

Africa: Is Aid an Answer?*

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Abstract

We address the poverty trap rationale for aid to Africa. We calibrate models that embody typical explanations for stagnation: coordination failures, ineffective mix of occupational choices and imperfect capital markets, and insufficient human capital accumulation coupled with high fertility. Calibration is ideally suited for this evaluation given the paucity of high-quality data, the high degree of model nonlinearity, and the need for conducting counterfactual policy experiments. We find that calibrations that yield multiple equilibria – one prosperity and the other stagnation – are not particularly robust in capturing the African situation. This tempers optimism about foreign aid typically prescribed based on models of multiplicity. Moreover, conditional on multiplicity, the calibrated models indicate that the cost of policy interventions needed to trigger development in stagnant economies is small. The lack of reforms in Africa, despite the low estimated costs, suggests political hurdles to reform. It is not clear that foreign aid would be able to circumvent these. Taken together, we conclude that the case for foreign aid to Africa is weak.

Keywords: Coordination failure, Occupational choice, Human capital accumulation, Poverty trap, Calibration.

JEL Classification: O100, O110, E600

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1 Introduction

Few would disagree with the assertion that several sub-Saharan African (sSA) economies have been stagnant over the last four decades.¹ However, there is widespread disagreement on whether foreign aid from the world's richest countries would pry these economies out of stagnation. Jeffrey Sachs (2005) diagnoses the problem of Africa as one of a "poverty trap": "The key problem for the poorest countries is that poverty itself can be a trap. When poverty is very extreme, the poor do not have the ability – by themselves – to get out of the mess... In these conditions the need is for more capital – physical, human, natural..." (p. 56) His solution is a large infusion of foreign aid. While Sachs does not argue for a one-shot infusion of aid – indeed, he makes the case for *annual* expenditures by the rich countries to the tune of 0.7 percent of their GNP – his characterization of these economies as trapped carries the implication that the aid has to be large enough to dislodge them from their current low equilibrium and set them on the path toward a higher equilibrium. For instance, he notes: "...foreign aid (over several years) that raises the capital stock from \$900 per person to \$1,800 per person would enable the economy to break out of the poverty trap and begin growing on its own. It would also enable the economy to benefit from increasing returns to capital." (p. 250) He calls for doubling foreign aid in 2006, then nearly doubling it again by 2015.

This view is challenged by other economists. For instance, William Easterly (2006, p. 4) writes, "...the West spent \$2.3 trillion on foreign aid over the last five decades and still had not managed to get twelve-cent medicines to children to prevent half of all malaria deaths." He instead emphasizes reforms on a smaller scale, and holding agencies that implement them accountable. He argues (p. 28), "...Western aid is not the answer..." to the question of how to achieve long-run prosperity in the rest of the world.

In this paper, we conduct a quantitative analysis to address two questions related to the above debate. First, can the stagnant sSA economies be characterized as being in a poverty trap? In other words, how relevant is the multiple-equilibrium aspect of these models in explaining economic stagnation seen in the data? When there are multiple steady states, a "one-shot" policy

¹During 1965-1998, the average annual per capita GDP growth rate in the *entire* sSA region was 0.15% (*World Development Indicators*). The median growth rate during 1965-1998 for some of the worst-performing countries – Angola, Benin, Burkina Faso, Burundi, Central African Republic, Chad, Dkibouti, Guinea, Guinea-Bissau, Malawi, Mali, Mozambique, Niger, Rwanda, Somalia, Tanzania, and Uganda – was zero percent, and the average -0.15%. For detailed evidence on the stagnancy of sub-Saharan Africa see Acemoglu, Johnson, and Robinson (2002) and Caucutt and Kumar (2007).

intervention, say a large injection of foreign aid, can alter the country's initial condition and steer the economy toward the high development steady state.² On the other hand, when there is a unique low development steady state, the policy or institutional change has to be permanent. Second, what is the "size" of intervention required to move a typical economy out of stagnation? Such estimates would allow one to assess whether foreign aid is a realistic option or even necessary for African development.

To answer these questions, we apply the methodology of calibration to three models. Each represents one of three explanations typically offered for economic stagnation: 1) Unresolved coordination problems in the presence of increasing returns, 2) Occupational choices detrimental to development arising from imperfect capital markets, and 3) Insufficient human capital accumulation and high fertility, also in the presence of capital market imperfections. While other explanations and models exist, the ones chosen capture a diverse set of explanations as well as economic agents such as individuals, households, and firms.³ The coordination problem explanation focuses on the firm and investment, the human capital and fertility explanation on household investment in children and capital market imperfections, and the occupational choice explanation connects households and employment through the role played by capital market imperfections in firm formation.

Calibration is ideally suited for the study of sSA, where the scarcity of high-quality data makes detailed econometric analysis, especially at the macroeconomic level, difficult.⁴ Calibration also readily lends itself to analyzing counterfactual policy experiments that try to pry an economy out of stagnation.

After evaluating the robustness of a model in producing a "trap", we design, implement, and evaluate policy experiments that are appropriate to the model. We quantify each policy in terms of tax rates, size of redistribution,

²As Banerjee and Newman (1993) note, "Under the guidance of the linear model, which usually displays global stability, one is led to conclude that continual redistributive taxation, with the distortion it often entails, is required for achieving equity. The nonlinear model, by contrast, raises the possibility that one-time redistributions may have permanent effects, thereby alleviating the need for distortionary policy." (p. 296)

³See Azariadis (1996), Bowles, Durlauf, Hoff (2003), and Kraay and Raddatz (2007) for detailed surveys on models of poverty traps.

⁴For examples of econometric work, see Durlauf and Johnson (1995), who find multiple regimes in cross-country dynamics, Quah (1996), who studies distribution dynamics, and McKenzie and Woodruff (2002), who find little evidence for production non-convexities as a source of poverty traps among Mexican microenterprises.

or cost of subsidies as a fraction of GDP in order to assess the size of policy intervention required. Mauritius, a successful economy in sSA, often serves as an empirical anchor against which we assess a model's policy recommendations.⁵

To study coordination problems, we calibrate the “Big Push” models of Murphy, Shleifer, and Vishny (1989), which feature expectations-driven multiple equilibria. Each sector in the economy is willing to incur a fixed cost and implement a labor saving technology if it expects all other sectors to do so, but not otherwise. We can find parameters for which this multiplicity results. However, for this and other models we study, multiplicity is not particularly robust to changes in parameters in the direction of greater empirical plausibility. Conditional on multiplicity, a fairly low rate of one-time subsidy of fixed costs, around 5% for most parameterizations, is enough to avoid stagnation.

We calibrate the Banerjee and Newman (1993) model to study the role of occupational choice in stagnation.⁶ In this model, imperfect enforcement in the capital market motivates collateral-based lending for project financing. Based on the level of their initial wealth, agents choose to be workers, self-employed, or entrepreneurs. If the starting ratio of workers to entrepreneurs is low, the dynamics are characterized by high wages and a prosperous steady state will be reached. However, if this ratio starts off high, the wage remains low, and the economy is trapped in an absorbing, subsistence state. A highly restricted set of parameters yields the configuration for multiplicity, but we are able to map initial wealth distributions of Tanzania and Mauritius to the model, and demonstrate how a “bad” initial distribution could have led Tanzania toward stagnation and a “good” one led Mauritius to prosperity. The one-time redistribution needed to change the distribution from “bad” to “good” is 3.2% of total initial wealth.

The Becker, Murphy, and Tamura (1990) model is used to study the human capital and fertility explanation.⁷ Fixed costs in terms of time and

⁵While Mauritius is not a “typical” sSA country – being an island in the Indian ocean and populated by immigrants from Asia – there are not many successful countries in the region to use as benchmarks. As Caucutt and Kumar (2007, p. 301) note, “Botswana is the other possibility, but that would be even less desirable, since the availability of diamonds has clearly helped its development. The development of Mauritius is policy-driven and can be potentially replicated in other sSA countries...”

⁶Similar and more recent studies by Townsend and Ueda (2006) and Jeong and Townsend (2007) do not feature multiplicity.

⁷The more recent model of Galor and Weil (2000) features fertility and human capital accumulation. But, the model is “...clearly not fully applicable to countries that are developing today,” (p. 826) since the existence of a large stock of technology available for import

resources are incurred by parents to raise children. Time devoted by parents and the current stock of human capital are inputs in the production of future human capital. Altruism toward each child (a component of the discount rate) is assumed to decrease in the number of children. When the cost of having children is low, parents will have many children, which increases the discount rate relative to the return on investment in human capital of the child. There is no human capital investment, and a steady state with zero aggregate human capital results. If the stock of human capital is sufficiently large, the rate of return in investing in children increases. The time cost of children also increases, and parents have fewer children. The return to human capital investment increases relative to the discount rate, positive investment results, and there could be another steady state with a positive amount of human capital. For our benchmark parameters, we obtain only the low steady state. We can obtain multiple steady states only when we deviate from these parameters, and that too at the cost of not being able to pin down the fertility rate to a value relevant to sSA. Conditional on multiplicity, foreign aid to the tune of 1.13% of GDP can be used to stimulate human capital accumulation and development. But, for the empirically relevant single stagnant steady state, the tax needed on each child to increase the cost of children and avoid the low steady state is very high. More to the point, we find that foreign aid given to a stagnant economy increases fertility without getting the economy out of stagnation.

Comprehensive, good-quality data is rarely available for a particular sSA country. Therefore in our calibration, we use data relevant for sSA from whichever country and source it is available (including comparable developing countries in other regions), and rely on ranges of estimates where needed. For “structural” parameters that are expected to hold everywhere, we use the more readily available data from developed countries. It is important to note that using such parameters does not make the calibrated model irrelevant to sSA. In models with multiple equilibria, countries that face the same parameters can still end up at different steady states depending on other criteria such as their initial condition. For instance, in the Banerjee and Newman (1993) model, whether the economy ends at a prosperous or a stagnant steady state depends exclusively on the initial wealth distribution. And we bring sSA data to bear on this initial distribution. While our focus on steady states does not allow comparison of transition dynamics in the model and data to validate

by such countries makes the relationship between population and technology less relevant. Moav (2005), Azariadis and Drazen (1990) and Durlauf (1993) are other models that feature multiplicity.

calibration, wherever possible we compare ancillary outcomes not part of the calibration process with data to gauge the validity of parameters.⁸

In addition to studying model outcomes for our preferred benchmark parameters, we search for parameter combinations that can yield multiplicity. Sometimes, this involves finding any set of parameters that can produce the trap outcome of the model and then evaluating the empirical validity of the parameters, rather than starting with parameters that are *a priori* reasonable. Giving a model its best shot at multiplicity allows us to see how “far” from empirically relevant parameters we have to be to get multiplicity, and also seems a conservative approach given our conclusion that these models do not robustly yield multiple steady states. In order to preserve the authors’ original intent, we do not modify their models. However, our aim is not to merely survey these models; our calibration and policy experiments are original additions that subject these models to the rigor of quantitative analysis. Policy implications are mentioned in this literature, but typically not analyzed or quantified. When we conduct policy experiments for configurations that yield multiplicity, our goal again is to give a model its best shot at making policy predictions and reinforce the point that large resource costs are not the impediments to reform.

What answers can we provide to the questions that motivated this study? First, it is possible to find parameterizations for all models – some empirically more reasonable than others – that are consistent with stagnation in sSA. But across the models, we find that calibrations that yield multiple equilibria – one prosperity and the other stagnation – are not particularly robust. Given the difficulty of obtaining multiple equilibria, we see the need for caution in advocating one-shot or temporary policies such as a large injection of aid that aim to shift the economy from a low equilibrium to a high equilibrium (i.e. “jump start” development). At the same time, accepting the fragility of multiplicity, when we proceed to quantify the cost of implementing policies suggested by the models, we find that the resource costs are typically not very high. Therefore, it might appear that the “targeted investments backed by donor aid,” recommended by Sachs (2005; p. 250) is a realistic proposition. However, the absence of reforms in Africa, despite the low estimated costs, suggests that foreign aid may not be able to circumvent internal political hurdles. Taken together, we conclude that the case for foreign aid to Africa is

⁸The issue of which equilibrium the observed data should be attributed to is a challenge facing all models with multiple equilibria. One of the conclusions of our work is that in these models, multiplicity is not a robust outcome when using plausible parameters. Therefore, the problem of identifying which equilibrium the economy is in, is not an issue.

weak.

Kraay and Raddatz (2007) conduct an exercise similar in spirit to ours. They calibrate models of low saving and low technology which can give rise to poverty traps. They too conclude that these models require unreasonable values for key parameters to generate traps. While they construct stylized models to capture these explanations, we use established models in the development literature to evaluate the plausibility of traps. More importantly, we evaluate models that feature a richer set of explanations for traps – coordination failures, choice of occupations with low productivity, and trading off higher fertility for human capital.

Sections 2 through 4 consider, respectively, the explanations of coordination failure, occupational choice, and human capital accumulation. For each, we present a brief summary of the model, the calibration strategy, the potential of the calibrated model to explain stagnation, and the outcome of policy experiments. A collective evaluation is provided in Section 5. Section 6 concludes.

2 Coordination Failure

We consider the work of Murphy, Shleifer, and Vishny (1989) to analyze coordination failure. Here, a firm’s investment exerts a pecuniary externality on other firms by increasing the market size or decreasing infrastructure costs. Since individual firms do not take this effect into account, there could be a coordination failure which causes stagnation. Coordination of investment across sectors could give the economy a “Big Push” and move it to the good equilibrium; simultaneous industrialization could be self-sustaining even if a sector cannot afford to industrialize on its own.

2.1 Model

Murphy, Shleifer, and Vishny (MSV) first consider a unit interval of goods with the utility function, $\int_0^1 \ln x(q) dq$, which implies equal expenditure shares. There are L units of labor, with wage being the numeraire. Each sector has a competitive fringe, which converts labor to output one for one, and a potential monopolist with an increasing returns to scale technology, each unit of labor yielding $\alpha > 1$ units of output. For a firm to acquire the increasing returns technology (become “industrialized”) and gain monopoly over an entire sector, it has to incur a fixed cost of F units of labor. Since the firm faces the entire demand curve for the good, given income y , the firm’s profit is $\pi = ay$,

where $a \equiv (1 - 1/\alpha)$ is the markup. If n sectors industrialize, aggregate profits are $\Pi = n\pi$. These are repatriated to the households, implying an income of $y = \Pi + L$. Without any industrialization, income is L . Income increases with the degree of industrialization, n ; an industrializing sector gives profits back to consumers who spend it on *all* goods and raise the profits of *all* industrialized firms. This basic setup gives only one equilibrium – stagnation or industrialization – depending on the parameters. If it is unprofitable for one firm to industrialize when its income is only L , and if it industrializes anyway, it reduces aggregate income making it more unprofitable for all other firms to industrialize. MSV then present three extensions to ensure a firm that engages in an unprofitable investment can still benefit other sectors, making it likely they find investment profitable. This yields multiple equilibria and the possibility of a Big Push.

The first extension assumes that to attract workers away from CRS farm work to IRS manufacturing, firms have to pay a premium, since working in factories entails a disutility of v . Given a farm wage of one, the factory wage is $1 + v$. The condition for no industrialization (stagnation) to occur is $L(1 - (1 + v)/\alpha) - F(1 + v) < 0$. If a firm expects no other firm to industrialize, and therefore aggregate income to be L , it does not incur the fixed cost of F units of factory labor. The condition for all firms to expect a high level of income and sales from simultaneous industrialization and be willing to incur the fixed cost is $\alpha(L - F) - L(1 + v) > 0$. If both conditions are satisfied, both equilibria are possible. It is convenient to write the condition that parameters need to satisfy for multiplicity as

$$(1 + v) < \alpha(1 - F/L) < (1 + v) + \alpha v F/L. \quad (1)$$

The second extension is a two-period model of investment, with the extended utility specification $\left[\int_0^1 x_1^\gamma(q) dq\right]^{\frac{\theta}{\gamma}} + \beta \left[\int_0^1 x_2^\gamma(q) dq\right]^{\frac{\theta}{\gamma}}$; the intertemporal elasticity of substitution is $1/(1 - \theta)$ and elasticity of substitution across goods is $1/(1 - \gamma)$. The discount factor is β . In the first period, only the CRS technology is available. This is also available in the second period; however, a potential monopolist can invest F units of labor in the first period to acquire the IRS technology in the second period. The profit for such a monopolist is given by $\pi = (1/(1 + r)) ay_2 - F$, where r is the interest rate, y_2 the second period income, and a is the markup defined earlier. The condition for no sector to industrialize is $(1/(1 + r)) aL - F < 0$. The demand firms expect to obtain in the second period is too low for them to break even on their investments, and the realized income is indeed low. The income of L in each period is consistent with the interest factor $(1/(1 + r)) = \beta$. The condition for

an industrialized equilibrium is $(1/(1+r))a\alpha L - F > 0$, where the interest factor consistent with a first period income of $(L - F)$ and a second period income of αL is $(1/(1+r)) = \beta(\alpha L/(L - F))^{\theta-1}$. The increase in investment demand by the firms increases the interest rate, decreasing the discount factor a firm uses to assess profitability. The effect of increased income from monopoly profits (repatriated to consumers) has to dominate this decrease in the discount factor. Again for some parameter values both conditions are met. The condition for multiplicity is

$$\frac{1}{\alpha^\theta \left(1 - \frac{F}{L}\right)^{1-\theta}} < \beta a < F/L, \quad (2)$$

which uses the above-mentioned interest factors.

The third extension considers an investment in infrastructure, say a railroad. The $\theta = 1, \gamma = 0$, version of the above utility is used. Though MSV ignore β by setting it to one, we retain it to facilitate realistic calibration and comparability to the other two models. CRS technologies can be set up anywhere and don't use the railroad. IRS technologies are location specific and need the railroad to sell their products. A fraction n of the sectors need a first-period fixed cost of F_1 units of labor to industrialize while the remaining $(1 - n)$ need fixed cost $F_2 > F_1$. It costs R units of labor to build the railroad in the first period and the marginal cost of its use is zero. The type of the firm is private information and the monopolistic railroad cannot price discriminate. It is assumed that even if all type 1 firms industrialize, the surplus generated will not cover the cost R ; both types of firm must industrialize.

There are two considerations – whether the railroad is built even if it is efficient, and whether multiplicity can exist even if the railroad is built. The condition for an equilibrium in which the railroad is built and all sectors industrialize is $(1/(1+r))a\alpha L - F_2 > R$. Given the inability to price discriminate, the railroad company extracts all the surplus of high-cost firms and extracts the same from low-cost firms, leaving them with a positive surplus. With $\theta = 1$, there is no interest rate effect and $(1/(1+r)) = \beta$. Even when railroad building is efficient, that is, when $(1/(1+r))a\alpha L - nF_1 - (1 - n)F_2 > R$, if the stronger industrialization condition is not satisfied, the railroad will not be built. The condition for no industrialization is $(1/(1+r))aL - F_1 < 0$. The condition for multiplicity is, therefore

$$(F_2/L + R/L)/\alpha < \beta a < F_1/L. \quad (3)$$

If this condition holds, the uncertainty concerning equilibrium selection might cause the railroad to not be built, since the railroad will be profitable if the

economy industrializes but incur a large loss if no industrialization occurs. This factor, in addition to the inability to price discriminate, might warrant subsidization of railroad construction. Additionally, coordination of investments might be required to avoid multiplicity of equilibria.

2.2 Calibration

As outlined in the introduction, we begin by studying the outcomes of the model calibrated to a preferred set of benchmark parameters. The degree of increasing returns, α , is common to all three MSV models. Based on studies for Asia, Latin America, and Northern Africa, Tybout (2000) cites values for returns to scale between 1.05 and 1.10. In his examination of whether exporting increases productivity in manufacturing in nine sSA countries, Van Biesebroeck (2005) estimates the returns to scale parameter to be between 1 and 1.17 (Table 4, p. 381 and Table 5, p. 387). We choose his 1.17 estimate for nonexporters as our benchmark value for α . This can be viewed as the *potential* returns to scale, since Van Biesebroeck interprets exporting as an activity that would exhaust most of the scale economies that the common production possibilities frontier allows. An alternate interpretation of this parameter is that it is the ratio of labor productivity in manufacturing to agriculture. Martin and Mitra (2001) examine 50 countries (two-thirds of which are developing countries) over the period 1967-1992 and conclude technical progress was faster in agriculture than manufacturing. This evidence implies over time the productivity in both sectors would eventually converge resulting in a value for α not much higher than 1.⁹

The normalized cost of adopting the increasing-returns technology, F/L , is also common to the three MSV models. One option is to use data from the US on labor costs of adopting a new technology under the assumption it is likely to be similar everywhere. The share of skilled labor in total costs could therefore be used for F/L . Greenwood and Yorukoglu (1997) view

⁹Estimates from the U.S. for the returns to scale parameter are higher. Hall (1988) presents estimates of the markup ratio (price to marginal cost) in the US economy, which corresponds to the α of the MSV model. The estimates for one-digit industries range from 1.864 for services to 3.791 for trade. Hall (1990) presents direct evidence on the IRS parameter, which ranges from 1.08 in services to 10.03 for transportation. The highest value reported in Basu and Fernald (1997) for the entire private economy is lower, at 1.72.

The ratio of the income between the industrialized and non-industrialized economies at the end of the second period in the two-period models is also α , which would argue for a higher value. When we later resort to seeking for parameters that yield multiplicity, we use all this evidence to assess plausibility for the value of α chosen.

adoption in this fashion and turn to data from Bartel and Lichtenberg (1987) for empirical support. The data in Bartel and Lichtenberg indicates that the ratio of earnings of those with 13 or more years of education to those with less was fairly stable at 0.6 in US manufacturing from the 60s through the 80s. This implies a skill share in total labor costs of 0.375. However, the assumption that the *entire* skilled labor force is used for technology adoption could overstate this cost. Another possibility is to count only scientists, engineers, technicians, and technical managers among the employed toward the cost of adoption. Calculating F/L in this fashion, yields an value close to 0.1.¹⁰ A third alternative is to use historical data from the industrial revolution. In late eighteenth and early nineteenth centuries, the proportion of labor force employed in industry increased and that in agriculture decreased rapidly in Europe. The percentage of labor in industry around this period could be viewed as the critical mass of labor required for an industrial takeoff and serve as a proxy for F/L . Crafts (1985, p. 62-63) presents the percentage of male labor force employed in European industry as 16.9% in 1760 and 25.3% in 1840; the figures for Britain are much higher at 23.8% and 47.9%. These values are closer to the one obtained by using all skilled labor (0.375) than the one from using scientists and engineers alone (0.1). We consider the range of 0.1-0.375 as plausible, and examine model outcomes in this entire range.

For the factory premium model, we use the urban-rural income gap to proxy for the factory disutility v . Among developing countries, China appears to have the best documented evidence on this gap. For instance, Sicular et al (2007), report a PPP-adjusted urban-rural gap of 2.24 for China in 1995 and 2.27 in 2002. However, a quarter of this gap can be explained away by education (Table 13b, p. 120). We therefore use a value of 1.69 (three-fourths of 2.25), which translates to a v of 0.69.¹¹

For the investment model, we follow Gomme and Rupert (2005) and

¹⁰From NSF's *Science & Engineering Indicators 2008*, Volume 2 (Appendix Tables 3-1 through 3-3), we calculate the number of scientists and engineers as a fraction of employees in all occupations during the years 2004 through 2006. We weight the employment figures by average earnings to calculate the F/L ratio in efficiency units.

¹¹An alternative is to look at the ratio of manufacturing to agricultural wages (or cost per unit labor). From the *World Development Indicators* (2000), we found that this ratio was 1.35 in 1980-1984 for China, increasing to 2.24 during 1995-1999, mirroring the urban-rural income gap we use. These figures are higher for a few other countries for which we can find data. For instance, for India the ratio is 5.05 and 4.87 for the two periods. Given this wide range, it would be useful to examine other values for this parameter later.

assume an annual discount factor β of 0.986.¹² This annual value has to be compounded over a gestation period that is typical of large-scale industrial projects. If one takes the MSV model seriously, this period would correspond to the time it takes for a country to industrialize once it incurs the required costs. The recent industrialization experience of an East Asian miracle economy might give us a few clues in this regard. For instance, from WDI data, the value added by industry as a percentage of GDP in Korea increased from 17.7% in 1960 to close to 40% in 1985 and stabilized around that value after that. We choose 25 years as the gestation period and study the sensitivity to this assumption later. The annual β of 0.986 compounded by 25 years yields a value of 0.7029, which we use for the model β .

Whether the industrialization condition for the two-period investment model is met or not depends strongly on the value used for θ , which controls the effect of deferred consumption on the interest rate. Agénor and Montiel (1999, p.468) summarize the estimates for the intertemporal elasticity of substitution for a few developing countries. Panel data estimates taken from multiple sources are: 0.4 for Africa, 0.8 for Asia, 0.4 for Latin America, 0.3 for low-income countries and 0.6 for middle-income countries. We choose a value of 0.5 in the middle of this range, which corresponds to $\theta = -1$.

For the railroad cost, R/L , in the infrastructure model, we use the data for investment in US railroad construction during the 19th century presented by Rhode (2000). Rhode presents a series of railroad investment and GNP. We calculate the ratio of railroad investment to GDP for each of the years in 1870-1909 (Table 2, p. 29-30). The average value of 1.72% is our proxy for R/L .¹³

This model extension also requires that entry costs be broken into low and high costs. In line with our calibration of the fixed cost F/L above, we use for F_1/L and F_2/L the lower and upper ends of the range of labor cost share of highly educated workers as reported in Bartel and Lichtenberg (1987): 0.307 for Wood Containers, and 0.433 for Electronic Components.¹⁴ A similar

¹²What matters is the annual β compounded by a gestation period. Different values of the annual β and gestation periods are therefore compatible with the final value used.

¹³The 1.72% figure is in the ballpark of two alternatives. The *World Development Report 1994*, states that public infrastructure investment in developing countries ranges from 2 to 8%, with an average of 4%. The US infrastructure spending was between 2.5% and 3% of GDP during 1956-1991, according to the Congressional Budget Office's, *Trends in Public Infrastructural Spending*, 1999.

¹⁴Another interpretation of differing fixed costs could be that some firms are more *efficient* than others at adopting similar technologies. However, given greater data availability, we

segmentation of costs is harder to do for the other sources we considered for F/L , namely the Science & Engineering or industrial revolution data. Instead, we conduct a sensitivity analysis of adoption costs for this model. Table 1 summarizes the benchmark parameters used for the MSV models.

have chosen the interpretation that differing industry-specific technologies are the source of different fixed costs.

Table 1: Parameters for Murphy-Shleifer-Vishny Models

Parameter	Value	Comment
α	1.17	Estimate of scale parameter for non-exporters; Van Biesebroeck(2005)
F/L	.1-.375	Skill share in total labor costs; Bartel & Lichtenberg(1987), NSF(2008), Crafts(1985)
v	.69	From urban-rural income gap in China; Sicular et al(2007)
β	.7029	Annual value of 0.986 compounded over 25 years
θ	-1	Intertemporal elasticity of substitution of .5; based on Agénor & Montiel(1999)
R/L	.0172	Railroad expenditure over GDP in 19th century US; Rhode(2000)
F_1/L	.307	Lower end of skill share in labor costs; Bartel & Lichtenberg(1987)
F_2/L	.433	Upper end of skill share in labor costs; Bartel & Lichtenberg(1987)

2.3 What the Calibrated Models Explain

For each model, we examine if the condition for multiplicity – (1) through (3) – is satisfied. (In these conditions, the first inequality corresponds to the industrialization condition and the second stagnation.) As mentioned in the previous section, point estimates do not do justice for some model parameters (for instance, α , v , β , F/L) in the sSA context. Given the wide range of estimates available for these parameters, we combine a sensitivity analysis with the exercise mentioned in the introduction of finding parameter ranges for which multiplicity holds.

We examine the agriculture-to-manufacturing model first. The condition for multiplicity is not satisfied for the parameters fixed in Table 1 (for the entire range of F/L), but the stagnation condition is. The industrialization condition cannot be satisfied for the α and the upper end of F/L fixed in Table 1, as no positive v will satisfy the industrialization condition: $1 + v < \alpha(1 - F/L)$.¹⁵ For the lower end of F/L , an empirically implausible value of $v < 0.05$ will satisfy industrialization. For the given α and v , no positive cost, F/L , will satisfy the condition. If we instead fix v at 0.69 and F/L at the upper end, the lowest α that would satisfy the industrialization condition is 2.70. In other words, the increasing returns would have to be high enough for industrialization to be profitable. This would also satisfy the stagnation condition and cause multiplicity. The higher end of the values reported by Hall (1988, 1990) and discussed in the previous section are consistent with this higher value for α .¹⁶ However, these high estimates have been called into question by some economists; see Tybout (2000), for example. With the lower end value of F/L , the minimum α that would satisfy the industrialization (and hence multiplicity) is 1.88, which is more reasonable than the value of 2.70, but higher than most of the evidence cited in the previous subsection.

¹⁵Indeed, the benchmark values chosen for α and v do not even satisfy the MSV condition of $\alpha - 1 > v$, for the increasing returns to be sufficiently high to warrant the higher factory wages.

¹⁶Based on diverging evidence for increasing returns to scale, one explanation for the industrialization of the US (and presumably Europe) could be that they have been better able to exploit increasing returns than sSA. In the next section, we explore policies sSA could itself follow given technological constraints in order to trigger development.

Table 2: Outcomes for Murphy-Shleifer-Vishny Model 1

v	F/L	α	Comment
.69	(.1, .375)	1.17	Benchmark; only stagnation; v & α empirically relevant for sSA
.43	.375	(2.29, 3.08)	Multiplicity; v urban-rural income gap US; α less defensible
.43	.1	(1.59, 1.67)	Multiplicity; v urban-rural income gap US; permissible α decreases
.35	.375	(2.16, 2.73)	Multiplicity; v low urban-rural income gap China; α less defensible
.35	.1	(1.50, 1.56)	Multiplicity; v low urban-rural income gap China; α less defensible, restrictive
.1	.375	(1.76, 1.87)	Multiplicity; α in ballpark of Basu & Fernald(1997); v arbitrarily low
.1	.1	(1.22, 1.24)	Multiplicity; α close to benchmark but restrictive range; v arbitrarily low

Table 3: Outcomes for Murphy-Shleifer-Vishny Model 2

β	Gestation	F/L	θ	α	Comment
.7029	25 years	(.1, .375)	-1	1.17	Benchmark; only stagnation; θ & α empirically relevant sSA
.60	36 years	.375	1	2.67	Knife-edge multiplicity; α high & θ very high sSA
.11	156 years	.1	1	10.00	Knife-edge multiplicity; α high & θ very high sSA
.5	49 years	.375	(.78, 1)	(3, 4)	Multiplicity; α high & θ very high sSA

Table 4: Outcomes for Murphy-Shleifer-Vishny Model 3

R/L	α	Comment
.0172	1.17	Benchmark; only stagnation; R/L and α empirically relevant
.02	(1.64, 1.78)	Multiplicity; R/L from LDC, US data; α in ballpark of Basu & Fernald(1997) estimate
.03	(1.66, 1.78)	Multiplicity; R/L from LDC, US data; α in ballpark of Basu & Fernald(1997) estimate
.04	(1.67, 1.78)	Multiplicity; R/L from LDC data; α in ballpark of Basu & Fernald(1997) estimate

An alternate strategy is to fix some parameters and vary those for which a range of parameters are available in the literature, in order to search for parameter ranges satisfying multiplicity according to (1). The lowest estimate for v presented in the previous section is from the ratio of manufacturing to agricultural wages of 1.35 during 1980-1984 for China. This implies a v of 0.35. To satisfy multiplicity, with $F/L = 0.375$, we need $\alpha \in (2.16, 2.73)$; with $F/L = 0.1$, we need $\alpha \in (1.50, 1.56)$, which is a more plausible range, but also highly restrictive. While the lower bound on α is driven by the need for high enough increasing returns to allow for industrialization, the upper bound ensures that industrialization is not so profitable that stagnation would never occur. What if v is chosen to be 0.43 to correspond to the USDA's Economic research service report that the rural wage is about 70% of urban wage? For multiplicity with $F/L = 0.375$, we then need $\alpha \in (2.29, 3.08)$, increasing both bounds and the range; with $F/L = 0.1$, we need $\alpha \in (1.59, 1.67)$. What if v is arbitrarily chosen low, say at 0.1? The range for α when $F/L = 0.375$ is $(1.76, 1.87)$, which is much tighter; when $F/L = 0.1$, the range for α is $(1.22, 1.24)$, approaching empirical plausibility. In other words, as the urban-rural wage gap increases, the value as well as the range of the increasing returns parameter needed to satisfy multiplicity increases; lower adoption costs yield lower, more plausible ranges for α . Lower values for α are empirically more justifiable, but the lower values for v associated with them are not. Table 2 summarizes these findings.

In the two-period investment model, multiplicity is not satisfied for the entire range of F/L given in Table 1. The stagnation condition is readily satisfied for most values of the adoption cost. However, at its lower bound, the condition is satisfied as an equality. In addition to α , the parameters we vary to study multiplicity in this model are the discount factor β , and the intertemporal substitution parameter θ . For the benchmark β and θ , no value of $\alpha > 1$ satisfies the industrialization condition, for the entire range of F/L . Indeed, as α increases, given the negative value for θ , the industrialization condition gets harder to satisfy. Likewise, for the given α and β , no $\theta \leq 1$ satisfies the industrialization condition, again for the entire range of F/L . Changing a combination of these parameters would be necessary to satisfy the conditions for multiplicity.

For any given β , the stagnation condition determines the maximum α can be (otherwise, the increasing return is too high and makes industrialization profitable), and the industrialization condition determines the minimum α can be (otherwise, industrialization is not profitable). For instance, for the benchmark β of 0.7029 (and adoption cost of 0.375), the stagnation condition dictates $\alpha < 2.14$. However, even with this maximum possible value of α and

the maximum possible value of θ of 1 (infinite elasticity of substitution or alternately, an open economy), the industrialization condition is not satisfied. Evidently, the crucial consideration is for β to be low enough to allow the stagnation condition to deliver an α high enough that would satisfy the industrialization condition. When the adoption cost is set to the lower bound of 0.1, the stagnation condition dictates $\alpha < 1.17$, and again the industrialization condition is not satisfied.

To find the highest possible β for multiplicity, we substitute the maximum α allowed by stagnation into the industrialization condition, and set θ to its maximum value of 1. When F/L is 0.375, this yields $\alpha < 2.67$ and $\beta < 0.6$. That is, when $\alpha = 2.67$, $\theta = 1$, and $\beta = 0.60$, all three expressions in (2) are equal. This value for β corresponds to the yearly discount factor being compounded over a 36-year gestation period. When $F/L = 0.1$, the corresponding values are $\alpha < 10.0$ and $\beta < 0.11$. This β corresponds to an even longer gestation period of 156 years! A lower adoption cost requires an even lower β to satisfy the stagnation condition and a higher α to satisfy the industrialization condition, making it that much harder to simultaneously satisfy both conditions. Lower values of β permit $\theta < 1$, but increase the α required at the lowest permissible θ . Lower values for β can be justified by the longer industrialization periods seen in the past rather than the smaller periods seen recently for the East Asian miracles. For instance, when $\beta = 0.5$ (for the higher adoption cost), $\alpha \in (3, 4)$ and $\theta \in (0.78, 1)$ are compatible with multiplicity; the upper bound for α corresponds to the lower bound of θ and vice versa. Table 3 summarizes the above findings.

Multiplicity is not satisfied for the parameters listed in Table 1 for the infrastructure model as well. We seek parameter deviations that will satisfy multiplicity here too. As in the two-period investment model and for similar reasons, the stagnation condition determines the maximum α and the industrialization condition the minimum. However, unlike the investment model, even the benchmark β can provide a range of α for which multiplicity is satisfied. Indeed, when we decrease the value of β , the bounds for α increase (since they have opposing effects on profitability). Since higher values of α are hard to justify empirically, we leave the β at the benchmark value of 0.7029. Instead, we increase R/L to cover the range of values mentioned in the previous section. As the cost of infrastructure increases, the upper bound for α is unchanged, since the stagnation condition is independent of this cost. But the lower bound of α increases slightly, narrowing the range of permissible values for α . This is intuitive, as the higher infrastructure cost can be compensated by the higher profitability arising from a higher degree of increasing returns.

Table 4 summarizes these findings. As mentioned earlier, we have not

assumed a range of adoption costs for this model. Therefore, we search for adoption costs compatible with multiplicity for any given α , β , and R/L . The stagnation condition provides a lower bound for F_1/L and the industrialization condition an upper bound for F_2/L . For instance, for the benchmark parameter combination in the first row of Table 4, multiplicity is satisfied for $F_1/L > 0.1021$ and $F_2/L < 0.1023$, which are close to the lower bound on adoption cost assumed earlier. For the higher α values that are needed in conjunction with higher infrastructure costs, higher adoption costs are needed for multiplicity. For instance, for the $R/L = 0.03$, $\alpha = 1.66$ combination, multiplicity results when $F_1/L > 0.2795$ and $F_2/L < 0.4339$.

In summary, the increasing returns, intertemporal elasticity of substitution, and discount factor are too low, and the urban-rural wage gap and costs of industrialization are too high at the benchmark for multiple equilibria to arise. However, it is possible to find parameters for which the multiplicity conditions hold for all three models of MSV, though the deviations from the benchmark parameters vary by model. The infrastructure model needs the least deviation from benchmark parameters; the increasing return parameter needs to be more in line with US than sSA estimates. The agriculture-manufacturing model needs either an unreasonably low value for the urban-rural wage gap or an unreasonably high value for the increasing return parameter. The two-period model needs the most deviation from benchmark parameters – unreasonably high values are needed for the intertemporal elasticity of substitution *and* the degree of increasing returns in order to get multiplicity.

2.4 Policy Experiments

The MSV models identify conditions under which a given set of parameters satisfy both industrialization and stagnation. However, they do not take a stance on equilibrium selection. Therefore, we assume that extrinsic conditions resulted in the selection of the stagnant equilibrium in sub-Saharan Africa (sSA). The task in this subsection then is to identify policies that would give a Big Push to the economy to pry it out of stagnation, and explore whether similar policies have worked in the region. MSV mention the policies of investment subsidies and coordination, but do not explicitly analyze them. However, it is fairly straightforward to derive the minimum rate of subsidy required for the fixed cost (investment) to break the stagnation conditions and spur industrialization. The aim is to reduce the effective cost, F , by enough, say to $(1 - s)F$, such that even if a potential monopolist does not expect other sectors to industrialize (thereby expecting an aggregate income of only L), he would individually find it profitable to industrialize. We assume that the cost

of funding these subsidies, sF , is met by taxing income.¹⁷

First consider the factory premium model. We can convert the stagnation condition $L(1 - (1 + v)/\alpha) - F(1 + v) < 0$ into an industrialization condition by writing

$$(L - sF)(1 - (1 + v)/\alpha) - (1 - s)F(1 + v) > 0.$$

We start with parameter combinations that yield multiplicity in Table 2 (for $F/L = 0.375$), even if they are empirically untenable. Since the upper bounds of α are dictated by the stagnation condition, the subsidy (income tax) payments, sF , as a fraction of the stagnant income L , would be negligible at or close to these values for α . When α is at the lower bound, the payments are higher, ranging from 5.2% when v is 0.1 to 15.2% when v is 0.43. A higher degree of increasing return and the higher profitability it brings are consistent with a lower level of subsidy. Since stagnation obtains at the benchmark (albeit as a unique equilibrium), the above expression can also be used to calculate the subsidy in that case. Since the low α and high v make the inequality much harder to reverse, 50.5% of the stagnant income needs to be paid as subsidy. Indeed, the raw subsidy rate, s , exceeds 1. That is, industries need to be paid more than the fixed cost! For the lower adoption cost of 0.1, as expected, the subsidies are lower. They range from 1.2% of income when v is 0.1 to 3.2% when v is 0.43, for the respective lower bounds on α reported in Table 2. To emerge from stagnation at the benchmark, the subsidy needs to be 28.7% of income.

In the two-period investment model, $(1/(1+r))aL - F < 0$, is the condition for stagnation. However, we cannot set the interest rate factor to β , if we expect to fund investment subsidies from taxes on first period income. It would have to be consistent with the consumption of $L - sF$ and L in the two periods. Therefore, we write the condition for the required subsidy as

$$\beta((L - sF)/L)^{1-\theta} aL - (1 - s)F > 0.$$

Financing fixed cost subsidies by taxing first period consumption automatically accomplishes the MSV recommendation of “discouraging current consumption.” The upper bound for α of 4, in the last row of Table 3, for the parameter combination that yields multiplicity ($\beta = 0.5$, $F/L = 0.375$) is derived from the stagnation condition; so as above, the subsidy payment would be negligible at or close to this value for α . The subsidy payment as a fraction

¹⁷Since there is no labor-leisure choice, we need not differentiate between a lump-sum and a proportional income tax.

of stagnant income for the lower bound of α of 3 (which corresponds to $\theta = 1$), is 4.2%. As with the first model, we apply the above condition to the stagnant steady state that results for the benchmark parameters. Since the industrialization inequality is hard to overturn in this case also, subsidy payments of 33% of income are needed to encourage investment.¹⁸

In the infrastructure model, the condition to overcome stagnation is simply

$$\beta aL - (1 - s) F_1 > 0.$$

For the lowest α in Table 4 that yields multiplicity, the subsidy payment as a fraction of stagnant income is 3.3%; it will be lower for lower α values. Lower values for F_1/L (derived while attempting to find ranges that would yield multiplicity) would result in lower subsidies. Yet again, at the benchmark value of 1.17 for α , the subsidy as a fraction of income is much higher at 20.5%.

Conditional on using parameters that yield multiplicity, we find that modest rates of subsidy for the fixed cost, in the order of 5% for most cases, are adequate to trigger development in an economy stuck in the stagnant equilibrium. Has there been any sSA economy that has successfully developed by following policies of market expansion, simultaneous industrialization, and investment tax credit or subsidy?¹⁹ The economy of Mauritius was languishing until 1970, following policies of import substitution. The establishment of export processing zones (EPZs) in 1970, with tax incentives, exemptions from import duties, and preferential credit facilities, boosted the economy, increased investment, and provided global markets to Mauritian firms, especially in textiles. The average annual growth rate between 1971 and 1977 was 8.3%. The Mauritian economy rebounded from a slowdown during 1978-1983, to record annual real output growth of 7% during 1984-1988, and growth rates of close to 6% during the recent years. In 1991, manufacturing was 23.3% of GDP, with EPZs alone accounting for 12.1%. Exports of manufactured goods rose from a negligible share of all exports in 1961 to 67% in 1991, nearly all of it from EPZs. Mauritius' tax code has been characterized by generous investment tax credits for industrial, manufacturing, shipping, and tourist activities, permitting, for instance, a deduction from income tax equal to 30%

¹⁸We do not repeat this condition for the lower bound on adoption costs, since the stagnation condition is satisfied as an equality.

¹⁹While one could also search for a case where such a policy did not work, finding one where it does work is in the spirit of casting each model in the best possible light and of identifying individual components of what might be a successful suite of policies.

of the cash paid up as share capital.²⁰ By 1998, Mauritius had grown enough to have a per capita GDP of \$8,236, more than ten times the per capita GDP of the worst-performing sSA countries. Even though the MSV models consider closed economies, the Mauritian drive toward expanding markets and increasing economies of scale by promoting exports, especially via investment incentives, are in the spirit of the Big Push policies. One could argue that import substitution is also capable of providing a big push by fostering local industry. However, available experience appears to suggest that protectionism leads to an uncompetitive industrial base more interested in rent-seeking activities than innovation and growth.

2.5 Discussion

In the context of static and two-period models it is a bit tricky to address the issue of whether a one-time policy intervention or a continuous one is needed to get an economy out of stagnation. The expectational nature of multiplicity and the types of policies needed to break the “bad” expectations lead us to interpret the policy intervention as one-shot. Even if only one equilibrium obtains, provided it is stagnation, the quantitative estimates of policies discussed in the previous subsection would continue be relevant as they are derived from the stagnation condition. However, they would have to be interpreted as permanent policy changes. For benchmark stagnation, the costs of such policies are high.

A narrow view of the fixed costs in MSV would identify them only with technological costs; however, a broader view would include the costs of regulation. Regulation costs of starting a business, which are 224.2% of per capita income in sSA, but only 8.1% for OECD countries and 11.3% in the prosperous Botswana even within sSA, could also be potentially identified with these fixed costs.²¹ The huge costs seen for sSA imply that only the stagnation condition would be satisfied for all three MSV models, further reinforcing the benchmark findings, and causing additional concerns about the relevance of multiplicity. This suggests a complementary policy intervention, namely regulatory reforms to ease entry costs. However, it is not possible to estimate the cost of such reforms within the context of the MSV model.

²⁰See *Structural Transformation of the Mauritian Economy: 1960s - Beyond 2000*, at <http://ncb.intnet.mu/medrc/beyond.htm>, and Lamusse (1995), *Mauritius* at <http://www.taxhavenco.com/osm/taxhavens/Mauritius.html>, for details.

²¹See Djankov, La Porta, Lopez-de-Silanes, and Shleifer (2002).

3 Occupational Choice

We consider the work of Banerjee and Newman (1993), in which the presence of imperfect capital markets and heterogeneity in wealth affect occupational decisions of agents, and hence economic and institutional development. We focus on a particular example, in which both a stagnant and prosperous steady state are possible; if the initial distribution is tilted toward the poor, with a small measure of middle-income agents, stagnation can result.

3.1 Model

Banerjee and Newman (BN) consider a two-period overlapping generations setup with a continuum of agents of measure one. Agents derive utility according to the function $c^\gamma b^{1-\gamma} - z$, where c is consumption, b is bequest given to the child, and z is labor expended. If income is y , the indirect utility is $\delta y - z$, where $\delta \equiv \gamma^\gamma (1 - \gamma)^{1-\gamma}$. There are four possible occupations: (1) Subsisters who derive return from a “backyard” technology, which has gross return $\hat{r} < 1/(1 - \gamma)$. (2) Workers, who are hired by entrepreneurs at the competitively determined wage v (subsisters are viewed as potential workers whose services are not in demand). (3) Self-employed agents, who require I units of capital to start a project with random gross return $r : r_0$ with probability $(1 - q)$ and r_1 with probability q , with the mean return denoted by \bar{r} . (4) Entrepreneurs, who can manage $\mu > 1$ workers, *each* needing I units of capital. The random gross return is r' with the same mean return $\bar{r} : r'_0$ with probability $(1 - q')$ and r'_1 with probability q' . The worker / subsister group is denoted by L, self-employed by M, and entrepreneurs by U – the lower, middle, and upper income groups respectively. An individual’s state is w , the bequest given by the parent, while the aggregate state is $G_t(w)$, the distribution of wealth.

Self-employed agents and entrepreneurs need to borrow to finance their projects. Enforcement is imperfect. Any agent who puts down a collateral of w and borrows L , can run away forfeiting collateral, but will get caught with probability π , and suffer a monetary punishment of F . Therefore, loans made satisfy $L \leq w + (\pi F / \hat{r})$.

The measures of the agents in the three income groups are denoted by p_i , $i \in \{L, M, U\}$. Entrepreneurs demand a total amount of labor of μp_U , while the maximum supply of labor by workers is p_L . Only two equilibrium wages are possible. The low wage of $\underline{v} = 1/\delta$ is the minimum wage needed to induce subsisters to work and results when $p_L > \mu p_U$. The high wage of $\bar{v} \equiv ((\mu - 1) / \mu) I (\bar{r} - \hat{r})$ is the maximum wage that will leave the entrepreneurs

indifferent to being self-employed instead, and results when $p_L \leq \mu p_U$.

Given the capital market imperfection, occupational choice is driven by wealth thresholds. Agents with wealth $w \in [0, w^*]$, where $w^* = I - (\pi F / \hat{r})$, are workers (but if wage is \underline{v} , the labor market clears by some workers subsisting). Those with $w \in [w^*, w^{**}]$, qualify for a loan to finance self employment, where $w^{**} = \mu I - (\pi F / \hat{r})$. Finally, agents with $w \in [w^{**}, \bar{w}]$, where \bar{w} is the highest possible wealth level that can be sustained in the long run, qualify to become entrepreneurs (but if wage is \bar{v} , they are indifferent to being self-employed, and the labor market clears by p_L / μ becoming entrepreneurs and the remaining $p_U - p_L / \mu$ staying self-employed). It follows that $p_L = G_t(w^*)$, $p_U = 1 - G_t(w^{**})$, and $p_M = 1 - p_L - p_U$.

The bequest given from current income induces the distributional dynamics in wealth. That is, $w_{t+1}(w_t) = b_t = (1 - \gamma) y_t(w_t)$. This is not a linear system since the transition *rule* itself changes depending on the current distribution and therefore the equilibrium wage. However, this wage takes only one of two values, \underline{v} and \bar{v} . Moreover, attention is restricted to parameter configurations that yield tractable transition functions. If *every* starting wealth level within a given income group for a given realization of the return implies a transition into *a single* income group in the next period – for example, children of *all* the M -agents who have a good realization this period start next period as U -agents – then the two state variables, p_L , p_U , are sufficient statistics for the distribution. As BN note (p. 286), “...transitions depend only on what interval one is in and not on the precise wealth level within that interval.”

We focus on BN’s example of prosperity and stagnation. The transition function for this example is given in their Figure 4 and the phase diagram in Figure 5. The differential equations for p_L and p_U are given in their equations (6) and (7). This case results when self-employment earnings have a large spread and entrepreneurial spreads are even larger. When the low wage prevails, the low income state is absorbing; bad realizations in the middle and upper income states can push their next generations into this absorbing state. If the ratio of the poor (L) to wealthy (U) starts off high, with few middle-income agents (M), both the U and L -agents grow at the expense of the M -agents and the economy collapses to stagnation.

When the wage is high, the low income state allows escape into the middle income group and through it to the upper income group for good return realizations. Therefore, movements from the middle and upper income groups to the lower income group caused by bad return realizations are purely transitory. A higher measure of middle-class agents implies a lower measure of poor agents, increasing the chance of a high wage economy with the concomitant benefits of transition described above. Moreover, the high mobility

of the middle-class can increase the measure of entrepreneurs and the wage over time even when starting from a low-wage situation. Therefore, if the starting ratio of poor to wealthy is low, or high but with a lot of middle-class agents, the prosperous steady state will be reached. Which steady state the economy ends at depends *exclusively* on the initial wealth distribution. In particular, focusing on tractable transition functions, as mentioned earlier, does not predetermine the steady state that will be reached.

3.2 Calibration

The strategy of starting with data-driven parameters does not allow us to replicate the prosperity versus stagnation example in a way that preserves the tractability of the BN model.²² Indeed, multiplicity is highly sensitive to the set of parameter values presented in Table 5. Deviations from this set cause the transition function configuration in BN's Figure 4 to not be satisfied.²³ We therefore resort to assessing these parameters for empirical plausibility. To capture the spirit of the BN model, we assume that all the model parameters are structural (invariant) across countries and differences in long-run attainment result *only* from differences in the initial distribution of wealth.

²²However, it is important to note this does not rule out multiple steady states in a more general setup; we do not pursue the computation of such a setup as it would lead us far afield of BN's treatment.

²³Even with the parameters chosen, we do not match the BN transition function for the high wage in one respect, though it does not seem crucial. With the bad realization, entrepreneurial incomes are negative, even though expected incomes are positive. We, therefore, need to assume an insurance scheme, presumably funded by the government from lump-sum taxes, that will cover losses and leave the children in the low-income category next period with zero rather than negative wealth.

Table 5: Parameters for Banerjee-Newman Model

Parameter	Value	Comment
γ	.9	Utility parameter; implied intergenerational persistence of .11; Stokey(1998)
\widehat{r}	1.1	Annual risk free rate of 0.48% compounded over 20 years; Dimson et al.(2002)
μ	2.2	Span of control; Ortin-Áugel & Salas-Fumás(2002)
r'_0	1.3	Entrepreneur's low annual return of 1.32% compounded; Burtless(1999)
r'_1	10.2	Entrepreneur's high annual return of 12.31% compounded; Burtless(1999)
q'	.4607	Probability of high entrepreneurial return; determines average return \bar{r} below
r_0	1	Self-employed low annual return of 0%; Moskowitz & Vissing-Jorgensen(2002)
r_1	18.6	Self-employed high return of 15.74%; Moskowitz & Vissing-Jorgensen(2002)
q	.25	Probability of high self-employed return; to get average return \bar{r} below
\bar{r}	5.4	Annual average return of 8.8%; Burtless(1999)
I	2.95	Backed out from rich-poor wage ratio of 5; Ashenfelter & Jurajda(2001)
πF	2.515	Collateral to loan ratio 64.8%; <i>Fed's Survey of Terms of Business Lending 2004</i>

We assume each model period (generation) is 20 years.²⁴ The gross subsistence or risk-free return used is, $\hat{r} = 1.1$, which translates into an annual return of 0.48%. In comparison, according to Dimson, Marsh, and Staunton (2002), average annualized real return on long-term bonds across sixteen countries during 1900 through 2001, was 0.7%. The assumed figure while low appears to be in the ballpark.²⁵ The utility parameter γ is set to 0.9, which results in $\delta = 0.72$. This value of γ implies an intergenerational persistence in the model of $(1 - \gamma)\hat{r} = 0.11$. While early estimates of this parameter in data were in the 0.2 to 0.25 range, according to Stokey (1998) later estimates, which correct for problems in the data, are in the 0.5 to 0.6 range. These are much larger than the value implied by the choice of γ that yields multiplicity. The “span of control” parameter μ is 2.2. Ortin-Ángel and Salas-Fumás (2002, Table 2) estimate the log of span of control to be between 1.024 and 1.5642 for a general manager, depending on the functional area – the value that yields multiplicity is in the ballpark of the 2.78 figure implied by the lower end of the above range.

The entrepreneurial returns needed for multiplicity are, $r'_0 = 1.3, r'_1 = 10.2$, which translate to annual bad and good returns of 1.32% and 12.31%. These appear plausible given stock market returns.²⁶ The probability of the good outcome is $q' = 0.4607$, which yields an average return of $\bar{r} = 5.4$. Annualized, this is 8.8%, which is a bit higher than the 6.3% historical return presented in Burtless (1999). The self-employed returns are $r_0 = 1, r_1 = 18.6$, which in annual terms are 0% and 15.74%. The probability of the good outcome q is set to 0.25, to equate the mean returns for both types of project. If one interprets entrepreneurial (large project) and self-employed (small project) returns as the returns to public and private equity respectively, the higher spread for self-employed returns is consistent with the higher dispersion for

²⁴This choice mainly plays a role in interpreting the project returns in annual terms and transition times in years.

²⁵The real return to saving – the most widely available alternative instrument – is the closest counterpart in data to the risk-free return of the model. Since this has often been negative in many low-income countries, the lower value might be justified.

²⁶See, for instance, Chart 1, in Burtless (1999), which conveniently presents 15-year average annual returns from 1871-1998. While the high value we use corresponds quite closely to his data, the low value is higher than the slightly negative return he obtains. Note that the BN model constrains all returns to be positive.

private equity reported by Moskowitz and Vissing-Jorgensen (2002).^{27 28}

We interpret \underline{v} and \bar{v} as the wages in poor and rich countries, anticipating their steady states. The ratio of wages, $p \equiv \bar{v}/\underline{v}$, is set to 5. Data on nominal wage differences across individual countries are too widely dispersed to be of use in our calibration. Ashenfelter and Jurajda (2001, Table 2) compute real wages in terms of Big Macs per hour of work across 27 countries at vastly different levels of development. Calculating the averages of these wages in the top and bottom quartiles, we obtain a PPP-adjusted wage differential of 7.4, which is in the ballpark of the p used. Using the expressions for the wages, we can back out $I = p\mu / (\delta(\bar{r} - \hat{r})(\mu - 1))$, which yields, $I = 2.95$.

Let x denote the minimum fraction of a loan needed as collateral. Since w^* is the minimum wealth needed to qualify for a loan, we write $w^* = xI = I - (\pi F / \hat{r})$, which in turn implies $\pi F = (1 - x)I\hat{r}$. We require $x = 0.225$, which yields $\pi F = 2.515$; we do not need to pin down π and F separately. Using this in the expressions for the thresholds, we get, $w^* = 0.6638$, and $w^{**} = 4.2054$. We compute the maximum possible wealth, \bar{w} , as 6.3. The collateral to loan ratio at w^{**} (for the marginal entrepreneur) is $w^{**}/\mu I = 64.8\%$. As a point of empirical contact, The *Fed's Survey of Terms of Business Lending, 2004*, reports that the percentage of value of commercial and industrial loans made by domestic banks, which we interpret as entrepreneurial loans, secured by collateral is 65%.

²⁷The use of “entrepreneurship” in Moskowitz and Vissing-Jorgensen (MVJ) differs from BN’s use of the word. BN connect “factories” with entrepreneurs and “cottages” with the self-employed. Therefore, it appears reasonable to connect the private equity of MVJ to the self-employed returns of BN. MVJ note that the “average return to private equity is similar to that of public equity,” which is consistent with the BN assumption of equal average returns for both types of projects.

Incidentally, compounded real returns computed from MVJ’s minimum and maximum nominal returns for a cross-sectional distribution on public equity are in the ballpark of the r'_0 , r'_1 used. While their lowest private equity return is negative in the cross-section, we assume a value of zero for r_0 , the lowest return consistent with model assumptions. The value for r_1 is close to their 3rd quartile return.

²⁸Evidence on return to self-employment in developing countries is not readily available. As Pietrobelli et al (2004, p. 809) note, “Empirical evidence is also very mixed on self-employment earnings, and therefore on the expected relationship between self-employment and its opportunity cost, i.e. the wage foregone.” However, they present preliminary evidence that the presence of medium and large-sized manufacturing enterprises (share of manufacturing value added in GDP) in developing countries is negatively associated with self-employment. This is consistent with the transitory nature of the self-employed group and emergence of an entrepreneurial class in the BN framework as the economy becomes prosperous.

In summary, while the set of parameters needed to replicate the stagnation and prosperity example is extremely limited, some of them appear empirically relevant, with the preference parameter, γ , the least plausible. The outcome is highly sensitive to the parameters assumed. A low steady state of $p_L^* = 1$, $p_M^* = p_U^* = 0$ (stagnation) and a high steady state of $p_L^* = 0.4063$, $p_M^* = 0.4063$, $p_U^* = 0.1873$ (prosperity) result.²⁹

3.3 What the Calibrated Model Explains

As mentioned earlier, the BN model explains prosperity versus stagnation based on initial income distribution. Can we find examples of sSA countries that can illustrate this? We consider the examples of Tanzania and Mauritius. Considering two sSA economies that differ only in their initial wealth distributions would be in the spirit of multiple equilibria models such as the one in BN, in which common parameters give rise to multiple steady states but where an economy ends depends on initial conditions. The relative prosperity of Mauritius was discussed in Section 2. In contrast, Tanzania had a PPP adjusted per capita GNP of only \$483 in 1998. Can differing past distributions of income in the two countries explain how part of this difference could have arisen?

There is a system of two linear differential equations in p_L and p_U for each of the two wage regimes. Exact solutions can be computed to these linear systems.³⁰ Computation of several transition paths confirms the dynamic behavior summarized earlier. A substantial measure of middle-income (self-employed) agents is needed to set the economy on the path toward prosperity.

While computing transition paths and mapping a *given* initial condition to a steady state can be done entirely in terms of the summary distribution statistics, p_L , p_U , using income distribution data to first back out the initial

²⁹The measure of entrepreneurs in the high steady state (18.73%) is higher than the 12% number reported, for instance, by De Nardi and Cagetti (2003), but in the same order of magnitude.

³⁰The exact solution is of the form:

$$\begin{bmatrix} \widehat{p}_L \\ \widehat{p}_U \end{bmatrix} = a_{1i} V_{1i} \exp(\lambda_{1i} t) + a_{2i} V_{2i} \exp(\lambda_{2i} t), \quad i = L, H.$$

where V_i is the eigenvector corresponding to the eigenvalue λ_i . Each system has two negative eigenvalues. The constants a_{ji} are pinned down by the initial conditions for p_L and p_U . The hat notation refers to deviations from the steady state values. The MATLAB program used for the computation is available from the authors on request. The computation also checks for switches in the wage regime along a path.

conditions of an economy requires knowledge of the entire wealth distribution, which the model does not track. Therefore, we make the simplifying assumption that the entire mass of agents in a given wealth interval is concentrated at the midpoint of the interval: p_L at $w^*/2$, p_M at $(w^* + w^{**})/2$, and p_U at $(w^{**} + \bar{w})/2$. We use poverty headcount from the *World Development Indicators (WDI)* to pin down p_L . We then solve for a p_U such that the income Gini coefficient calculated from the piecewise linear Lorenz curve of the model matches the income Gini reported in Deininger and Squire (1996).

Poverty headcounts are available sporadically and only for recent years. For this reason, we are forced to assume that the percentage of people living below the international poverty line of \$2 per day of 59.7% in Tanzania in 1993 is the same in 1977, when its Gini coefficient was 0.52. Likewise, the only poverty headcount data listed in the WDI for Mauritius during the period 1984-2000 is 10.6%, which we assume is the same in 1980 (a year close to the 1977 used for Tanzania), when its Gini coefficient was 0.457. Our method of mapping distribution data to model measures yields the following “initial” conditions: $p_L = 0.597$, $p_M = 0.1071$, and $p_U = 0.2959$, for Tanzania, and $p_L = 0.106$, $p_M = 0.4323$, and $p_U = 0.4617$, for Mauritius.

As one might suspect, given the high initial measure of middle-income agents, Mauritius is more likely to reach the high steady state. Indeed, we compute paths from the above initial conditions, and show that Tanzania heads toward the stagnant steady state and Mauritius heads toward the prosperous steady state.³¹ Most of the convergence occurs in two generations.

3.4 Policy Experiments

BN note that given the multiplicity of steady states, a one-time intervention is all that is needed to alter the distribution of wealth to one leading to prosperity instead of stagnation. It is easier to consider the redistribution of start of period wealth rather than end of period income. We can view this as an unexpected imposition of an estate tax once bequest decisions of the previous generation have been made. This tax is designed to alter the composition of the population by moving people across the distribution: p_L , p_M , and p_U . But it does not change the wealth *within* each category, which continues to be given by $w^*/2$, $(w^* + w^{**})/2$, and $(w^{**} + \bar{w})/2$ for L , M , and U respectively. Given

³¹The ratios of GDP per capita in the prosperous to the stagnant steady state is 38, more than twice the ratio of 17 seen in data between Mauritius and Tanzania. This discrepancy could arise from our assumption that the entire mass within a wealth interval is concentrated at the midpoint.

the parameters, the within-category wealth values (and indeed the transition diagrams) are fixed. The aim is to alter the initial distribution of the population across these wealth categories so that the economy *traverses* a path toward prosperity rather than stagnation. Such a scheme would work within the constraints of tractability considered earlier. Feasibility requires that the new level of aggregate wealth does not exceed the old level. We can show that redistribution is constrained by

$$(p_{U,o} - p_{U,n})(w^{**} + (\bar{w} - w^*)) / 2 \geq (p_{M,n} - p_{M,o}) w^{**} / 2,$$

where the subscripts o and n refer to the old and new distributions.³² The aim is to decrease the measure of the L and U agents and increase the measure of M agents. The left-hand side is the amount taken away from $(p_{U,o} - p_{U,n})$ U -agents, making them M -agents in the process. Each L -agent needs a transfer of $w^{**}/2$ to become an M -agent. The right hand side limits the number of such M -agents who can be created using the taxes collected from the U -agents. When the above expression holds with equality, it captures the maximum amount of redistribution possible. When it is a strict inequality (as it will be in the smallest perturbation considered below), the government will have taxes left over after it has effected the redistribution.

Consider the initial Tanzanian distribution discussed above. The smallest perturbation we could find that would get the economy on a path to prosperity is $p_L = 0.5962$, $p_M = 0.1323$, and $p_U = 0.2715$. This increase in the measure of M -agents relative to the initial distribution involves a redistribution of 3.2% of the total initial wealth. As a fraction of wealth held by the richest group, the redistributive taxes are 4.2%. A maximum redistribution of 13.8% of total initial wealth is possible. This will start the economy with $p_L = 0.4688$, $p_M = 0.3349$, and $p_U = 0.1964$, amounting to a much larger increase of M -agents.³³ As a fraction of the wealth held by the richest group, the redistributive taxes in this case are 17.9%. The larger redistribution would shave the transition time to the high steady state by more than a generation.

³²This expression is derived by stipulating that the aggregate wealth, $p_L (w^*/2) + (1 - p_L - p_U) (w^* + w^{**}) / 2 + p_U (w^{**} + \bar{w}) / 2$, at the new distribution does not exceed that of the old. Only a subset of U -agents needs to be taxed, presumably through a lottery.

³³Finding the smallest perturbation involves computing multiple transition paths and choosing one close enough to the original initial condition that leads to the high steady state. The maximum redistribution point presented is further along the path, closer to the steady state.

3.5 Discussion

In the BN framework, multiplicity is highly sensitive to the parameters chosen. Empirical counterparts can be found to some of the calibrated parameter values. The policy conclusion that a one time redistribution of wealth can alter the path of development finds empirical support in the land reforms of China in the early 80s, which some associate with the subsequent Chinese economic development.³⁴ The experiments also indicate a trade-off between the amount of redistribution – which is, in turn, connected to the issue of whether such transfers are politically feasible – and transition times.

4 Human Capital and Fertility

We calibrate the model of Becker, Murphy, and Tamura (1990). The model features: fixed time and resource costs of rearing children; parental time and existing human capital stock as complementary inputs in the production of new human capital; and diminishing per-child altruism. These features interact to potentially produce two steady states – one with high fertility and no human capital investment and another with low fertility and high human capital investment.

4.1 Model

Becker, Murphy, and Tamura (BMT) develop a two-period overlapping-generations model, with time-consistent preferences given by: $V_t = u(c_t) + a(n_t) n_t V_{t+1}$, where $a(n_t)$, the altruism toward *each* child, is decreasing in the number of children, n_t . Consumption is denoted by c_t , and V_t and V_{t+1} are the values for the parents and the child, respectively. Parents spend a fixed resource cost of f , and time cost of v , per child. Each child is endowed with H^0 units of “raw” human capital. Human capital *accumulated* by the beginning of period t is denoted by H_t . Goods are produced according to the production function: $Dl_t(dH^0 + H_t)$, where D is a productivity parameter, l is the time spent by parents producing consumer goods, and d is the rate of exchange between H^0

³⁴See the volume *Land Reform: Land Settlement and Cooperatives* (Special edition), 2003, published by the FAO and the World Bank for experiences and perspectives of land reform and its effect on growth and poverty reduction in several countries.

However, the disastrous consequences of forced redistribution undertaken recently in Zimbabwe serves as a counterexample.

and H . Human capital is accumulated according to the production function

$$H_{t+1} = Ah_t (bH^0 + H_t)^\beta, \quad (4)$$

where A is the productivity parameter in the human capital sector, h is time spent by parents in each child's human capital production, and b is the rate of exchange between H^0 and H . The rate of return to human capital investment is increasing in the current stock of human capital. The coefficient $\beta \leq 1$ measures the effect of scale on the production of human capital.

The resource and time constraints can therefore be written as

$$\begin{aligned} c_t + fn_t &= Dl_t (dH^0 + H_t), \\ l_t + n_t(v + h_t) &= T, \end{aligned}$$

where T is the time endowment of parents.

To begin with, BMT assume that $b = d = 1$, which we also impose.³⁵ They also parameterize $a(n) = \alpha n^{-\epsilon}$ and $u(c) = c^\sigma/\sigma$, with $0 \leq \epsilon < 1$ and $0 < \sigma < 1$. Here, α is the degree of pure altruism that obtains when $n = 1$, and ϵ is the constant elasticity of per-child altruism with respect to n_t .

The intuition for the possibility of multiple steady states is easily described. When the cost of having children is low (which will be true, among other things, when the stock of human capital is low and wages are low), parents will have many children, which increases the discount rate relative to the return on investment in a child's human capital. There is no human capital investment, and a steady state with zero aggregate human capital results. If R_h denotes the return to human capital investment, and n_u the fertility rate at the stagnant steady state, a necessary and sufficient condition for a steady state with $H = 0$ is

$$[a(n_u)]^{-1} > R_h, \text{ when } H = 0.$$

The zero steady state condition holds when fertility is high, and the productivity of the human capital sector is low. Fertility is high when the rate of return to quantity of children is high, which is true when H^0 is high (even without human capital accumulation, raw endowment is high enough to result in high earnings) and the resource and time costs are low.

If the stock of human capital is sufficiently large, as seen from the human capital production function, the rate of return in investing in children

³⁵Assuming $b < d$ implies that H^0 has less of role in HC production; alternately, H has a comparative advantage in HC production.

increases. At the same time, the time cost of children increases, and parents have fewer children. In other words, the right hand side in the above inequality increases, the left decreases, and positive investment becomes a possibility. There could therefore be another steady state with a positive amount of human capital in which

$$[a(n^*)]^{-1} = R_h(H^*).$$

The return R_h will increase with H for at least a while, but if it later decreases with H , then H^* represents a steady state; if R_h asymptotes to a constant value then H^* represents a balanced growth path. The former will result when $\beta < 1$, and the latter when $\beta = 1$, and human capital can be accumulated without diminishing returns. BMT focus on the $\beta = 1$ case, in which expressions for returns are easier to derive analytically. We focus on $\beta < 1$, since the model outcome matches data better in this case (given our interest in computation and calibration, analytical ease is not a primary concern). As we will argue in Section 4.3, as β increases toward 1, while the calibrated model is capable of yielding multiple steady states, it does so without matching the fertility rate of sSA. When matching the fertility rate at a stagnant steady state, β does not play a role.

A single equilibrium with stagnation or multiple equilibria both seem theoretically possible, so the exercise of seeing which case results in the calibrated model is a meaningful one.

4.2 Calibration

We assume agents are born at age 6 and are young until the age of 25; they become adults at the age of 26, have children, and die at the age of 45. The model period is thus 20 years. The life-span corresponds closely to the median life expectancy of 45.5 years in a sample of stagnant sSA countries (Caucutt and Kumar, 2007). As mentioned above, we set $b = d = 1$. We normalize $T = 1$, and interpret other times – work, child rearing, and human capital investment in children – as fractions of the available time. We also normalize the goods productivity parameter, $D = 1$, and let the human capital productivity parameter, A , vary.

The utility curvature parameter, σ , is stipulated to be greater than zero. This implies that the CRRA associated with the utility function has to be less than one (log utility). This rules out a value around 2, fairly widely used in calibration exercises. To get close to it, we choose a small value of σ ; we set $\sigma = 0.15$ and study the sensitivity to varying this parameter. Altruism dependent on fertility is not widely used, which makes it difficult

to pin down ϵ . We follow Doepke (2005) and set $\epsilon = 1/2$ and again study the sensitivity to this parameter. The quantity $a(n)n$ would be the effective discount factor when mapped to models without fertility. We assume a value of 0.98 for this discount factor, which is in line with Gomme and Rupert (2005).³⁶ The total fertility rate for sSA is 5.7 (UN Population Division, Population Estimates and Projections, 2000 Revision). Therefore $n_u = 5.7$ will be the main empirical target for our calibration. For the chosen ϵ of $1/2$, and the target n_u , when the discount factor is set to 0.98 compounded for 20 years, that is, $\alpha n_u^{1-\epsilon} = (0.98)^{20} = 0.6676$, we get $\alpha = 0.2796$.³⁷

The parameter governing the curvature of the human capital production function, β , cannot be pinned down within a stagnant steady state since the level of human capital and time spent investing is zero. We therefore need to turn to data from developing and developed countries. One way of calibrating the curvature in the human capital production function, β , is to take the logarithm of (4) and interpret β as the coefficient of a regression of $\log(H_{t+1})$ on $\log(H_t + H^0)$. If we assume that H^0 is small relative to H_t , which should be the case in developed countries, and that human capital proxies for earnings, β would then be the intergenerational persistence parameter. As mentioned in Section 3, Stokey (1998) reports values in the range of 0.5 to 0.6 for this parameter. Therefore, we set $\beta = 0.5$. Another interpretation of β is as the elasticity of the student's human capital with respect to the teacher's. The value of 0.5 we use is within the range of values Bils and Klenow (2000) consider in calibrating their human capital production function, and is in fact below their upper bound, .67. We perform sensitivity analysis over β , and find that the lower the β , the less likely there is to be multiplicity. Therefore, a β on the high end of the range is a conservative assumption.

The parameters that remain to be chosen are: v , f , A , and H^0 . Of these parameters, equation (13) in BMT shows that at stagnation the fertility rate depends on v , but is independent of the human capital productivity parameter, A . This is intuitive, since at stagnation there is no human capital transmission. Fertility also depends only on the *ratio* of f/H^0 rather than on each parameter

³⁶This corresponds to a real rate of return of 2%. Note that when doing the sensitivity analysis, changes in ϵ change the effective discount factor. When $\epsilon = .35$, this implies an annual discount rate of .9929, and when $\epsilon = .65$, this implies an annual discount rate of .9673.

³⁷This α , when used for Mauritius, which has a fertility rate of 2, yields a yearly discount factor of 0.95, which is within the range typically assumed.

separately.³⁸ We therefore seek empirical evidence for f/H^0 , and use it to find a v that yields the sSA fertility of 5.7 mentioned above. We proceed as follows:

- We are unable to find evidence on monetary costs of rearing children from sSA. However, Khan et al (1993) present evidence using a survey conducted in rural Bangladesh. The findings on costs from this agrarian economy is likely to be relevant to sSA as well. Their estimate for food and non-food (monetary costs) for a one-year old child is 9.23 Taka per *week* per child for their “middle” household categories. In the survey year of 1984-85, using the income and exchange rate data from Penn World Table 6.2, Bangladesh had a per capita income of 23,842 Taka. The monetary costs are therefore 2% of income. If the weekly expense of the “rich” category (15.5 Taka) is used, the cost is 3.3% of income. Khan et al (1993) also note, “Even for landless farm households, child costs are less than 5 per cent of the total household income.” The cost as a fraction of income ranges from 2 to 5%. We start with the upper end of the range and conduct sensitivity analysis. Since the income is lH^0 at stagnation, we set $f/(lH^0) = 0.05$. Given that the time constraint implies, $l = 1 - n_u\nu$, we can write this condition as

$$f/H^0 = 0.05(1 - n_u\nu). \quad (5)$$

- Using this in equation (13) in BMT implies a value of $v = 0.1435$ to match the empirical fertility target of 5.7. This is our benchmark value of v . How does this correspond to evidence on the time cost of rearing children in developing countries? Khan et al (1993) report child care performed by women in the landless household category as 21.39 hours *per week per child*, while the men provide 1.77 hours (Table 2). We assume 70 hours of time per adult (see, for instance, Bar and Leukhina (2005)). Therefore, $23.16/140 = 0.165$ is the fraction of available time spent on child care. Little or no child care time is needed for older children; indeed Khan et al (1993) report time spent *by* children aged 10 to 14 time on child care rather than time spent *on* them. To capture this, given our 20-year period, we divide this 0.165 by 2 to get 0.0825. In the case of sSA, where there are many households with only one parent, the value is likely to be greater than 0.08 (but unlikely to be more than

³⁸Equation (13) in the BMT paper, derived when $\beta = 1$, can be shown to hold even when $\beta < 1$. This derivation, and that of the expression for the return to human capital used later are available from the authors on request.

double of that value, 0.16). The value of v resulting from our calibration strategy therefore appears to be in the right ballpark. Note that the fact that the v we use is on the high end of the range seen in the data is a conservative pick. As v declines, the likelihood of stagnation increases.

- Bigsten et al (2000) report a return of 3% at the primary level based on evidence from a few sSA countries. This is consistent with the low returns reported by Nielsen and Westergaard-Nielsen (2001); they estimate a return of 3% to males in urban areas (p. 383). We set this return, compounded appropriately, equal to the return to human capital when $\beta < 1$ (the analogue of BMT’s equation (10))

$$A(1 - vn_u) / (H^0)^{1-\beta} = (1.03)^{20}. \quad (6)$$

We later experiment with changing the value assumed for the return.

- Since we do not have evidence on f , we fix a value for this cost. We then use (5) and (6) to find values H^0 and A respectively, that correspond to the stagnant steady state with our benchmark value of v and a fertility rate of 5.7. We then examine the transition function for H that we get by solving the dynamic problem and check if there is a non-zero steady state. Since we calibrate only to a stagnant steady state, examining the entire transition function that arises from this calibration appears to be a valid approach for searching for multiple steady states. We repeat this procedure for many values of f . However, we find that the actual value of f matters little for our results. We already noted the independence of fertility on f by itself. The resource cost affects the *levels* of H^0 and A , and the endogenous quantities such as consumption and income. But the empirical targets are *ratios* of these quantities to income. For instance, when f increases, H^0 and A both increase, with no material difference to ratios, such as consumption as a fraction of income.

Results from the above procedure are summarized in the next subsection. We list the benchmark parameters for the BMT model in Table 6.

Table 6: Parameters for Becker-Murphy-Tamura Model

Parameter	Value	Comment
σ	.15	Curvature of utility function
α	.2796	Pure altruism
ϵ	.5	Elasticity of altruism per child
β	.5	Curvature of HC production
v	.1435	Fixed time cost

4.3 What the Calibrated Model Explains

A stagnant (zero) steady state readily obtains with the benchmark parameters. As f is increased, the H^0 and A needed to maintain the fertility rate at 5.7 increases, as can be seen from (5) and (6).³⁹ In the model, a stagnant steady state is more likely when f and A are low, and H^0 is high. Therefore, there are opposing effects on the likelihood of stagnation as f increases, but for the range we study, a zero steady state always results. Moreover, for all these cases, the transition function for human capital is such that the only steady state is stagnation – we do not obtain multiple steady states (or a single positive steady state). Investment in human capital is zero in all cases.

While we are convinced that multiple steady states or a positive steady state do not obtain for various combinations of f , A , and H^0 , for our set of benchmark parameters, to ensure that this outcome is not dependent on the specific benchmark parameters themselves, we conduct sensitivity analysis with respect to them. We adjust one parameter at a time, and find a v that yields $n_u = 5.7$. As done above, we then examine the outcomes for a range of f . We vary σ between 0.05 and 0.25, ϵ between 0.35 and 0.65, and $f/(lH^0)$ between 0.02 and 0.05. In all cases we obtain a single stagnant steady state. If we abandon the goal of matching fertility and keep increasing v in each of the experiments, we will obtain a single positive steady state; a low cost of raising children increases the likelihood of higher fertility and stagnation. Table 7 lists the v for various experiments that is needed to match the fertility rate as well as the lowest v that will result in a single positive steady state.

While the values for v to obtain a fertility of 5.7 are in the ballpark of the empirical estimate provided in the previous section, those needed for a positive steady state are considerably higher. The corresponding fertility rates are also much lower than the empirical value of 5.7. We do not obtain multiple steady states.

Since the return to human capital is increasing in β , would increasing it from the benchmark value of 0.5 induce convexity in the transition function and cause multiple steady states? For a β of 0.7 or higher, multiplicity indeed results, but only for a range of v much higher than the empirically relevant value cited earlier. (For a β of 0.6 or lower, a single stagnant steady state obtains for a v of 1.35 and lower – the empirically relevant range – and a single positive steady state for higher v .) Multiplicity is primarily governed by the β, v combination. We therefore lose the ability to pin down v on the basis

³⁹For instance, when $f = 0.001$, $H^0 = 0.11$, $A = 3.30$, and when $f = 1$, $H^0 = 110.04$, $A = 104.25$.

of fertility observed in sSA in this set of experiments. The fertility we obtain at both steady states is considerably lower. Table 8 summarizes the results of searching for β, v combinations that yield multiplicity.⁴⁰

⁴⁰We fix $f = 0.001$, but as discussed earlier, changing this value does not appreciably alter outcomes as measured in ratios.

Table 7: Sensitivity Analysis for Becker-Murphy-Tamura Model

Experiment	v for fertility of 5.7	lowest v for positive SS	fertility at positive SS
$\sigma = .05$	.16	2.42	.25
$\sigma = .25$	.13	.94	.22
$\epsilon = .35$	.17	1.87	.14
$\epsilon = .65$	.10	1	.34
$f/(lH^0) = .02$	.15	1.38	.25
$f/(lH^0) = .05$	.14	1.36	.25

Table 8: Multiplicity in Becker-Murphy-Tamura Model

β	Lower bound for v for multiplicity					Upper bound for v for multiplicity				
	v	n_u	n^*	h^*	$(H^* + H^0)/H^0$	v	n_u	n^*	h^*	$(H^* + H^0)/H^0$
.9	1.04	.38	.26	.33	6.22	1.35	.26	.15	.56	87.51
.8	1.25	.29	.22	.26	2.61	1.34	.26	.17	.41	5.37
.7	1.35	.26	.22	.13	1.48	1.35	.26	.22	.13	1.48

Here, n_u is the fertility rate at the stagnant steady state. The starred quantities obtain at the higher steady state; n^* , h^* , and $(H^* + H^0)$ are respectively the fertility rate, time investment in children's human capital, and the stock of human capital. As with the previous models, we continue to use Mauritius as a benchmark for an economy that is at a good steady state. The fertility rate of Mauritius from the same source we use for sSA is 2. Just as the values for n_u are too low in Table 5 when compared to the empirical counterpart of 5.7, the values for n^* are too low compared to 2.

While the time cost parameter is too high and fertility too low for parameters that yield multiple steady states, the percentage of time invested in children's human capital (n^*h^*) is "reasonable", ranging from 2.9% to 8.6%. Given the occupational specialization observed in real economies, if we assume the variation of individual work hours in the population is small, the above-mentioned time investment in children's human capital accumulation can be mapped into the fraction of population engaged in teaching. Using Mauritius again as an example of an economy at a high steady state, data in the *World Development Indicators* yield primary and secondary teachers as a fraction of population over 15 between 1.29% to 1.51% for 1991-2005. The fraction of time invested in the model is the fraction of adult time. Since there are two adults in the family, and the data is in per capita terms, we need to adjust this to per adult time, 1.45%-4.3%. The model outcomes are on the high end of the range seen in the data, but unlike the fertility rate are at least in the same order of magnitude.

If we assume that the labor supplied per household is the same in Mauritius and the rest of sSA, the ratio of human capital, $(H^0 + H^*)/H^0$, can be interpreted as the ratio of incomes. Using Mauritius' PPP per capita GNP in 1998 of \$8,236 and \$1,440 for all of sSA from the 2000 *World Development Indicators*, we can write $(H^0 + H^*)/H^0 = 8,236/1,440 = 5.72$. The model outcomes for the upper end of v for $\beta = 0.8$ and lower end of v for $\beta = 0.9$ are in the ballpark of this figure.

Finally, we increase the return to primary education assumed earlier to be 3%. For returns up to 11.32%, a single stagnant steady state returns, with the fertility rate at 5.7. For higher values, a single positive steady state results; we do not obtain multiple steady states.

In summary, for the various parameter combinations that yields a steady state fertility rate of 5.7, we do not obtain multiple steady states in the BMT model. A single stagnant steady state results for the most realistic parameters. Neither the parameters that yield multiplicity nor the fertility outcomes in the equilibria that result are very consistent with data.

4.4 Policy Experiments

Akin to the other two models, we can compute the cost of moving the economy from the low to high steady state for a calibration that yields multiplicity, even if the parameters are not empirically convincing. When there are two stable steady states and the economy is stuck at the lower one, the stock of human capital has to be increased at least to the unstable steady state, H^{**} , to cause the economy to transit to the higher steady state. In the BMT model where there is no heterogeneity among agents, it is not possible to tax one group and subsidize another in order to increase human capital investment and kick start the process of development.⁴¹ We instead calculate the human capital investment needed in order to increase the stock of human capital from H^0 at stagnation to the threshold for development, H^{**} . From (4), we can see this amount is

$$h^{**} = H^{**}/A (H^0)^\beta.$$

Since parents forgo this (time) investment and instead choose to work at the stagnant steady state, they would have to be provided a subsidy (presumably from foreign aid) of $n_u h^{**} H^0$ as compensation for lost labor time. Using the above expression for h^{**} , this subsidy amounts to $n_u H^{**} (H^0)^{1-\beta} / A$, which can be calculated as a fraction of GDP at stagnation, $(1 - vn_u) H^0$. When we use the $\beta = 0.7$ parametrization in Table 5, we find that the cost of subsidy / aid is 1.13% of GDP, an empirically plausible amount. The aid will be effective only if the human capital investment can be enforced.⁴²

We conduct an alternate policy experiment with our benchmark parameters. Recall that we obtain only a single stagnant steady state in that case. We are therefore interested in a policy that would pry the economy out of a zero steady state and yield a positive steady state. Since a low resource cost of children relative to income can cause stagnation, it is natural to consider a fixed tax on each child to increase the cost of bearing children and decrease fertility. The proceeds are then rebated to the households lump-sum. We find that very large taxes on children are needed to pry the economy out of stagnation. For instance, we need to make the cost 56 times or higher

⁴¹See Caucutt and Kumar (2007), where there is heterogeneity of agents and such a policy experiment is feasible.

⁴²The cost of subsidy however increases with β . When $\beta = 0.8$, the cost is 17.9% of GDP and when 0.9, as high as 77.1% of GDP. This is partly due to the higher fertility at stagnation with higher β . But, more importantly, the threshold human capital that needs to be crossed (the unstable steady state) increases rapidly with β . However, it is the case that the level of human capital at the new positive steady state is much higher as well.

than the benchmark resource cost, for a single positive steady state to result. The fertility rate drops to 2.52 and the human capital ratio, $(H^* + H^0)/H^0$, nudges over 1.

We also study the effect of foreign aid in the context of benchmark stagnation. Such aid would increase the income of parents. Foreign aid of 10% of GDP (which will increase individual incomes by the same proportion) will increase fertility from 5.7 to 5.83, without getting the economy out of stagnation. This experiment addresses the title question of this paper directly. Foreign aid to a stagnant economy can increase fertility without increasing human capital or spurring development. Even with multiple steady states, aid is effective only if investment in human capital can be enforced.

4.5 Discussion

For empirically realistic parameters and fertility outcomes, we only obtain a single stagnant steady state in the BMT model. A very large tax on children is required to pry the economy out of stagnation. Such a tax is unlikely to be politically popular, but is the only policy readily suggested by the model. China's one child policy, which imposed huge costs on parents who had more than one child, could presumably be seen to fall in this category. For those parameterizations for which we obtain multiplicity, a low amount of aid (1.13% of GDP) is enough, in some cases, to move the economy from a steady state with zero human capital to a steady state with a positive level of human capital.

5 A Collective Evaluation

What conclusions can we draw by considering these models collectively? All the models we consider are capable of generating multiple equilibria. So it is natural to ask how robustly this happens for realistic parameter values. In the Big Push model, multiplicity results for a limited range of high degree of increasing returns, high intertemporal elasticity of substitution, and low urban-rural wage gap. A very specific set of parameters is needed in the occupational choice model for multiplicity to result, given tractability considerations. The human capital and fertility model can deliver multiplicity only if we abandon the ability to match the fertility rate, a crucial empirical target. Therefore, across the models, we conclude that while obtaining multiple equilibria is possible, it cannot be done in a very robust manner for empirically plausible parameters.

Regarding policies to overcome stagnation, the Big Push models suggest fixed cost (investment) subsidies, the occupational choice model suggests redistribution of initial wealth, and the human capital and fertility model suggests foreign aid for education subsidy or a tax on children. Given the above discussion on robustness of multiple equilibria, one needs to be cautious about claims that one-shot policies, such as the injection of a large dose of foreign aid to fund these interventions, will revive stagnant economies.

If we accept the empirical fragility of multiplicity, and proceed to quantify the cost of implementing policies suggested by the models, we can shed light on whether high resource costs would stymie reform. The policy interventions suggested by the models are not large: around 5% of income given as cost (investment) subsidy to give the economy a Big Push, around 3% of initial wealth redistribution to get a better mix of occupations, and around 1% of GDP as aid directed to education. Politico-economic forces or the lack of applicability of models with multiple equilibria might therefore be needed to explain why such seemingly low-cost policies are not implemented widely. If these countries do not have the political will to undertake reform – for instance, a portion of the 1% of GDP for human capital subsidies could be met by redirecting military expenditure, which was 3.1% of GNP in sSA – it is not clear that foreign aid will trigger reform or even successfully reach the intended target.⁴³ On the other hand, Mauritius, a success story in sSA, has received far less aid than other sSA countries.⁴⁴ But it has on its own implemented several of the policies suggested by the above models, such as investment tax credits and human capital subsidies, and enjoys a much higher per capita income than sSA countries that receive more aid.

⁴³See *2000 World Development Indicators*, Table 5.7, for military expenditure data for 1992. Our conclusion is consistent with Burnside and Dollar (2000), who find that aid has a positive impact on growth in developing countries with good policies, but little effect on those with poor policies.

⁴⁴Official development assistance (ODA) for Mauritius shrunk from 3.7% of GDP in 1990 to about zero by 2003 (*World Development Indicators*). The figure for sub-Saharan Africa as a whole ranged between 4% and 7% during these years. While the per capita dollar amount of aid received by Mauritius occasionally exceeds the average for sSA (reaching a peak of \$83.50 in 1990), this is still a fraction of the per capita aid received by countries such as Cape Verde, Sao Tome and Principe, and Seychelles. More generally, as Easterly (2006, p. 27) notes, “The developing countries that are in the bottom fourth in terms of aid receipts as a percent of their income have had no trouble achieving healthy growth rates, seeing a 2.5-fold increase in income over the last four decades.”

6 Conclusions

We have addressed the question of whether foreign aid is an effective solution to African development. We find that a prime rationale for foreign aid – the existence of poverty traps – does not obtain in a robust manner. Even when we assume parameters that yield multiplicity, policy analysis indicates that enough resources might be available locally to kick-start development. The absence of economic reform in sSA in this situation would suggest a lack of political will, a malady that foreign aid is unlikely to remedy. We therefore conclude that the case for aid to Africa is weak.

The methodology we employ in this context is of interest in its own right. Calibration is an ideal choice for evaluating models of stagnation, given the problems of data availability and nonlinearity, and the ease with which it allows the study of counterfactual policy experiments.

It would be fruitful to extend some of these models with the aim of larger scale computation and calibration. With the burden of analytical tractability reduced, several of the suggested channels of stagnation, including politico-economic factors, could be studied in an integrated fashion, where the costs of the different policy alternatives could be compared in a more meaningful way. It would also be useful to study how foreign aid alters the distribution of political power among local constituencies and stymies or aids development.

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