AN EMPIRICAL TEST OF THE POVERTY TRAPS HYPOTHESIS

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ABSTRACT

This paper presents an empirical test of a subclass of poverty traps hypotheses. The test is based on the observation that the nonconvexities in the production function necessary to generate multiple equilibria need only be present in the region between the equilibria. Increasing returns should therefore be strongest when the economy is transitioning between steady states than when it is at or near one of those steady states. I implement this idea by estimating the degree of increasing returns during growth accelerations and growth transitions for a panel of developing and developed economies using UNIDO's Database of Industrial Statistics. I find no evidence of systematic differences in economies of scale between transition and non-transition episodes, shedding doubt on the idea that increasing returns in manufacturing generate poverty traps.

1 INTRODUCTION

There is a vast literature in the fields of economic development and growth that attempts to answer the question of why there exist such vast differences in output per worker and living standards across countries. Explanations range from those that emphasize policy choices to those that center on deeper institutional and structural characteristics. A plethora of empirical studies evaluating these hypotheses has emerged in the cross-country context as well as in the tradition of in depth country- or region-specific case studies of economic growth. As would be natural to expect in such a broad and diverse literature, some of its main findings are hotly contested, making it possible to find advocates and detractors of almost all hypotheses that have been put forward. Furthermore, there are serious econometric criticisms that have been leveled at the cross-national regression approach, shedding doubt on the robustness and reliability of the conclusions that can be drawn from comparing growth rates across relatively diverse groups of economies.

There is a distinct class of models of economic growth, however, which is much less amenable to evaluation in the cross-country regression framework and has therefore been the subject of a much more reduced literature. This is the group of models characterized by the existence of multiple equilibria, or "poverty traps". In those models, the fundamental explanation for differences in per capita income is that some countries fall into self-reinforcing “vicious circles” in low levels of income are at once the result and the explanation.

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For example, a poor country may be unable to collect enough taxes to finance infrastructure investment, while the lack of infrastructure may explain its low productivity and consequent low levels of average income. Alternatively, a small, backward economy may not have the market size necessary to make a modern manufacturing sector profitable, but the lack of a modern manufacturing sector ensures that the economy remains backward. By their nature, these models predict that two economies that may be identical in their fundamental determinants of living standards (quality of institutions, savings behavior, government policies) may end up displaying very different levels of income , perhaps due to historical coincidences that led them to traverse different paths in the past.

This feature of poverty trap models— that otherwise identical countries may end up having very different trajectories in income—is also what limits the possibility of evaluating them in the standard cross-country framework. The reason is that the workhorse regression in cross-national empirical studies of economic growth relies on a specification in which incomes or growth rates depend on fundamentals. Since poverty trap models contend the opposite—that income does not depend on fundamentals—there is no direct relationship between the statistical significance of coefficients in a growth regression and the validity of the poverty traps hypothesis. Furthermore, given that vicious cycles may well end up affecting the right-hand side variables in growth regressions (e.g.: a poor state is likely to provide low levels of public education) then these will be unlikely to satisfy the exogeneity conditions necessary for the coefficient estimates to be unbiased.[1]

Technically speaking, there are two different types of models of poverty traps in development economics. On the one hand, there are genuine models of multiple equilibria, in which at any given moment of time two economies with exactly the same parameters and the same historical evolution will have different levels of output per worker. In these models it is actually feasible for an economy to jump from being a rich economy to being a poor economy if agents suddenly become convinced that everyone else will pay the strategies leading to the inferior equilibrium. On the other hand, there are models of multiple steady states. In these models, two economies may share the same parameters but will end up in different long-run equilibria because they either had different starting conditions or faced a different evolution of shocks.

Models of multiple steady states are best known and form part of the conventional textbook description of poverty traps. For example, the conventional Solow model of economic growth can be modified by adding nonconvex regions to the production function, generating multiple long-run rest points in the resulting dynamical system. Economies with different starting points will be in different basins of attraction and thus converge to different long-run steady states. However, pure models of multiple equilibria are also common in the growth literature. Perhaps the best known example comes from Murphy, Shleifer and Vishny's (1989) model of the "Big Push", in which firms decide to adopt modern production technologies characterized by increasing returns to scale only if they expect that demand will exist for their production, but this demand will only materialize if workers are being paid the wages that they can earn when they are working with modern production technologies. In this model, it is sufficient for firms to expect that there will be demand for their products for them to decide to invest in the modern production technology, making their expectation a self-fulfilling prophecy.

Commonly, poverty-trap based explanations of underdevelopment emphasize the role of the manufacturing sector in the escape from poverty.[2] This is not only a prevalent assumption in the older development literature (Prebisch, 1950, Rostow, 1961) but is also present in numerous modern models (Murphy, Shleifer and Vishny, 1989, Matsuyama, 1991, Laitner, 2000). The emphasis on manufacturing is natural because manufacturing firms appear to be characterized by substantial setup costs and manufacturing environments appear to be better suited to the type of interactions that would generate learning externalities. It is also commonplace to assume that development can only happen by industrialization, though this assertion is controversial.[3] It thus appears natural to study the prevalence of the mechanisms generating multiple equilibria in the manufacturing sector.

Despite the difficulties for evaluating poverty trap models in a cross-country regression framework, a number of authors have attempted to evaluate poverty trap models using the cross-national data. Not surprisingly, the interpretation of the evidence is very much under discussion. Broadly speaking, there appear to be two types of empirical papers that attempt to evaluate models of poverty traps using the cross-country data. On the one hand, there are studies that derive macroeconomic implications of poverty trap models for the evolution of economic growth over time and compare them with the patterns present in the data. Easterly (2006), Sachs et al. (2004), and Kraay and Raddatz (2005) are typical of this approach. On the other hand, a second group of contributions studies the patterns of the cross-country distribution of income and compares it to what one would expect under both multiple equilibria and single equilibria models of growth. Quah (1996), Azariadis and Stachurski (2004), and Bloom, Canning and Sevilla (2003) are examples of this second strand of research. The distinction between the two groups is not always airtight because it is difficult to talk about cross-country patterns of growth without talking about the emerging distribution. In that sense, the discussion is somewhat reminiscent of the debate between β -convergence and σ -convergence advocates, although a full analysis of the relationship between both types of approaches has yet to be carried out.

There is no conclusive pattern either of confirmation or rebuttal of poverty trap hypotheses that seems to emerge from these studies. The key findings of the literature could be summarized as follows. First, there are twin peaks in the world income distribution, either unconditionally (Quah, 1996 Azariadis and Stachurski, 2004) or conditional on geographic factors (Bloom, Canning and Sevilla, 2003). This observation is consistent with the idea of multiple steady states, though it could also be generated by single equilibria models combined with a bimodal distribution either of the disturbances or of the explanatory variables. Some poor countries have grown at very low rates, in contrast to rich countries that have grown very rapidly (Sachs et al., 2004). However, there is little evidence of a savings-induced poverty trap at the macro-level since very poor countries have not had very low savings rates (Easterly, 2006, Kraay and Raddatz, 2005). There are plenty of transitions between poor and rich countries, and most of them don't occur through growth accelerations. If one does a horse race between policies and initial poverty, one finds that the bad policies explanation has more power (Easterly, 2006).

Part of the inconclusiveness has to do with the fact that different authors adopt different splits for the data. For example, Easterly (2006) and Sachs et al. (2004) adopt different definitions of the relevant set of poor countries in order to distinguish whether they grow more slowly than the rest of the economy. However, the deeper problem appears to be that a number of patterns (such as the bimodality in the data) are consistent with multiple equilibria as well as with other hypotheses. Therefore it is necessary to come up with tests that break the observational equivalence between multiple equilibrium and single equilibria model.

The basic idea of this paper starts out from the observation—first made by Cooper and John (1988) that multiple equilibria require positive spillovers. These spillovers can occur at the level of many strategic interactions among agents: production, savings, or fertility decisions. They also imply the existence of some type of scale economies at the national level. This is because the fact that the payoff to one agent is positively related to the other agent's action implies that if both agents undertake an action their joint payoff must be higher than an agent's individual payoff if no one else takes that action.

As we show, the Cooper and John results effectively require the existence of positive spillovers only in the region between equilibria, but not at or near the equilibria themselves. This is the basis for our empirical strategy: to separately estimate the degree of increasing returns for countries that appear to be transitioning between equilibria—either because they are growing or declining very rapidly. If the poverty traps explanation of underdevelopment were correct, these countries should be the most stringent candidates for examples of transitions between equilibria. If these countries are effectively transitioning between equilibria, then we should be able to find evidence that positive spillovers are stronger among them than in the rest of the sample.

The intuition for our approach can be illustrated by going back to the Murphyh, Shleifer and Vishny (1989) model of manufacturing and increasing returns. As the economy transitions from being traditional to being modern, we find that firms in the modern manufacturing sector are becoming more profitable at the same time that they are expanding, as the growth in the economy's market size makes them increasingly capable of recouping their fixed costs. Thus, if we were to study the economy during this transition, we would find evidence of economy-wide scale economies. Similarly, if the economy enters into a growth collapse—whereby the shrinking size of the economy makes it more difficult for firms to cover their fixed costs, then we will also find that firms are becoming less profitable as they are shrinking, again providing evidence of economy-wide scale economies. But if, in contrast, we were to study the economy at any of its long-run equilibria (either in its traditional or modernized state) then we would find no relationship between the economy's aggregate size and the profitability of firms.[4]

This idea can be used to evaluate the existence of poverty traps in a number of models. As long as we can produce estimates of positive spillovers in any dimension, we can evaluate whether the magnitude of these spillovers is greater in countries that are experiencing very high or very low growth rates. In order to obtain a precise definition of what a very high or very low growth rate is, we borrow from the recent literature on growth transitions.[5] In this paper we illustrate this idea by centering on one of the channels for positive spillovers most prevalent in the poverty traps literature: the presence of increasing returns in the manufacturing sector. Using UNIDO's Database of Industrial Statistics, we will estimate manufacturing production functions for 44 countries and test whether they are systematically different in countries undergoing growth collapses and growth accelerations.

One important caveat about our paper is that, since our data set covers only the manufacturing sector, we are able to evaluate only manufacturing-based versions of the poverty trap hypothesis. To the best of our knowledge, there is no comparable cross-national database that allows us to implement our approach in services or agriculture. Nevertheless, as we have already argued, a large number of multiple equilibria models of underdevelopment emphasize precisely the significance of externalities in manufacturing during the process of an economy's modernization. It is also the case that our method can be extender to the study of savings rates, fiscal policy, and other potential determinants of positive spillovers.

The rest of the paper proceeds as follows. Section 2 presents the theory of positive spillovers behind the empirical strategy. Section 3 introduces the industry-level data and presents our estimation results. Section 4 concludes.

2 THE THEORY OF POSITIVE SPILLOVERS AND TESTING FOR MULTIPLE EQUILIBRIA

All models of poverty traps have essentially the same underlying story. Agents in an economy are trapped in a situation in which their actions generate a situation of low income/productivity and at the same time the economy's low level of income has the consequence of generating incentives for agents not to change their actions. If all agents in an economy could coordinate to change their actions to those that will generate high levels of income, then they would find it rational to do so. But they will find it rational to undertake the action with virtuous consequences only if everyone else does so; otherwise their incentive will be to take the action that produces low levels of income.

This general story covers many potential mechanisms of poverty traps. Firms may find it optimal to adopt expensive, high productivity technologies only if everyone else does so. Individuals may be willing and able to save only if they are above their subsistence level of income, something that will only occur if everyone else saves enough so as to finance high levels of capital accumulation. The average family in a poor country will tend to decide to have many children, but a high population growth rate makes it difficult for the economy to accumulate a sufficient stock of productive assets per worker, thus keeping the economy poor.

In all of these explanations, there exists a feedback mechanism from collective decisions to the incentives of a particular agent. A firm will decide whether to adopt a technology not only based on its technical productivity but also on the level of aggregate demand in the economy. An individual will decide to save more or to have fewer children only if her income is sufficiently high, and this will happen only if the economy has a sufficiently high stock of capital per worker.

In a classic paper, Russell Cooper and Andrew John (1988) identified the key causal link in all of these explanations as the existence of strategic complementarities combined with positive spillovers. Broadly speaking, positive spillovers exist whenever there is an action that, if it is undertaken by all other agents, will generate an overall superior situation for the remaining agent, while a strategic complementarily exists when the private benefit of undertaking an action is higher for each individual when other individuals are undertaking it. More formally, suppose that there exist N agents, which we index by $i = 1...N$. Let $V(e_i, \bar{e})$ denote the payoff to agent i from carrying out action e_i if all other agents are carrying out action $\bar{e}$. There will be a positive spillover when

$$V_2 = \frac{\partial V}{\partial \bar{e}} > 0, \tag{1}$$

that is, each individual benefits from all other individuals increasing their level of e .
A strategic complementarily will be defined as a situation in which:

$$V_{12} = \frac{\partial^2 V}{\partial e_i \partial \bar{e}} > 0, \tag{2}$$

that is, the marginal payoff to agent i from increasing her action e_i must increase when everyone increases that action. Cooper and John's key results are that (i) A strategic complementarily is a necessary condition for multiple equilibria, and (ii) These equilibria can be Pareto-ranked by the equilibrium action if there are positive spillovers. Precisely when this happens can we talk about the existence of poverty traps: equilibria in which the reinforcing decision (not) to take a particular action generates an outcome in which all agents are worse off.

A commonly overlooked fact about the Cooper and John results is that the requirement of positive spillovers is local to the range between the two equilibria. In other words, suppose that equilibrium 1 (the poverty trap) is characterized by a level of action e' while equilibrium 2 is characterized by action $e'' > e'$. In that case, the positive spillover condition $V_2(e_{i,} \bar{e}) > 0$ need only occur for the range $\bar{e} \in [e', e'']$. Positive spillovers may be absent for $\bar{e} < e'$ or $\bar{e} > e''$.[6]

This observation forms the basis for our empirical strategy, as it implies that one should only expect to find economies of scale in the range between equilibria or, in other words, when the economy is transitioning either into or out of a poverty trap. As stated, the Cooper and John model places no restriction on the level of scale economies when the economy is at either of the equilibria.

These requirements are actually even stronger in many of the relevant models of economic growth characterized by multiple steady states, where it is necessary for positive spillovers to be present only in the region between the steady states. In order to show this, we set up a simple Solow-style model characterized by increasing returns. Let an individual firm's production function be given by:

$$y_{it} = A(k_t) f(k_{it}) \tag{3}$$

where $k_t = \sum_{i=1}^{n} \frac{k_{it}}{N}$ .The first part of the production function captures the feedback from the aggregate capital stock to an individual firm's productivity, whereas the second part encapsulates the private part of the firm's payoffs which depend only on its actions. We say that there are positive spillovers when $A' > 0$ Assuming that there is a symmetric equilibrium in which all identical firms take the same production decision, we can define the GDP function:

$$Y = \sum_{i=1}^{N} y_{it} = A(k_t) \sum_{i=1}^{N} f(k_t) = A(k_t) g(k_t) \tag{4}$$

for $g(k_t) = \sum_{i=1}^{N} f(k_t)$ .Let us suppose that capital accumulation in the economy is given by the simple Solow closure:

$$k_{t+1} - k_t = sy_t - (n+\delta)k_t \quad (5)$$

In this case the steady state will be the level of capital stock such that:

$$h(k) = \frac{A(k)g(k)}{k} = \frac{(n+\delta)}{s}. \quad (6)$$

In order for this economy to have several steady states, this equation must have more than one solution. Let us concentrate on the two steady states corresponding to the lowest and highest levels of k_t respectively labeled $\underline{k}$ and $\overline{k}$. Note that it is necessary for the model to be minimally consistent with reality for both of these equilibria to be stable: otherwise, the model would imply that if the capital stock was to fall below $\underline{k}$ (increase above $\overline{k}$), it would decline (grow) without bounds. Mathematically, this implies that:

$$\begin{aligned} h'(\underline{k}) &< 0 \\ h'(\overline{k}) &< 0 \end{aligned} \quad (7)$$

Since $h(\underline{k}) = h(\overline{k})$ then it must also be the case that the average derivative between $\underline{k}$ and $\overline{k}$ is zero:

$$\int_{\underline{k}}^{\overline{k}} h'(k)dk = 0 \quad (8)$$

Note that the definitions of $\underline{k}$ and $\overline{k}$ imply:

$$\begin{aligned} h(k) &> h(\underline{k}) \text{ for } k < \underline{k} \\ h(k) &< h(\overline{k}) \text{ for } k > \overline{k} \end{aligned} \quad (9)$$

With the implication that:

$$\int_{0}^{\underline{k}} h'(k)dk < 0 \quad (10)$$

$$\int_{\overline{k}}^{\infty} h'(k)dk < 0 \quad (11)$$

Expressions (8)-(11) imply that the average value of h' is higher in the range $[\underline{k}, \overline{k}]$ than outside this range. In order to get a more concrete idea of the meaning of this, note that:

$$h'(k) = \frac{\left(A'fk + f'Ak - Af\right)}{k^2} = \frac{1}{k}\left(A'f + f'A - \frac{Af}{k}\right) \quad (12)$$

If we assume the production function f is Cobb-Douglas, this implies:

$$\begin{aligned} h'(k) &= \frac{1}{k}\left(A'k^{\alpha} + A\alpha k^{\alpha-1} - Ak^{\alpha-1}\right) \\ &= \frac{A}{k^{1-\alpha}}\left(\frac{A'}{A} + \alpha k^{-1} - k^{-1}\right) \\ &= Ak^{\alpha}\left(\varepsilon_{Ak} + \alpha - 1\right) \end{aligned} \tag{13}$$

where $\varepsilon_{Ak} = \frac{A'k}{A}$, the elasticity of productivity with respect to the capital stock. Now (7) and (8) imply that there must be a $k \in (\underline{k}, \overline{k})$ for which $h'(k) > 0$ and, by (13), $\varepsilon_{Ak} > 1-\alpha > 0$. So there must be a range over which the function has increasing returns. Furthermore, (8) also implies that the output-weighted elasticity must be greater than $(\alpha-1)\hat{y}$, with $\hat{y}_{\kappa}^{\overline{\kappa}} = \int \mathrm{A}\kappa^{\alpha} dk$ denoting the average level of income in the range between $\underline{k}$ and $\overline{k}$. This requires again that ε_{Ak} be positive over part of this range, implying the existence of economies of scale. However, no such implication is true for the ranges $[0,\underline{k}]$ and $[\overline{k},\infty]$, where (10) and (11) are consistent with $\varepsilon_{Ak} \leq 0$. Furthermore, manipulating these expressions one can reach the following conditions:

$$\frac{\int_{\underline{k}}^{\overline{k}} \mathrm{A}k^{a}\varepsilon_{\mathrm{A}k}dk}{\hat{y}_{\underline{k}}^{\overline{k}}} = 1-\alpha \tag{14}$$

$$\frac{\int_{0}^{\underline{k}} \mathrm{A}k^{\alpha}\varepsilon_{\mathrm{A}k}dk}{\hat{y}_{0}^{\underline{k}}} < 1-\alpha \tag{15}$$

$$\frac{\int_{\overline{k}}^{\infty} \mathrm{A}k^{\alpha}\varepsilon_{\mathrm{A}k}dk}{\hat{y}_{\overline{k}}^{\infty}} > 1-\alpha \tag{16}$$

In other words, the (value-weighted) elasticity of productivity with respect to the capital stock must be equal to 1- α in the range $[\underline{k},\overline{k}]$, but must strictly less than this value in the ranges $[0,\underline{k}]$ and $[\overline{k},\infty]$. If we assume that ε_{Ak} is equal to constants e^m , e^l and e^h respectively in these three ranges, then the conditions boil down to:

$$\begin{aligned} e^m &> e^l \\ e^m &> e^h \end{aligned} \tag{17}$$

In sum, the degree of increasing returns must be greater in the range between the lowest and highest level stable equilibria. It is important to note that the degree of increasing returns must be high **both** when the economy is going from being a poor to being a rich country (a growth acceleration) and when it is going from being a rich to being a poor country (a growth collapse), as in both cases there is a positive relationship between the size of the economy and the marginal private return to capital accumulation

This result provides us with a mechanism that can be used to test for the existence of multiple equilibria. The idea is to identify situations in which we suspect that the economy may be in the range between $[\underline{k}, \bar{k}]$. If we estimate ε_{Ak} in this range, we should get values which are on average higher than outside of that range (or than locally at any of the extreme).[7] Although we have illustrated this in the context of a simple Solow-style growth model, the general framework can be extended to many other mechanisms that generate multiple equilibria in growth models, such as subsistence consumption or endogenous fertility.

3 EVIDENCE FROM MANUFACTURING

In this section we follow up on the results presented in the previous section by investigating the evidence of systematic differences in the magnitude of external effects in different regions of the production function. Our tests rely on the idea that, if poverty traps were the fundamental explanation behind the vast differences of income per capita across countries, then the periods during which the economy is transitioning between different steady states should correspond to either growth accelerations or growth collapses. But, according to the results of the previous section, the magnitude of the external effects present in these economies should also be systematically different in these periods in contrast of periods during which an economy is not transitioning between steady states.

Our empirical strategy is thus based on the following idea: First, we identify the periods of *growth transitions*. These are the periods during which an economy appears to have fallen into a poverty trap or to have escaped from it. We can identify these periods because when an economy is transitioning from a lower-level (upper-level) steady state to an upper-level (lower-level) one we should observe a growth rate that is systematically different from that which we observe when the economy is at or near one of the steady states. Second, we separately estimate the aggregate production function for the countries in our data set and evaluate whether it is systematically different during these periods of growth transitions than during the rest of the sample.

Our identification of growth transitions is done using data on PPP-adjusted per capita and per worker output from the Penn World Tables 6.2 data set. If an economy is close to its steady state, we should expect it to be growing at approximately the rate of world technological progress, which we shall call x.

We define a threshold difference in the growth rate $x+\delta$ such that we will consider an economy growth acceleration if two conditions are held: (i) its growth rate exceeds $x+\delta$ on average over a five year period, and (ii) its growth rate exceeds x on every single year of this five year period. Similarly, we define a growth collapse as a five year period during which (i) the growth rate is less than $x-\delta$ on average during a five year period, and (ii) the growth rate is less than x on every single year of that five-year period.

In the following empirical exercise, we set $x=\delta=2$. The first of these finds a basis in a number of analyses of long-run economic growth, which have argued that the long-run rate of technological progress can be adequately proxy by the long-run growth rate of the US economy, which is approximately two percent (e.g., Parente and Prescott, 2000). The assumption that $\delta=2$ has the convenient feature of being the only symmetric assumption that also identifies as growth collapses only those episodes associated with negative economic growth. This implies that our episodes of growth collapses will coincide with the episodes of length greater than five years identified by Hausmann, Rodríguez and Wagner (2008).

Our filter for accelerations is different from that used by Hausmann, Rodrik, and Pritchett (2008), though, since these authors emphasize any significant positive changes in the growth rate, while we are most interested in those changes that are consistent with the economy moving away from a steady state.

We generate these growth transitions using both Real GDP per Capita and Real GDP per Worker from the Penn World Tables data. In the per capita metric, 11.6% of country-years correspond to growth accelerations while 10.9% correspond to growth collapses. Using the per-worker metric, the corresponding figures are 9.9 and 11.9 percent. This is due to the fact that for most of the sample the growth in the labor force is higher than that of population growth, making it more difficult to meet a pre-specified growth threshold (and easier to fall below a collapse threshold) when one uses the per worker metric. The four countries spending the highest amount of time in a growth acceleration (using the per capita metric) coincide with the well-known cases of growth accelerations that appear to be the strongest candidates for a story of “escape from a poverty trap." These are Korea (43 years), Taiwan (40 years), Thailand (32 years), and Malaysia (30 years). Similarly, the four top places for period of time undergoing a growth collapse go to well-known basket cases such as Madagascar (40 years), Kuwait (26 years), Jordan (25 years) and Ecuador, Brunei and Kenya (each with 24 years).

We now turn to examining whether the countries undergoing these transitions display greater evidence of economies of scale in the microeconomic data. We will estimate these economies of scale using data from industrial surveys covering the manufacturing sector from the Industrial Statistics Database produced by the United Nations Industrial Development Organization (UNIDO, 2005). This institution currently collects yearly country-level data on industrial aggregates by industry for 181 countries. This effort, which started in 1977, has allowed the construction of a data set that goes back to 1963 for the 3-Digit ISIC Revision 2 classification. The data is collected through annual questionnaires that are sent to the statistical offices of countries with an industrial level survey or census. The data is then checked for consistency and errors by UNIDO and supplemented with national and international statistical sources as well as data collected by statisticians engaged by UNIDO to work in specific countries. The statistical checks are designed to ensure cross-national comparability: as stated by UNIDO (2003), this database is primarily intended to meet the statistical needs of researchers engaged in international, or cross-country, studies rather than country-specific investigations. (p. 3)

Since our data contains industry-level aggregates—as opposed to firm-level information—separately identifying the spillover effect from the aggregate characteristics of the production function can be difficult. Ideally, one would like to be able to gauge the responsiveness of firm-level production to aggregate production. However, this is not strictly necessary to test the hypotheses presented in the previous section. To see why this is the case, note that in the case in which g is Cobb-Douglas we have:

$$\varepsilon_{Yk} = \frac{dA(k)g(k)}{dk}\frac{k}{Y} = \frac{dA(k)}{dk}\frac{g(k)k}{A(k)g(k)} + \frac{dg(k)}{dk}\frac{A(k)k}{A(k)g(k)} = \varepsilon_{Ak} + \varepsilon_{gk} \qquad (19)$$
$$= \varepsilon_{Ak} + \alpha$$

Note that this is the same as the value inside the parentheses in (13) (minus one). In other words, what matters for the generation of a poverty trap is the concavity/convexity of the aggregate production function $y(k)$, not how it is divided between $A(k)$ and $g(k)$.

The stylized description that we have presented has relied on the existence of a spillover effect in the capital stock. More generally, the production function could be characterized by increasing returns in both capital and labor. A standard description would be:

$$\log y_{it} = \log A_{0i} + \alpha \log k_{it} + \beta \log l_{it} + \gamma t. \tag{20}$$

It is common at least since Nerlove (1963) to estimate the dual of this problem, which is given by the associated cost minimization problem. Given a production technology as described in (20), it is straightforward to derive the associated cost function:

$$\log C_{it} = \ln B_{0i} + \frac{1}{s}\ln y_{it} + \frac{\alpha}{s}\ln r_{it} + \frac{\beta}{s}\ln w_{it} - \frac{\gamma}{s}t \tag{21}$$

where $s = \alpha + \beta$ is a measure of returns to scale (in what follows we use the convention of reporting $s' = s - 1$). Substituting $\frac{\beta}{s} = 1 - \frac{\alpha}{s}$ gives us:

$$\log C_{it} / r_{it} = \ln B_{0i} + \frac{1}{s}\ln y_{it} + \frac{\beta}{s}\ln w_{it} / r_{it} - \frac{\gamma}{s}t \tag{22}$$

Our key hypothesis, derived in (17) is that the degree of increasing returns in the production function (given by s in (22) will be higher during growth transitions than during growth accelerations. In principle, we could test this by evaluating whether these parameters change considerably during a growth transition:

$$\log c_{it} = \log \mathrm{B}_{0i} + \theta_1 \log y_{it} + \theta_2 \log \tilde{\omega}_{it} + \theta_3 t + \theta_4 \mathrm{I}\{i \in \mathrm{T}\} \log y_{it} \tag{23}$$

where we would test the hypothesis that $\frac{1}{\theta_1} < \frac{1}{\theta_1 + \theta_4}$. Alternatively, we can distinguish between growth accelerations and growth collapses, thus estimating:

$$\log c_{it} = \log \mathrm{B}_{0i} + \theta_1 \log y_{it} + \theta_2 \log \tilde{\omega}_{it} + \theta_3 t + \theta_4 \mathrm{I}\{i \in \mathrm{T}_A\} \log y_{it} + \theta_5 \mathrm{I}\{i \in \mathrm{T}_C\} \log y_{it} \tag{24}$$

and testing $\frac{1}{\theta_1 + \theta_4} > \frac{1}{\theta_1}$, $\frac{1}{\theta_1 + \theta_5} > \frac{1}{\theta_1}$.

In estimating a cost function using cross-national data, it is important to take into account that countries may be producing below their potential output because of institutional, policy, or other country-specific inefficiencies. These inefficiencies may generate the illusion of non-convexities in the production technology which are in effect due to the fact that some countries are well below their actual productive capacity. As our interest in this paper lies in understanding whether the production technology is characterized by increasing returns in the neighborhood of growth transitions (and not whether poverty traps operate through more complex institutional channels), it is important for us to model these inefficiencies explicitly. In order to do so, we adopt a stochastic production frontier specification as proposed by Kumbhakar and Lovell (2000). In essence, we model the production function as containing an asymmetric inefficiency term:

$$\log y_{it} = \log A_{0i} + \alpha \log k_{it} + \beta \log l_{it} + \gamma t + \xi_{it} \tag{25}$$

with $\xi_{it} < 0$. Kumbhakar and Lovell shows that this assumption leads to an econometric cost function specification with two disturbance terms:

$$\log c_{it} = \theta_0 + \theta_1 \ln y_{it} + \theta_2 \ln \tilde{\omega}_{it} + \theta_3 t + v_{it} + u_{it} \tag{26}$$

with $u_{it} \geq 0$. This model can be estimated via maximum likelihood methods.

In order to estimate these equations using the UNIDO data we will need data on factor cost, employment and the capital stock. The UNIDO database has aggregate payments to capital and labor as well as employment and nominal gross fixed capital formation by three-digit sector. The UNIDO database also has three-digit sector production indices which we can use to derive sector-specific output deflators. We convert factor costs to real terms using these deflators. However, the generation of real investment is more difficult as we do not have investment deflators in the UNIDO data. As an investment deflator, we use the domestic price of investment from the Penn World Tables data. After deflating the investment level, we then build perpetual inventory capital stock estimates, using a depreciation rate of 4 percent and an initial capital stock estimate equal to three times value added (measured in terms of investment goods) in the initial year of the data. We derive r as the average operating surplus divided by the estimated capital stock, and w as the average employee compensation divided by the total number of employees. Regrettably, only 44 countries have sufficient data to allow us to estimate all of these variables. However, as shown in Appendix Table 1, the list of countries is sufficiently heterogeneous, including 19 developed countries and 25 developing countries. Of the developing countries, seven are in Latin America, six in the Middle East and North Africa, six in Asia, four in Eastern Europe, and two in sub-Saharan Africa. In the per-worker metric, 21.8% of country-years in our sample are undergoing growth accelerations, while 14.1% correspond to growth collapses.

It is also worth noting that our sample is composed primarily of economies in which the manufacturing sector is important. This fact can be seen in Appendix Table 1, which shows that the average share of manufacturing exports as a percentage of total exports in our sample is 53.35 (as opposed to 36 percent for all countries in the World Development Indicators). This is of course a reflection of the fact that it is precisely in countries where manufacturing is more important that we are likely to have enough data to carry out our calculations. At the same time, if we were to find evidence of a manufacturing-based poverty trap, we would expect it to be strongest precisely in this subset of countries.

TABLE 1

Cost Function Panel Estimates

Dependent Variable: ln(Cost/r)	(1)	(2) Per Capita	(3) Collapses	(4) Per Worker	(5) Collapses
w/r	0.4641	0.4657	0.4527	0.4655	0.448
	(0.0416)**	(0.0420)**	(0.0439)**	(0.0415)**	(0.0426)***
Output	0.7595	0.7552	0.7335	0.7709	0.7301
	(0.0316)**	(0.0345)**	(0.0355)**	(0.0353)**	(0.0355)***
Trend	0.0046	0.0048	0.0053	0.0044	0.0052
	(0.0015)**	(0.0015)**	(0.0016)**	(0.0016)**	(0.0016)***
Growth Transitions		-0.0904		0.3747	
		(0.2281)		(0.2291)	
Transitions*output		0.0048		-0.0136	
		(0.0093)		(0.0093)	
Growth Collapses			0.9747		1.4202
			(0.5312)*		(0.3686)***
Growth Accelerations			-0.7725		-0.6687
			(0.2247)***		(0.2144)***
Collapses*Output			-0.038		-0.0537
			(0.0222)*		(0.0149)***
Accelerations*Output			0.0314		0.0268
			(0.0091)***		(0.0088)***
Constant	-7.4857	-7.8686	-8.1216	-7.3147	-7.7946
	(2.3391)**	(2.4130)**	(2.4453)**	(2.4174)**	(2.4357)***
Observations	1280	1280	1280	1280	1280
Number of countries	44	44	44	44	44
R-squared	0.82	0.82	0.82	0.83	0.83
Returns to Scale Baseline (no transition)	0.3166***	0.3241***	0.3633***	0.2971***	0.3696***
Transition		0.3157***		0.3204***	
Collapses			0.4378***		0.4784***
Accelerations			0.3073***		0.3211***
Differences in coefficients Transitions-Baseline		-0.0083		0.0232	
Collapses-Baseline			0.0744		0.1087***
Accelerations-Baseline			-0.0559***		-0.0484***

Robust standard errors in parentheses.

* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 1 shows the results of our estimates of the cost function using the UNIDO dataset, with each observation corresponding to the manufacturing sector of country i at time t. Therefore these estimates should be considered aggregate estimates of the manufacturing production function. We start out with the simple dual cost specification in (22) and augment it with interactions with growth transitions and for growth collapses and accelerations separately as in (23) and (24). We control for country-specific fixed effects to capture country-specific heterogeneity. Column 1 shows the effect of estimating (22), without drawing a distinction between countries according to whether they are experiencing a transition. We estimate $s' = .317$, indicating strong evidence of increasing returns to scale in the sample as a whole. However, when we include the interaction between output and growth transitions, our estimate for economies undergoing a transition is $s_t^{'} = .316$, very close to the one for non-transition economies of $s_{nt}^{'} = .324$ (column 2 - sub indices nt , a , g , and c denote respectively no transition, transition, acceleration and collapse). Once we distinguish between growth collapses and growth accelerations we get $s_c^{'} = .438$, which is significantly higher than $s_{nt}^{'} = .363$ and $s_a^{'} = .307$. Note that the pattern of coefficients that emerges is somewhat surprising. Remember form the previous section that the degree of increasing returns should *increase* both during growth collapses and during growth accelerations. If there is evidence that the degree of returns to scale increase during a growth transition, this appears to be happening only under growth collapses. The degree of scale economies under growth accelerations actually appears to be lower than that in no transition economies. The coefficient on growth collapses is, however, not statistically different from the one on non-transition episodes—although the one on growth accelerations is significantly lower. This result sheds doubt on the idea that we can understand growth miracles as occurring because countries are able to escape from a poverty trap.

Broadly similar results emerge from the use of the definitions of growth collapse and accelerations in per worker terms. Remember that this specification arguably captures more adequately the spirit of the aggregate production function as a measure of productive efficiency. The significant difference that emerges in this specification is that the estimate of returns to scale during growth collapses $s_c^{'} = 478$ is now significantly higher at 1% than that on non-transition episodes ($s_n^{'} = .370$) as well than those on growth accelerations ($s_a^{'} = .321$) . The evidence thus could support the hypothesis that countries that are collapsing are falling into poverty traps.

Table 2 presents the results of the stochastic frontier estimates. It is interesting to notice that the key results are unaltered in this more sophisticated estimation exercise. The estimate of returns to scale on the whole sample is $s' = .291$, only slightly lower than the one presented in Table 1. Again, there is no significant pattern of differences in returns to scale between transitions and non-transitions considered as a whole, but when the latter are split between collapses and accelerations, we find a significantly higher degree of scale economies in growth collapses than in non-transitions, and a significantly lower degree in growth accelerations.

The exercise presented in the previous tables assumes the existence of an aggregate production function for manufacturing which maps the inputs of the whole sector into aggregate output. It also assumes that the nonconvexities or external effects driving increasing returns are present in manufacturing as a whole. Either of these assumptions may be wrong: sector-specific production functions may not easily aggregate into a manufacturing-level production function and increasing returns may operate at the sector level but not necessarily at the aggregate level. Therefore, in Table 3 (see Appendix page 19) we proceed to estimate the degree of increasing returns separately for each one of the 28 3-digit sectors for which the UNIDO database has sufficient data.

TABLE 2

Stochastic Frontier Panel Estimation

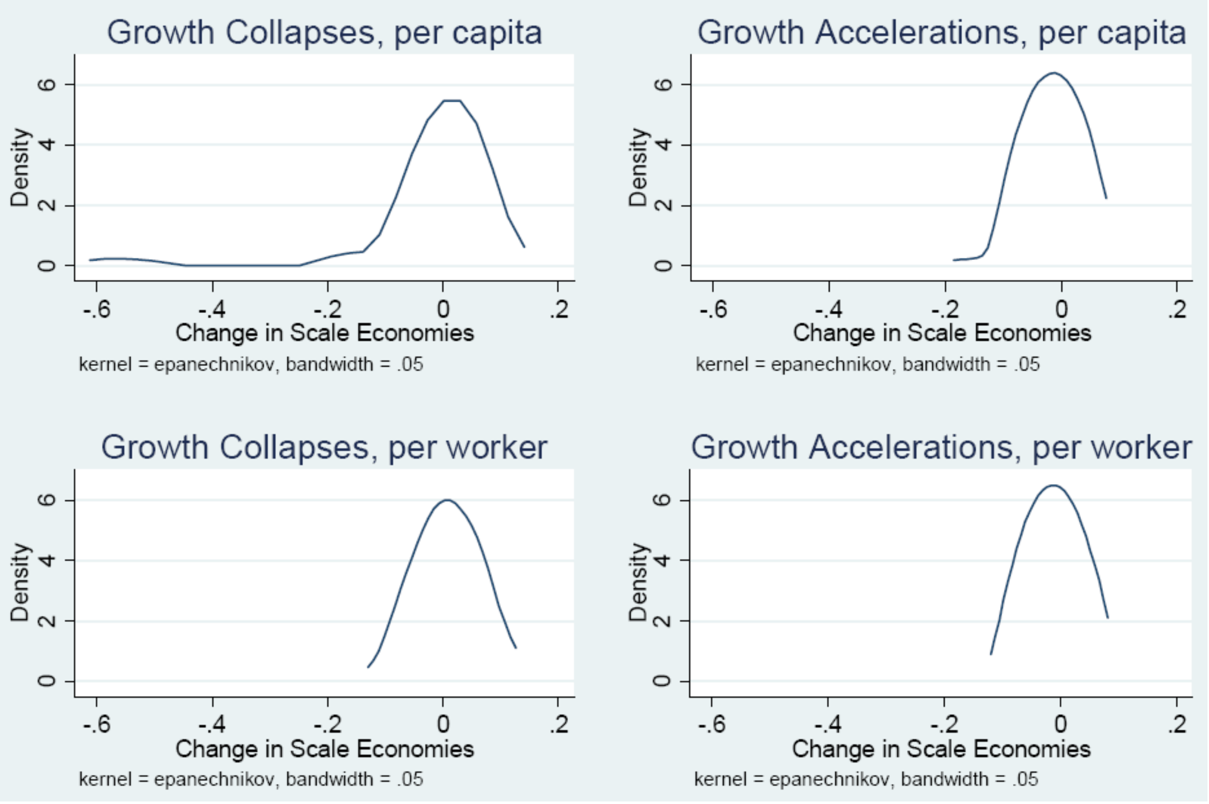
Dependent Variable: ln(Cost)	(1)	(2) Per Capita	(3) Collapses	(4) Per Worker	(5) Collapses
ln(wage)	0.4683	0.47	0.4582	0.4696	0.4538
	(0.0130)***	(0.0130)***	(0.0133)***	(0.0129)***	(0.0130)***
Output	0.7747	0.7716	0.7555	0.785	0.7546
	(0.0213)***	(0.0223)***	(0.0228)***	(0.0222)***	(0.0230)***
Trend	0.0039	0.0041	0.0044	0.0038	0.0042
	(0.0011)***	(0.0011)***	(0.0011)***	(0.0011)***	(0.0011)***
Growth Transitions		-0.0761		0.3843	
		-0.2239		(0.2231)*	
Transitions*output		0.0042		-0.0139	
		-0.0093		-0.0093	
Growth Collapses			0.9479		1.3847
			(0.4267)**		(0.3478)***
Growth Accelerations			-0.7131		-0.5822
			(0.2688)***		(0.2869)**
Collapses*Output			-0.037		-0.0524
			(0.0184)**		(0.0147)***
Accelerations*Output			0.0291		0.0234
			(0.0111)***		(0.0118)**
Constant	-8.4991	-8.8062	-8.7798	-8.4026	-8.3533
	(1.8914)***	(1.8992)***	(1.8797)***	(1.9005)***	(1.8516)***
Observations	1280	1280	1280	1280	1280
Number of countries	44	44	44	44	44
R-squared					
Returns to Scale Baseline (no transition)	0.2908**	0.2959***	0.3235***	0.2739***	0.3251***
Transition		0.2889***		0.2969***	
Collapses			0.3916***		0.4241***
Accelerations			0.2745***		0.2853***
Differences in coefficients					
Transitions-Baseline		-0.007		0.023	
Collapses-Baseline			0.0681*		0.0989***
Accelerations-Baseline			-0.049**		-0.0398*

In our baseline estimation, all manufacturing sectors are characterized by statistically significant increasing returns, with a minimum level for s' of .114 (plastics) and a maximum of 1.791 (printing). At a sector level, the average value of $s_{nt}^{'}$ is $.636$, while the median value is .594. On average, sectors in countries undergoing transitions actually have lower economies of scale parameter. In 10 of the 28 sectors, this parameter is significantly lower, for transitions while in the remaining 18 sectors, the difference is not statistically significant. When we allow the interactions on collapse and acceleration episodes to differ, we get a majority of sectors (24 out of 28) displaying a lower degree of scale economies than in the non-transition episodes. In 16 of these 24 cases, the difference is statistically significant, with a change in scale economies ($s_a^{'} - s_{nt}^{'} = -.061$) similar to those found in the aggregate estimations.
In the case of collapses, the pattern is less strong, with 18 out of 28 sectors presenting greater economies of scale than in the baseline sectors. The results are somewhat stronger again when we use the arguably superior per-worker metric: here the degree of scale economies increases in 21 out of 28 sectors during the collapse cases, (13 of them significantly so) while they decrease in 25 of the 28 cases for growth accelerations (17 significant).

The pattern of these differences is illustrated in Figure 1, where we plot density estimates for the differences between collapse and acceleration episodes, on the one side, and non-transition episodes, on the other. While close inspection of the figure does reveal that the densities for accelerations appear to fall more to the left than those of collapse episodes, what is striking about these figures is the fact that the densities appear not to be very dissimilar, with a large fraction of sectors falling in regions in which there is no substantial difference between the degree of scale economies in transitions and those in accelerations.

FIGURE 1

Changes in Scale Economies During Transitions



The results of this section thus do not give strong support to the hypothesis that growth transitions occur as a result of countries moving between different equilibria. There appears to be no overwhelming evidence that the form of the production function changes systematically in the direction of more convexity during growth transitions. Some of our estimates give tentative evidence that may be consistent with the poverty traps hypothesis for growth collapses.

4 CONCLUSIONS

This paper has presented a simple idea for evaluating the relevance of poverty trap explanations for the development process. The idea relies on the observation that if positive spillovers are the basis for multiple equlibria, then these spillovers should be particularly prevalent when countries are transitioning either into or out of poverty traps. Thus we should find that the spillovers are strong souring periods of growth collapses and growth accelerations—at least if these collapses and accelerations can be explained as transitions into and out of poverty traps.

Our idea can be applied to any estimate of the positive spillovers generating multiple equilibria. We illustrate our method by estimating economies of scale in manufacturing using data from UNIDO's Industrial Statistics Database. For a sample of 44 countries that is evenly balanced between developed and developing economies, we find no significant evidence that growth transitions are systematically different from non-transition episodes in terms of the level of increasing returns present in the manufacturing production functions. Once we split the sample between growth collapses and growth accelerations, we do find that on average growth collapse experiences appear to show a higher degree of scale economies than non-transition episodes.

Our exercise suggests that scale economies may have had something to do with the growth collapses of economies in our database such as Bolivia, Iran and Kenya. We find evidence that this group of countries shows increased nonconvexities in their transition from higher to lower levels of income, suggesting that they may have entered a self-reinforcing cycle whereby initial declines of income translate into further declines in productivity. On the other hand, we do not find evidence that scale economies in manufacturing were any more prevalent in countries undergoing growth accelerations, such as Chile, Korea, and Singapore. This suggests that the manufacturing-based increasing returns explanation for these growth miracles is not consistent with the data. However, the hypothesis that increasing returns in other sectors, such as agriculture, may have been behind these growth miracles, is still a possible explanation.[8]

There are many other channels aside from increasing returns in manufacturing that can generate poverty traps in development, and we have evaluated just one of them. Thus our results should not be interpreted as disproving the idea of poverty traps. That said, we have evaluated an idea that is central to much of the development literature: that taking advantage of increasing returns in manufacturing is a key mechanism through which development happens. While our estimates do find a significant level of increasing returns in manufacturing, we do not find that these scale economies are more prevalent in the countries that are experiencing growth accelerations. An obvious direction for future research consists in evaluating the prevalence of alternative positive spillover mechanisms in growth transitions.

APPENDIX

APPENDIX TABLE 1

Composition of UNIDO Sample

Country	**Initial Year**	**Final Year**	**Number of Years**
Australia	1963	2001	37
Austria	1969	2000	31
Belgium	1963	1999	35
Bolivia	1970	1998	29
Bulgaria	1991	2002	12
Canada	1963	1990	28
Chile	1963	1998	36
Colombia	1963	2000	38
Costa Rica	1963	1968	3
Cyprus	1971	2002	32
Finland	1963	2000	38
France	1977	2000	21
Hong Kong	1973	2002	30
Hungary	1970	2000	27
India	1977	2001	25
Indonesia	1970	2002	33
Iran	1963	2001	38
Ireland	1963	1991	29
Israel	1963	2001	39
Italy	1988	2000	12
Japan	1963	2000	38
Jordan	1974	2002	29
Kenya	1967	2002	36
Korea, Republic	1963	2001	39
Kwait	1670	2001	32
Latvia	1997	1998	2
Luxembourg	1963	1992	30
Malaysia	1968	2001	33
Mexico	1970	2000	31
Morocco	1967	2001	22
Netherlands	1963	1993	31
Norway	1963	2001	39
Portugal	1971	2000	24
Senegal	1974	1997	20
Singapore	1963	2002	40
Slovenia	1990	2002	13
Spain	1964	2000	37
Sweden	1963	1987	25
Trinidad &Tobago	1966	1995	22
Tunisia	1963	2001	28
Turkey	1963	2000	38
United Kingdom	1963	2000	34
United States	1963	2001	38
Uruguay	1968	2000	26
Total	1963	2002	1280

TABLE 3

Industry-Level Estimates of Scale Economies

	Per Capita								Per Work							
	Baseline	**Transitions**	**Transitions-Baseline**	**Baseline**	**Collapses**	**Collapses-Baseline**	**Accelerations**	**Accelerations-Baseline**	**Baseline**	**Transitions**	**Transitions-Baseline**	**Baseline**	**Collapses**	**Collapses-Baseline**	**Accelerations**	**Accelerations-Baseline**
Median	0.594	0.509	-0.032	0.564	0.526	0.031	0.503	-0.061	0.581	0.513	-0.017	0.559	0.596	0.090	0.513	**-0.063**
Mean	0.636	0.615	-0.021	0.674	0.599	-0.075	0.597	-0.078	0.654	0.600	-0.054	0.716	0.673	-0.043	0.572	**-0.144**
Minimum	0.114	0.114	-0.292	0.133	-2.698	-4.300	0.101	-0.501	0.115	0.109	-0.350	0.140	-1.901	-3.829	0.103	**-0.724**
Maximum	1.791	2.337	0.959	1.953	2.242	0.942	2.271	0.669	1.805	1.669	0.100	2.037	2.414	0.412	1.588	**0.043**
5th percentile	0.218	0.185	-0.183	0.222	0.167	-0.254	0.157	-0.366	0.215	0.191	-0.282	0.222	0.152	-0.192	0.140	**-0.455**
95th percentile	1.378	1.608	0.032	1.602	1.996	0.309	1.586	0.044	1.791	1.523	0.048	1.928	1.444	0.376	1.555	**0.031**
Positive	**28**	**28**	**7**	**28**	**27**	**18**	**28**	**4**	**28**	**28**	**11**	**28**	**27**	**21**	**28**	3
Poistive and Significant	**28**	**28**	**0**	**28**	**27**	**5**	**28**	**0**	**28**	**28**	**2**	**28**	**26**	**13**	**28**	0
Negative	**0**	**0**	**21**	**0**	**1**	**10**	**0**	**24**	**0**	**0**	**17**	**0**	**1**	**7**	**0**	25
Negative and Significant	0	0	10	0	0	3	0	16	0	0	8	0	1	4	0	17

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NOTES

1. This is of course a restatement of the endogeneity problem that has plagued cross-country regression work and which is not restricted to the subclass of poverty trap models. While some credible attempts have been in the coss-country literature to attack this problem—mostly through the use of instrumental variables methods—their success implies at best that part of the variation in cross-country income or growth performance can be explained as a result of exogenous covariates, but does not invalidate the hypothesis that a large part of the remaining variation may be due to the existence of povetry traps.

2. Murphy, Shleifer and Vishny (1989, p. 1003-4) write: "When domestic markets are small and world trade is not free and costless, firms may not be able to generate enough sales to make adoption of increasing returns profitable, and hence industrialization is stalled."

3. See Lederman and Maloney (2007).

4. A distinction must be drawn in this example between internal firm economies (which are present in the modernized equilibrium but not in the traditional one) and economy-wide external effects, It is the latter, not the former, which generate multiple equilibria. However, in the version of the Solow model that we use for our empirical tests, it becomes unnecessary to make this distinction.

5. See, for example, Hausmann, Pritchett and Rodrik (2005), Cerra and Saxena (2005), Reddy and Minoiu (2007), Hausmann, Rodríguez and Wagner (2008).

6. This follows from Proposition 4 of Cooper and John (1988), which uses the positive slope of the derivative of the outcome function over the range between the equilibria. Therefore the presence—or lack thereof—of positive spillovers in this range is irrelevant.

7. Note that (7) implies that at any local small interval around k and $\bar{k}$, $\varepsilon_{Ak} < 1 - \alpha$

8. See Sachs and Woo (1999) for an explanation of China's growth miracle that attributes a central role to productivity gains in agriculture.

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