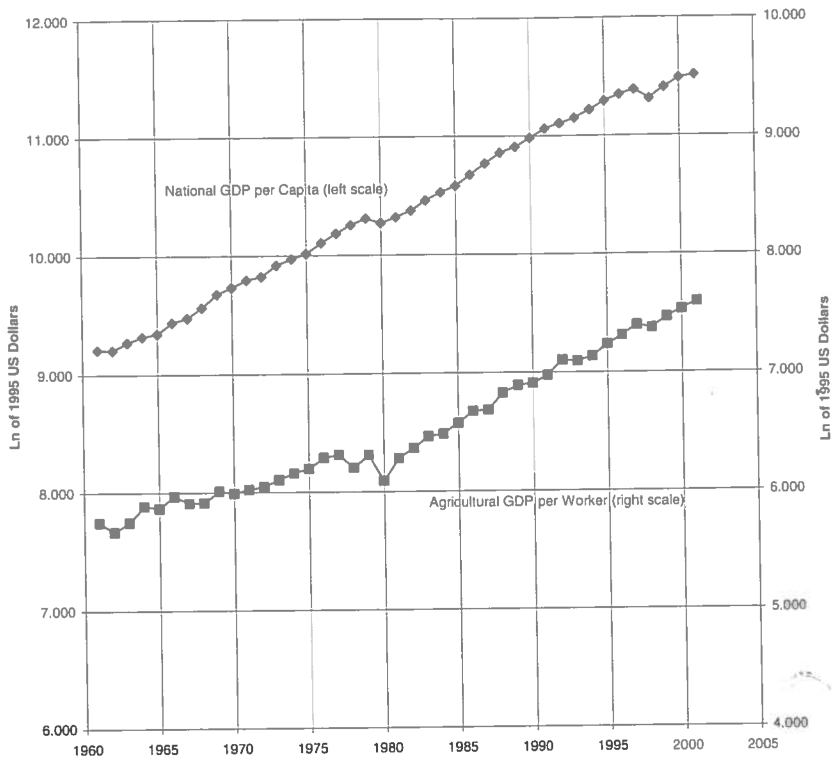

Figure 4. Agricultural GDP and national GDP: Korea.

GDP growth for rural poverty are even more complicated to analyze. The preponderance of evidence appears to support the conclusion that agricultural productivity growth is poverty reducing (see Hazell and Haddad, 2001; IFAD, 2001). But for the United States at least, real income growth in the nonfarm sector was found to be more fundamentally important in increasing low farm incomes than any specifically agricultural variable (Gardner, 2000). Timmer (2002) reports similarly but more nuanced findings for a sample of developing countries in terms of the linkages between nationwide per capita income and incomes in the lowest quintile, but he does not distinguish between agricultural and nonagricultural sources of national GDP.

4. Concluding discussion

The chief candidates for causes of growth in agricultural value-added (GDP) and rural household income growth are:

1. Macroeconomic and political stability
2. Property rights and incentives
3. Productivity-enhancing new technology
4. Access to competitive input and product markets
5. Real income growth in the nonagricultural economy

The first four of these have been discussed with reference to agricultural GDP growth, the fifth with reference to rural household income growth. Case studies have found all of these factors to be important, but compelling as the case may be, on the basis of observation and thought, for these causes being important, the cross-country empirical evidence on their role, in this paper and elsewhere, is mixed. The Green Revolution showed that some success can be achieved even without significant changes in (1), (2), (4), and (5); but transforming those gains into permanent increases in rural living standards has proven elusive.

What is scarcest is observations of sustained growth in developing countries. Where growth in rural household incomes has been achieved, all five factors are substantially present. In all these countries agriculture as a share of national GDP has fallen substantially, and only in a few agricultural exporting countries can agriculture really be said to be making a major contribution to national economic growth. Even in the fast-growing East Asian countries where agriculture has grown, this appears to be as much due to government subsidies as to growth dynamics generated by technological change or other productivity improvements within agriculture (Tsay, 2002).

In the context of overall real income growth in a country, it is important to distinguish between agricultural GDP in aggregate and agricultural GDP per worker. With appropriate institutions and policies GDP per worker may increase in all countries, but there is no expectation that the size of agriculture as a sector (aggregate agricultural GDP) would increase in all countries. Because of location-specific changes in technology or changes in relative factor prices because of different countries' factor endowments, some countries are expected to gain, but others lose, comparative advantage in agriculture under economic growth. So success in growth should not automatically be identified with increasing agricultural GDP (or output). On the other hand, increasing productivity or agricultural GDP per worker is generally an indicator of success, in the sense of providing the material basis for an improved standard of living for both rural and urban residents. That is why this paper focuses on GDP per worker rather than aggregate GDP or agricultural output.

Even when agricultural productivity grows, it is apparent that rural household incomes may not grow, as the earlier discussion of the United States indicated. It appears likely that a similar lesson will emerge from the East Asian countries where rural household incomes are growing: what is necessary is real average income growth in the economy as a whole, and that may be sufficient for rural income growth even if agriculture shrinks. In this context, some of the factors that did not show well in the cross-country regressions explaining agricultural GDP per worker may nonetheless be important causes of rural workers' income growth. It is well attested that education, to take the prime example, is valuable in increasing workers' earnings. But this value is not nearly so evident in farm production.

Although the arguments and evidence have hardly been touched upon here, it seems likely that the preceding conclusion applies also to rural poverty. To remedy rural poverty, what is most needed is improvement in the labor market generally more than, say, improved crop varieties. This is not to say that agricultural research, rural infrastructure investment, or the development of agricultural export sectors are not valuable or that their net effect on poverty is not in the right direction. The literature cited earlier suggests otherwise. Agricultural research and rural education and infrastructure development efforts have been highly profitable investments with a regularity that defies most commercial innovations. Agricultural economics is the discipline that can analyze the possibilities for these and other profitable investment opportunities in farm commodity and input markets. Yet it is becoming evident that rural income growth and poverty alleviation are not sub-fields of agricultural economics.[18]

In closing, I have to say that I am uneasy about the preceding conclusions. What they mostly rest upon is a failure to find sufficiently strong associations between variables representing hypothesized causal factors in agricultural GDP growth and differences across countries in actual growth rates of agricultural GDP per worker. Many of the variables are crude proxies for the real variables, and for these proxies measurement errors are likely. So the conclusions are even more than usually tentative. I am continuing these investigations together with Isabelle Tsakok and would be happy to eat what I have written here if further data and analysis change the story.

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[18] Evolution in how the agricultural sector is treated in the World Bank illustrates the problems that can arise. Traditionally an agricultural unit within the Bank made sense because of loans that had a central technical and business focus on agricultural production, so one needed technical experts in these matters. But as the Bank came to focus more on broader structural and policy matters in client countries, and on poverty reduction as a goal, to be useful an agricultural unit had to broaden greatly to become a rural development unit with expertise in all manner of socioeconomic issues. But when this is done, as exemplified in the Bank's recent rural strategy document (World Bank, 2002), it is not clear why the most appropriate policies and lending are not those centered in other parts of the Bank, such as education or health.

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