2000 Annual Meeting American Agricultural Economics Association

Tampa, Florida

WHY IS AGRICULTURAL LABOUR PRODUCTIVITY HIGHER IN SOME COUNTRIES THAN OTHERS?

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April, 2000

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Abstract

Agriculture productivity varies dramatically in different regions of the world. Using recent theories of economic growth and new data sets (Larson and al., 1999) as a guide, this study finds some empirical regularities between agricultural labour productivity growth, investment and education, as also for environmental factors, for 44 countries during the period 1980-1993. We find strong evidence that where agricultural investment and educated people rates are higher, agricultural labour productivity grows faster. Secondly, geographical factors as well as freer trade influence growth. Finally, we find evidence of conditional convergence, which means that cross-country agricultural productivity does not converge to the same level of steady state but that productivity in each country converges to its own long-run equilibrium.

Key Words: growth, labour productivity, convergence.
JEL Classification Nos.: O47, Q18, R11.

1 Introduction

Why has agricultural labour productivity in some countries grown more than in others? The remarkable growth in agricultural productivity is a truism, but the unanimity disappears when we need a theory to explain the source of agricultural productivity growth, and also the differences across regions or countries, Mundlack(1997). Using World Bank's 1998 World Development Indicator, in 1996 over 1.3 billion of the World's economically active population were involved in the agricultural sector and 1.1 billion of these lived in countries that the World Bank labels as low income countries.[1] In these countries, the average agriculture gross domestic product (GDP) per worker in the period 1994-1996 amounted to US $ 293 (1987 US prices). This means, for instance, that in the Netherlands, the GDP per worker in the same period was 140 times higher than the average agriculture GDP in low income countries. In other words, a Netherlands farmer produced as much in less than three days as an average farmer in low income countries produced in one year.[2] Moreover, Gini coefficients for the years 1980, 0.65, and 1993, 0.70, point to increasing disparities in the agricultural GDP per worker across 85 countries. These facts provide the background to the questions which this paper attempts to answer. What factors influence the labour productivity growth? Why has labour productivity apparently not converged in the last twenty years? Focusing our attention on the first question, in the last ten years a broad consensus has emerged between endogenous as well as neoclassical growth researchers that one of the key variables that explains growth is the increase in the quantity of human capital per person. This tends to lead to higher rates of investment in human as well as physical capital, and hence, to higher per capita growth (Barro, 1991). There is less agreement on the neoclassical hypothesis of per capita income convergence across region or countries.[3] As is well known, in the neoclassical growth models, diminishing returns to reproducible capital assure that cross countries income per capita converges towards a common steady state. Thus, poor countries where the capital to labour ratio is lower and the marginal product of capital is higher, will grow at a faster rate, converging on those with a higher capital to labour ratio. Empirical evidence does not show absolute convergence, i.e. countries do not converge to the same level of labour productivity. In other words, low income countries do not converge toward high income countries as is inferred by the neoclassical growth theory. Endogenous growth researchers, drawing on Romer's (1986) and Lucas's (1988) seminal works, attribute this fact to constant returns associated to a broad concept of capital which includes not only reproducible capital but also human capital. Thus, in these models per capita output may grow indefinitely because the return on investments do not necessary diminish as economies develop. A second piece of empirical evidence indicates that lack of convergence may be the result of different conditions in the various economies. If we take these differences into account convergence may still be true. This latter form of convergence, which has been labelled conditional convergence, is definitely weaker than the former. It implies that countries will converge to different labour productivity steady states but that a country that is further below its own steady state will grow faster. In the paper, we address these themes from the perspective of agricultural labour productivity. The results develop those of Gutierrez (1999; 2000). Empirical evidence shows that agricultural labour productivity is closely linked to investment in technical input as well as in human capital. Secondly, freer trade and geographical factors exert a significant role in enhancing labour productivity in the agricultural sector. Finally, our empirical evidence refutes the hypothesis of absolute labour productivity convergence across countries but we find evidence of conditional convergence.

2 Specifying Growth Models

The acquisition of new machinery, the building of new infrastructure or, in other words, the accumulation of physical capital is, without doubt, one of the necessary conditions for sustained productivity growth in the agricultural sector. But this is only part of the story. The effective use of new technologies requires high levels of education or accumulation of human capital. Education interacts with new technologies in two different ways. First, higher levels of education are fundamental for the vast majority of innovations. Much of the increase of agricultural productivity beyond the constraint of soil fertility can be assigned to what Hayami(1997) labels science-based agriculture. Second, the effective use of new technologies often requires highly skilled individuals such as, for example, for the use of modern sophisticated machinery. Moreover, health care may contribute to the growth of agricultural productivity through improvements in the farmers' productive capacity. Thus, investment in human capital has to be seen not only as investment in higher skills but also as investment in better health. A second constraint on agricultural labour productivity growth may be geographical constraints such as soil quality, climate or the location of the country. Recent analysis (Gallup et al., 1999) has shown that these factors affect economic growth and especially the agricultural sector. While limited endowments of natural resources are a major constraint for low income economies, developing economies may escape from resource endowment constraints by the use of man-made technical inputs.

A country's location may also influence agricultural labour productivity. It is well known that transferring advanced agricultural technologies developed in the temperate zone to the tropical zone may be difficult. For example, Hayamy (1997, pg. 83) points out that high-yielding rice varieties for temperate zones are susceptible to pests and insects found in tropical zones and so agricultural technology transfer from one environment to another is impossible without appropriate adaptive research. Barro and Sala-i-Martin (1995, Ch. 8) have made a theoretical analysis of the problem where the equilibrium rate of growth in the poorer country (in our case the tropical country) depends on the cost of imitation, and on its initial stock of knowledge. If the costs of imitation are lower than the cost of innovation, the poorer country can grow faster than the advanced one.

In the paper we address this problem analysing whether tropical agriculture registered significant differences in agricultural labour productivity growth compared to temperate agriculture. Finally, we analyse whether or not freer trade causes higher rates of productivity growth in the agricultural sector. A complete analysis of the enormous literature on the theoretical relationship between openness and productivity cannot be addressed in this paper. Two principal lines of analysis seems to have emerged in recent years. The first is connected to the endogenous economic growth theory, where openness may affect productivity growth through a country specialising in the production of intermediate inputs in which they have comparative advantage. In this case, a large number of inputs will be available at lower cost. A second line of analysis takes a different perspective and highlights that, abstracting from the aforementioned geographical constraints, a higher degree of openness will allow smaller countries to absorb technology developed in the advanced nations at a faster rate and thus they will grow more rapidly, as was shown in Grossman and Helpman's (1991) and Edwards' (1992, 1998) models.

In the empirical literature on cross-country growth regressions, authors often focus on the analysis on the neoclassical production function $y = Ak^{\alpha}$, where y and k are respectively the output and capital per unit of effective labour and $\alpha < 1$. Expressed in this form, the production function shows diminishing marginal productivity of capital. We can introduce now the steady state level of the output per effective unit of worker, denoted y^*. If the capital stock converges gradually to its steady state, output per worker will also converge. We can write the growth equation in the following form:

$$\gamma_i = \left[dy_{i(t+T)}/y_{it} \right] /T = c + \lambda \left(lny_i^* - lny_{it} \right) \quad i = 1, ..., N \tag{1}$$

where on the left side we have the average growth rate of output per effective worker in country i measured over the interval between the period t and T. The growth rate depends on a constant c, and on the gap between the steady state level of output per worker and the level of output per worker in the initial period t. Now we can assume that the steady state output per effective worker may be approximated by the following log-linear relationship $lny_i^* = \delta' X_i$ where X_i is a vector of variables which influence the steady state of output per worker, such as for example the previous analysed variables given by the investment ratio, the level of human capital, the environmental and geographical constraints and the degree of openness. Finally, δ is a vector of coefficients. Introducing the previous expression on equation (1) we end up with the following conditional growth rate equation:

$$\gamma_i = c + \lambda \delta' X_i - \lambda lny_{it} \quad i = 1, ..., N \tag{2}$$

Equation (2) has become extremely popular in the last ten years.[4] The average growth rate is the function of the variables X_i and the initial output per worker. The latter term is of great importance because from the λ parameter we can learn whether there is tendency toward convergence of output per worker, as neoclassical models asserts or divergence, as postulated by the endogenous growth researchers. An estimated value of $\lambda > 0$ in the equation (2) is taken as evidence for a type of convergence labelled *conditional convergence*. In this case a country that is further away from its output per worker steady state will grow faster, but its own steady state will be in general different from that registered in others countries. This form of convergence is definitely weaker than absolute convergence, where all countries converge to the steady state of the same level of output per worker.

3 Empirical Results

The empirical analysis is based on a sample of 44 countries for which we collected data on agricultural GDP per worker and life expectancy from World Bank, investment ratios[5] from Larson and al. (1999) [6], human capital from Barro and Lee (1996) and finally fertilizer and trade variables from FAO. The availability of data[7] determined which countries were included in the study. As previously mentioned, agricultural productivity in a country depends on its own growth determinants and, as we have seen, particularly on the investment ratio and on the level of human capital. In Table 1, we analyze how the growth determinants for a given country compare with those of other countries.

Table 1

From the Table it emerges that during the period 1980-1993 the country where agricultural GDP per worker was highest in the initial period, the Netherlands, grew faster than the average growth rate of the sample countries and, above all, faster than the country with the lowest GDP per worker, Malawi, where labour productivity decreased at an annual average rate of 1.1%. Looking at the growth determinants, the Table highlights that the investment ratio, the average years of secondary schooling and life expectancy are relatively much higher in the Netherlands than Malawi. The same pattern is shown in the cross-countries average. These value seems to confirm those of a large empirical literature that shows a positive relationship between investment, human capital and income per capita growth, Barro and Sala-I-Martin (1995). Later in this paper we introduce further results on this relationship using cross-section estimates. In Table 2 we present the estimated coefficients for five cross-section regressions.

Table 2

In the first regression we regress the average annual growth rate of agricultural labour productivity on a constant and on the logarithm of the agricultural GDP per worker in 1980. The results show a positive and significant relationship between the productivity growth rate and the 1980 GDP per worker level. Thus, as previously noted, the estimate refutes the absolute convergence hypothesis that agricultural labour productivity in different countries converges to a common steady state level. In order to take account of cross-countries differences in the growth determinants, we began by introducing the logarithm of the ratio of agricultural fixed investment to agricultural GDP in the initial period in the regression. The estimated coefficient is positive and significant at the 5% level for a two sided test. Although the coefficient shows a positive relationship between investment and labour productivity growth, reserve causality may still hold. Countries where GDP per worker is higher may expect a higher savings rate which increases agricultural investment. This pitfall may be avoided by using of the investment ratio in the starting period of analysis. We also run a regression where the investment variable was given by fixed investment plus livestock and orchards investments Larson and al. (1999). In this case, the estimated coefficient is still positive but not statistically significant. In the third regression we introduce the logarithm of the ratio of fertilizer to agricultural land area. The effect of fertilizers on agricultural labour productivity is positive and significant. Note that in the regression the investment ratio coefficient does not change from the previous regression. Finally the estimated coefficient of the log GDP per worker is now negative but not significant. In the regression

(4) we introduce as proxies of the human capital level in the countries the logarithm of years of secondary school of the total population, Barro and Lee (1996), and the life expectancy. Both coefficients are positive and significant at the usual 5% confidence level. The regression does not change the estimated coefficients related to the investment ratios and fertilizers variables. What it seems relevant to emphasise is that the coefficient of the log GDP per worker is now negative and strongly significant. When we introduce the human capital variable the regression shows conditional convergence. That is countries converge to different labour productivity steady states, and the steady state is mainly conditioned by the level of physical as well as human capital. We will return to this point later, when we discuss on the rate of convergence. Finally, in the last regression we address the issues connected to the empirical relationship between openness, a country's location and agricultural labour productivity growth. In regression (5) we introduce a dummy variable which is 1 if more than fifty percent of the land area in a country is inside the tropics, and two openness indicators. The first is given by the log of the ratio of agricultural exports plus imports to the total GDP. This openness indicator is ready-available but has many limitations, as a country can distort agricultural trade heavily, and still have a high value for the ratio. The second indicators is Sachs and Warner's (1995) openness dummy variable based on five trade-related indicators, including tariff and non tariff barriers, black market premia and the role of the state in the economy. As for

the investment ratio variable and for the agricultural trade ratio, we use the 1980 values for Sachs and Warner's dummy in order to avoid reversed causality. The tropical dummy coefficient is negative and significant. This means that, all other things being equal, tropical labour productivity has grown on average more slowly than in temperate countries. Thus, geographical factors greatly limit agricultural labour productivity growth. Finally, both openness indicators have a positive effect. Thus, the results confirm those found in the large empirical literature that freer trade increases productivity. We can now measure the relative importance of the variables included in the regression and look at the effect of a one-standard-deviation increase in a single variable on the agricultural labour productivity growth. When we raise the ratio of real agricultural fixed investment to real agricultural GDP by one-standard-deviation, the agricultural labour productivity growth rate is estimated to rise by 0.9% points per year whereas the effect of the secondary school and life expectancy variables is respectively of 0.7% and 0.9% per year. Thus, secondary school education plays a significant role in the growth regression, but a less important one than life expectancy. This result is common in the empirical literature on growth regressions and has been justified with the arguments that life expectancy is a proxy for features other than good health, such as better work habits or higher level of skills, Barro and Lee (1994). Finally, a one-standard-deviation shock on the fertilizers variable and on the ratio of exports plus import to total GDP variable raises the labour productivity growth rate by 0.4% and 0.6% per year respectively. We now return to the problem of convergence. As we have seen, the coefficient on the log of initial GDP per worker can be used to estimate the convergence rate, i.e. the rate at which a country converges to its own steady state of labour productivity. Using the values of regressions (4) or (5) we note that the convergence rate is 0.014 which means that each year there is reduction equivalent to 1.4 percentage point in a country's own agricultural GDP per worker gap[8]. Thus the convergence of agricultural labour productivity is lower than for the whole economy, where the convergence rate is usually estimated to be 2% per year.

4 Conclusions

Differences in agricultural labour productivity growth rates across countries are large and, as we have shown, related to a set of quantifiable explanatory variables. Our empirical analysis suggest that countries where agricultural labour productivity is higher have a higher rate of investment in physical and human capital. Thus, agricultural sector performance in the long run is determined by government policies to promote the development of institutions which encourage farmers to invest, increase their labour skills and introduce new methods of production. Freer trade may foster agricultural labour productivity and the implementation of liberalizing trade reforms may reduce productivity differentials. Finally, geographical factors influence labour productivity. We have shown that, during the period 1980-1993 and all else being equal, agricultural labour productivity in the tropical countries grew less on average than in temperate countries. This may be the result of a large set of different factors but we think that many of these may be connected to frictions in transferring technologies developed in the temperate zone to the tropical zone. Thus, further reflection is needed on how to increase appropriate research and technology transfer from one environment to another. Finally, regressions show the tendency for conditional convergence. In other words the analysis predicts higher growth of agricultural labour productivity in response to lower starting GDP per worker only if other explanatory variables are held constant. The estimated coefficient implies that convergence occurs at the rate of 1.4% per year.

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Notes

[1] World Bank defines a low income country as a country with a GDP per capita less than US $785.
[2] It is well known that using the US dollar official exchange rate we tend to underestimate the level of economic welfare in low income countries relative to high income economies. Nonetheless even if using purchasing power parities reduces the gap, it will usually remain extremely wide.
[3] See on this theme Gutierrez(2000).
[4] For a theoretical derivation of the equation (2) the reference is Barro and Sala-i-Martin(1995).
[5] The data set on investment in the agricultural sector has been kindly provided by Donald Larson. The investment ratio variable that has been calculated has the ratio of real fixed investment to real agricultural GDP.
[6] We thank Donald Larson for making available the dataset used in this study.
[7] The 44 countries are: Argentina, Australia, Austria, Canada, Chile, Colombia, CostaRica, Cyprus, Denmark, DominicanRepublic, Egypt, ElSalvador, Finland, France, Greece, Honduras, India, Indonesia, Iran, Italy, Jamaica, Japan, Kenya, KoreaRep., Malawi, Mauritius, Netherlands, New Zealand, Norway, Pakistan, Peru, Philippines, South Africa, Sri Lanka, Sweden, Syria, Trinidad and Tobago, Tunisia, Turkey, United Kingdom, Uruguay, United States, Venezuela, Zimbabwe.
[8] The convergence rate (can be rapidly calculated using the relationship $\beta = (1 + \lambda T)/T$, where $T = 13$. See Gutierrez(1999) for the analytical derivation.

Tables

Table 1. Agricultural GDP growth determinants

Countries	GDP per worker 1980 (1987 US$)	Annual Average Growth Rates 1980-1993	Investment Ratios 1980	Secondary Education 1980	Life Expectancy 1980
Highest GDP per worker	23.131	3.6%	35%	2.6	76
Average GDP per worker	6.316	3.1%	18%	1.6	66
Lowest GDP per worker	162	-1.1%	6%	0.1	44

Source: World Bank, Barro and Lee(1996) Larson & al. (1999) data sets.

Table 2. Cross-section Regressions

Variables	Regressions				
	(1)	(2)	(3)	(4)	(5)
Constant	-0.031	0.037	0.030	0.025	0.126
	(-1.550)	(1.011)	(0.894)	(0.643)	(2.319)
	[-2.376]	[1.129]	[0.989]	[0.851]	[2.880]
Log GDP per worker,1980	0.006	0.001	-0.001	-0.012	-0.013
	(2.574)	(0.198)	(-0.233)	(-2.700)	(-3.075)
	[4.119]	[0.228]	[-0.264]	[-2.901]	[-3.305]
Log Investment ratio [1], 1980		0.011	0.010	0.013	0.009
		(2.199)	(2.271)	(3.062)	(2.185)
		[2.530]	[2.547]	[3.313]	[2.616]
Log fertilizer[2], 1980			0.006	0.0045	0.003
			(2.891)	(2.348)	(1.437)
			[3.256]	[2.822]	[2.225]
Life expectancy, 1980				0.001	0.001
				(1.924)	(1.581)
				[2.133]	[1.837]
Log secondary education [3], 1980				0.008	0.008
				(2.063)	(1.778)
				[2.323]	[2.293]
Log openness[4]					0.008
					(2.131)
					[2.588]
Sachs-Warner openness dummy, 1980					0.012
					(1.546)
					[1.814]
Dummy for tropical countries					-0.019
					(-2.486)
					[-2.740]
Implied $\hat{\beta}$	-0.006	-0.001	0.001	0.013	0.014
	(-2.671)	(-0.199)	(0.236)	(3.356)	(3.862)
	[-4.273]	[-0.299]	[0.268]	[3.606]	[4.152]
Number of observations	44	44	44	44	44
R^2	0.14	0.23	0.36	0.51	0.65
F test	6.63	6.03	7.53	7.77	7.34
LM normality test[5]	1.89	1.52	2.53	2.20	0.73
Heteroskedastic Breush-Pagan test[6]	62.79	54.13	55.57	52.42	27.93

Source: author's calculation using World Bank, FAO, Larson & al. (1999), Barro and Lee(1996) data sets.
In round brackets t-statistics. In square brackets White (1980) heteroskedastic consistent t-statistics.
[1] Log ratio of agricultural fixed investment to agricultural GDP.
[2] Log ratio of fertilizer to total agricultural area.
[3] Log average yeras of secondary schooling in the total population.
[4] Log average 1979-1980 agricultural (export+imports)/total GDP.
[5] LM test on the null hypothesis that the errors are normally distributed.
[6] Breush- Pagan test on the null hypothesis that errors are homoskedastic.