Evaluating Explanations for Stagnation*

Elizabeth M. Caucutt
University of Western Ontario
ecaucutt@uwo.ca

Krishna B. Kumar
USC Marshall School of Business
kbkumar@usc.edu

July 2005

Abstract

Understanding the causes of economic stagnation and exploring policies to overcome it has significant implications for human welfare. In this paper, we evaluate three proposed explanations for stagnation that cover different facets of an economy: coordination failures, ineffective mix of occupational choices, and insufficient human capital accumulation. We calibrate models that embody these explanations in the context of the stagnant economies of sub-Saharan Africa. 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 one-shot or temporary development policies such as foreign aid that are conventionally prescribed based on models of multiplicity. Nevertheless, the calibrated models indicate that even the cost of continuous policy interventions needed to trigger development in stagnant economies is small.

Keywords: Coordination failure, Occupational choice, Human capital accumulation, Economic Development, Calibration.

JEL Classification: O100, O110, E600

*We are grateful to Daron Acemoglu, Michele Boldrin, Oded Galor, Doug Joines, Larry Jones, Pete Klenow, Romain Ranciere, Nancy Stokey, Chris Udry, and participants at various seminars and conferences for their comments and suggestions.

1 Introduction

A substantial branch of the literature on economic growth and development is devoted to understanding stagnation, a condition in which economies are locked into low output and income. Understanding the causes of stagnation and exploring policies to overcome it has immense implications for human welfare. Most papers in this tradition develop theoretical models to highlight how a particular economic force could yield multiple equilibria with prosperity or poverty, and provide conditions under which an economy is trapped in the bad outcome. Policy implications are mentioned, but typically not analyzed or quantified. When there are multiple steady states, a one-time policy intervention, say a large injection of foreign aid, can alter the initial condition and steer the economy toward the high development steady state instead of stagnation. On the other hand, when there is a unique low development steady state, the policy or institutional change has to be permanent.[1]

How relevant is the multiple-equilibrium aspect of these models in explaining economic stagnation seen in the data? What are the quantitative implications of policies they suggest? Are there any policy lessons to be learned by considering these models collectively? These are a few of the questions we address in this paper, by applying the methodology of calibration to selected models. The poorest countries in sub-Saharan Africa (sSA), in which per capita income and output have been low and stagnant during the last three to four decades, provide a natural context for such an evaluation. To the best of our knowledge, ours is the first attempt at a joint quantitative evaluation of models of stagnation.[2]

We evaluate three explanations for stagnation found in the literature: 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, also driven by capital market imperfections. We choose models that are representative of each explanation for our calibration exercise. While other explanations and models could be found, the ones chosen do capture diverse facets of the economy suitable for this exercise. The coordination problem explanation focuses on the firm and investment, the human capital explanation on households and capital market imperfections relating to educational investment, and the occupational choice connects households and employment

[1] As 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 achieveing 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)

[2] Kraay and Raddatz (2005) conduct an exercise similar in spirit to ours, and reach broadly the same conclusions. They focus on the role of savings behavior in generating traps. See their paper and Azariadis (1996), and Bowles, Durlauf, and Hoff (2003) for state-of-the-art surveys on models of poverty traps. For detailed evidence on the stagnancy of sub-Saharan Africa see Acemoglu, Johnson, and Robinson (2002) and Caucutt and Kumar (2004).

via capital market imperfections in firm formation.

Calibration is ideally suited for the study of stagnant environments, where the scarcity of high-quality data makes detailed econometric analysis, especially at the macroeconomic level, difficult.[3] Calibration also readily lends itself to analyzing counterfactual policy experiments that can pry an economy out of stagnation. We distinguish between parameters that are "structural" in the sense that they are expected to hold everywhere, and those particular to sSA that cause stagnation in a given model. For structural parameters we use the more readily available data from developed countries. For particular parameters, we use data from sSA, from whichever country and source it is available, and rely on ranges of estimates where needed.

Once we evaluate the robustness of a model in producing the stagnant outcome, we design and implement policy experiments that are appropriate to the model. We quantify each policy in terms of tax rates, cost of subsidies as a fraction of GDP, or welfare gain in terms of equivalent variation in order to asses 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.

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 most 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 investment subsidy, 4 to 7% for most parametrizations, is enough to avoid stagnation. The drive toward industrialization by Mauritius in the 70s, using investment tax subsidies and other incentives to foster export processing zones, provides empirical support for this type of policy intervention.

We calibrate the Banerjee and Newman (1993) model to study the role of occupational choice in stagnation. 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 restricted set of parameters yields this 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

[3] For 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.

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 about 4% of total wealth.

We develop and calibrate our own model to study the human capital explanation. In this heterogeneous-agent model, developed with the explicit intent of calibration, high costs of education relative to low income and skill premium cause the economy to stagnate in a low steady state with minimal educational attainment. While the model is theoretically capable of yielding multiple steady states, the benchmark calibration yields only a single stagnant steady state. A continual tax and in-kind subsidy that effectively redistributes resources from poor households with lower ability children to those with higher ability children can pry the economy out of stagnation. We find that a GDP share of education of 3.2% is required in the calibrated model to produce a Mauritius-like outcome, close to the actual expenditure share seen in data.[4]

The models we evaluate are stylized, with authors abstracting along several dimensions in order to focus on one main channel.[5] Moreover, comprehensive, good-quality data is rarely available for a particular sSA country. Both these considerations necessitate a flexible approach toward calibration. Sometimes, this involves finding any set of parameters that can produce the stagnation outcome of the model and then evaluating the empirical validity of the parameters, rather than starting with parameters that are *a priori* reasonable. In order to preserve the authors' original intent, we do not modify their models. 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. None of these models attempt to explain all the income differences seen in the data. Therefore, we confine our quantitative analysis to the stagnation seen in sSA.

What answers can we provide to the questions that motivated this study? First, it is possible to find parametrizations 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. Second, accepting the fragility of multiplicity, we nevertheless proceed to quantify the cost of implementing policies suggested by the models. This would shed light on whether reforms are rarely implemented because

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[4] Azariadis and Drazen (1990), Becker, Murphy, and Tamura (1990), and Durlauf (1993) are a few of the other models that feature multiplicity.

In Caucutt and Kumar (2005), we consider politco-economic explanations of stagnation that do not feature multiple equilibria.

[5] As Murphy, Sleifer, and Vishny (1989) note, "... because all our models are highly stylized and capture what we can only hope to be one aspect of reality, policies suggested by these models should be interpreted with caution." (p. 1006)

the resource requirements are too high or there is a lack of political will. We find that the resource costs are not very high. This is true even in our human capital model, where we study only permanent policies. Third, considering the models together also allows us to identify recurring factors – the initial income distribution, human capital, and capital market imperfections – with sufficient power to explain stagnation, and serve as leading candidates for inclusion in a more comprehensive model of stagnation.

Beyond this, our exercise naturally allows us to identify the relative quantitative strengths and weaknesses of each model. We defer a more detailed collective evaluation until Section 5, and first present the individual analyses. 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. 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 $L\left(1-(1+v)/\alpha\right)-F(1+v)<0$. 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 $\alpha\left(L-F\right)-L\left(1+v\right)>0$. If both conditions are satisfied, both equilibria are possible. It is convenient to write the condition that parameters need to satisfy for multiplicity as

$$(1+v)<\alpha\left(1-F/L\right)<(1+v)+\alpha vF/L. \tag{1}$$

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 $1/\left(1-\theta\right)$ and elasticity of substitution across goods is $1/\left(1-\gamma\right)$. 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 $\pi=\left(1/\left(1+r\right)\right)ay_2-F$, 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 $\left(1/\left(1+r\right)\right)aL-F<0$. 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 $\left(1/\left(1+r\right)\right)=\beta$. The condition for an industrialized equilibrium is $\left(1/\left(1+r\right)\right)a\alpha L-F>0$, where the interest factor consistent with a first period income of $\left(L-F\right)$ and a second period income of αL is $\left(1/\left(1+r\right)\right)=\beta\left(\alpha L/\left(L-F\right)\right)^{\theta-1}$. 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

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

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

$$(F_2/L + R/L)\,/\alpha < \beta a < F_1/L. \tag{3}$$

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, 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

We realize the need to be flexible in calibrating stylized models written with the aim of highlighting particular forces of economic development analytically. Therefore, for this and the occupational choice models, we search for empirically reasonable parameters that yield multiple equilibria, rather than follow the usual strategy of fixing some of the parameters *a priori* using independent evidence, and calibrating others to match empirical targets. Table 1 summarizes the parameters we use.

Table 1: Parameters for the Murphy-Shleifer-Vishny Models

Parameter	Value	Comment
α	3	IRS parameter for nondurables; Hall (1988, 1990)
F/L	0.375	Skill share in total labor costs; Bartel and Lichtenberg (1987)
v	0.4286	From rural-urban wage gap; USDA
β	0.3151 - 0.5401	Annual value of 0.9259 compounded over 8 to 15 years
θ	0.35 - 0.75	"Closed" economy; intertemporal elasticity of 1.5 to 4
	1	"Open" economy; infinite intertemporal elasticity
R/L	0.03 - 0.08	Public infrastructure investment; *World Development Report 1994*
F_1/L	0.307	Lower end of skill share in labor costs; Bartel and Lichtenberg (1987)
F_2/L	0.433	Upper end of skill share in labor costs; Bartel and Lichtenberg (1987)

The parameters that are common to all three models are α, the degree of increasing returns, and F/L, the normalized cost of adopting the increasing-returns technology. 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. We find that a value of $\alpha = 3$, which is roughly the value for nondurables in both estimates, works for all three models. This might seem like a high value, especially in light of the highest value of 1.72 reported in Basu and Fernald (1997) for the entire private economy. However, 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, and from this viewpoint a value of 3 does not appear to be too high.

In the context of the MSV model, the quantity F/L can be interpreted as the fraction of either labor or resources devoted to technology adoption. We use the share of skilled labor in total costs. Greenwood and Yorukoglu (1997) view 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. This is higher than other candidate proxies – the actual employment share of educated workers, which ranges from .158 to .271 during that period, and the 12% of the population who are entrepreneurs (De Nardi and Cagetti (2003)).

For the factory premium model, we use the rural-urban wage gap to proxy for the factory disutility v. The USDA's Economic research service reports rural wages of about 70% of urban wages, which implies $v = 0.4286$. This is comparable to the value of 0.376 derived from BLS weekly earnings ratio in the goods-producing industry to the private service-providing industry.[6]

For the investment model, we assume a base annual real interest rate of 8%. This implies an annual discount factor β of 0.9259.[7] This annual value has to be compounded over a gestation period that is typical of large-scale industrial projects. Given the varying gestation periods observed for different industries, we study a range of values for the compounded β: 0.5401 for 8-year compounding, 0.4631 for 10 years, and 0.3151 for 15 years. Whether the industrialization condition is met or not depends strongly on the value used for θ, which controls the effect of deferred consumption on the interest rate. The easiest to consider is $\theta = 1$, which implies infinite substitutability across periods. An alternate interpretation is a small open economy in which there are no interest rate effects of increased investment. Other values we use for θ range from 0.35 to 0.75, which yield elasticity of substitutions of 1.5 to 4. While this elasticity is not far from the value of 1 often used in the calibration of macroeconomic models, it is much larger than the 0.2 to 0.4 figure reported by Patterson and Pesaran (1992) for the US and UK, which imply a θ of -4 to -1.5.[8] Any value of θ less than 0.35 causes the interest rate effect to dominate and makes industrialization impossible.[9]

For the railroad cost, R/L, in the infrastructure model, we use the information from the *World Development Report 1994*, that public infrastructure investment in developing countries ranges from 2 to 8%, with an average of 4%. These figures are in the ballpark of the US infrastructure spending, which was between 2.5% and 3% of GDP during 1956-1991.[10] We use the figures of 3% and 8% to cover a broad enough range. 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.[11]

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[6] The values chosen for α and v satisfy the MSV condition of $\alpha - 1 > v$, for the increasing returns to be sufficiently high to warrant the higher factory wages.

[7] As will be seen, what matters is the annual β compounded by a gestation period. Different values of the annual β and years are therefore compatible with the final values used.

[8] Guvenen (2003) argues that a higher elasticity would result when wealth data, rather than consumption data, is used. These higher estimates are connected to aggregate investment and output, and seem more relevant for our purposes.

[9] That is, even though MSV focus mainly on domestic markets, it is the open economy version of their model that most robustly yields multiple equilibria.

MSV assume $\alpha < 1/\gamma$ to ensure a sufficiently inelastic demand. For our chosen value of α, we need $\gamma < 1/3$, which implies an elasticity of substitution among goods of less than 1.5. For instance, the Cobb-Douglas aggregator $\int_0^1 \ln x\,(q)\,dq$, satisfies this constraint.

[10] See the Congressional Budget Office's, *Trends in Public Infrastructural Spending*, 1999.

[11] Another 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 have chosen the interpretation

We have assumed that these parameters are "structural" and hold across all economies; this is easier to defend if we take the view that all parameters are purely technological. This allows us to assume, in the spirit of MSV, that some economies stagnate purely on account of bad expectations, and focus on Big Push policies to undo these expectations. However, we later discuss the possibility of identifying the fixed costs with business entry costs, which are much higher on average in sSA than in OECD countries.

2.3 What the Calibrated Models Explain

The benchmark values satisfy the multiplicity condition in the factory premium model, (1), by yielding: $1.4286 < 1.875 < 1.9108$. High enough values for v, F/L, and α are needed for the condition to hold. If the alternate value of 0.376 is used for the factory wage premium v, the no-industrialization condition will cease to hold. This also happens if the share of entrepreneurs in the population, 0.12, is used for the fixed cost F/L. If a lower value for the IRS parameter α, say 2, is used, the degree of increasing returns is not enough to warrant the fixed costs and only the no-industrialization condition is satisfied.

In the open economy version of the two-period investment model (with $\theta = 1$), the condition for multiplicity, (2), is satisfied for values of discount factor β involving 8 or more years of project gestation period. For instance, with 8-year compounding, the condition is satisfied as: $0.125 < 0.3602 < 0.375$. Lower values for F/L will necessitate compounding by longer periods. The condition for no industrialization will cease to hold for a high β, low F/L combination – the discounted gains from industrialization exceed the cost. Greater variation in α can be tolerated for this model; for instance a value of 1.5 will work.

The closed economy version of the model is highly sensitive to the value assumed for θ, and also for β. The following combinations of parameters yield multiplicity when the benchmark value of F/L is used: $\theta = 0.35 - 0.5$ and $\beta = 0.5401$ (8 years), $\theta = 0.425 - 0.45$ and $\beta = 0.4631$ (10 years), and $\theta = 0.675 - 0.75$ and $\beta = 0.3151$ (15 years). Any value of θ lower than those specified will decrease the intertemporal elasticity of substitution enough to cause the interest rate effect to dominate; only the no-industrialization condition will be left standing. As in the open economy version, a high β, and a low F/L will break the no industrialization condition.

Finally, the infrastructure model satisfies the multiplicity condition (3) for an 11-year β of 0.4288. With a railroad cost factor R/L of 0.03, the condition is satisfied as $0.1543 < 0.2858 < 0.307$, and also for an R/L of 0.08, with the first number now becoming 0.171. Since the relevant fixed cost is now lower (as $F_1/L < F/L$), any higher value for β will make the fixed investment attractive enough to break the no industrialization condition. Lower values of α, say 2.5, will help in this regard, but tighten the condition needed for industrialization.

In summary, it is possible to find parameters for which the multiplicity conditions hold for

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

all three models of MSV, which warrants the study of policies involving a Big Push. A high enough value for fixed costs is crucial in all three models to satisfy the no-industrialization condition, which, given the interest in stagnation, is the more important of the two conditions.

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 investment subsidy required, in each of the three models, to break the stagnation condition and spur industrialization. The aim would be to reduce the effective cost of fixed investment F by enough, say to $(1-s)\,F$, such that even if a potential monopolist does not expect other sectors to industrialize, and therefore expects 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.[12]

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

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

For the parameter values assumed in Table 1, this implies a minimum investment subsidy rate of 3.5%. As a fraction of the stagnant income L, the income tax payments, sF, are 1.3%.

The condition for stagnation in the two-period investment model is $(1/\,(1+r))\,aL-F<0$. 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 investment subsidies by taxing first period consumption automatically accomplishes the MSV recommendation of "discouraging current consumption." The $\theta=1$ case is again the easiest to consider. With a β computed for 8 years, the minimum subsidy rate required is about 4%; as a fraction of the stagnant income, income tax payments are 1.5%.

[12] Since there is no labor-leisure choice, we need not differentiate between a lumpsum and a proportional income tax.

These rates are highly sensitive to β. If a 10-year compounding is used, these rates increase to 17.3% and 6.5% respectively.

When $\theta < 1$, the first term in the above condition also decreases with s, reflecting the increased interest rate needed to induce consumers to postpone consumption. However, it declines less steeply in s than the second term, and a unique minimum subsidy rate, $0 < s < 1$, can be found. As θ (the intertemporal substitutability) decreases, the minimum subsidy increases; the monopolist discounts more due to the increased interest rate, and requires higher subsidies. When an 8-year β is used, the subsidy rate is 4.8% when θ is 0.5, and 5.2% when θ is 0.35; the corresponding income tax rates are 1.8% and 1.9%. As in the $\theta = 1$ case, these rates are highly sensitive to β. With a 10-year β, and θ set to the 0.45 value that results in multiplicity, the minimum subsidy rate required is 20.9% and the income tax rate is 7.8%.

In the infrastructure model, in which θ has already been set to 1, and therefore the relevant discount factor for the monopolist is just β, the condition to overcome stagnation is simply

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

Using the parameters of the previous subsection, we get a minimum subsidy rate of 6.9%, which translates to an income tax rate of 2.6%.

Conditional on using parameters that satisfy the criteria for multiplicity, we find that modest rates of investment subsidy, 4 to 7% 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 polices of market expansion, simultaneous industrialization, and investment tax credit or subsidy?[13] 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%

[13] While 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.[14] 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.

2.5 Discussion

We can find empirically plausible parameters that yield multiple equilibria in the MSV model. 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 polices 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.

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.[15] The huge costs seen for sSA imply that only the stagnation condition would be satisfied for all three MSV models, 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.

3 Occupational Choice

We consider the work of Banerjee and Newman (1995), 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.

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

[15] See Djankov, La Porta, Lopez-de-Silanes, and Shleifer (2002).

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 $\widehat{r} < 1/(1-\gamma)$. (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 $\overline{r}$. (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 $\overline{r} : r'_0$ 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 $L \leq w + (\pi F/\widehat{r})$.

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 $\overline{v} \equiv ((\mu-1)/\mu) I (\overline{r} - \widehat{r})$ is the maximum wage that will leave the entrepreneurs indifferent to being self-employed instead, and results when $p_L \leqslant \mu p_U$.

Given the capital market imperfection, occupational choice is driven by wealth thresholds. Agents with wealth $w \in [0, w^*]$, where $w^* = I - (\pi F/\widehat{r})$, 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 $w^{**} = \mu I - (\pi F/\widehat{r})$. Finally, agents with $w \in [w^{**}, \overline{w}]$, where $\overline{w}$ is the highest possible wealth level that can be sustained in the long run, qualify to become entrepreneurs (but if wage is $\overline{v}$, 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 $\overline{v}$. 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.

We focus on BN's example of prosperity and stagnation.[16] 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.

3.2 Calibration

As with the MSV models, here too we find parameters that yield multiplicity and then assess them for empirical plausibility.[17] 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. The parameters used are presented in Table 2.[18]

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[16] 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 equations (6) and (7).

[17] 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. However, 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.

[18] We do not match the BN transition function for the high wage in one respect that 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 lumpsum taxes, that will cover losses and leave the children in the low-income category next period with zero rather than negative wealth.

Table 2: Parameters for the Banerjee-Newman Model

Parameter	Value	Comment
γ	0.9	Utility parameter; implied intergenerational persistence of 0.11; compare with Stokey (1998)
$\widehat{r}$	1.1	Annual risk free rate of 0.48% compounded over 20 years; compare with Dimson et al. (2002)
μ	2.2	Span of control; Ortin-Áugel and Salas-Fumás (2002)
r'_0	1.3	Entrepreneur's low annual return of 1.32% compounded; compare with Burtless (1999)
r'_1	10.2	Entrepreneur's high annual return of 12.31% compounded; compare with Burtless (1999)
q'	0.4607	Probability of high entrepreneurial return; determines average return $\overline{r}$ below
r_0	1	Self-employed low annual return of 0%; compare with Moskowitz and Vissing-Jorgensen (2002)
r_1	18.6	Self-employed high return of 15.74%; compare with Moskowitz and Vissing-Jorgensen (2002)
q	0.25	Probability of high self-employed return; to get average return $\overline{r}$ below
$\overline{r}$	5.4	Annual average return of 8.8%; compare with Burtless (1999)
I	2.95	Backed out from rich-poor wage ratio of 5; Ashenfelter and Juradja (2001)
πF	2.515	Implied collateral to loan ratio of 64.8%; *Fed's Survey of Terms of Business Lending 2004*

We assume each model period (generation) is 20 years.[19] The gross subsistence or risk-free return is, $\widehat{r} = 1.1$, which translates into an annual return of 0.48%. 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%. So the assumed figure appears reasonable. 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 $(1-\gamma)\widehat{r} = 0.11$. 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 our parameters. The "span of control" parameter μ is 2.2. Ortin-Áugel 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 we use is in the ballpark of the 2.78 figure implied by the lower end of the above range.

We use $r'_0 = 1.3, r'_1 = 10.2$, for entrepreneurial returns, which translate to annual bad and good returns of 1.32% and 12.31%. These appear plausible given stock market returns.[20] We use a probability of the good outcome of $q' = 0.4607$ which yields an average return of $\overline{r} = 5.4$. Annualized, this is 8.8%, which is a bit higher than the 6.3% historical return presented in Burtless (1999). The self-employed returns we need are $r_0 = 1, r_1 = 18.6$, which in annual terms are 0% and 15.74%. The probability of the good outcome q has to be 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

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

[20] See, 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 model constrains all returns to be positive.

equity respectively, the higher spread for self-employed returns is consistent with the higher dispersion for private equity reported by Moskowitz and Vissing-Jorgensen (2002).[21]

We interpret $\underline{v}$ and $\overline{v}$ as the wages in poor and rich countries, anticipating their steady states. The ratio of wages, $p \equiv \overline{v}/\underline{v}$, 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 Juradja (2001, Table 1) 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 $I = p\mu / \left(\delta \left(\overline{r} - \widehat{r}\right)(\mu - 1)\right)$, 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 $w^* = xI = I - (\pi F/\widehat{r})$,which in turn implies $\pi F = (1 - x) I\widehat{r}$. 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, $\overline{w}$, 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%.

In summary, while the parameters that are able to replicate the stagnation and prosperity example need to be rationalized ex post, most 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.[22]

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

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[21] The 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 we compute 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' we use. 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 we use for r_1 is close to their 3rd quartile return.

[22] The 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.

consider the examples of Tanzania and Mauritius. Considering two economies in the same sSA region would be in the spirit of BN of holding all parameters except the initial wealth distribution constant across countries. 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 distributions of income in the two countries during prior years explain how a part of this difference could have arisen? Answering this requires two sets of details to be addressed – the computation of the dynamic paths, and the mapping of empirical initial distributions to the model measures p_L, p_M, p_U.

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.[23] In practice, we start from the neighborhood of a given steady state and work backward by reversing the original differential equations. By setting the initial deviations from the steady state appropriately, one could, in principle, trace out *all* the paths that lead to this steady state.[24] 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 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 $(w^{**} + \overline{w})/2$. We use poverty headcount from the *World Development Indicators* 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

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[23] The 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 computations are available from the authors on request.

[24] If we instead work forward from a given initial condition, we will not know the steady state we will end up at, and the computation of deviations would have to be done by trial and error. However, hitting an exact initial condition would involve trial and error when we work backward, a process which we did not find too onerous. The computation also checks for switches in the wage regime along a path.

line of \$2 per day of 59.7% in Tanzania in1993 is also relevant for 1977, when its Gini coefficient was 0.52. Likewise, the only poverty headcount data we have for Mauritius is 10.6% in the 90s, which we assume is relevant for 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 are able to compute paths from initial conditions that are nearly identical to the above starting distributions implied by the data, such that Tanzania heads toward the stagnant steady state and Mauritius heads toward the prosperous steady state.[25] 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 get an economy to the distribution that would imply 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. Feasibility requires that the new level of aggregate wealth does not exceed the old level. Continuing with the assumption that wealth within each level is concentrated at the midpoint, we can show that redistribution is constrained by

$$(P_{U,o} - P_{U,n})\,(\overline{w} - w^*) \geqslant (P_{L,o} - P_{L,n})\,w^{**},$$

where the subscripts o and n refer to the old and new distributions.[26] The aim is to decrease the measure of the L and U agents and increase the measure of M agents. Beyond this we can be agnostic about the exact flow of wealth across agents. The above expression evaluated at equality indicates the maximum amount of redistribution possible, dictated by the wealth constraint. When it is a strict inequality, the right hand side can be used to evaluate the actual amount of redistribution that occurs.

Consider the initial Tanzanian distribution discussed above. The smallest perturbation we could find that would get the economy on a path to prosperity is $p_L = 0.5962$, $p_M = 0.1378$, and $p_U = 0.2693$. This increase in the measure of $M-$agents by 3.2 percentage points involves a redistribution of 3.9% of the initial wealth. A maximum redistribution of 27.9% of initial wealth is possible. This will start the economy with $p_L = 0.4688$, $p_M = 0.3349$,

[25] The 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.

[26] This expression is derived by stipulating that the aggregate wealth, $p_L\ (w^*/2) +\ (1 - p_L - p_U)\ (w^* + w^{**})/2 +\ p_U\,(w^{**} + \overline{w})/2$, at the new distribution does not exceed that of the old.

and $p_U = 0.1964$, amounting to an increase of $M-$agents by 22.9 percentage points.[27] This much larger redistribution would shave the transition time to the high steady state by more than a generation.

3.5 Discussion

The calibrated parameter values are empirically defensible and result in multiple steady states. However, this multiplicity is highly sensitive to any change in parameters. Despite these limitations, and the complete dependence on initial conditions to generate different outcomes, the calibrated model has the potential to explain how two economies identical in *all* respects except their initial distributions, could have ended up at very different steady states. 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.[28] The experiments also indicate a trade-off between the amount of redistribution – which is, in turn, connected to political feasibility – and transition times.

4 Human Capital Accumulation

We calibrate a simple heterogeneous-agent, two-period overlapping generations model of education acquisition that exhibits stagnation when the cost of education is high relative to income. Caucutt and Kumar (2004) provides a detailed theoretical and quantitative exposition of different education policies such as a tax-and-subsidy scheme, abolition of child labor, and compulsory education. We provide a synopsis here and focus only on the tax-and-subsidy policy and the lack of necessity of foreign aid.

4.1 Model

The economy is populated by a continuum of two-period lived agents, each generation of measure one, in an overlapping generations setup. Children differ in their ability to become educated; more generally, this captures the "functionality" of a family. Conditional on being enrolled, a child with ability a completes education with probability $\pi(a)$; with probability $(1-\pi(a))$, the child drops out and becomes an uneducated worker. The probability function satisfies: $\pi(0) = 0$, $0 < \pi(a) \leqslant 1$, $\forall\, a \in (0,1]$, $\pi^{'}(a) > 0$, $\forall\, a \in [0,1]$. The function π can be

[27]This experiment 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.

[28]See 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.

used to capture the quality of the educational system. The distribution function for ability on the support $[0, 1]$ is denoted by $F(\cdot)$, and $f(\cdot)$ is the corresponding density function. Ability draws are iid.

Enrolling a child involves a real cost of e_d units of consumption. A parent cannot borrow to finance her child's education. If a child is not enrolled she can work and add w_c to the family's consumption, by performing tasks such as tending livestock, fetching water, and helping in the fields, in addition to supplying labor outside the family. If the child is enrolled in school, she can contribute only φw_c to the family, where $0 < \varphi < 1$. The total cost is $e = e_d + (1 - \varphi) w_c$, the sum of direct and indirect costs. If education costs are subsidized to the level s, it is netted out of the cost e.[29]

The aggregate state variable in this economy is the measure of educated workers entering the labor force at any period, n_e. The wage earnings of an educated parent as a function of the aggregate state is denoted by $W_e(n_e)$, and that of an uneducated parent by $W_u(n_e)$. The earnings of a household that does not enroll its child is $w_j(n_e) \equiv W_j(n_e) + w_c, (j = e, u)$, and one that does is $w_j(n_e) - e$. Workers inelastically supply their unitary time endowment.

There is a single consumption good produced using educated and uneducated labor as inputs. The CES production function is $Y = A[\theta(N_e + \gamma N_u)^\nu + (1-\theta)(N_u + \varepsilon N_e)^\nu]^{\frac{1}{\nu}}$, where $0 < \gamma, \varepsilon, \nu < 1$, and $\gamma < \varepsilon$.[30] Here, N_e is the number of educated workers, and N_u the uneducated workers, employed by the firm. The first term within the square brackets can be thought of as "brain" (supplied primarily by educated workers) and the second term as "brawn" (supplied mainly by uneducated workers). The weight of uneducated workers in "brain", γ, is small and keeps wages bounded even in a stagnant economy. In a competitive labor market, the wage rates W_e and W_u would be the appropriate marginal products and decreasing in N_e and N_u respectively.

A parent of a given type, who has a child of ability a, optimally decides between enrolling and not enrolling the child, weighing the utility cost of education against the possibility the child becomes educated and gets higher utility. The intergenerational discount (altruism) factor is β. The future aggregate state is posited to follow $n_e' = \Phi(n_e)$, which is consistent with the outcome of a perfect foresight equilibrium.

This model delivers a threshold ability for enrollment; parent type j enrolls her child

[29] While the model is in the spirit of Galor and Zeira (1993) in that it features indivisibility of education and fixed costs, enrollment does not automatically imply success in our model. It is probabilistic and depends on ability. This is empirically relevant, and more importantly, leads to the implication that redistribution even among the poor is capable of prying the economy out of stagnation.

The Galor and Zeira (1993) setup allows one to think of redistribution from the rich to the poor, but this channel is inoperative at a stagnant steady state.An external shock can shift the transition function in their paper and also in the representative agent setup of Becker, Murphy, and Tamura (1990), who additionally consider fertility decisions. We instead devise policy measures that would shift the transition function upward.

[30] Stokey (1996) considers a similar production function.

if $a \geqslant a_j^*(n_e)$, and does not otherwise. If $a_j^*(n_e) = 1$, even the most able child will not be enrolled, and the enrollment rate of type j children, given by $\left(1 - F\left(a_j^*(n_e)\right)\right)$, is zero. Enrollment rates are higher among the rich; $a_e^*(n_e) < a_u^*(n_e)$, for $n_e \in [0, 1]$.

A steady state satisfies $\Phi(n_e^*) = n_e^*$, with stagnation defined as a locally stable steady state at $n_e^* = 0$. Caucutt and Kumar (2004) show that a necessary condition for stagnation is $a_u^*(0) = 1$ (the poor do not enroll their children). This condition is sufficient if it additionally holds in a neighborhood of $n_e = 0$. When the initial fraction of educated people in the workforce is too low, the wages of the uneducated workers are too low for them to find it profitable to send their children to school. This results in a decrease in the fraction of educated workers next period, which further decreases the wages of the *un*educated workers and reinforces the above-mentioned behavior. The dynamic behavior of the economy around the origin is therefore mainly governed by the utility cost of poor parents. Provided e is not prohibitively high, rich parents always enroll a positive fraction of their children, especially near the origin when their wages are very high. But there is vanishingly small measure of them.

What conditions yield $a_u^* = 1$ in the neighborhood of the origin and hence stagnation? For a general utility function, a sufficient condition is

$$(u(w_u(0)) - u(w_u(0) - e)) > \left(\beta / \left(1 - \beta \int_0^1 \pi(a)\, dF(a)\right)\right) [u(w_e(0) - e) - u(w_u(0) - e)].$$

The left hand side is the *utility* cost of education to the *poor* parent. When this is greater than the discounted, maximum possible utility gain from education, stagnation results. The discount factor reflects differential enrollment rates. With an isoelastic utility function $u(c) = c^{1-\sigma}/(1-\sigma)$, $\sigma \geqslant 0$, it can be shown that the condition for stagnation is more likely to be satisfied when the curvature of the utility function and cost of education are high, and the wage gap and the discount factor are low.

Similar to the models considered in the previous two sections, ours is capable of delivering an additional stable steady state with a positive fraction of educated agents. This happens if the rate of enrollment of the uneducated increases rapidly when n_e increases (w_u increases). Whether an economy ends up at the low or high steady state would then depend on the starting level of n_e.

4.2 Calibration

The predetermined ("structural") parameters we use are summarized in Table 3.

Table 3: Predetermined Parameters for the Caucutt-Kumar Model

Parameter	Value	Comment
β	0.6676	Annual discount factor of 0.98 compounded over 20 years
ν	0.35	Educated-uneducated elasticity of substitution of 1.54; Autor et al. (1998)
ε	0.1	Skilled labor counts 10% of unskilled labor towards "brawn"
σ	3.5	Utility RRA parameter; refer Ogaki and Zhang (2001)
$F(a)$	a	Uniform ability distribution

We assume that all children are born with two years of education ("uneducated") and successful education involves completion of a further eight years of schooling ("educated" agents thus have ten years of education). For eighteen of the worst-performing sSA countries, we use the data in Barro and Lee (1996) to find that median years of primary attainment is about 1.5 years; this motivates our baseline level of education.[31] Secondary schooling indicators are often used in cross-country growth studies and completion of education at this level is considered the minimum level needed for a worker to perform well in the modern economy; this motivates our definition of educated workers. The median years of secondary attainment in the above-mentioned sample of sSA countries is 0.15, which conforms to our view of stagnation. 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 a child, 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 this sample.

We start by assuming values for certain parameters that are commonly used in the literature. The generational discount factor is set at $\beta = 0.6676$, which corresponds to a yearly discount factor of 0.98 compounded over 20 years. We set $\nu = 0.35$, which corresponds to an elasticity of substitution between educated and uneducated labor of 1.54. Autor, Katz, and Krueger (1998) report that the emerging consensus on the elasticity between skilled and unskilled labor is approximately 1.4 to 1.5. In the absence of direct evidence, we set $\varepsilon = 0.1$, (each unit of skilled labor counts 10% of unskilled labor toward brawn) and leave $\gamma < \varepsilon$ as a free parameter. We appeal to arguments for a negative relationship between relative risk aversion and wealth (see, for instance, Ogaki and Zhang (2001)), and set the curvature parameters of the utility function, σ, at a higher value of 3.5 instead of the 2 usually assumed in calibrated macroeconomic models. We assume a uniform ability distribution in $[0, 1]$; that is, $F(a) = a$.

We allow for the possibility that the human capital production functions can differ across the two types of families, to account for the advantages educated families might have in the production of human capital. The parametric form we use is $\pi_i(a) = k_i\left(4a^3\right)$, in the interval $[0, 1/2]$ and $k_i\left(1 - 4(1-a)^3\right)$ in $[1/2, 1]$. This convex-concave parametric form was chosen

[31] The countries we consider are Angola, Benin, Burkina Faso, Burundi, Central African Republic, Chad, Djibouti, Guinea, Guinea-Bissau, Malawi, Mali, Mozambique, Niger, Rwanda, Somalia, Tanzania, and Uganda.

because it allows us to better match the enrollment and dropout rates in the vicinity of stagnation. Such a shape is not *required* to obtain a stagnant steady state. We set $k_e = 1$ and allow only k_u to vary. Therefore, the production parameters, A, θ, and γ, education parameters e_d, s, w_c, φ, and the human capital production parameter k_u need to be chosen. Since high costs for low quality education and a low wage gap are responsible for stagnation in our model, we choose these remaining parameters to specifically match the following sSA targets. We again use data from wherever it is available, and specify ranges where necessary.

1. Education attainment: We target an attainment, n_e^*, of zero. Calibrating the model to a steady state attainment close to zero instead of exactly zero will not alter the policy conclusions significantly.

2. Skill premium: Bils and Klenow (2000) present Mincer regression coefficients on schooling for a few sSA countries: 0.207 for Cote d'Ivoire, 0.126 for Botswana, and 0.067 for Tanzania. Given the use of log wages and 8 years of schooling, we compute the corresponding premia to be 5.24, 2.74, and 1.71 respectively. When the figures reported in Bigsten et. al. (2000) are used to compute the premium for our education definition, we obtain a value of 1.42.[32] The premium therefore spans the rather wide range of 1.42 to 5.24.

3. Enrollment rates: In the model, education begins at the third year and continues for eight years. Using year-to-year survival rates from the *World Education Indicators*, we calculate enrollment rates conditional on surviving the first two years of education; the average of this enrollment rate is 22.9%.

4. Dropout rates: The dropout rate conditional on surviving the first two years of education is 13.5%. This is probably a low estimate, since data is missing for several of the poorest countries, where dropout rates are likely to be the highest.

5. Education subsidy as a fraction of parental cost: Ablo and Reinikka (1998), in Table 5, present data on parental and government spending in Uganda for 1991 through 1995. In conjunction with the per capita GNP figures, we compute the annual share of income that is spent on education and the parental share of this cost, averaged over 1991-95. If we denote per capita income by y, then $\lambda_1 \equiv \textit{total direct cost}/y = 8.1\%$, $\lambda_2 \equiv \textit{govt. cost}/y = 2.7\%$, and therefore $\lambda_1 - \lambda_2 = \textit{parent's cost}/y = 5.4\%$. This implies the ratio of subsidy to direct cost of education is $s/e_d = 1/3$.

6. Indirect cost: Bredie and Beeharry (1998), in Annex A, present time use data of school-aged children in Madagascar and conclude that the opportunity cost for boys in school is 20 hours per week. This figure is in line with the 21 hours per week reported by Beegle, Dehejia, and Gatti (2002) for Tanzania. We assume this is half the adult work week; non-schoolgoing children work half an adult week and schoolgoing children work none. We impute the average

[32] We use their coefficients from regression (3) in Table 7 to compute wages for 2 and 8 years of education.

wage in the economy to this time; we set $w_c = 0.5y$, where y is the average wage earnings (w_u in a stagnant economy).

7. Education expenditure to GDP: Consider family income when the child is not enrolled. The present value of the parent's annual income y over 20 years at an 8% annual rate of discounting is $10.6y$. The present value of the child's income is half this at $5.3y$. If the family enrolls the child, the present value of the annual parental cost of education $(\lambda_1 - \lambda_2)\, y$ over the eight schooling years is $6.2\,(\lambda_1 - \lambda_2)\, y$. If the child goes to school, it is assumed that after the first 8 years, the child can work the rest of his youth years with annual earnings of $0.5y$; the increased earnings due to education are not realized until adulthood.[33] The present value of these earnings is $2.2y$. Therefore, φ, the ratio of the earnings of the schoolgoing child to the non-schoolgoing child is $2.2/5.3 = 0.415$. We also calculate the direct education expenditure net of government subsidies as a fraction of GDP as $(e_d - s)/Y = 6.2\,(\lambda_1 - \lambda_2)\, y/10.6y = 0.0316$.

Table 4: sSA-specific Parameters for the Caucutt-Kumar Model

Parameter	**Value**	**Comment**
A	2	TFP; consistent with stagnation $(n_e^* = 0)$
θ	0.48	Skill share in production; θ and γ pinned down by skill premium
γ	0.05	Unskilled labor counts 5% of skilled labor towards "brain"; θ and γ pinned down by skill premium
k_u	0.85	Human capital production parameter for poor; governed by enrollment and dropout rates
e_d	0.0326	Direct cost of education; from direct education costs borne by families as a fraction of GDP
s	0.0109	Subsidy; from fraction of education costs subsidized in Ablo and Reinikka (1998)
w_c	0.3439	Child's wage; governed by indirect cost of education in Bredie and Beeharry (1998)
φ	0.415	Earnings ratio of schoolgoing to non-schoolgoing child; calculated from Ablo and Reinikka (1998)

In Table 4, we present values for the specific parameters resulting from our calibration attempt to best match the above targets. Given that we fixed $\varepsilon = 0.1$, it is reassuring that a $\gamma = 0.05 < \varepsilon$ results from our calibration; a unit of unskilled of labor contributes less to "brain" than does a unit of skilled labor to "brawn". Likewise, given that we set $k_e = 1$, it is reassuring that $k_u = 0.85$; the human capital production function for families with educated parents dominates the one for families with uneducated parents. Finally, the resulting value for the total cost of education, $e\ (= e_d + (1 - \varphi)\, w_c)$, is 0.234; in other words, the direct cost is only 14% of the total costs.

4.3 What the Calibrated Model Explains

With the chosen parameters, stagnation results $(n_e^* = 0)$. The skill premium is 4.96, which is within the range seen in data, though close to the upper end. Exactly at the point of

[33] With this assumption, we attempt to account for the experience premium, which we have not explicitly modeled.

stagnation, there is no enrollment; $a_u^* = 1$, and even though $a_e^* = 0.12 < 1$, there is a zero measure of educated people. Therefore, we examine the average dropout and enrollment rates in the "vicinity" of stagnation ($n_e = 0.00 - 0.15$), with the interpretation that these economies are headed toward stagnation if they are not already in it. The enrollment rate is in the range of 0 to 21%, which is a bit lower than the target rate given in the previous subsection, but in the ballpark. The dropout rate is in the range of 24 to 43%, higher than the target rate (which, as mentioned earlier is probably underestimated).

Even though multiple steady states are theoretically possible, for the chosen calibration the transition function yields stagnation as the only steady state.[34] An increase in the discount factor, β, and a decrease in the curvature of the utility function, σ, results in a non-zero steady state. Our assumption that a higher wage from education does not materialize until the second period has implications for the value of the indirect cost. A higher value for φ decreases the opportunity cost of education and makes stagnancy less likely.

4.4 Policy Experiments

Given the single stagnant steady state that we obtain, we only study continuous policies to revive these economies, rather than one-shot policies to change the initial measure of educated. Since the uneducated poor form the entire population in a stagnant steady state, it is natural to consider a policy of subsidizing their direct, and possibly indirect, costs of education.[35] We assume all students, rich or poor, get a subsidy of s each, and all workers are taxed at the rate τ. The government balances its budget every period. We hold the subsidy, s, constant at the level that leads to the target steady state. The tax rate τ is varied each period so as to balance the government budget. In all experiments, we hold the π functions at their benchmark specification; we do not make any adjustment for the quality of the education system. We do not have enough data on quality, especially from this region, to calibrate changes in π. We also expect the quality of educational institutions to move upward more sluggishly than enrollment.

We use Mauritius, as we did in Sections 2 and 3, as an example of a high-performing sSA economy. Barro and Lee (1996) indicate that the percentage of population who attended secondary school in Mauritius was 36.5% in 1990 and the percentage who completed secondary school was 28.1%. While the average primary expenditure per pupil for our sub-sample decreased from \$135.6 in 1960 to \$79.8 in 1990, it increased in Mauritius from \$256 in 1960 to as high as \$544 in 1980. The public education expenditure as a fraction of GDP was higher

[34] Since this is our own model, we take the liberty of not searching for a set of parameters that yields multiplicity. The framework is rich enough to accommodate developed countries such as the US, since higher education expenditures, higher TFP, and better quality education systems are associated with higher steady states. We do not pursue this route here.

[35] Mexico's *Progresa* program, for instance, subsidizes both the direct and indirect costs.

for Mauritius in 1990 at 3.6% when compared to the average of 2.8% for the rest (which is inflated by low GDP levels). In 1980, nearly 20% of government expenditures in Mauritius went to fund education. Given these facts one could plausibly argue that education policies were at least partly responsible for its solid economic performance. Moreover, the primary enrollment rate was close to 100% in 1960, a decade before the economy started growing, when its expenditure per pupil was nearly twice as high as the other sSA countries. These facts allay concerns that education might have *followed* rather than preceded development; indeed it has been argued that the export-oriented industries, mentioned in Section 2, were attracted to Mauritius because of its better educated workforce.[36] We therefore analyze policies for the other sSA countries that would result in a steady state close to the 30% level of educational attainment seen in Mauritius. Since our calibration indicates that at the prevailing subsidy level, the net educational cost is still too high to escape stagnation, our aim is to find a subsidy level that would shift the transition function upward and cause the economy to not only emerge from stagnation, but also result in a $n_e^* = 0.3$.

A subsidy level of 0.09, which is 38.5% of total costs, is needed to take the economy to a steady state of $n_e^* = 0.3$. It is not enough for the government to subsidize only the direct costs of education; it would have to defray part of the child's contribution to the family income that is lost by sending the child to school. At the steady state, a tax rate of 3.2% needs to be levied on all workers to meet the cost of subsidies.[37] Since all workers are taxed at the same rate, the ratio of government expenditure to GDP will also be 3.2%. This is close to the 3.6% figure cited earlier for Mauritius and thus appears to be an achievable target. The closeness of the model outcome to data from a country that was not originally part of the calibration, lends support to the validity of the calibrated model and the use of education subsidies as a development policy. The expenditure to GDP figure of 3.2% can be put in perspective by comparing it with military expenditure as a fraction of GNP, which was 3.1% in sSA in 1992.[38]

Each agent would have to be given 20.3% more consumption every period in the stagnant state, in order to equate an aggregate welfare measure – weighting generations within a period equally and using a discount factor of β for future generations – to that in the new steady state. When the costs of transition (increased taxes and educational investment when

[36] See, for instance, Anker et. al. (2001) and also Lamusse (1995),who attributes the success of the export processing zones to "a reserve labor force of literate women who were readily trainable for semi-skilled production jobs..."

[37] This policy increases output by close to 50%. The ratio of the subsidy to per capita GDP is 8.75%. The skill premium drops considerably, to 1.54. Given the skill premium of 2.1 in Malaysia, a country of comparable educational and economic development, calculated from Bils and Klenow (2000), the drop in premium appears to be overstated. The economywide enrollment rate is 36.2%, which masks the relatively high enrollment of 61% for educated parents. The dropout rate is close to 20%.

[38] See *2000 World Development Indicators*, Table 5.7, for military expenditure data.

uneducated workers' wages are still low) is taken into account, the gain in welfare in terms of equivalent consumption of 6.6% is much lower, but still significant. The economy is very close to the steady state in four to five model periods.

4.5 Discussion

The redistribution motive in our setup arises from the indivisibility of education, liquidity constraints, and the focus on aggregate welfare. If the return to education falls a bit short of the amount required for enrollment for every student, aggregate welfare could be improved by redistributing and making the return attractive at least for the most able students. At the stagnant steady state everyone is poor, and it is redistribution across ability rather than income levels that gives the initial kick-start to the economy. It is important to note that the child's ability need not be observed by anyone other than the parent; the in-kind nature of the subsidy would automatically attract the more able students. This implicit, rather than explicit, redistribution across abilities makes such a scheme politically feasible.

The tax-and-subsidy experiment suggests that even an economy locked into stagnation need not be dependent on foreign aid to trigger development. When we do conduct an experiment with foreign aid paying for subsidies instead of local taxes, welfare is obviously higher. But it appears inconceivable that rich countries will be willing to donate foreign aid to the tune of 3.2% of GDP (4.8% relative to pre-subsidy levels) for purposes of education alone, year after year. An intermediate strategy would be for the government to borrow, if possible, on a long-term basis from other countries or development agencies to finance increased education expenditures and alleviate transitional costs.

5 A Collective Evaluation

What conclusions can we draw by studying 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 fixed costs of industrialization and a high degree of increasing returns. The dynamic investment model is most robust if an open economy assumption is used to sidestep the effect of increased investment on interest rates. A very specific set of parameters is needed in the occupational choice model for multiplicity to result, given tractability considerations. But in both models, the parameters needed are not indefensible from an empirical standpoint. For the human capital model, we followed the strategy of calibrating parameters from *a priori* evidence in our model, and get only the single, stagnant steady state. Therefore, across the models, we conclude that while obtaining multiple equilibria is possible, it cannot be done in a very robust manner.

Regarding policies to overcome stagnation, the Big Push models suggest investment subsidies and tax credits, the occupational choice model suggests redistribution of initial wealth, and the human capital model suggests education subsidies. The first two are one-shot interventions, while the third is a permanent policy. Given the above discussion on robustness of multiple equilibria, one needs to be cautious about concluding that temporary policies will suffice to revive stagnant economies.

If we accept the fragility of multiplicity, and proceed to quantify the cost of implementing policies suggested by the models, we might be able to shed light on whether high resource costs stymie reform. The policy interventions suggested by the models are not large: 4 to 7% investment subsidy rate and even lower income tax rate to give the economy a Big Push, and 4% of initial wealth redistribution to get a better mix of occupations. Even the continuous policy of subsidizing human capital accumulation is relatively inexpensive at around a 3% tax rate. Politico-economic forces might therefore be needed to explain why such seemingly low-cost policies are not implemented widely.[39]

Consider the ease of calibration next. We have attempted to calibrate models not originally intended for calibration, which poses challenges. Our model, developed explicitly for calibration, was naturally easier in this regard. High-quality data is not abundant for the sSA region to which the models are calibrated. Therefore, data used from this region could be considered less reliable than the developed country data used to calibrate the "structural" parameters of the Big Push and occupational choice models. Stagnation in the Big Push model arises from a bad equilibrium selection and except to validate the policy of investment subsidy by comparing it to the one followed in Mauritius, we do not need any sSA data. In the occupational choice model, stagnation arises purely from a bad initial condition, and we need only the income distribution data for our candidate countries of Tanzania and Mauritius. The human capital model on the other hand, relies heavily on sSA data to calibrate education costs relative to income and the skilled-unskilled wage gap. However, greater reliance on sSA data increases confidence in the model's ability or inability to generate multiplicity in that particular region.

The models allow us to identify complementary channels and recurring factors that would be leading candidates for inclusion in a more comprehensive model. Decreasing inequality would help avoid stagnation in the occupational choice setup, and if broadly interpreted, in the human capital framework. Education subsidies form the central policy recommendation of the human capital model. Since we associate fixed costs of technology adoption with skilled labor in the calibration of the MSV models, increases in human capital would decrease costs

[39] For instance, in the model in Section 4, there is a drop in wages of the educated of about 61% going from stagnation to the Mauritius-like subsidy level. Across all steady state comparisons, the currently uneducated prefer subsidies more than the currently educated. There is therefore an incentive for the educated "elite", who often occupy key policy making positions in these countries, to *not* subsidize education and preserve the monopoly they enjoy for their children who are more likely to be educated.

Caucutt and Kumar (2005) quantitatively explore models which explicitly consider the political economy of stagnation.

and play a positive role in their setup as well. Finally, capital market imperfections are an important feature of the occupational choice and human capital explanations.

Indeed, Mauritius, the success story of this region has followed several of the suggested policies, such as investment tax credits and human capital subsidies, simultaneously. Since the reasons for stagnation are likely to be multiple, and the cost of each policy not inordinate (or independent of each other), following multiple policies appears to be a prudent approach.

6 Conclusions

Our paper makes both a methodological and a substantive contribution. We use the methodology of calibration to study models of stagnation, each of which captures a different explanation. We think 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. On the substantive front, we provide quantitative estimates of policy interventions that can overcome economic stagnation. In terms of tax or subsidy rates, or costs as a fraction of GDP, these are not high. However, we see both the need to be cautious about advocating one-shot or temporary policies, and the advantages of following a multipronged approach.

We find that even stylized models can be calibrated with considerable success. And one can find empirical counterparts for the policies they recommend. Given these outcomes, 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 instruments and welfare gains could be compared in a more meaningful way.

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