Testing for Poverty Traps

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Abstract:

We extend the Davis and Weinstein (2002, 2004) methodology for testing for multiple equilibria to growth and poverty traps: looking for permanent GDP/capita effects from a temporary shock. Our exogenous shocks are temporary changes to the terms of trade in small economies. Our approach has the advantage that it does not resort to taking a stand on a particular model of how poverty traps are delivered. We find no evidence that even the largest of these temporary shocks, on the order of 1-2% of GDP per capita, induce permanent effects to the growth path of per capita GDP.

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1 Introduction

The salient fact of economic growth is the existence of two distinct convergence clubs (Baumol 1986). Within the same club, the poorer countries have tended to grow faster and overtake the richer countries. But the countries in the poor club are not overtaking the countries in the rich club. In fact, the distance between clubs seems to be increasing (Quah 1996, 1997) as the rich club enjoys sustained growth while poor club countries grow in fits and starts with frequent backsliding. The failure of many countries in the poorest club to make the transition to sustained and rapid growth gives rise to the question of whether these countries will inevitably remain poor due to bad luck and/or intrinsic characteristics, or whether they can be helped, via sound macro-economic policy and/or external assistance, to join the rich convergence club.

From a theoretical perspective, there are many reasons why countries might be caught in the poor club: (i) bad macroeconomic policies—political instability and/or violence, poor direction of public investment, inefficient systems of taxation, corrupt bureaucracy, unchecked spending leading to excessive money growth and hyperinflation, failure to diversify export earnings—(ii) unproductive household habits and customs—high population growth, low investment rates in physical and/or human capital; or (iii) plain bad luck such as unfavorable geography or a difficult sequence of trade shocks. Many growth models predict *conditional* convergence implying countries with different parameters should expect to have different long-run steady state growth paths. In these cases, the answer is to fix the poor macroeconomic policies, encourage cultural change toward adoption of more promising habits, and mitigate unfavorable geography as much as possible. Eventually, as countries manage to adjust policies and habits and enjoy a run of good luck, they will join the rich convergence club. Indeed, many East Asian countries have done so over the past forty years.

But there are two other reasons why poor countries might be poor. The defining characteristic of both of these lines of reasoning is that the problem cannot necessarily be fixed from within, hence both of these mechanisms go by the name of "poverty trap." The first possibility is that there exists some non-convexity in the aggregate production function due to network effects between firms or industries. As a result, two countries with identical parameters may have different long-run steady-state growth paths simply because they had different initial conditions: meaning they arrived at those identical parameters via different histories or had different levels of income at the time that technological change introduced the non-convexity. In this case, parameters are defined rather broadly to include everything from savings rates and population growth to geography and even policy.

The other type of poverty trap comes from the idea that changing the critical parameters is not simply a matter of reforming policy and household behavior and that such reforms are not a simple matter. This approach holds that there are powerful feedback loops whereby low income countries find it extremely difficult to engender "good" behavioral parameters. In other words, parameters are endogenous or state-dependent. For example, the existence of a minimum subsistence level of consumption means the poorest countries have very low savings rates for physical capital or poor health reduces the returns to schooling and thus the ability to invest in human capital.

Both explanations that emphasize non-convexities in the production function and explanations that emphasize feedbacks constraining household behavior deliver a multiplicity of steady states. In fact, they are generally mathematically equivalent in modified Solow models. In the broadest sense, Azariadis and Stachursky define a poverty trap as "…any self-reinforcing mechanism which causes poverty to persist."

Narrowing the question somewhat, we are principally concerned with whether poor countries, left to their own devices, will eventually develop sustained growth and converge to the rich club, how long this process may take, and whether active help from well-intentioned outsiders can shorten this period.[1] As we shall discuss shortly, for many decades, the notion of poverty traps has been taken as a rationale for increased foreign aid.

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 in time, two economies with identical parameters and history may have different levels of output per worker. In these models it is actually feasible for an economy to jump from being rich to poor, or vice-versa, if agents suddenly become convinced that everyone else will play conforming strategies. Economic development is merely a process of developing common conjecture! On the other hand, there are models of multiple steady states in which two economies may share the same parameters but will end up in different long run steady state growth paths because they either had different initial conditions or were dealt different sets of shocks.

Models of multiple steady states are best known and form part of the textbook description of poverty traps. For example, modifying the standard Solow model with a production function having non-convex regions generates multiple long-run resting points for the ratio of capital per effective worker—and thus multiple steady state growth paths—for the same set of parameters. Economies with different initial positions will be in different basins of attraction and thus converge to different long-run steady state growth paths.[2]

Poverty trap models predict that the mapping from parameters to income levels is not a single-valued function. As a result, they are not amenable to the standard cross-country growth regression. Indeed, many authors are skeptical that models of multiple equilibria are scientifically valid in the sense of producing refutable hypotheses. Nevertheless, a number of authors have attempted to evaluate these models using cross-country data. Not surprisingly, the interpretation of this evidence is very much under discussion.

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[1] Matsuyama and others (see Azariadis and Stachursky) have noted that we needn't have an absolute poverty trap. We may have a "narrow escape" bottle: a situation from which countries take a long time to emerge. But as with an absolute poverty trap, this gives scope for outside help.

[2] It is worth asking what we mean by initial position. Consider it the point at which the countries' parameters come into congruence. In the traditional Solow model with a single steady-state growth path, congruence in parameters implies identical growth path; history before congruence matters only in determining the starting point on that path.

There are a large variety of approaches to searching for poverty traps. The literature testing for poverty traps at the macroeconomic level is characterized by several approaches. Several studies derive macroeconomic implications of poverty trap models for the evolution of economic growth over time and then compare these predictions to data. Easterly (2006), Sachs et al (2004), and Kraay and Raddatz (2005) are typical of this approach. A second group of papers compares the observed evolution of the cross-country distribution of income with the evolution predicted by models exhibiting single- and multiple- steady states. Quah (1996), Azariadis and Stachurski (2004), and Bloom, Canning, and Sevilla (2003) are examples of this approach. The distinction between the two groups is not always airtight because it is difficult to speak of cross-country patterns of growth without speaking of the emerging distribution. An alternate approach is to look for evidence of transitions between steady states. For example, Rodrik (1998) looks at growth accelerations to see whether they are also accompanied by increases of the savings rate which would constitute evidence for a savings-trap hypothesis.

Finally, there is a well-developed literature on whether foreign aid increases growth rates. Unfortunately, no clear consensus yet in this literature. Burnside and Dollar (2001) conclude that aid helps in good environments. Collier and Dehn (2001) and Guillamont and Chauvet (2001) both find that aid can mitigate negative terms-of-trade shocks. Hansen and Tarp (2001) review previous studies and conclude that, in small amounts, aid can help growth rates. But Easterly (2004) warns that these results are fragile to definitions of growth, aid, and "good" policy. Most importantly, these papers look at the increase in the growth rate over a very short period (typically four years) concurrent with the increase in aid. As such, they do not test whether aid contributes to permanently higher levels of output from sustained output growth during a transition to a higher steady state. In fact, when Easterly looks at the growth effects over longer periods, the positive effects of aid disappear.

On the whole, no conclusive pattern, either of confirmation or rebuttal of poverty trap hypothesis 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, Azariadis-Stachurski) or conditional on geographic factors (Bloom Canning, and Sevilla). This observation is consistent with the idea of multiple steady states but it could also be generated by a single equilibrium model combined with a bimodal distribution of either of disturbances or the explanatory variables. Second, many poor countries have grown at very low rates in contrast to rich countries that have grown very rapidly (Sachs et al). 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, Kraay and Raddatz). There are plenty of transitions between poor and rich countries, and most of them don't occur through growth accelerations (Easterly). If one conducts a horserace between bad policies and initial poverty, one finds that the "bad policies" explanation has more power (Easterly).

Part of this inconclusiveness has to do with the fact that different authors adopt different splits of the data. For example, Easterly and Sachs adopt different definitions when constructing the set of poor countries to distinguish whether they grow more slowly than the rest of the world. However, the deeper problem appears to be that a number of patterns (such as the bimodal distribution) are consistent with a variety of hypotheses, including multiple steady states. It is therefore necessary to derive a test to break the observational equivalence between models of single and multiple steady states.

Our test borrows from work by Davis and Weinstein (2002, 2004) on economic geography. These authors use episodes of Allied bombing to test for the existence of multiple equilibria in industry location. Their key finding is that very large shocks to city size and industrial composition due to bombings have no effect on long-run city size and industrial composition.

The general approach is simple. Assume an economy starts in steady state and apply a large, temporary shock. If, long after the shock has dissipated, the economy has failed to return to its steady state, then we may conclude that the economy has been pushed into a new basin of attraction and found a new steady state thus implying a world with multiple steady states. If, long after the shock has dissipated, the economy returns to the original steady state, then the shock was insufficiently large to push the economy beyond the current basin of attraction. This cannot be taken as proof of a single equilibrium world—the shock may simply not have been large enough—but the size of the shock may be taken as a lower bound on the proximity of alternate steady states.

We extend the Davis and Weinstein methodology to growth and poverty traps, using temporary changes to the terms of trade in small economies as the exogenous shock. Our approach has the advantage that it does not resort to taking a stand on a particular model of how poverty traps are delivered—savings, industrial spillovers, institutions, etc. As Azariadis and Stachursky put it, "the set of all self-reinforcing mechanisms which can potentially cause poverty is large."

The paper proceeds as follows. Section 2 presents a theoretical model to motivate the specific form of the empirical work. Section 3 presents the data, empirical work, key results, and robustness checks. Section 4 discusses the relevance to the broader picture and concludes.

2 Exogenous Shocks: Theory

To motivate the particular form of our regression, we study a variant of the Ramsey growth model. The key difference is that the economy receives an exogenously determined level of export revenues which can be exchanged for imported investment goods. Thus shocks to export revenues have a direct effect on GDP. This enables us to derive a test of the role of temporary terms of trade shocks.

2.1 Model without productivity growth

Consumers maximize the following inter-temporal utility function:

$$U = \int_0^\infty e^{-(\rho-n)t} \ln|c_t| dt \tag{1}$$

subject to the constraints:

$$y_t = Ak_t^\alpha \tag{2}$$
$$y_t = c_t + i_t^d \tag{3}$$
$$\dot{k}_t = i_t^d + i_t^m - k_t(\delta + n) \tag{4}$$
$$i_t^m = z_t \tag{5}$$

where lower case letters denote per capita variables (i.e. divided by L_t). The equation of motion for the capital stock includes terms for domestic investment, i^d, and imported investment goods, i^m, financed by export revenues, z.

The household's Hamiltonian is thus[3]

$$H = e^{-(\rho-n)t} \ln|c_t| + \mu_t \left[Ak_t^\alpha - k_t(\delta + n) - c_t - z_t\right] \tag{6}$$

With necessary conditions:

$$\frac{\partial H}{\partial c_t} = e^{-(\rho-n)t}\frac{1}{c_t} - \mu_t = 0 \tag{7}$$
$$\frac{\partial H}{\partial k_t} = \mu_t\left[A\alpha k_t^{\alpha-1} - (\delta+n)\right] = -\dot{\mu}_t \tag{8}$$

transversality condition:

$$\lim_{t\to\infty} k_t \mu_t = 0 \tag{9}$$

and initial condition:

$$k_0 = \overline{k_0} \tag{10}$$

We are interested in the case where the economy starts at its steady state: $k_0 = k_{ss}$ corresponding to a given level of $z_t = z_{ss}$ and is perturbed by a shock to z_t which disappears gradually, in a way that we make precise below. From the necessary conditions we can derive the equation of motion for consumption

[3] By omitting a constraint that $c_t < y_t$, we allow for domestic dis-investment ($i_t^d < 0$).

$$\dot{c}_t = c_t\left(A\alpha k_t^{\alpha-1} - \delta - \rho\right) \tag{11}$$

Which, together with the equation of motion for capital stock

$$\dot{k}_t = Ak_t^{\alpha} - k_t(\delta + n) - c_t + z_t \tag{12}$$

and the initial and terminal conditions give us a system of differential equations for the state variables, k and c. We assume that the data generating process for export revenues is:

$$\tilde{z}_t \equiv \frac{z_t}{k_t} = \tilde{z}_{ss}\left(1+\theta^t\right); \quad \theta < 1 \tag{13}$$

Thus describing a process whereby an initial shock decays exponentially. The steady state of the system is thus given by:

$$k_{ss} = \left(\frac{\delta+\rho}{A\alpha}\right)^{\frac{1}{\alpha-1}} \tag{14}$$

$$c_{ss} = A\left(\frac{\delta+\rho}{A\alpha}\right)^{\frac{\alpha}{\alpha-1}} - (\delta+n)\left(\frac{\delta+\rho}{A\alpha}\right)^{\frac{1}{\alpha-1}} + z_{ss} \tag{15}$$

This system can be solved by log-linearization around the steady state, giving the solution:

$$\begin{bmatrix} \dfrac{\partial \ln c_t}{\partial t} \\ \dfrac{\partial \ln k_t}{\partial t} \end{bmatrix} = \begin{bmatrix} 0 & (\delta+\rho)(\alpha-1) \\ -\left(\dfrac{\delta+\rho}{\alpha} + \tilde{z}_{ss} - (\delta+n)\right) & \rho - n + \tilde{z}_{ss} \end{bmatrix} \begin{bmatrix} \ln\left(\dfrac{c_t}{c_{ss}}\right) \\ \ln\left(\dfrac{k_t}{k_{ss}}\right) \end{bmatrix} + \begin{bmatrix} 0 \\ \tilde{z}_{SS}\theta^t \end{bmatrix} \tag{16}$$

It can be checked that this system has eigenvalues of opposite sign and is thus saddle-path stable. Let V denote the associated matrix of eigenvectors. Then we can define the new variables:

$$\begin{bmatrix} z_1 \\ z_2 \end{bmatrix} = V^{-1} \begin{bmatrix} \ln c \\ \ln k \end{bmatrix} \tag{17}$$

so as to diagonalize equation (16) and solve uncoupled differential equations for z_1 and z_2 after which we can transform back into the original state variables. This delivers the following results:

$$\ln k = \ln k_{ss} + \left[\log k_0 - \log k_{ss} - \left(\frac{\ln\theta}{(\lambda_1 - \ln\theta)(\lambda_2 - \ln\theta)}\right)\tilde{z}_{ss}\right]e^{\lambda_2 t} + \left(\frac{\ln\theta}{(\lambda_1 - \ln\theta)(\lambda_2 - \ln\theta)}\right)\tilde{z}_{ss}\theta^t \tag{18}$$

where λ_1 and λ_2 are the eigenvalues of the system. If we assume the economy is starting from its steady state, and is perturbed by a shock to $\tilde{z}_{ss}$, this becomes:

$$\ln k = \ln k_{ss} + \left(\frac{\ln\theta}{(\lambda_1 - \ln\theta)(\lambda_2 - \ln\theta)}\right)\tilde{z}_{ss}\left(e^{\lambda_2 t} - \theta^t\right) \tag{19}$$

And since log y = log A + α log k,

$$\ln\frac{y_t}{y_0} = -\alpha\left(\frac{\ln\theta}{(\lambda_1 - \ln\theta)(\lambda_2 - \ln\theta)}\right)\tilde{z}_{ss}\left(e^{\lambda_2 t} - \theta^t\right) \tag{20}$$

This expression equals zero at t=0, is positive for t>0, and tends to zero as t→∞. More concretely, as t→∞,

$$\ln y_t - \ln y_1 \to \alpha\left(\frac{\ln\theta}{(\lambda_1 - \ln\theta)(\lambda_2 - \ln\theta)}\right)\tilde{z}_{ss}\left(e^{\lambda_2 t} - \theta^t\right) = -\left(\ln y_1 - \ln y_0\right) \tag{21}$$

implying that the entire output-effect of the temporary export-revenue shock is reversed in the long run.

2.2 Model with productivity growth

Since economies generally experience steady-state growth due to productivity, we wish to add a productivity trend to the basic model. In order to do this, express TFP as:

$$A = \left(A_0 e^{\varsigma t}\right)^{1-\alpha} \tag{22}$$

so that the production function becomes:

$$Y = K^{\alpha}\left(\left(A_0 e^{\varsigma t}\right)L\right)^{1-\alpha} \tag{23}$$

Note that the solution to the problem is still the system of differential equations given by equations (11) and (12), with equation (22) taking the place of A. As usual, we simply need to transform the state variables into quantities per effective unit of labor $A_0 e^{\zeta t} L$.

Letting "hats" denote quantities in terms of effective units of labor, we can rewrite the equations of motion for consumption and the capital stock as:

$$\dot{\hat{c}}_t = \hat{c}_t\left(\alpha\hat{k}_t^{\alpha-1} - \delta - \rho - \varsigma\right) \tag{24}$$

$$\dot{\hat{k}}_t = \hat{k}_t^{\alpha} - \hat{k}_t(\delta + n + \varsigma) - \hat{c}_t + \widetilde{z}_t \tag{25}$$

And the initial and terminal conditions can be written as

$$\hat{k}_0 = \overline{\hat{k}_0} \tag{26}$$

$$\underset{t\to\infty}{Lim}\, k_t\mu_t = \underset{t\to\infty}{Lim}\, \hat{k}_t e^{\varsigma t}\mu_t = 0 \tag{27}$$

The system is identical to the system of equations (11) and (12) with δ+ζ taking the place of δ. Hence the solution is identical.

$$\ln\frac{\hat{y}_t}{\hat{y}_0} = -\alpha\left(\frac{\ln\theta}{(\lambda_1 - \ln\theta)(\lambda_2 - \ln\theta)}\right)\widetilde{z}_{ss}\left(e^{\lambda_2 t} - \theta^t\right) \tag{28}$$

with appropriately redefined eigenvalues. In per capita terms, this becomes:

$$\ln\frac{y_t}{y_0} = -\alpha\left(\frac{\ln\theta}{(\lambda_1 - \ln\theta)(\lambda_2 - \ln\theta)}\right)\widetilde{z}_{ss}\left(e^{\lambda_2 t} - \theta^t\right) + \varsigma t \tag{29}$$

And in this case, as t→∞,

$$\ln\frac{y_t}{y_1} \to \alpha\left(\frac{\ln\theta}{(\lambda_1 - \ln\theta)(\lambda_2 - \ln\theta)}\right)\widetilde{z}_{ss}\left(e^{\lambda_2 t} - \theta^t\right) = -\left(\ln\frac{y_1}{y_0}\right) + \varsigma t \tag{30}$$

Again, the effect of a one-time shock to per capita GDP is completely reversed once the steady state growth from TFP growth has been taken into account.

2.3 Model with trend and exogenous determinants of productivity

The final step is to bring the model from Solow and Ramsey to include the insight from cross-country regressions. We now assume that productivity can depend on a set of production function shifters, $W_t = \{W_{1,t}, \ldots, W_{n,t}\}$ such as institutions, policies, and structural variables. We assume that there is a given, known dynamic evolution of these variables characterized by steady state levels $W_{ss} = \{W_{1,ss}, \ldots, W_{n,ss}\}$. We assume that productivity depends on these shifters according to:

$$A = \left[\prod_{j=1}^{n} (W_j)^{\pi_j} \right] (A_0 e^{\varsigma t})^{1-\alpha} \tag{31}$$

So that the production function becomes

$$Y = \left[\prod_{j=1}^{n} (W_j)^{\pi_j} \right] K^{\alpha} \left((A_0 e^{\varsigma t}) L \right)^{1-\alpha} \tag{32}$$

Or, more compactly,

$$Y = w_t K^{\alpha} \left((A_0 e^{\varsigma t}) L \right)^{1-\alpha} \tag{33}$$

$$w_t \equiv \left[\prod_{j=1}^{n} (W_j)^{\pi_j} \right] \tag{34}$$

Our system now becomes:

$$\dot{\hat{c}}_t = \hat{c}_t \left(w_t \alpha \hat{k}_t^{\alpha-1} - \delta - \rho - \varsigma \right) \tag{35}$$

$$\dot{\hat{k}}_t = w_t \hat{k}_t^{\alpha} - \hat{k}_t (\delta + n + \varsigma) - \hat{c}_t + \tilde{z}_t \tag{36}$$

Normalizing $w_{ss} = 1$ and then following the now familiar steps to solve the system delivers:

$$\begin{bmatrix} \dfrac{\partial \ln \hat{c}_t}{\partial t} \\ \dfrac{\partial \ln \hat{k}_t}{\partial t} \end{bmatrix} = \begin{bmatrix} 0 & (\delta + \rho + \varsigma)(\alpha - 1) \\ -\left(\dfrac{\delta + \rho + \varsigma}{\alpha} + \tilde{z}_{ss} - (\delta + \varsigma + n) \right) & \rho - n + \tilde{z}_{ss} \end{bmatrix} \begin{bmatrix} \ln\left(\dfrac{\hat{c}_t}{\hat{c}_{ss}} \right) \\ \ln\left(\dfrac{\hat{k}_t}{\hat{k}_{ss}} \right) \end{bmatrix} + \begin{bmatrix} (\delta + \rho + \varsigma) \ln w_t \\ \tilde{z}_{SS} \theta^t + \dfrac{(\delta + \rho + \varsigma)}{\alpha} \log w_t \end{bmatrix} \tag{37}$$

Notice that this is the same system with a different forcing process. The method of solution is as before and the resulting evolution of per capita income is given by:

$$\ln \hat{y} = \ln \hat{y}_{ss} - \alpha \left(\frac{\ln \theta}{(\lambda_1 - \ln \theta)(\lambda_2 - \ln \theta)} \right) \tilde{z}_{ss} \left(e^{\lambda_2 t} - \theta^t \right) + \ln w_0 e^{-\psi t} + P \ln w_0 \left(e^{-\psi t} - e^{-\lambda_2 t} \right) \tag{38}$$

where

$$P = \frac{\delta + \varsigma + \rho}{(\lambda_1 + \psi)(\lambda_2 + \psi)}\left[\lambda_1\lambda_2 - \frac{(\delta + \varsigma + \rho)(\alpha - 1)}{\alpha}\psi\right] \tag{39}$$

In this case, it is not natural to assume the economy starts at its steady state because w_0 may be far above or below the steady state. Thus we assume that a natural starting point is $\hat{y}_0 = \hat{y}_{ss} + \log w_0$. Thus:

$$\begin{aligned} \ln \hat{y}_t / \hat{y}_0 &= -\alpha\left(\frac{\ln\theta}{(\lambda_1 - \ln\theta)(\lambda_2 - \ln\theta)}\right)\tilde{z}_{ss}\left(e^{\lambda_2 t} - \theta^t\right) \\ &\quad + \left\{\ln w_0\left(e^{-\psi t} - 1\right) + P\ln w_0\left(e^{-\psi t} - e^{-\lambda_2 t}\right)\right\} \end{aligned} \tag{40}$$

Notice that the first part of this expression equals zero at t=0, is positive for t>0, and tends to zero as t→∞. The second part also tends to 0 as t→∞. To see this, notice that

$$\begin{aligned} &\ln w_0\left(e^{-\psi t} - 1\right) > 0 \quad as \quad w_0 < 0 \\ &\ln w_0\left(e^{-\psi t} - 1\right) < 0 \quad as \quad w_0 > 0 \end{aligned} \tag{41}$$

so that if institutions are below their steady-state value the first term of the second part will be positive and increasing over time whereas the opposite takes place if institutions are above their steady state value.

The sign of the second term depends on the sign of:

$$P\left(e^{-\psi t} - e^{\lambda_2 t}\right) \tag{42}$$

which will be positive so long as

$$\psi < 2\alpha\left(\frac{\delta + \zeta + \rho}{\alpha} + \tilde{z}_{ss} - (\delta + \varsigma + n)\right) \tag{43}$$

Therefore, if institutions are below their steady state value (log $w_t < 0$) and the rate of institutional convergence is not too high then this term will be positive and will decline toward zero as t→∞.

In any case, theoretical considerations alone do not clarify which of these terms outweighs the other. Nevertheless, the second term is a multiplicative function of initial institutions and time, where the slope of the function will depend on whether institutions begin above or below their steady state values. As a result, the evolution of per capita income is now given by:

$$\ln \frac{\hat{y}_t}{\hat{y}_0} = -\alpha\left(\frac{\ln\theta}{(\lambda_1 - \ln\theta)(\lambda_2 - \ln\theta)}\right)\tilde{z}_{ss}\left(e^{\lambda_2 t} - \theta^t\right) + \left\{\ln w_0\left(e^{-\psi t} - 1\right) + P\ln w_0\left(e^{-\psi t} - e^{-\lambda_2 t}\right)\right\} + \varsigma t \tag{44}$$

so that, as t→∞,

$$\ln y_t - \ln y_1 \to \alpha\left(\frac{\ln\theta}{(\lambda_1 - \ln\theta)(\lambda_2 - \ln\theta)}\right)\tilde{z}_{ss}\left(e^{\lambda_2 t} - \theta^t\right) = -(\ln y_1 - \ln y_0) + \left\{\ln w_0\left(e^{-\psi t} - 1\right) + P\ln w_0\left(e^{-\psi t} - e^{-\lambda_2 t}\right)\right\} + \varsigma t$$

$$= \ln y_1 - \ln y_0 + \left\{\log w_0\left(e^{-\psi t} - 1\right) + P\ln w_0\left(e^{-\psi t} - e^{-\lambda_2 t}\right)\right\} + \varsigma t \tag{45}$$

We take equation (45) as the basis for our empirical work.

3 Exogenous Shocks: Estimation

Our estimation strategy relies on the use of temporary terms of trade shocks as forces that could—in a world of multiple steady states—push an economy from one steady state to another. In essence, a temporary shock will cause a one-time change in per capita income from y_t to y_{t+1}. If the economy is characterized by a single steady state, then over long-run the effect of the shock will evaporate and the economy will, on average, return to its previous growth path. But if multiple steady states exist and the shock is sufficiently large, this initial impulse will have permanent effects which remain long after the temporary shock has dissipated.

The model developed successively in section 2 delivers a specification for this test as well as the hypothesis for a single steady-state world. Operationalizing equation (45) yields the following specification:

$$\ln y_{t+n} - \ln y_{t+1} = \beta_0(\ln y_{t+1} - \ln y_t) + \beta_1 t + \beta_2(t)\ln w_0 + \varepsilon_{t+n} \tag{46}$$

where $\varepsilon_{t+n} = \sum_{i=0}^{n} u_{t+i}$, the accumulation of a set of white noise disturbances to income.

The null hypothesis

$$H_0 : \beta_0 = -1$$

corresponds to a world with a single steady-state in which temporary deviations from the steady state growth path do not translate into permanent deviations.

We are somewhat hampered in our ability to implement the full equation. Namely, we are hampered by the data on institutional quality. While many fine indicators have been developed, measured, and brought to bear in cross-country growth regressions and other work, panel data is available for very few of them. For the most part, they are either time-invariant or measured only once. While equation (46) requires only a measure at the beginning of the shock, we will be looking at shocks starting at any and all dates in the sample, thus we need a panel measure. In lieu of this, we have for the moment used fixed effects to gather the entire set of country-specific shocks: both those that can be measured with specific institutions and those that cannot. Since we are not explicitly interested in the effects of these institutions, the bundling into a single fixed effect is not a concern. In the one instance where we can find reliable panel data on institutional quality, the polity IV dataset, we include it explicitly.

3.1 Data

Data on per capita income comes from Penn World Tables 6.2. Data on export revenues were taken from various volumes of the UNCTAD Handbook of International Trade and Development Statistics. These data were then standardized and joined to form a single, consistent time series. Polity refers to the polity2 score summarizing the democracy and autocracy scores from the polity IV dataset.

3.2 Instrumenting with Temporary Export Revenue Shocks

The first complication is that this hypothesis describes the evolution of the economy in response to exogenous shocks. If the initial deviation from steady state comes from a change in fundamentals—such as enhanced TFP growth—then there is likely to be a correlation between ($\ln y_{t+1}$- $\ln y_t$) and ($\ln y_{t+n} - \ln y_{t+1}$) that will bias in the coefficient estimates. To address this problem, we use the change in export revenues as an instrument for ($\ln y_{t+1}$- $\ln y_t$). However, the previous argument suggests we are interested in whether *temporary* shocks deliver permanent changes to steady state per-capita output. A permanent decline in export revenues would be expected to deliver a permanent decline in the steady state. So in fact, we are interested in the temporary component of changes to export revenues. Thus we first filter export revenues to isolate their temporary component.[4] Finally because the effects of terms-of-trade changes can take a while to show up in GDP figures, we include three lags.[5] Hence our first stage regression is:

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[4] We have used the Christiano-Fitzgerald filter with plo = 2 and phi = 10. Thus the longest shock deemed temporary dissipates in 5 years. In our early work, we compared a variety of different filters including Hodrick-Prescott, Baxter-King, Butterworth, and a simple high-pass filter. Over a variety of cases, the Christiano-Fitzgerald filter seemed to best capture the spirit of a temporary shock to export revenues. The definition of temporary was chosen to be relatively short so as to enable our regression, limited in length by the data set, to look for effects twenty years after the original impulse has dissipated.

[5] We have chosen this number of lags to maximize the first stage F statistic.

$$\ln y_{t+1} - \ln y_t = \alpha_0 + \sum_{k=1}^{3} \alpha_k \left(\ln \bar{z}_{t-k} - \ln \bar{z}_{t-1-k} \right) \qquad (47)$$

where $\bar{z}$ is the temporary component of export revenues. Our instruments are the (lagged) percentage change in export revenues that comes from temporary shocks. We estimate (46) and (47) as a system using panel 2SLS with country fixed effects. We use shocks that dissipate within five years and a horizon of 25 years.[6] Finally, we control for initial level of income to account for convergence

The results are presented in column (1) of table 1. The first stage passes both Craig-Donald tests at the highest confidence level mitigating concerns about weak instruments. As previously mentioned, most institutional variables exhibit very low inter-temporal variation and are thus collinear with our country fixed effects. The second specification adds one of the few indicators of institutional quality with sufficient variation to stand out from the country fixed effects.[7] As we can see, it doesn't change the character of the results.

The results themselves are overwhelmingly supportive of the null hypothesis. The estimated β_1 is statistically indistinguishable from -1, suggesting that the per-capita income effect of a temporary shock to export revenues completely dissipates over the twenty-five year horizon in question.

3.3 Robustness: big shocks only and rich vs. poor

Such overwhelmingly strong evidence engenders suspicion: perhaps the experiment is not clean after all. Here are two possible critiques necessitating a more nuanced test.

Big shocks only: In the long run, an economy remains near its steady state. The theoretical argument was that, in a world of multiple equilibria, an exogenous shock may push an economy from one basin of attraction to another and thus the long run will be characterized by a different steady state. But this can happen only if the shock is sufficiently large. Shocks that are below the threshold result in no change, even in an economy of multiple equilibria. The current strategy is biased against finding an effect because the ineffective small shocks are included along with the large shocks. Therefore, we ought to focus only on the largest shocks, to see whether they have an effect.

In order to isolate the largest shocks, we calculate the three-year shocks to export revenues, rank them, and take the largest 1/n of the positive shocks and the largest 1/n of the negative shocks. Then we generate a new instrument which takes the value zero if the

[6] As a robustness check we have also looked at longer-lived shocks—those that dissipate within ten years—as well as a shorter horizon of only twenty years. The statistical significance of certain coefficients change but the results are broadly upheld: there is no evidence of LR effects of temporary shocks.

[7] Unfortunately, while there are many, many indicators of institutional quality which have been targeted in growth regressions, time-varying measures are available for very few of them. Most of them—such as rule of law—are measured only very infrequently and are thus collinear with our country fixed effects.

cumulative shock is small but is the same as the sum of the three most recent export revenue shocks if the cumulative shock is large enough to make our cutoff.[8] We repeat this for n = 3, 5.

$$\text{New Instrument} = D_{large} * \sum_{k=1}^{3}\left(\ln \bar{z}_{t-k} - \ln \bar{z}_{t-k-1}\right)$$

$$D_{large} = \begin{cases} 1 & \text{if} \quad \sum_{k=1}^{3}\left(\ln \bar{z}_{t-k} - \ln \bar{z}_{t-1-k}\right) \geq cutoff \\ 0 & else \end{cases}$$

The results are reported in table 2. Notice first that this modified instrument is much stronger than the original, suggesting that shocks to export-revenues do have a non-linear effect on GDP. Otherwise, the results confirm the previous pattern: we cannot reject the hypothesis that temporary shocks to export revenues have no permanent effects on per capita income.

Rich vs. Poor: Multiple steady-states arise because of a non-convexity in the Solow diagram. But it does not necessarily follow that non-convexities exist near every country's steady state. Rather, different countries may be in different equilibria with different basins of attraction and thus the threshold shock may be of different sizes. Figure 1 provides a simple example. Depending on the mechanism generating the non-convexities and thus the multiple steady states, the shape of the basin of attraction, and thus the size of the shock required to trigger a permanent transition to a new steady state, might depend on many country-specific variables. As a first pass, we will assume countries share a common Solow diagram but that countries at different levels of income per capita may be in different basins of attraction. Thus we split our sample into low- and high-income countries and re-run the regressions separately within each sub-sample. We have produced the split in two different ways: first by considering whether per-capita income was in the top or bottom half of the entire sample; second by considering whether per-capita income was in the top or bottom half of the particular year in question.

The results are reported in table 3. Not surprisingly, the instrument is weaker for the upper half of the income distribution. Nonetheless, for the poor countries, for which the instrument is sufficiently strong, we remain unable to reject the null of no permanent effects.

3.4 Is the Instrument Valid?

The strength of the first stage F-statistics, generally passing the Craig-Donald critical values at the highest levels, suggests that the instrument is not weak. However,

[8] The switch from using the last three periods as separate instruments to summing them and using the cumulative change as the instrument comes because our method of zeroing out the small shocks leads to excessive collinearity between the instruments if used separately (they all have zeros in the same place).

one might worry as to whether the instruments from equation (47) are correlated with the error from equation (46). For the small economies under discussion, most people view commodity prices as exogenous (see Collier and Gunning). Nonetheless, there are complex feedbacks between export revenues and total output and, not surprisingly given the complex time-series behavior of GDP, there is some doubt as to the direction of Granger causality between the two.

There are two important aspects of our empirical approach that combine to guard against reverse causality. The first is the use of lagged changes to export revenues. The second is the use of the temporary component of export-revenues as the instrument for GDP. Here are three examples illustrating the robustness of the technique.

Scenario A: An adverse productivity shock in the home-country's export industry. For example, a major export industry is nationalized leading to poor management and poor investment decisions.

Shocks to export revenues—which then may or may not spread to GDP—are precisely the channel of interest. The only way this scenario causes endogeneity problems is if the productivity shock is caused by prior changes to GDP. For example, GDP growth is poor leading to the election of populist governments which then nationalize export industries causing productivity to decline. While this is possible, we do not think it sufficiently common to overturn our approach.

Scenario B: An increase in home country GDP (perhaps due to an exogenous increase in productivity in non-tradable sectors) leads to an increase in domestic demand and thereby a decline in the excess-supply of the export-good and thus a decline in exports.

This looks to be a genuine case of reverse causality: an effect starts in GDP and moves to export revenues. First, note that if this is a permanent shock, then we have a permanent decline in export revenues which doesn't get past our filter. But if it is a temporary shock, it is true that we will measure the reversal of the shock as a decline in GDP akin to that of the return to steady-state in a single-equilibrium world (see figure 2). However, because the instrument is lagged, the instrumented value of $(y_{t+1}-y_1)$ will not pick up the change to export revenues caused by this shock. Hence the decline in $(y_{t+25}-y_{t+1})$ will simply be part of the error term.

Scenario C: A common shock that affects GDP in both the country in question and its trade partners. For instance, FDI dries up for an entire region due to investor herding and poor differentiation by foreign investors among the various countries in the region.

If this were a permanent shock, then the change to export revenues would not pass our filter and, as with scenario B, it would simply enter the error term. However, if this were a temporary shock, we could see a temporary effect on GDP and a temporary effect on export revenues, both caused by the external event. This event would deliver spurious correlation if the decline in foreign country GDP occurred prior to the decline in home country GDP, thus giving a pattern whereby export revenues decline first, and then home country GDP follows, but is not caused by the decline in export revenues. While this is possible, we submit that the required lag structure on the propagation of the shocks is unlikely to be common.[9]

To reiterate, because our instrument is both filtered and lagged, it is difficult to tell a story of a type of shock which is likely to deliver reverse causality with the requisite lag structure. Such stories are not impossible, but they seem neither likely nor commonplace.

3.5 How Big are these Shocks?

Our empirical work strongly indicates that temporary shocks to per-capita income due to changes in export-revenue have no permanent effects. The implication is that there is no alternate steady-state nearby into which a shock may jostle an economy. Nonetheless, because our shocks are of limited size, we cannot rule out the possibility that an alternate basin of attraction exists beyond the range of these shocks. Thus, rather than a repudiation of multiple steady-states, these results deliver a lower bound on the size of the basin of attraction in which an economy currently rests.

To calculate the size of the bound requires calculating the size of the GDP-effects of these temporary export-revenue shocks. To do so, we use the fitted coefficients from the first stage to rescale the export shocks to GDP, thus calculating the extent to which the past few years of export revenue shocks have contributed to the current one-year change in per-capita GDP.[10]

The case for foreign aid commonly invokes the idea of providing sufficient extra resources to push an economy from its old steady state into the basin of attraction of a higher steady state and thus on the convergence path towards this higher steady state. Our results give a lower bound on how large foreign aid must be relative to GDP.

It is instructive to discuss our results in light of the magnitudes of current foreign aid initiatives. The Millenium Challenge Account set a goal of an additional $5 billion/year in development assistance for low and lower-middle income countries (those with per capita incomes below $2975 in FY 2006). Based on 2007 GDP figures, this constitutes 0.1% of total GDP in these countries. The more ambitious Monterrey

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[9] To investigate further the role of fluctuations in trade-partner GDP, we constructed a trade-weighted measure of trade-partner GDP and extracted the temporary component to such fluctuations, as per the filtering method described above. We then estimated equation (46) using this measure as the instrument for shocks to home-country GDP instead of shocks to export revenues. It turns out this measure is an unbelievably weak instrument, far too weak for reliable results. At first blush this would seem to be at odds with the much-replicated results from the gravity models of trade. Upon further reflection, it is in fact evidence regarding a different frequency of fluctuation. Gravity models are estimated on cross-sectional data and thus constitute evidence for long-term stable relationships. Our exercise was evidence on the (near-zero) high-frequency correlation between trade partners' GDP. This lack of high frequency correlation suggests that we needn't worry too much about endogeneity from scenario C.

[10] Note this is slightly different than the standard question relating to instruments: how much variation in the independent variable is explained by the instrument.

Consensus of 2002 called for an increase in aid devoted to official development assistance (ODA) to 0.7% of rich countries' GDP. This would constitute 4.1% of total GDP of lower and lower-middle income countries or an increase in aid of 2.1% of recipient country GDP from the 2005 figure. (According to the OECD, ODA was 106.5 billion, or ~2% of recipient country GDP in 2005).

The question is whether there is any evidence that an increase of 0.1% - 2% of GDP translates into permanent growth via an escape from a reinforcing poverty trap. Our results suggest not: that increases of this magnitude are not sufficient to lift an economy into a new basin of attraction.[11]

4 Conclusion

There are a variety of theoretical mechanisms capable of generating self-reinforcing poverty. Traditional macroeconomic tests of poverty traps often have trouble distinguishing between a world characterized by multiple steady states and a world characterized by twin peaks in the distribution of parameters. Applying the insights of Davis and Weinstein, we focus on one clear distinction between these two worlds that enables us to test for multiple steady states. Namely, that large, temporary, exogenous shocks to per capita income ought to lead to permanent effects if alternate steady states exist nearby.

We construct a modified Ramsey model including technological growth to inform our specification. Motivated by the model, and by the persistent view that export revenues are exogenous to small open economies, we use export revenues as our shock and look for permanent effects on the growth path of per capita GDP. We check that the effect is robust to non-linearity in the size of the shocks or the set of countries involved. In all specifications, we are unable to reject the null hypothesis of no permanent effects; suggesting a world with a single steady state.

One might reasonably claim that these export-revenue shocks are not large enough to conclusively demonstrate the non-existence of multiple steady-states at all points in the aggregate production function. We agree. Nonetheless, they provide evidence that the threshold for non-linear effects must be greater than a few percentage points, suggesting that the current aid programs will not likely deliver non-linear benefits. In sum, shocks to per capita GDP of similar magnitude to those increases in official development assistance being currently contemplated, delivered via export revenues, have not in the past led to permanent departures from the steady state growth path. In other words, the data suggest a single *relevant* steady-state.

[11] One might object that aid flows are not temporary but permanent increases. Nonetheless, if a shock is not sufficient to lift an economy out of the basin of attraction, the fact that the shock is permanent does not change this. The permanent flow will prevent the economy from lapsing back to the poor steady state but will not be enough to deliver the economy to the new steady state. The recipient economy will simply be permanently closer to escaping the poverty trap.

Bibliography

Azariadis, Costas and John Stachurski (2004) “Poverty Traps” in Aghion, P., and S. Durlauf, eds. *Handbook of Economic Growth*. Amsterdam. North-Holland.

Baumol, William (1986) “Productivity Growth, Convergence, and Welfare: What the Long-Run Data Show” *American Economic Review*, vol. 76, pp 1072-1085.

Bloom, David, David Canning, and Jaypee Sevilla (2003) “Geography and Poverty Traps”, *Journal of Economic Growth*, vol. 8, pp. 355-78.

Burnside, Craig and David Dollar (2000) “Aid, Policies, and Growth” *American Economic Review*, vol. 90, pp. 847-68.

Collier, Paul and Jan Dehn (2001) “Aid, Shocks, and Growth” *World Bank Policy Research Working Paper*, No. 2688.

Davis, Donald and David Weinstein (2002) “Bones, Bombs, and Breakpoints: The Geography of Economic Activity” *American Economic Review*, vol. 92, 1269-89.

Davis, Donald and David Weinstein (2004) “A Search for Multiple Equilibria in Urban Industrial Structure” *NBER Working Papers*, No. 10252.

Dehn, Jan (2000) “Commodity Price Uncertainty in Developing Countries” *World Bank Policy Research Working Papers*, No. 2426.

Easterly, William (2006) “Reliving the 1950s: the Big Push, Poverty Traps, and Takeoffs in Economic Development” *Journal of Economic Growth* vol. 11, pp. 289-318.

Hansen, Henrik and Finn Tarp (2000) *Journal of International Development* vol. 12, pp 375-398.

Kraay, Art and Claudio Raddatz (2007) ‘Poverty Traps, Aid, and Growth” *Journal of Development Economics*, vol. 82, pp. 315-47

Quah, Danny (1996) “Twin Peaks: Growth and Convergence in Models of Distribution Dynamics” *Economic Journal*, vol. 106, pp. 1045-55.

Quah, Danny (1997) “Empirics for Growth and Distribution: Stratification, Polarization, and Convergence Clubs” *Journal of Economic Growth*, vol. 2, pp. 27-59.

Rodrik, Dani (1998) “Where Did All the Growth Go? External Shocks, Social Conflict and Growth Collapses” *NBER Working Papers*, No. 6350.

Sachs, Jeffrey, John W. McArthur, Guido Schmidt-Traub, Margaret Kruk, Chandrika Bahadur, Michael Faye, and Gordon McCord (2004) “Ending Africa’s Poverty Trap” Brookings Papers on Economic Activity I:2004..

Table 1: Full Sample

$\ln y_{t+25} - \ln y_{t+1}$		(1)	(2)
t	(ζ)	0.006	0.005
		(4.48)***	(3.74)***
$\ln y_{t+1} - \ln y_{t+0}$	(β_1)	-1.006	-0.987
		(7.97)***	(8.10)***
Polity	(β_2)		-0.0003
			(1.08)
N		848	871
Second Stage R^2		0.617	0.630
Craig-Donald First-stage			
Wald F-statistic		22.12	22.29
Shea Partial R^2		0.073	0.076
Sargan Overidentification		0.171	0.367
Chi-sq p value		0.918	0.832
Chi-sq test ($\beta_1 = -1$)		0.00	0.01
Prob > Chi-sq		0.959	0.914

T-statistics reported. Significance levels * 10%, ** 5%, *** 1%

Unreported controls: $\ln y_{t+0}$

Table 2: Big Shocks Only

$\ln y_{t+25} - \ln y_{t+1}$	(3)	(4)	(5)	(6)
cutoff	Largest 1/3 of shocks		Largest 1/5 of shocks	
t	0.006	0.005	0.006	0.004
	(4.96)***	(4.26)***	(4.89)***	(3.73)***
$\ln y_{t+1} - \ln y_{t+0}$	-1.014	-1.027	-0.968	-0.974
	(11.89)***	(12.19)***	(13.67)***	(14.04)***
Polity		-0.000		-0.002
		(1.07)		(1.64)
N	898	871	898	871
Second Stage R^2	0.616	0.627	0.619	0.631
Craig-Donald First-stage				
Wald F-statistic	53.63	51.70	84.47	82.61
Shea Partial R^2	0.161	0.161	0.232	0.234
Sargan Overidentification	1.189	1.980	0.585	0.970
Chi-sq p value	0.551	0.372	0.746	0.616
Chi-sq test ($\beta_1 = -1$)	0.03	0.10	0.20	0.14
Prob > Chi-sq	0.866	0.752	0.655	0.711

T-statistics reported. Significance levels * 10%, ** 5%, *** 1%

Unreported controls: $\ln y_{t+0}$

Table 3: By Income

$\ln y_{t+25} - \ln y_{t+1}$	(7)	(8)	(9)	(10)
	Upper and lower halves of entire dataset		Upper and lower halves by year	
(range for y)	330-2000	2000-28800	330-2350	1770-28800
t	0.003	0.011	0.004	0.105
	(1.81)*	(5.38)***	(2.49)**	(4.80)***
$\ln y_{t+1} - \ln y_{t+0}$	-1.025	-1.068	-1.032	-0.968
	(9.21)***	(2.10)**	(9.32)***	(1.81)*
N	444	452	437	454
Second Stage R^2	0.687	0.574	0.695	0.559
Craig-Donald First-stage				
Wald F-statistic	16.81	4.83	16.60	4.52
Shea Partial R^2	0.110	0.034	0.110	0.031
Sargan Overidentification	0.743	0.663	0.301	0.480
Chi-sq p value	0.690	0.718	0.860	0.787
Chi-sq test ($\beta_1 = -1$)	0.05	0.02	0.08	0.00
Prob > Chi-sq	0.820	0.893	0.771	0.952

T-statistics reported. Significance levels * 10%, ** 5%, *** 1%

Unreported controls: $\ln y_{t+0}$

Table 4: Size of the shocks

	Cumulative % Change in Export Revenues (absolute value) $\left\lvert \sum_{k=1}^{3} \left(\ln \bar{z}_{t-k} - \ln \bar{z}_{t-k-1} \right) \right\rvert$	Resulting Fitted Change in GDP/capita (absolute value) $\left\lvert \sum_{k=1}^{3} \hat{\alpha}_k \left(\ln \bar{z}_{t-k} - \ln \bar{z}_{t-1-k} \right) \right\rvert$	Actual Total Change in GDP/capita $\lvert \ln y_{t+1} - \ln y_t \rvert$
25th percentile	4.6%	0.09%	1.47%
50th percentile	11.1%	0.57%	3.31%
75th percentile	25.0%	1.07%	6.02%
90th percentile	43.4%	1.52%	9.71%
95th percentile	61.7%	2.93%	13.01%

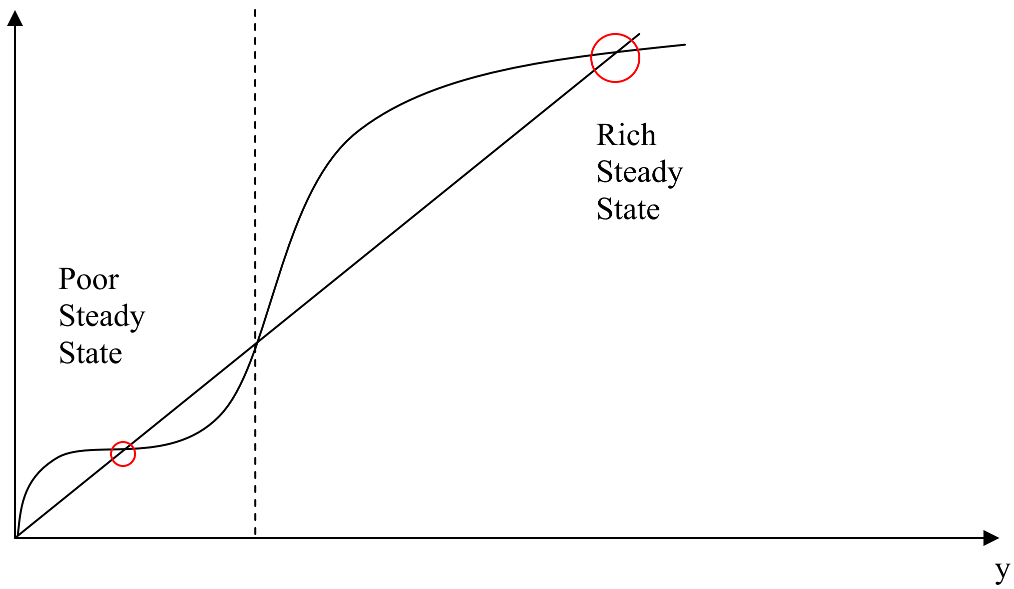

Figure 1: Stylized Solow diagram illustrating a world with two steady states and hence two basins of attraction, separated by the dotted line. The point is the threshold—the minimum size of the shock necessary to push a country into a different steady state—is not the same for all countries. In this example, the threshold is lower for poor countries.

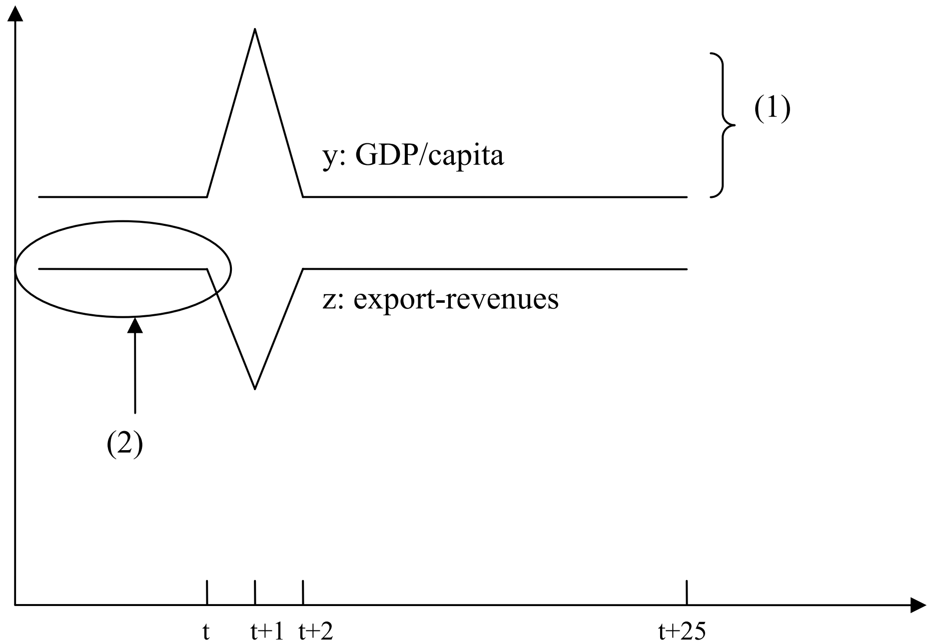

Figure 2: The case of a temporary shock to non-tradables GDP leading to an increase in domestic demand and a decline in excess supply of tradables. **(1)** y_{t+25}-y_{t+1} shows a reversion. (2) But instrument is lagged so the *instrumented* value of y_{t+1}-y_t is unaffected. Hence the revision is simply part of the error in equation (46) and doesn't bias the estimates.