We develop a stochastic political economy model to explain the trade-off between growth and inequality during the process of technology adoption. In the model endogenous growth occurs through physical and human capital deepening. Agents can adopt either of the two risky high-return technologies, one of which is only available to those who can afford the entry cost associated with financial intermediation. We assume that this entry cost depends on the proportion of government revenue that is allocated towards cost-reducing financial development expenditure, and that agents decide on this proportion through a voting mechanism. The results show that certain interest groups comprising of both the poorest and the richest agents block the policies that are aimed at allocating resources towards costreducing financial development expenditure in the early stages of the economy’s development. However, as redistribution continues from generation to generation, the middle of the distribution successively becomes thicker and consequently the majority of agents start supporting reallocation in the form of cost-reducing financial development expenditure. In the transition to the steady state, inequality patterns show recurring ‘Kuznets-like curves’. Furthermore, high initial inequality tends to hasten the pace at which growth and inequality converge towards the steady state paths, while low inequality result in more fluctuations in transitional growth and inequality. Finally, our results show that although the political outcomes do not coincide with the welfare maximisation outcomes in the early and the transitional stages of the economy, the two outcomes eventually converge in the long-run.
Financial Intermediation and Costly Technology Adoption under Uncertainty: A Political Economy Perspective

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Abstract

We develop a stochastic political economy model to explain the trade-off between growth and inequality during the process of technology adoption. In the model endogenous growth occurs through physical and human capital deepening. Agents can adopt either of the two risky high-return technologies, one of which is only available to those who can afford the entry cost associated with financial intermediation. We assume that this entry cost depends on the proportion of government revenue that is allocated towards cost-reducing financial development expenditure, and that agents decide on this proportion through a voting mechanism. The results show that certain interest groups comprising of both the poorest and the richest agents block the policies that are aimed at allocating resources towards cost-reducing financial development expenditure in the early stages of the economy’s development. However, as redistribution continues from generation to generation, the middle of the distribution successively becomes thicker and consequently the majority of agents start supporting reallocation in the form of cost-reducing financial development expenditure. In the transition to the steady state, inequality patterns show recurring ‘Kuznets-like curves’. Furthermore, high initial inequality tends to hasten the pace at which growth and inequality converge towards the steady state paths, while low inequality result in more fluctuations in transitional growth and inequality. Finally, our results show that although the political outcomes do not coincide with the welfare maximisation outcomes in the early and the transitional stages of the economy, the two outcomes eventually converge in the long-run.

Keywords: political economy, overlapping generations model, growth and inequality, technology adoption, redistribution

JEL Classification: O1, O3
1. Introduction

There is consensus among empirical studies that incomes across developed and developing economies and within most developing economies have generally diverged over the past century (see De Long, 1988; Quah, 1996; Keefer and Knack, 1997; Fagerberg and Verspagen, 1996; Pekkala, 1999; Terrasi, 1999; Akita, 2003). Attempts to explain this non-convergence has led to the development of a number of endogenous growth models. Some of the common explanations suggested in these models include differences in levels technological progress, human capital development and institutional factors (see e.g. Mokyr, 1993; Greenwood and Yorukoglu, 1997; Perente and Prescott, 1994, 2004; Glomm and Ravikumar, 1992; Ray and Streufert, 1993; Galor and Mayer, 2004; Barro and Sala-i-Martin, 1992). A feature that is central in most of these models is heterogeneity in the initial resource endowment. Initial inequality then determines the extent to which different agents can access opportunities and in turn the long term economic outcomes of a nation.

Other theoretical extensions attempt to show that given an initial distribution of income, inequality can worsen if an economy does not meet certain conditions. The degree of capital market imperfections is one such condition, emphasised in studies such as Aghion and Bolton (1997), Banerjee and Newmann (1993), and Galor and Zeira (1993). Capital market imperfections, in some sense, determine the extent to which richer agents can borrow to finance productive activities at the expense of poorer agents.

Given the importance of initial inequality in determining economic outcomes, it becomes imperative to analyse whether growth can be enhanced by using policies or any other interventions to influence inequality. However, there is recognition that such interventions are normally endogenous in the sense that their success depends on the preferences of different agents in the economy. The eventual outcome is then influenced by groups of agents that either constitute the majority or have greater influence in the political process underlying the determination of such policies. It is then more appropriate to model such issues using a political economy construct that captures these features.

Thus far, there have been several attempts to address the role of political economy on the growth-inequality trade-off, albeit with mixed conclusions. One strand of these studies includes endogenous growth models by Alesina and Rodrik (1994) and Persson and Tabellini (1994) where agents are allowed to vote for the tax rate on capital. The political outcome in these models depends on the preferences of the median agent. Consequently, in a society that is highly unequal, the political outcome is characterised by a high capital tax rate resulting in
a negative relationship between growth and initial inequality as the median agent is poor. Persson and Tabellini (1994) provide evidence that the inverse relationship between growth and inequality holds for democracies, but not for non-democracies. Although Alesina and Rodrik (1994) also provide evidence of negative relationship between growth and inequality using measures of inequality based on income (Gini coefficient) and land distribution, they do not find statistically significant evidence that this relationship differs between democracies and non-democracies.

However, there also exists empirical evidence against the negative relationship between growth and inequality. For instance, Clarke (1995) show that the negative relationship between inequality and growth is neither robust across different income inequality measures nor robust across specifications of the growth regression. Similarly, Barro (2000) provides panel regression evidence based on a combined sample of both rich and poor countries consistent with the Kuznets (1955) idea that the relationship between growth and inequality is non-monotonic. However, by breaking the sample between rich and poor countries, the author finds that the growth-inequality relationship is negative for the poor nations while it positive for the rich nations. Forbes (2000) provides panel regression evidence of a positive association between growth and inequality although the sample comprises mostly OECD nations. Li and Zou (1998) provide additional evidence that growth and inequality is either positive or ambiguous. In their theoretical explanation for these findings, Li and Zou (1998) argue that the negative relationship predicted in models such as by Alesina and Rodrik (1994) is due to the assumption that the role of the government is only limited to providing the productive technology. They then show that if government were to be involved in provision of public consumption, and this consumption were to be incorporated in agents’ preferences, the growth-inequality outcomes would depend on the trade-off between private and public consumption.

A related strand of political economy literature has analysed the growth and inequality implications of the adoption of new technologies. Two studies are of particular interest to the current study. The first study by Krusell and Rios-Rull (1996) develops a three-period lived model where agents vote on whether to adopt new technologies or maintain the old technology. In the presence of heterogeneity in initial endowments, vested-interest groups comprising of the innovators of the old technology will attempt to block the new technologies through the political process. This then results in low rates of technological change and economic growth. The second study by Lahiri and Ratnasiri (2012) develops a two-period lived overlapping generations model with more general preferences but a relatively simpler
technological structure relative to that of Krusell and Rios-Rull (1996). The political outcomes of Lahiri and Ratnasiri (2012) are somewhat similar to Krusell and Rios-Rull (1996) in the sense that certain groups of agents tend to delay the adoption of new technologies.

In the two technology-adoption political economy models mentioned above, one feature that delays the adoption of new technologies is the existence of a cost of adoption. This cost is in the form of the time and other resources spend on learning the skills needed to operate the new technology. However, there is also evidence that technology adoption may be delayed due to the fact that the returns on the new technology may be subject to uncertainty. For instance, Mehra, (1981), Chand, et al. (2011), Ray et al. (1988) and Sharma, et al. (2006) provide evidence that India’s 1970s adoption of new agricultural technology (commonly known as the green revolution or high-yield-varieties (HYVs)) coincided with high levels of state-idiosyncratic instability due to factors such as weather and climate. Here idiosyncratic risk emanates from the fact that weather and climate would impact on the proportion of fertilizer use that is optimal with high-yield-variety crops. Thus farmers would need time to learn the optimal fertilizer application with HYVs in different weather and climatic conditions. Such learning is not necessary with the traditional varieties as learning associated with them has already taken place. Another source of idiosyncrasy in HYVs adoption stems from the learning environment itself. For instance, more learning externalities may accrue to farmers whose farms are located near those who have already successfully adopted HYVs compared to those who are located far. Finally, HYVs involve greater fertilizer use and the prices of such inputs are subject to fluctuations, which creates an additional uncertainty.

Dasgupta and Ajwad (2011) also provide evidence based on survey data suggesting that income shocks resulting from the 2007-2008 global financial crisis resulted in the reduction of households’ investment in education in countries such as Armenia, Bulgaria, Montenegro, Romania, and Turkey. Because learning is an important element in technology adoption, shocks that adversely affect investment in education would delay technology adoption in the long run. The shocks are more likely to affect developing countries given that their traditional investment in education is low.

The current study, then, is motivated by the issues discussed above. Specifically, we develop a model that has somewhat similar technological and preference structures to those of Lahiri and Ratnasiri (2012). However, our model considers technology adoption in an environment that is subject to idiosyncratic risk as discussed above. The model developed is a two-period overlapping-generations economy with N-agents whose wealth holdings are
heterogeneous. Endogenous growth takes place through physical and human capital deepening. Agents have the choice to invest in either of the two technologies available in the economy. The first is a high return technology but is subject to idiosyncratic shocks. The second technology is also high return but is only available through financial intermediaries who are able to reduce the risk associated with the technology through risk pooling. However, using the financial system is subject to intrinsic entry and periodic costs.\footnote{Note that we do not necessarily model financial intermediation. Financial intermediation is simply interpreted as a mechanism through which agents are able to alleviate the downside component of the idiosyncratic shocks thereby helping agents to efficiently utilise the high-risk high-return technology. Thus, any activity/intervention that reduces the costs associated with financial intermediation is seen as capital deepening as it will improve the efficiency with which the risky technology is being used. As such, it is possible to generalise our model to suit any form of capital deepening.}

The economy also consists of a government. The government raises revenue by levying a constant and exogenous tax rate on agents’ wealth. Agents are then allowed to vote on the proportion of government revenue that should be spent on two competing alternatives. One alternative is a lump-sum transfer to agents and another is cost reducing financial development/R&D expenditure. The voting process takes place before agents know the type of idiosyncratic shock that they are going to face.

Including uncertainty in the model yields dividends in the sense that we are able to provide findings distinct from those of Lahiri and Ratnasiri (2012), which may be considered the benchmark upon which the extension of this paper is founded. More specifically, once we account for idiosyncratic risk, our results show that certain \textit{groups} comprised of both the richest and the poorest agents \textit{involuntarily} collude to block redistribution through cost-reducing financial development expenditure.\footnote{As shall become clear later, ‘richest’ and ‘poorest’ agents are defined in a relative to a certain threshold level of wealth that is required to access financial intermediaries.} A key factor behind our results is that agents with different wealth levels face different trade-offs, and that these trade-offs change in non-monotonic ways as wealth increases. This leads to the ‘ends against middle’ feature which is in part consistent with Epple and Romano’s (1996). In Lahiri and Ratnasiri (2012), the trade-offs are quite certain as agents do not face idiosyncratic risk. This explains why the political outcomes of their model mainly hinge on the ‘rich against the poor’.

The results based on numerical experiments show that as redistribution takes place, the middle of the distribution successively becomes thicker. Consequently policies aimed at redistribution through cost reducing financial development expenditure start gaining support. Inequality shows patterns of recurring ‘Kuznets-like’ curves during the transition to the steady state. However, given the structure of our model, the inequality patterns do not
necessarily relate to various stages of development as with the Kuznets hypothesis. Instead the recurring ‘Kuznets-like curves’ patterns arise because the evolution of inequality is endogenous. More specifically, high initial inequality induces redistribution in the next period, thus resulting in reduction of inequality. The resulting low inequality in turn induces less need for redistribution, thus resulting in an increase in inequality in the subsequent period. This cycle continues in the political economy until the inequality has reached its steady state path.

In the transition to the steady state, both growth and inequality generally decrease. However, the relationship between growth and inequality is non-linear and bidirectional. These latter features emanate from the fact that initial inequality influences output and other outcomes through the political process. These outcomes in turn impact on inequality and consequently redistribution in the next period. The presence of these features suggests that growth-inequality empirical studies whose estimates are based on non-linear and non-parametric models (e.g. Banerjee and Duflo, 2003) are more plausible than studies that impose linear, parametric or one-way link between the two variables (e.g. Forbes, 2000; Li and Zou, 1998).

Finally, we compare the political economy outcomes to the outcome that would result if choices were based on welfare maximization considerations. Welfare maximization is defined in the simple utilitarian sense, i.e. maximizing sum of the utilities of all agents. The numerical results show that the political economy is inefficient in the early and the transitional stages of the economy in the sense that it produces outcomes which are different from those that maximise the collective welfare of agents. However, once the economy reaches the steady state path, the political economy path coincides with the one that maximizes the collective welfare of the agents.

The remainder of the paper is organised as follows. In Section 2, we describe the economic environment and carry out some comparative static analysis with the political economy model. To shed light on the dynamics, in Section 3, we conduct some numerical experiments with the political economy model. We then compare the political outcomes to the welfare maximizing outcomes. In Section 4, we conclude the paper. The appendix presents some technical details of the analysis in Section 2.
2. The Economic Environment

We consider a two-period overlapping-generations economy with $N$-agents whose wealth holdings are heterogeneous. A new generation is born every period. Each $i^{th}$ agent is born with a unit of unskilled labour endowment that can earn them a subsistence wage $\bar{w}$. Agents born in period $t$ also inherit wealth from their parents in the form of bequests. Time is discrete, with $t = 0, 1, 2, \ldots$, and initial distribution of wealth is described by $W(\cdot)$.

The economy has two technologies, one subject to high risk (hereafter referred to as Technology B) and another, that is only accessed through financial intermediaries, who are able to minimize the risk by pooling risks of all agents (hereafter referred to as Technology F). The total return on Technology B has two components and is given by $\vartheta_t = \eta + \epsilon_t$, where $\eta > 0$ is a time-invariant and non-stochastic component and $\epsilon_t$ is a time-variant shock that is agent-idiosyncratic. If the agent faces a bad shock, and this occurs with the probability $p$, then $\epsilon_t = \varepsilon_t < 0$, while if the agent faces a good shock $\epsilon_t = \varepsilon_g > 0$. We assume that $E[\epsilon_t] = 0$ and $|\epsilon_t| < \eta$. The return on Technology F is similar to that of Technology B when the agent faces a good shock i.e. $\vartheta_t = \eta + \varepsilon_g$. However, when the agent faces a bad shock, the return on Technology F is $\phi$ where $\eta + \varepsilon_t < \varepsilon_g < \eta$. This modelling approach follows an idea by Townsend and Ueda (2006, 2010).

As in Townsend and Ueda (2006, 2010), agents who decide to use financial intermediaries will deposit all their wealth in financial intermediaries. However, we assume that agents cannot borrow to adopt a certain technology. Rather, financial intermediaries invest on behalf of all the agents who deposit funds with them and offer the returns as described above depending on the type of shock that an agent faces. Financial intermediaries charge two intrinsic and non-refundable costs. Firstly they charge a once-off fixed entry fee $\psi > 0$. This fee implicitly represents the registration and other fees that financial intermediaries incur including any mark-up they charge on customers. Secondly they charge a periodic service fee $\lambda \in [0,1]$, which is a constant proportion of the returns on Technology F. Thus if agent $i$ uses financial intermediaries, his/her return at any time $t$ is given by $R(\vartheta_t) = (1 - \lambda) \max(\vartheta_t, \phi)$.

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3 As we shall discuss later, $\psi$ is endogenous in this model. They are determined by the proportion $\alpha$ of government revenue allocated towards financial intermediation. Every period agents vote for on the desired level of $\alpha$ and the winning $\alpha$ becomes the proportion that the government allocates towards financial intermediation.
There is also a government in the economy. The government supervises the financial intermediaries.\textsuperscript{4} The government raises its revenue by levying a constant tax rate of $\tau$ is levied on the heterogeneous agents’ total endowment. The distribution of the agents’ total endowment is described by a density function $f(W(.))$ with support $(0, \kappa)$. The total revenue that the government raises in any period is described by:

$$GR_t = \tau \left\{ \kappa \int_{0}^{\kappa} W(.) f(W(.)) \, dW(.) \right\} = \tau \overline{W}_t$$

where $W(.)$ is as defined earlier and $GR_t$ is the revenue raised in period $t$. The government then uses a proportion $g_t = \alpha \tau \overline{W}_t$ of the funds to reduce the cost associated with registering a financial intermediary and to fund its regulatory activities. The latter cost may, for example, include things such as the cost of training a financial regulator, engaging in research and other activities aimed at improving the financial system. Thus $\psi$ is decreasing in $g_t$ which in turn depends on $\alpha$. The remainder of the revenue $t\tau = (1 - \alpha) \tau \overline{W}_t$ is given to all the young agents in the form of a lump-sum transfer.

In this model, we consider the following properties for the functional forms of $\psi$ \textsuperscript{5}

(i) $\psi'(g) < 0 ; \psi''(g) \geq 0$.
(ii) $\psi(\ g \ ) = 0$ as $g \to \infty$.

The fixed cost is specified as follows: $\psi(g_t) = \left( \frac{\overline{\psi}}{1+g_t} \right)$, where $\psi(0) = \overline{\psi}$.

We assume that the tax rate $\tau$ is exogenously determined by the government. However, the agents vote on the proportion $\alpha$ that should be allocated towards cost-reducing financial development expenditure. Voting takes place at the ‘first stage’ of each period $t$ and the political outcome is determined by majority rule.\textsuperscript{6} In the “second stage” of period $t$, after considering the political outcome, agents now decide whether they should use financial intermediaries or not. The timing of events is as characterised by Figure 1 below:

\textsuperscript{4} We assume that there are extortionist elements in the financial system that would charge exorbitant fees without appropriate supervision. Note that we do not explicitly model financial regulation.
\textsuperscript{5} We also explored the case where $\lambda$ is endogenous. However, the results for this case were too obvious. As would be expected, both analytical and numerical result showed that the agents who adopt Technology F would favour the highest possible $g_t$ to be allocated towards the reducing $\lambda$ while the agents who adopt Technology B prefer the highest possible $tr_r$. We provide a formal explanation in Appendix 3.
\textsuperscript{6} In cases where there is no majority, the political outcome will be determined by plurality rule.
The economy produces output \( Y \) using capital \( K \). The production functions \( G(K) \) assume a simple “AK” specification. Specifically, the production functions for Technology \( F \) is \( G(K_t) = B K_t \) and for Technology \( B \) is \( G(K_t) = F K_t \), where \( B \) and \( F \) denote the respective total factor productivity parameters associated with the two technologies, and \( B < F \).

The agent does not consume in the first period of his life. The utilities of the agents use and those who do not use financial intermediaries are as described in equations (2) and (3), respectively:

\[
U(c_{it+1}^{B,l}, c_{it+1}^{B,h}, b_{it+1}^{B,l}, b_{it+1}^{B,h}) = p \ln(c_{it+1}^{B,l}) + (1 - p) \ln(c_{it+1}^{B,h}) + \theta p \ln(b_{it+1}^{B,l}) + \theta (1 - p) \ln(b_{it+1}^{B,h}) \tag{2}
\]

\[
U(c_{it+1}^{F,l}, c_{it+1}^{F,h}, b_{it+1}^{F,l}, b_{it+1}^{F,h}) = p \ln(c_{it+1}^{F,l}) + (1 - p) \ln(c_{it+1}^{F,h}) + \theta p \ln(b_{it+1}^{F,l}) + \theta (1 - p) \ln(b_{it+1}^{F,h}) \tag{3}
\]

In equations (2) and (3), \( c_{it+1} \) and \( b_{it+1} \) denote period 2 household consumption and bequests for the \( i^{th} \) agent. Superscripts \( B \) and \( F \) simply imply that the agent adopts Technology \( B \) and Technology \( F \), respectively, while superscripts \( l \) and \( h \) denote that the agent faces a bad shock and a good shock, respectively. The parameter \( \theta \) describes the extent of imperfect intergenerational altruism in the model.

Every period each generation faces a problem regarding whether to use financial intermediaries or not. This decision depends on an agent’s resource endowment and this depends upon the resources they inherited from their parents through bequests.

Agents face different budget constraints depending on whether they use the financial intermediaries or not. The budget constraints for agents that do not use the financial intermediaries are as follows:

---

7 This type of preference structure is consistent with the idea that ‘consumption’ consists of household consumption which includes the consumption of the children. The agent therefore ‘consumes’ part of the consumption of his parents in the first period of his life and undertakes the consumption decision in the second period with his offspring in mind.

---
The resource endowments for agents depend on whether their parents used financial intermediaries or not, in addition to the idiosyncratic shocks faced by their parents. The resource endowment for agents whose parents did not use financial intermediaries is given by $W_t = W_t^{B,x} = b_{it}^{B,x}$, while the endowment of agents whose parents used financial intermediaries is given by $w_t = w_t^{F,x} = b_{it}^{F,x}$, where $x = h, l$.

For agents who use financial intermediaries, the budget constraints are described as follows:

$$c_{it+1}^{F,l} = (1 - \tau) (\eta + \varepsilon_l) (w + W_{it}) - b_{it+1}^{F,l} + (1 - \alpha) \tau W_t - \psi(g_t)$$

(6)

$$c_{it+1}^{F,h} = (1 - \tau) (1 - \lambda) (\eta + \varepsilon_h) (w + W_{it}) - b_{it+1}^{F,h} + (1 - \alpha) \tau W_t - \psi(g_t)$$

(7)

Agent $i$’s problem is make choices of $c_{it+1}$, $b_{it+1}$ that maximise his/her utility. More specifically, agents that do not seek financial intermediation maximise equation (2) subject to constraints (4) and (5). This yields the following optimal state-contingent consumptions and bequest plans:

$$c_{it+1}^{B,l} = \frac{1}{1 + \theta} \left[ (1 - \tau) (\eta + \varepsilon_l) (w + W_{it}) + (1 - \alpha) \tau W_t \right]$$

(8)

$$c_{it+1}^{B,h} = \frac{1}{1 + \theta} \left[ (1 - \tau) (1 - \lambda) (\eta + \varepsilon_h) (w + W_{it}) + (1 - \alpha) \tau W_t \right]$$

(9)

$$b_{it+1}^{B,l} = \frac{\theta}{1 + \theta} \left[ (1 - \tau) (\eta + \varepsilon_l) (w + W_{it}) + (1 - \alpha) \tau W_t \right]$$

(10)

$$b_{it+1}^{B,h} = \frac{\theta}{1 + \theta} \left[ (1 - \tau) (1 - \lambda) (\eta + \varepsilon_h) (w + W_{it}) + (1 - \alpha) \tau W_t \right]$$

(11)

Alternatively, agents who use financial intermediaries maximise equation (3) subject to constraints (6) and (7). This yields the following optimal state-contingent consumption and bequest plans.
The $i^{th}$ agent will seek the financial intermediation \textit{iff}.

\[ U^F(c_{it+1}^*, b_{it+1}^*) \geq U^B(c_{it+1}^*, b_{it+1}^*) \]  

where $U^F$ and $U^X$ represent the indirect utility functions for the agents who use financial intermediaries and agents who do not use financial intermediaries respectively and the subscript * denotes the optimal choice of the variable in question. It can then be shown that (16) implies the following (See proof in Appendix 1):

\[
\left[ \frac{(1-\tau)(1-\lambda)(\bar{w}+W_{it}^*)+(1-\alpha)\bar{W}_t}{(1-\tau)(\eta+\varepsilon_h)(\bar{w}+W_{it}^*)+(1-\alpha)\bar{W}_t} \right]^p \geq \left[ \frac{(1-\tau)(\eta+\varepsilon_h)(\bar{w}+W_{it}^*)+(1-\alpha)\bar{W}_t}{(1-\tau)(1-\lambda)(\bar{w}+W_{it}^*)+(1-\alpha)\bar{W}_t} \right]^{1-p} 
\]  

In equation (18), the LHS gives the ratio of the expected wealth of an agent who uses financial intermediaries to the expected wealth of an agent who does not use financial intermediaries in the event that they face a bad shock. Alternatively, the RHS gives the ratio of the expected wealth of an agent who does not use financial intermediaries to the expected wealth of an agent who uses financial intermediaries in the event that they face a bad shock. Since in equation (17), the RHS $> 1$, it is clear that an agent will use financial intermediaries, \textit{iff} the risk-alleviating benefits of financial intermediaries are such that in the event of a bad shock, the expected wealth of an agent who uses financial intermediaries will outweigh the expected wealth of an agent who does not.

We define $W^*$ as the $W_t$ that solves equation (17).\footnote{Intuition and numerical analysis suggest that this must be the case but it is difficult to provide formal proof.} This $W^*$ would represent the threshold level of initial endowment that is required for an agent to enter the financial intermediary.
system. It is possible to gain some insight on how people vote by analysing the total change of \( W^* \) with respect to changes in \( \alpha \). The results of the comparative static analysis presented in Appendix 2 show that \( W^* \) is decreasing in \( \alpha \). This then suggests that agents are likely to prefer a high \( \alpha \) in order to enter the financial intermediary system quickly. However, this decision is not clear cut because agents also receive a lump-sum transfer payment \((1 - \alpha) \tau W_i\) , which is decreasing in \( \alpha \). Thus agents will have to weigh the trade-off between the benefits from a reduction of \( W^* \) (in the form of high expected returns from financial intermediaries) and the lump-sum transfer. This trade-off is likely to vary from agent to agent depending how close they are \( W^* \).

Thus, it is important to analyse how the indirect utilities of individual agents change as \( \alpha \) changes. More specifically, we compute the partial derivatives of the indirect utility functions of each agent \( i \) with respect to the parameter \( \alpha \) i.e. \( V_{i,t}'(\alpha, \tau) \). Although it would be intuitive to argue that the rich agents would favour \( \alpha > 0 \) (and poor people \( \alpha = 0 \)) to benefit from a reduction in entry costs, the political solution from this exercise is not conclusive because the sign of \( V_{i,t}'(\alpha, \tau) \) is neither clear nor constant across the range of values of \( \alpha \). Furthermore, the presence of uncertainty in the model introduces more complexity. This is because \( W^* \) also shifts depending on the sign of \( \varepsilon_t \). More specifically, if \( \varepsilon_t < 0 \), \( W^* \) increases while if \( \varepsilon_t > 0 \), \( W^* \) decreases. Based on this observation, it is intuitive to further subdivide the rich \( W_{it} \geq W^* \) and the poor \( W_{it} < W^* \) in the four groups: (i) the poorest \( W_{it} \ll W^* \) who are at the lowest end of the distribution; (ii) the lower middle income \( W_{it} < W^* \) who are below but close \( W^* \); (iii) the upper middle income \( W_{it} \geq W^* \) who are above but close to \( W^* \); (iv) the richest \( W_{it} \gg W^* \) who are at the top end of the distribution.

It is then possible to draw some intuition on how the four groups of agents vote on in the presence of uncertainty. Essentially, in the presence of uncertainty, the choice of \( \alpha \) is now motivated by two more things. Firstly, a high \( \alpha \) that reduces \( W^* \) would be useful for agents just below \( W^* \) (i.e. \( W_{it} < W^* \)) especially when they expect that \( \varepsilon_t = \varepsilon_h > 0 \) because it could give them an opportunity to enter the financial system. However, agents \( W_{it} \ll W^* \) would

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9 See the derivatives in Appendix 2.
10 Recall that the shock is only revealed after agents have voted.
not benefit as they are too far below $W^\ast$. Secondly, a high $\alpha$ that reduces $W^\ast$ would be useful for agents just above $W^\ast$ (i.e. $W_{it} \geq W^\ast$) especially when they expect that $\varepsilon_t = \varepsilon I < 0$ because it will protect them from the possibility of exiting the financial system. However, agents with $W_{it} >> W^\ast$ would not worry about exiting financial system because they are too far above $W^\ast$. In summary, the presence of uncertainty is likely to result in involuntary collusion of poorest and richest agents ($W_{it} << W^\ast$ and $W_{it} >> W^\ast$) in favour of $\alpha = 0$ and involuntary collusion of agents $W_{it} < W^\ast$ and $W_{it} \geq W^\ast$ to vote $\alpha > 0$. This collusion of agents at both ends of the distribution to oppose the choices of the agents at the middle of the distribution is partly consistent with Epple and Romano’s (1996) idea of the ‘ends against the middle’. In what follows we now present and discuss the results from numerical experiments with our model.

3. Numerical Experiments and Discussion

In this section, we use numerical experiments to analyse how agents vote for their desired $\alpha$. The section is divided into two main parts. In the first part, we analyse how the winning value of $\alpha$ is determined through the political process. Subsequently, we analyse the implication of the political outcome for technology adoption decisions, and the evolution of growth and inequality over time. In the second part, we then examine how the outcome of the political process compares to an outcome that would result if the choice of $\alpha$ was based on social welfare consideration.

The initial distribution of wealth for the reported results is assumed to be lognormal with a mean of 2.5 and standard error of 0.4 and there are 501 agents. The parameters used are reported in Table 1. The parameter choices are guided by the conditions set in the Section 2. The numerical results presented are robust to sensitivity tests with different distributions and parameter values.

<table>
<thead>
<tr>
<th>$\phi$</th>
<th>$\eta$</th>
<th>$\theta$</th>
<th>$\varepsilon_a$</th>
<th>$\varepsilon_i$</th>
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<td>1</td>
<td>1</td>
<td>-1</td>
<td>0.5</td>
<td>200</td>
<td>10</td>
<td>0.02</td>
</tr>
</tbody>
</table>
3.1 The Political Outcome

The results from the numerical experiments with the models are shown in Figure 1. In Figure 1, panel (a) shows the number of agents who use financial intermediaries versus those who do not. The winning values of $\alpha$, and the proportion of agents voting for the winning value are shown in panels (b) and (c), respectively. Panels (d) and (e) show the implication of the political process on the transitional dynamics of inequality and growth, respectively.

The numerical results shown on Figures 1 are quite consistent with the intuition set out in Section 2. Generally, the majority of the agents prefer the entire tax revenue to be allocated in the form of a lump-sum transfer payment during the early stages of development.

The explanation for this political outcome is based on the different preferences of the interest groups as outlined above. To elaborate on this point, agents at the lowest end of the distribution, $W_{it} << W^*$ and those in the uppermost end of the distribution, $W_{it} >> W^*$ prefer redistribution in the form of a lump-sum transfer, albeit for different reasons. For the poorest agents, the lump-sum transfer is preferable because a reduction in $\psi$ will not help them enter the financial system since their initial endowment is too far below from $W^*$. For the richest agents, the lump-sum transfer is preferable. This is because a reduction in $\psi$ will not benefit them much given their endowment large enough; they can still afford to use financial intermediaries even in the event of a bad shock. On the other hand, the agents at the middle of the distribution i.e. $W_{it} < W^*$ and $W_{it} \geq W^*$ prefer $\alpha > 0$, but also for different reasons. The lower-middle income agents $W_{it} < W^*$ choice for $\alpha > 0$ is motivated by the fact that a reduction in $W^*$ will help them enter the financial system in the event that they face a good shock. On the other hand, the upper middle income agents $W_{it} \geq W^*$ preference of $\alpha > 0$ is motivated by the desire to secure themselves from exiting the financial system in the event that they face a bad shock (i.e. if $\epsilon_t = \epsilon_l < 0$). Because most agents are poor in the early stages of development (see panel (a) of Figure 1), the political outcome is characterized by $\alpha = 0$.

As redistribution of wealth through the lump sum transfers continues, most agents are likely to move from extreme ends of the distribution, i.e. $W_{it} << W^*$ and $W_{it} >> W^*$ and to converge towards the middle income brackets i.e. $W_{it} < W^*$ and $W_{it} \geq W^*$. Given that the middle income groups prefer that $\alpha > 0$, this explains the sudden increase in the winning $\alpha$ and
the proportion of agents voting for this value (see (b) and (c)). However, because agents’ wealth is subject to idiosyncratic shocks, the changes in winning α and number of agents voting it are non-monotonic at least in the early stages of the economy.

As more and more agents enter the financial system, the winning α keeps increasing and so does the proportion of agents voting it. However, there is a tendency for both the winning α and the proportion of agents voting for it to keep fluctuating even after everyone has entered the financial system. In our view, this feature reflects ‘precautionary voting’ by agents whose wealth is close to the $W^*$ in face of idiosyncratic risk. More specifically, in the presence of uncertainty, agents $W_{it} \geq W^*$ face two competing choices. Firstly they face the opportunity to further increase their wealth through large transfer receipts the winning α is low. This is especially true if they would then to face $\bar{\epsilon}_i = \bar{\epsilon}_h > 0$. However, they also face the risk that a low α would leave them vulnerable to the possibility of exiting the financial system especially if they face $\bar{\epsilon}_i = \bar{\epsilon}_i < 0$. Thus, until their $W_{it}$ becomes secure, these agents have a tendency to keep shifting their preferred α from time to time. As time passes and agents’ wealth moves further above $W^*$, the proportion of agents voting winning α stabilizes at 100%. Thereafter, the winning α starts to decreases monotonically until it eventually converges to zero.

Inequality (see panel (b)) falls sharply in the transition to the steady. The decrease in inequality is due to the redistributive effects of taxation and transfer payments and is consistent with the idea that the downward segment of the Kuznets curve is driven by political reforms (see Lindert, 1994; Lahiri and Ratnasiri, 2012). However, in some periods along the transitional path, the inequality patterns reveal recurring ‘Kuznets-like’ curves. As discussed earlier, this feature emanates from the fact that there is two-way link between the periodic evolutions of inequality and redistribution.

Panel (c) shows the implication of the political process on transitional growth. We separate the growth in to three categories: the poor, representing 20% of the agents at the lowest end of the distribution, the rich, representing 20% of the agents at the highest end of the distribution, and average, representing the average growth of all agents. During the early stages of the economy, the growth patterns vary across the different groups. Initially, the growth rate for richest agents is high but it gradually decreases, albeit non-monotonically. This highlights the fact that their tax payments outweigh the lump-sum transfer receipts. On the contrary, the growth rate of the poor agents start low but non-monotonically increases implying that the lump-sum transfer receipts outweigh their tax payments. The transitional
The path of the average growth rate seems to be driven by the growth rate of richer agents although it remains below the former. Eventually, the growth rates of all agents in the economy converge to a unique steady state.

Generally, the numerical results show that both inequality and average growth generally decrease in the transition to the steady state (see Panels (d) and (e) of Figure 1). However, given the periodic non-monotonicity in the changes of these two variables, the relationship is bidirectional and non-linear. As argued earlier, these features of the model entail that empirical studies that impose linear and parametric relationship between growth and inequality are unlikely to appropriately capture the transitional relationship between these two variables within a political economy.

Figure 1: The political outcome
We experiment with different levels of inequality to examine the effect of initial inequality on the transitional path of growth and inequality. We report the numerical results in Figure 2. Panel (a) shows the Gini coefficients, panels (b), (c), (d) shows the average growth, growth of poor agents and the growth of the rich agents, respectively. Two interesting features are evident from these results. Firstly, high initial inequality hastens the pace at which economy convergences to the steady state. This shows that the redistributive effect of taxation and transfer payments is more effective if the initial inequality is high. This rapid fall in inequality can also be explained by comparing the growth rates of the poor and the rich. It is evident that the higher the level of initial inequality, the faster the increase (decrease) in the growth rate of the poor (rich). Secondly, low initial inequality does not only delay the rate with which the economy converges towards the steady state, but it is associated with more fluctuations in growth and inequality in the transition path.

These two features highlight the importance of initial inequality in driving the outcomes of a political economy. More specifically, high initial inequality entails that most agents are poor. Consequently, redistribution policies easily succeed through the political process and the economy will converge to its steady state quickly. On the contrary, if initial inequality is low, poor agents are few. Thus, the success of redistribution policies hinge on whether poor agents get the support of other groups of agents in the economy.

Given the wealth trade-offs in the current model, such support is only forthcoming from agents at the top end of the distribution. However, the political decision the latter agents (especially those just above $W_{it} \geq W^*$) depends on the type of shock they faced in the previous period. If they faced a bad shock, their wealth would have moved towards $W_{it} \geq W^*$. Thus, they will vote against redistribution policies in the next period to minimise the possibility of exiting the financial system should the successive shock be also bad. If they faced a good shock, their wealth would have moved further away from $W_{it} \geq W^*$. Thus, they will vote for redistribution policies in the next period. This explains the fluctuations of growth and income in the transitional path as well as the sluggish pace with which the economy converges to the steady state in the presence of low initial inequality.
3.2 The Political Outcome versus Social Welfare Maximization

In this section we compare the political economy $\alpha$ with the $\alpha$ that would result if its choice was motivated by social welfare considerations. We define social welfare maximization in the utilitarian sense, i.e. the value of $\alpha$ that maximizes the sum of the utilities of all agents in the economy is the welfare maximizing outcome. The numerical results from this exercise are reported in Figure 3. The solid line shows the winning $\alpha$ from the political economy, while the broken lines shows the $\alpha$ that would result when choice was based on maximum of the sum of welfare of all agents.

It is interesting to note that policy choices differ between the political economy and the welfare maximization both in the early stages of the economy and in the transition to the steady state. At the early stages of development, the political process tend to produce a winning $\alpha$ that is significantly below the one that maximizes social welfare. The explanation for this is that at the early stages of the economy, most agents are poor and they prefer lump-sum transfer payments. As redistribution occurs through each successive generation, the middle of the distribution becomes thicker. This then explains why the winning $\alpha$ from the political economy moves above the $\alpha$ that maximizes total welfare. However, because of the
precautionary behaviour of agents in the face of uncertainty as described earlier, there is a tendency for the political economy $\alpha$ to keep fluctuating. Once all agents enter the financial system and their wealths have become secure, the winning $\alpha$ from the political process converges to that of the welfare maximizing case. At this stage both $\alpha$'s start decreasing monotonically and eventually converge to zero.

Figure 3: Political process versus welfare maximization

### 3.2.1 Policy Choice: Political Outcome versus Social Welfare Maximization

Thus far, an important revelation from the numerical experiments is that certain groups block development-oriented policies especially at the early stages of the economy. This implies that policies that maximize the overall welfare of the society may continue to face resistance. The question that arises, then, is whether an economy that is run with the objectives of maximizing overall welfare result in better growth and inequality outcomes compared to a political economy.

This debate has indirect empirical relevance for some economies. An example that commonly features in comparative economics literature is that of China and India (see Wong, 1989; Nin-Pratt, et al., 2008; 2010), two economies that that are well known for the large geographical size and large population, the majority of which remained poor during most part of the twentieth century (Nin-Pratt, et al., 2010). Since the late 1970s both countries embarked in rapid reforms that included accelerated industrialisation, international trade reforms, agricultural reforms, etc (Anderson, 2003). However, while China, a ‘command
economy’ experienced sevenfold increase in GDP and sustained growth in agricultural sector productivity, India, an ‘open, participatory and multiparty democracy’ only experienced twofold increase in GDP and quite disappointing increases in agricultural sector productivity (see Nin-Pratt, et al., 2010). Data from World Development Indicators (2010) show that China has also outperformed India in other development indicators such as per capita GDP, life expectancy, child mortality, and human capital development, as measured by adult literacy, tertiary enrolment rate. Some of the key explanations that have been suggested for the impressive performance of China over India include the additional institutional reforms in China that resulted in migration of labour from agriculture to other sectors of the economy (Boswell and Collins, 2008; Hari, 2002).

An argument that has been made by some political analysts and academics, then, is that given its ‘command economic system’, China might have managed to implement growth-oriented policies relatively easily while India, a ‘multiparty democracy’ might have found it difficult to implement growth-oriented reforms due to opposition from lobbies and interest groups (see Huang, 2011). To some extent this argument has indirect support from the analysis that follows. Specifically, we compare the outcomes of the political economy case with that which would prevail if a social planner maximized the collective welfare of all agents in the economy. While we do not claim that the latter case proxies a ‘command economy’ in the style of China, the analysis below does serve to highlight that the endogeneity of policies that is typical in democracies may result in ‘sub-optimal’ outcomes.

Figure 4 compares the growth and inequality outcomes of a political economy to those of an economy that is run on social welfare considerations. Panel (a) compares technology adoption decisions, panel (b) compares the transitional dynamics of inequality, and panels (c) and (d) compare the transitional behaviour of average growth, under the two policy choices. In all the panels, the solid line represents the political economy outcomes and the broken line represents the social welfare outcomes.

It is evident that the timing of technology adoption does not seem to differ much between these two cases. However, the transitional behaviour of both growth and inequality differ. Inequality tends to converge to the steady state quicker under the welfare-maximizing economy than the political economy. Moreover, because the welfare-maximizing choices are more likely to result in the pooling of the risks faced by individual agents, the convergence of inequality to the steady state is much smooth while under the political economy, the convergence is non-monotonic. The same can be said with regards to the average growth rate. However, the transitional fluctuations of the political outcomes from the welfare maximising
outcomes are not as large. Furthermore, the two outcomes eventually converge once economy reaches its steady state.

![Figure 3(a): Political Process versus Central Planner under endogenous entry cost](image)

4. **Concluding Remarks**

The paper contributes growing body of literature that analyses the role of the political economy on the trade-off between growth and inequality. We develop an endogenous growth model where agents vote on their preferred mode of redistributing wealth. In the model, agents can either adopt a high-risk, high-return technology or another high return technology that is available through financial intermediaries that are able to alleviate risk through risk pooling. The use of financial intermediaries is subject to entry and periodic costs, with the former cost depending on the proportion of government revenue spent on supervising and developing the financial system. This proportion in turn depends on the preference of the agents in the economy who express their preferences by voting between distributing government revenue through cost-reducing financial development expenditure and lump sum transfers. The political outcome is based on either majority or plurality rule.
The analytical and numerical results show that certain groups of agents comprising of both the poorest and the richest *involuntarily* collude to block expenditures towards cost-reducing financial development expenditure during the early stages of the economy. This collusion emanates from the fact that agents with different wealth levels face different trade-offs, and these trade-offs change in non-monotonic ways as wealth increases. However, as redistribution continues through generations, the middle of the distribution becomes successively thicker and the majority of the agents start supporting policies aimed at cost-reducing financial development expenditure.

Although both growth and inequality generally decrease during the transition to the steady state, their relationship is non-linear and bidirectional. Transitional inequality patterns show signs of reverting ‘Kuznets-like curves’. Another interesting feature of our model is that high initial inequality hastens the pace at which the growth rate and inequality converge to their steady state paths. Finally, the results show that the political outcomes do not necessarily coincide with the welfare maximising outcomes in the early and the transitional stages of the economy. This is in line with the idea that *interest* groups in the economy slow the pace of technological advancement (see Krusell and Rios-Rull, 1996). However, in the transitional process, as the middle of the distribution becomes successively thicker, the political process tends to produce policies that lead to development, albeit subject to reversals. In the long-run, the political economy converges to the welfare maximising path.
Appendix 1

Proof of Equation (19)

Agents invest in project B \textit{iff} indirect utility of project B is greater than indirect utility of project A. This implies that agents invest in project B

\[
\text{iff } U^F(c_{it+1}^{F,h}, c_{it+1}^{F,l}, b_{it+1}^{F,h}, b_{it+1}^{F,l}) \geq U^X(c_{it+1}^{X,h}, c_{it+1}^{X,l}, b_{it+1}^{X,h}, b_{it+1}^{X,l})
\]

Substituting for the functional forms of the utility function we get,

\[
p \ln(c_{it+1}^{F,h}) + (1-p) \ln(c_{it+1}^{F,h}) + \theta p \ln(b_{it+1}^{F,h}) + \theta (1-p) \ln(b_{it+1}^{F,h}) \geq p \ln(c_{it+1}^{X,h}) + (1-p) \ln(c_{it+1}^{X,h}) + \theta p \ln(b_{it+1}^{X,h}) + \theta (1-p) \ln(b_{it+1}^{X,h})
\]

Recognising that \(b_{it+1} = \theta c_{it+1}\), we can substitute for \(b_{it+1}\) and using the laws of logarithms and then simplifying, we can obtain the following:

\[
p \ln(c_{it+1}^{B,h}) + (1-p) \ln(c_{it+1}^{B,h}) \geq p \ln(c_{it+1}^{X,h}) + (1-p) \ln(c_{it+1}^{X,h})
\]

Since log is a monotonic transformation, it must be that:

\[
\left[C_{it+1}^{F,l}\right]^p \cdot \left[C_{it+1}^{F,h}\right]^{(1-p)} \geq \left[C_{it+1}^{X,l}\right]^p \cdot \left[C_{it+1}^{X,h}\right]^{(1-p)}
\]

Which we can alternatively express as follows:

\[
\frac{C_{it+1}^{F,l}}{C_{it+1}^{X,l}} \geq \frac{C_{it+1}^{F,h}}{C_{it+1}^{X,h}}
\]

Now rewriting \(c_{it+1}^{F,l}, c_{it+1}^{F,h}, c_{it+1}^{X,l}, c_{it+1}^{X,h}\) in terms of their definitions in steady state equations (10), (11), (14), (15) and given that there exist a level of endowment \(W^*\) that equates the LHS to the RHS, we can obtain equation (19).
Appendix 2

Comparative Statics Analysis

Assuming that $W^*$ exist, we can rewrite equation (19) in logarithmic form as follows:

LHS: \[ p \ln \left[ (1-\tau)\phi (1-\lambda)(\bar{w} + W^*) + ((1-\alpha)\bar{W}_t) - \psi_t(g_t) \right] - p \ln \left[ (1-\tau)(\eta + \varepsilon_t) (\bar{w} + W^*) + ((1-\alpha)\bar{W}_t) \right] \]

RHS: \[ (1-p) \ln \left[ (1-\tau)(\eta + \varepsilon_b)(\bar{w} + W^*) + ((1-\alpha)\bar{W}_t) \right] - (1-p) \ln \left[ (1-\tau)(1-\lambda)(\eta + \varepsilon_b)(\bar{w} + W^*) + ((1-\alpha)\bar{W}_t) - \psi_t(g_t) \right] \]

Then taking the total derivative of $W^*$ with respect to $\alpha$, simplifying and collecting like terms will yield the following for the LHS:

\[
\frac{dW^*}{d\alpha} = \left[ \frac{p(1-\tau)(1-\lambda)\phi C_{it+1}^{F, h} + (1-p)(1-\tau)(1-\lambda)(\eta + \varepsilon_b)C_{it+1}^{F, l} - p(1-\tau)(\eta + \varepsilon_t)C_{it+1}^{B, h} + (1-p)(1-\tau)(\eta + \varepsilon_b)C_{it+1}^{B, l} + \psi'(g_t)\left[ p C_{it+1}^{F, h} + (1-p)C_{it+1}^{F, l} \right]}{C_{it+1}^{F, h} C_{it+1}^{F, l}} \right] > 0
\]

It is convenient to interpret the first fraction in the brackets as some weighted average consumption for an agent $i$ who seek financial intermediation and the second term as some weighted average consumption for an agent $i$ who do not seek financial intermediation after multiplying the consumption under each state with the net return on investment under that state. Since the model is such that the agents who use financial intermediaries are on average better off than agents who do not use financial intermediaries, it is easy to see that the above expression is greater than zero.

For the RHS we obtain the following:

\[
\left[ \frac{p \tau \bar{W}_t C_{it+1}^{X, h} + (1-p) \tau \bar{W}_t C_{it+1}^{X, l} - p \tau \bar{W}_t C_{it+1}^{F, h} C_{it+1}^{F, l} + (1-p) \tau \bar{W}_t C_{it+1}^{X, h} C_{it+1}^{X, l} + \psi'(g_t)\left[ p C_{it+1}^{X, h} + (1-p)C_{it+1}^{X, l} \right]}{C_{it+1}^{F, h} C_{it+1}^{F, l}} \right] < 0
\]

Here we can interpret first fraction in the brackets as some weighted average consumption for an agent $i$ who seek financial intermediation and the second term as some weighted average consumption for an agent $i$ who do not seek financial intermediation each multiplied by government revenue. Since, the first term is greater than the second term, the sign of the above expression is inferred from the third term. Since $\psi'(g_t)<0$, the third expression is less than zero. Thus, \[
\frac{dW^*}{d\alpha} < 0
\]

\[11\] Notice that by using the steady state consumption functions in equations (10) to (19), it is possible to write each of the terms in brackets in equation (14) and (15) as: \((1+\theta)C_{it+1}^{B, s}, (1+\theta)C_{it+1}^{F, s}\) where superscript $s = h, l$. 

24 | Page
Appendix 3

Examining the changes in Indirect Utility Functions (IUF) with respect $\alpha$ to when $\lambda$ is endogenous:

All agents $W_{it} < W^*$ will adopt *Technology X*. Thus their preferences are characterised by equation (2).

$$ p \ln(c_{it+1}^{X,l}) + (1 - p) \ln(c_{it+1}^{X,h}) + \theta \ln(b_{it+1}^{X,l}) + \theta(1 - p) \ln(b_{it+1}^{X,h}) $$

Recognising that $b_{it+1}^{X,l} = \alpha w_{it+1}$, we can substitute for $b_{it+1}^{X,l}$ and using the laws of logarithms and then simplifying, we can obtain the following indirect utility function:

$$ p(1 + \theta) \ln(c_{it+1}^{X,l}) + (1 - p)(1 + \theta) \ln(c_{it+1}^{X,h}) + \theta \ln \theta $$

Now we can substitute for $c_{it+1}^{X,l}$ and $c_{it+1}^{X,h}$ using their optimal consumptions equations (10) and (11) to obtain the following:

$$ IUF^X(\alpha) = p(1 + \theta) \ln(1 - \tau(\eta + \epsilon_t)(\bar{w} + W_{it}) + (1 - \alpha)\bar{w}_{it}) + (1 - p)(1 + \theta) \ln(1 - \tau(\eta + \epsilon_t)(\bar{w} + W_{it}) + (1 - \alpha)\bar{w}_{it}) + \theta \ln \theta $$

Now differentiating with respect to $\alpha$ and simplifying we can get the FOC for $IUF^X$

$$ \frac{\partial IUF^X(\alpha)}{\partial \alpha} = - \frac{\tau \bar{W} (p C_{it+1}^{X,h} + (1 - p) C_{it+1}^{X,l})}{C_{it+1}^{X,h}{C_{it+1}^{X,l}}} < 0 $$

All agents $W_{it} > W^*$ will adopt *Technology F*. Thus their preferences are characterised by equation (3). By following the same steps as above, it is possible to derive the following FOC for $IUF^F$ with respect to $\alpha$:

$$ \frac{\partial IUF^F(\alpha)}{\partial \alpha} = - \frac{(1 - \tau)(\bar{w} + W_{it})\lambda w_t [p \phi C_{it+1}^{F,h} + (1 - p)(\eta + \epsilon_t) C_{it+1}^{F,l}]}{C_{it+1}^{F,h} C_{it+1}^{F,l}} - \frac{\tau \bar{W} (p C_{it+1}^{F,h} + (1 - p) C_{it+1}^{F,l})}{C_{it+1}^{F,h} C_{it+1}^{F,l}} > 0 $$

where $g_t = \alpha \tau \bar{w}_t$. Since $\lambda$ is decreasing in $\alpha$, it is easy to see that the first term positive.

Thus,

$$ \frac{\partial IUF^F(\alpha)}{\partial \alpha} > 0 $$

Therefore, if $\lambda$ is endogenous and $\psi$ is exogenous, the political economy is characterised by agents $W_{it} < W^*$ voting $\alpha = 0$ and agents $W_{it} > W^*$ voting $\alpha > 0$. 

25 | P a g e
References


Huang, Y., 2011. Does democracy stifle economic growth? Public Lecture, Massachusetts Institute of Technology


