Dual Economies and International Total Factor Productivity Differences*

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Abstract

This paper argues that a significant part of measured TFP differences across countries is attributable not to technological factors that affect the entire economy neutrally, but rather, to variations in the structural composition of economies. In particular, the allocation of scarce inputs between agriculture and non-agriculture seems to be important. We provide a theory which links the institutional framework to the long-run composition of the economy, and thereby to measured TFP and income per worker. A decomposition analysis suggests that between 30 and 50 percent of the international variation in TFP can be attributed to the composition of output. Estimation exercises suggest that recent findings of a conducive effect from institutions, and to some extent, geography, on long-run prosperity and TFP, may be thus explained.

Keywords: Dual Economy, Structural Change, Total Factor Productivity, Institutions, Geography

JEL Classification: O41, O47, O50

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It is certainly unwise to suggest that all economies are equally efficient at reallocating inputs across sectors. This difference will be reflected in $A(t)$, and maybe not only there [...] the non-technological sources of differences in TFP may be more important than the technological ones. Indeed, they may control the technological ones, especially in developing countries.
– Robert Solow (2001, p.285 and 287).

1 Introduction

The problem of economic growth is often viewed as a problem of structural change. Be it the neoclassical growth models from the sixties or models from the new growth theories in the nineties, the issue of "duality" remains a central focus. In the former literature it was framed in the context of "agriculture versus industry" or "rural versus urban" while more recently it has manifested itself in terms of "unskilled versus skilled". For economists such as William Arthur Lewis, the central problem of development was to be solved by ensuring that agriculture continued to maintain its production levels while workers moved to the nascent industrial sector. In the more recent economic growth literature, papers such as Mankiw, Romer and Weil (1992) provided evidence that an augmented version of the Solow Model with human capital provided better empirical support than a specification with only raw labor and physical capital, paving the way for a huge literature based on the distinction between the educated versus the uneducated.

A more recent outgrowth of the new growth theory has been increasing evidence suggesting that differences in living standards can be overwhelmingly explained by differences in total factor productivity (TFP) and not differences in the stocks of raw labor, human capital and physical capital. Hall and Jones (1999) and Klenow and Rodriguez-Clare (1997) were the initial studies suggesting that differences in TFP might explain more than 60% of the differences in output per worker.[1] Not surprisingly, this has led to an increasing focus on explaining differences in TFP rather than factor accumulation. For example, Hall and Jones themselves provide estimates that the "social infrastructure" of societies are important in explaining these differences. Social infrastructure is argued to be determined by factors such as the long run evolution of institutions that protect property rights, in turn affected by colonial history, and even geographical factors.[2] Of course ultimately these factors may help determine the pace of technology adoption and factor accumulation – the more proximate determinants of output.

[1] Recent work supporting this view includes Easterly and Levine (2001) and Hendricks (2002).

[2] Other contributions supporting the view that institutions are key, and that geography matter indirectly through them, include Acemoglu, Johnson and Robinson (2001) and Easterly and Levine (2002).

In this paper we attempt to build a bridge between these recent developments and the more long-standing view that an economy's living standards are strongly tied to its composition of output. More specifically, we show that there exists a mapping from two sector models to the single sector models of the type used by Hall and Jones (which represents a large class of models in growth theory) such that the aggregate TFP measured in the latter variety can be significantly influenced by the structure of an economy. Moreover, we incorporate a mechanism such that institutional quality determines the composition of output and hence, build a theory that explicitly models the links from institutional differences to differences in aggregate TFP. Our claim, therefore is that the correlation between institutions and TFP arises primarily because the former determines the composition of the economy between agriculture and non-agriculture. The theoretical argument rests on three elements.

First, aggregate income per worker can be regarded as a weighted sum of labor productivity in the individual sectors of the economy. At its most basic level; a weighted sum of labor productivity in agriculture and "non"-agriculture. When levels accounting is conducted, then part of the "residual" will be explained by the weights and the relative productivity of the respective sectors. Second, the agricultural sector is usually more labor intensive, and less capital intensive, than the non-agricultural sector. In order to simplify the theoretical analysis, we will make the extreme assumption that capital only serves as an input in the non-agricultural sector.[3] Third, "weak" institutions tend to make foreign investors less willing to supply funds for domestic borrowers. Specifically, while domestic borrowers are credit constrained in the international capital markets, a more "sound" institutional framework facilitates the access to these markets, where capital can be obtained at a lower cost. Institutions will therefore matter for the rate of capital accumulation, and ultimately, for the structure of the economy and the standards of living.

The three elements interact in the following way. In countries with a "strong" institutional framework, the rate of capital accumulation will be higher due to the relatively easy access to world capital markets. As capital accumulates, labor is shifted from agriculture into manufacturing, since the latter is able to offer a higher wage. In transition, therefore, the economy ventures through the structural transformation described by authors such as Kuznets (1957) and Chenery (1960),

[3] A recent study Martin and Mitra (2002) estimates a Cobb-Douglas production function for a cross-section of developing countries and find that the capital elasticity in agriculture is relatively modest, at 0.12. However, the authors also find that the translog production function outperforms the Cobb-Douglas specification. Thus, the share is likely to change during development. In any case, suppressing capital in the agricultural sector has been a commonly used simplification in the literature on dual economies. See e.g. Jorgenson (1961) and Dixit (1970). More recent examples include Kögel and Prskawetz (2001) and Galor, Moav and Vollrath (2002). In our accounting exercise, however, we do allow capital to enter the agrarian production function.

whereby output is reallocated from agriculture into sectors such as manufacturing and services. However, in the present framework, the agricultural sector is not degenerate, in the sense that its size tends to become infinitesimally small in the long-run. Rather, the size of the agricultural sector will tend to a (non-zero) steady state plateau. In the steady state countries with strong institutions, will be characterized by lower agricultural output shares. Since the average productivity in agriculture is relatively lower than in non-agriculture, a higher share of agriculture will entail lower aggregate income per worker. Moreover, we show how standard calculations of aggregate TFP will tend to engulf this composition effect. Therefore, in a reduced form sense, aggregate TFP will be affected by institutions.

Finally our model also suggests alternative routes through which human capital can affect aggregate TFP as opposed to the more traditional catch-up arguments.[4] As long as human capital increases the marginal product of labor in the non-agricultural sector more than in agriculture, an increase in the stock of human capital moves labor into the non-agricultural sector. This occurs due to the interaction between human capital and capital accumulation in the non-agrarian sector. Again as long as the relative productivity in agriculture is lower, this raises aggregate output per worker. Aggregate calculations of TFP will also mask this effect. Further if one concurs with the view that measures of human capital should also include health capital, then to the extent that geography matters for health outcomes, geography will matter too, for aggregate TFP independently of institutions.[5]

In the empirical portion, we undertake some static decomposition exercises to support our argument that observed variations in measured aggregate TFP are indeed driven by differences in the composition of output. These exercises are similar in spirit to Hall and Jones (1999) and Klenow and Rodriguez-Clare (1997). The theoretical model provides a framework to do this without us requiring any further assumptions beyond the standard assumptions prevalent in the literature on levels-accounting, and without actually estimating sector specific levels of TFP. Finally, we present econometric evidence suggesting that the historical determinants of the evolution of institutions and to some extent geographical factors are significant in explaining the structure of output across economies which in turn are more important in explaining TFP differences. In fact, once the structural composition of the economy is controlled for, measures of institutional quality are no longer significantly related to the level of TFP, which indicates that a critical manifestation of "high

[4] See Nelson and Phelps (1965).

[5] See Bloom and Sachs (1998) and Schultz (1999), on the relationship between climate and health. See Weil (2001) for a discussion of microeconomic evidence on the relationship between health and productivity, as manifested by variation in individual wages and the effects of health on cross country output per worker differences.

quality institutions" is that they ensure an efficient allocation of scarce resources across sectors. This is, we believe, encouraging news, in that it opens up for the possibility of affecting TFP through conventional policy instruments (like taxes and subsidies) thus compensating for weak underlying institutions.[6]

The paper proceeds as follows. After discussing related literature, Section 2 outlines the theoretical model. Section 3 contains the decomposition analysis and the econometric evidence. Section 4 concludes.

1.1 Related Literature

As mentioned above, the present paper relates to two distinct lines of literature; the empirical literature which attempts to understand why levels of production per worker vary across countries, and the (mostly) theoretical literature on dual economies of agriculture versus industry variety.

The latter literature is rather large. Initial contributions studied the conditions under which the economy would be able to transition from relying mainly on the (backward) agricultural sector to an "industrial" society (e.g. Jorgenson, 1961; Mas-Colell and Razin, 1970; Dixit, 1970). This first wave of contributions typically assumed that fertility was exogenous, or, postulated a link between population growth and income per capita.[7] The challenge of understanding the (very) long-run evolution of the economy has recently received renewed attention, following the work of Galor and Weil (2000). This literature attempts to understand the evolution of economic systems over hundreds of years. In particular the focus has been to clarify, not only the key driving forces behind the industrial revolution, but also the demographic transition whereby fertility first increases but ultimatly stagnates and declines. Endogenizing the fertility decision is key, in that this literature views the transition into "the modern growth regime" and the demographic changes as highly interrelated occurrences. Recent models which combine the older literature on dual economies, with the more recent contributions on growth over the very long run, includes Hansen and Prescott (2002) and Kögel and Prskawetz (2001). The two papers most closely related to the theoretical

[6] In the end, combining the finding that TFP is the main source of global inequality with the notion that institutions determines TFP is slightly worrisome. At face value, together these findings essentially mean that a variable that measures our ignorance can be explained by a variable we don't really know how to create.

[7] A series of recent contributions examine this structural transformation of the economy in models featuring optimizing behavior of households, but exogenous fertility. Kongasmut *et al* (2002) extends the analysis to allow for a service sector, the importance of which rises during development. Gollin *et al* (2000, 2002) argues that a major reason for the variation in living standards, as reflected in post-WWII data, can be attributed to differences in the timing of the structural transformation. A view very much in accord with the ideas forwarded in Lucas (2000). Laitner (2000) shows how the savings rate may increase over time in an economy, as a consequence of structural adjustment, and Robertson (1999) argues that a dual economy framework may be useful in understanding how large income differences may co-exist along side small differences in real rates of return on capital.

argument forwarded here, however, are Graham and Temple (2001) and Restuccia (2002). Both papers establish a link from the composition of output to measured TFP, albeit through different mechanisms.

Graham and Temple (2001) considers the possibility of economies of scale in the non-agricultural sector, arising from agglomeration externalities. These are shown to lead to multiple steady states, distinguished by the level of income per worker, and by the output contribution of agriculture. The authors show that standard measures of TFP might be capturing the influence from such multiplicity, and consequently, from the sectoral composition of output. Restuccia's (2002) argument builds on the premise that the level of agricultural TFP is lower than that of the non-agricultural sector. He proceeds to show how aggregate TFP may be regarded as (roughly) a weighted sum of TFP in the two sectors, where the weights consists of the respective labor shares. He also shows how barriers to capital accumulation will matter for the long-run output composition of the economy.[8]

The present paper does not focus on the issue of multiple equilibria, makes no use of externalities, is consistent with common levels of TFP across sectors, and moreover, provides a theoretical link between institutions, the size of the agrarian sector, and TFP. Irrespective of these differences in analytical framework, it should however be pointed out that our empirical approach is unable to distinguish between different mapping from sectoral shares to GDP. Consequently our empirical results can equally well be seen as supportive of the views forwarded in Graham and Temple (2001) and Restuccia (2002).

Our empirical work is related to the recent inquiry into the causes of differences in levels of income per worker, which argues that institutions (and indirectly, geography) are pivotal in understanding such differences (Hall and Jones, 1999; Acemoglu et al, 2001; Easterly and Levine, 2002), as well as contributions which have focused on quantifying the growth contributions stemming from structural change (Robinson , 1971; Dowrick and Gemmel, 1991; Caselli and Coleman, 2001). Robinson find, in a cross-section of developing countries, that between fifteen and twenty percent of the annual growth from 1955-1968 can be attributed to the reallocation of resources, i.e. capital and labor, from agriculture to (a more productive) non-agricultural sector. Dowrick and Gemmel attempt to distinguish between different convergence clubs, and also find that intersectoral labor allocation has a significant effect on growth from 1960-85. Caselli and Coleman (2001) argue that the structural transformation of the US economy was instrumental for the observed regional convergence of income per worker.

[8]Finally, another approach at explaining TFP differences is that of Caselli and Coleman (2002) where TFP or efficiency is "factor-specific". They find that increased efficiency associated with skilled labor comes at the cost of reduced efficiency of unskilled labor. Thus they focus on factor differences and not on sectoral differences.

Our approach combines these two strands of literature in arguing that climate and institutions matter for the reallocation of resources and thus for growth, as manifested in levels. A difference, however, to previous contributions on the growth implications of structural transformation is that while these concentrated on income per worker (or capita), we examine the implications for measured TFP. Like the recent empirical literature on level differences, we pay close attention to the endogeneity of both institutions, and the composition of output.

2 The Model

Consider a small open economy where individuals have partial access to international capital markets. The economy is inhabited by an infinite sequence of overlapping generations. The total population is assumed constant and of measure one. Time is discrete $t = 0, 1, 2...$, and all markets are competitive. The economy comprises two sectors producing a homogenous good, which can either be consumed or invested. The price of output is normalized to one. The two sectors differ with respect to their inputs, as detailed below.

2.1 Production

Consider the agricultural sector (from now on referred to as "the a-sector"). Here production uses human capital, h, raw labor, L^a, and a natural resource, N, which can be thought of as land. The production technology is Cobb-Douglas:

$$Y_t^a = A_t^a \left(hL_t^a\right)^\gamma N^{1-\gamma}, \ 0 < \gamma < 1. \tag{1}$$

As the size of the labor force has been normalized to one, L_t^a also represents the share of the labor force allocated to the a-sector. As can be seen, constant returns to labor and land is assumed to prevail. A_t^a represents an index for technology in the a-sector. It expands over time at the exogenous rate g. The stock of human capital is constant over time, but may vary from one economy to the next, due to differences in schooling and/or geographic circumstances. The latter caused by the likely relationship between climate and health status, as argued above. For simplicity land is considered a free good which is being fully utilized at all points in time. Without loss we normalize N to one in the remaining. In order to avoid the need for handling pure profits, we assume that all rents in the a-sector go to labor. As a result, the real wage in the a-sector, w^a, is given by the average product of labor:

$$w_t^a = \frac{Y_t^a}{L_t^a}. \tag{2}$$

In the non-agricultural sector ("the m-sector") production makes use of physical capital, K_t, human capital, and labor L^m. This sector also enjoys exogenous technical progress:

$$Y_t^m = K_t^\alpha \left(A_t^m h L_t^m\right)^{1-\alpha} \Leftrightarrow \frac{Y_t^m}{L_t^m} = A_t^m \left(\frac{K_t}{Y_t^m}\right)^{\frac{\alpha}{1-\alpha}} h, \tag{3}$$

where $0 < \alpha < 1$. It will be maintained throughout that the the growth rate of A^m and A^a coincide.[9] As is apparent, technological progress is assumed to manifest itself in different ways in the two sectors. This assumption is made so as to allow for a steady state with constant output shares.[10] Producers face competitive factor markets, and maximize profits. Consequently, in this sector both factors of production are hired until their respective marginal products equal the relevant factor prices, i.e.

$$r_t = \alpha \frac{Y_t^m}{K_t} - \delta,\ w_t^m = (1-\alpha)\frac{Y_t^m}{L_t^m}, \tag{4}$$

where δ is the rate of depreciation of capital. It is assumed, for simplicity only, that capital depreciates fully during a period: $\delta = 1$. Since the consumers are borrowing constrained, as explained below, the domestic real rate of interest will not generally equal the rate of interest prevailing on the world capital market, r^w. Indeed, we will assume that r^w falls short of the domestic real rate of return, so as to ensure that consumers are borrowing constrained at all points in time. This assumption will, as demonstrated below, allow for a simple link between "institutions", capital accumulation, duality of production and, ultimately, long-run productivity.

2.2 Labor Market Clearing

Allowing labor to be fully mobile across sectors implies that the real wages in the two sectors will be fully equalized. According to prevailing empirical evidence, however, this is not a realistic feature.[11] Rather, real wages appear to be lower in the a-sector. In order to allow for a persistent wage gap we follow Jorgenson (1961) in assuming that workers are indifferent between working in either sector if

$$w_t^a = (1-\mu) \cdot w_t^m = w_t,\ 0 < \mu < 1. \tag{5}$$

[9] While conventional wisdom is that TFP is likely to be lower in the agricultural sector, recent empirical work has shed some doubt about this proposition. The study by Bernard and Jones (1996) show no tendency for the level nor the growth rate of TFP to be lower in agriculture than in manufacturing, in a sample of OECD countries. Similarly, Martin and Mitra (2002) find, in a sample of developing countries, that TFP growth is as least as high in agriculture as in the manufacturing sector.

[10] An alternative would be to allow for different growth rates of A in the two sectors, and then assume that the two growth rates are such that a steady state with constant output shares exist. Restuccia (2002) follows this approach.

[11] See Temple (2002) for a discussion of evidence on wage differences across sectors in less developed economies. The wage level in manufacturing tend to be (at least) 40 percent higher than in agriculture.

One may think of μw^m as the total costs associated with searching for, and obtaining, a job in the m-sector.[12] Accordingly, we posit the equalization of "net wages", while the gross wage (excluding costs of search, migration etc.) w^m exceeds the comparable wage in the a-sector, consistent with the above mentioned evidence.

Equation (5), along with the production functions introduced above, imply that the share of the work force working in the m-sector is given by

$$L^m(x_t) = \begin{cases} 1 - \left((1-\alpha)(1-\mu)h^{1-\gamma}\bar{a}x_t^{\alpha}\right)^{\frac{-1}{1-\gamma}} & \text{if } x_t > \hat{x} \equiv \left((1-\alpha)(1-\mu)\bar{a}h^{1-\gamma}\right)^{-\frac{1}{\alpha}} \\ 0 & \text{otherwise} \end{cases}, \quad (6)$$

where $x_t \equiv (K_t/Y_t^m)^{1/(1-\alpha)}$ and $\bar{a} \equiv A^m/A^a$. Equation (6) shows that only when the capital stock becomes (start out being) sufficiently large will the wage in the m-sector be high enough to attract workers from the a-sector. In the remaining we will focus on the case where $x_t > \hat{x}$, i.e. the scenario where the m-sector is active. In this regime the accumulation of capital will entail a gradual structural transformation of society, whereby labor is shifted from agriculture to the non-agricultural sector, due to capital-labor complementarity in the m-sector.[13] In the steady state, however, the capital-output ratio will be constant. Consequently, the share of employment will be constant according to equation (6). Aside from the influence of physical capital, relative levels of technology will also influence the allocation of labor across sectors; a higher relative level of technology in the m-sector, $\bar{a}$, will work so as to shift labor into the m-sector. Finally, *for a given capital to m-sector output ratio*, a larger human capital stock will shift employment into the m-sector. The reason is that if h is increased in equation (6), this amounts to an experiment whereby the capital stock is increased so as to maintain the K/Y^m ratio. If this occurs, then effectively speaking the m-sector features constant returns to human capital augmented labor input, while diminishing returns to hL prevail in the a-sector. Consequently, more human capital will increase the marginal product of raw labor relatively more in the m-sector, and, as a result, push workers into m-sector employment. Naturally, such an off-setting increase in K may not materialize. Thus, in order to analyze the consequences of a change in the stock of human capital for the employment shares, it is necessary to look into the process of capital accumulation.

[12] Caselli and Coleman (2001) argue that income convergence of (US) southern regions was to a large extend facilitated by declining costs for workers of moving from agriculture to non-agriculture, i.e. in the present setting: a declining μ.

[13] This mechanism only hinges on the assumption that the m-sector is *relatively* more capital intensive. Thus, the simplifying assumption of capital only being used in the m-sector is not crucial.

2.3 Consumers

Consumers live for two periods, and enjoy utility from consumption during youth, c_t^y, as well as old-age, c_{t+1}^o. The preferences of a representative young individual, born at time t, are assumed to be Cobb-Douglas:

$$U = \log c_t^y + \frac{1}{1+\rho} \ln c_{t+1}^o,$$

where $\rho > 0$ is the rate of time preference. The first period budget constraint is given by

$$K_{t+1} + c_t^y = w_t + b_{t+1}.$$

In the first period of life households work and receive wage income w_t. Income can also be supplemented by borrowing abroad, b_{t+1}. Indeed, obtaining foreign loans to finance domestic saving, K_{t+1}, and first period consumption will be attractive if the world real rate of interest, r^w, falls short of the domestic real return, r_t. In this event, however, borrowing is only possible up to a point. Specifically, individual borrowing is subject to the following constraint:

$$b_{t+1} = \eta \cdot w_t, \; \eta > 0. \tag{7}$$

Hence, maximum borrowing is constrained by life-time labor income. The size of the parameter η can be thought to reflect foreign investors' perception of the riskiness of domestic lending, which plausibly is related to the quality of domestic institutions. Accordingly, it will be maintained that the parameter η is lower in countries with "weak" institutions, represented by, for example, lack of a well-functioning legal framework.[14] It will be assumed throughout that the borrowing constraint is binding.

In the second period of life consumers live off their net savings, $r_{t+1}K_{t+1} - r^w b_{t+1}$. Thus the budget constraint during old-age is given by:

$$c_{t+1}^o + r^w b_{t+1} = r_{t+1} K_{t+1}.$$

Assuming the borrowing constraint is binding it can be shown that optimal saving by the consumer is given by

$$K_{t+1} = \left[\frac{1+\eta}{2+\rho} + \frac{(1+\rho)\, \eta r^w}{(2+\rho)\, r_{t+1}} \right] w_t. \tag{8}$$

[14] In the empirical section we will use the index of institutional quality developed by Knack and Keefer (1995), as detailed below. Knack and Keefer, in turn, draws on the International Country Risk Guide (ICRG). The ICRG data are sold to international financial investors, who presumably use these to guide future investments. That, at least, seems to be the intention behind the construction of the data.

It is clear that a more "lax" borrowing constraint implies higher savings, as individuals are able to capitalize on the lower world market interest rate. If borrowing is impossible ($\eta = 0$), the solution collapses to the one familiar from the closed economy version of the Diamond model with Cobb-Douglas preferences; savings are a constant fraction of life-time income.

2.4 Capital Accumulation and Steady State Analysis

The savings of the young determines the amount of capital available for production in the following period. Recalling that the size of the labor force has been normalized to one, it follows that total savings in the economy is given by equation (8). Using the fact that $\left(\frac{K}{A^m}\right) = \left(\frac{K}{Y^m}\right)^{\frac{1}{1-\alpha}} hL^m$,[15] substituting for w and r, using equation (4), and applying the fact that $A^m_{t+1} = (1+g)\, A^m_t$, equation (8) can be restated to yield:

$$x_{t+1}L^m_{t+1} = \left[\frac{1+\eta}{2+\rho} + \frac{(1+\rho)\,\eta}{(2+\rho)}\frac{r^w}{\alpha}x^{1-\alpha}_{t+1}\right]\frac{(1-\alpha)\,(1-\mu)}{1+g}x^{\alpha}_t. \tag{9}$$

Observe that the stock of human capital does not enter into this equation. The reason is the following. On the one hand, a higher human capital stock enhances the real wage, which works to increase x. On the other hand, a larger stock of human capital tends to increase the average productivity of capital in the m-sector, thus lowering the ratio of the capital stock to m-sector output. On net, these two effects exactly cancel each other out.

The dynamical system of the model consists of equations (6) and (9). A steady state of the system is a pair (x, L^m). The steady state capital to m-sector output ratio respects equation (9) and is such that $x_t = x_{t+1} = x$. Given x, the steady state employment share in manufacturing, L^m, can be obtained from equation (6). Appendix A demonstrates that the system is locally stable. Hence, if the economy initially is equipped with an $x_0 : \hat{x} < x_0 < \bar{x}$, the a-sector employment share will gradually decline as the economy approaches its steady state. Once in the steady state the employment shares and K/Y^m remain constant, if not disturbed by changes in structural characteristics. As is apparent, the system is highly non-linear, and a closed form solution for x, in the steady state, cannot be derived. However, the qualitative steady state properties of the model can be assessed geometrically.

The geometric characterization of the steady state centers around equations (6) and (9), where the conditions $x_{t+1} = x_t = x$ and $L^m_{t+1} = L^m_t = L^m$ has been imposed:

$$L^m = 1 - \left(\frac{1}{(1-\alpha)\,h^{1-\gamma}\bar{a}\,(1-\mu)\,x^{\alpha}}\right)^{\frac{1}{1-\gamma}} \equiv L(x)\,, \tag{10}$$

[15] Straight forward manipulation of the expression $K/Y^m = K/\left(K^{\alpha}\,(A^m hL^m)^{1-\alpha}\right)$ yields this result.

$$L^m = \frac{1+(2+\rho)\eta}{2+\rho}\frac{(1-\alpha)(1-\mu)}{1+g}x^{\alpha-1} + \frac{\eta}{2+\rho}\frac{r^w}{\alpha}\frac{(1-\alpha)(1-\mu)}{1+g} \equiv \psi(x). \tag{11}$$

From equation (10) it follows immediately, that the share of labor allocated to the m-sector is increasing in x (the K/Y^m ratio). The reason is that capital increases the marginal productivity of labor in the m-sector, thus providing workers with the incentive to leave the a-sector. Obviously, the employment share is bounded from above.

Based on equation (11), the following properties of the $\psi(x)$-function can be verified:

$$\begin{aligned} \psi'(x) &< 0,\ \psi''(x) > 0\ \forall\ x, \\ \psi(0) &= \infty,\ \psi(\infty) = \frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}\frac{(1-\alpha)(1-\mu)}{1+g} \equiv \underline{L}^m. \end{aligned}$$

The negative association between x and L^m is due to the familiar "capital dilution" effect; increasing the number of workers in the m-sector, reduces the amount of capital available per worker, and consequently the capital-output ratio. In order to ensure the existence of a steady state, which geometrically is found at the intersection point between $L(x)$ and $\psi(x)$, it is assumed that $\underline{L}^m < 1$, as illustrated in Figure 1. It is clear that the steady state is unique. However, changes in structural characteristics, most notably with respect to institutions (η) and human capital (h), will induce changes in these steady state values.

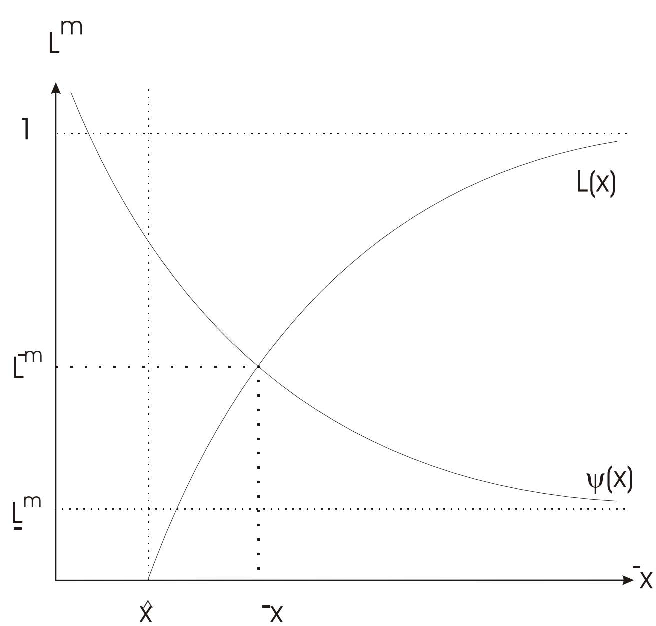

Figure 1: Comparative Statics at the Steady State.

More specifically, consider an increase in η, i.e. the case where the institutional framework is improved.[16] This change enables individuals to borrow funds from abroad for investment purposes. As a result, more capital is accumulated, and labor will therefore shift into the non-agricultural sector. In the long-run, therefore, the economy ends up with a higher capital-output ratio, and a larger share of the labor force employed in the m-sector. Geometrically, the change in η entails an upward shift in the $\psi(x)$ curve, while the $L(x)$ curve remains fixed.

Next consider the effect of changing the stock of human capital. If h is adjusted upward then it follows from equation (10) that the $L(x)$-curve shifts upwards. From equation (11) its clear that the $\psi(x)$-curve is invariant to changes in h. This is due to the two off-setting effects on the capital-output ratio from increasing h mentioned above: higher wages, which enables more capital accumulation, and a negative effect on the capital-output ratio stemming from the fact that a higher level of human capital leads to a higher level of output. As mentioned above, these two effects exactly cancels out, implying that the $\psi(x)$ function remains in place when the human capital stock is expanded. Consequently, the employment share in the m-sector rises, and the capital to m-sector output declines. Hence the model implies, ceteris paribus, that countries with a more educated labor force will tend to have higher long-run employment shares in the non-agricultural sector. Likewise, if the stock of human capital depends on climate related circumstances, then more "hostile" environments should be characterized by a large share of employment in agriculture.

A third experiment consists of increasing the migration costs, μ. As can be seen from equation (10), increasing μ implies a downward shift of the $L(x)$ curve. Moreover, from equation (11) it follows that the $\psi(x)$ curve also shifts downward. Hence, increasing μ leads unambiguously to a lower share of employment in manufacturing, as one would expect. However, the impact on the steady state level of capital to output in the m-sector is ambiguous. On the one hand, less labor tends to increase the capital-output ratio (capital dilution effect in reverse), while, at the same time, a lower (net) wage tend to reduce the capital-output ratio, by curbing savings and investments.

While Figure 1 is useful in capturing the qualitative implications of the model with respect to long-run employment shares of the individual sectors, it is uninformative as to the level of income per capita in the steady state. To assess the implications for income per worker, of changing central parameters of the model, a few additional calculations are necessary.

First, by identity, aggregate GDP (or output per worker, as the size of the labor force has been

[16] Implicitly, of course, we are assuming that ex-post the increase in η , the borrowing constraint continues to bind.

normalized to one) is given by the sum of production in the two sectors, i.e.

$$y_t = Y_t^a + Y_t^m = \left(L_t^a \frac{Y_t^a / L_t^a}{Y_t^m / L_t^m} + L_t^m \right) \cdot \frac{Y_t^m}{L_t^m}. \tag{12}$$

Second, from equations (2), (4) and (5) it follows that relative labor productivity is given by

$$\frac{Y^a}{L^a} \bigg/ \frac{Y^m}{L^m} = (1-\alpha)(1-\mu) < 1. \tag{13}$$

Observe that labor productivity is lower in the a-sector compared with the non-agricultural sector. This result follows from the assumption that obtaining a job in the m-sector is costly, and from the a-sector being relatively more labor intensive.[17] Finally, substitute for $\frac{Y^a}{L^a} / \frac{Y^m}{L^m}$ and Y^m/L^m, using equations (13) and (3). Then output per worker can be expressed as:

$$y_t = \lambda_t (L^m, \alpha, \mu) A_t^m h \left(\frac{K_t}{Y_t^m} \right)^{\frac{\alpha}{1-\alpha}} \tag{14}$$

where $\lambda_t (L^m, \alpha, \mu) \equiv (1-\alpha)(1-\mu) + (\mu + \alpha(1-\mu)) L_t^m$. It is easily seen that $\partial \lambda / \partial L^m > 0$, due to the labor productivity difference between the two sectors in favor of the non-agricultural sector. Accordingly, since $x \equiv (K_t/Y_t^m)^{1/(1-\alpha)}$ it follows that if both x and L^m increases, then, by equation (14), so does output per worker. However, consider the implications of increasing h. From the analysis above, the net effect on y appears to be ambiguous. On the one hand, both the increase in h and the induced increase in L^m work to increase output per worker. On the other hand, x declines. As it turns out, the net effect is positive. A simple argument makes this clear. Consider the steady state employment share of agriculture, which can be inferred from equation (10). As a matter of steady state analysis, increasing h decreases x; hence the net effect on L^a is determined by

$$\frac{\partial \ln L^a}{\partial h} = -\frac{d \ln h}{dh} - \frac{\alpha}{1-\gamma} \frac{d \ln x}{dh}.$$

Now, when $\frac{d \ln h}{dh} > 0$ the second term is positive. But since we know that $\frac{\partial \ln L^a}{\partial h} < 0$ it follows that

$$\frac{d \ln h}{dh} > -\frac{\alpha}{1-\gamma} \frac{d \ln x}{dh} = -\frac{1}{1-\gamma} \frac{\alpha}{1-\alpha} \frac{d \ln K/Y^m}{dh} > -\frac{\alpha}{1-\alpha} \frac{d \ln K/Y^m}{dh}.$$

[17] In fact the latter would be sufficient to generate $\frac{Y^a}{L^a} \Big\backslash \frac{Y^m}{L^m} < 1$. This can be seen from the following argument. Suppose one were to assume that a-sector labor were paid its marginal value only. Then the equation would read $\frac{Y^a}{L^a} \Big\backslash \frac{Y^m}{L^m} = (1-\alpha)/\gamma$, ignoring μ for a moment. Hence, as long as $\gamma > 1-\alpha$ this qualitative property holds. In equation (13), γ does not enter, as we have assumed that all rents acquire to labor in the a-sector. Under this assumption, labors' share is – effectively speaking – one.

Thus, if the human capital stock is increased, it will unambiguously increase long run productivity. By the same token, if countries with the bulk of population situated in tropical areas are characterized by comparatively low levels of human capital, one would expect such places to be characterized by low levels of income per worker, in addition to a large share of income being generated in agriculture. The exact same line of reasoning makes clear that an increase in the costs of migration, μ, always will lead to lower long-run income per worker.

2.4.1 Towards Empirical Testing: Aggregate Income per Worker and Total Factor Productivity

In the light of the discussion above it should be evident that when "levels-accounting" is performed (e.g. Klenow and Rodriguez-Clare, 1997; Hall and Jones, 1999; Easterly and Levine, 2001), the obtained residual is likely to capture more than the influence from technology. To bring this out more clearly, one can rewrite equation (14) purely in terms of aggregate capital and output so as to obtain the following expression for income per worker, at time t in country j :

$$y_{jt} = TFP_{jt} \cdot h_j \left(\frac{K_{jt}}{Y_{jt}} \right)^{\frac{\alpha}{1-\alpha}}, \tag{15}$$

$$TFP_{jt} \equiv \left(\frac{(1-\alpha)(1-\mu)}{\sigma^a_{jt}(1-(1-\mu)(1-\alpha)) + (1-\mu)(1-\alpha)} \right) \times \left(\frac{1}{1-\sigma^a_{jt}} \right)^{\frac{\alpha}{1-\alpha}} A^m_{jt}, \tag{16}$$

where $(1-\alpha)(1-\mu)$ reflect relative labor productivity between the two sectors, y^a_{jt}/y^m_{jt}, while $\sigma^a_{jt} \equiv Y^a_{jt}/Y_{jt}$ is the share of agricultural output in total output.[18] Note an apparent "illusion" here: The agricultural TFP, A^a_{jt}, term seems to have disappeared. Actually, it has been subsumed in σ^a. This is because in deriving the above expression we began from equation (14) which expresses aggregate ouput per worker as a function of output per worker in the non agricultural sector. If we had instead written aggregate output per worker as a function of output per worker in the agricultural sector, then A^m_{jt} would have been subsumed in $(1-\sigma^a)$ while A^a_{jt} would have appeared explicitly. The advantage of this should be obvious: In the empirical work, we need to deal with only one unknown rather than two.

Obviously TFP_{jt} above mirrors exactly the residual obtained by Hall and Jones and others. Moreover this term captures more than pure "technology"; the structural composition of individual

[18] Using the fact that $\sigma^a \equiv Y^a/Y = 1/(1+Y^m/Y^a)$ in conjunction with equation (13) allows one to derive σ^a as a function of L^m. Substituting this relationsship into equation (14), and observing that $Y^m = (1-\sigma^a)Y$, leads to the stated result.

economies matters as well. Whether TFP is declining in σ^a_{jt}, or not, is not a given. In fact it can be shown that

$$\frac{\partial TFP}{\partial \sigma^a} \begin{cases} < 0 \text{ if } \sigma^a < \hat{\sigma}^a \\ \geq \text{ otherwise} \end{cases},$$

where $\hat{\sigma}^a \equiv \frac{\mu(1-\alpha)}{1-(1-\mu)(1-\alpha)} > 0$. Accordingly, calculated TFP will be a decreasing function of σ^a insofar as the share remains below the threshold level, $\hat{\sigma}^a$. Conversely, beyond this critical level, further increases in σ^a should be associated with higher levels of calculated TFP. Whether economies across the globe have $\sigma^a \gtreqless \hat{\sigma}^a$ is an empirical matter. In the empirical section we adress this issue by allowing for a non-linear relationship between measured TFP and the agricultural shares. Anticipating our results, we find little evidence in favor of such non-linear effects, but rather a strong negative relationship, suggesting that most countries are below the threshold.

The analysis above delivers a set of predictions regarding likely determinants of sectorial shares-cum-calculated TFP which are useful in the context of the empirical analysis below. First, institutions are key determinants of the long-run composition of the economy, and as a result, should matter for TFP too. In discerning the impact from the structural composition of output on calculated TFP, by way of regression analysis, measures of institutional quality are less useful as instruments, however, since they are undoubtedly endogenous to income per capita. But exogenous determinants of institutions are reasonable candidates as instruments for σ^a, as detailed below. Moreover, insofar as climactic circumstances are important determinants of the quality of the labor force, as argued above, the model suggests that such variables could be important determinants of the long-run structural composition of the economy. Consequently, "geographic" variables will also invoked as instruments for σ^a.

Before we turn to the empirical investigation of these issues it is worth briefly considering the implications of removing one simplifying analytical assumption; that technology is strictly exogenous. As an alternative, one could argue that technologies are in fact adopted from the worlds' innovation centers (such as, say, the US, or OECD area). Abstractly, technologies are adopted from a “technical progress frontier”, T_t, which could be assumed to shift outwards at the (from the perspective of the individual country) exogenous rate g.[19] Adopting the formalization suggested by Nelson and Phelps (1965), technology will then be dependant on “world growth”, g, and the rate of adoption ϕ:

$$A_{t+1} - A_t = \phi \left(T_t - A_t \right). \tag{17}$$

[19] See Howitt (2000) for a model incorporating such a feature. In Howitt's model, however, g itself is endogenous, at the global level.

In the long run, the stage of technological development relative to the frontier (the A_t/T_t ratio), will be determined by the rate of adoption and the rate of world growth: $\phi/(\phi+g)$. At this junction, A_t grows smoothly over time, at the rate g. Now it may well be argued that institutions matters directly for adoption, by affecting ϕ. Likewise, geographic variables may affect ϕ directly too, as hypothesized by Sachs (2001). By testing whether institutions and geography matters for TFP, above and beyond their influence on σ^a, one may attempt to sort out whether this is likely to be the case or not.

3 Evidence

The data come mainly from two sources, Hall and Jones (1999) and World Development Indicators (2001). Hall and Jones reduce the GDP in the economy (measured in 1988) by the size of the mining sector (and assume that all capital and labor are used in the non-mining sectors). Using their mining shares, we inflate GDP once again to include mining. The reason for this procedure is that data are not available on total employment in the mining sector. In contrast to Hall and Jones we make use of relative labor productivity in the two sectors. Correcting output, then, without correcting employment, would potentially bias our results seriously. Rather than correcting the data, we go through a series of robustness checks below. The data for labor and output shares in agriculture come from WDI (2001) as does total population.[20] Since the decomposition and the regression exercises require use of output and labor shares, we dropped countries that had more than 15% of their GDP in the mining sector as their relative productivities are likely to be significantly affected by their resource endowments. Further given their special circumstances, we also dropped all the "transition" economies (as defined by the World Bank). This gives us 103 countries to begin with.

3.1 Decomposition

The motivation for the static decomposition analysis pursued in this section comes from equations (15) and (16). A problem however is that the model developed above assumes that there is no capital in agriculture. Secondly the model assumes that human capital per person is the same in all sectors. While these assumptions greatly simplify the theoretical analysis, any realistic decomposition exercise would need to take cognizance of these facts. In reality, undoubtedly $K_t^m/Y_t^m = \kappa_t^m \cdot K_t/Y_t$, where $\kappa_t^m \in (0, \overline{\kappa})$ and $h^m = \theta h$, $\theta \in (0, \bar{\theta})$, where κ_t^m and θ represent the

[20] With exceptions for USA, Taiwan, Uruguay, Switzerland and Spain where the data were taken from the CIA Factbook 1990.

respective proportions and $\overline{\kappa}$ and $\overline{\theta}$ are finite upper bounds. Incorporating these factors naturally changes the expression in equation (16). Specifically, allowing for sector specific human capital and capital-output ratios implies that the production function for the non-agricultural sector can be written as,

$$\frac{Y_t^m}{L_t^m} = A_t^m h^m \left(\frac{K_t^m}{Y_t^m}\right)^{\frac{\alpha}{1-\alpha}} \Rightarrow \frac{Y_t^m}{L_t^m} = (\kappa_t^m)^{\frac{\alpha}{1-\alpha}} \theta_t \cdot A_t^m h_t \left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}}, \tag{18}$$

The above equation implies that the aggregate TFP equation for country j at time t, can now for the purpose of empirical implementation be written as (instead of equation (16)):

$$TFP_{jt} = \left[\frac{y_{jt}^a / y_{jt}^m}{\sigma_{jt}^a \left(1 - y_{jt}^a / y_{jt}^m\right) + y_{jt}^a / y_{jt}^m} \left(\kappa_{jt}^m\right)^{\frac{\alpha}{1-\alpha}} \theta_{jt}\right] \cdot A_{jt}^m. \tag{19}$$

Hence, this more complete description of the underlying economic structure conveys the same message as the analysis above in that measured TFP fundamentally comprises two elements. The first is A_t^m which represents the level of technology (and thus TFP) in the non-agricultural sector. The rest is a rather complicated looking multiplicative term involving relative productivities in the two sectors, the share of agriculture in total output, σ_t^a, and terms reflecting relative capital intensities (physical and human) in the two sectors of the economy, κ_{jt}^m and θ_{jt} respectively. Assuming for a moment that everything within the squared parentheses can be measured, one can then proceed to calculate A^m as a residual of the Hall and Jones TFP measure (HJ-TFP) and "the composition term". With these two measures in hand one can then attribute the variance of TFP across countries to either the composition effect and TFP in manufacturing. If the variance in TFP across countries is largely explained by the variance in the composition effect then this supports our claim that the structural composition of individual economies is important in explaining the variance of aggregate TFP's. On the other hand if the A_t^m term explains the variance then the allocation of resources between agriculture and non-agriculture can be regarded as relatively unimportant vis-a-vis understanding differences in aggregate TFP.

Next, as for measurement, it turns out that most of the elements in the squared brackets can be calculated, using data on relative worker productivities and output shares (both from WDI 2001) and by applying the usual approximation, $\alpha = 1/3$. Obtaining data on $\left(\kappa_{jt}^m\right)^{\alpha/(1-\alpha)}$ and θ_{jt} is more difficult. But what we can do as a first exercise is to define

$$COMP \equiv \left(\frac{y_{jt}^a / y_{jt}^m}{\sigma_{jt}^a \left(1 - y_{jt}^a / y_{jt}^m\right) + y_{jt}^a / y_{jt}^m}\right) \tag{20}$$

and the residual as

$$RES = \frac{HJ - TFP}{COMP} \equiv \left(\kappa_{jt}^{m}\right)^{\frac{\alpha}{1-\alpha}} \theta_{jt} A_{jt}^{m}. \tag{21}$$

This implies that RES picks up some of the variance in TFP which should be attributed to the actual composition effect. However whether this will increase or decrease the variation in TFP attributable to composition effects is not quite clear since the variance in TFP is the sum of the variances in COMP, $(\kappa_t^m)^{\frac{\alpha}{1-\alpha}}$, θ_{jt} and A_t^m and twice their covariances:

$$Var(TFP) = \sum_{v} Var(v) + \sum_{v} \sum_{u} 2Cov(v, u),$$

where v, u = COMP, $(\kappa_t^m)^{\frac{\alpha}{1-\alpha}}$, θ, A_t^m and $v \neq u$. One the one hand, attributing all of the variance of $(\kappa_t^m)^{\frac{\alpha}{1-\alpha}}$ and θ to the residual would underestimate the share explained by composition terms. On the other hand it is not clear exactly in which directions the covariances will go. The covariance between θ and A_t^m is likely to be positive, but there is little that one can say about the covariance of the remaining two combinations. Despite these limitations, it is instructive to see how a decomposition exercise between COMP and the rest looks like.

Table I reports some summary statistics for HJ-TFP, COMP and RES and also agricultural shares (ASHARE) and relative productivities (RPROD).

>Table I here <

Table II reports the correlations.

>Table II here<

The values for the HJ-TFP, COMP and RES are relative to that of the USA. As can be seen from the summary statistics, both COMP and RES reflect about the same magnitudes as HJ-TFP. An interesting observation is the range of variation of the relative productivity variable across countries. The country with the lowest relative productivity is Burkina Faso at 3.9% and Bolivia has the highest with agricultural productivity being 28 times that of the non-agricultural economy. The sample mean of 1.4 is actually quite unrepresentative of the worldwide variation. In particular at least five countries: Niger, Peru, Fiji, Colombia and Bolivia have agricultural productivities at least six times higher than the rest of their economies. As can be seen from Figure 2, where countries are arranged in the order of relative productivities, most of the countries in the world have agricultural productivities less than that in the rest of the economy.

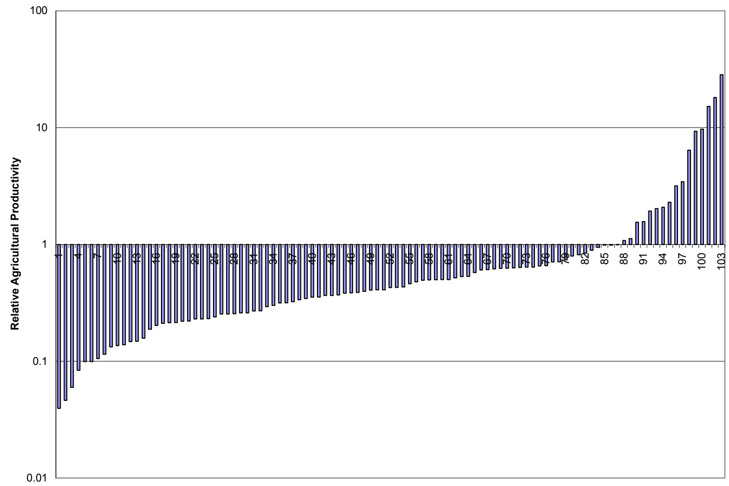

Figure 2: Countries Arranged in Order of Relative Productivity (Labor Productivity in Agriculture Relative to Rest of the Economy)

Further, the correlation between aggregate output per worker and relative productivity is not significantly different from zero for the entire sample of countries. However for the subsample of countries that have relative productivities less than 1, the correlation jumps to 0.65 (not shown in the table). Our conjecture is that countries at higher levels of development have less institutional barriers between sectors and thus there one might expect agricultural productivity not to be significantly different from the rest of the economy.[21] Also note that in equation (20) above, if a country has relative productivity equal to 1, then COMP reduces to 1 as well. However neither κ^m nor θ are necessarily equal to 1 and hence aggregate TFP may still be partially explained by composition effects though its importance would probably be diminished. Finally, note that COMP's correlation with HJ-TFP is considerably less than A_t^m's correlation with HJ-TFP suggesting that while inter-sectoral differences may be important, broader national differences are still key.

The decomposition of TFP is undertaken the same way as done in Klenow and Rodriguez-Clare (1997) – taking logs of the levels of HJ-TFP, COMP and RES and then using the fact that:

$$1 = \frac{Var(\ln COMP)}{Var(\ln HJ-TFP)} + \frac{Var(\ln RES)}{Var(\ln HJ-TFP)} + \frac{2Cov(\ln COMP, \ln RES)}{Var(\ln HJ-TFP)}$$

[21] In their analysis of sectoral convergence of worker productivities and TFP in developed economies, Bernard and Jones (1996), find that the worker productivity in the agricultural sector lies within the same band as manufacturing and services in 1987, with the exception of Japan which has a relatively low agricultural productivity (See figure 2 in Bernard and Jones). Note that none of the countries which have relative productivities greater than 1 in our sample are considered "high income" countries.

Table 3, column (1) lists each of the terms in the above expression.

>Table 3 here<

Attributing half of the covariance to each of the two components, COMP can easily account for about 40% of the variation in TFP differences while RES still explains 60%. The most pessimistic allocation would be to contribute all of the negative movements in the covariance to COMP. Even then, the composition effect explains as much as 30% of the total variation in aggregate TFP. To check for the sensitivity of the results, we removed all countries that had populations less than 1 million in 1990 – for such countries the distinction between agriculture and the rest of the economy may be less meaningful and one can expect the economy to be more specialized in one sector. Though this reduces the sample size to ninety countries, as far as the decomposition exercise is concerned, the results hardly change. The 40-60 split is retained. As an additional sensitivity check, we dropped all countries that had relative productivities greater than 1. As noted earlier there are some countries in the sample that have unusually high agricultural productivities. The results are displayed in column (3). Dropping these countries leads to a substantial increase in the share that is accounted for by COMP: about 47%. To further control for outliers we, instead, dropped all countries that had relative agricultural productivities less than 0.10 and greater than 10. Not surprisingly, this does reduce the role of the sectoral composition: now only 32% of the variance is attributable to COMP. Finally as another check, we limited the sample to just OECD countries. The variation now motivated by the composition term drops dramatically to 12%. This is, of course to be expected. These are all countries that have low agricultural shares to begin with.[22] These results clearly suggest an important role for the output structure of the economy.

Despite these encouraging results, one might still be concerned with the treatment of κ_t^m and θ. Unfortunately there is really no way of figuring out the ratio of human capital per worker in the non-agricultural sector relative to that of the entire economy and we are not aware of any cross country estimates that exist.[23] However there has been some progress towards estimating the stock of capital in the agricultural sector. In particular Crego, Larson, Butzer and Mundlak (1997) have estimated the fixed capital stock in agriculture for 62 countries for various years covering the period 1967-92. In addition to fixed capital stocks in agriculture, they also estimated fixed capital stocks

[22] Within this group Turkey has the highest share in agriculture at 18%. This is almost twice that of the next country, Greece (10%). Turkey also has the lowest relative productivity at 0.25. The sample correlation between agricultural share of output and relative agricultural productivity is -0.53 (21 observations).

[23] At the minimum one would require estimates of sector specific returns to education and sector specific average years of education.

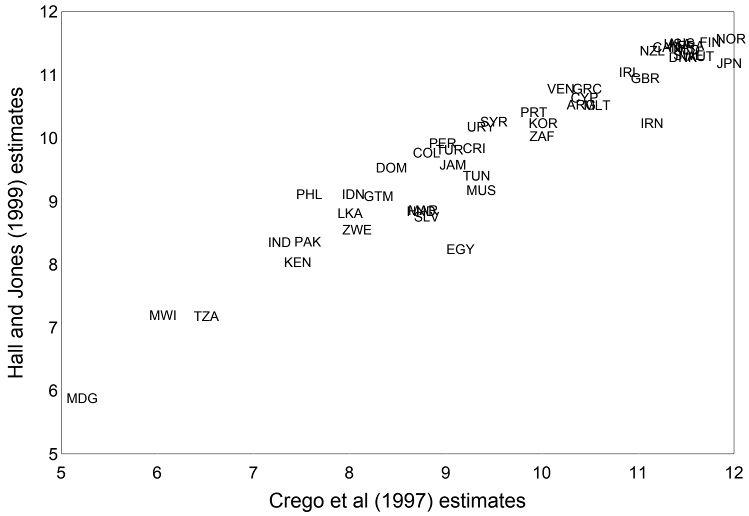

Figure 3: Aggregate Capital Stock per Worker (1988 Logged Values)

in manufacturing and the entire economy.[24] The estimates of the latter are independent from those of Hall and Jones and therefore it is easy to compare the reliability of the two data sets, at least for the economy-wide measures. A simple correlation between the two data sets for the year 1988 imply a correlation of 0.95 for a sample of 49 countries and a regression (with the constant suppressed) of the Crego *et al* numbers on the H-J numbers yield a coefficient of 0.98. Figure 3 plots the fixed capital per worker for both the series.

The strong correlation is quite obvious. We proceeded to do a second decomposition where we explicitly allow for $(\kappa_t^m)^{\frac{\alpha}{1-\alpha}}$. Therefore, we carried out a three way decomposition of the variance into COMP, $(\kappa_t^m)^{\frac{\alpha}{1-\alpha}}$ and a revised residual:

$$RES2 \equiv \frac{HJ - TFP}{COMP \cdot (\kappa_t^m)^{\frac{\alpha}{1-\alpha}}}.$$

The results are presented in Table 4. Of course we are now limited to a much smaller number of countries with the truncation taking place mainly at the lower end of the income distribution. De-

[24]In addition to fixed agricultural capital they also estimate a broader measure of capital stock which includes livestock and orchards (treestock). The aggregate fixed capital stock in their estimates is greater than the sum of fixed capital stocks in agriculture and manufacturing, leaving room for other sectors. That is, the three series are independent estimates.

spite that, the table suggests that the variance in COMP can explain roughly 33% of the variance in aggregate TFP. Also the variance of κ_t^m is relatively insignificant though it does show sizeable negative covariances with both COMP and the residual. It is no longer possible to simply attribute the covariance to each component of the decomposition. That would mean that the total contribution of κ_t^m is negative – a nonsensical result. Therefore we leave the interpretation of these numbers to the reader. However the numbers roughly suggest a 30-70 split between the composition terms and A_t^m.

>Table 4 here<

3.2 Regression Analysis

Having shown that a substantial fraction of the variation in measured aggregate total factor productivity can be attributed to composition effects, we next undertake some econometric exercises of how important the composition issue can be in explaining the same.

>Table 5a and 5b here<

Tables 5a and 5b present the correlations between agricultural shares, relative productivities in the two sectors, output per worker, the log of aggregate total factor productivity. The only difference between the two tables is that the latter drops all countries with relative productivities greater than 1. As is clear from the table all the correlations are quite strong except between relative productivities and the rest of the variables in Table 5a. Once countries with unusually high relative productivities are dropped, the correlation between the variable and the rest also jump up to significant magnitudes. However the model developed in Section 2 does not suggest a clear relationship between relative productivities and total factor productivity. Further our attempt here is to investigate the relationship between output shares and TFP (for which we have a clearer theoretical relationship). Hence we retain countries with high relative productivities in our sample.

>Table 6a and 6b here<

Table 6a presents the first set of regression results. Column (1) shows the result from regressing the log of total factor productivity on agricultural share of output (ASHARE). We have argued earlier that institutional factors may be the key determinant of the composition of output through its effects on aggregate TFP. To test for the effects of institutional quality on TFP, we ran a regression using the Social Infrastructure (SOCINF) variable introduced by Hall and Jones (1999). The variable is the mean of the Sachs and Warner index of openness to international trade (OPENNESS) and a measure of "Government Anti-Diversionary Policy" (GADP) – a composite average of five variables published in the International Country Risk Guide that measure country risk for international investors. The latter group of five variables were introduced into the literature by Knack and Keefer (1995). Hall and Jones were attempting to construct a variable that could adequately reflect "institutions and government policies that determine the economic environment within which economic individuals accumulate skills, [and] firms accumulate capital and produce output." Of course the average of the GADP variable and the Sachs-Warner variable is only a proxy for what constitutes SOCINF. We would like to argue that the composition of output in the economy is also driven by the same factors and hence should have the same effects as SOCINF. Further in our model the relationship between output shares and TFP is clear cut while the relationship between SOCINF and TFP (or output per worker) is more argumentative. Therefore, our attempt here is to refine the arguments made by Hall and Jones and provide in effect a theory for TFP differences. Column (2) shows the direct effect of SOCINF on TFP which is clearly significant though the R-Square is much lower compared to column (1). In Column (3) we use both the social infrastructure variable and the agricultural share of output as independent variables. Clearly the agricultural share of output robs SOCINF of any predictive power. Also note that the R-Square in columns (1) and (3) are not significantly different. Since SOCINF comprises of two variables, GADP (measure of institutional quality) and OPENNESS (Sachs Warner Openness Index), we entered them independently in the regression. Columns (4) and (5) replaces SOCINF with these two variables. Column (4) shows that both GADP and OPENNESS have significant independent impacts on aggregate TFP. However once ASHARE is added, both variables become insignificant. This lends some support that inefficient institutions might be affecting TFP by affecting the composition of output.

A potential problem with the regressions above is that they are likely to suffer from simultaneity bias. Hall and Jones stressed this issue in the context of social infrastructure, and it is not clear why the share of output in agriculture should be free of the same biases (though running in the opposite direction). Therefore we need instruments for both social infrastructure and the share of agriculture.

Since our hypothesis is that institutional and geographical factors determine the composition of output, there is no reason why we cannot use the same variables as instruments for agricultural shares as those used by Hall and Jones for SOCINF. The instruments we selected include a) the fraction of the population speaking one of Western Europe's five main languages including English

(EURFRAC), b) the absolute value of the latitude (ABSLAT) c) the logarithm of predicted trade share of an economy based on a gravity model that only uses a country geographical and population figures (LOGFRANKROM) and d) A measure of long run existence of formal governments (STATEHIST).[25] The first three variables come from Hall and Jones and were used to instrument SOCINF. STATEHIST comes from Bockstette, Chanda and Putterman (2002).[26] This variable measures the length and coverage of formal states in current geographical borders over the past 2 millennia. The motivation is that a long experience with formal bureaucracies can lead to a greater stock of institutional capital which might position some countries more favorably than others in framing appropriate legal systems, property rights etc. Since the variable is based on actual histories from 1-1950 CE it is free of problems of reverse causality. Further Bockstette *et al.* show that it is a better instrument for social infrastructure than most of the instruments suggested by Hall and Jones.

Table 6b presents results with the use of these instrumental variables. The coefficients in column (1) suggest an even stronger negative effect of agricultural shares on TFP. The effect of SOCINF is also strenghned as is clear from Column (2). The results in Columns (3) and (4) are similar to what we have seen in the same columns in table 6a. In Column (5), while agricultural share continues to be significant, so is openness to international trade. It is possible that while institutional quality may affect TFP by working its way through the sectoral composition of output, openness may also increase TFP for reasons unrelated to output shares, e.g. openness is often considered as a channel for international technological spillovers. Still, it is worth noting that the point estimate of openness declines considerably, when the GDP share of agriculture is added, suggesting that some of the effect of openness on TFP may be due to trade's impact on the composition of output.

The tables also list the p-values for Sargan's test statistic for overidentifying restrictions.[27] The values imply that the null hypothesis of orthogonality cannot be rejected. On the whole, these results clearly shows that the composition of output plays an important role in explaining international differences in TFP. The results in the tables also provide some quantitative idea of the effect of changes in sectoral composition on TFP. For example, the results in column (1) imply that a one standard deviation reduction in the share of agriculture would lead to a doubling in its

[25] Hall and Jones also used another variable, ENGFRAC, the fraction of the population that speaks English, as an instrumental variable. However, we ultimately dropped this variable, since, in our initial investigations, keeping this variable in the set of instruments led to poor identification results. Further, the variable fared poorly in terms of predictive power in the first stage regressions.

[26] Bockstette et al create different values for STATEHIST using different rates for "discounting the past". The variable here uses a 5% rate of discounting- the same that is used for all the econometric exercises in their paper.

[27] The regressions were run in Stata using the ivreg2 command.

TFP. For a more extreme result, suppose the country with the highest agricultural share of output in the sample instead had the lowest share. This would imply a change of 0.56 points in the share. Based on the estimated coefficient, this would mean that the country's TFP would now be 12 times greater. Clearly these are very significant effects but they are not implausibly large. In Hall and Jones (1999), the TFP estimates for Zambia, for example, is one twelfth of the US. The second part of the table lists the results of the first stage results for the IV regressions where the components of SOCINF are entered separately (column 5). It seems that EURFRAC, has a significant effect on all three variables. This suggests a rather strong role for colonial history. Geographical factors as captured by ABSLAT has a strong effect on ASHARE and GADP – supporting the geography-institutions link. On the other hand it is not important in predicting openness to international trade. STATEHIST clearly influences both openness to international trade and the structure of the economy.

We also tried to look at estimations including a squared term for σ^a, since the theoretical model indicates that the relationship may be non-linear. However, adding a second order term turned out to be of little additional value so we did not pursue it further.[28]

One could argue, based on equation (11) above that what one needs to look at is not necessarily the share of agriculture in output but rather the share of agriculture in the labor force since the model itself undertakes a steady state analysis based on the labor force shares and not output shares *per se*. The two terms, labor force shares in agriculture and agricultural share in output are highly correlated, however, with a value of 0.81 for the sample.[29] Of course, the relationship is not completely linear. Still, for our sample in which the mean relative productivity is 1.3, a linear fit produces an R-Square of 0.99.[30] Tables 7a and 7b repeat the same exercise as Tables 6a and 6b but the dependent variable now is the agriculture's share in the labor force (AGRLF).[31]

The OLS results in table 7a clearly indicate that the share of the labor force in agriculture too has a negative effect on TFP. However columns (3) and (5) suggest that this does not necessarily replace the effects of SOCINF, GADP or OPENNESS. Table 7b suggests the same interpretation for the IV estimation. As before, openness to international trade continues to have a significant effect

[28] The two terms are in any case very strongly correlated with the value of the correlation coefficient equal to 0.95 for the sample of 89 countries that we have. Regression results are available upon request.

[29] The model's uses the share of the non-agricultural labor force as the variable of interest. However to keep the next empirical analysis consistent with the earlier ones we use the agricultural labor force share as the independent variable.

[30] If instead only countries with relative productivity less than 1 were used, the sample average of relative productivity would decline to 0.4. Then a linear fit produces an R-Square 0.94 with the coefficient being 0.92.

[31] The numbers for labor force shares are for 1990 from WDI (2001)

on aggregate TFP. The weaker results with the labor force numbers might imply that institutional features matters not only for the allocation of labor, but also for the allocation of capital (physical and human). Since the latter is only indirectly controlled for, when the share of labor in agriculture is used as right hand side variable (since it is a co-determinant of labor across sectors), while implicitly enters directly insofar as the output share is used as control, this may explain why SOCINF shows up significant in Table 7a - 7b.

>Table 7a, 7b<

Nevertheless, the overall conclusion, that the structure of the economy plays an important role in aggregate TFP differences, is reconfirmed. The other conclusion that one can draw again from these estimates is that this structure may have less to do with trade and more to do with institutional factors. Finally as is clear from the instrumental variable estimates, it is not easy to disentangle geography from institutions.

4 Concluding Remarks

Prescott's (1998) call for "a theory of total factor productivity" has produced a large body of research which attributes differences in output per worker to technological differences (often assumed to be the same as TFP) generated by institutional barriers and, not unrelated, geographical factors, which hamper the adoption of socially profitable innovations. However, arguing that aggregate TFP is *solely* determined by technological factors is almost certainly wrong. That the composition of output enters into measured aggregate TFP follow almost directly from aggregation. In this paper we have tried to take this observation one step further, by asking whether this influence is of any quantitative importance. We believe it is. Specifically we have demonstrated that a significant fraction of the observed variation in measured TFP is not "technological" *per se*, but is attributable to the allocation of inputs across sectors, and furthermore, that the efficiency with which inputs are channeled to high productivity sectors is strongly affected by the institutional environment of individual economies. Different sectors may be characterized by varying levels of labor productivity for any number of reasons. Whatever the ultimate driving force, the findings above clearly indicate the need to move from a one-sector aggregate model to a multi-sector model which can account for the vast differences that exist in the output composition of economies today. Furthermore, our empirical findings are based on a very parsimonious specification. For example, in our decomposition analysis, we did not rely on specific assumptions regarding the values for factor intensities, sector specific TFP's, etc. Our results were arrived at by using assumptions that are already commonplace in the literature (e.g. share of capital in output being one third). From a policy perspective the results are encouraging, in that the output structure of an economy is a variable that is more amenable to policy rather than the vaguer notion of "institution building". In sum, it seems that in order to provide a rigorous theory of cross-country total factor productivity differences, a theory of output's structural composition will be an important component.

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A Deriving the Dynamical system

Note that the first order condition for labor in the m-sector:

$$w = (1-\alpha)(1-\mu)\frac{Y^m}{L^m} = (1-\alpha)A_t^m\left(\frac{K_t}{Y_t^m}\right)^{\frac{\alpha}{1-\alpha}} h(1-\mu)$$

and that $\alpha\left(Y_{t+1}^m/K_{t+1}\right) = r_{t+1}$. Using this in the law of motion for k_t leads to:

$$k_{t+1} = \left[\frac{1+\eta}{2+\rho} + \frac{(1+\rho)\eta r^w}{(2+\rho)\alpha\left(Y_{t+1}^m/K_{t+1}\right)}\right](1-\alpha)A_t^m\left(\frac{K_t}{Y_t^m}\right)^{\frac{\alpha}{1-\alpha}} h(1-\mu),$$

or in efficiency units:

$$\frac{k_{t+1}}{A_{t+1}^m} = \left[\frac{1+\eta}{2+\rho} + \frac{(1+\rho)\eta r^w}{(2+\rho)\alpha\left(Y_{t+1}^m/K_{t+1}\right)}\right](1-\alpha)\frac{A_t^m}{A_{t+1}^m}\left(\frac{K_t}{Y_t^m}\right)^{\frac{\alpha}{1-\alpha}} h(1-\mu)$$

$$\frac{k_{t+1}}{A_{t+1}^m} = \left[\frac{1+\eta}{2+\rho} + \frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}\frac{K_{t+1}}{Y_{t+1}^m}\right]\frac{1-\alpha}{1+g}h\left(\frac{K_t}{Y_t^m}\right)^{\frac{\alpha}{1-\alpha}}(1-\mu). \tag{22}$$

Observe that

$$\begin{aligned}
\frac{K}{Y^m} &= \frac{K}{K^\alpha (A^m h L^m)^{1-\alpha}} \\
&= \frac{K^{1-\alpha}}{(A^m h L^m)^{1-\alpha}} = \left(\frac{k}{A^m}\right)^{1-\alpha} (hL^m)^{\alpha-1} \\
&\Updownarrow \\
\frac{K}{Y^m} (hL^m)^{1-\alpha} &= \left(\frac{k}{A^m}\right)^{1-\alpha} \\
&\Updownarrow \\
\left(\frac{k}{A^m}\right) &= \left(\frac{K}{Y^m}\right)^{\frac{1}{1-\alpha}} hL^m.
\end{aligned}$$

Inserted into 22

$$\begin{aligned}
\frac{k_{t+1}}{A^m_{t+1}} &= \left[\frac{1+\eta}{2+\rho} + \frac{(1+\rho)\,\eta}{(2+\rho)} \frac{r^w}{\alpha} \frac{K_{t+1}}{Y^m_{t+1}}\right] \frac{(1-\alpha)\,(1-\mu)}{1+g} h \left(\frac{K_t}{Y^m_t}\right)^{\frac{\alpha}{1-\alpha}} \\
&\Updownarrow \\
\left(\frac{K_{t+1}}{Y^m_{t+1}}\right)^{\frac{1}{1-\alpha}} hL^m_{t+1} &= \left[\frac{1+\eta}{2+\rho} + \frac{(1+\rho)\,\eta}{(2+\rho)} \frac{r^w}{\alpha} \frac{K_{t+1}}{Y^m_{t+1}}\right] \frac{(1-\alpha)\,(1-\mu)}{1+g} h \left(\frac{K_t}{Y^m_t}\right)^{\frac{\alpha}{1-\alpha}}
\end{aligned}$$

Next, use the definition:

$$x_t \equiv \left(\frac{K_t}{Y^m_t}\right)^{\frac{1}{1-\alpha}}$$

which inserted into the above equation:

$$x_{t+1} L^m_{t+1} = \left[\frac{1+\eta}{2+\rho} + \frac{(1+\rho)\,\eta}{(2+\rho)} \frac{r^w}{\alpha} x^{1-\alpha}_{t+1}\right] \frac{(1-\alpha)\,(1-\mu)}{1+g} x^\alpha_t. \tag{23}$$

Finally we have, from equilibrium in the labor market:

$$\begin{aligned}
L^m_{t+1} &= 1 - L^a_{t+1} = 1 - \left(\frac{1}{(1-\alpha)\,h^{1-\gamma}\,(1-\mu)}\right)^{\frac{1}{1-\gamma}} x_{t+1}^{-\frac{\alpha}{1-\gamma}} \\
L^m_{t+1} &= 1 - \left(\frac{1}{(1-\alpha)\,h^{1-\gamma}\,(1-\mu)\,x^\alpha_{t+1}}\right)^{\frac{1}{1-\gamma}}
\end{aligned}$$

Use the latter in the dynamical system for x :

$$\begin{aligned}
x_{t+1} - \left(\frac{1}{(1-\alpha)\,(1-\mu)\,h^{1-\gamma} x^\alpha_{t+1}}\right)^{\frac{1}{1-\gamma}} x_{t+1} &= \left[\frac{1+\eta}{2+\rho} + \frac{(1+\rho)\,\eta}{(2+\rho)} \frac{r^w}{\alpha} x^{1-\alpha}_{t+1}\right] \frac{(1-\alpha)\,(1-\mu)}{1+g} x^\alpha_t \\
x_{t+1} - \left(\frac{1}{(1-\alpha)\,h^{1-\gamma}\,(1-\mu)}\right)^{\frac{1}{1-\gamma}} x_{t+1}^{\frac{1-\gamma-\alpha}{1-\gamma}} &= \left[\frac{1+\eta}{2+\rho} + \frac{(1+\rho)\,\eta}{(2+\rho)} \frac{r^w}{\alpha} x^{1-\alpha}_{t+1}\right] \frac{(1-\alpha)\,(1-\mu)}{1+g} x^\alpha_t.
\end{aligned}$$

$$x_{t+1} = \left[\frac{1+\eta}{2+\rho} + \frac{(1+\rho)\,\eta}{(2+\rho)}\frac{r^w}{\alpha}x_{t+1}^{1-\alpha}\right]\frac{(1-\alpha)(1-\mu)}{1+g}x_t^{\alpha} + \left(\frac{1}{(1-\alpha)\,h^{1-\gamma}(1-\mu)}\right)^{\frac{1}{1-\gamma}} x_{t+1}^{\frac{1-\gamma-\alpha}{1-\gamma}}. \quad (24)$$

The next section provides the conditions under which a steady state exists.

A.1 Steady state analysis

Basically we have a two-equation system. One is the equation governing the share of employment in the m-sector:

$$L_t^m = 1 - \left(\frac{1}{(1-\alpha)(1-\mu)\,\bar{a}h^{1-\gamma}x_t^{\alpha}}\right)^{\frac{1}{1-\gamma}} \equiv L(x_t).$$

and in addition an equation governing capital:

$$x_{t+1}L_{t+1}^m = \left[\frac{1+\eta}{2+\rho} + \frac{(1+\rho)\,\eta}{(2+\rho)}\frac{r^w}{\alpha}x_{t+1}^{1-\alpha}\right]\frac{1-\alpha}{1+g}x_t^{\alpha}$$

(cf. 23). Now assume the system is in steady state. That is, suppose $x_t = x_{t+1} = \bar{x}$, and that $L_t^m = \bar{L}^m$. Then these two equations collapse to a system in $\bar{x}, \bar{L}$ which we can have a look at. Considering the equation of employment share:

$$\begin{aligned} L(\bar{x}) &= 1 - \left(\frac{1}{(1-\alpha)\,h^{1-\gamma}\bar{a}\,(1-\mu)}\right)^{\frac{1}{1-\gamma}} x^{-\frac{\alpha}{1-\gamma}} \\ &= 1 - \left(\frac{1}{(1-\alpha)\,h^{1-\gamma}\bar{a}\,(1-\mu)\,\bar{x}^{\alpha}}\right)^{\frac{1}{1-\gamma}} \end{aligned} \quad (25)$$

$$\begin{aligned} L'(x) &= \frac{\alpha}{1-\gamma}\left(\frac{1}{(1-\alpha)\,h^{1-\gamma}\bar{a}\,(1-\mu)}\right)^{\frac{1}{1-\gamma}} x^{-\frac{\alpha}{1-\gamma}-1} > 0 \\ L''(x) &= \frac{-\alpha}{1-\gamma}\left(1+\frac{\alpha}{1-\gamma}\right)\left(\frac{1}{(1-\alpha)\,h^{1-\gamma}\bar{a}\,(1-\mu)}\right)^{\frac{1}{1-\gamma}} x^{-\frac{\alpha}{1-\gamma}-2} < 0. \end{aligned}$$

For $1 > L^m > 0$:

$$\begin{aligned} 1 &> \left(\frac{1}{(1-\alpha)\,h^{1-\gamma}\bar{a}\,(1-\mu)}\right)^{\frac{1}{1-\gamma}} \bar{x}^{-\frac{\alpha}{1-\gamma}} \\ \bar{x} &\geq \left(\frac{1}{(1-\alpha)\,h^{1-\gamma}\bar{a}\,(1-\mu)}\right)^{\frac{1}{\alpha}} \equiv \hat{x}. \end{aligned} \quad \text{(CON1)}$$

Hence, the capital stock (in efficiency units) has to be sufficiently large. Otherwise the m-sector will never be able to attract any labor.

From the accumulation equation:

$$x_{t+1}L_{t+1}^m = \left[\frac{1+\eta}{2+\rho} + \frac{(1+\rho)\,\eta}{(2+\rho)}\frac{r^w}{\alpha}x_{t+1}^{1-\alpha}\right]\frac{(1-\alpha)(1-\mu)}{1+g}x_t^{\alpha}$$

$\Rightarrow$

$$\bar{x}\bar{L}^m = \frac{1+\eta}{2+\rho}\frac{(1-\alpha)(1-\mu)}{1+g}\bar{x}^\alpha + \frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}\frac{(1-\alpha)(1-\mu)}{1+g}\bar{x},$$

or

$$\bar{L}^m = \frac{1+\eta}{2+\rho}\frac{(1-\alpha)(1-\mu)}{1+g}\bar{x}^{\alpha-1} + \frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}\frac{(1-\alpha)(1-\mu)}{1+g} \equiv \psi(\bar{x}). \tag{26}$$

Its straight forward to show that

$$\begin{aligned} \psi'(\bar{x}) &< 0,\ \psi''(\bar{x}) > 0 \text{ for all } x, \\ \psi(0) &= \infty \\ \psi(\infty) &= \frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}\frac{(1-\alpha)(1-\mu)}{1+g} \equiv \underline{\mathrm{L}}^m. \end{aligned}$$

So as to ensure existence of an interior steady state, assume that

$$\frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}\frac{(1-\alpha)(1-\mu)}{1+g} \equiv \underline{\mathrm{L}}^m < 1. \tag{CON2}$$

Under CON1 and CON2, equations (26) and (25) together determine the steady state. There is a unique intersection. Hence a steady state exists, and it is unique. The next section proves local stability.

A.2 Local Stability

We start by considering the dynamics of the model derived above, equation (24):

$$x_{t+1} = \left[\frac{1+\eta}{2+\rho} + \frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}x_{t+1}^{1-\alpha}\right]\frac{(1-\alpha)(1-\mu)}{1+g}x_t^\alpha + \left(\frac{1}{(1-\alpha)h^{1-\gamma}\bar{a}(1-\mu)}\right)^{\frac{1}{1-\gamma}} x_{t+1}^{\frac{1-\gamma-\alpha}{1-\gamma}}$$

Define

$$\begin{aligned} f(x_t, x_{t+1}) \equiv x_{t+1} &- \left[\frac{1+\eta}{2+\rho} + \frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}x_{t+1}^{1-\alpha}\right]\frac{(1-\alpha)(1-\mu)}{1+g}x_t^\alpha \\ &- \left(\frac{1}{(1-\alpha)h^{1-\gamma}\bar{a}(1-\mu)}\right)^{\frac{1}{1-\gamma}} x_{t+1}^{\frac{1-\gamma-\alpha}{1-\gamma}} = 0 \end{aligned}$$

The relevant derivative:

$$\frac{\partial x_{t+1}}{\partial x_t} = -\frac{f_1'(x_t, x_{t+1})}{f_2'(x_t, x_{t+1})}$$

The numerator is

$$f_1'(x_t, x_{t+1}) = -\alpha\left[\frac{1+\eta}{2+\rho} + \frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}x_{t+1}^{1-\alpha}\right]\frac{(1-\alpha)(1-\mu)}{1+g}x_t^{\alpha-1}$$

while the denominator becomes

$$\begin{aligned} f_2'(x_t, x_{t+1}) &= 1 - \frac{(1-\alpha)^2(1-\mu)}{1+g}\frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}x_t^{\alpha}x_{t+1}^{-\alpha} \\ &\quad - \frac{1-\gamma-\alpha}{1-\gamma}\left(\frac{1}{(1-\alpha)h^{1-\gamma}\bar{a}(1-\mu)}\right)^{\frac{1}{1-\gamma}} x_{t+1}^{\frac{1-\gamma-\alpha}{1-\gamma}-1} \\ &= 1 - \frac{(1-\alpha)^2(1-\mu)}{1+g}\frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}x_t^{\alpha}x_{t+1}^{-\alpha} \\ &\quad - \frac{1-\gamma-\alpha}{1-\gamma}\left(\frac{1}{(1-\alpha)h^{1-\gamma}\bar{a}(1-\mu)}\right)^{\frac{1}{1-\gamma}} x_{t+1}^{\frac{-\alpha}{1-\gamma}}. \end{aligned}$$

Hence

$$\frac{\partial x_{t+1}}{\partial x_t} = \frac{\alpha\left[\frac{1+\eta}{2+\rho} + \frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}x_{t+1}^{1-\alpha}\right]\frac{(1-\alpha)(1-\mu)}{1+g}x_t^{\alpha-1}}{1-\left(\frac{(1-\alpha)^2(1-\mu)}{1+g}\frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}x_t^{\alpha}x_{t+1}^{-\alpha} + \frac{1-\gamma-\alpha}{1-\gamma}\left(\frac{1}{(1-\alpha)h^{1-\gamma}\bar{a}(1-\mu)}\right)^{\frac{1}{1-\gamma}} x_{t+1}^{\frac{-\alpha}{1-\gamma}}\right)}.$$

Consider steady state where $x_{t+1} = x_t = \bar{x}$:

$$\frac{\partial x_{t+1}}{\partial x_t}_{|x_{t+1}=x_t=\bar{x}} = \frac{\alpha\left[\frac{1+\eta}{2+\rho}\frac{(1-\alpha)(1-\mu)}{1+g}\bar{x}^{\alpha-1} + \frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}\frac{(1-\alpha)(1-\mu)}{1+g}\right]}{1-\left(\frac{(1-\alpha)^2(1-\mu)}{1+g}\frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha} + \frac{1-\gamma-\alpha}{1-\gamma}\left(\frac{1}{(1-\alpha)h^{1-\gamma}\bar{a}(1-\mu)\bar{x}^{\alpha}}\right)^{\frac{1}{1-\gamma}}\right)}. \tag{27}$$

We proceed in two steps. First, we'll establish that $\frac{\partial x_{t+1}}{\partial x_t}_{|x_{t+1}=x_t=\bar{x}} > 0$. Then it will be established that $\frac{\partial x_{t+1}}{\partial x_t}_{|x_{t+1}=x_t=\bar{x}} < 1$.

Step 1. In the last section we saw that in the steady state (cf equation (25)):

$$\bar{L}^m = \frac{1+\eta}{2+\rho}\frac{(1-\alpha)(1-\mu)}{1+g}\bar{x}^{\alpha-1} + \frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}\frac{(1-\alpha)(1-\mu)}{1+g}$$

Inserted into (27):

$$\frac{\partial x_{t+1}}{\partial x_t}_{|x_{t+1}=x_t=\bar{x}} = \frac{\alpha\bar{L}^m}{1-\left(\frac{(1-\alpha)^2(1-\mu)}{1+g}\frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha} + \frac{1-\gamma-\alpha}{1-\gamma}\left(\frac{1}{(1-\alpha)h^{1-\gamma}\bar{a}(1-\mu)\bar{x}^{\alpha}}\right)^{\frac{1}{1-\gamma}}\right)}$$

Consider the denominator

$$1-\left(\frac{(1-\alpha)^2(1-\mu)}{1+g}\frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}+\frac{1-\gamma-\alpha}{1-\gamma}\left(\frac{1}{(1-\alpha)h^{1-\gamma}\bar{a}(1-\mu)\bar{x}^{\alpha}}\right)^{\frac{1}{1-\gamma}}\right)$$

$$\text{substract, and add }\left(\frac{1}{(1-\alpha)h^{1-\gamma}\bar{a}(1-\mu)\bar{x}^{\alpha}}\right)^{\frac{1}{1-\gamma}}$$

$$\begin{aligned}
&= \left(1-\left(\frac{1}{(1-\alpha)h^{1-\gamma}\bar{a}(1-\mu)\bar{x}^{\alpha}}\right)^{\frac{1}{1-\gamma}}\right)\\
&\quad -\frac{(1-\alpha)^2(1-\mu)}{1+g}\frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}-\left(\frac{1-\gamma-\alpha}{1-\gamma}-1\right)\left(\frac{1}{(1-\alpha)h^{1-\gamma}\bar{a}(1-\mu)\bar{x}^{\alpha}}\right)^{\frac{1}{1-\gamma}}\\
&= \left(1-\left(\frac{1}{(1-\alpha)h^{1-\gamma}\bar{a}(1-\mu)\bar{x}^{\alpha}}\right)^{\frac{1}{1-\gamma}}\right)\\
&\quad -\frac{(1-\alpha)^2(1-\mu)}{1+g}\frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}+\frac{\alpha}{1-\gamma}\left(\frac{1}{(1-\alpha)h^{1-\gamma}\bar{a}(1-\mu)\bar{x}^{\alpha}}\right)^{\frac{1}{1-\gamma}}
\end{aligned}$$

notice that $\left(1-\left(\frac{1}{(1-\alpha)h^{1-\gamma}\bar{a}(1-\mu)\bar{x}^{\alpha}}\right)^{\frac{1}{1-\gamma}}\right)=\bar{L}^m$, so

$$\begin{aligned}
&= \bar{L}^m-\frac{(1-\alpha)^2(1-\mu)}{1+g}\frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}+\frac{\alpha}{1-\gamma}\bar{L}^m\\
&= \bar{L}^m\left(1+\frac{\alpha}{1-\gamma}\right)-\frac{(1-\alpha)^2(1-\mu)}{1+g}\frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}.
\end{aligned}$$

Recall that $\frac{(1+\rho)\eta}{(2+\rho)}\frac{r^w}{\alpha}\frac{(1-\alpha)(1-\mu)}{1+g}\equiv\underline{L}^m$. Then

$$=\bar{L}^m\left(1+\frac{\alpha}{1-\gamma}\right)-(1-\alpha)\underline{L}^m>0\text{ since }\bar{L}^m>\underline{L}^m\text{ and }\left(1+\frac{\alpha}{1-\gamma}\right)>(1-\alpha).$$

In sum:

$$\frac{\partial x_{t+1}}{\partial x_t}_{|x_{t+1}=x_t=\bar{x}}=\frac{\alpha\bar{L}^m}{\bar{L}^m\left(1+\frac{\alpha}{1-\gamma}\right)-(1-\alpha)\underline{L}^m}>0.$$

Step 2: Stability requires

$$\frac{\partial x_{t+1}}{\partial x_t}_{|x_{t+1}=x_t=\bar{x}}<1$$

$$\frac{\alpha\bar{L}^m}{\bar{L}^m\left(1+\frac{\alpha}{1-\gamma}\right)-(1-\alpha)\underline{L}^m}<1.$$

Assume for a contradiction that

$$\alpha\bar{L}^m>\bar{L}^m\left(1+\frac{\alpha}{1-\gamma}\right)-(1-\alpha)\underline{L}^m$$

$\Leftrightarrow$

$$\alpha\bar{L}^m - \bar{L}^m\left(\frac{\alpha}{1-\gamma}\right) > \bar{L}^m - (1-\alpha)\,\underline{\mathrm{L}}^m$$
$$\Updownarrow$$
$$-\bar{L}^m\alpha\left(\frac{\gamma}{1-\gamma}\right) > \bar{L}^m - (1-\alpha)\,\underline{\mathrm{L}}^m,$$

which is a contradiction since $\bar{L}^m - (1-\alpha)\underline{\mathrm{L}}^m > 0$. Accordingly $0 < \frac{\partial x_{t+1}}{\partial x_t}_{|x_{t+1}=x_t=\bar{x}} < 1$. The steady state is locally stable.

The crucial assumption we need to make is that $\underline{\mathrm{L}}^m < 1$ (otherwise existence is not guaranteed), i.e. CON2 above. But given this a steady state exists, and its locally stable.

B Tables

TABLE 1: SUMMARY STATISTICS[32]

	N	Mean	Std Dev	Min	Max
Agricultural Share	**103**	**0.208**	**0.155**	**0.004**	**0.653**
Relative Productivity	**103**	**1.389**	**3.770**	**0.040**	**28.33**
COMP	**103**	**0.785**	**0.302**	**0.113**	**1.433**
RES	**103**	**0.712**	**0.373**	**0.098**	**2.015**
HJ-TFP	**103**	**0.537**	**0.329**	**0.097**	**1.524**

TABLE 2: CORRELATIONS

(n=103)

	AShare	RPROD	COMP	RES	HJ-TFP
AShare	**1**	**...**	**...**	**...**	**...**
RPROD	**0.0013**	**1**	**...**	**...**	**...**
COMP	**-0.5966**	**0.4550**	**1**	**...**	**...**
RES	**-0.2991**	**-0.2626**	**-0.1999**	**1**	**...**
HJ-TFP	**-0.7244**	**-0.0642**	**0.4881**	**0.6620**	**1**

TABLE 3: VARIANCE DECOMPOSITION[33]

	1	2	3	4	5
Var(COMP) share	**0.52**	**0.55**	**0.50**	**0.32**	**0.15**
Var(RES) share	**0.72**	**0.73**	**0.55**	**0.69**	**0.72**
Cov(COMP, RES) share	**-0.12**	**-0.14**	**-0.03**	**-0.01**	**0.07**
N	**103**	**90**	**79**	**81**	**21**

[32] The sample of 103 countries exclude countries in transition (formerly communist) and those with a mining sector greater than 15% of GDP.

[33] Column (1) excludes all transition countries and those with mining shares greater than 15% of GDP. Column(2) additionally drops all countriesl with population less than a million in 1990. Column (3) further drops countries which have relative agricultural productivites less than 1. Column (4) drops countries with relative agricultural productivities less than 0.1 and greater than 10 instead. Column (5) uses only OECD countries with populations greater than a million, mining share less than 15% and not in transition.

Table 4: Variance Decomposition[34]

	1	2	3	4	5
Var(COMP) share	**0.334**	**0.333**	**0.327**	**0.324**	**0.162**
Var $((\kappa^m)^{\frac{\alpha}{1-\alpha}})$ share	**0.013**	**0.013**	**0.014**	**0.013**	**0.006**
Var(RES2) share	**0.676**	**0.679**	**0.494**	**0.676**	**0.700**
Cov(COMP, $(\kappa^m)^{\frac{\alpha}{1-\alpha}}$) share	**-0.049**	**-0.049**	**-0.06**	**-0.059**	**-0.029**
Cov(COMP, RES2) share	**0.088**	**0.086**	**0.184**	**0.092**	**0.114**
Cov($(\kappa^m)^{\frac{\alpha}{1-\alpha}}$, RES2) share	**-0.050**	**-0.050**	**-0.04**	**-0.041**	**-0.019**
N	**49**	**47**	**42**	**46**	**19**

Table 5a: Correlations[35]

	AShare	RPROD	AGRLF	Y/L	Log HJ-TFP
AShare	1.000				
RPROD	0.046	1.000			
AGRLF	0.801	-0.315	1.000		
Y/L	-0.796	-0.087	-0.715	1.000	
Log HJ-TFP	-0.763	-0.047	-0.656	0.805	1.000

Table 5b: Correlations[36]

	AShare	RPROD	AGRLF	Y/L	Log HJ-TFP
AShare	1.000				
RPROD	-0.499	1.000			
AGRLF	0.901	-0.745	1.000		
Y/L	-0.793	0.65	-0.847	1.000	
Log HJ-TFP	-0.763	0.569	-0.782	0.802	1.000

[34] Column (1) excludes all transition countries and those with mining shares greater than 15% of GDP. Column(2) additionally drops all countriesl with population less than a million in 1990. Column (3) further drops countries which have relative agricultural productivites less than 1. Column (4) drops countries with relative agricultural productivities less than 0.1 and greater than 10 instead. Column (5) uses only OECD countries with populations greater than a million, mining share less than 15% and not in transition.

[35] Notes: AGRLF refers to the percentage of labor force in agriculture in 1990, Y/L refers to output per worker in 1988 from Hall and Jones (1999). The number of observations is 81. (Countries with mining shares greater than 0.15, those undergoing transition, with populations less than a million or Ashare greater than 0.6 are excluded).

[36] This table is based on a sample which excludes countries with relative productivities greater than 1. The sample size is 70. For description of variables see footnote to Table 5a.

Table 6a[37]

Aggregate TFP and Agricultural Share in Output

Dependent Variable: Log of HJ-TFP

OLS Estimation

	1	2	3	4	5
Constant	-0.094	-1.604***	-0.421*	-1.758***	-0.341
	(0.061)	(0.136)	(0.234)	(0.166)	(0.317)
Ashare	-3.581***		-2.995***		-3.052***
	(0.301)		(0.475)		(0.519)
SOCINF		1.644***	0.428		
		(0.189)	(0.264))		
GADP				1.181***	0.070
				(0.302)	(0.365)
OPENNESS				0.634***	0.271
				(0.215)	(0.182)
R-Square	0.58	0.41	0.59	0.42	0.59
N	81	81	81	81	81

[37] GADP refers to the average measure of country risk in Hall and Jones (1999). SOCINF refers to Social Infrastructure and OPENNESS refers to the Sachs-Warner index. All three variables are from Hall and Jones. For a description of excluded and included observations see footnote to Table 5a. ***: significant at 1%. ** significant at 5% and *: significant at 10%. Heteroscedastic consistent standard errors in parentheses.

TABLE 6B

AGGREGATE TFP AND AGRICULTURAL SHARE IN OUTPUT

DEPENDENT VARIABLE: LOG OF HJ-TFP

IV ESTIMATION[38]

SECOND STAGE REGRESSIONS

	1	2	3	4	5
Constant	0.097	-2.169***	-0.791	-2.267***	-0.524
	(0.068)	(0.138)	(0.611)	(0.289)	(0.937)
Ashare	-4.573***		-2.845**		-3.189**
	(0.39)		(1.237)		(1.6)
SOCINF		2.779***	1.115		
		(0.252)	(0.772)		
GADP				1.655**	0.183
				(0.685)	(0.967)
OPENNESS				1.208***	0.644*
				(0.444)	(0.372)
R-Square[39]	0.54	0.21	0.53	0.24	0.53
N	81	81	81	81	81
Hansen J-stat.	3.785	1.91	0.23	1.77	0.007
P-value	0.28	0.59	0.88	0.41	0.93

FIRST STAGE REGRESSIONS FOR COLUMN (5) ABOVE

	Ashare	GADP	OPENNESS
EURFRAC	-0.145***	0.092**	0.267***
	(0.027)	(0.041)	(0.083)
ABSLAT	-0.004***	0.007***	0.002
	(.0008)	(0.001)	(0.002)
LOGFRANKROM	-0.003	0.001	0.102**
	(0.016)	(0.023)	(0.048)
STATEHIST	-1.249**	0.091	0.551***
	(0.051)	(0.076)	0.155
R-Square	0.52	0.52	0.34

[38] The instruments used are EURFRAC, Absolute value of the latitude, LOGFRANKFROM - all from Hall and Jones (1999) and STATEHIST05 from Bockstette et al (2002).

[39] This refers to the Centered R-Square.

Table 7a

Aggregate TFP and Share of the Labor Force in Agriculture

Dependent Variable: Log of HJ-TFP

OLS estimations

	1	2	3	4	5
Constant	-0.278***	-1.604***	-0.943***	-1.175***	-1.103***
	(0.083)	(0.136)	(0.241)	(0.166)	(0.277)
AGRLF	-1.506***		-0.949***		-0.933***
	(0.169)		(0.245)		(0.246)
SOCINF		1.644***	0.959***		
		(0.189)	(0.275)		
GADP				1.181***	0.671**
				(0.302)	(0.341)
OPENNESS				0.634***	0.388*
				(0.215)	(0.221)
R-Square	0.43	0.41	0.51	0.42	0.51
N	81	81	81	81	81

Table 7b

Aggregate TFP and Share of the Labor Force in Agriculture

Dependent Variable: Log of HJ-TFP

IV Estimations

	1	2	3	4	5
Constant	0.019	-2.169***	-1.22**	-2.267***	-1.222*
	(0.072)	(0.138)	(0.513)	(0.289)	(0.68)
AGRLF	-2.391***		-1.104*		-1.106*
	(0.268)		(0.579)		(0.635)
SOCINF		2.779***	1.632**		
		(0.252)	(0.67)		
GADP				1.655**	0.807
				(0.685)	(0.796)
OPENNESS				1.208***	0.821**
				(0.444)	(0.391)
R-Square	0.28	0.21	0.41	0.24	0.41
N	81	81	81	81	81
Hansen's J-Statistic	9.44	1.91	0.07	1.77	0.07
P-value	0.02	0.59	0.96	0.41	0.78

First Stage Regressions of Column (5) above

	AGRLF	GADP	OPENNESS
EURFRAC	0.026***	0.092**	0.267***
	(0.083)	(0.041)	(0.083)
ABSLAT	-0.006***	0.007***	0.002
	(0.002)	(0.001)	(0.002)
LOGFRANKROM	-0.016	0.001	0.102**
	(0.035)	(0.023)	(0.048)
STATEHIST	-0.163	0.091	0.551***
	(0.115)	(0.076)	(0.155)
R-Square	0.46	0.52	0.34