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Structural Transformation and Cross-Country Income Differences

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ABSTRACT
This paper examines the effect of agricultural policy on a country's development and growth. We find that low agricultural productivity can delay the start of industrialization in a country for a long period of time, causing a country's per capita income to fall far behind the industrial leader. Once industrialization begins, this trend is reversed. However, the extent to which a country catches up to the leader depends primarily on factors that affect productivity in non-agricultural activities. Agricultural policy, therefore, is largely irrelevant in the long run. But in the short run, a country that experiences large improvements in agricultural productivity, due to say a Green Revolution, will experience an increase in its income relative to the leaders.

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1. Introduction

One of the longstanding questions in economics is why some countries are so much richer than others. Today, for example, income per capita in the world's richest countries is roughly thirty-five times greater than it is in the world's poorest countries. Recent efforts aimed at understanding current international income differences (e.g., Lucas 2001, and Ngai 1999) argues that the proximate cause of the disparity is that today's poor countries began the process of industrialization much later than today's rich countries, and that this process is rather slow.

A basic development fact is that countries experience a structural transformation as they develop. The rich countries of the world currently have less than 10 percent of their workforce in agriculture, while for many of the world's poorest countries this figure exceeds 60 percent. However, this is roughly the employment share that existed two centuries ago in today's rich countries. In this paper we argue that a simple model of this process of structural transformation provides a useful theory both of why industrialization occurs at different dates, and why once underway the process occurs slowly. A key implication of our analysis is that a greater understanding of the determinants of agricultural productivity is key to building models that can better confront the issues facing many of today's developing nations.

Our model builds on Gollin et al. (2002), (henceforth, GPR). That model is an extension of the standard neoclassical growth model that includes an agriculture sector and in which individuals face subsistence food requirements. A key feature of that model is that resources cannot move out of agriculture unless the subsistence needs of the population are met. It follows that the pace of industrialization depends on developments in the agricultural sector.[1] Factors that lead to low agricultural productivity can, therefore, delay a country's development. Consequently, technological innovations (e.g., the Green Revolution), institutional changes (e.g., land reforms), or even policy changes (e.g., tax or regulatory changes) that lead to increases in agricultural productivity will affect the pace of industrialization and hence the time series of the cross-country income distribution. This is the case even though the productivity of the agricultural sector is irrelevant for the asymptotic distribution of international incomes. Asymptotically, this distribution is determined entirely by the distribution of policies and institutions in each country that affect productivity in the nonagricultural sector.

The main difference between the model considered in this paper and in GPR is that here we allow for a feedback from the non-agriculture sector to the agriculture sector. There was no such feedback in GPR because that model abstracted from capital and land inputs in the agricultural technology. In this paper we allow for such a feedback from non-agriculture to agriculture by assuming that capital produced in the non-agriculture sector can be used in agriculture. The introduction of this feedback implies a much richer set of predictions relative to GPR. (2002). The main differences in findings are as follows:

- Although the date at which an economy starts to industrialize is again determined exclusively by agricultural TFP, the differences in agricultural TFP that are needed to delay the industrialization process for two centuries are much smaller compared to GPR.

[1] This observation is emphasized in an older strand of the development literature. See, for example, Schultz (1964), and Johnston and Mellor (1961), who argued that productivity improvements in agriculture are a precondition for an economy to industrialize.

- The rate of structural transformation now depends importantly on the non-agricultural policy.
- A poor country that has started to industrialize can undergo a growth miracle either by improving agricultural policy or improving non-agricultural policy.

Development economists have long emphasized the role of agriculture in the development process.[2] Macroeconomists have only recently begun to emphasize its role. Caselli and Coleman (2001) argued that explicit modeling of the structural transformation is central to understanding the evolution of relative incomes across regions in the United States. Several others have also analyzed models of the structural transformation that explicitly incorporate an agricultural sector. These include Echevarria (1995, 1997), Kongsamut, Rebelo and Xie (1998), Laitner (1998), Glomm (1992), Matsuyama (1992), and Goodfriend and McDermott (1995). While our model shares several features with these other papers, none of them use their models to explore the evolution of cross-country income differences over time.

2. A Model of Structural Transformation

2.1 The Economy

Our model is an adaptation of those of Laitner (1998) and Hansen and Prescott (forthcoming). The basic structure of our model is that of the one-sector neoclassical growth model extended to allow for an explicit agricultural sector in addition to the usual

[2] The contributions are far too numerous to include an exhaustive list, but important references include Johnston and Mellor (1961), Fei and Ranis (1964), Schultz (1964), Lewis (1965), Kuznets (1966), Chenery

non-agricultural sector. The extension is done in such a way that the process of development is associated with a structural transformation of economic activity, characterized by a declining share of economic activity accounted for by the agriculture. Asymptotically, agriculture's share of the labor force shrinks to zero, and the model becomes identical to the standard one-sector neoclassical growth model.[3]

Economies are treated as being closed. Hence, each economy is required to produce its own food. This assumption precludes a poor country that is relatively unproductive at producing food from simply importing it, a restriction that can be significant for some specifications of our model. However, this assumption is not particularly at odds with the data--the evidence is that imports of basic foodstuffs tend to be quite small in developing countries.[4]

Preferences

The economy is populated by an infinitely-lived representative family. Instantaneous utility is defined over two consumption goods: a non-agricultural good denoted by c_t, and an agricultural good denoted by a_t. To account for the secular decline in agriculture's share of economic activity we follow the convention of assuming a utility function of the

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and Syrquin (1975), Johnston and Kilby (1975), Hayami and Ruttan (1985), Mellor (1986), Timmer (1988), and Syrquin (1988).

[3] In reality it may be that although agriculture's share of economic activity becomes small, it remains bounded away from zero. This would not matter at all for our analysis.

[4] We do not model why a country that would benefit from food imports chooses not to do so. While this may reflect trade barriers, it may also reflect the lack of sufficient infrastructure to feasibly deliver food to rural areas.

Stone-Geary variety. To keep the analysis simple, we adopt a rather extreme functional form, namely[5],

$$U(c_t, a_t) = \begin{cases} \dfrac{c_t^{1-\sigma} - 1}{1-\sigma} + \bar{a} & if \quad a_t > \bar{a} \\ a_t & if \quad a_t \leq \bar{a} \end{cases}. \tag{1}$$

Lifetime utility is given by:

$$\sum_{t=0}^{\infty} \beta^t U(c_t, a_t), \tag{2}$$

where β is the subjective time discount factor.

These preferences imply that a family will never consume the agricultural good beyond $\bar{a}$ no matter how cheap agricultural goods may be relative to nonagricultural goods. In equilibrium this will imply that once output in the agricultural sector reaches $\bar{a}$, all remaining labor will flow out of agriculture regardless of the state of the non-agricultural sector. More generally, one might expect that a very low level of relative productivity in the non-agriculture sector might cause more labor to be allocated to agricultural production as consumers shift their consumptions bundles toward agricultural goods. This is potentially an important effect and one that we focused on in Gollin, Parente and Rogerson (2000). We abstract from it here, not because we believe it is insignificant, but rather because we want to focus attention on feedback effects going in the other direction, i.e., how the state of the agricultural sector affects the labor available for the manufacturing sector.

[5] Technically we should assume that a family has a very small endowment of the nonagricultural good that is always consumed to avoid the issue that instantaneous utility is lowered when c increases from zero to a small positive amount. We ignore this for simplicity.

Endowments

The representative family is endowed with one unit of time each period. Additionally, the family is endowed with the economy's stock of land denoted by L, which is normalized to 1. Land does not depreciate in the model. The family is not endowed with any capital. It will, however, come to own capital at some date.

Technologies

Non-Agriculture

Following the tradition in the literature, we refer to the nonagricultural sector as the manufacturing sector, though in fact it is meant to capture the full range of activities in the nonagricultural sector. For this reason we use the subscript, *m*, to refer to non-agricultural variables. The nonagricultural sector produces output (Y_t) using capital (K_{mt}) and labor (N_{mt}) as inputs according to the following constant returns to scale technology:

$$Y_t = E_m[(1+\gamma_m)^t K_{mt}^{\theta} N_{mt}{}^{1-\theta} + \varepsilon N_{mt}]. \quad (3)$$

In equation (3), E_m is a total factor productivity parameter, and γ_m is the constant exogenous rate of technological change.[6] This technology is standard except for the term εN_{mt}. This term is added to the production function so that an economy with no physical capital can start manufacturing and accumulate capital. In the numerical work that follows we will pick ε to be a small number.[7]

[6] We abstract from issues such as embodiment of technology and appropriate technology.
[7] Alternatively, we could have assumed that all countries are naturally endowed with a very small amount of capital that is always available. This would not affect our results at all.

The TFP parameter, E_m, is assumed to be country-specific, being determined by policies and institutions that impact on activity in the non-agriculture sector.[8] It can be interpreted as the fraction of the exogenous stock of knowledge in the world that a country would use, given its institutions, were it to produce the non-agricultural good. In contrast, the parameters γ_m and ε are identical across countries. To be sure, the growth rate of productive knowledge has not been constant through history. The assumption of a constant rate of technological change, however, is not critical to the results we establish in this paper. Additionally, much of the stock of useful knowledge owes its creation to research and development in the rich countries. Poor countries, however, are generally not in the business of creating ideas, and so from their perspective, the assumption of exogenous technological change is reasonable.

Output from the manufacturing sector can be used for consumption or to augment the capital stock. The non-agriculture resource constraint is thus,

$$c_t + x_t \leq Y_{t,}, \tag{4}$$

and the law of motion for the stock of capital in the economy is

$$k_{t+1} = (1-\delta)k_t + k_t. \tag{5}$$

Agriculture

We distinguish between three technologies to produce the agricultural good. The first of these, which is indexed by 0, corresponds to a traditional technology. The key features of this technology are that it is not subject to exogenous technological change and it is not affected by policy. The inputs to the traditional technology are labor services (N_{0t}) and

[8] See Parente and Prescott (2000) for an explicit discussion of a mapping from policies into the level of TFP at the aggregate level. Certainly, an important issue in this literature is to identify those policies and institutions that are most responsible for generating cross-country differences in TFP. While we believe this

land services (L_{0t}). The amount of output produced from the traditional technology (A_{0t}) is given by

$$A_{0t} = N_{0t}^{\alpha} L_{0t}^{1-\alpha} \tag{6}$$

We assume that when all of the economy's labor and land are employed in the traditional technology the economy produces $\bar{a}$ units of the agricultural good. Given our normalization of the family's endowments of time and land, this assumption implies $\bar{a} = 1$. There is nothing particularly special about this normalization. Our results would not be much affected by alternatively introducing a TFP parameter to the traditional technology and using a different value for $\bar{a}$.[9]

The other two agricultural technologies, indexed by the numbers 1 and 2, are both subject to exogenous technological change and policy. The key difference between them is that technology 2 uses land, labor, and capital produced in the manufacturing sector whereas technology 1 uses only land and labor. Agricultural output from technology 1 (A_{1t}) is given by

$$A_{1t} = E_a (1+\gamma_1)^t N_{1t}^{\alpha} L_{1t}^{1-\alpha}, \tag{7}$$

whereas agricultural output produced using technology 2 (A_{2t}) is given by

$$A_{2t} = E_a (1+\gamma_2)^t K_{2t}^{\phi} N_{2t}^{\varphi} L_{2t}^{1-\phi-\mu}. \tag{8}$$

In equations (7) and (8), E_a is a total factor productivity parameter, which is country-specific. As was the case with the manufacturing technology, one source of cross-country differences in this parameter is policies and or institutional features that impact on

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remains an important issue in this literature, it is not central to our purpose, and hence we feel the reduced form approach makes our analysis more transparent.

agricultural activity. However, another very important source of variation is differences in the amount or quality of land per person, and climate. In particular, technological innovations that are useful for a specific crop in a given climate may not be particularly relevant for other crops in other parts of the world, thus generating large differences in cross-country productivity levels that are independent of policy.

The parameter, γ_a, denotes the rate of exogenous technological change in the modern agricultural technology. Though it is easy to imagine circumstances in which because technological innovations are not applicable in all countries, growth rates of technology may differ across countries, for the purposes of our analysis here, we assume that this value is common to all countries.

There are several reasons why we use two "modern" agricultural technologies rather than one. The first reason is purely technical. We need to allow for some mechanism by which the structural transformation can begin. If the agricultural technology given by equation (7) did not exist, no economy would ever be able to move resources out of agriculture and grow. Second, as the Green Revolution has shown, important increases in output have been realized without significant inputs produced by the manufacturing sector. As the green revolution has shown, large increases in rice harvests followed the introduction of new seed varieties even though farmers continued to use animal power. This belies what we view as the key feature that separates these two technologies: namely, whether production is dependent on animal power or machine power.

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[9] We note that there are reasons to believe that a value close to $\bar{a}$ is appropriate. Models in which fertility is endogenous suggest that output per capita will be close to subsistence levels for economies that have not begun the process of industrialization.

Output from the agriculture sector can only be used for consumption purposes. The agriculture resource constraint for the economy is simply $a_t \leq \sum_{i=0}^{2} A_{it}$. The assumption we make on the economy imply that the traditional technology will not if either of the modern technologies is used.

2.2 Solving for Equilibrium

We focus on the competitive equilibrium for this economy. Our primary interest is in how different values of the technology parameters E_a and E_m affect the resulting dynamic allocations generated by the competitive equilibrium. Solving the competitive equilibrium is fairly straightforward. As long as $E_a(1+\gamma_1)^t < 1$, an economy will specialize in agriculture using the traditional technology in order to meet its subsistence needs. The economy will switch into agricultural technology 1 in the first period for which $E_a(1+\gamma_1)^t \geq 1$, and will begin manufacturing in the first period in which $E_a(1+\gamma_1)^t >$ 1. Denote the first period in which the economy can move resources into manufacturing by T. The competitive equilibrium allocations solve the following planner's problem starting with T

$$\max \sum_{t=T}^{\infty} \beta^{t-T} \left[\frac{c_t^{1-\sigma} - 1}{1-\sigma} + \bar{a} \right]$$

subject to

i. $c_t + k_{t+1} \leq E_m (1+\gamma_m)^t K_{mt}^{\theta} N_{mt}^{1-\theta} + \varepsilon E_m N_{mt} + (1-\delta) k_t$

ii. $E_a (1+\gamma_1)^t N_{1t}^{\alpha} L_{1t}^{1-\alpha} + E_a (1+\gamma_2)^t K_{2t}^{\phi} N_{2t}^{\mu} L_{2t}^{1-\phi-\mu} \geq \bar{a}$

iii. $K_{mt} + K_{2t} \leq k_t$

iv. $N_{mt} + N_{1t} + N_{2t} \leq 1$

v. $L_{1t} + L_{2t} \leq 1$

vi. k_T=0.

The maximization is over the sequence of choices $\{c_t, K_{mt}, K_{2t}, N_{mt}, N_{1t}, N_{2t}, k_{t+1}\}_{t=T}^{\infty}$. Let the numeraire for the economy be the agricultural good. Prices can be determined as follows. First, the rental prices of land and labor are just the marginal physical products from the agricultural technology that is used. Second the price of the consumption good can be determined by using the marginal physical product of labor from agriculture with the marginal physical product of labor from manufacturing. If agricultural technology is used, then its rental price of capital is the marginal physical product from agricultural technology 2 provided that technology is used in the period. Otherwise, all capital is used in manufacturing so that the rental price of capital is just the price of the consumption good times the marginal physical capital evaluated at the optimal allocations.

Computationally, we exploit the fact that in the limit the economy converges to the one-sector neoclassical growth model. We employ a shooting algorithm in which only a guess for the value for k_{T+1} is needed to compute the entire path of allocations for the economy from t=T to t=T+350. As part of this algorithm, we determine for any k_t the optimal allocations of capital, labor and land service inputs for all technologies

3. Numerical Experiments

3.1 Benchmark Parameterization

In this section we report some numerical results that serve to illustrate our main findings. We begin by providing a benchmark specification that loosely captures the development of the United Kingdom over the last 250 years. We choose the length of a time period to be one year. Without loss of generality the value of E_m is normalized to one for the UK. Asymptotically, the growth rate of (per capita) output in this economy will be equal to $(1+\gamma_m)^{1/(1-\theta)}$. Since, Maddison (1995) reports that the growth rate of per capita output in the United Kingdom has been around 1.3 percent per year over the last 100 years, we choose γ_m=.0067.

Table 1: Calibration Parameters

Parameter	**Value**	**Observation**	**Comment**
a	1.0		Normalization
β	.96	Asymptotic real interest rate of 5 percent	
ε	.0001		
θ	.50		Intangible plus tangible capital
E_m	1.0		Normalization
δ	.065		Standard
γ_m	.0064	1.3 % U.K per capita GDP growth reported by Maddison (1995)	
α	.7		Ag. Production Function estimates
ϕ	.1		Hayami and Ruttan
μ	.6		
γ_a	.0074	1801 Ag. Employ. share of 35% reported by Kuznets (1966)	
E_a	.992	1950 Ag. Employment share of 5% reported by Kuznets (1966)	

The capital share parameter, θ, is set to 0.50. This is a somewhat higher value than those typically used in the real business cycle research. This reflects two factors. First, recent revisions to capital stock series for the US suggest substantially higher capital stocks. (See Cooley and Prescott 19xx.). Second, the higher value reflects the realization that intangible capital is also an important input in the production of non-agricultural goods, but is unmeasured in the national accounts.[10] The depreciation rate is set to 0.065. The final parameter in the non-agriculture technology is ε, which we set to 0.0001. The motivation for this choice is that the parameter must be non-zero so that the economy can accumulate capital starting with no capital, but it should be close to zero so that it does not affect the model's predictions once the economy has a positive capital stock.

The parameters E_a and γ_a are set so that the model matches UK agriculture employment shares in 1800 and 1950, which are reported by Kuznets (1966) to be 35 percent and 5 percent respectively. The implied value for E_a is .992 and the implied value for γ_a is .0072. The labor share parameter, α, in both the traditional agricultural technology and agricultural technology 1 is set to 0.70. The capital share parameter, ϕ, and the labor share parameter, μ, in the modern agricultural technology 2 are set to .10 and .60 respectively. Finally, the intertemporal substitution parameter, σ, is set to 1.0 and the subjective and the subjective time discount factor, β, is set to .96 so that the asymptotic annual interest rate is 5 percent.

Given our interpretation of capital in the manufacturing sector, there is an important adjustment that needs to be made when making comparisons between the model and the data. This adjustment is necessitated by the fact that intangible capital goes unmeasured in the national income and product accounts. Consequently, output in the model will not correspond to GDP. This necessitates that we adjust output by subtracting off the amount of intangible capital investment when making comparisons with the data. We do this very crudely in the following experiments by assuming that half of all investment is intangible. This split is conservative relative to the estimates of Parente and Prescott (2000) that place the size of unmeasured investment to GDP between 25 and 50 percent.[11]

Figures 1-3 compare the time series generated by the model to UK data taken from Kuznets (1966). According to this calibration, the first year in which resources are moved out of agriculture in the United Kingdom is 1728 and the first year in which agriculture starts using physical capital is 1763. Despite the model's simplicity, it matches the UK development and growth experience closely over the last 250 years. Figure 1 displays agriculture's employment share. By the process of the calibration, the model trivially matches agriculture's share of employment in 1800 and 1950. As can be seen, the model's predictions for the period between 1820 and 1950, and the period after 1950 are also very close to the actual data. Figure 2 displays the path of per capita output over the 1820-1990 relative to the 1820 value. As can be seen the model matches the path of UK output fairly closely except for the period comprising the two World Wars. It is well known that the British economy grew well below trend values during the interwar

[10] See Parente and Prescott (1994, 2000) for a formal discussion of the size of the intangible capital stock and its implications for total capital's share.

[11] A more sophisticated method would compute the investment rates by decomposing Km(t) into both intangible and tangible components. The split would depend critically on the share parameters for the two capital stocks, which could be pinned down by matching the model's equilibrium to measured investments share of GDP.

period, a phenomenon that is still subject to some debate and one that our calibration does not attempt to capture. Finally, Figure 3 displays agriculture's share of output at each date measured in date t prices. Here too the model, despite its rather simple structure, does a fairly good job at matching the decline in agriculture's share of output.

3.2 Implications for Cross-Country Income Differences

In this section we explore the implications of cross-country productivity differences for the evolution of cross-country income differences and economic structure over time. As already mentioned, we use these productivity differences as a reduced form catchall to reflect cross-country differences along a number of dimensions, including taxation, regulation, assignment and enforcement of property rights, institutions such as collective bargaining, and soil and climate conditions. Recall that the values of E_a and E_m were normalized to one for the benchmark economy. In what follows we will refer to an economy as being distorted if either E_a or E_m, or possibly both, is less than one, even though the difference may not result from policy.[12]

Given our simplifying assumptions, a property of our model is that the date at which an economy industrializes is determined solely by the agriculture TFP parameter. The value of the non-agricultural TFP parameter does not affect this date. However, it does affect the rate at which the agriculture's share of economic activity declines over the industrialization process. Thus, for the purpose of determining the model's predictions for a country's relative income, we begin by fixing E_m at the benchmark value and consider how only differences in E_a affect an economy's development path. We then follow this experiment with ones that varies the value of E_m keeping the value of E_a fixed in order to show how non-agricultural TFP affects the an economy's rate of structural transformation and relative output.

Figure 4 depicts the path of the agricultural employment share for economies that start to industrialize in 1800, 1850, 1900, 1950, and 2000, and Table 2 reports the value of E_a for which the model implies these industrialization dates together with the per capita GDP of the distorted economy relative to the benchmark economy at these dates. To reiterate, all economies in this experiment are assumed to have the same non-agricultural TFP. Relative income for each distorted economy is computed using year 2000 prices from the benchmark economy. A country that begins to industrialize in the year 1800 has an agricultural TFP equal to 59 percent of the industrial leader, and an 1800 per capita income equal to 40 percent of the leader. Between 1800 and 2000, agriculture's share of employment declines in this economy from 100 percent to 11 percent. In contrast, a country that begins to industrialize in 1950 has an agricultural TFP equal to 20 percent of the leader and a 1950 per capita income equal to 5 percent of the leader. Between 1950 and 2000, agriculture's share of employment declines from 100 percent to 31 percent. These values are typical of the employment shares and relative incomes observed among the poorest countries in the world over the second half of the twentieth century.[13] From a quantitative perspective, the longstanding idea in the

[12] More precisely, these economies are only distorted relative to the benchmark. While we normalized the TFP values for the benchmark to equal one, this does not imply that this economy is not itself distorted in the sense that its policies result in TFP levels below what is technically achievable.

[13] The required differences in agricultural TFP in the model would be even smaller if capital were included as an input in agricultural technology 1.

development literature that distortions that impact on the agricultural sector are a major reason that some countries are so poor is entirely plausible.

Table 2: Agricultural TFP and Industrialization

Date	E_a	Relative Income
1800	.59	40.0%
1850	.41	21.0%
1900	.28	11.0%
1950	.19	5.5%
2000	.14	2.9%

Although in our model productivity differentials in agriculture have important consequences for a country's development, they have no consequences for its asymptotic income level. To make this point perfectly clear we plot the path of per capita GDP over the period 1725-2050 for economies with distortions to agricultural activity that correspond to initial industrialization dates of 1750, 1850 and 1950. These paths are shown in Figure 5. For transparency here, we assume no distortions to non-agricultural activity (i.e., E_m = 1.0) so that all distorted economies, asymptotically, have an income equal to the benchmark economy. Each country's per capita output at each date is calculated relative to the benchmark economy using its prices in year 2000 as the base year.

There are a number of interesting implications that follow from Figure 5. One implication is that it is potentially quite misleading to interpret current cross-country differences in income as steady state differences. Such an approach is taken by Parente, Rogerson, and Wright (2001), Parente and Prescott (1994, 2000), Chari, Kehoe, and McGrattan (1996), Schmitz (2001), Restuccia and Urrutia (1999) and Mankiw, Romer and Weil (1992) to name a few. Another implication of Figure 5 is that countries that start the development process later will tend to grow faster than earlier entrants as they industrialize. This prediction is broadly consistent with the finding of Parente and Prescott 1994, which shows that countries that achieved a certain level of income (say, e.g. $2,000) later in history were able to double their income (to $4,000) in a far shorter period than countries that achieved this level of income earlier in history.

Another significant point to be taken from the plots in Figure 5 concerns its implications for the speed of development once industrialization begins. As already noted, a country that begins to industrialize in 1950 would not be near its steady state output level until roughly one hundred years later. It is important to emphasize that this transition is much slower than one would observe if one simply started out with a small capital stock in the one-sector neoclassical growth model. The reason is that in our model labor is only moved slowly into the non-agricultural sector, whereas in the standard one-sector neoclassical growth model the entire labor endowment is always in that sector. This matters a lot for the speed of convergence to the steady state.

One final important point to note in these simulations is how a productivity differential or “distortion” in only one sector can have such a large aggregate impact on an economy. In general, if only one activity is distorted, economic agents will devote fewer resources to that activity and more to the other activities, thereby lessening the impact of the distortion. However, in our model output from agriculture is necessary and hence the economy cannot substitute away from it. Moreover, if productivity in agriculture goes down, then there will actually be an increase in the number of resources devoted to that activity.

We now consider the impact of non-agricultural policy on the structural transformation process. Although the non-agricultural TFP parameter does has no effect on the date at which industrialization begins it does affect the rate at which the agricultural sector declines. Towards this end, we compute the equilibrium for a number of economies all of which begin the process of industrialization in 1950 but which differ in non-agricultural TFP. The values of E_m we consider are .50, .25 and .10. Figure 6 shows agriculture's share of employment for these distorted economies and Figure 7 shows relative per capita GDP for these economies over the 1950-2050. Per capita GDP in date t is expressed relative to date t per capita GDP for the benchmark economy using year 2000 prices in the benchmark economy.

Figure 6 shows that differences in non-agricultural TFP can have large effects on the rate of decline on agriculture's share of employment. For instance, agriculture's share of employment in the economy with E_m=.10 reaches 50 percent 32 years later and reaches 25 percent 49 years compared to the economy with E_m=.50. We note that the first date in which the agricultural technology using capital uses is 1962, 1979 and 2080 in the three economies.

In terms of relative outputs, differences in non-agricultural TFP have very different implications for development paths. For the economy with $E_m = .10$ relative per capita GDP continues to fall over the industrialization process: for the economy with $E_m = 0.25$, relative per capita GDP does not change much over the industrialization process: and for the economy with $E_m = 0.50$ relative per capita GDP increases. We note that asymptotically, the per capita GDP of these three economies relative to the benchmark are 25, 6.25 and 1 percent.

To the extent that most poor countries in the world have started to industrialize, we can ask whether the disparity in incomes between the richest and poorest countries will increase or decrease over the next century. Whether the poorest countries continue to lose ground depends on how low non-agricultural TFP is in those countries. According to the model, if non-agricultural productivity is less than 25 percent the U.K. level, then the poorest countries in the world will get poorer over the next century. TFP for a number of manufacturing and service industries are estimated Bailey (1993), Bailey and Gerbach (1995), and Bailey and Solow (2001) for a set of rich and middle- income countries. These studies suggest that TFP in manufacturing and service industries differs a lot across rich countries. Although these studies do not cover the poorest countries in the world, (the poorest nation covered in these studies is Brazil), they do not rule out a further widening in income disparities over the next century.

3.2 Productivity Increases in Agriculture and Manufacturing

We now turn to the question of the importance of reforms in agriculture and in non-agriculture on an economy's development path. We begin by examining the effect of a one-time increase in agricultural TFP on an economy's development path. More specifically, we ask what would be the impact over the 1950-2000 period of a one-time increase in productivity in agriculture equal to 100 percent in 1950? We emphasize that there is a real world basis for this question. A substantial literature describes the Green Revolution of the period 1960-2000 in developing countries. (See, for example, Evenson and Gollin 2002.) Crop-level estimates of yield gain from the Green Revolution range from 20 percent to 100 percent.[14]

Figure 8 shows the relative income of the distorted economy, both with and without the productivity innovation. Without the innovation, E_a = .19. This is essentially the value of the non-agricultural TFP parameter that generates a starting date of 1950. With the innovation E_a = .38. In both cases E_m = .25. The results are striking. With the innovation, income relative to the benchmark economy in 1975 is equal to 18 percent. Without the innovation, income is equal to 8 percent of the benchmark economy's income. These differences decrease over time; in the year 2000, relative incomes of the distorted and the reform economies are 16 percent and 23 percent respectively. And by 2050, the relative income of both economies is roughly equal. Improvements in agricultural productivity, therefore, can have large impacts on cross-country income differences.[15] Equivalently, though we have not reported the growth rates of the two

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[14] . The Green Revolution is the term used to describe the application of modern (conventional) plant breeding techniques to the problems of developing countries. Although the biggest gains of the Green Revolution occurred in wheat and rice, advances have been made in almost all crops. Since 1960, more than 8,000 modern crop varieties have been released by breeding programs in the developing world. Crop-level estimates of yield gain from the Green Revolution range from 20 percent to 100 percent. According to Evenson (1999), the Green Revolution has contributed significantly to growth in agricultural TFP, which has increased at an annual rate of more than 1 percent over long time periods. Hence, this type of experiment is relevant for assessing the consequences of this type of change on the cross-country income distribution. In addition to technology changes, a number of counties have improved agricultural productivity through major changes in institutions – such as land reform designed to let individual farmers gain title to the land that they work. By improving the incentives of farmers, land reform can lead to dramatic increases in productivity. Taiwan offers a useful example of this. A major land reform in 1952 altered the incentives for smallholders to farm and to invest in land improvements. This land reform reinforced changes in technology and encouraged the rapid diffusion of modern rice varieties.

[15] The experiment just considered might well understate the true effects of technological innovation in the agricultural sector for the reason that the assumed innovation is associated with a one-time change in the

economies over time, it is clear that the economy with the innovation grows a lot faster over the period 1950-2000, implying that a productivity innovation can have substantial effects on growth rates over the short and medium run.

There are large differences in the size of agricultures share of employment between the two economies subsequent to 1950. We highlight these differences in Figure 9. In 1975, the economy with the innovation has xx percent of its labor force in agriculture, and in 2000 this value is down xx percent. In comparison, the economy without the innovation has an agriculture share of employment of xx percent in 1975 and xx percent in 2000. Larger increases in agricultural productivity result in larger decreases in agricultural employment.

We now consider how an increase in non-agricultural TFP affects an economy's development path, in particular, agriculture's share of employment and relative GDP per capita. Like the unexpected and permanent increase in the agricultural TFP parameter, an unexpected and permanent increase in the non-agricultural TFP will have consequences for the economy's development path in the short run. However, it also has consequences to the economy's development in the long run.

We attempt to highlight these short-run and long-run consequences by conducting the following experiment. Namely, we fix E_a = .19 and determine the value of E_m so that year 1985 relative GDP is the same as year 1985 relative output for the economy with the permanent and unexpected increase in agricultural TFP in 1950. The implied value for E_m is .37. This represents a 50 percent increase in non-agricultural TFP relative to the economy that does not undergo any 1950 reforms and the economy that undergoes a 1950

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level of productivity. As a matter of fact, introductions of new seed varieties were accompanied by changes in TFP agricultural growth.

agricultural reform. We include in Figure 8 the path of relative GDP for the economy that undergoes a 1950 non-agricultural reform. Asymptotically, the economy that undergoes the non-agricultural reform will have a relative income 14 percent of the benchmark economy's level whereas the economies that do not undergo non-agricultural reforms will be 6.25 percent the benchmark economy's level.

There is really nothing special about the year 1985. We could have chosen the value for E_m so that 1975 relative GDPs are the same across countries. This would imply a larger increase in non-agricultural TFP, and hence a larger asymptotic difference in relative outputs. To attain the same level of per capita GDP in 1975 as the economy that undergoes an agricultural reform, the non-agricultural TFP parameter must be .43 in the non-agricultural reform economy. Asymptotically, this country will have a per capita GDP that is 18 percent of the benchmark level.

Although these economies have the same per capita GDP in 1985, they look very different in terms of their structures. Figure 9 makes this point by including the plot of agriculture's share of employment for the economy that undergoes a non-agricultural reform in 1950. Agriculture's share of employment between the distorted and the non-agricultural reform economy are not much different over the 1950 to 2050 period. They are far smaller for the economy that undergoes the agricultural reform.

The relation between agriculture's share of f employment is a lot less clear. If we use each country's date t price of the manufacturing good to calculate agriculture's share of output, the output shares mimic the employment shares. This is shown in Figure 10. If however, we use a common price to value the manufacturing good we see that agriculture's share of output for the non-agricultural reform economy is very similar to the agricultural reform economy. These results are a consequence of the manufacturing good being relatively cheap in the non-agricultural reform economy.

4. Empirical Support

Underlying all of the above results is the implication that improvements in agricultural productivity allow resources to be released to other activities. Before going further with our analysis it is instructive to ask what the empirical support is for this proposition. In this section we document three facts about the agricultural transformation. First, in most poor countries, large amounts of labor and land are devoted to the production of basic foods for domestic consumption – in other words, to meeting subsistence needs. Second, increases in the productivity of the agricultural sector are associated with a structural transformation: the shifting of resources away from agriculture and into non-agriculture. Third, this structural transformation appears to play a critical role in economic growth: productivity gains in agriculture and the movement of resources into non-agriculture together account for the majority of growth in aggregate incomes. We consider these three facts in turn.

Subsistence needs

In most poor countries, agriculture accounts for very large fractions of employment and value added. Some agriculture is devoted to producing non-food export crops are important in some places. But in general, most of the land and labor in poor countries are devoted to food production – and specifically, to meeting the subsistence needs of the population.

Table 3 at the end of the paper shows the extent to which resources in the developing world are allocated to meeting subsistence needs. For the 97 countries in the data, in 1999, about 65 percent of arable land was devoted to grains, roots, and tubers.[16] Of the resulting production, almost all was devoted to domestic consumption: only a handful of developing countries were net exporters of grain or root crops (Argentina, Guyana, India, Paraguay, Thailand, Uruguay, and Vietnam).[17] Of these, only Argentina exported more than a quarter of its grain production (FAOSTAT 2001).

Thus, in today's poor countries, most of the resources in agriculture are used for meeting domestic food needs. The resources required are large, relative to the aggregate economy.

Productivity growth and the agricultural transformation

Early development economists were uncertain about the forces driving the agricultural transformation. One view, articulated by Lewis 1965, among others, was that the agricultural labor force was essentially a residual pool of effectively unemployed labor. In this view, the agricultural transformation was assumed to result from the emergence of a dynamic non-agricultural sector that would accumulate capital and perhaps bring improved technology.

An alternative view, identifiable in Schultz (1964) as well as in Johnston and Mellor (1961), was that productivity improvements within the agriculture sector were

[16] The data include all countries classified by the United Nations Food and Agriculture Organization (FAO) as developing countries for which arable land in 1999 was greater than 100,000 ha. The major countries missing from the data are the countries of the former Soviet Union, along with some small island countries and some small oil producers.

Note that it is possible for some arable land to be cropped more than once per year. This is why some countries show more than 100 percent of the arable land planted to grain, roots, and tubers.

[17] A number of countries from the former Soviet Union are major exporters of grain, including Ukraine and Kazakhstan.

critical to the agricultural transformation and would eventually – almost paradoxically – lead to the diminishing importance of the agricultural sector.

Forty years later, it seems fairly clear that the second view is more consistent with the data.[18] On average, countries that have succeeded in increasing productivity in agriculture have experienced relatively sharp declines in agriculture's share of GDP. In other words, growth in agricultural productivity has been associated with a diminishing role for agriculture. This result is fairly robust to the ways in which we measure agricultural productivity, and it mirrors results reported by Timmer (1988), among others.

Using data on a set of 62 countries defined as developing by the Food and Agriculture Organization (FAO) of the United Nations, and for which all relevant data were available, we can examine the relationship between agricultural productivity growth and structural change. Table 4 reports the results of an OLS regression on the data, for the 1960-90 period. The results show a negative and significant relationship between the change in agriculture's share of employment and the change in agricultural output per person.[19] A similar (stronger) result obtains if we use agricultural output per worker on the right-hand side, although this variable by construction is linked with agriculture's share of employment.[20]

The implication is that countries experiencing increases in agricultural productivity are able to release labor and other resources from agriculture into other sectors of the economy. This finding is particularly important because the data suggest that in most

[18] See the survey of Rosenszweig (1988) for persuasive defense of this.
[19] Agriculture's share of employment is a useful measure of agriculture's importance in economic activity. The other commonly reported measure – agriculture's share of GDP – is directly related to increases in productivity and thus is a less attractive measure of agriculture's importance in the economy.
[20] This also supports the notion that the increase in agricultural productivity is not occurring simply because unproductive labor is being removed from the sector.

poor countries, output per worker in non-agriculture is far higher than in agriculture. This means that a shift of workers from agriculture to non-agriculture increases average productivity in the economy. For example, shifting a worker from agriculture to non-agriculture in 1960 would have tripled his or her output in Korea or Malaysia; it would have increased it by a factor of nine in Thailand.

Agricultural productivity growth and economic growth

Productivity growth in agriculture thus has two major effects on economic growth. First, since agriculture is the largest sector in most poor countries, increases in agricultural productivity have a big direct impact on aggregate output. Second, by stimulating the movement of resources into non-agriculture, productivity growth in agriculture can help to raise the average productivity of the economy.

The first effect is visible in the data of Table 4, included at the end of the paper, which reports growth rates in agriculture, non-agriculture, and per capita GDP for the 1960-90 period. For most of the countries that grew the fastest in terms of real per capita GDP, agricultural productivity growth over this period was more rapid than non-agricultural productivity growth. This reflects, in part, the large initial size of the agricultural sector and the difficulty of achieving high growth in GDP per capita without gains in agriculture.

The second important effect of productivity growth in agriculture is to release workers to the non-agriculture sector. As noted above, the movement of labor from agriculture into non-agriculture is a critical part of the growth story.

Thus, the data support the idea – somewhat unconventional, in terms of the current growth literature – that improvements in agricultural productivity play an important role in stimulating economic growth. To formalize this idea, consider a decomposition of economic growth into three components: growth within agriculture, growth within non-agriculture, and growth attributable to sectoral shifts. Growth within agriculture is simply the growth in output per worker within agriculture, weighted by agriculture's share of GDP in the initial period. Similarly, growth within non-agriculture is the growth in output per worker in non-agriculture, weighted by the initial share of non-agriculture in GDP. Together, these two measures show how much growth could have been expected if the sizes of the two sectors had remained constant, and the only source of growth had been improvements in productivity within each sector. In actuality, however, there is a third source of growth – from sectoral shifts that reallocated workers from low productivity sectors to high productivity ones.

This decomposition is presented in Table 5. For 50 of the countries in the data, agricultural productivity growth and sectoral shifts were together more important contributors to the growth of real per capita GDP than is non-agricultural growth. These countries include Malaysia, Indonesia, Thailand, and China (though not Korea or Singapore). In slightly more than half of the countries – 36 out of 62 – agricultural productivity growth was higher than non-agricultural productivity growth. If one averages over the sample, one finds that the contribution of agricultural growth, non-agricultural growth, and sectoral shifts are 30 percent, 20 percent and 50 percent respectively. From this decomposition, we conclude that agricultural productivity growth, along with the ensuing sectoral shifts in employment, is an important source of economic growth.

5. Conclusion

We have shown in a rather simple model that low agricultural productivity can delay industrialization process for a long period of time. By delaying the industrialization process, such policies result in a country's per capita income falling far behind the leader. Improvements in agricultural productivity can hasten the start of industrialization, and by doing so can have large effects on a country's relative income. Such changes will, in the short-run have a larger impact than a comparable change in non-agriculture. Ultimately, however, the nature of non-agricultural policy determines a country's position to the leader. While we have painted a picture of development that uses fairly broad brush strokes, we believe the important message that emerges is that greater attention to the determinants of productivity in agriculture will greatly enhance our understanding of cross- country differences in income.

References

Bailey, Martin. 1993. Competition, Regulation, and Efficiency in Service Industries, *Brookings Papers on Economic Activity,* Microeconomics 2, 71–130.

Bailey, Martin and H. Gerbach. 1995. Efficiency in Manufacturing and the Need for Global Competition. *Brookings Papers on Economic Acrivity*, Microeconomics, 307-47.

Bailey, Martin and Robert M. Solow. 2001. International Productivity Comparisons Built from the Firm Level. *Journal of Economic Perspectives* **15** (Summer), 150-172.

Caselli, Francesco and Wilbur John Coleman II. Forthcoming. How regions converge. *Journal of Political Economy.*

Chari, V.V., Patrick Kehoe, and Ellen McGrattan. 1996. The poverty of nations: A quantitative exploration." NBER Working Paper 5414.

Chenery, H.B. and M. Syrquin. 1975. *Patterns of Development, 1950-1970*. London: Oxford University Press.

Echevvaria, Cristina. 1995. Agricultural development vs. industrialization: Effects of trade. *Canadian Journal of Economics* 28 (3): 631-47.

Echevarria, Cristina. 1997. Changes in sectoral composition associated with economic growth. *International Economic Review* 38 (2): 431-52.

Fei, John C. H. and Gustav Ranis. 1964. *Development of the Labor Surplus Economy*: *Theory and Policy*. A Publication of the Economic Growth Center, Yale University. Homewood, Illinois: Richard D. Irwin, Inc.

Gollin, Douglas, Stephen L. Parente, and Richard Rogerson. 2000. Farmwork, Homework and International Income Differences. Unpublished Manuscript.

Gollin, Douglas, Stephen L. Parente and Richard Rogerson. 2002. The Role of Agriculture in Development. *American Economic Review: Papers and Proceedings*.

Glomm, Gerhard. 1992. "A Model of Growth and Migration." *Canadian Journal of Economics*. 42 (4): 901-22.

Hansen, Gary and Edward C. Prescott. Forthcoming. From Malthus to Solow. *American Economic Review* .

Hayami, Yujiro and Vernon W. Ruttan. 1985. *Agricultural Development: An International Perspective*. Baltimore: Johns Hopkins University Press.

Johnston, Bruce F. and John W. Mellor. 1961. The role of agriculture in economic development. *American Economic Review* 51(4): 566-93.

Johnston, Bruce F. and Peter Kilby. 1975. *Agriculture and Structural Transformation: Economic Strategies in Late-Developing Countries*. New York: Oxford University Press.

Kuznets, Simon. 1966. *Modern Economic Growth*. New Haven: Yale University Press.

Kongsamut, Piyabha, Sergio Rebelo, and Danyang Xie. 1997. Beyond balanced growth. NBER Working Paper 6159.

Lucas, Robert E. 2001. Some Macroeconomics for the 21st Century. *Journal of Economic Perspectives* 14: 159-68.

Laitner, John. 1998. Structural change and economic growth. Manuscript: Department of Economics, University of Michigan.

Maddison, Angus. 1995. *Monitoring the World Economy: 1820-1992*. Paris: Development Centre of the OECD.

Mankiw, N. Gregory, David Romer, and David N. Weil. 1992. A contribution to the empirics of economic growth. *Quarterly Journal of Economics* 107 (2): 407-37.

Matsuyama, Kiminori. 1992 Agricultural productivity, comparative advantage, and economic growth. *Journal of Economic Theory* 58 (2): 317-34.

Mellor, John W. 1986. Agriculture on the road to industrialization. In *Development Studies Reconsidered*, ed. John P. Lewis and Valeriana Kallab. Washington DC: Overseas Development Council.

Ngai, Rachel. 1999. Barriers and the Transition to Modern Growth. Unpublished Manuscript, University of Pennsylvania.

Parente, Stephen L. and Edward C. Prescott. 1994. Barriers to technology adoption and development. *Journal of Political Economy* 102 (2): 298-321.

Parente, Stephen L. and Edward C. Prescott. 2000. Barriers to Riches. Cambridge: MIT Press.

Parente, Stephen L., Richard Rogerson, and Randall Wright. 2000. Home work in development economics: home production and the wealth of nations. *Journal of Political Economy*.

Schultz, T. W. 1964. *Transforming Traditional Agriculture*. New Haven: Yale University Press.

Syrquin, Moshe. 1988. Patterns of structural change. Chapter 7 in *Handbook of Development Economics, Vol. I*, ed. H. Chenery and T.N. Srinivasan. Amsterdam: Elsevier Science Publishers.

Timmer, C. Peter. 1988. The agricultural transformation. Chapter 8 in *Handbook of Development Economics, Vol. I*, ed. H. Chenery and T.N. Srinivasan. Amsterdam: Elsevier Science Publishers.

Table 3: Regression results: Changes in agricultural productivity and their relationship to changes in agriculture's share of employment, 1960-1990, for 62 developing countries.

Dependent Variable: Change in Log of Agriculture's Share of Employment

Regression Statistics	
Multiple R	0.423
R Square	0.179
Adjusted R Square	0.137
Standard Error	0.093
Observations	62
Significance – F	0.009

ANOVA

	Df	*SS*	*MS*	*F*
Regression	3	0.109	0.036	4.218
Residual	58	0.501	0.009	
Total	61	0.610		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-0.052	0.035	-1.479	0.145
Change in log ag output per person	-0.150	0.072	-2.076	0.042
Ag Output per Person 1970	-1.6E-4	8E-05	-1.984	0.052
Dummy: 1960 data	-0.075	0.024	-3.018	0.004

Table 4: Variables relating to the structural transformation of agriculture, 62 developing countries, 1960-90.

Country	Non-Ag Productivity Growth	Ag Productivity Growth	Fraction of Workforce in Agriculture, 1960	Fraction of Workforce Moving to Non-Agriculture	Initial Ratio of Non-Ag Prod to Ag Prod	Average Growth in GDP Per Capita (PWT), 1960-90	Notes on GDP Growth Rates
Singapore	1.068	1.081	0.074	0.070	2.035	1.074	
Korea Rep	1.055	1.059	0.613	0.432	2.938	1.071	
Malaysia	1.030	1.046	0.633	0.359	3.295	1.046	
Indonesia	1.039	1.015	0.748	0.196	2.800	1.045	
Lesotho	1.077	1.010	0.473	0.073	0.295	1.045	
Thailand	1.026	1.020	0.837	0.196	8.954	1.042	
Jordan	1.026	1.059	0.498	0.347	3.767	1.041	
Syria	1.000	1.073	0.607	0.275	5.087	1.037	
China	1.011	1.039	0.830	0.110	16.945	1.037	
Brazil	1.017	1.030	0.552	0.319	4.747	1.035	
Congo, Dem R	0.991	1.057	0.793	0.115	17.755	1.033	
Egypt	1.010	1.025	0.658	0.255	3.779	1.032	
Cameroon	0.991	1.019	0.892	0.195	12.317	1.031	
Nigeria	1.018	1.015	0.732	0.301	1.543	1.029	
Ecuador	1.015	1.015	0.594	0.262	3.560	1.029	1970-87
Algeria	0.994	1.073	0.710	0.449	10.344	1.028	
Morocco	1.002	1.037	0.731	0.284	7.487	1.028	
Colombia	1.013	1.027	0.521	0.255	2.380	1.025	
Paraguay	1.019	1.026	0.542	0.153	2.066	1.025	
Dominican Rp	1.005	1.022	0.636	0.388	2.992	1.024	
Gabon	0.996	0.989	0.852	0.337	12.127	1.023	
Pakistan	1.025	1.012	0.658	0.140	2.236	1.023	
Sri Lanka	1.015	1.018	0.566	0.081	2.811	1.023	
Mauritius	1.036	1.068	0.396	0.229	2.695	1.022	1960-89
Fiji Islands	1.023	1.008	0.596	0.142	2.638	1.022	
Rwanda	1.029	0.975	0.947	0.030	7.483	1.022	1960-89
Togo	1.012	1.009	0.801	0.145	3.312	1.019	1960-88
Trinidad Tob	1.013	0.986	0.217	0.106	2.058	1.017	
India	1.012	1.009	0.754	0.114	3.706	1.017	1970-90
Costa Rica	1.009	1.023	0.512	0.251	2.520	1.016	
Philippines	1.005	1.021	0.636	0.178	5.074	1.015	
Kenya	1.000	1.009	0.879	0.083	11.719	1.015	
Honduras	0.993	1.011	0.725	0.311	4.406	1.012	
Gambia	0.993	1.000	0.892	0.072	12.838	1.012	
Burkina Faso	1.014	0.995	0.918	-0.006	13.780	1.010	1960-89
Malawi	0.988	1.011	0.936	0.070	14.671	1.010	
Guatemala	0.993	1.007	0.661	0.137	4.174	1.010	
Zimbabwe	0.989	1.009	0.808	0.126	16.015	1.010	1960-89
Bangladesh	0.982	1.006	0.876	0.224	8.370	1.008	

Country	Non-Ag Productivity Growth	Ag Productivity Growth	Fraction of Workforce in Agriculture, 1960	Fraction of Workforce Moving to Non-Agriculture	Initial Ratio of Non-Ag Prod to Ag Prod	Average Growth in GDP Per Capita (PWT), 1960-90	Notes on GDP Growth Rates
Chile	1.008	1.027	0.303	0.115	4.177	1.007	
Uruguay	1.009	0.989	0.213	0.071	0.891	1.007	1960-89
Jamaica	1.003	1.014	0.415	0.169	6.104	1.007	
Mali	1.002	0.997	0.938	0.080	6.518	1.006	
Argentina	0.990	0.996	0.206	0.085	1.787	1.006	
El Salvador	1.003	0.997	0.618	0.254	1.978	1.005	
Peru	0.998	0.978	0.523	0.167	4.061	1.005	
Burundi	1.032	1.013	0.947	0.030	6.046	1.004	
GuineaBissau	0.971	1.012	0.912	0.060	8.492	1.004	
Senegal	0.992	0.998	0.839	0.071	17.071	1.002	
Papua N Guin	0.972	0.978	0.896	0.104	10.600	1.001	
Mauritania	0.953	1.003	0.921	0.369	12.435	1.001	
Uganda	0.963	1.004	0.927	0.082	11.850	0.999	
Venezuela	0.988	1.036	0.334	0.214	9.947	0.996	
Ghana	0.992	1.006	0.633	0.040	2.499	0.995	
Benin	0.968	0.998	0.850	0.215	6.629	0.995	
Sierra Leone	0.950	1.006	0.813	0.139	7.334	0.995	
Cent Afr Rep	0.948	1.007	0.934	0.132	14.921	0.995	
Guyana	0.976	1.021	0.377	0.158	1.700	0.993	
Nicaragua	0.948	1.010	0.630	0.344	3.161	0.990	
Zambia	0.962	1.007	0.846	0.099	28.722	0.990	
Madagascar	0.953	0.991	0.862	0.080	16.639	0.980	1960-86
Chad	0.941	0.975	0.955	0.123	30.765	0.971	

Table 5: Growth decomposition, 62 countries, 1960-90.

Country	Contribution from non-agriculture only	Contribution from agriculture only	Contribution from sectoral shifts
Singapore	0.068	0.000	0.006
Korea Rep	0.045	0.011	0.015
Malaysia	0.022	0.013	0.011
Indonesia	0.018	0.008	0.020
Lesotho	0.046	0.004	-0.005
Thailand	0.010	0.013	0.020
Jordan	0.022	0.009	0.010
Syria	0.000	0.024	0.014
China	0.003	0.028	0.006
Brazil	0.013	0.007	0.015
Congo, Dem R	-0.003	0.038	-0.003
Egypt	0.006	0.010	0.016
Cameroon	-0.003	0.013	0.020
Nigeria	0.010	0.006	0.012
Ecuador	0.010	0.005	0.013
Algeria	-0.004	0.019	0.013
Morocco	0.001	0.017	0.010
Colombia	0.009	0.007	0.008
Paraguay	0.011	0.010	0.003
Dominican Rp	0.004	0.006	0.014
Gabon	-0.002	-0.006	0.031
Pakistan	0.012	0.006	0.005
Sri Lanka	0.008	0.009	0.007
Mauritius	0.030	0.011	-0.019
Fiji Islands	0.012	0.004	0.006
Rwanda	0.002	-0.023	0.043
Togo	0.004	0.006	0.009
Trinidad Tob	0.012	-0.002	0.007
India	0.004	0.006	0.007
Costa Rica	0.007	0.006	0.003
Philippines	0.003	0.010	0.003
Kenya	0.000	0.007	0.008
Honduras	-0.004	0.004	0.012
Gambia	-0.001	0.000	0.013
Burkina Faso	0.001	-0.005	0.014
Malawi	-0.002	0.010	0.002
Guatemala	-0.003	0.004	0.009
Zimbabwe	-0.003	0.006	0.007
Bangladesh	-0.006	0.004	0.010

Chile	0.007	0.005	-0.004
Uruguay	0.008	-0.002	0.001
Jamaica	0.002	0.003	0.002
Mali	0.000	-0.002	0.009
Argentina	-0.009	0.000	0.015
El Salvador	0.002	-0.001	0.004
Peru	-0.001	-0.008	0.013
Burundi	0.003	0.012	-0.011
GuineaBissau	-0.004	0.010	-0.002
Senegal	-0.002	-0.001	0.005
Papua N Guin	-0.006	-0.018	0.025
Mauritania	-0.021	0.002	0.020
Uganda	-0.006	0.004	0.001
Venezuela	-0.010	0.004	0.002
Ghana	-0.003	0.004	-0.005
Benin	-0.012	-0.002	0.008
Sierra Leone	-0.016	0.004	0.008
Cent Afr Rep	-0.010	0.006	-0.001
Guyana	-0.019	0.005	0.007
Nicaragua	-0.037	0.003	0.025
Zambia	-0.010	0.005	-0.006
Madagascar	-0.010	-0.007	-0.003
Chad	-0.010	-0.021	0.002

Figures

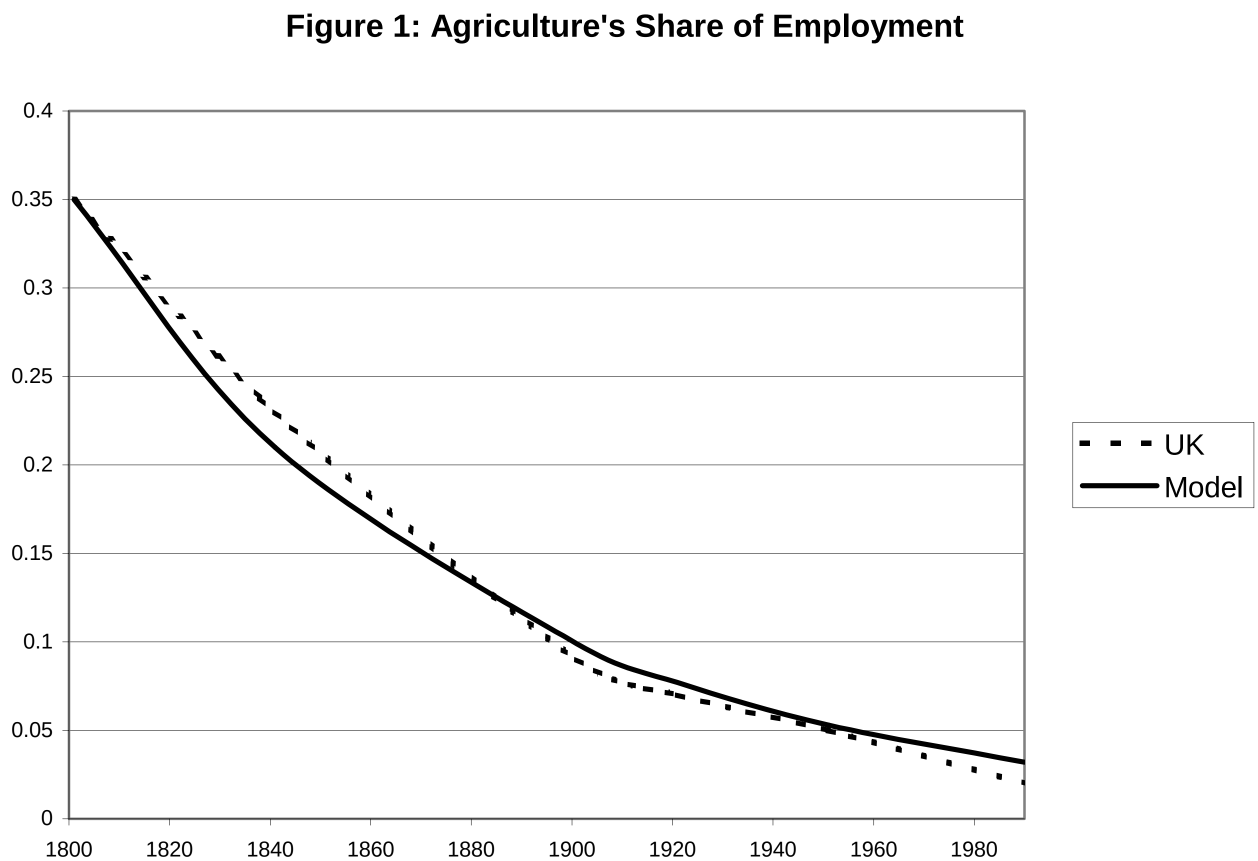
Figure 1: Agriculture's Share of Employment
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1800
1820
1840
1860
1880
1900
1920
1940
1960
1980
UK
Model

Figure 2: Per Capita GDP relative to 1820

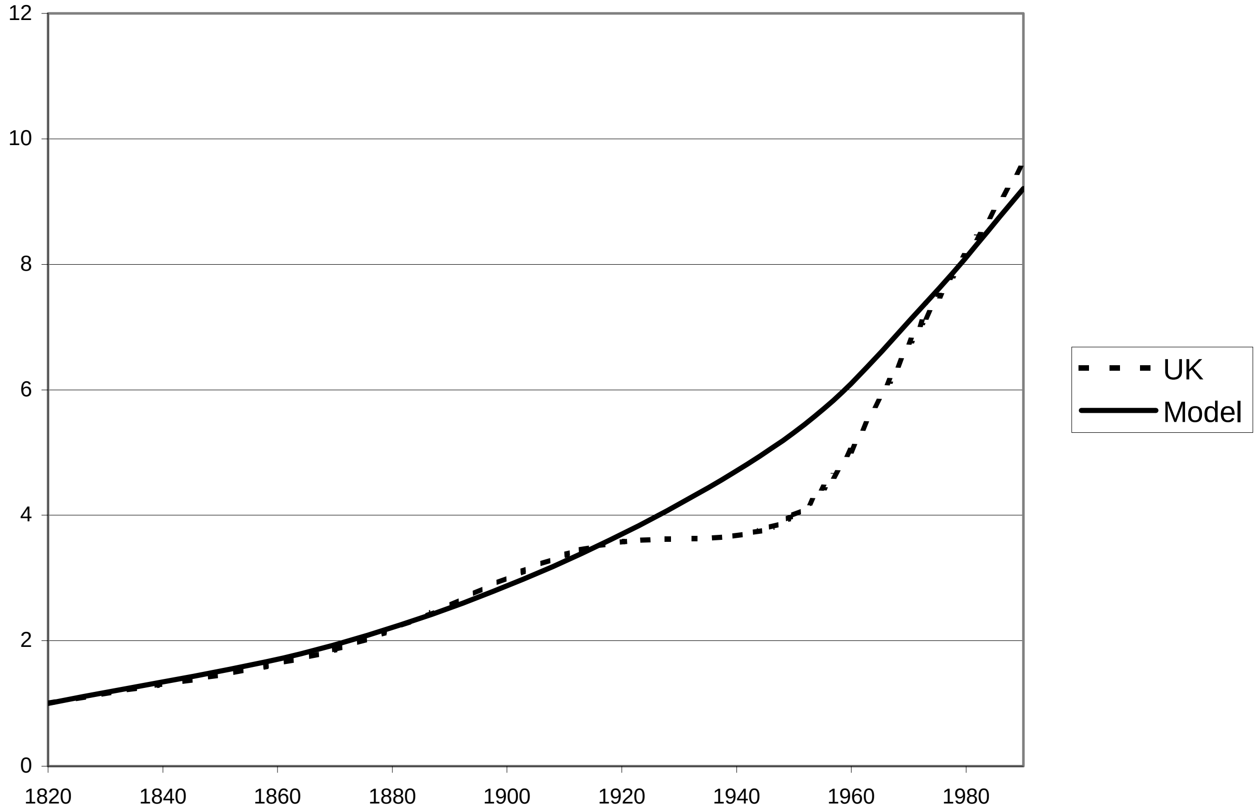

Figure 3: Agriculture's Share of Output

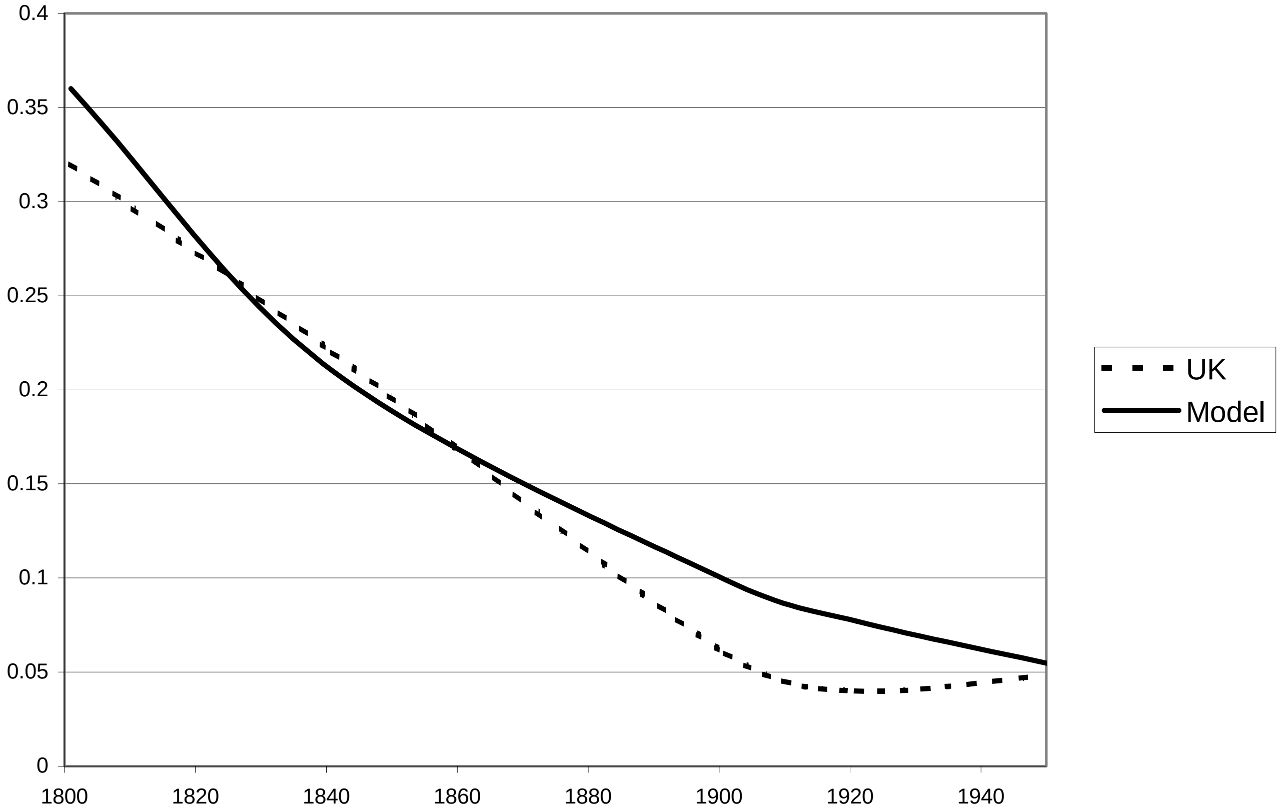

Figure 4: Agriculture's Share of Employment for Different Industrialization Dates

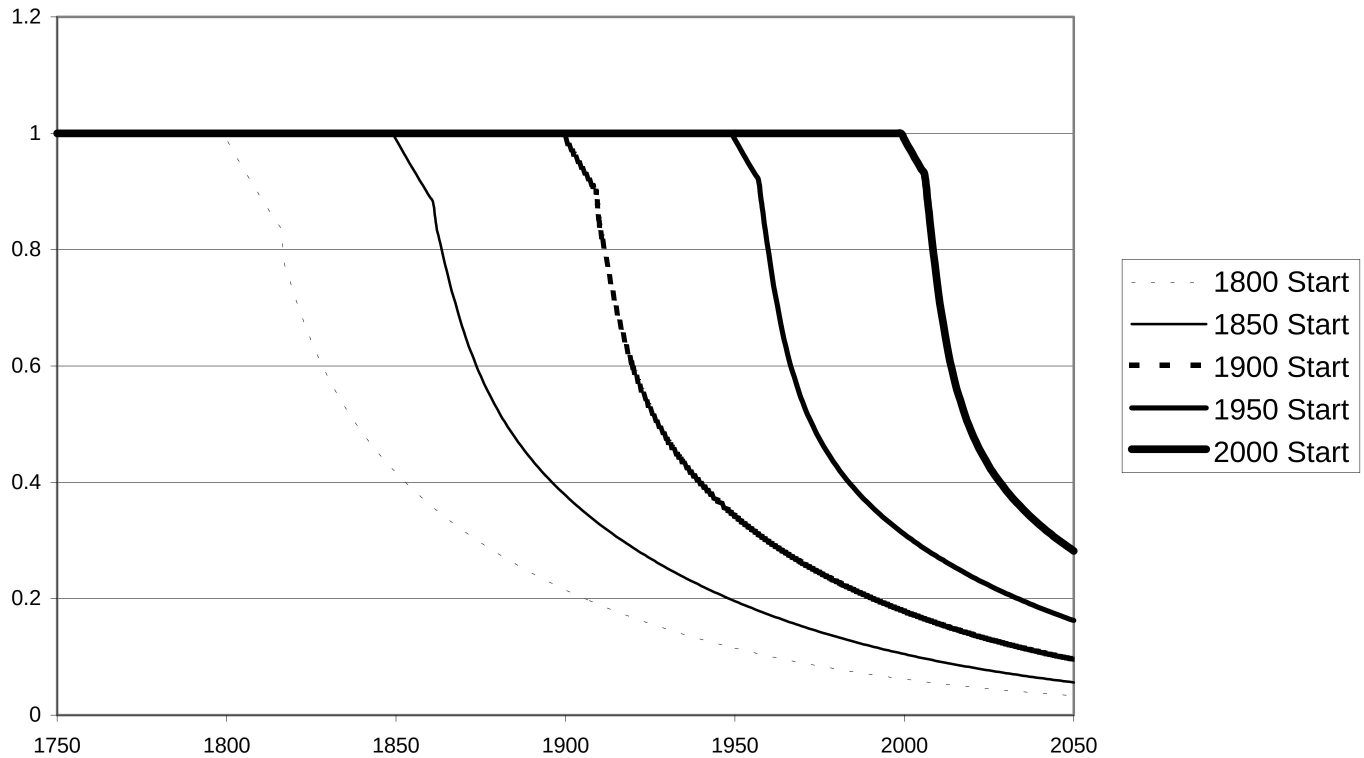

**Figure 5: Relative Per Capita GDP
for Different Industrialization Dates**

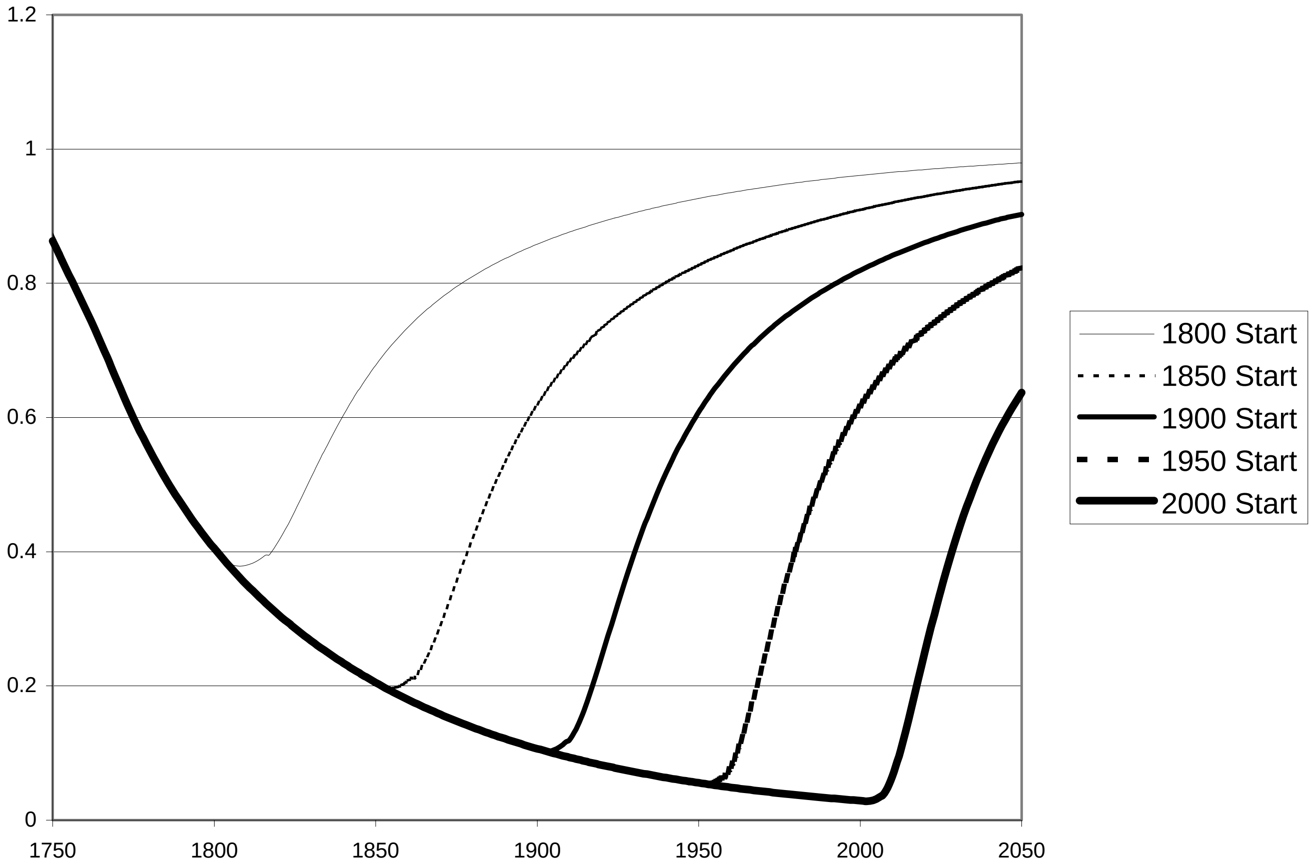

Figure 6: Agriculture's Share of Employment for Different Non-Agriculture Productivity

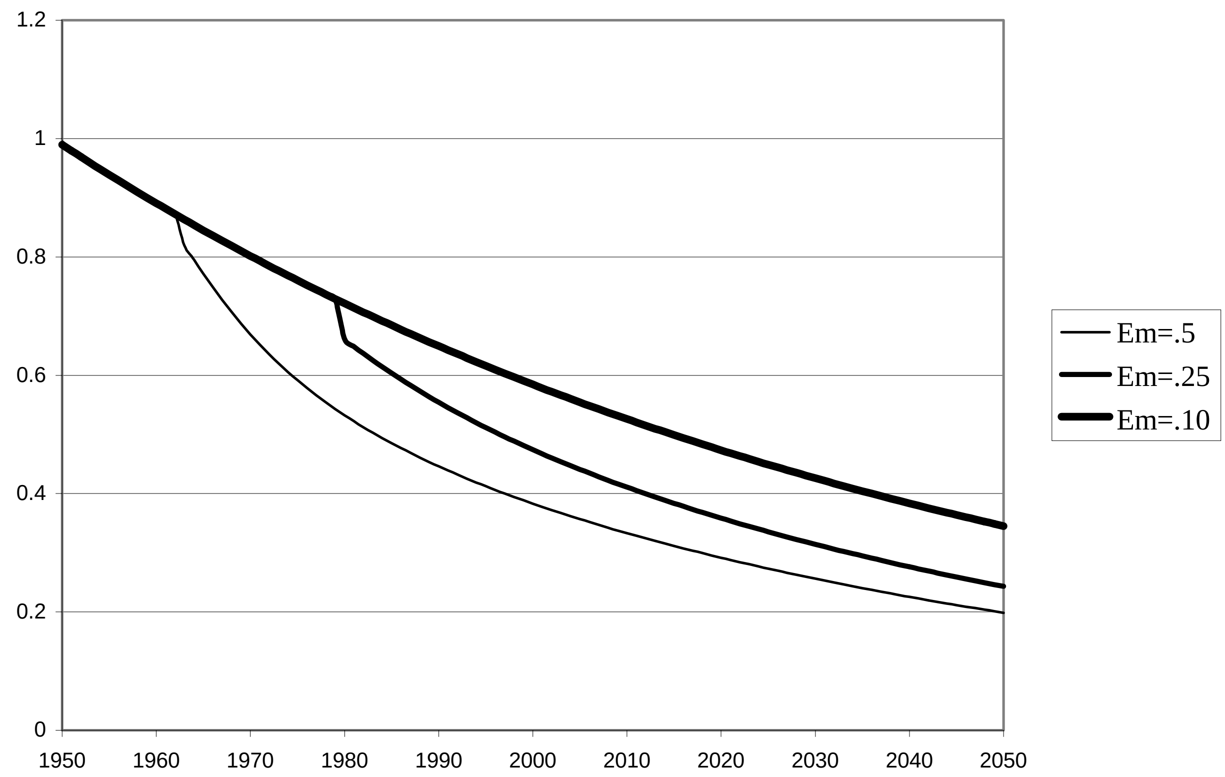

Figure7: Relative Per Capita GDP
for Different Non-Agricultural Productivity

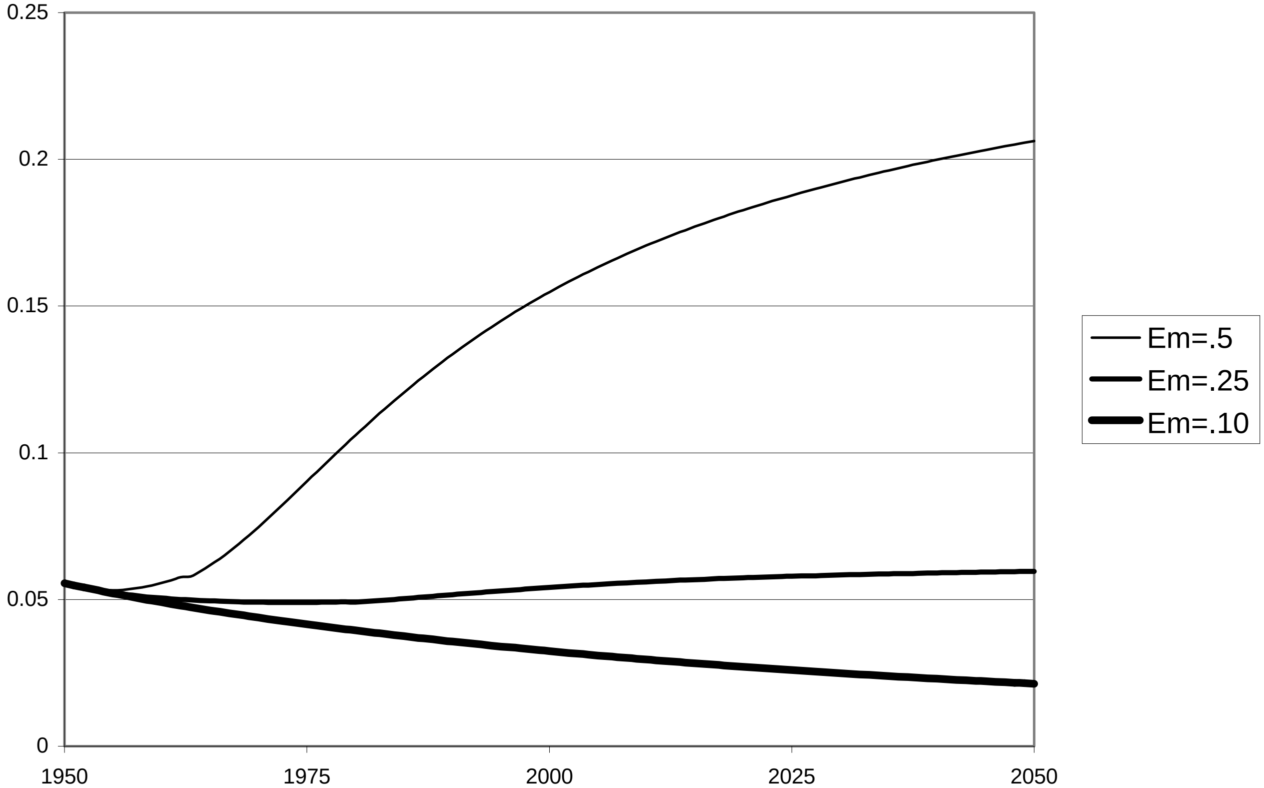

Figure 8: Relative per capita GDP following Reforms

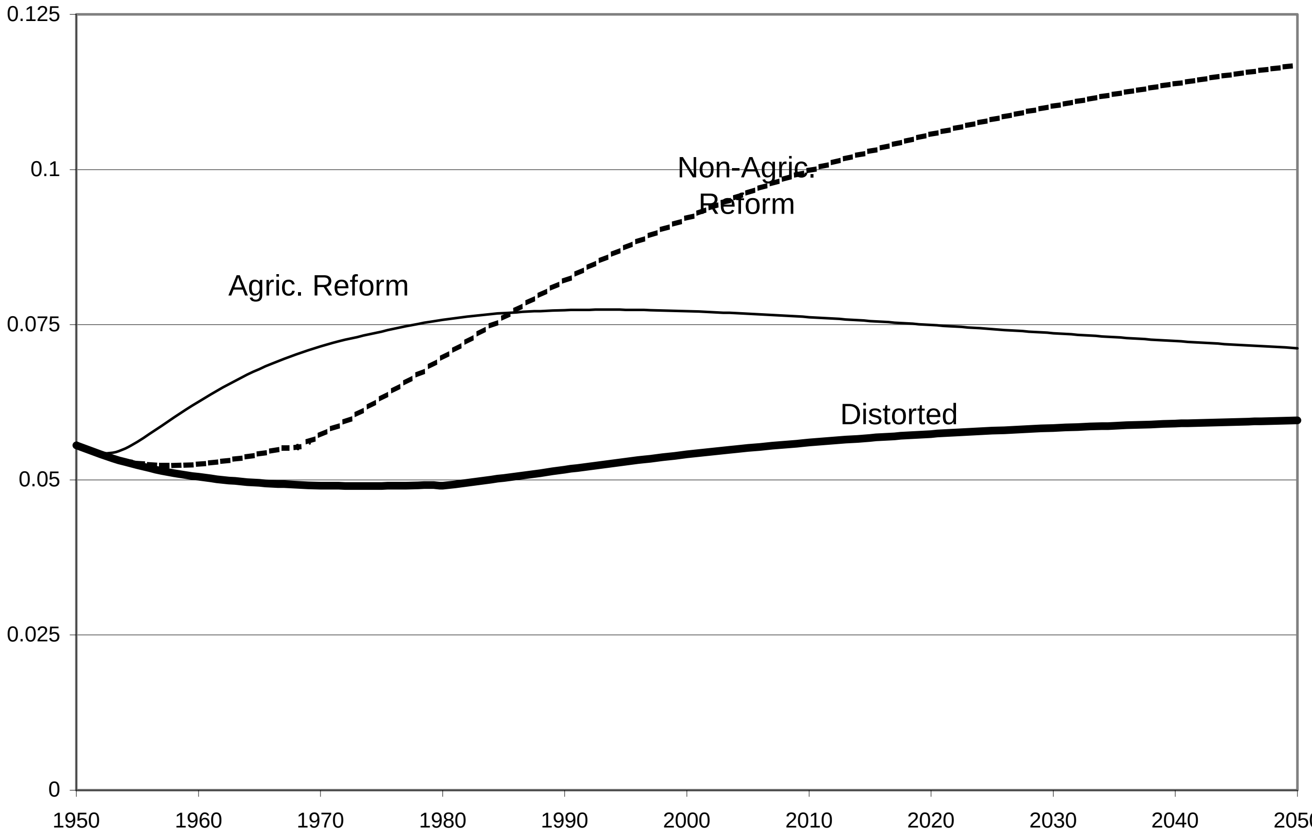

Figure 9: Agriculture's Share of Employment following 1950 Reforms

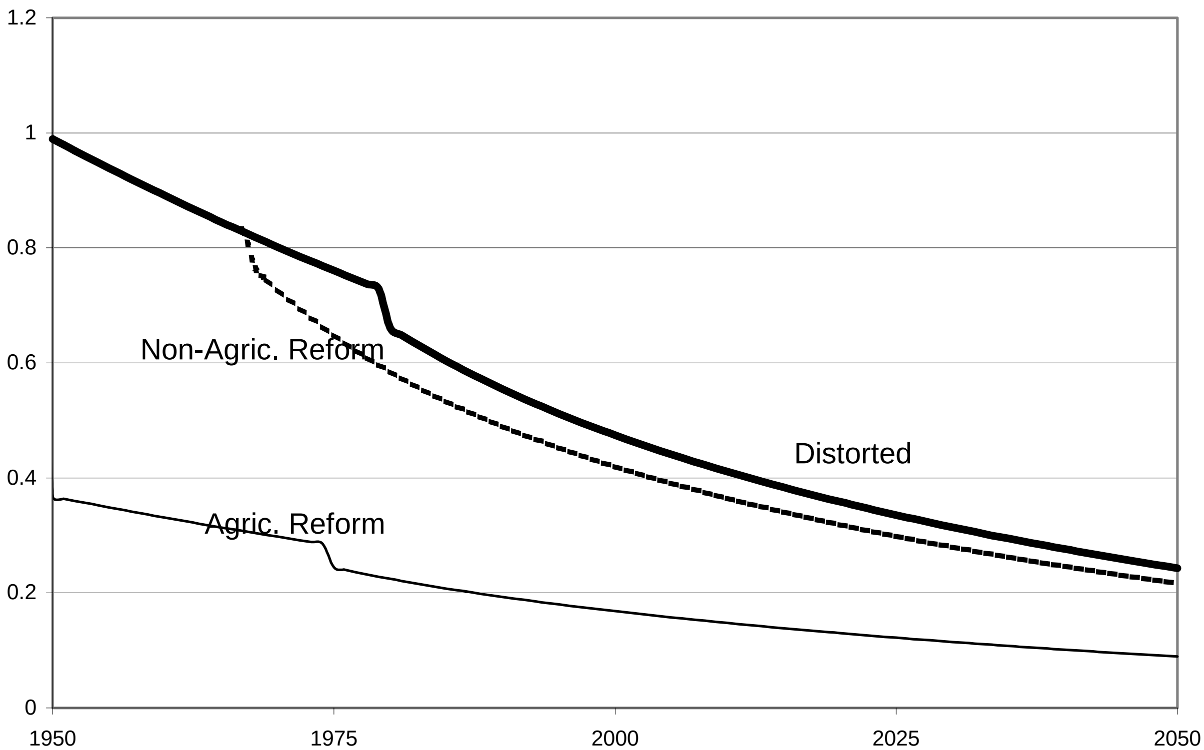

Figure 10: Agricultures Share of GDP Following Reforms
(date t country prices)

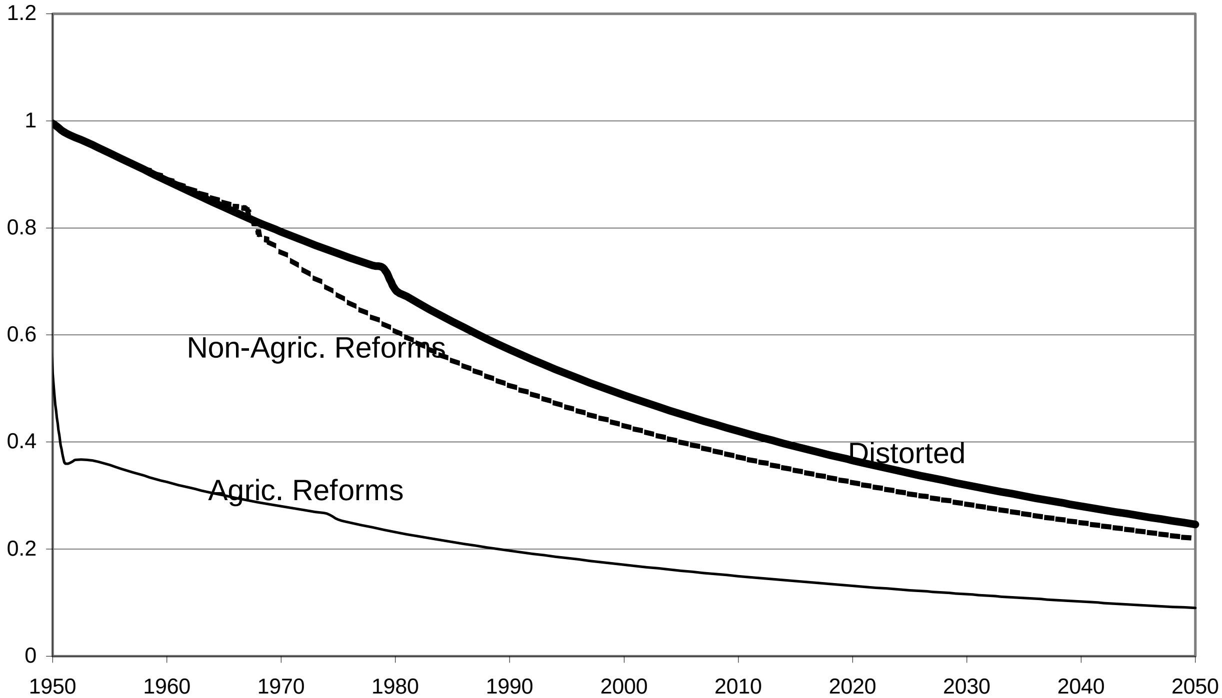

Figure 11: Agriculture Shares of GDP following Reform
(year 2000 UK prices)