Essays on Political Economy and Economic Development

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Essays on Political Economy and Economic Development

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Acknowledgments

I grew up in an economy which was trying to transit from a socialist autocracy to a market economy with democratic politics and the dominance of the rule of law. A long, highly turbulent and sometimes reversing process of economic and political transformation motivated numerous public and private discussions - on TV, in newspapers, among my family members and, of course, academics. As long as I was a school student, academic discussion was far above my level, and therefore I was not able to follow it. However, I was following numerous political talk shows on TV, as well as what was discussed in my family. As a result, politics and development became my main interests which motivated me to start searching for explanations and solutions to the problems of emerging societies. As a school student and within my first years at the University, being focused too much on history and directed by individuals who did not have sufficient training in economic development or political economy, I failed to find convincing explanations to those problems I was interested in, and therefore my first intellectual quest was not very successful. However, later on I was lucky to discover a paper written by three academics who were working in the field of political economy. Their results were impressively consistent with what I was observing in my home economy, and helped me start developing my intellectual views in the area of development economics. After this pivotal discovery, it was just a matter of time to find other scholars who were working in the same field. After a while, what these academics were doing became the intellectual context of my professional life.

I was trying to find myself in the industry, as research opportunities in my home country were extremely weak. Finding an interesting work, however, was not an easy task in a slowly developing economy, where most of jobs are quite routine and hardly fit one's intellectual frontier. Therefore, when I received an opportunity to spend five years in a highly intellectual environment, focusing on my preferred intellectual context - development and political economy - there was no need for me to compromise.

I spent very interesting time at Tinbergen Institute, and I would like to thank those individuals who contributed to this pleasant part of my life, as well as those ones who made it at all possible.

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Ivan Lyubimov
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Chapter 1

Introduction

The spillover of information from more developed economies to the less developed ones is of key importance for sustainable transition towards higher living standards in emerging societies. The amount and type of essential information which is transferred to developing world is far from being exhausted by technological spillover effect, which is extensively studied in the literature (see, for instance, Acemoglu et al, 2006). Of equal importance is, for instance, information about comparative performance of foreign societies, as it helps identifying how far home country is from what this world considers as a group of leading economies. A possibility to compare the level of development in domestic economy with the one in foreign societies is also important for dynamic comparisons, as the latter helps assessing the progress which a developing society is making.

How fast does an economy evolve is closely linked to the quality of public goods provided by the state, as the rule of law, security of property rights, public infrastructure, etc. As long as public policies are designed or implemented with substantial flaws, the quality of public goods provision remains below its frontier level, which not only has direct effects, as less safety or low accessibility of education, but also reduces the pace of economic growth.

An opportunity to observe the level of economic maturity, as well as the effect of public policies in more developed societies can enhance the demand for higher quality public goods at home. The latter will require the bureaucracy to perform closer to its frontier level, which a less effective authority, especially a corrupt one, would like to avoid, as corruption and high-quality public goods are hardly compatible. As a conflict of interests between society and corrupt bureaucracy might transform into political confrontation and undermine political status quo, the regime has incentives to restrict information flows about the reference economy.

In the second chapter I consider an autocratic society where a ruling regime limits its access to information flows concerning the outside world, to prevent its citizenry from learning about the comparatively poor performance of home economy. I analyze the use of censorship in the context of asymmetric information. However, I deviate from conventional representation of information asymmetry, where the more informed agent, in contrast to the less informed one, knows the precise realization of a particular random variable. In my setting, the latter is instead publicly known, while only the informed agent is aware of how the random variable is distributed. As an application of this type of information asymmetry I refer to Socialist autocracies, as the Soviet Union, GDR or North Korea, where, considering the comparative performance of the home economy, the ruling regime acquired the role of informed agent, whereas the citizenry had instead little opportunity to compare their living standards with the ones abroad. As a result of asymmetric information, the regime in power can distort information regarding the comparative development of the home economy, even though the level of development itself can be publicly observable.

I find that higher technological backwardness, lower quality of domestic institutions, low level of income inequality and low costs of collecting information about foreign economies lead to more restrictive and comprehensive censorship. These findings are consistent with the stories of socialist dictatorships, as the Soviet Union or North Korea, where very restrictive forms of censorship, as political isolationism, were/are used.

I also explain why these forms of censorship are less popular now. I argue that isolationism restricts interactions among societies, and therefore limits opportunities for adoption of frontier technologies, which results in underdevelopment, higher vulnerability to negative shocks, and potentially higher political turbulence. This for instance was the case for Japan in the 17th-19th centuries, the Russian Empire under the rule of tsar Nicolas I, China in the 14th-19th centuries, the Soviet Union, and it is still the case for modern Cuba and North Korea. All these regimes experienced severe economic and technological backwardness as a result of limited interactions with foreign economies. In the Soviet Union a sharp drop in oil prices in mid-1980s led to food shortages. Chronic deficits resulted in mass protests in the late 1980s and the Soviet regime in Russia collapsed shortly. To avoid these outcomes, a ruling regime might reconsider its plan to implement the most restrictive forms of censorship. This finding is in line with censorship policy which is implemented in nowadays China.

In the third chapter I emphasize the importance of complementarity among key determinants of economic growth. As this complementarity can be important in particular cases, reforming one fundamental, while ignoring substantial flaws inherent to another key variable, might have low effectiveness. For instance, a reform which aims to increase the stock of human capital by improving the quality of education in the economy where property rights are weakly protected might fail to achieve its goals. Insufficient protection of property rights discourages firms from investing into technologies and capital, which restricts demand for skills, as a higher human capital level becomes an advantage if it is complemented with appropriate technology. Similarly, a low level of human rights protection encourages individuals to transfer their human capital to another economy, thus reducing the stock of human capital in the source economy and making investment into new technologies less effective, as the latter can't be combined with sufficient number of qualified employees.

I consider a developing economy in which the representative firm's production function exhibits complementarities between human capital and the available level of technology. The firm invests in the acquisition of new technology, while employees decide how much human capital to acquire. The speed of human capital accumulation positively affects the growth rate of the economy, and as a result a reform that improves the educational system can lead to faster growth. Importantly though, if property rights are weakly enforced, firms have limited incentives to invest in the acquisition of new technologies. This might constrain the demand for human capital, making an educational reform potentially unsuccessful. I thus conclude that only if an improvement in the school system is combined with better property rights enforcement will an educational reform unambiguously lead to faster growth.

This model can potentially explain why, instead of increasing the level of skills in the economy, an educational reform can result in the outflow of human capital. If a high level of corruption in the economy restricts the level of investment and slows down the pace of technological evolution, individuals have incentives to transfer their human capital to a less corrupt country, where technology is more advanced and incomes are therefore higher. Individuals thus might benefit from the implementation of an educational reform in the source country, as they can acquire more education and use it later in a more developed economy. The latter result is similar to ”knowledge leaks” which are discussed in Easterly (2001). When the level of knowledge in a particular society is on average high, individuals have high incentives to invest into education. If instead the level of knowledge is low, individuals have little incentives to invest into human capital, or if they do so, they will likely migrate from the economy in a ”brain drain”.

In the last chapter I examine the role of income redistribution in political sustainability of development policies in emerging economies. As high quality public goods and policies are of key importance for fast economic growth, the presence of less corrupt and more professional bureaucracy in power might be pivotal for catching up with more developed societies. The latter is not an easy task though. Since the presence of a large cohort which is separated from fast growing markets is a feature of many developing societies, and as the process of integration of disadvantaged individuals into rapidly developing sectors might be complicated and slow, in the short term economic growth alone can therefore be insufficient for reducing the level of poverty. As a result, the poor remain politically sensitive to income transfers, and thus they grant their support to political force which, as they expect, will provide them with a higher level of transfers. As those features which are important for enhancing economic growth are not necessarily required to perform income redistribution, a more professional and less corrupt bureaucracy, unless it provides income transfers, might not receive political advantage in such a society.

My study was motivated by one of the most intriguing results of the Georgian parliamentary elections of 2012, where economic success of a growth-enhancing policy was not followed by a higher political popularity of the ruling regime. In the context of a non-overlapping generations growth model with high-skilled and low-skilled employees, I argue that a potential explanation for this result is that growth policies ignore the importance of income redistribution. Even though reforms enhance economic growth, most of their benefits might be transferred to high-skilled individuals. Their low-skilled counterparts' gains from economic growth are instead low and therefore leave this group poor and sensitive to income transfers. If the latter are not provided, the reformist regime's likelihood to survive in power declines, even though its policies increase growth rates. I also show that a policy which enhances social mobility, thus helping low-skilled individuals to transit to the high-skilled group, can be a long-run substitute for income redistribution, but can not replace the latter in the short term.

Chapter 2

Extractive Institutions, Closed Borders and Economic Development

Information flows are often strategically manipulated. In politics, control over information helps securing power and even gaining popularity, and can be achieved using a variety of different instruments. Politicians can try to influence the media and suppress independent journalists, might close national borders and not let their own citizens travel abroad, they might not allow foreigners to visit their country, or they can even create totalitarian societies to keep communications among people under control.

For instance, today's Chinese government retains control over media[1] and severely regulates access to the Internet[2]; independent journalists are often under attack in Russia, and several of them have ended up losing their lives while carrying out inquires into the murky interactions between business and politics [3]; the leaders of North Korea keep the country in isolation[4], and do not allow North Koreans to travel abroad freely. In the past, the Stalinist Soviet Union encouraged people to live in communal apart-

[1]See Brady, A-M., 2007, ”Marketing Dictatorship: Propaganda and Thought Work in Contemporary China,” Rowman & Littlefield Publishers.

[2]Human Rights Watch, 2006, ”How Censorship Works in China: A Brief Overview”. http://www.hrw.org/reports/2006/china0806/3.htm.

[3]Crowfoot, J. (edited), 2009, ”Partial Justice: An inquiry into the deaths of journalists in Russia,” 1993-2009, IFJ: Brussels.

[4]The Economist magazine, September 27th, 2008.

ments, where they could be supervised by informers, and, as a result, flatmates were bewaring each other and practiced self-censorship[5].

In autocracies, the ruling regimes usually use power to silent political opponents, and therefore placing itself on pedestal is relatively easy there. Individuals, however, can acquire negative information about the ruling regime from communications with numerous foreign sources. To avoid this, censorship in non-democratic societies covers not only domestic information, but also news about particular foreign economies and their leaders, who are perceived as direct ideological opponents and critics of the domestic regime. For instance, Russian state-controlled media readily releases a negative news about those foreign politicians who are in conflict with the leadership of Russia, while in many cases a news about the Russian leadership from a foreign media is a taboo on Russian TV, people from mainland China need to receive a pass from authorities to visit Taiwan, CNN is not broadcasting in Cuba, and it is difficult to find an issue of the Yedioth Ahoronoth in Tehran.

In this chapter we study a particular restriction on information flows which results in a special case of information asymmetry. In most of the existing literature where information asymmetry is key to the analysis, the informed player knows how a particular random variable is distributed and what is its precise realization. Instead, the uninformed player is only aware of the distribution of the random variable.

We consider a different type of information asymmetry, where the informed player again knows the distribution function of a random variable and its precise outcome, however, the uninformed agent knows a particular realization of the random variable, but not its distribution function.

We summarize these two cases in the following table:

[5]Figes, O., 2007, ”The Whisperers: Private Life in Stalin’s Russia,” Penguin

Information Asymmetry		
What do players know about the random variable of interest?		
Players	Literature	This model
The informed player	distribution and precise realization	distribution and precise realization
The uninformed player	distribution	precise realization

Table 1. Different cases of information asymmetry.

As an application of this type of information asymmetry, we refer to the politics of the Socialist autocracies, as the Soviet Union, GDR or North Korea, where, considering the relative performance of the home economy, the ruling regime acquired the role of informed agent, whereas the citizenry had instead little opportunity to compare their living standards with the ones abroad. These regimes practiced restrictions on information flows from all around the world and restricted the mobility of their citizens, not allowing most of them to cross national borders. As a result of this censorship, in many socialist autocracies, as the Soviet Union, a lot of people were convinced that capitalist societies practiced significant income inequality and that rich individuals enjoyed luxurious lives there, while relatively poor cohorts were instead living in misery.

The goal of this chapter is to develop a model which helps understanding the key commonalities among autocratic regimes practicing the most restrictive forms of censorship of information flows about other economies[6]. To this end, our work answers the following questions: what kind of rational motives do autocrats follow when they introduce censorship? What are the main determinants of censorship policy? We address these two questions and build a theoretical model which is able to explain regime's incentives for censorship.

We find that a low level of income inequality, low-quality institutions, a high technological backwardness under autocratic rule, as well as low costs of acquiring in-

[6]As, for instance, political isolationism.

formation about a reference foreign economy, all result in a higher likelihood of introducing isolationism. These findings are consistent with particular episodes from the history of socialist dictatorships, such as the Soviet Union, GDR, Cuba and North Korea, where isolationism was/is implemented.

When the cost of acquiring information about reference economies is relatively low, and the home economy remains less developed as a result of bad policies, the regime in power has higher incentives to introduce more restrictive forms of censorship, as otherwise individuals can learn about the comparatively high level of development abroad and turn against the ruling regime. This result can probably explain why common borders with developed countries or geographic proximity to more developed economies made isolationism particularly attractive for countries as the Soviet Union or North Korea.[7]

Better technology or institutions in foreign societies increase the gap between incomes in the home economy and the ones abroad. As home individuals stay relatively poor, an opportunity to compare their incomes with the ones of the foreigners and to learn about the comparatively poor performance of th home economy, might reduce the level of support to the ruling regime. To avoid this outcome, the regime in power can implement more restrictive forms of censorship. The socialist economies, such as Maoist China or GDR, which practiced isolationism and censorship, were, at the same time, characterized by comparatively poor institutions and a low level of non-military technological development.[8]

Finally, if income inequality in the home country is comparatively low, and the economy is poor, most of individuals from home are worse off than their foreign counterparts. As this might lead to a lower level of political support to the ruling regime, the latter has incentives to restrict information flows about foreign societies. Again, one can notice that income inequality in the Soviet Union, GDR, Cuba and North Korea

[7]The Soviet Union's neighbours were, among other economies, Norway and Finland, and North Korea shares one of its borders with the Republic of Korea.

[8]Ellman (1986), for instance, points on significant technological gap between the Soviet Union and the West.

was/is very low.

We also discuss the key trade-offs which arise when extremely restrictive forms of censorship, as political isolationism, are introduced. We assume that this kind of censorship imposes significant costs on home economy. Distorting information about a foreign country, or even directly restricting communications between home economy and a foreign country, can result in significant deterioration of bilateral relationships, an therefore economic, educational, technological and other forms of interactions between nations might also be negatively affected.[9] As a consequence, this can lower the home economy's opportunities to imitate technologies from the world technological frontier, which might reduce the pace of technological development, as well as the rate of economic growth. The latter corresponds to the case of Japan during the 17-19th centuries (see, for instance, Bernhofen and Brown, 2004 and Bernhofen and Brown, 2005) or the Russian Empire under the rule of tsar Nicolas I (see Acemoglu and Robinson, 2006), as well as the late Soviet Union. It also reflects the case of modern Cuba and North Korea. All these regimes experienced substantial economic and technological backwardness, and fell far behind technologically advanced economies.[10]

As a result of slow growth, home economy remains poor and therefore sensitive to various negative shocks, as adverse natural conditions which can affect food supplies and lead to starvation, or sharp reduction in exports prices, etc.[11] Seeing their living standards decline, citizens can start feeling discontent about the regime in power,

[9] A long-term diplomatic conflict can, for instance, reduce developing country's opportunities to adopt technologies from the world technological frontier.

Hayakawa, Kimura and Lee (2011) emphasize external conflicts as one of the main negative determinants of the FDI level. Since FDI is an important source of technological spillover, a threat of an external conflict can therefore reduce the spillover effect. Guiso, Sapienza and Zingales (2009) argue that nations which have a higher level of trust to each other also tend to invest more into each other's economies. Bottazzi, Da Rin and Hellmann (2010) show that a more trusted country has more chances to attract venture capital from a trusting economy.

[10] There is evidence that this technological backwardness was in large part due to the fact that censorship and isolationism complicated the process of technological diffusion and technological progress (for instance, Malia, 1994, argues that technological gap between isolated Soviet Union and the West was widening).

[11] For instance, a negative oil price shock in the second half of the 1980s resulted in a significant reduction in living standards in the Soviet Union.

which can transform into mass protests and result in a regime change. To avoid the latter, the ruling regime might implement less restrictive forms of censorship.

The remainder of this chapter is organized as follows. Section 2 surveys the related literature and outlines our model. Section 3 introduces the baseline model, and Section 4 incorporates technological diffusion into the benchmark model in order to consider the cost of censorship. Section 5 concludes the chapter.

2.1 Related Literature and an Outline of the Model

2.1.1 Literature Review

The existing literature provides an extensive discussion of various issues related to the effects of control over media. The analysis of censorship, however, is scant and the study of the effects of isolationism has mainly focused on trade isolationism.

We first mention particular papers which emphasize the importance of media for the formation of public opinion. Gentzkow (2004) shows a significant negative impact on voters turnout in the United States which was caused by introduction of television. A lower coverage of elections by television in comparison to newspapers resulted in smaller turnout rates, which indicates that television can be considered as the key media source for influencing individuals' political participation. Gentzkow and Shapiro (2004) show how media shape attitude towards the United States in a number of Muslim countries. Della Vigna and Kaplan (2007) analyzed in a quasi experimental setting the effect of the introduction of Fox News on voting behavior in a metropolitan area in the United States, and found a positive impact on the share of Republican vote during presidential elections.

Although it is natural to assume that the news content influences readers' views, the reverse could also be true. Mullainathan and Shleifer (2005) consider the determinants of news accuracy. They find that higher competition among media companies does not necessarily guarantee higher accuracy of information. At the same time, the heterogeneity of readers' political views leads to polarization of competing media and thus a reader with access to all media sources can gain an unbiased perspective on the news.

Since media is a powerful mean of formation of political views, there is little surprise that the politicians try to take it under control. McMillan and Zoido (2004) analyze media capture in Peru during Alberto Fujimori's presidency. They show that the media is the most important of the whole checks and balances system: legislative and judicial systems are less crucial for the civic control.

Shleifer, Djankov, McLiesh and Nenova (2003) test the public interest theory against the public choice one regarding the state control over media. They show that the former, which assumes that government interferes mainly as the market does not provide the Pareto efficient solution, fails against the latter, which instead suggests that the state ownership over media is mostly caused by self interested motives of bureaucrats. In particular, the authors showed that in most of cases, media firms have ownership structures with controlling and large shareholders, who are either families or governments. The authors also found that poorer, more autocratic countries with relatively low primary school enrollment rates, and more intervening state, are characterized by greater state ownership of the media. Besides, greater state ownership is accompanied by less free press, weaker political rights, poor governance, underdeveloped capital markets, and bad health outcomes.

Besley and Prat (2006) study in what cases media capture is more likely to emerge. They define censorship as the elimination from the news of any negative information about a ruler. Authors conclude that higher media pluralism, lower rents from holding office, higher media independence and higher commercialization of the media lead to lower corruption, higher turnover and lower probability of media capture.

Leeson (2008) examines the relationship between media freedom and political participation, voters turnout and political knowledge. He finds that low media freedom is associated with poor political knowledge, low political participation and low voters turnout.

Egorov, Guriev and Sonin (2006) study why an independent media can serve autocrat's interests and how the abundance of natural resources limits this opportunity.

As we mentioned before, studies on isolationism are restricted to the effects of trade isolationism. For instance, Alesina, Spolaore and Wacziarg (2001), Alcala and Ciccone (2003), Spolaore and Wacziarg (2005) conclude that economic performance depends positively on a country's size and openness, but negatively on the interaction between size and openness, showing that the benefits from size are larger for less open countries, and benefits from openness are higher for smaller economies. Based on these results, small countries have particularly strong interests in maintaining free trade, as so much of their economy depends upon international markets. Spolaore and Wacziarg (2005) treat openness as an endogenous variable, and show empirically that larger countries tend to be more closed to trade.

2.1.2 Model Outline

In most of the mentioned literature censorship is narrowed to the state control over national media. The latter, however, is only one source of information, although a very important one. But there are many more: foreign media, visits to foreign economies, contacts with foreigners visiting the home country, etc. The literature normally does not discuss at length a possibility of censoring these sources, even though this sort of censorship was widely introduced in the past century's autocracies, modern Cuba and North Korea still use it, and some other autocracies practice it in less restrictive and more fragmented forms.

We are trying to fill this gap in this chapter and consider limits on the inflow of information which comes from the outside the country, as foreign TV channels, newspapers and magazines, contacts with foreigners, or visits to foreign countries. As we focus on non-democratic regimes, where national media is typically under control, we assume that the local media industry is censored.[12]

[12]The elite in power might be concerned about a free media, as the latter can play a crucial role in replacing the regime (see, for instance, McFaul, 2005), so the latter might prefer keeping the media

We introduce a simple growth model, in which the quality of institutions and technological development affect the level of per capita income in each of two economies - Home and Foreign - and income distribution determines how well-off a particular individual is relative to other individuals within her home economy. Per capita income and income distribution also define whether an individual belonging to a particular income group in Home is better or worse off compared to an individual from a similar income group in Foreign.

We assume that the ruling regime in Home needs public support to stay in power, and if the regime's policies satisfy the majority of population this support is provided, while in the opposite case the regime is instead forced to resign. In the baseline version of the model we assume that the regime is overthrown if in the steady-state the majority of home individuals do not believe they are at least as rich as their counterparts abroad.

We assume that the ruling regime in Home will derive a private benefit as long as the quality of institutions remains low. However, if the quality of institutions in Home is low, the majority of Home citizens receive a smaller income than individuals in Foreign, where, by contrast, the quality of institutions is high. The latter result holds even if Home and Foreign share the same level of technology. As the regime in power knows that the presence of low-quality institutions will result in comparatively low incomes and, as a consequence, in public discontent about the regime's policies, it introduces isolationism, thereby preventing individuals from comparing their incomes with Foreign's.

The key results of the benchmark model are as follows: a low level of income inequality, low costs of acquiring information about Foreign, low-quality institutions and a low level of technology in Home, all lead to a higher likelihood of introducing isolationism.

Censorship, however, results in significant costs for the economy, and some of these costs are surveyed in the literature (see, for instance, Egorov, Guriev and Sonin

under control. However, non-democratic elites are much less able to control foreign media, as well as other non-national news sources, directly.

2006). However, as the existent studies do not address the issues of censorship of information about foreign economies, they do not consider costs which are specific to this particular kind of censorship. We therefore incorporate these costs into our model by assuming that isolated countries are likely to fall down into technological backwardness, as an isolated economy also has a lower access to innovations developed abroad.

We argue that, as a consequence of a lower opportunity to imitate foreign technologies, growth rates decline, and therefore home economy remains poor and thus sensitive to various negative shocks, as adverse natural conditions, sharp reduction in exports prices, etc.[13] Seeing their living standards decline as a result of a shock, citizens can start feeling discontent about the regime in power, which can turn into mass protests and result in a regime change. Therefore, the ruling regime might also have incentives to avoid isolationism.

We discuss these features in an extension, where we introduce a possibility of technological diffusion in home economy. We assume that isolationism reduces Home's opportunities to imitate technologies, and thus Home fails to catch up with the foreign level of technology. As a consequence, isolationism, together with low quality institutions, reduces growth rates, resulting in persistently poor society which is highly sensitive to negative shocks. A negative shock can push incomes of the majority of individuals below a particular minimal threshold. As the latter can result in political turbulence, the regime in power is likely to be more careful when it decides whether isolationism should or should not be implemented, and, overall, there is less chance that isolationism will be introduced.[14] However, a careful consideration of the effect of isolationism on technological evolution requires a separate study, and therefore we restrict our contribution to discussion.

[13] As, for instance, a negative oil price shock which resulted in a significant reduction in living standards in the Soviet Union in the second half of the 1980s.

[14] If, however, home country is technologically self-sufficient, then its output is less sensitive to the opportunity to access foreign technologies. In this case, isolationism is more likely to be introduced. In particular, the latter is the case when the initial level of technology and the rate of innovations in Home are large.

2.2 The Baseline Model of Censorship

2.2.1 A Solow model with institutions

We consider a Solow model economy where labor-augmenting technology is evolving at a constant rate g, but where population instead does not grow.[15] A Cobb-Douglas technology combines labor L, capital $K(t)$, the level of labor-augmenting technology $A(t)$, and the quality of institutions β to produce a single output good $Y(t)$:

$$Y(t) = \beta K^{\eta}(t) \left(A(t)L\right)^{1-\eta} \tag{2.1}$$

We assume that the quality of institutions β can take two values:

$$\beta = \begin{cases} \beta^{HIGH} \\ \beta^{LOW} \end{cases}, \quad \beta^{HIGH} > \beta^{LOW} \tag{2.2}$$

The level of β is chosen by the ruling regime, and we will discuss later how does the regime make a decision about the quality of institutions.

In terms of per unit of effective labor, equation (2.1) can be rewritten as follows:

$$\hat{y}(t) = \hat{k}^{\eta}(t) \tag{2.3}$$

where $\hat{y}(t) = \frac{Y(t)}{\overline{A}(t)L}$ represents the level of output per unit of effective labor, $\hat{k}(t) = \frac{K(t)}{\overline{A}(t)L}$ corresponds to the level of capital per effective labor unit, and $\overline{A}(t) = \beta^{\frac{1}{1-\eta}} A(t)$.

The capital accumulation process is driven by the following standard rule:

$$\frac{\partial \hat{k}(t)}{\partial t} = s\hat{k}^{\eta}(t) - (\delta + g)\hat{k}(t) \tag{2.4}$$

where δ reflects a depreciation rate and s is a saving rate. For derivation of equation

[15] The latter assumption is introduced to simplify derivations and it does not affect any essential result of our model.

(2.4) see Appendix A.1.

In the steady-state[16] $\frac{\partial \hat{k}(t)}{\partial t} = 0$, which implies that the steady-state level of capital per effective labor unit is as large as follows:

$$\hat{k}(t) = \left(\frac{s}{\delta + g}\right)^{\frac{1}{1-\eta}} \tag{2.5}$$

Given this result, the steady-state output level per unit of effective labor can therefore be derived from equation (2.3):

$$\hat{y}^*(t) = \left(\frac{s}{\delta + g}\right)^{\frac{\eta}{1-\eta}} \tag{2.6}$$

It follows that the steady-state per capita income level, which is defined as $y^*(t) = \overline{A}(t)\hat{y}^*(t)$, is thus given by:

$$y^*(t) = \beta^{\frac{1}{1-\eta}} A(0)e^{gt} \left(\frac{s}{\delta + g}\right)^{\frac{\eta}{1-\eta}} \tag{2.7}$$

Finally, the steady-state level of output is equal to $Y^*(t) = y^*(t)L$, and, as $y^*(t)$ is determined in equation (2.7), $Y^*(t)$ is therefore equal to the following expression:

$$Y^*(t) = L\beta^{\frac{1}{1-\eta}} A(0)e^{gt} \left(\frac{\delta + g}{s}\right)^{\frac{\eta}{1-\eta}} \tag{2.8}$$

2.2.2 The political process

The quality of institutions β is chosen by the ruling regime. The latter obtains a private benefit from staying in power, which is a function of the quality of institutions β:

$$D = \begin{cases} B > 0 & \\ & if \\ 0 & \end{cases} \begin{matrix} \beta = \beta^{LOW} \\ \\ \beta = \beta^{HIGH} \end{matrix} . \tag{2.9}$$

[16]To avoid unnecessary complications, we will not consider transitional dynamics in this work, and focus our analysis on the steady-state.

As the ruling regime extracts benefits from the low-quality institutions, it is therefore interested in maintaining the quality of institutions at a low level, even though, as it follows from equation (2.7), bad institutions result in a lower level of per capita income (see also Acemoglu (2003) or Sonin, (2003)). The regime in power therefore sets $\beta = \beta^{LOW}$.

However, to stay in power, the regime needs to gain support from a fraction α of the population which is as large as L. The regime will enjoy sufficient popularity if enough citizens are convinced that per capita income in the home economy is at least as high as per capita income in some "reference" foreign country.[17]

We assume that the national media is under control of the political regime, and therefore the regime in power can censor any news. As a result, citizens can learn about the level of per capita income in the foreign country only from communications with foreigner individuals, visiting the foreign economy, or from the foreign media. We assume that the latter sources supply unbiased news about the foreign economy.

Even though the regime can not directly influence the foreign media news content, it can however dump the foreign media down inside the home economy. The regime can also ban citizens to leave the home country. We assume that all these restrictions are implemented synchronically, and therefore we can aggregate them into a single policy which we call "isolationism". If citizens can not visit the foreign country and have no access to the foreign media, then they receive information about the foreign economy only from the ruling regime.

The regime can control the level of censorship by setting a particular value of the

[17]History provides a lot of examples of elites and nations who considered other economies as reference points: the Soviet Union and the US, North Korea and South Korea, the GDR and Western Germany, etc. For the Soviet elite it was always important to keep people convinced that the Soviet regime performs better than the one in the US, for the North Korean regime it is of primary importance to make its citizens think that it does better than the regime in South Korea, and for Chinese communists it has always been important to compare China's performance with that of Taiwan.

following parameter:

$$\theta = \begin{cases} \theta^{I} \\ \\ \theta^{NI} \end{cases} \tag{2.10}$$

where θ^I corresponds to “isolationism”, while θ^{NI} instead reflects “non-isolationism”. We assume that choosing θ^I allows the regime to distort information about the foreign economy. For instance, if at a particular point in time t the true value of per capita income in the foreign country is $y^F_{true}(t)$, the regime can instead report a different value $y^F_{false}(t) < y^F_{true}(t)$, and, as the home economy is isolated, individuals have no opportunity to verify whether this information is correct or not.

Finally, we assume that accessing the state-controlled media is free of charge, while other sources of information, as visits to Foreign, are costly, and the fee for alternative sources of information is equal to T, which remains constant over time.

2.2.3 Home and Foreign: the baseline differences

In this subsection, we summarize the key differences between home and foreign economies, which we call Home and Foreign in the remaining part of the chapter.

First, we assume that β, the level of institutional quality, is higher in Foreign:

$$\beta^i = \begin{cases} \beta^{HIGH} & \\ & if \\ \beta^{LOW} & \end{cases} \begin{matrix} i = F \\ \\ i = H \end{matrix} \tag{2.11}$$

where H corresponds to Home, and F, instead, reflects Foreign, $\beta^{HIGH} > \beta^{LOW}$.

Second, we assume that the initial level of technological development $A(0)$ also differs for Home and Foreign:

$$A^i(0) = \begin{cases} A^{HIGH}(0) & \\ & if \\ A^{LOW}(0) & \end{cases} \begin{matrix} i = F \\ \\ i = H \end{matrix} \tag{2.12}$$

and $A^{HIGH}(0) > A^{LOW}(0)$.

These two assumptions, together with an assumption that α, δ, g, s and L are identical for two economies, imply that per capita income in Home is lower than per capita income level in Foreign, i.e. $y^H(t) < y^F(t)$.[18].

We also assume that output is distributed unequally both in Home and in Foreign. This implies that per capita income in Home $y^H(t)$ and per capita income abroad $y^F(t)$ do not necessarily reflect the income level of a random individual. As the Solow growth model does not explicitly consider the issue of capital and labor ownership, we therefore assume that each individual supplies a particular amount of capital and labor inelastically. Then, a citizen receives income corresponding to her labor and capital contributions.

Individual $j's$ share in the steady-state income is equal to γ_j^H in Home and γ_j^F in Foreign, $j = 1, ..., L$, and shares of all citizens sum up to 1 in each economy. We also assume that $\gamma_i^j \in \left[\underline{\gamma}^i, \overline{\gamma}^i\right]$ is uniformly distributed,[19] where $0 \leq \underline{\gamma}^i \leq 1$ and $0 \leq \overline{\gamma}^i \leq 1$, $\underline{\gamma}^i \leq \overline{\gamma}^i$, $i = H, F$, are, correspondingly, the lower and the upper bounds of the respective income shares. A larger distance between $\overline{\gamma}^i$ and $\underline{\gamma}^i$ reflects a higher level of inequality in a particular economy. An individual whose share γ^i is close to $\underline{\gamma}^i$ receives a low level of income, while those individuals whose shares γ^i are instead closer to $\overline{\gamma}^i$ are, on the contrary, rich. Finally, the cumulative distribution function $F(\gamma')$ reflects the proportion of individuals whose income shares do not exceed a particular share γ'.

[18] As $A^F(0) > A^H(0)$ and $\beta^F > \beta^H$, from equation (2.8) it follows that the level of income in the steady-state is $Y^*(t) = L(\beta)^{\frac{1}{1-\eta}} A(0)e^{gt}\left(\frac{s}{\delta+g}\right)^{\frac{\eta}{1-\eta}}$, and thus we conclude that income is larger in the foreign economy, i.e.

$$Y_F^*(t) > Y_H^*(t)$$

or, alternatively

$$L\left(\beta^F\right)^{\frac{1}{1-\eta}} A^F(0)e^{gt}\left(\frac{s}{\delta+g}\right)^{\frac{\eta}{1-\eta}} > L\left(\beta^H\right)^{\frac{1}{1-\eta}} A^H(0)e^{gt}\left(\frac{s}{\delta+g}\right)^{\frac{\eta}{1-\eta}}$$

Since we assume that the population size in two economies is identical, it also follows that $y^H(t) < y^F(t)$.

[19] We don't consider a non-linear distribution, as the latter substantially complicates our analysis, without producing, at the same time, any important results.

When income distribution in economy $i = H, F$ is perfectly equal, all income shares γ^i reduce to a constant $\frac{1}{L}$, i.e. $\gamma^i = \frac{1}{L}$ for all individuals in country $i = H, F$. However, if income distribution in economy $i = H, F$ is instead not perfectly equal, then γ^i can take different values. In the latter case the mean values of γ^i is equal to $\frac{\overline{\gamma}^i + \underline{\gamma}^i}{2}$, $i = H, F$.[20]

It therefore follows that citizen j's income in country $i = H.F$ corresponds to her share in the level of output produced in this economy:

$$R_j^i = \gamma_j^i Y^i(t) \tag{2.13}$$

As the cost of acquiring information from alternative sources is equal to T, only those Home individuals whose income level satisfies the following condition can afford paying this cost:

$$R_j^H = \gamma_j^H Y^*(t) \geq T \tag{2.14}$$

The threshold individual who is as rich as to be able to afford paying this fee is thus defined from the following equation:

$$\gamma^{th}(t) = \frac{T}{Y^*(t)} \tag{2.15}$$

Therefore, the proportion of individuals whose income level is sufficient to pay the cost corresponds to the following expression:

$$\overline{L} = \frac{\overline{\gamma}^H - \gamma^{th}(t)}{\overline{\gamma}^H - \underline{\gamma}^H} L \tag{2.16}$$

---

[20]In general, the mean of γ^i is equal to $\frac{\overline{\gamma}^i + \underline{\gamma}^i}{2}$, while in the case of perfectly equal distribution the mean is instead equal to $\frac{1}{L}$, as $\overline{\gamma}^i = \underline{\gamma}^i = \frac{1}{L}$.

We introduce a number of assumptions about income distribution and we show that $\frac{\overline{\gamma}^i + \underline{\gamma}^i}{2} = \frac{1}{L}$. As this finding is purely technical, we place a derivation of it in Appendix A.2.

Given this result, we conclude that even though inequal income distribution implies the existance of individuals with higher and lower income shares, on average an individual receives exactly a share $\frac{1}{L}$ of the total income.

Therefore, from $\frac{\overline{\gamma}^i + \underline{\gamma}^i}{2} = \frac{1}{L}$, where $i = H, F$ we can also conclude that $\overline{\gamma}^H - \overline{\gamma}^F = \underline{\gamma}^F - \underline{\gamma}^H$. See Appendix A.2 for a derivation of this result.

We notice that $\gamma^{th}(t)$ declines over time if the level of $Y^t(t)$ instead increases.

2.2.4 Incentives for censorship

No difference in average incomes: $A^F(0) = A^H(0)$**,** $\beta^F = \beta^H$ **, and** $T = 0$**.**

In this subsection, we introduce a number of simplifying assumptions and first analyze a very basic version of the model to focus on its important features. We remove these restrictions in the following sections and build upon the basic version to derive our key results.

We assume temporarily that, first, the level of technology and the quality of institutions are the same in Home and Foreign, i.e. $A^F(0) = A^H(0)$ and $\beta^F = \beta^H$, which implies that income levels in two countries are also the same, i.e. $y^H(t) = y^F(t)$, and second, we assume that the cost of purchasing information about Foreign, i.e. T, equals to zero.

To grasp the main features of the model, we will be using a graphical representation throughout the entire chapter. In Figure 1, the income share γ^i, where $i = H, F$, is placed along the horizontal axis, while the vertical axis instead reflects its cumulative distribution function. We consider a particular example where income shares are distributed more unequally in Home than in Foreign. As a consequence of comparatively more equal income distribution in Foreign, the cumulative distribution function of income shares in the foreign economy, i.e. γ^F, which is represented as the thick line, is steeper and both its limit points are located closer to the vertical line. The vertical line starts from the point $\gamma = \frac{1}{L}$ on the horizontal axis, and reflects the egalitarian distribution. We introduce this line for technical convenience, as it helps to compare the level of inequality and income in Home and Foreign. Finally, the thin line illustrates the cumulative distribution function of income shares in Home. As income distribution is less equal in Home, the thin line is flatter and its limit points are less close to the vertical line[21]

[21]Each cumulative distribution function also has two horizontal parts, one starts from zero and goes

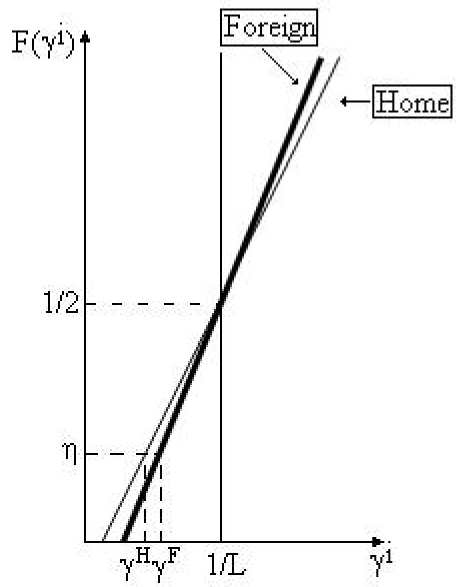

Figure 1. Income distribution in Home and Foreign. Income distribution is more unequal in Home, while the level of output is the same in Home and Foreign.

To proceed, we rank individuals according to their income shares in two economies, and then consider a random pair of individuals, one from Home and the other one from Foreign, having the same rank. As we can see, apart from the intersection point between the thick and the thin lines, where $\gamma^H = \gamma^F = \frac{1}{L}$, these two individuals have different incomes.[22] For instance, relatively poor citizens in Home receive a lower

along the horizontal axis up to point $(\underline{\gamma}^i, 0)$, $i = H, F$, and the other one instead starts at point $\left(\overline{\gamma}^i, F\left(\overline{\gamma}^i\right)\right)$ and goes parallel to the horizontal axis. However, as these parts never appear in our analysis, we therefore do not reflect them in any figure.

[22]We assume that poor people from Home compare their incomes with incomes belonging to the Foreign poor, rich individuals from Home compare their incomes with the ones of rich individuals from Foreign, and Home middle class citizens compare their incomes with the ones of middle class individuals from the foreign economy. At the first glance, this assumption might look a bit extreme, as it should be hard for a person who visits a foreign country for a short period of time, or who reads a foreign newspaper, to find out the exact earnings of a foreign individual which belongs to her same income quantile. However, in real life a lot of indirect opportunities for comparison are available. In countries with high income inequality, poor individuals reside in shanty towns, while the rich instead occupy luxurious neighbourhoods, so if a poor person from a country with lower income inequality visits a country with higher income inequality, she will probably infer that individuals belonging to her social class are better off in Home.

income share than the respective foreigners. This fact can be observed if we track the dashed line which starts at point η on the vertical axis, until its intersection with the thin and the thick lines, and then go vertically down and compare the respective income shares. It occurs that the larger share belongs to a foreign individual, as γ^H, representing a share of particular individual from Home, is lower than γ^F, reflecting instead the income share of the corresponding foreigner. As long as η, corresponding to a random point on the vertical axis, is less than $\frac{1}{2}$, which implies that the cohort under consideration is comparatively poor, the relation between γ^F and γ^H remains the same, i.e. $\gamma^F > \gamma^H$.

Therefore, when inequality in Home is higher, we conclude that Home poor individuals, i.e. those individuals whose income shares are less than $\frac{1}{L}$, are poorer than their Foreign counterparts. Similarly, we can show that the rich in Home, whose shares are instead larger than $\frac{1}{L}$, are richer than the respective individuals in Foreign.

If there is no difference in income inequality between two countries, then the thick and the thin lines coincide, and Home individuals are equally well off in Home and Foreign.

Finally, if Foreign is more unequal than Home, then the rich are worse off in Home, while their poor compatriots are instead worse off in Foreign.

We summarize this discussion in the following Lemma.

Lemma 1. *For $F\left(\gamma^F\right) = F\left(\gamma^H\right)$, where $F\left(\gamma^F\right)$ and $F\left(\gamma^H\right)$ are cumulative distribution functions of income shares in Foreign γ^F and Home γ^H respectively:*

1. Assume that the difference between the lowest income share in Home and the one in Foreign is negative, i.e. $\underline{\gamma}^H - \underline{\gamma}^F < 0$, which implies a higher level of inequality in Home. In this case, an individual from Home is poorer than her counterpart from Foreign, i.e. $\gamma^H < \gamma^F$, if she belongs to the poor cohort, i.e. if $\gamma^H < \frac{1}{L}$;

She is as rich as the respective foreigner, i.e. $\gamma^H = \gamma^F$, if her income share is equal to the average one, i.e. $\gamma^H = \frac{1}{L}$;

She is richer than her foreign counterpart, i.e. $\gamma^F < \gamma^H$, if she belongs to the rich *group, i.e.* $\gamma^H > \frac{1}{L}$.

2. Assume that the difference between the lowest income share in Home and the one in Foreign is positive, i.e. $\underline{\gamma}^H - \underline{\gamma}^F > 0$*, which implies a higher level of income inequality in Foreign.*

In this case, an individual from Home is richer than her counterpart from Foreign, i.e. $\gamma^F < \gamma^H$*, if she belongs to the poor cohort, i.e. if* $\gamma^H < \frac{1}{L}$*;*

She is as rich as the respective foreigner, i.e. $\gamma^H = \gamma^F$*, if her income share is equal to the average one, i.e.* $\gamma^H = \frac{1}{L}$*;*

She is poorer than her foreign counterpart, i.e. $\gamma^H < \gamma^F$*, if she belongs to the rich group, i.e.* $\gamma^H > \frac{1}{L}$*.*

3. Assume that the difference between the lowest income share in Home and the one in Foreign is zero, i.e. $\underline{\gamma}^H - \underline{\gamma}^F = 0$ *which implies no difference in income inequality between two economies. In this case all individuals in Home are exactly as rich as their counterparts in Foreign, i.e.* $\gamma^H = \gamma^F$*.*

This Lemma follows from the following expression:

$$\gamma^F = \gamma^H + \frac{2\left(\gamma^H - \frac{1}{L}\right)\left(\underline{\gamma}^H - \underline{\gamma}^F\right)}{\overline{\gamma}^H - \underline{\gamma}^H} \tag{2.17}$$

which we derive in Appendix B.1

Therefore, if incomes in two economies are the same, the rich are better off in less equal Home, while the poor instead are worse off living there. As a result, the former sympathize the ruling regime, while their poor compatriots, by contrast, oppose it.

Average incomes are different, but $T = 0$.

We remove two simplifying assumptions which were introduced in the previous subsection, and instead assume that $A^F(0) > A^H(0)$, and $\beta^F > \beta^H$. We, however, keep the assumption regarding the cost of acquiring information from alternative sources T, which remains zero.

From equation (2.7) we can notice that a higher level of technology, as well as a higher quality of institutions in Foreign, result in a larger level of per capita income in Foreign, which becomes larger than the one in Home, i.e. $y^F(t) > y^H(t)$. When output in Foreign becomes higher, it is no longer the case that the entire rich cohort in more unequal Home is richer than the respective cohort in the foreign economy. As we will see shortly, the share of income belonging to a rich individual from Home should be substantially larger than the average share $\gamma^H = \frac{1}{L}$ to let this individual be richer than her foreign counterpart.

Let us again consider a graphical representation, which explicitly takes into account the differences in per capita income levels in two economies.

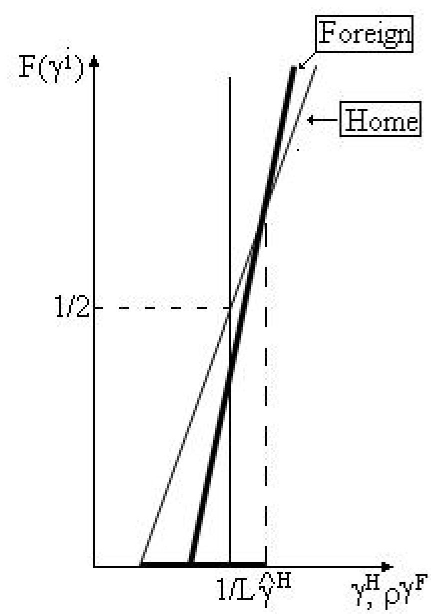

Figure 2. Comparison of Home and Foreign individuals: the case of higher inequality in Home, income level is higher in Foreign.

The case which is illustrated in Figure 2 is similar to the one which we discussed in Figure 1, as income inequality in Home is again higher than in Foreign. However, we now allow for different initial levels of technological development $A^F(0) > A^H(0)$

and institutional quality $\beta^F > \beta^H$, which results in a positive difference between per capita steady-state income levels in Home $y^H(t)$ and abroad $y^F(t)$. As a consequence of a higher income in the foreign economy, the cumulative distribution function for Foreign, which is represented as the thick line, is shifted to the right. The difference between $y^F(t)$ and $y^H(t)$ also affects the composition of variables on the horizontal axis, where $\rho\gamma^F$ substitutes γ^F. We will consider parameter $\rho = \left(\frac{\beta^F}{\beta^H}\right)^{\frac{1}{1-\eta}} \frac{A^F(0)}{A^H(0)}$ again shortly.

From Figure 2 we can identify a cohort of individuals from Home who are at least as rich as their foreign counterparts. These individuals' output shares γ^H should be at least as large as $\widehat{\gamma}^H$, where the latter represents a threshold income share corresponding to a particular individual from Home whose income level is as large as the one of the respective individual from Foreign. Therefore, it follows that the cohort of relatively rich home individuals, whose income shares range from $\frac{1}{L}$ to $\widehat{\gamma}^H$, are less rich than their foreign counterparts. This result differs from the one of the previous subsection, where, as we concluded from Figure 1, all Home individuals with income shares ranging from $\frac{1}{L}$ to $\overline{\gamma}^H$ either as well off as, or better off than the respective foreigners. In this subsection, even though rich individuals in Home again possess higher income shares than their foreigner counterparts, a part of them is, nevertheless, comparatively poorer, since the effect of a lower income level in Home dominates as long as income shares remain lower than $\widehat{\gamma}^H$. As a consequence, the group of individuals who are worse off than the respective foreigners, and therefore stay in opposition to the ruling regime, is larger compared to the case of equal income levels in Home and Foreign, i.e. $y^H(t) = y^F(t)$, which was considered in the previous subsection. This cohort corresponds to the bold section of the horizontal axis in Figure 2, which is as large as $\widehat{\gamma}^H - \underline{\gamma}^H$, while in the previous section it was equal to $\frac{1}{L} - \underline{\gamma}^H$, which is smaller than $\widehat{\gamma}^H - \underline{\gamma}^H$, as $\frac{1}{L}$ is lower than $\widehat{\gamma}^H$.

We now repeat the same comparison algebraically. Our goal is to define the number of regime supporters in Home. By assumption, only those individuals who are richer than their foreign counterparts support the political regime. As a Home individual who supports the regime is at least as well off in Home as in Foreign, her income $R_j^H = \gamma_j^H Y^H(t)$ should therefore be at least as large as the one of the respective foreigner, which is equal to $R_j^F = \gamma_j^F Y^F(t)$. As α, δ, g, s and L are the same in two countries, from equation (2.7) it follows that $\gamma_j^H Y^H(t) \geq \gamma_j^F Y^F(t)$ corresponds to the following inequality:

$$\gamma_j^H \left(\beta^H\right)^{\frac{1}{1-\eta}} A^H(0) \geq \gamma_j^F \left(\beta^F\right)^{\frac{1}{1-\eta}} A^F(0)^{23} \tag{2.18}$$

We normalize both sides of inequality (2.18) over $\left(\beta^H\right)^{\frac{1}{1-\eta}} A^H(0)$, and, as a result, its left-hand side, i.e. $\gamma^H \left(\beta^H\right)^{\frac{1}{1-\eta}} A^H(0)$, reduces to γ^H, while the right-hand side, i.e. $\gamma^F \left(\beta^F\right)^{\frac{1}{1-\eta}} A^F(0)$, becomes equal to $\gamma^F \left(\frac{\beta^F}{\beta^H}\right)^{\frac{1}{1-\eta}} \frac{A^F(0)}{A^H(0)}$.[24] To see how many individuals from Home are richer than corresponding foreign individuals, and thus how popular the ruling regime is, we equalize γ^H and $\gamma^F \left(\frac{\beta^F}{\beta^H}\right)^{\frac{1}{1-\eta}} \frac{A^F(0)}{A^H(0)}$, as we need to define a threshold level of γ^H belonging to a particular individual from Home who is as well off as the respective foreign individual. We then combine $\gamma^H = \gamma^F \left(\frac{\beta^F}{\beta^H}\right)^{\frac{1}{1-\eta}} \frac{A^F(0)}{A^H(0)}$ with equation (2.17) to receive the following expression:

$$\gamma^H \left(\beta^H\right)^{\frac{1}{1-\eta}} A^H(0) =$$

$$= \left(\gamma^H + \frac{2\left(\gamma^H - \frac{1}{L}\right)\left(\underline{\gamma}^H - \underline{\gamma}^F\right)}{\overline{\gamma}^H - \underline{\gamma}^H}\right) \left(\beta^F\right)^{\frac{1}{1-\eta}} A^F(0) \tag{2.19}$$

[23]To show that the latter is indeed the case, we can use equation (2.8) again and notice that

$$\gamma_j^F Y_F^*(t) = \gamma_j^F L \left(\beta^F\right)^{\frac{1}{1-\eta}} A^F(0) e^{gt} \left(\frac{\delta + g}{s}\right)^{\frac{\eta}{\eta-1}}$$

and

$$\gamma_j^H Y_H^*(t) = \gamma_j^H L \left(\beta^H\right)^{\frac{1}{1-\eta}} A^H(0) e^{gt} \left(\frac{\delta + g}{s}\right)^{\frac{\eta}{\eta-1}}$$

After we cancel out identical factors, we notice that $\beta^F = \beta^{HIGH}$, $\beta^H = \beta^{LOW}$, $\beta^{HIGH} > \beta^{LOW}$, $A^F(0) = A^{HIGH}(0)$, $A^H(0) = A^{LOW}(0)$, and $A^{HIGH}(0) > A^{LOW}(0)$. We substitute these values into $\gamma_j^H \left(\beta^H\right)^{\frac{1}{1-\eta}} A^H(0)$ and $\gamma_j^F \left(\beta^F\right)^{\frac{1}{1-\eta}} A^F(0)$ to receive the required result.

[24]Where $\left(\frac{\beta^{HIGH}}{\beta^{LOW}}\right)^{\frac{1}{1-\eta}} \frac{A^F(0)}{A^H(0)} > 1$, since, by assumption, $A^F(0) > A^H(0)$ and $\beta^F > \beta^H$.

In Appendix B.2 we show how to derive the following result from equation (2.19):

$$\widehat{\gamma}^H = \frac{1}{L}\frac{\frac{\overline{\gamma}^H - \underline{\gamma}^H}{\overline{\gamma}^F - \underline{\gamma}^F} - 1}{\frac{\overline{\gamma}^H - \underline{\gamma}^H}{\overline{\gamma}^F - \underline{\gamma}^F}\left(\frac{\beta^H}{\beta^F}\right)^{\frac{1}{1-\eta}}\frac{A^H(0)}{A^F(0)} - 1} \tag{2.20}$$

The right-hand side of equation (2.20) therefore defines the share $\widehat{\gamma}^H$ belonging to the threshold individual from Home, who is as well off as the respective foreign individual.

In the following proposition, we summarize the key findings which follow from equation (2.20):

Proposition 1. *As long as the cost of acquiring information about the foreign economy T is equal to zero, the following results hold:*

1. *if Home is more unequal than Foreign, i.e. if $\frac{\overline{\gamma}^H - \underline{\gamma}^H}{\overline{\gamma}^F - \underline{\gamma}^F} > 1$, then a higher initial level of technology $A^F(0)$ and a higher quality of institutions β^F in Foreign, a lower level of technology $A^H(0)$, a lower quality of institutions β^H and a lower relative inequality in Home $\frac{\overline{\gamma}^H - \underline{\gamma}^H}{\overline{\gamma}^F - \underline{\gamma}^F}$, all result in a higher $\widehat{\gamma}^H$, implying less support to the ruling regime and, as a consequence, a higher level of censorship*[25]*;*

2. *if instead Foreign is more unequal than Home, i.e. if $\frac{\overline{\gamma}^H - \underline{\gamma}^H}{\overline{\gamma}^F - \underline{\gamma}^F} < 1$, then a higher initial level of technology $A^F(0)$ and a higher quality of institutions β^F in Foreign, a lower level of technology $A^H(0)$, a lower quality of institutions β^H and a higher relative inequality in Home $\frac{\overline{\gamma}^H - \underline{\gamma}^H}{\overline{\gamma}^F - \underline{\gamma}^F}$, all result in a lower $\widehat{\gamma}^H$, implying less support to the ruling regime and, as a consequence, a higher level of censorship;*

3. *finally, if Home is as unequal as Foreign, i.e. if $\frac{\overline{\gamma}^H - \underline{\gamma}^H}{\overline{\gamma}^F - \underline{\gamma}^F} = 1$, then $\widehat{\gamma}^H = 0$, , implying no support to the regime in power.*

Proof. See Appendix B.3. ■

[25] As political isolationism

Intuition behind this proposition is as follows. If income is more unequal in Home, which is the case when $\frac{\overline{\gamma}^H - \underline{\gamma}^H}{\overline{\gamma}^F - \underline{\gamma}^F} > 1$, then a higher technological endowment in Foreign, i.e. a larger $A^F(0)$, or better foreign institutions, i.e. a higher β^F, and therefore a larger income gap between Home and Foreign, reduce the cohort of those rich individuals from Home who are better off living in Home than in Foreign. As the latter reduces the number of individuals supporting the regime in power, the authority has higher incentives to introduce isolationism. The opposite is true if the level of initial technology $A^H(0)$, or the quality of institutions β^H in Home becomes higher. In this case, the group of rich individuals in Home who are richer than the corresponding foreign individuals becomes larger. At the same time, as long as the level of income in Home is lower than the one in the foreign economy, the entire group of poor individuals in Home is worse off than their foreign counterparts, as Home is not only more inequal and, therefore, pro-rich, as was the case in the previous subsection, but it is also poorer than Foreign.

In the opposite case of lower income inequality in Home corresponding to $\frac{\overline{\gamma}^H - \underline{\gamma}^H}{\overline{\gamma}^F - \underline{\gamma}^F} < 1$, a higher level of technology $A^F(0)$ or a higher quality of institutions β^F in Foreign results in a lower share $\widehat{\gamma}^H$. We can see this result in Figure 3, where, as before, the thick line represents Foreign, and the thin one corresponds instead to Home. However, this time the thin line is steeper, which reflects a lower income inequality in Home. An increase in $A^F(0)$ or β^F results in a higher $\gamma^F \left(\frac{\beta^F}{\beta^H}\right)^{\frac{1}{1-\eta}} \frac{A^F(0)}{A^H(0)}$, and, as a consequence, the thick line shifts to the right. The new intersection point is now at point B, i.e. below and to the left from the initial point A. Therefore, better institutions and better technologies in Foreign result in a larger number of foreigners who are richer than home individuals, thus reducing the level of the ruling regime support from $F(\overline{\gamma})L$ individuals to $F(\overline{\overline{\gamma}})L$. The latter increases the ruling regimes incentives to implement more restrictive forms of censorship.

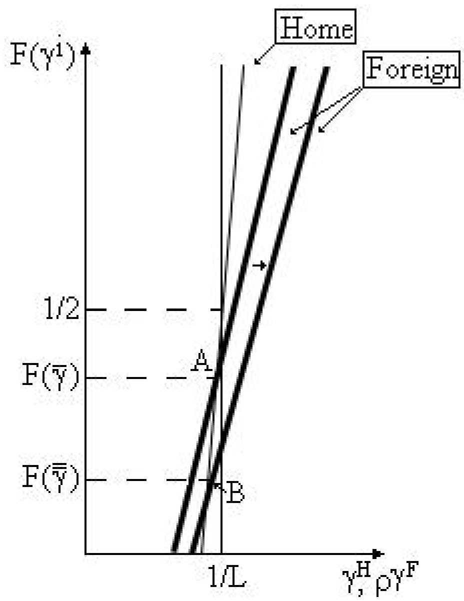

Figure 3. Comparison of home and foreign individuals: the case of lower inequality in Home, average incomes are different in Home and Foreign.

When income inequality is lower in Home than in Foreign, an increase in the level of inequality in Home, i.e. a larger $\frac{\overline{\gamma}^H-\underline{\gamma}^H}{\overline{\gamma}^F-\underline{\gamma}^F}$, results in a reduction of $\widehat{\gamma}^H$. This result is intuitive, as if Home is less unequal than Foreign, as is the case in Figure 3, an increase in the level of inequality in Home results in a larger number of poor individuals who are poorer than their foreign counterparts. As a result, this reduces the share of individuals who support the regime in power.[26]

When the level of income inequality in Home is, by contrast, larger than in Foreign, an increase in $\frac{\overline{\gamma}^H-\underline{\gamma}^H}{\overline{\gamma}^F-\underline{\gamma}^F}$ results is a larger number of rich Home individuals who are better off living in Home, as a higher inequality benefits the rich cohort. As a consequence, the regime becomes more popular among rich individuals, while dissatisfaction among the poor instead increases.

[26]As inequality in Home becomes higher, the thin line in Figure 3 is getting flatter and the intersection point with the thick line moves down along the thick line representing Foreign, more far away to the left from point $\frac{1}{L}$ on the horizontal axis.

If two countries have the same level of income inequality, i.e. if $\frac{\overline{\gamma}^H - \underline{\gamma}^H}{\overline{\gamma}^F - \underline{\gamma}^F} = 1$, then the thin line representing Home is located entirely parallel and to the left from the thick line, which implies that no one is better off in Home than in Foreign, and, as a result, no one supports the regime in power.

Average incomes are different and $T > 0$.

We, finally, consider the case when purchasing information about Foreign is costly, and therefore T becomes a positive value. We remind that the threshold individual who can afford paying T is defined from the following expression:

$$\gamma^{th}(t) = \frac{T}{Y^H(t)} \tag{2.21}$$

where $Y^H(t) = L\left(\beta^H\right)^{\frac{1}{1-\eta}} A^H(0)e^{gt}\left(\frac{\delta+g}{s}\right)^{\frac{\eta}{1-\eta}}$.

In the presence of positive T and comparatively higher income inequality in Home, the ruling regime is supported by two different groups of individuals: the poorest and the richest. As individuals belonging to the former group are very poor, they can't afford paying T and therefore receive information about Foreign from the official media. The latter group is instead rich, and it supports the regime as this cohort is better off living in more unequal Home than in less unequal Foreign. Since there are $\frac{\gamma^{th}(t) - \underline{\gamma}^H}{\overline{\gamma}^H - \underline{\gamma}^H} L$ individuals belonging to the former group and $\frac{\overline{\gamma}^H - \widehat{\gamma}^H}{\overline{\gamma}^H - \underline{\gamma}^H} L$ to the latter, the number of individuals in opposition therefore equals to the remaining part of the population, which is as large as follows:

$$L^o = \frac{\widehat{\gamma}^H - \gamma^{th}(t)}{\overline{\gamma}^H - \underline{\gamma}^H} L \tag{2.22}$$

We remind that, by assumption, the regime stays in power if at least αL individuals support it, and thus isolationism is introduced if the number of supporters reduces below αL, or, alternatively, when the number of oppositionists, who, in this particular case, are represented by the middle-class individuals, becomes larger than $(1 - \alpha)L$, i.e. when the following condition holds:

$$\frac{\widehat{\gamma}^H - \gamma^{th}(t)}{\overline{\gamma}^H - \underline{\gamma}^H} L > (1-\alpha)L \tag{2.23}$$

If income distribution is instead less unequal in Home than in Foreign, the group supporting the regime in power is represented by the poorest individuals, as they are better off in Home than in Foreign. As $\frac{\widehat{\gamma}^H - \underline{\gamma}^H}{\overline{\gamma}^H - \underline{\gamma}^H} L$ individuals belong to this group, the size of the group at the opposition is thus belongs to the remaining part of the population and is reflected in the following expression:

$$L^o = \frac{\overline{\gamma}^H - \widehat{\gamma}^H}{\overline{\gamma}^H - \underline{\gamma}^H} L^{27} \tag{2.24}$$

Therefore, the ruling regime introduces isolationism when the following condition holds:

$$L^o = \frac{\overline{\gamma}^H - \widehat{\gamma}^H}{\overline{\gamma}^H - \underline{\gamma}^H} L > (1-\alpha)L \tag{2.25}$$

From Proposition 1 we know how does the threshold share $\widehat{\gamma}^H$, which is a part of equations (2.22) and (2.24), react if any of $A^F(0)$, β^F, $A^H(0)$, β^H, $\overline{\gamma}^H - \underline{\gamma}^H$ or $\overline{\gamma}^F - \underline{\gamma}^F$ changes. From equation (2.21) we know how $\gamma^{th}(t)$, which is also a part of equation (2.22), is affected by a change in the level of T or $Y^H(t)$. We therefore can summarize all these effects in the following proposition.

Proposition 2. *As long as the cost of acquiring information about the foreign economy T is positive, the following results hold*:

1. *if income inequality in Home is higher than in Foreign, then a higher cost of acquiring information from alternative sources T or a higher level of income inequality in Home $\overline{\gamma}^H - \underline{\gamma}^H$, a lower level of technology $A^F(0)$, a lower quality*

[27] Alternatively, the size of opposition can be equal to $L^o = \frac{\overline{\gamma}^H - \gamma^{th}(t)}{\overline{\gamma}^H - \underline{\gamma}^H} L$ if $\gamma^{th}(t) > \widehat{\gamma}^H$. We, however, assume that $\gamma^{th}(t) \leq \widehat{\gamma}^H$ to exclude this case, and we explain why do we do so in the next footnote.

of institutions β^F and a lower income inequality $\overline{\gamma}^F - \underline{\gamma}^F$ in Foreign, do not result in a larger opposition cohort. The latter implies a lower level of censorship in Home. The effect of a higher level of technology $A^H(0)$ or a higher quality institutions β^H in Home is instead ambiguous;

2. *if income inequality is higher in Foreign than in Home, and $\widehat{\gamma}^H > \gamma^{th}(t)$, then a higher quality of institutions β^H, a higher level of technological development $A^H(0)$ in Home, a higher cost of acquiring information from alternative sources T, a higher level of income inequality $\overline{\gamma}^F - \underline{\gamma}^F$, a lower level of technology $A^F(0)$ and a lower quality of institutions β^F in Foreign, do not result in a larger opposition cohort. The latter implies a lower level of censorship in Home. The effect of a lower level of income inequality in Home $\overline{\gamma}^H - \underline{\gamma}^H$ is instead ambiguous.*[28]

Proof. See Appendix B.4 for the proof. ■

We do not explicitly carry out a comparative static exercise on δ, s, L, g, as the results of this exercise are very standard and intuitive. Moreover, we limit our discussion of Proposition 2 to those results which illustrate particular historical episodes, and mention all other findings very briefly.

The intuition for Proposition 2 is as follows. When the level of T is larger, which implies that acquiring information about Foreign is more expensive, the size of the group that can afford paying T is comparatively small, and, as a result, the group opposing the ruling regime is lower as well. Therefore, a low T instead might potentially result in a larger group of oppositionists, which creates higher risks for the ruling regime. This result can probably explain why common borders with developed countries or geographic proximity to more developed economies, all implying a very low

[28] We introduce the following assumption:

$$\widehat{\gamma}^H > \gamma^{th}(t)$$

in the second part of Proposition 2, as otherwise there is more ambiguity when the values of parameters change. For instance, assume that initially $\widehat{\gamma}^H$ is lower than $\gamma^{th}(t)$, and an institutional reform results in a higher level of β^H. As a consequence, $\widehat{\gamma}^H$ goes up, while $\gamma^{th}(t)$ instead goes down. If $\widehat{\gamma}^H < \gamma^{th}(t)$ is still satisfied after this reform is implemented, then the regime in power loses popularity even though it introduced a positive change, which is counterintuitive.

value of T, made isolationism particularly attractive for countries as the Soviet Union, GDR, North Korea or Cuba.[29]

Better technology or institutions in Foreign, i.e. $A^F(t)$ or β^F, increase incomes abroad, and, as a result, home individuals become comparatively poorer. In this case, according to equations (2.22) and (2.24) the number of opposition members increases and, as a consequence, the likelihood of isolationism becomes larger. Again, the socialist economies, such as the Soviet Union, Maoist China, Cuba, GDR and North Korea, which practiced isolationism and censorship, were, at the same time, characterized by comparatively poor institutions and a low level of non-military technological development.[30]

If income inequality is lower in Home than in Foreign, then according to equation (2.24) the number of individuals who do not support the regime in power is large. Only very poor individuals are better off in Home, and therefore they provide political support to the ruling regime. As the number of oppositionists in much larger, the regime in power has incentives to end up using isolationism. Again, one can notice that income inequality in the Soviet Union, GDR, Cuba and North Korea was/is very low.[31]

If income inequality is comparatively higher in Home than in Foreign, then an increase in income inequality in Foreign tends to decrease the number of those rich individuals in Home who are better off than their counterparts in Foreign, therefore resulting in a lower popularity of the ruling regime. If inequality is instead increasing in Home, then one can notice that the number of poor individuals who can afford paying T, and thus receive unbiased information regarding their comparative incomes, declines, whereas the number of home individuals who are richer than the respective

[29]The Soviet Union's neighbours were, among other economies, Norway and Finland. GDR was having a common border with Western Germany, North Korea shares one of its borders with the Republic of Korea, and Cuba is located close to the US.

[30]Ellman (1986), for instance, points at a significant technological gap between the Soviet Union and the West.

[31]Using better opportunity to manipulate information flows, political regimes in these isolated economies were convincing their citizenry that capitalist societies were instead highly inequal, and that most of the wealth there was belonging to the rich elites.

foreign individuals becomes instead larger. Therefore, the number of individuals belonging to the middle income group who, as they are worse off than their foreign counterparts, are in opposition to the ruling regime, becomes lower, and thus there is less need for the regime to introduce isolationism. The case when an ineffective and corrupt regime is opposed by the middle class individuals, but earns support from the rich who benefit from a high level of income inequality, and the poor who receive information regarding their comparative incomes from the state-controlled media, is consistent with a number of recent historical episodes, as the ones of modern Venezuela or Russia.

If income inequality is lower in Home than in Foreign, better home technology and better domestic institutions will result in a larger support from the poorest individuals, as, since Home is more equal, and therefore more pro-poor than Foreign, the number of poor individuals who are better off than corresponding poor individuals abroad increases. But those Home individuals who are comparatively rich will remain unsatisfied, as, first, Home stays poorer than the foreign economy, and second, the rich receive lower stakes in Home than their counterparts in Foreign. However, the number of regime supporters becomes unambiguously larger when domestic technology and institutions improve. More formally, as a result of higher quality institutions in Home, according to equation (2.20) the new threshold level $\widehat{\gamma}^H$ becomes larger. As the level of income in Home is comparatively lower, from equation (2.24) it follows that those individuals whose income share satisfy $\widehat{\gamma}^H < \gamma \leq \overline{\gamma}^H$ oppose the regime in power. As the share $\widehat{\gamma}^H$ increases, the size of the group at opposition reduces, and thus the number of regime's supporters becomes larger.

If income inequality is instead larger in Home than in Foreign, the effect of having access to a better technology or better institutions in Home is more complicated. On one hand, a higher level of technology or better institutions result in a larger income level, and, as Home is more inequal and therefore more beneficial for the rich, more individuals from the rich group support the regime in power. However, as poorer individuals also become richer, more of them can afford paying T, and, as a result, a larger cohort of poor citizens becomes aware that their consumption standards are still lower than the ones of their foreign counterparts. As a consequence, a part of poor individuals can turn against the regime in power. Which effect dominates remains ambiguous.

One can notice that the above environment gives a too strong prediction in particular cases. For instance, as we concluded above, if inequality in Home is higher than in Foreign, then a larger group of poor individuals can't afford paying T. If Home does not improve its technology fast enough, then the gap between Home and Foreign decreases slowly. At the same time, as the level of technology in the home economy becomes higher over time, Home individuals become richer in absolute terms, while the value of T, by assumption, remains constant. From equation (2.21) it follows that there are less people who can not afford acquiring information from alternative sources and therefore are unaware that they are poorer than foreigners, i.e. $\gamma^{th}(t)L$ becomes smaller over time. As a result, the amount of regime supporters declines, and thus the number of regimes practicing isolationism should grow. However, this prediction contradicts the reality, as the number of isolationist economies instead becomes lower.

We suppose that this contradiction follows as we did not consider the costs associated with isolationism in our study. As a consequence, since isolationism is assumed to be costless, our analysis has so far shown that growing discontent about the policy of the ruling regime unambiguously results in the introduction of isolationism. However, as is argued below, the presence of the costs resulting from isolationism can significantly change the behavior of the ruling regime.

2.3 Isolationism and Technological Diffusion

So far, we have developed a one-direction relationship between economic growth and censorship: as we showed in the previous section, slow economic growth is more likely to result in censorship, as the ruling regime has incentives to hide the fact that Home does not catch up with Foreign from the public. We, however, suppose that this relationship is instead two-sided: not only does the pace of economic growth affects a decision to introduce isolationism, but isolationism can itself affect economic development. Historical evidence suggests that economies in isolation fall down into technological backwardness.[32] A potential explanation for this result is that isolationism complicates the process of technological diffusion, thus leading to a lower pace of technological development in the isolated economy.[33] As a consequence of slow evolution of technology, the level of output can also grow slowly. In the presence of slow economic growth, a developing society might remain poor and, as a result, sensitive to various macro shocks. Therefore, a shock can substantially increase the level of poverty, thus resulting in mass protest and creating serious political risks for the ruling regime. As an illustration, we refer to the example of the late Soviet Union. With its ineffective economic and political institutions, the latter was not able to catch up with more developed Western economies. However, as a vast majority of Soviet citizens were deprived from a possibility to visit the West because of isolationism, they had very little chance to compare their incomes with the ones in the Western block. As a result of isolationism, the Soviet economy had limited opportunities to imitate technologies from the world technological frontier, and therefore evolution of technology in most of sectors of the Soviet economy was slow (see, for instance, Harrison, 1993).

[32]This was the case for Japan in the 17th-19th centuries, the Russian Empire under the rule of tsar Nicolas I, China in the 14th-19th centuries, the Soviet Union, and it is still the case for modern Cuba and North Korea. All these regimes experienced severe economic and technological backwardness as a result of limited interactions with foreign economies.

[33]Isolationism can result in deterioration of bilateral diplomatic relation, which can, in turn, negatively affect other forms of cooperation between the involved economies. For instance, Pollins (1989a) and (1989b) provides an empirical evidence on relation between bilateral trade and diplomacy. He argues that countries with better diplomatic relations have closer trade connections. A long-term diplomatic conflict can also result in a lower level of foreign investment into conflicting economies. Hayakawa, Kimura and Lee (2011) emphasize external conflicts as one of the main negative determinants of the FDI level. As FDI is an important channel of technological spillover, a threat of a conflict can therefore lower the spillover effect. Guiso, Sapienza and Zingales (2009) argue that nations which trust each other also tend to invest more into each other's economies. Bottazzi, Da Rin and Hellmann (2010) show that a more trusted country has better opportunities to attract venture capital from a trusting economy. Since political conflict can undermine the level of trust among the conflicting nations, the presence of a conflict can therefore have a negative impact on the willingness of involved nations to invest into each other's economies. As a result, the spillover of knowledge from a more developed country to a less developed one can become lower.

Nevertheless, because of high oil prices during most of 1970s, as well as in the first half of 1980s, the Soviet regime was able to satisfy basic needs of the majority of the Soviet citizens. However, this became difficult when oil prices declined in mid-80s. The latter resulted in mass protests against the communist rule. In 1991 the Soviet regime was displaced.

In this section, we add technological diffusion to the Solow model to show how a possibility of technological spillover increases per capita income in the steady-state. In the absence of technological diffusion economic growth is instead slow, and therefore the steady-state level of per capita income is lower compared to the economy with technological adoption. However, as a careful consideration of the effect of isolationism requires a separate study, we restrict our analysis of the costs of isolationism to discussion.

We extend our baseline model and allow Home to adopt foreign technologies. The latter possibility is captured in the following equation, which corresponds to Acemoglu (2008):

$$\frac{\partial A^H(t)}{\partial t} = \left(A^F(t) - A^H(t)\right)\mu + gA^H(t) \tag{2.26}$$

The first term on the right-hand side of equation (2.26), i.e. $\left(A^F(t) - A^H(t)\right)\mu$, reflects the improvement to the existing technology that is brought about by diffusion, where $0 \leq \mu \leq 1$ is the rate of technological adoption. The other term, i.e. $gA^H(t)$, captures instead the innovative component of technological progress, where g corresponds to the rate of innovation. Therefore, Home's technology improves as a result of two different processes: first, Home copies foreign technologies, and second, it develops new technologies itself. As in the previous section, the rate of innovation g is assumed to be the same in two economies, Home and Foreign.

Capital is accumulated according to a standard process:

$$\frac{\partial \hat{k}(t)}{\partial t} = s\hat{k}^{\eta}(t) - (\delta + \lambda)\,\hat{k}(t)$$

The only difference between this equation and its analog from the previous section, i.e. equation (2.4), is that now the rate of technological progress corresponding to λ is equal to $\mu\frac{1}{a(t)} + (g - \mu)$, where $a(t) = \frac{A^H(t)}{A^F(t)}$, while in the economy without technological diffusion it was instead equal to g.[34] The term $a(t) = \frac{A^H(t)}{A^F(t)}$ captures the rate of technological backwardness of the home economy, which diminishes over time as a result of technological diffusion.

In Appendix C.2 we show that a positive rate of diffusion μ implies that the level of technology in Home catches up with the one in Foreign, i.e. $a(t) = 1$, or $A^H(t) = A^F(t)$. As the home economy catches up with the leading technological frontier $A^F(t)$, its steady-state level of technology $A^H(t)$ therefore becomes equal to $A^F(0)e^{gt}$ instead of $A^H(0)e^{gt}$ in the case of no diffusion. Moreover, as a result of technological adoption, the steady-state level of per capita income also becomes larger, since $A^F(0) > A^H(0)$:[35]

$$y(t) = \beta^{\frac{1}{1-\eta}} A^F(0)e^{gt} \left(\frac{\delta + g}{s}\right)^{\frac{\eta}{\eta-1}} \tag{2.27}$$

Assume that isolationism affects the rate of diffusion μ. In particular, let us consider the diffusion rate μ as a function of θ, representing a decision on isolationism, which was introduced in equation (2.10). For simplicity, assume the following link between μ and θ:

$$\mu(\theta) = \begin{cases} 0 & \theta = \theta^I \\ & if \\ \overline{\mu} > 0 & \theta = \theta^{NI} \end{cases} \tag{2.28}$$

Condition (2.28) implies that under isolationism Home citizens can't copy foreign technologies, and, as a result, the rate of technological diffusion $\mu(\theta^I)$ equals to 0. As it follows from equation (2.27), in this case Home ends up having the same steady-state levels of technology $A^H(t) = A^H(0)e^{gt}$ and per capita output $y(t)$[36] as in the previous section where a possibility of diffusion was not considered. The steady-state level of

[34] This result is derived in Appendix C.1.

[35] For the proof of this result see also Appendix C.2.

[36] Where $y(t) = \beta^{\frac{1}{1-\eta}} A^H(0)e^{gt} \left(\frac{\delta+g}{s}\right)^{\frac{\eta}{\eta-1}}$

per capita income therefore becomes lower if isolationist policy is introduced. If there is no isolationism, i.e. if $\theta = \theta^{NI}$, then $\mu(\theta^{NI})$ is equal to a positive constant $\overline{\mu}$ and, thus, the steady-state level of technology in Home $A^H(t)$ catches up with the level of technology in Foreign $A^H(t)$.

We therefore notice the important difference with the discussion in the previous section. There, isolationism was immaterial for economic growth, as economic growth affected isolationism, but not vice versa. In this section, the influence is instead two-sided: economic performance of the home economy affects the regime's decision to introduce isolationism, and, on the contrary, isolationist policy influences economic growth.

As isolationism results in a lower level of per capita output compared to the case of no isolationism, its implementation becomes costly for the economy. If the level of output per capita remains relatively low because of slow growth, then a negative shock can result in adverse consequences for a large group of individuals, as their incomes might decline below a particular minimal threshold. A natural disaster, a technological cataclysm, a mistake in a policy, a drop in the price level of a key exported commodity, or any other negative macro shock, can lead to a shortage of basic consumption goods, mass homelessness, etc. There are many historical illustrations available. China during the Great Leap Forward (see, for instance, Li and Yang, 2005), a policy which was introduced by Chairman Mao to increase the share of industrial sector in the economy, was designed with significant flaws, which caused millions of deaths all over China. The inefficiency of North Korean agriculture and its inability to provide food in sufficient amounts for North Koreans resulted in hundreds of thousands of died because of hunger in mid-1990s.[37] In the Soviet Union a sharp drop in oil prices in mid-1980s led to food shortages. Chronic deficits in Soviet Russia resulted in mass protests in the late 1980s and the Soviet regime collapsed shortly.

Therefore, as a relatively poor country is more vulnerable to negative shocks, it can become a place of significant political turbulence, which can create threats to political

[37] http://news.bbc.co.uk/2/hi/asia-pacific/281132.stm

stability of the ruling regime. Higher growth rates can thus be very important for the ruling regime, as with faster income growth the economy has better chances to reach higher levels of income before a negative shock hits the economy.

As a final illustration to our discussion we briefly mention the history of modern China. Under the rule of Chairman Mao, China practiced isolationism and experienced significant economic turmoil, which resulted in multiple losses of lives. In terms of our model, the latter can be considered as the effect of a negative macro shock. After Mao's death, Deng Xiaoping improved institutions, opened the economy, and therefore enhanced the opportunity to adopt foreign technologies. The latter was followed by high growth rates and larger incomes, which resulted in a higher legitimacy of the ruling Communist Party.

2.4 Conclusion

In this chapter, we consider a political regime which derives private benefits from maintaining low-quality institutions. As long as the quality of institutions remains low, the economy can not catch up with a more developed foreign country. As citizens consider the latter as a reference economy, they might turn against the regime in power since their incomes remain persistently lower compared to the ones in the foreign economy. To prevent political unrest, the regime in power can strategically isolate the economy and therefore eliminate the opportunity to collect information about the living standards in the foreign country.

We first introduce a baseline model where we assume no technological diffusion from the more developed foreign country to the low-developed home economy. In the context of a Solow growth model, we show that the most restrictive forms of censorship, as political isolationism, are more likely to be implemented if a country is a technological or institutional laggard, i.e. if the reference economy is more developed than the home country considering the level of technology and the quality of institutions. Isolationism is also more likely to occur if the home economy is less inequal than the foreign one. Finally, the chance for isolationism is higher when collecting information about the reference foreign economy is less costly. These findings are consistent with particular episodes from the history of socialist dictatorships, such as the Soviet Union, GDR, Cuba and North Korea, where isolationism was/is used.

We proceed with a discussion of the costs of censorship, and suggest how do these costs might result in a slower pace of technological development and potential political turbulence. We assume that isolationism reduces the level of technological diffusion, and, as a consequence, the speed of technological development, as well as output growth, become lower. As a result of low growth rates, a substantial part of population can stay comparatively poor and therefore sensitive to negative shocks which might potentially hit the economy. As a consequence of such a shock incomes can end up falling below a particular minimal threshold, which might result in political unrest and a regime change. The ruling regime therefore has incentives to avoid using isolationism and instead improve the quality of institutions. The latter finding can be illustrated with the history of modern China, which transited from a more restrictive isolationist regime under the rule of Mao Zedong to a less restrictive one under his successor, Deng Xiaoping.

2.5 Appendices

2.5.1 Appendix A.1

As the production function has a Cobb-Douglas form, the output per unit of effective labor can therefore be written as follows:

$$\hat{y}(t) = \hat{k}^{\eta}(t)$$

The level of capital per unit of effective labor, in turn, is equal to $\hat{k}(t) = \frac{K(t)}{\overline{A}(t)L}$, and therefore the level of output per effective labor unit is $\hat{y}(t) = \frac{Y(t)}{\overline{A}(t)L}$.

As $g = \frac{\frac{\partial \bar{A}(t)}{\partial t}}{\bar{A}(t)} = \frac{\beta^{\frac{1}{1-\eta}} \frac{\partial A(t)}{\partial t}}{\beta^{\frac{1}{1-\eta}} A(t)} = \frac{\frac{\partial A(t)}{\partial t}}{A(t)}$, a solution for $A(t)$ is equal to $A(0)e^{gt}$, where $A(0)$ corresponds to the initial state of technology in the economy.

Given no population growth, differentiation of $\hat{k}(t)$ with respect to t results in the following expression:

$$\frac{\partial \hat{k}(t)}{\partial t} = \frac{\frac{\partial K(t)}{\partial t}\overline{A}(t)L - \frac{\partial \overline{A}(t)}{\partial t}K(t)L}{\left(\overline{A}(t)L\right)^2} = \frac{\frac{\partial K(t)}{\partial t}}{\overline{A}(t)L} - g\hat{k}(t) \tag{2.29}$$

As $\frac{\partial K(t)}{\partial t} = sY(t) - \delta K(t)$, equation (2.29) can, thus, be rewritten as follows:

$$\frac{\partial \hat{k}(t)}{\partial t} = \frac{sY(t) - \delta K(t)}{\overline{A}(t)L} - g\hat{k}(t) = s\hat{k}^{\alpha}(t) - (\delta + g)\,\hat{k}(t)$$

2.5.2 Appendix A.2

First, we discuss the technical result which we use in Section 2.2.3. This result claims that $\frac{\overline{\gamma}+\gamma}{2} = \frac{1}{L}$.

To begin with, we consider the case of egalitarian income distributions. Assume that in a particular society consisting of L[38] individuals, everyone receives the same

[38]Where L is finite.

income share $\gamma = \frac{1}{L}$.

Next, assume that the ruling regime decides to redistribute income shares to create a cohort of relatively poor individuals, as well as a cohort of relatively rich citizens.

Assume also that $\gamma_{i+1} - \gamma_i = d$ for $i = 1, ...L - 1$, where $d > 0$.

If $\gamma_1 = \underline{\gamma}$ then one can derive the following result:

$$\gamma_L = \underline{\gamma} + (L-1)\,d = \overline{\gamma} \tag{2.30}$$

We then sum all the income shares up:

$$\gamma_1 + ... + \gamma_L = \underline{\gamma} + ... + \underline{\gamma} + (L-1)\,d =$$

$$= L\underline{\gamma} + \frac{L-1}{2}\left(2d + (L-2)\,d\right) =$$

$$= L\underline{\gamma} + \frac{L-1}{2}Ld = L\left(\underline{\gamma} + \frac{L-1}{2}d\right) = L\left(\frac{\underline{\gamma} + \underline{\gamma} + (L-1)\,d}{2}\right)$$

To derive the latter result, we used the definition of the sum of a finite arithmetic progression.

As all shares sum up to 1, we can derive the following expression:

$$\gamma_1 + ... + \gamma_L = L\left(\frac{\underline{\gamma} + \underline{\gamma} + (L-1)\,d}{2}\right) = 1 \tag{2.31}$$

We combine equations (2.30) and (2.31) to receive the planned result:

$$L\left(\frac{\underline{\gamma} + \overline{\gamma}}{2}\right) = 1$$

or, alternatively,

$$\frac{\overline{\gamma} + \underline{\gamma}}{2} = \frac{1}{L} \tag{2.32}$$

If one needs to use a different income distribution implying a different value of d, and if, in addition, L stays constant, then one can notice that equation (2.32) holds again.

We now consider a particular procedure which the ruling regime implements to run the income distribution policy. First, the regime in power takes a value ε from one individual and transfers this value to another individual. The former individual is then ranked as the poorest citizen, while the latter is instead considered as the richest one. After that, the regime takes a value which is smaller than ε from an individual who is then considered as a slightly richer one than the poorest citizen and transfers it to a person who is then considered as a slightly poorer one than the richest individual, etc.

As a result, the difference in income shares between the richest and the poorest individuals is as large as $\gamma_L - \gamma_1 = \overline{\gamma} - \underline{\gamma} = 2\varepsilon$, the difference between the second richest and the second poorest individuals is, respectively, equal to $\gamma_{L-1} - \gamma_2 = 2\varepsilon - 2d$, the next difference is equal to $\gamma_{L-2} - \gamma_3 = 2\varepsilon - 4d$, and so on.

One can notice that the index belonging to the first term on the left-hand side of the above sequence starts from the highest number L and then reduces, while index belonging to the second term starts instead from 1 and goes up. Indexes converge at $\frac{L}{2}$, and thus we can conclude that $\gamma_{L-\frac{L}{2}} - \gamma_{\frac{L}{2}} = 0$. Therefore, $2\varepsilon - Nd = 0$ or $d = \frac{2\varepsilon}{N}$. Since ε reflects a particular income distribution policy, which affects the level of d, then the value of d also reflects the same income distribution policy.

In this work we assume that L is large enough, and therefore we can use the properties of the continuous uniform distribution function to derive the required results.

In this Appendix we also prove that from

$$\overline{\gamma}^i = \frac{2}{L} - \underline{\gamma}^i, i = H, F \tag{2.33}$$

it follows that

$$\overline{\gamma}^H - \overline{\gamma}^F = \underline{\gamma}^F - \underline{\gamma}^H \tag{2.34}$$

We can see that the difference between the uppermost point in the domain of γ^i

and its lowermost point is equal to the following expression:

$$\overline{\gamma}^i - \underline{\gamma}^i = \frac{2}{L} - \underline{\gamma}^i - \underline{\gamma}^i = \frac{2}{L} - 2\underline{\gamma}^i = 2\left(\frac{1}{L} - \underline{\gamma}^i\right) \tag{2.35}$$

where $i = H, F$, and $\overline{\gamma}^i$ is the uppermost point in the set of realizations of γ^i, while $\underline{\gamma}^i$is instead the lowermost point belonging to the same set.

As both distributions of $\gamma^i, i = H, F$ are characterized by the same mean $\frac{1}{L}$, then the upper and the lower bounds of income shares distributions in Home and in Foreign are related to each other as follows:

$$\frac{\overline{\gamma}^H + \underline{\gamma}^H}{2} = \frac{\overline{\gamma}^F + \underline{\gamma}^F}{2} \tag{2.36}$$

and therefore we can conclude the following:

$$\overline{\gamma}^H + \underline{\gamma}^H = \overline{\gamma}^F + \underline{\gamma}^F \tag{2.37}$$

or, alternatively,

$$\overline{\gamma}^H - \overline{\gamma}^F = \underline{\gamma}^F - \underline{\gamma}^H \tag{2.38}$$

2.5.3 Appendix B.1

Consider a particular value $\omega^H = F\left(\gamma^H\right)$ belonging to the vertical axis in Figure 2. Given this value, we can find the respective income share in Home, which is equal to γ^H. As the share of income γ follows a uniform distribution, and the upper and the lower bounds of the share γ in Home are equal to $\overline{\gamma}^H$ and $\underline{\gamma}^H$ respectively, we conclude that $\omega = \frac{\gamma^H - \underline{\gamma}^H}{\overline{\gamma}^H - \underline{\gamma}^H}$.

Similarly, we can derive the respective value of ω^F for the foreign country: $\omega^F = \frac{\gamma^F - \underline{\gamma}^F}{\overline{\gamma}^F - \underline{\gamma}^F}$.

Equalizing these two values results in the following expression:

$$\frac{\gamma^H - \underline{\gamma}^H}{\overline{\gamma}^H - \underline{\gamma}^H} = \frac{\gamma^F - \underline{\gamma}^F}{\overline{\gamma}^F - \underline{\gamma}^F} \tag{2.39}$$

From the previous discussion we know that $\frac{\overline{\gamma}^i + \underline{\gamma}^i}{2} = \frac{1}{L}$, where $i = H, F$, and the upper bound in the domain of γ^i, which is $\overline{\gamma}^i$, is as larger as the following: $\overline{\gamma}^i = \frac{2}{L} - \underline{\gamma}^i$, $i = H, F$.

After substituting the latter result into equation (2.39), we obtain the following expression:

$$\frac{\gamma^H - \underline{\gamma}^H}{\frac{1}{L} - \underline{\gamma}^H} = \frac{\gamma^F - \underline{\gamma}^F}{\frac{1}{L} - \underline{\gamma}^F} \tag{2.40}$$

After rearranging, we receive the following result:

$$\frac{\gamma^H \left(\frac{1}{L} - \underline{\gamma}^F\right)}{\frac{1}{L} - \underline{\gamma}^H} - \frac{1}{L} \frac{\left(\underline{\gamma}^H - \underline{\gamma}^F\right)}{\frac{1}{L} - \underline{\gamma}^H} = \gamma^F \tag{2.41}$$

Finally, the next trick helps to reach the desired expression:

$$\frac{\gamma^H \left(\frac{1}{L} - \underline{\gamma}^H + \underline{\gamma}^H - \underline{\gamma}^F\right)}{\frac{1}{L} - \underline{\gamma}^H} - \frac{1}{L} \frac{\left(\underline{\gamma}^H - \underline{\gamma}^F\right)}{\frac{1}{L} - \underline{\gamma}^H} =$$

$$= \gamma^H + \frac{2\left(\gamma^H - \frac{1}{L}\right)\left(\underline{\gamma}^H - \underline{\gamma}^F\right)}{\overline{\gamma}^H - \underline{\gamma}^H} = \gamma^F \tag{2.42}$$

In addition, as $0 \leq F(\gamma) \leq 1$, one needs to impose the following restriction:

$$\frac{\gamma^i - \underline{\gamma}^i}{\overline{\gamma}^i - \underline{\gamma}^i} \leq 1, \text{or } \gamma^i \leq \overline{\gamma}^i \text{ and } \underline{\gamma}^i \leq \gamma^i, \text{ where } i = F, H$$

2.5.4 Appendix B.2

To start from, we first consider expression (2.19):

$$\gamma^H \left(\beta^H\right)^{\frac{1}{1-\eta}} A^H(0) = \left(\gamma^H + \frac{2\left(\gamma^H - \frac{1}{L}\right)\left(\underline{\gamma}^H - \underline{\gamma}^F\right)}{\overline{\gamma}^H - \underline{\gamma}^H}\right) \left(\beta^F\right)^{\frac{1}{1-\eta}} A^F(0)$$

As $\frac{1}{L} = \frac{\overline{\gamma}^H + \underline{\gamma}^H}{2}$, equation (2.19) can be rewritten as follows:

$$\gamma^H \left(\beta^H\right)^{\frac{1}{1-\eta}} A^H(0) = \left(\gamma^H + \frac{\left(\gamma^H - \frac{1}{L}\right)\left(\underline{\gamma}^H - \underline{\gamma}^F\right)}{\frac{1}{L} - \underline{\gamma}^H}\right) \left(\beta^F\right)^{\frac{1}{1-\eta}} A^F(0)$$

We derive the following result from the above expression:

$$\widehat{\gamma}^H = \frac{\frac{1}{L}\left(\underline{\gamma}^F - \underline{\gamma}^H\right)\left(\beta^F\right)^{\frac{1}{1-\eta}} A^F(0)}{\left(\frac{1}{L} - \underline{\gamma}^H\right)\left(\beta^H\right)^{\frac{1}{1-\eta}} A^H(0) - \left(\frac{1}{L} - \underline{\gamma}^F\right)\left(\beta^F\right)^{\frac{1}{1-\eta}} A^F(0)} \tag{2.43}$$

We can use the following result from Appendix A2:

$$\frac{1}{L} = \frac{\overline{\gamma}^H + \underline{\gamma}^H}{2} = \frac{\overline{\gamma}^F + \underline{\gamma}^F}{2}$$

which can, alternatively, be represented as

$$\overline{\gamma}^H - \overline{\gamma}^F = \underline{\gamma}^F - \underline{\gamma}^H$$

to derive the following equation:

$$\underline{\gamma}^F - \underline{\gamma}^H = \frac{2(\underline{\gamma}^F - \underline{\gamma}^H)}{2} = \frac{\underline{\gamma}^F - \underline{\gamma}^H + \overline{\gamma}^H - \overline{\gamma}^F}{2} =$$

$$= \frac{\overline{\gamma}^H - \underline{\gamma}^H - (\overline{\gamma}^F - \underline{\gamma}^F)}{2} \tag{2.44}$$

To proceed, we substitute this result into equation (2.43) and again use the fact that

$$\frac{1}{L} = \frac{\overline{\gamma}^H + \underline{\gamma}^H}{2} = \frac{\overline{\gamma}^F + \underline{\gamma}^F}{2}$$

to receive the following equation:

$$\widehat{\gamma}^H = \frac{1}{L} \frac{\left(\left(\overline{\gamma}^H - \underline{\gamma}^H\right) - \left(\overline{\gamma}^F - \underline{\gamma}^F\right)\right)\left(\beta^F\right)^{\frac{1}{1-\eta}} A^F(0)}{\left(\overline{\gamma}^H - \underline{\gamma}^H\right)\left(\beta^H\right)^{\frac{1}{1-\eta}} A^H(0) - \left(\overline{\gamma}^F - \underline{\gamma}^F\right)\left(\beta^F\right)^{\frac{1}{1-\eta}} A^F(0)} \tag{2.45}$$

Dividing and multiplying equation (2.45) by $\left(\overline{\gamma}^F - \underline{\gamma}^F\right)\left(\beta^F\right)^{\frac{1}{1-\eta}} A^F(0)$ gives us the final expression:

$$\widehat{\gamma}^H = \frac{1}{L}\frac{\frac{\overline{\gamma}^H - \underline{\gamma}^H}{\overline{\gamma}^F - \underline{\gamma}^F} - 1}{\frac{\overline{\gamma}^H - \underline{\gamma}^H}{\overline{\gamma}^F - \underline{\gamma}^F}\left(\frac{\beta^H}{\beta^F}\right)^{\frac{1}{1-\eta}}\frac{A^H(0)}{A^F(0)} - 1}$$

2.5.5 Appendix B.3

Let $\frac{\left(\bar{\gamma}^H - \underline{\gamma}^H\right)}{\left(\bar{\gamma}^F - \underline{\gamma}^F\right)} = x$, $\left(\left(\frac{\beta^H}{\beta^F}\right)^{\frac{1}{1-\eta}}\frac{A^H(0)}{A^F(0)}\right) = B$ and $\frac{1}{L} = b$.

We notice that equation (2.20) can be rewritten as follows:

$$y = b\left(\frac{x-1}{Bx-1}\right) \tag{2.46}$$

where $B > 1$, as $\left(\frac{\beta^H}{\beta^F}\right)^{\frac{1}{1-\alpha}}\frac{A^H(0)}{A^F(0)} < 1$ by assumption.

It, then, follows that a derivative of y with respect to x is equal to the following:

$$\frac{\partial y}{\partial x} = b\frac{\partial\left(\frac{x-1}{Bx-1}\right)}{\partial x} = b\frac{Bx-1-Bx+B}{\left(Bx-1\right)^2} = b\frac{B-1}{\left(Bx-1\right)^2} < 0 \tag{2.47}$$

Therefore, the threshold share $\widehat{\gamma}^H$ decreases when income inequality in the home country increases, or, alternatively, when income inequality in the foreign country decreases.

A derivative of y with respect to B corresponds to the following expression:

$$\frac{\partial y}{\partial B} = b\frac{\partial\left(\frac{x-1}{Bx-1}\right)}{\partial B} = b\frac{x\left(1-x\right)}{\left(Bx-1\right)^2} \tag{2.48}$$

The sign of the above expression depends on whether the value of x is larger or smaller than 1.

If $x = \frac{\left(\bar{\gamma}^H - \underline{\gamma}^H\right)}{\left(\bar{\gamma}^F - \underline{\gamma}^F\right)} > 1$, then $\frac{\partial y}{\partial B} < 0$, and if instead $x = \frac{\left(\bar{\gamma}^H - \underline{\gamma}^H\right)}{\left(\bar{\gamma}^F - \underline{\gamma}^F\right)} < 1$, then

$\frac{\partial y}{\partial B} > 0$.

The value of B increases when β^H increases, β^F decreases, $A^H(0)$ increases and $A^F(0)$ instead decreases.

2.5.6 Appendix B.4

To prove the first part of Proposition 2,[39] we use equations (2.20), (2.21) and (2.22).

Consider the effect of a higher T. We rewrite equation (2.22) as follows

$$L^o = \frac{f_1\big(L, A^H(0), \beta^H, A^F(0), \beta^F, \overline{\gamma}^H, \underline{\gamma}^H, \overline{\gamma}^F, \underline{\gamma}^F\big) -}{\overline{\gamma}^H - \underline{\gamma}^H}$$

$$\frac{-f_2\big(A^H(0), \beta^H, T, \delta, g, s, L, t\big)}{\overline{\gamma}^H - \underline{\gamma}^H} L \tag{2.49}$$

where $f_1\big(L, A^H(0), \beta^H, A^F(0), \beta^F, \overline{\gamma}^H, \underline{\gamma}^H, \overline{\gamma}^F, \underline{\gamma}^F\big)$ corresponds to $\widehat{\gamma}^H$, which is defined in equation (2.20), and $f_2\big(A^H(0), \beta^H, T, \delta, g, s, L, t\big)$ is equal to $\gamma^{th}(t)$, which is, in turn, determined in equation (2.21). We notice that T affects the second term in the large brackets.

From equation (2.21)

$$\gamma^{th}(t) = \frac{T}{L\left(\beta^H\right)^{\frac{1}{1-\eta}} A^H(0) e^{gt} \left(\frac{\delta+g}{s}\right)^{\frac{\eta}{\eta-1}}}$$

it follows that the level of T affects the second term in equation (2.49) positively. Therefore, a higher level of T leads to a reduction in the number of individuals belonging to the opposition.

We notice that $A^F(0)$, β^F , and $\overline{\gamma}^F - \underline{\gamma}^F$ are all belong to the first term of equation (2.49), and, as it follows from Proposition 1, if these parameters become lower, $\widehat{\gamma}^H$ becomes lower as well. This increases the level of popularity of the regime in power.

[39] i.e. the part which cinsiders the case of comparatively higher income inequality in Home.

A higher $\overline{\gamma}^H - \underline{\gamma}^H$ results in a reduction in the level of $\widehat{\gamma}^H$, and moreover, the denominator of equation (2.22) becomes larger. The latter increases the amount of the regime supporters unambiguously.

According to Proposition 1, a higher level of $A^H(0)$ and a higher level of β^H, both result in a reduction in the level of $\widehat{\gamma}^H$. However, from equation (2.21) it follows that they also reduce the second term in equation (2.49), and thus it remains ambiguous which effect dominates. A reduction in the level of $\widehat{\gamma}^H$ increases the number of relatively rich supporters, however, at the same time, a reduction in the level of $\gamma^{th}(t)$ decreases instead the number of the regime supporters among relatively poor individuals.

To prove the second part of Proposition 2,[40] we use equation (2.24):

$$L^o = \frac{\overline{\gamma}^H - f\left(L, A^H(0), A^F(0), \beta^H, \beta^F, \overline{\gamma}^H, \underline{\gamma}^H, \overline{\gamma}^F, \underline{\gamma}^F\right)}{\overline{\gamma}^H - \underline{\gamma}^H} L$$

From Proposition 1 we know that a lower $A^F(0)$ and a lower β^F, a higher $A^H(0)$, a higher β^{LOW} and a higher $\overline{\gamma}^F - \underline{\gamma}^F$, all result in a larger value of $\widehat{\gamma}^H$, and therefore the second term of equation (2.24) increases, which reduces the number of individuals who do not support the regime in power. A lower level of $\overline{\gamma}^H - \underline{\gamma}^H$ results in a higher value $\widehat{\gamma}^H$, and therefore the second term in equation (2.24) increases. Given that $\underline{\gamma}^H = \frac{2}{L} - \overline{\gamma}^H$, the first term in equation (2.24) can be rewritten as $\frac{1}{2}\frac{\overline{\gamma}^H}{\underline{\gamma}^H - \frac{1}{L}}$ and thus we can write the following expression:

$$\frac{\partial\left(\frac{\overline{\gamma}^H}{\overline{\gamma}^H - \frac{1}{L}}\right)}{\partial\, \overline{\gamma}^H} = \frac{\overline{\gamma}^H - \frac{1}{L} - \overline{\gamma}^H}{\left(\overline{\gamma}^H - \frac{1}{L}\right)^2} = -\frac{\frac{1}{L}}{\left(\overline{\gamma}^H - \frac{1}{L}\right)^2} < 0$$

As a consequence, the first term increases when the level of $\overline{\gamma}^H - \underline{\gamma}^H$ decreases. The latter results in ambiguity considering the influence of the level of $\overline{\gamma}^H - \underline{\gamma}^H$ on the number of regime supporters.

[40] i.e. the one which assumes a lower level of income inequality in Home.

Finally, the requirement that $\widehat{\gamma}^H > \gamma^{th}(t)$ was introduced in the second part of Proposition 2, as otherwise there is more ambiguity resulting from a change in parameters' values. For instance, assume that initially $\widehat{\gamma}^H < \gamma^{th}(t)$, and then a positive change in the level of domestic institutions β^H will result in a higher level of $\widehat{\gamma}^H$ and a lower $\gamma^{th}(t)$ at the same time. If condition $\widehat{\gamma}^H < \gamma^{th}(t)$ is still satisfied after this change takes place, then the regime loses popularity, even though it introduces a positive change, which is counterintuitive.

2.5.7 Appendix C.1

With adoption of technologies, technological development in Home is driven by the following equation:

$$\frac{\partial A^H(t)}{\partial t} = \left(A^F(t) - A^H(t)\right)\mu + gA^H(t) = \mu A^F(t) + (g-\mu)A^H(t) \tag{2.50}$$

We can use equation (2.50) to derive the expression for the capital accumulation process:

$$\frac{\partial \hat{k}(t)}{\partial t} = \frac{\frac{\partial K(t)}{\partial t}\overline{A}(t)L - \frac{\partial \overline{A}(t)}{\partial t}K(t)L}{\left(\overline{A}(t)L\right)^2} = \frac{\frac{\partial K(t)}{\partial t}}{\overline{A}(t)L} - \frac{\mu A^F(t) + (g-\mu)\,A^H(t)}{A^H(t)}\hat{k}(t) =$$

$$= \frac{\frac{\partial K(t)}{\partial t}}{\overline{A}(t)L} - \left(\mu\frac{1}{a(t)} + (g-\mu)\right)\hat{k}(t) = s\hat{k}^{\eta}(t) - \left(\delta + \mu\frac{1}{a(t)} + (g-\mu)\right)\hat{k}(t)$$

where $a(t) = \frac{A^H(t)}{A^F(t)}$

2.5.8 Appendix C.2

As in the steady-state $\frac{\partial a(t)}{\partial t} = 0$, we can derive the following result:

$$\frac{\partial a(t)}{\partial t} = \frac{\frac{\partial A^H(t)}{\partial t}A^F(t) - \frac{\partial A^F}{\partial t}(t)A^H(t)}{\left(A^F(t)\right)^2} = \frac{\mu A^F(t) + (g-\mu)A^H(t)}{A^F(t)} - ga(t)$$

$$= \mu + (g - \mu)a(t) - ga(t)$$

or, alternatively

$$\mu\,(1 - a(t)) = 0 \tag{2.51}$$

As $\mu > 0$, equation (2.51) holds if $a(t) = 1$, which implies that $A^H(t) = A^F(t) = A^F(0)e^{gt}$.

The level of technology is larger in the case of technological adoption, as $A^H(t) = A^F(0)e^{gt} > A^H(0)e^{gt}$, and therefore from equation (2.7) it follows that the level of per capita output in Home becomes larger as well.

2.5.9 Appendix C.3

In this part of the current Appendix we are considering the transitional dynamics of the economy with technological diffusion.

Equation (2.50) takes the following form after we differentiate it with respect to t once again:

$$\frac{\partial^2 A^H(t)}{\partial t^2} = \mu \frac{\partial A^F(t)}{\partial t} + (g - \mu)\,\frac{\partial A^H(t)}{\partial t} \tag{2.52}$$

A solution for equation $\frac{\partial A^F(t)}{\partial t} = gA^F(t)$ corresponds to the following expression:

$$A^F(t) = A^F(0)e^{gt} \tag{2.53}$$

Therefore, equation (2.52) can be rewritten as follows

$$\frac{\partial^2 A^H(t)}{\partial t^2} = \mu g\, A^F(t) + (g - \mu)\,\frac{\partial A^H(t)}{\partial t} \tag{2.54}$$

From equation (2.50) one can receive the following result

$$A^F(t) = \frac{\frac{\partial A^H(t)}{\partial t} - (g - \mu)A^H(t)}{\mu} \tag{2.55}$$

One can substitute equation (2.55) into equation (2.54) to receive the following expression:

$$\frac{\partial^2 A^H(t)}{\partial t^2} = g\left(\frac{\partial A^H(t)}{\partial t} - (g-\mu)A^H(t)\right) + (g-\mu)\,\frac{\partial A^H(t)}{\partial t} =$$

$$= (2g-\mu)\,\frac{\partial A^H(t)}{\partial t} - g(g-\mu)A^H(t)$$

or

$$\frac{\partial^2 A^H(t)}{\partial t^2} - (2g-\mu)\,\frac{\partial A^H(t)}{\partial t} + g(g-\mu)A^H(t) = 0 \qquad (2.56)$$

The particular integral of (2.56) is zero, as $g(g-\mu)A^H(t) = 0$.

We, first, need to find a solution of the homogeneous equation which corresponds to equation (2.56):

$$r^2 - (2g-\mu)\,r + g(g-\mu) = 0$$

As a result, we receive the following solutions:

$$r_1 = \tfrac{g+g-\mu-\mu}{2} = g-\mu$$
$$r_2 = \tfrac{g+g-\mu+\mu}{2} = g$$

It follows that

$$A^H(t) = A_1^H e^{(g-\mu)t} + A_2^H e^{gt} \qquad (2.57)$$

When $t = 0$, from equation (2.57) we can derive the following result:

$$A^H(0) = A_1^H + A_2^H$$

$$A_1^H = A^H(0) - A_2^H \qquad (2.58)$$

At $t = 0$ equation (2.50) turns into the following equation:

$$\frac{\partial A^H(t)}{\partial t} = \mu A^F(0) + (g-\mu)A^H(0) \qquad (2.59)$$

And a derivative of equation (2.57) with respect to t, evaluated at $t = 0$, results in the following expression:

$$\frac{\partial A^H(t)}{\partial t} = A_1^H (g - \mu) + A_2^H g \tag{2.60}$$

Setting equations (2.59) and (2.60) equal to each other, and using equation (2.58), gives the following result:

$$(\lambda - \mu) \left(A^H(0) - A_2^H\right) + gA_2^H = \mu A^F(0) + (g - \mu)A^H(0)$$

or, alternatively:

$$(\lambda - \lambda + \mu) A_2^H = \mu A^F(0)$$

and, therefore:

$$A_2^H = A^F(0) \tag{2.61}$$

and

$$A_1^H = A^H(0) - A^F(0) \tag{2.62}$$

Finally, substituting expressions (2.61) and (2.62) into equation (2.57) results in the following equation:

$$A^H(t) = \left(A^H(0) - A^F(0)\right) e^{(g-\mu)t} + A^F(0)e^{gt} \tag{2.63}$$

If $\mu \geq g$, equation (2.63) turns into $A^H(t) = A^F(t)$ in the steady-state.

Chapter 3

Are Educational Reforms Necessarily Growth-Enhancing? Weak Institutions as the Cause of Policy Failures

A vast literature has emphasized the role of human capital as a key determinant of long-term growth (see, for instance, Mincer, 1984, Lucas, 1988, Stokey, 1991, Barro and Lee, 1993 and Barro, 2002). Quantitative estimates by Barro (1998) suggest that on average one additional year of upper-level schooling for males raises the growth rate by 1.2% per year.

At the same time, many papers indicate that the provision of educational services in developing economies operates relatively far away from the efficient frontier (see, for instance, Hanushek, 1995, Glewwe, 1999a), even if these countries spend hundreds of billions dollars every year to support and improve education (see, for instance Glewwe, 2002). In fact PISA[1] (OECD, 2010) results indicate that the vast majority

[1]"PISA (the Programme for International Student Assessment) is an international study that was launched by the OECD in 1997. It aims to evaluate education systems worldwide every three years by assessing 15-year-olds' competencies in the key subjects: reading, mathematics and science. To date

of developing countries perform below the OECD average as far as scores in reading, mathematics and sciences are concerned. This implies that there is a significant potential for improvement in education standards, and much attention has been dedicated in the literature to these issues. For instance, Glewwe (2002) studies what kind of cognitive skills are more relevant for individual income growth. The World Bank (2001) argues that investment in education, which should result in a better educational infrastructure, properly trained teaching staff and equipped classrooms and laboratories, is a policy priority. Thus, a reform of the educational system which is aimed at dealing with the variety of inappropriate practices impeding the transfer of knowledge to young generations and at improving education standards has the potential to be a solution to these problems. In this chapter, we argue though that this type of reform taken in isolation does not necessarily lead to the desired outcomes, and that the results highlighted in the existing literature are driven by a partial equilibrium focus.

To capture the important interaction between demand and supply of human capital we develop a general equilibrium model, in which we show that the equilibrium level of education can fail to adjust to the positive changes introduced by the educational reform. This can be the case when an improvement in the quality of the education system does not lead to an actual increase in the demand for education.

Why can the demand for education be low? In the case of developing economies, the literature has highlighted the role of liquidity constraints, which make it impossible for individuals to choose their education optimally (see Morley and Coady, 2003 or the World Bank, 2001). In this chapter we instead show that even if liquidity constraints are not binding, education opportunities might remain unexploited. We argue that an individual's demand for education depends indirectly on institutional features, as the quality of property rights protection, the risk of expropriation, etc. When property rights are weakly enforced, returns on investments are low, and firms tend to acquire less new capital and technologies. Therefore, if factors of production are complements, employees prefer to invest less in the acquisition of human capital, as the level

over 70 countries and economies have participated in PISA", http://www.oecd.org/pisa/

of a corresponding complementary factor remains low. Thus, if an economy is characterized by poor protection of property rights, then higher education standards can be demanded only if individuals have the opportunity to transfer their human capital to another economy, where the level of technology is higher, and, as a result, the returns on human capital are higher as well. We thus argue that to be successful in bringing about faster growth, an educational reform should be accompanied by an institutional reform, which improves the quality of property rights protection.

Our work thus builds on the literature emphasizing the importance of complementarity between production factors. Following Acemoglu (1994) and Redding (1996) we argue that the investment into one factor of production affects the decision to invest into another factor. Importantly, these papers pay limited attention to what can restrain the accumulation of complementary factors. Our contribution lies in modelling the role of corruption as a key obstacle to the investment into a complementary factor. Our work is therefore also related to the broad literature which links corruption and the quality of institutions to investments and growth. For instance, Mauro (1995) and Mo (2001) provide quantitative estimates of the negative influence of corruption on growth rates. Works by Clarke (2001) and Keefer and Knack (1997), which are closer to our work, show that R&D expenditures increase when the rule of law improves, and the risk of expropriation declines. Hanushek and Woessmann (2008) provide empirical evidence on the complementarity of skills and the quality of economic institutions. However, none of these papers provide a theoretical analysis of how imperfect institutions and, in particular, a high level of corruption affect human capital accumulation.

To fill this gap we develop a model which describes how this complementarity works. In our setting, identical firms combine technology and human capital to produce output. Following Redding (1996), we consider a non-overlapping generations economy where output is shared between firms' owners and employees. When a new generation arrives, firms produce output and invest part of it into the acquisition of a new technology. When young, the employees decide how to allocate their human capital stock, which they inherit from the previous generation, between production and investment in human capital. Education and investment in the new technology result, respectively, in a larger human capital stock and a higher level of technology, which are used to produce output when the generation becomes old. Firms and employee share the same information, and thus the employees can perfectly foresee how much output do the firms plan to invest in a new technology. When firms invest more into new technologies, employees also prefers to acquire more human capital, since the latter will earn a higher return. In this benchmark version of the model, the economy starts by imitating technologies from the leading frontier, and then converges to a steady-state, where it substitutes imitation with innovation.

Empirical evidence, however, suggest that convergence did not take place in the case of many developing countries (see, for instance, Acemoglu, 2008). In some instances, developing economies grow at relatively low rates and end up in non-convergence traps (see, for instance, Acemoglu at al, 2006). To incorporate this possibility, we add imperfect institutions to the baseline model. Following Shleifer and Vishny (1993), we introduce corruption in the economy and assume that firms need to share their profits with bureaucrats.[2] We show that corruption reduces firms' incentives to invest in a new technology, and this affects the economy's ability to catch up with the leading technological frontier. As production factors are complements, employees reduce their investments into human capital in response to a slower pace of technological advancement. Therefore, when an educational reform brings about new opportunities to acquire human capital, it can occur that the level of demand for these opportunities is low.[3] To induce the employees to use these opportunities, the government should encourage firms to invest more in the acquisition of new technologies.

To this end, the government can try to reduce the level of corruption by implement-

[2]Alternatively, we could introduce a manager to the model, assume that he steals a part of a typical firm's profit, and that the judiciary is too weak and corrupt to punish him. This argument has been pursued, for instance, by Boycko, Shleifer and Vishny (1993), Boycko, Shleifer and Vishny (1994), or Shleifer and Vishny (1997).

[3]It can also occur that such a reform reform will result in acquiring more education, if, at the same time, a typical employee can transfer her human capital to another economy where the level of technology is higher, and therefore her skills are in demand. Thus, instead of increasing the stock of domestic human capital, an educational reform might result in emigration of high-skilled individuals.

ing an anti-corruption policy. We argue that tackling corruption might be a solution to the problem of low investment in the acquisition of new technologies and human capital. An effective anti-corruption campaign[4] reduces the level of expenditures on bribes, therefore increasing firms' profits and inducing them to invest more in the acquisition of new technologies. When the level of investment into a new technology increases, employees acquire more human capital, and, as a result, an educational reform becomes more effective.

We thus emphasize that in the presence of corruption, an educational reform aiming to expand supply of high-quality educational services and therefore to increase the level of human capital in the economy can become less effective. As corruption reduces incentives to invest in the acquisition of new technologies, and as technology and human capital are complementary factors of production, the demand for education can decrease below the available level of supply. To avoid this potential imbalance between supply and demand for high-quality education, the government can intervene to induce firms to invest more into new technologies. To this end, the government might try to tackle corruption by introducing an anti-corruption campaign.

The remainder of the chapter is organized as follows. Section 2 introduces our baseline growth model. In Section 3 we incorporate corruption into the model and show how does it affect the effectiveness of an educational reform. In Section 4, we discuss the effect of an anticorruption policy on the acquisition of new technologies and human capital accumulation. Section 5 provides a summary.

3.1 The Model

In the following section we present our benchmark developing economy which invests in the acquisition of new technology and accumulates human capital. So far, we consider a low level of education supply as the only impediment to economic growth. To

[4]The literature which focuses on possible avenues of reducing the level of corruption is vast (see, for instance, Reinikka and Svensson, 2005, or OECD, 2005), and therefore surveying it is beyond this chapter's scope.

remove this barrier, the government introduces an educational reform. As a result, the level of human capital increases, as well as the rates of economic growth.

3.1.1 Production

In this section, we present our baseline growth model which builds upon Redding (1996). We consider a non-overlapping generations economy,[5] where each generation lives for two periods, $j = 1, 2$. In period 1 a new generation is born, produces output and makes investment decisions. In period 2 the same generation produces output once again and passes away.

Each generation is made up of M employees working at N identical firms, and N individuals, each owning one firm[6]. Every firm combines technology and human capital to produce the final output. In each period $j = 1, 2$, a typical firm produces the following level of output:

$$Y_{t,j} = A_{t,j}^{\theta} \left(h_{t,j} m_t\right)^{1-\theta} \tag{3.1}$$

where t represents a particular generation, $Y_{t,j}$ corresponds to the level of output which is produced in period $j = 1, 2$ by individuals belonging to generation t and employed at the representative firm, $A_{t,j}$ is the level of technology which is identical for every firm, $h_{t,j}$ reflects the amount of human capital per employee, and m_t denotes the number of employees per firm, which is also the same for every firm,[7] as well as for every period

[5]We use a non-overlapping generations framework, as we consider the evolution of two different production factors, and it is of key importance for us to make sure that the levels of these factors evolve synchronically. In the presence of a standard overlapping generations framework only the young generation has incentives to accumulate a particular factor of production, while the old generation, by contrast, prefers to consume instead of investing. Therefore, a standard overlapping generations model does not fit with our goals.
Alternatively, we could use an overlapping generation framework where each generation lives for three periods. However, the latter increases the number of overlapping cohorts, as well as the number of production factors. As a 3-period model is too difficult to analyze, we use an alternative dynamic framework where the economy is instead represented as a collection of non-overlapping two-period optimization problems.

[6]In the baseline version of our model we could consider an alternative economy where a single employee works for a single owner. However, as later in the chapter we show how restricted competition can help solving the problem of low investment, we need to introduce more than one firm, and therefore more than employee and one owners.

[7]As all the firms are identical and therefore are equally attractive for employees, the labor force is

$j = 1, 2.$[8]

The entire generation t therefore produces as much output as follows:

$$Y_t = N \sum_{j=1}^{2} A_{t,j}^{\theta} \left(h_{t,j} m_t\right)^{1-\theta} \tag{3.2}$$

The representative owner provides his workers with technology $A_{t,j}$ to produce output, and receives a payoff which is as large as a share $0 \leq \beta \leq 1$ of his firm's production level $Y_{t,j}$, $j = 1, 2.$[9] This sharing rule implies that both, the owner and the employees, can be considered as stakeholders, and therefore they all benefit when their firm produces a higher level of output.[10]

We assume that technology is transferred from the previous generation to the following one.[11] The presence of this intergenerational spillover effect implies that in

uniformly distributed among the firms, which implies that $m_t = \frac{M}{N}$.

[8] All the variables belonging to equation (3.2) do not have a subscript indicating that they correspond to a particular firm, as their values are identical for all N firms, and therefore there is no need to emphasize any difference among the firms by introducing a subscript.

[9] The workers instead receive $(1-\beta)\, Y_{t,j}$.

[10] β could be interpreted as an outcome of the Nash bargaining.

Moreover, this sharing rule also satisfies the conventional product sharing rule, where factors of production are paid according to their marginal contributions.

To show that the latter is indeed the case, we first decompose a particular level of output Y, which is produced using a Cobb-Douglas technology, into corresponding factor revenues:

$$Y = MPX_1 X_1 + MPX_2 X_2$$

where $MPX_n, n = 1, 2$ reflects the marginal contribution of factor $X_n, n = 1, 2$.

We notice that the income share corresponding to factor X_1 is equal to $\beta_{X1} = \frac{MPX_1 X_1}{Y}$, and therefore we can rewrite Y as

$$Y = \beta_{X1} Y + (1 - \beta_{X1})\, Y$$

Scaling the level of production by a positive constant δ will result in a different level of output satisfying the following decomposition:

$$\delta Y = \frac{MPX_1 \delta X_1}{\delta Y} \delta Y + \frac{MPX_2 \delta X_2}{\delta Y} \delta Y$$

We notice that $\frac{MPX_1 \delta X_1}{\delta Y} = \frac{MPX_1 X_1}{Y} = \beta_{X1}$. It therefore follows that β_{X1} is a constant function of δ and represents a particular output sharing rule.

[11] This intertemporal spillover effect can be interpreted as a bequest which the previous generation

period 1, a firm belonging to generation t uses the following technology to produce $Y_{t,1}$:

$$A_{t,1} = A_{t-1,2} \tag{3.3}$$

where $A_{t-1,2}$ is the level of technology which was used by generation $t-1$ in period 2.

Following Lucas (1988) and Redding (1996) we assume that human capital is also transferred from the preceding generation to the next one, and therefore a new generation t uses the following stock of human capital in period 1:

$$H_{t,1} = (1-\delta)H_{t-1,2} \tag{3.4}$$

where $0 < \delta < 1$ reflects the rate of intertemporal human capital depreciation.[12] We assume that all young members of generation t receive the same share in the aggregate human capital stock $(1-\delta)H_{t-1,2}$, which is inherited from the previous generation $t-1$. We therefore indicate that the level of wealth is equally distributed among the employees.[13]

3.1.2 Investment

In period 1 the representative owner chooses whether to retain the inherited technology $A_{t,1}$ or to improve upon it. The owner can improve upon the old technology in the following way:

$$A_{t,2} = \eta\left(\alpha_t\right) A^L_{t,1} + \left(1-\eta\left(\alpha_t\right)\right) A_{t,1} \tag{3.5}$$

Equation (3.5) reflects a possibility of *adoption* from exogenously given frontier

leaves to its successors.

[12]We assume that δ is sufficiently small, and therefore when a typical employee belonging to generation t invests in the acquisition of additional human capital, her final level of human capital is larger than the one of the representative employee from generation $t-1$ in period $j=2$.

[13]This assumption facilitates aggregation of the most important variables of our model. A different assumption would complicate aggregation and therefore the whole analysis of the model would become more difficult without adding any important results.

technology. We therefore consider technology as a stock of knowledge, which can be extended if a firm "buys" additional knowledge from the leading technological frontier. To see that the latter is indeed the case, we can rewrite $A_{t,2}$ as the sum of the old technology which is represented by $A_{t,1}$ and a particular share of the distance between the old technology and the leading frontier $\eta(\alpha_t)\left(A_{t,1}^L - A_{t,1}\right)$, where $0 \leq \eta(\alpha_t) \leq 1$, $\eta'(\alpha_t) > 0$, $\eta''(\alpha_t) < 0$, $\eta(0) = 0$, $A_{t,1}^L$ corresponds to the state of the world technological frontier in period 1, which evolves at an exogenously given rate g, and $0 \leq \alpha_t \leq 1$ reflects the share of income which the representative firm invests into a new technology. The level of technology in period $j = 2$, i.e. $A_{t,2}$, can thus be represented as $A_{t,2} = A_{t,1} + \eta(\alpha_t)\left(A_{t,1}^L - A_{t,1}\right)$, which, after minor manipulations, transforms into equation (3.5).

Even though in the presence of technological adoption the level of domestic technology $A_{t,1}$ can approach the leading frontier, it, however, can not converge to the world frontier entirely. Instead, the level of domestic technology always remains below the frontier technology level.[14] To allow for convergence, we assume that the economy substitutes imitation with innovation as soon as the level of $A_{t,1}$ becomes sufficiently high.[15] Before the level of technology reaches this particular threshold, firms prefer to invest into technological adoption, but as soon as firms reach this level of technology, they substitute imitation with innovation. This assumption is in line with the literature on technological progress and productivity growth. For instance,

[14]To show that the latter is indeed the case, we use the steady-state version of the adoption equation (3.5), which implies that as long as imitation of foreign technologies remains the only source of technological evolution, the level of domestic technology grows at the same rate as the leading frontier, i.e. at a rate g (we will prove this result shortly):
$A_{t,1}(1+g) = \eta(\alpha) A_t^L + (1-\eta(\alpha)) A_{t,1}$
where α is the steady-state level of α_t.
After rearranging, this equation transforms into the following expression:

$$A_{t,1} = \frac{\eta(\alpha) A_t^L}{g + \eta(\alpha)}$$

which, as $\frac{\eta(\alpha)}{g+\eta(\alpha)} < 1$, and as long as $g > 0$, implies that $A_{t,1} < A_t^L$.

[15]Starting from a particular instant, innovation should therefore lead to a faster pace of technological evolution compared to immitation. We remind that, as a result of the adoption, the steady-state level of technology evolves at the rate g, corresponding to the growth rate of the frontier technology.

Acemoglu et al, (2006) argue that at the earlier stages of development an economy benefits more from the state of the world technology, while at a higher stage of technological maturity, when the economy is close to the world technological frontier, innovations instead become comparatively more important. Equation (3.6) shows how the level of technology $A_{t,1}$ which was inherited from the previous generation $t-1$ can be improved when the representative firm *innovates*:

$$A_{t,2} = \mu\lambda\left(\alpha_t\right)A_{t,1} + \left(1-\mu\right)A_{t,1} \tag{3.6}$$

From equation (3.6) it follows that innovations come with a constant success probability μ, and a new innovation increases the level of technology $A_{t,1}$by a factor $\lambda\left(\alpha_t\right) \geq 1$, which is characterized by the following properties: $\lambda'\left(\alpha_t\right) > 0$, $\lambda''\left(\alpha_t\right) < 0$, $\lambda\left(0\right) = 1$. With probability $1-\mu$ the level of technology remains instead constant. Therefore, the right-hand side of equation (3.6) corresponds to the expected level of technology in period 2. The owner substitutes imitation with innovation when the following inequality holds:

$$\mu \geq \frac{g}{\lambda(\theta,\mu)-1} \tag{3.7}$$

It therefore follows that inequality (3.7)[16] holds if the success probability μ is large enough, and g, representing the growth rate of the frontier technology, is instead sufficiently small.

Finally, there is a storage technology which pays a return $r = 0$ in period 2 if the representative owner invests a part of his income in this technology in period 1.[17]

[16]As in the case of immitation the steady-state level of technology grows at the rate g, we therefore can rewrite equation (3.5) as follows:

$$A_{t,2} = (1+g)A_{t,1} \tag{3.8}$$

We notice that for innovations to be more productive than immitations, the following inequality should hold:

$$A_{t,2} = \mu\lambda\left(\alpha_t\right)A_{t,1} + \left(1-\mu\right)A_{t,1} \geq (1+g)A_{t,1} \tag{3.9}$$

After minor manipulations, we arrive at inequality (3.7).

[17]We incorporate the storage asset into the model to capture a possibility of a non-convergence trap, which emerges when the local technology does not converge to the world technological frontier.

A firm uses this alternative asset if investing into productive technology provides a negative payoff. In the latter case, the owner substitutes investing into a new technology with acquiring the storage asset, and therefore the economy stays with the same technology until the payoff from investing into a new technology becomes positive.

3.1.3 Equilibrium

In period $j = 1$ the representative firm invests $\alpha_t \beta Y_{t,1}$ into a new technology, and the returns are realized in period 2. The representative owner thus receives $(1 - \alpha_t)\, \beta Y_{t,1}$ in period 1 and $\beta Y_{t,2}$ in the following period 2. We remind that the level of output in periods $j = 1, 2$ is as large as $Y_{t,j} = A^{\theta}_{t,j} \left(h_{t,j} m_t\right)^{1-\theta}$, and therefore the owner's payoff function can be written as follows:

$$W_o = (1 - \alpha_t)\, \beta A^{\theta}_{t,1} \left(h_{t,1} m_t\right)^{1-\theta} + \beta A^{\theta}_{t,2} \left(h_{t,2} m_t\right)^{1-\theta} \tag{3.10}$$

Employees instead receive as much as $(1 - \beta)\, Y_{t,1}$ in period 1 and $(1 - \beta)\, Y_{t,2}$ in the following period 2. In period 1 they can also invest a fraction φ_t of their human capital endowment $h_{t,1}$ to increase their human capital stock. For simplicity, we assume that human capital is created according to a one-to-one technology, and therefore in period 2 an employee receives $(1 + \varphi_t)\, h_{t,1}$ if she invests $\varphi_t h_{t,1}$ in period 1.[18]

As we added a possibility of human capital accumulation to the model, we change the owner's payoff functions (3.10) into the following expression:

$$W_o = (1 - \alpha_t)\, \beta A^{\theta}_{t,1} \left(h_{t,1} \left(1 - \varphi_t\right) m_t\right)^{1-\theta} + \beta A^{\theta}_{t,2} \left(h_{t,1} \left(1 + \varphi_t\right) m_t\right)^{1-\theta} \tag{3.11}$$

At the beginning of period 1, firms decide how much to invest in the acquisition of new technologies, whereas employees decide how much human capital to acquire. When the level of technology is far from the leading frontier, the owner adopts new

[18] A different assumption would cost us algebraic and geometric convenience, including explicit algebraic solutions and their geometric representation, without producing any tangible benefits and additional insights.

technologies from the world frontier and thus maximizes the payoff function (3.11) s.t. equation (3.5), therefore choosing the optimal level of technological adoption. In this case, the corresponding first order condition for the owner is given by the following equation:

$$\eta'(\alpha_t^*) = \frac{1}{\theta\left(\frac{A_{t,1}^L}{A_{t,1}} - 1\right)} \tag{3.12}$$

From equation (3.12)[19] it follows that when the economy adopts technologies from the world technological frontier, the optimal share of income which the representative firm invests into a new technology, i.e the optimal α_t, is higher, the larger is the difference between the local technology and the leading frontier $\frac{A_{t,1}^L}{A_{t,1}}$, and the larger is the measure of importance of technology for production θ.

We remind that as soon as the distance to the frontier technology reaches a particular threshold level, the representative firm substitutes imitation with innovation. When the latter occurs, the owner maximizes equation (3.11) s.t. equation (3.6) to receive the optimal value of α_t. In the case of innovation, maximization results in the following first order condition:

$$\lambda'(\alpha_t^*) = \frac{1}{\theta\mu} \tag{3.13}$$

From equation (3.13) one can notice that the optimal value of α_t does not depend on the distance to the world frontier $\frac{A_{t,1}^L}{A_{t,1}}$ any longer and becomes instead a positive function of the constant probability of success μ. The effect of θ, the measure of importance of technology for production, on the optimal value of α_t remains positive. It therefore follows that α_t^* is a constant, which implies that the level of domestic technology increases at a constant rate, and thus the innovation stage corresponds to the balanced growth path.

When the representative firm improves upon its technology, a typical employee

[19] See Appendix A for the detailed derivation of equations (3.16), (3.12) and (3.13).

maximizes the following payoff function:

$$W_e = (1-\beta)\, A_{t,1}^{\theta} \left(h_{t,1}\,(1-\varphi_t)\, m_t\right)^{1-\theta} + (1-\beta)\, A_{t,2}^{\theta} \left(h_{t,1}\,(1+\varphi_t)\, m_t\right)^{1-\theta} \quad (3.14)$$

Differentiating equation (3.14) with respect to φ_t results in the following first order condition:

$$\frac{1+\varphi_t^*}{1-\varphi_t^*} = \frac{A_{t,2}}{A_{t,1}} \quad (3.15)$$

or, alternatively

$$\varphi_t^* = \frac{A_{t,2} - A_{t,1}}{A_{t,2} + A_{t,1}} \quad (3.16)$$

We notice that the right-hand side of equation (3.16)[20] is less than one and becomes smaller over time, since the difference between $A_{t,2}$ and $A_{t,1}$ decreases as long as the representative firm invests into a new technology.[21]

From equation (3.12) it follows that in the case of adoption, the value of α_t^* is larger the further away the level of domestic technology $A_{t,1}$ is from the leading frontier $A_{t,1}^L$. At the same time, from equation (3.5) we can conclude that a larger α_t^* results in a higher level of technology in period 2, i.e. in a higher $A_{t,2}$. According to equation (3.16), a larger distance between the level of technology in period 2, i.e. $A_{t,2}$, and its initial level $A_{t,1}$, results in a higher fraction of human capital φ_t^* which is invested into human capital accumulation. When firms innovate, from equation (3.13) it follows that α_t^* becomes a constant, and as a result φ_t^* becomes a constant as well.[22] Finally,

[20] See Appendix A for the detailed derivation of equations (3.16), (3.12) and (3.13).

[21] We can use equation (3.16) to show that the latter is the case. After minor manipulations, we arrive at the following result:

$$\varphi_t^* = 1 - \frac{2A_{t,1}}{A_{t,2} + A_{t,1}}$$

It follows that φ_t^* is going to 0 as soon as $A_{t,2}$ is getting closer to $A_{t,1}$, and it is instead close to 1 when $A_{t,2}$ is significantly larger than $A_{t,1}$.

[22] We can derive the latter result from equation (3.16):

$$\varphi_t^* = \frac{\mu\left(\lambda\left(\alpha_t\right) - 1\right)}{\mu\left(\lambda\left(\alpha_t\right) - 1\right) + 2}$$

It follows that φ_t^* is a constant, as, according to equation (3.13), α_t is also a constant.

when firms do not invest into new technologies, i.e. when $\alpha_t^* = 0$, the level of technology remains constant $A_{t,1} = A_{t.2}$, and therefore from equation (3.16) we obtain that $\varphi(0) = 0$.

We are now ready to summarize our findings in the following proposition:

Proposition 1.

1. *The economy converges to a unique steady-state.*

2. *Furthermore, an increase in the relative distance to the leading technological frontier $\frac{A_{t,1}^L}{A_{t,1}}$, an increase in the measure of importance of technology for production θ, and an increase in the probability of successful innovation μ, all increase incentives to invest into new technologies. In turn, a larger pace of technological evolution induces employees to acquire more human capital.*

Proof. We temporarily assume that adoption is the only source of technological progress in the economy and we first establish uniqueness. To this end, we lag equation (3.5) back to $t-1$ and use equation (3.3) to show that $A_{t,1}$ is a function of α_{t-1}^*, and therefore the more the previous generation $t-1$ invested into a new technology, i.e. the larger was the level of α_{t-1}^*, the higher is the level of technology $A_{t,1}$ which was inherited by generation t from its predecessors. As a result of a larger $A_{t,1}$, the distance between the level of domestic technology $A_{t,1}$ and the leading technological frontier $A_{t,1}^L$ becomes lower. From equation (3.12) it follows that the distance to frontier $\frac{A_{t,1}^L}{A_{t,1}}$ and the optimal share of income invested by the owner α_t^*, are positively related, and therefore as $\frac{A_{t,1}^L}{A_{t,1}}$ decreases, α_t^* becomes lower as well. As a result, the level of α_{t-1}^* exceeds α_t^*. However, in the opposite case of sufficiently low level of α_{t-1}^*,[23] the gap between the level of domestic technology $A_{t,1}$and the leading frontier $A_{t,1}^L$ becomes instead larger, and then, from equation (3.12) it follows that the value of α_t^* becomes larger as well. The latter result implies that α_t^* becomes larger than α_{t-1}^*. Finally, at a

[23] The level of α_{t-1}^* should be as low as to let the world frontier grow faster than the local technology.

particular level of α^*_{t-1} the gap between the level of domestic technology $A_{t,1}$ and the leading technological frontier $A^L_{t,1}$ remains constant, and, as a result, the level of α^*_t also remains constant, which implies that $\alpha^*_{t-1} = \alpha^*_t$.[24]

We can now characterize this steady-state. From the denominator of the right-hand side of equation (3.12) it follows that the optimal share of income invested by the owner α^*_t remains a constant when the distance between the level of domestic technology $A_{t,1}$ and the leading technological frontier $A^L_{t,1}$ does not change, which occurs when the local technology grows as fast as does the leading frontier, i.e. at a rate g.

Now, we add innovations to the economy. When the distance to the leading frontier becomes sufficiently small, the economy substitutes imitation with innovation. When firms innovate, they converge to the leading frontier $A^L_{t,1}$ at a rate which is defined by μ and θ.[25] As μ and θ are both constants, the steady-state level of α^*_t is unique, which implies that the steady-state level of φ is unique as well.
The proof of the second part of the proposition follows directly from equations (3.12), (3.13) and (3.16).

■

We can also introduce the same argument graphically.

[24]We complete the proof of uniqueness and global stability of the steady-state in Appendix A.

[25]As we showed earlier, this rate should be larger than g, as otherwise the representative firm does not have incentives to substitute adoption with innovation.

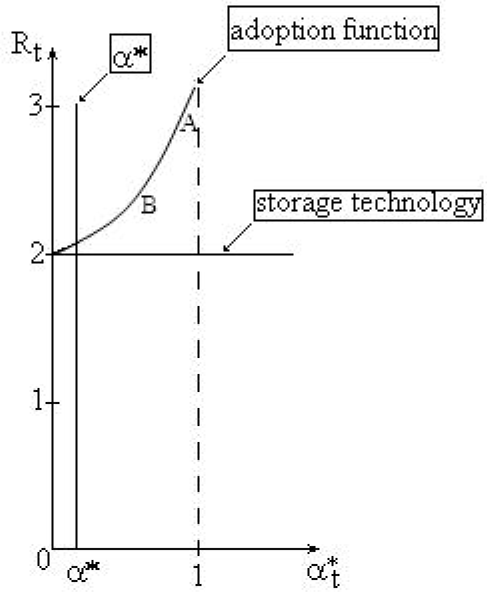

Figure 1. Steady-state level of investment into technological evolution in the economy without corruption.

To this end, we, first, compare the payoff from investing into a new technology and the one from investing into the storage asset. These two payoffs are identical when the following equation holds:

$$(1-\varphi(\alpha_t^*))^{1-\theta}\left[1-\alpha_t^*+\frac{1+\varphi(\alpha_t^*)}{1-\varphi(\alpha_t^*)}\right]=2 \tag{3.17}$$

In Figure 1, the share α_t^* is placed along the horizontal axis, whereas R_t, representing the payoff from investment, corresponds instead to the vertical one. The curve which we call the *adoption function* represents the left-hand side of equation (3.17), and reflects the payoff from adopting a technology from the world frontier. In Appendix A we show that the left-hand side of equation (3.17)[26] is an increasing function of α_t^*. As we know from equation (3.12), the larger is the distance to the leading

[26]Which is equal to $(1-\varphi(\alpha_t^*))^{1-\theta}\left[1-\alpha_t^*+\frac{1+\varphi(\alpha_t^*)}{1-\varphi(\alpha_t^*)}\right]$

frontier $\frac{A_{t,1}^L}{A_{t,1}}$, the higher is the value of α_t^*. Therefore, as the left-hand side of equation (3.17) increases when α_t^* grows, it also increases when the distance to the leading frontier $\frac{A_{t,1}^L}{A_{t,1}}$ becomes larger. On the contrary, when the distance to the leading frontier reduces, both, α_t^* and $(1-\varphi(\alpha_t^*))^{1-\theta}\left[1-\alpha_t^*+\frac{1+\varphi(\alpha_t^*)}{1-\varphi(\alpha_t^*)}\right]$, become lower. Consider a point on the adoption function which is close to the dashed line, as, for instance, point A. The dashed line intersects the horizontal axis in $\alpha_t^*=1$, corresponding to the largest possible value of α_t^*. Therefore, as point A is close to the dashed line, it reflects a comparatively large value of α_t^*, which, according to our discussion, corresponds to a higher level of distance to the world technological frontier $\frac{A_{t,1}^L}{A_{t,1}}$. By contrast, a point on the adoption function which is far away from the dashed line, as point B, corresponds to a lower level of α_t^*, which reflects a lower level of technological gap $\frac{A_{t,1}^L}{A_{t,1}}$.

When firms do not invest into new technologies, i.e. when $\alpha_t^*=0$, the left-hand side of equation (3.17) is equal to 2. The horizontal line, which reflects the payoff from investing into the *storage technology*, also intersects the vertical axis in $R_t=2$. However, when $\alpha_t^*>0$, the left-hand side of equation (3.17) is larger than 2, which implies that as long as $\alpha_t^*>0$. the payoff from investing into the storage asset is lower than the payoff from acquiring a new technology. When the gap between the level of domestic technology and the leading frontier is positive, i.e. when $\frac{A_{t,1}^L}{A_{t,1}}$ is larger than 1, the economy can imitate technologies from the leading frontier, and, as it follows from equation (3.12), α_t^* remains positive. Therefore, for $\alpha_t^*>0$, the adoption function is placed strictly above the horizontal line, representing the payoff from investing into the storage technology.

When α_t^* becomes equal to α^*, the economy substitutes imitation with innovation and transits to the balanced growth path. The vertical line, which we call the *innovation function*, intersects the adoption function in the point corresponding to the steady-state value α^*, which is obtained from equation (3.13). From equation (3.13) it also follows that α^* is positive when both θ and μ are positive, and, as the left-hand side of equation (3.17) is larger than 2 when $\alpha_t^*=\alpha^*>0$, it therefore follows that investing into innovations also result in a larger payoff level than acquiring the storage asset.

3.1.4 Education in the Economy without Corruption

In the previous subsection we focused on the behavior of α_t^*, the optimal share of income which the owner invests into a new technology. To see how an educational reform can result in a higher level of human capital and faster economic growth, we need instead to consider the behavior of $\varphi(\alpha_t^*)$, the optimal fraction of human capital endowment which is invested in human capital accumulation.

We notice that, as long as firms imitate technologies from the leading frontier, $\varphi(\alpha_t^*)$ is a concave function of α_t^*[27] and it becomes instead a constant when firms innovate. We call $\varphi(\alpha_t^*)$ the *dynamic demand function*, as it reflects the level of education demanded by each generation of employees.

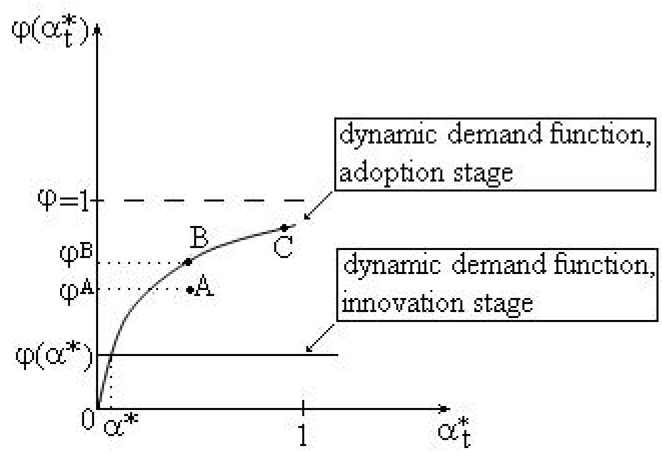

Figure 2. Educational reform in the economy without corruption.

[27]This result follows from the following two derivatives:

$$\frac{\partial \varphi(\alpha_t^*)}{\partial \alpha_t^*} = \frac{2A_{t,1}^2}{\theta\left(A_{t,2}(\alpha_t^*) + A_{t,1}\right)^2} > 0$$

$$\frac{\partial^2 \varphi(\alpha_t^*)}{\partial \left(\alpha_t^*\right)^2} = -4\frac{A_{t,1}^3}{\theta^2\left(A_{t,2}(\alpha_t^*) + A_{t,1}\right)^3} < 0$$

In Figure 2, the *dynamic demand function* corresponds to the curve as long as the economy adopts technologies from the leading frontier. The curve is therefore denoted as "*dynamic demand function, adoption stage*". However, after the economy substitutes imitation with innovation, the level of α_t^* becomes a constant and so does $\varphi(\alpha_t^*)$. Therefore, when the economy innovates, the *dynamic demand function* transforms instead into a horizontal line, which is called "*dynamic demand function, innovation stage*".

We start considering the behavior of $\varphi(\alpha_t^*)$ from the adoption stage. As it follows from equation (3.12), when the distance to the frontier technology $\frac{A_{t,1}^L}{A_{t,1}}$ is comparatively large, the value of α_t^* is high as well. At the same time, from equation (3.16) we conclude that a large α_t^* results in a high level of $\varphi(\alpha_t^*)$. The latter is comparatively close to $\varphi(\alpha_t^*) = 1$, corresponding to the largest possible value for $\varphi(\alpha_t^*)$, which is depicted in Figure 2 as a dashed line. Therefore, a point on the curve which is close to the dashed line, as point C, reflects a high value of α_t^* and mirrors a large level of technological backwardness $\frac{A_{t,1}^L}{A_{t,1}}$. On the contrary, a point belonging to a section of the "*dynamic demand function, adoption stage*", which is relatively far from the dashed line, as, for instance, point B, corresponds to a smaller value of α_t^* and thus to a lower distance to the frontier technology $\frac{A_{t,1}^L}{A_{t,1}}$.

When the economy substitutes imitation with innovation, the optimal share of income α_t^* which the owner invests into a new technology becomes a constant α^*, and therefore the corresponding value of $\varphi(\alpha^*)$, which can be obtained from equation (3.16), transforms into a constant as well. As a result, the dynamic demand function becomes a horizontal line, which implies that every subsequent generation invests the same share of its human capital stock in the acquisition of new human capital.

We now consider how a reform of educational system can result in a higher level of equilibrium $\varphi(\alpha_t^*)$, the optimal fraction of human capital endowment which is invested in education. We notice that point B, belonging to the "*dynamic demand function, adoption stage*" curve, represents the level of demand for education of a particular generation t. Assume that the level of supply of education corresponds instead to point A, which is located strictly below point B. The latter implies that for a particular generation t, the available level of supply φ_t^A is lower than the demanded level of education, corresponding instead to φ_t^B. In this case, if the government intervenes and introduces an educational reform which increases the supply of education φ_t^A from point A to point B, the human capital stock in the economy, and, as a result, the rate of economic growth, become larger.[28]

We are ready to formulate our next result:

Proposition 2. *As long as the economy is free of corruption, and if the level of demand for education is above the available supply, an educational reform results in a larger human capital stock.*

Proof. We, first, notice that the actual level of investment in the acquisition of additional human capital is defined from the following expression:

$$\varphi_t = min\left\{\varphi_t^{S,1}, \varphi_t^D\right\} \tag{3.18}$$

$\varphi_t^{S,1}$ corresponds to exogenously given level of supply of education, while $\varphi_t^D = \varphi(\alpha_t^*)$, where $\varphi(\alpha_t^*)$ is defined in equation (3.16), reflects instead the level of demand for education and belongs to *the dynamic demand function*. If the level of supply is lower than the level of education demanded by the employees, i.e. if $\varphi_t^{S,1} < \varphi_t^D$, then the actual level of investment in human capital is equal to $\varphi_t^{S,1} = min\left\{\varphi_t^{S,1}, \varphi_t^D\right\}$. An educational reform which increases the level of supply from $\varphi_t^{S,1}$ to $\varphi_t^{S,2} = \varphi_t^D$

[28]This kind of reform is relevant for developing countries, which typically have less developed education systems. A particular developing economy can, for instance, suffer from poorly trained teaching staff, a limited number of universities and schools, etc.

Many papers argue that the quantity of education, measured in terms of the average years of schooling (see, for instance, Hanushek and Woessmann, 2007), or adult literacy rate (see Durlauf and Johnson, 1995) have positive effect on economic growth. Other papers, as, for instance, Hanushek and Kimko (2000) and Hanushek and Kim (1995), report instead a strong and robust influence of the quality of education on economic growth. Thus, if an economy is characterized by a low level of human capital, growth can be accelerated if the most limiting constraints on education capacities can be removed. In this case, an educational reform, comprising technical and financial assistance aiming to improve education standards, can be promising.

therefore results in a larger level of investment in the acquisition of human capital $\varphi_t^{S,2} = \varphi_t^D = min\left\{\varphi_t^{S,2}, \varphi_t^D\right\}$, as $\varphi_t^{S,2} = \varphi_t^D > \varphi_t^{S,1}$. As a consequence, the level of human capital in the economy becomes larger. ■

Therefore, in our benchmark model an educational reform which is introduced in the presence of limited supply of education, can result in a higher level of human capital. However, as we will see in the following section, this result does not necessary hold in the presence of corruption.

3.2 Corruption

In this section, we introduce corruption into the model by assuming that the owners are required to pay a share of their income in order to receive a license, a permit, etc.[29] We consider an extreme case of corruption, where a bureaucrat completely avoids prosecution if he subtracts a part of the owner's income, and therefore can not be punished by the owner. We assume that the diverted income is not invested into a new technology, as it is instead pocketed by the bureaucrat. We show that the presence of corruption reduces firms' incentives to invest into new technologies. As a low level of investment in the acquisition of new technologies reduces the pace of technological evolution, the economy has less chances to approach the world technological frontier and to reach the innovation stage. Instead, it is more likely to end up in a non-convergence trap.[30] As a consequence, investments into human capital also decrease, and thus an educational reform which enhances educational opportunities might be ineffective.

[29]Our assumption about the presence of corruption in a developing economy corresponds to a broad literature, as, for instance, Mauro (1995), Shleifer and Vishny (1993) and Svensson (2005).

[30]Alternatively, we could consider the case of income diversion within the representative firm. Even though owners transfer the right to run a firm to managers, the latter, however, might pursue diffarent interests. As property rights are comparatively weakly protected in developing and transitional economies, powerful managers are able to follow their own interests therefore reducing shareholders' benefits (see, for instance Boycko, Shleifer and Vishny (1993), Boycko, Shleifer and Vishny (1994), or Shleifer and Vishny (1997), and Black (1998)).

In our setting, managers would be thus able to expropriate a part of the owners' income therefore reducing frims' incentives to invest into new technologies.

3.2.1 The Model with Corruption

Assume now that a part of the representative owner's income can be stolen at no cost. The latter, however, occurs only if the owner runs an investment project. In other words, if the representative firm does not adopt technologies or innovate, then income can not be taken away. A state official can subtract a share $0 < \gamma < 1$ of the owner's income, and, as a consequence, the owner receives the remaining share $1 - \gamma$.

Therefore, by contrast to the previous section, where the owner's payoff function corresponded to equation (3.14), in the presence of corruption the owner receives a lower income, which is reflected in the following expression:

$$W_o = (1-\gamma)\left[(1-\alpha_t)\,\beta A_{t,1}^{\theta}\,(h_{t,1}m_t)^{1-\theta} + \beta A_{t,2}^{\theta}\,(h_{t,2}m_t)^{1-\theta}\right] \tag{3.19}$$

Before he starts a new project, the owner needs to make sure that the project provides a higher payoff than investing in the storage technology, and the latter is the case if and only if the following inequality holds (see Appendix B for more details):

$$1-\gamma \geq \frac{2}{(1-\varphi(\alpha_t^*))^{1-\theta}\left[1-\alpha_t^* + \frac{1+\varphi(\alpha_t^*)}{1-\varphi(\alpha_t^*)}\right]} \tag{3.20}$$

We notice that in the previous section, where we considered the case without corruption, γ was equal to 0. In the presence of corruption, γ is instead positive and, as a result, the left-hand side of condition (3.20) is smaller than 1. At the same time, in the previous section we showed that the denominator of the right-hand side of inequality (3.20), which is identical to the left-hand side of equation (3.17), is converging to its lowest value, which is 2, if α_t^* is approaching 0. Therefore, if the latter is the case, the value of the entire right-hand side of inequality (3.20) is close to its maximum value, which is 1. Thus, for comparatively high values of γ and low values of α_t^*, condition (3.20) does not hold, as in this case its left-hand side is substantially lower than 1, while its right-hand side is instead close to one. The latter implies that in the presence of corruption the owner is less willing to invest into a new technology.

We assume that a bureaucrat chooses the level of γ exogenously, and the owner invests into a new technology as long as inequality (3.20) holds. The lowest level of α_t^* satisfying inequality (3.20) is the one which also satisfies equation (3.21):

$$\gamma = 1 - \frac{2}{(1-\varphi(\widehat{\alpha}^*))^{1-\theta}\left[1-\widehat{\alpha}^* + \frac{1+\varphi(\widehat{\alpha}^*)}{1-\varphi(\widehat{\alpha}^*)}\right]} \tag{3.21}$$

where $\widehat{\alpha}^*$ reflects the value of α_t^* at which the payoff levels from investing into a new technology and acquiring the storage asset are identical. We notice that in the benchmark version of our model both γ and $\widehat{\alpha}^*$ were equal to zero.

If we return back to Figure 1, we can observe that the vertical distance between a point on the adoption function and the payoff from the storage technology, represented as the horizontal line, is higher, the larger is the value of α_t^*. Therefore, after a bureaucrat subtracts a share γ from the owner's income, as long as α_t^* remains comparatively large, the owner's income from investing into a new technology is still larger than his payoff from acquiring the storage asset. However, when α_t^* becomes smaller, the difference between these two payoffs decreases and it becomes zero when α_t^* reduces to $\widehat{\alpha}^* > 0$. As $\widehat{\alpha}^* > 0$ results in a positive level of investment into a new technology, the distance to the leading frontier $\frac{A_{t,1}^L}{A_{t,1}}$ reduces, and for the next generation it occurs that, according to equation (3.12), the value of α_t^* becomes lower than $\widehat{\alpha}^*$, which implies that condition (3.20) does not hold any longer.[31] As a result, the owner starts investing into the storage asset instead of investing into a new technology. He will reverse his decision and will invest into new technologies again when the gap between the payoff from investment into a new technology and the one from investing into a storage asset becomes positive again. For the latter to occur, the level of α_t^* should increase, which, according to equation (3.12), is a consequence of a larger value of $\frac{A_{t,1}^L}{A_{t,1}}$, the measure of technological backwardness.

We consider the latter argument once again in more detail. Assume that a gen-

[31]This is because $\widehat{\alpha}^*$ corresponds to the lowest value of α_t^* for which inequality (3.20) holds.

eration t invests $\alpha_t^* = \widehat{\alpha}^*$ into a new technology, and therefore α_t^* satisfies equation (3.21), which implies that the actual level of investment in the acquisition of new technologies will be positive. As we know from Proposition 1, for the next generation $t+1$ the optimal share will be equal to α_{t+1}^*, which is lower than $\widehat{\alpha}^*$. This is because the economy is converging to the world technological frontier, and from equation (3.12) it follows that for generation $t+1$ investing $\alpha_{t+1}^* = \widehat{\alpha}^*$ is not any longer optimal. However, if, at the same time, the value of γ does not decline, and instead remains constant, then α_{t+1}^* does not satisfy inequality (3.20), as it is lower than $\widehat{\alpha}^*$, which is the lowest value satisfying this inequality. In this case, given the optimal $\alpha_{t+1} = \alpha_{t+1}^*$, which is defined from (3.12), and the level γ, the payoff from investing into the storage asset becomes larger than the payoff from investing into a new technology, which implies that the representative owner will not invest into technological adoption, and therefore the actual value of α_{t+1} will be equal to zero. At the same time, as the level of the leading technology instead increases at a rate g, the distance between the local technology and the world frontier will thus become larger. If, for generation $t+2$, the distance to the leading frontier $\frac{A_{t+2,1}^L}{A_{t+2,1}}$ becomes sufficiently large, the optimal value of α_{t+2} will satisfy inequality (3.20) and therefore the owner will start investing into a new technology again. However, investing into a new technology will result in a lower distance to the technological frontier $\frac{A_{t+3,1}^L}{A_{t+3,1}}$, and therefore will lead to a lower level of α_{t+3}^*, which might, potentially, not satisfy inequality (3.20). The latter will again reduce the payoff from investing into a new technology below the payoff from investing into the storage asset, and so on. From this discussion, it follows that in the presence of corruption, the economy does not converge to the technological frontier. Instead, the distance to the leading technology, on average, remains constant, which implies that in general the level of domestic technology and the world technological frontier grow at the same rate g. We label the latter result as the "*non-convergence trap*". As the economy does not approach the leading frontier, it therefore does not substitute imitation with innovation.

From equation (3.21) it follows that a larger share of income γ, which a bureaucrat subtracts from the owner's income, results in a higher threshold fraction of income $\widehat{\alpha}^*$ which the owner invests in the acquisition of new technologies. At the same time, according to equation (3.12), a higher $\widehat{\alpha}^*$ corresponds to a larger distance to the leading frontier $\frac{A_{t,1}^L}{A_{t,1}}$. If the distance to technological frontier can be considered as a measure of development, then, as a larger γ results in a higher value of $\frac{A_{t,1}^L}{A_{t,1}}$, it thus follows that a higher γ implies a larger technological backwardness, and therefore a lower level of development. We summarize the detrimental effect of corruption on technological evolution in the following expression:

$$\frac{A_{t,1}^L}{A_{t,1}} = f(\gamma) \tag{3.22}$$

Equation (3.22) implies that as long as the level of corruption γ does not change, the technological gap $\frac{A_{t,1}^L}{A_{t,1}}$ remains constant. We can also rewrite equation (3.22) as follows:

$$z_\gamma = \frac{A_{t,1}^L}{A_{t,1}} = f(\gamma) \tag{3.23}$$

where z_γ reflects the level of technological backwardness as a function of the level of corruption. Thus, when the level of corruption does not change, domestic technology remains a constant fraction $\frac{1}{z_\gamma}$ of the leading technology level. We summarize our finding in the following proposition:

Proposition 3. *The higher is the share of income γ which a bureaucrat diverts from the representative owner, the larger is the non-reducible gap which remains between the local technology and the world technological frontier.*

Proof. From equation (3.21) it follows that a larger is the share γ which a bureaucrat diverts from the representative owner, the larger is a threshold optimal share of income $\widehat{\alpha}^*$ which the owner invests into a new technology. From equation (3.12) it, in turn, follows that a larger $\widehat{\alpha}^*$ corresponds to a higher distance to the world technological frontier $\frac{A_{t,1}^L}{A_{t,1}}$. ∎

Therefore, we conclude that corruption can reduce the pace of technological evolution. As a consequence, in the presence of corruption, the economy might get into the *non-convergence trap*.

We illustrate these results in Figure 3:

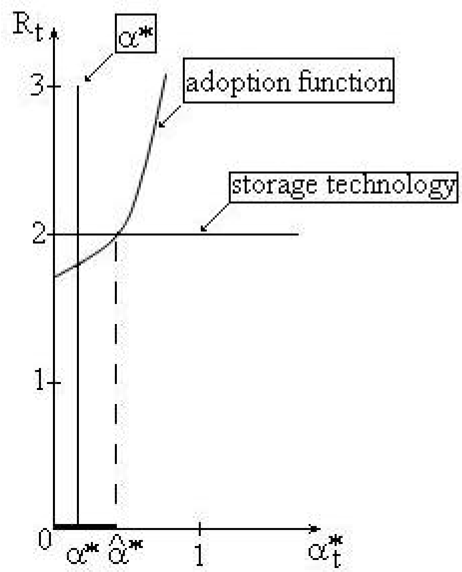

Figure 3. A non-convergence set in the economy with corruption.

This picture is similar to Figure 1, but there is one important difference: the presence of corruption shifts the adoption function down. On the contrary to the case without corruption, the set of optimal values α_t^* for which the storage asset provides a higher payoff than investing into a new technology is not empty any longer. In Figure 3, we can see a set of values $0 \leq \alpha_t^* \leq \widehat{\alpha}^*$ (represented as a bold section of the horizontal axis) for which the horizontal line, reflecting the payoff from storage asset, is located strictly above the adoption function, corresponding instead to the payoff from investing into a new technology. Whenever α_t^* belongs to this set, which we call the *non-convergence set*, a firm prefers to retain the old technology rather than to acquire a new one. Thus, if the level of α^*, corresponding to the share of income which the owner starts investing into technological evolution as soon as the economy reaches the innovation stage, belongs to this set, the economy can not substitute imitation with innovation. In Figure 3, α^* corresponds to the intersection between the vertical line, representing the innovation stage, and the adoption function. α^* thus reflects the stage of technological maturity at which the economy substitutes imitation with innovation, and in this particular example it belongs to the non-convergence set, which implies that no transition from adoption to innovation will occur in this economy. Instead, the economy will attain the level $\alpha_t^* = \widehat{\alpha}^*$ corresponding to the intersection between the adoption function and the horizontal line, representing the payoff from investing into the storage asset, and its technology will evolve at a pace g, reflecting the growth rate of the world technological frontier.

3.2.2 Education in the Economy with Corruption

As a higher level of corruption results in slower technological evolution, it should also reduce the rate of human capital accumulation. From equation (3.16) it follows that the optimal fraction of human capital endowment which is invested in the acquisition of human capital φ_t^* is equal to zero whenever $\alpha_t = 0$. Therefore, the employees do not acquire human capital when the representative owner does not invest in a new technology. In the previous subsection we showed that in the presence of corruption, the economy might end up in the non-convergence trap, where it grows as fast as does the world technological frontier, i.e. at the rate g, which is lower than the economy's potential growth rate. From equation (3.16) it follows that if the average growth rate of technology $A_{t,1}$ is as large as g, then the level of investment in human capital becomes a constant and equals to $\varphi_t^* = \frac{g}{2+g}$, which is also below its potential. It therefore follows that individuals acquire less human capital when the level of investment into adoption reduces as a result of corruption.

We can now show why the presence of corruption might reduce the effectiveness of educational reform. Again, we explain our argument graphically.

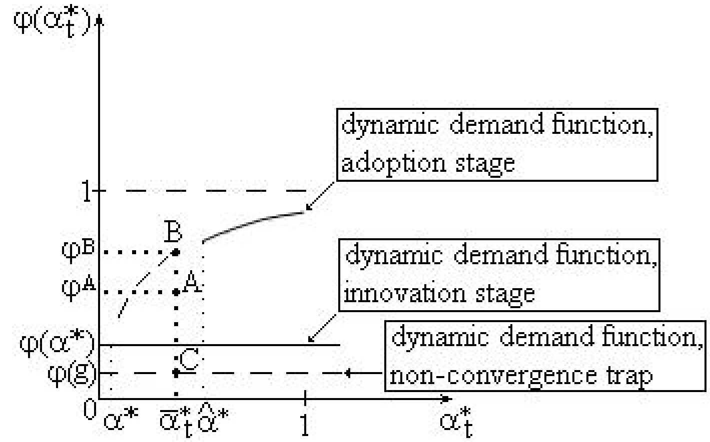

Figure 4. Educational reform in the economy with corruption

In Figure 4, as long as $\alpha_t^* \geq \widehat{\alpha}^*$, the *dynamic demand function* is represented by the same curve as in Figure 2. When α_t^* becomes lower than $\widehat{\alpha}^*$, the representative owner starts investing into the storage technology, as any α_t^* which is less than $\widehat{\alpha}^*$ does not satisfy inequality (3.20). As we showed in the previous subsection, the level of domestic technology increases, on average, at a rate g if the economy ends up in the non-convergence trap. The latter implies that the level of aggregate human capital stock H_t also grows at a constant rate which is determined by g. Therefore, after the economy reaches $\alpha_t^* = \widehat{\alpha}^*$, the dynamic demand function becomes a constant $\varphi(g)$ represented as point C on the dashed line which we denote as "*dynamic demand function, non-convergence trap*".

We notice that the level of $\varphi(g)$ is lower than the value of $\varphi(\alpha_t^*) = \varphi(\alpha^*)$ corresponding to the "*dynamic demand function, innovation stage*", depicted as the horizontal line which is located above the "*dynamic demand function, non-convergence trap*" dashed line. We remind that the "*dynamic demand function, innovation stage*" line reflects the level of demand for the acquisition of human capital when the economy reaches the innovation stage. That $\varphi(g)$ is less than $\varphi(\alpha^*)$ follows from our assumption regarding the innovation stage. There, the level of domestic technology increases at a rate which is higher than g, representing the growth rate of the leading technological frontier.[32] Therefore, from equation (3.16) it follows that $\varphi(g) < \varphi(\alpha^*)$.

Consider point C corresponding to $\overline{\alpha}_t^*$ on the horizontal axis, which is lower than $\widehat{\alpha}^*$, the lowest value of α_t^* satisfying inequality (3.20). As soon as the economy reaches $\widehat{\alpha}^*$, it transits from the "*dynamic demand function, adoption stage*" curve to point C, which is a part of the "*dynamic demand function, non-convergence trap*" line. On one hand, as $\overline{\alpha}_t^* < \widehat{\alpha}^*$ does not satisfy inequality (3.20), at $\overline{\alpha}_t^*$, the owner acquires the storage asset instead of investing in a new technology. However, on the other hand, $\overline{\alpha}_t^*$ also reflects the average share of income α_t which the representative owner invests in the acquisition of new technologies as long as the economy stays in the *non-convergence trap*. As we showed in the previous subsection, in the presence of corruption the actual level of α_t varies from zero, when α_t^* is too low to satisfy inequality (3.20), to $\alpha_t = \alpha_t^* > 0$, when, as a result of a higher distance to the leading frontier $\frac{A_{t,1}^L}{A_{t,1}}$, the optimal value of α_t, which is defined in equation (3.12), becomes larger, and thus satisfies inequality (3.20). On average, the level of technology evolves at the rate g, which determines the level of $\overline{\alpha}_t^*$. As the pace of technological advancement is as large as the one of the world technological frontier, it thus follows that the distance between the local technology and the leading frontier remains unaltered. Therefore, according to equation (3.16), the aggregate human capital stock H_t also grows at a constant rate, corresponding to the dashed line, which we call "*dynamic demand function, non-convergence trap*" , i.e. to $\varphi(g)$.

Assume that the government plans to implement a reform to improve the level of education in the economy, and the authority believes that the economy will continue converging to the leading frontier. The latter implies that the government believes that the *dynamic demand function* is continuous, as in Figure 2, and therefore the level of demand corresponds to point B. As in our benchmark model, we again assume that the available supply of educational services corresponds to point A. The actual level of demand for education is, however, represented by point C. Therefore, the level of

[32] As in the opposite case the economy will not be able to converge to the leading frontier.

demand for education is lower than the level of supply and thus an educational reform which increases the level of supply to point B, does not result in a higher human capital stock.

We are ready to formulate our key result:

Proposition 4.

1. *In the presence of corruption, the level of demand for education reduces as a consequence of a lower level of investment in new technologies.*

2. *Therefore, an educational reform which aims to increase the level of supply of education in order to accumulate a larger human capital stock, might fail to increase the equilibrium level of human capital.*

Proof. The first part of Proposition 4 follows directly from equation (3.16).
As for the second part, we, first, notice that, as in the previous section, the actual level of investment in the acquisition of additional human capital is defined from the following equation:

$$\varphi_t = min\left\{\varphi_t^{S,1}, \varphi_t^D\right\} \tag{3.24}$$

where $\varphi_t^{S,1}$ corresponds to the initial level of supply of education, and $\varphi_t^D = \varphi(\alpha_t^*)$, where $\varphi(\alpha_t^*)$ is determined in equation (3.16), reflects, by contrast, the level of demand for education. If the latter corresponds to the "*dynamic demand function, adoption stage*" curve, then, as we showed in the proof for Proposition 2, an educational reform is effective. If, however, *the dynamic demand function* is instead represented by "*dynamic demand function, non-convergence trap*" line, then the level of education which is demanded by the employees might be lower than the initial level of supply, i.e. $\varphi_t^D < \varphi_t^{S,1}$. In the latter case, the actual level of investment in the acquisition of human capital is equal to $\varphi_t^D = min\left\{\varphi_t^{S,1}, \varphi_t^D\right\}$, and thus an educational reform which increases the level of supply from $\varphi_t^{S,1}$ to $\varphi_t^{S,2}$, where $\varphi_t^{S,2} > \varphi_t^{S,1}$, does not result in a larger level of investment in the acquisition of human capital, as $\varphi_t = min\left\{\varphi_t^{S,2}, \varphi_t^D\right\} = \varphi_t^D$. ■

We therefore conclude that corruption might result in a low level of demand for education, and, as a consequence, the effect of educational reform can be limited.[33]

As we show in the following section, an educational reform, however, has a stronger potential to be successful if it is carried out together with an anti-corruption campaign. The latter reduces the level of γ, which shifts the adoption function in Figure 3 upward. As a consequence, the non-convergence set becomes smaller and therefore domestic technology has higher opportunity to converge to the world technological frontier. As a result, the employees invest a higher level of φ_t in the acquisition of human capital, and thus an educational reform becomes potentially more effective.

3.3 Dealing with low Level of Investment

As we showed in the previous section, corruption can result in a lower level of investment in the acquisition of new technologies. The latter weakens incentives to acquire human capital, and, as a result, an educational reform which aims to accumulate more human capital, might become ineffective. It thus follows that an educational reform

[33]Moreover, when individuals can transfer their human capital between two different economies, they might end up migrating to the economy where the level of corruption is lower. To show that this result is indeed the case, we consider two economies which have different levels of corruption, but are otherwise identical. Generation t belonging to less corrupt economy A invests into a new technology and acquires human capital, which implies that $\alpha_t^A > 0$ and $\varphi_t^A > 0$. More corrupt economy B invests instead into the storage asset, since corruption reduces the return to investment into a new technology.
Assume that individuals from economy B can freely transfer their human capital to country A, and vice versa. In equilibrium, a typical employee should earn the same income in both countries, which implies the following result:

$$\frac{m_A}{m_B} = \frac{1}{1-\varphi_t^A} \tag{3.25}$$

where m_j, is the number of employees who work at the representative firm in country $j = A, B$. As $0 \leq \varphi_t^A \leq 1$, it follows that $m_A \geq m_B$, which implies that the number of employees increases in economy A, while in country B it instead becomes lower. Therefore, it can occur that those employees who plan to transfer their human capital to economy A will benefit from the implementations of the educational reform in country B, as they can acquire more human capital which can be later used in economy A.

becomes more successful, if it is preceded by a policy which encourages firms to invest more in the acquisition of new technologies and therefore also induces individuals to acquire a higher level of human capital. In this section, we will briefly review the effect of an anti-corruption campaign which can be implemented to reduce the negative impact of corruption on the level of investment into a new technology and human capital.

As an effective anti-corruption campaign reduces the level of γ, from equation (3.21) it follows that the threshold fraction of income $\widehat{\alpha}^*$, which the owner invests in the acquisition of new technologies, also becomes lower. From equation (3.12) it follows that a lower level of $\widehat{\alpha}^*$ corresponds to a lower gap between domestic technology and the leading frontier $\frac{A^L_{t,1}}{A_{t,1}}$. Therefore, if γ becomes lower, the level of domestic technology moves closer to the leading frontier. If the level of corruption becomes low enough, the economy moves sufficiently close to the frontier technology to substitute imitation with innovation. As a consequence of a higher level of investment into a new technology, the level of demand for education increases, and therefore a reform which expands the level of supply of education becomes more effective.

The literature on various methods of reducing the level of corruption is vast (see, for instance, Reinikka and Svensson, 2005, or OECD, 2005.), and therefore we do not survey this literature in our work. Instead, we emphasize that the effectiveness of an anticorruption campaign might be limited. For instance, Persson, Rothstein and Teorell (2012) argue that a lot of anti-corruption reforms in Africa were unsuccessful. Bertucci and Armstrong, (2000) and Hanna at al (2011) survey possible reasons for the failure of anticorruption campaigns.

As the effect of an anticorruption campaign can be limited, in Appendix C we suggest an alternative solution to the problem of low investment. Even though this solution does not reduce the level corruption, in particular cases, it might, nevertheless, induce the economy to increase the level of investment into new technologies and acquire more human capital. We show, however, that the alternative approach can incur significant costs without producing, at the same time, any substantial result, and therefore it should be introduced with substantial cautiousness.

3.4 Conclusion

In this chapter, we consider a baseline economy where a typical firm combines technology and human capital to produce output. The representative firm also invests a part of its income in the acquisition of new technologies: it starts from imitating technologies from the world technological frontier, and later, when the economy moves closer to the frontier level of technology, it substitutes imitation with innovation. Employees use their human capital stock to produce output and to acquire more human capital. As technology and human capital are complementary factors of production, a larger pace of technological evolution encourages the employees to allocate more human capital to the acquisition of additional education.

We assume that the level of supply of education is low compared to the existing demand, and therefore a reform enhancing the availability of educational services might induce the economy to acquire a larger human capital stock.

As many developing economies suffer from the presence of imperfect institutions, we incorporate corruption into our baseline model. We show that the latter reduces firms' incentives to invest in the acquisition of new technologies. As a result, employees adjust their investment into human capital by acquiring less education. Therefore, an educational reform might become less effective, as an improvement in the education system brought about by the reform can remain unused.

As a particular solutions to the problem of low investment, we consider a policy which reduces the level of corruption, thus resulting in a faster pace of technological evolution and human capital accumulation.

This model can be extended to show how an educational reform can lead to the outflow of human capital. If the level of corruption in the economy remains high, individuals have incentives to transfer their human capital to a less corrupt country, where the level of technology and therefore incomes are higher. Thus, those individuals who plan to transfer their human capital to a less corrupt economy will benefit from the implementation of an educational reform in the source country, as there they can acquire more human capital which they will later use in a more developed economy. The latter result is similar to ”knowledge leaks” which are discussed in Easterly (2001). When the level of knowledge in a particular society is on average high, individuals have high incentives to invest into education. If instead the level of knowledge is low, individuals have little incentives to invest into human capital, or if they do so, they will likely migrate from the economy in a ”brain drain”.

3.5 Appendices

3.5.1 Appendix A

Derivation of equations (3.12), (3.13), (3.16). Each owner maximizes his income by choosing the optimal share α_t:

$$W_o = (1-\alpha_t)\,\beta A_{t,1}^{\theta}\left(h_{t,1}\left(1-\varphi_t\right)m_t\right)^{1-\theta} + \beta A_{t,2}^{\theta}\left(h_{t,1}\left(1+\varphi_t\right)m_t\right)^{1-\theta}$$

Employees instead search for the optimal share of their human capital endowment φ_t to maximize their labor income

$$W_e = (1-\beta)\,A_{t,1}^{\theta}\left(h_{t,1}\left(1-\varphi_t\right)m_t\right)^{1-\theta} + (1-\beta)\,A_{t,2}^{\theta}\left(h_{t,1}\left(1+\varphi_t\right)m_t\right)^{1-\theta}$$

The respective FOCs are:

$$-\beta A_{t,1}^{\theta}\left(h_{t,1}\left(1-\varphi_t\right)m_t\right)^{1-\theta} + \theta\beta A_{t,2}^{\theta-1}\frac{\partial A_{t,2}}{\partial\alpha_t}\left(h_{t,1}\left(1+\varphi_t\right)m_t\right)^{1-\theta} = 0$$

$$(1-\beta)(1-\theta)\left[A_{t,1}^{\theta}\left(h_{t,1}\left(1-\varphi_t\right)m_t\right)^{-\theta}h_{t,1}m_t - A_{t,2}^{\theta}\left(h_{t,1}\left(1+\varphi_t\right)m_t\right)^{-\theta}h_{t,1}m_t\right] = 0$$

After rearranging, we receive the following result:

$$\frac{\partial A_{t,2}}{\partial\alpha_t} = \frac{A_{t,1}}{\theta} \tag{3.26}$$

$$\frac{A_{t,2}}{A_{t,1}} = \frac{1+\varphi_t}{1-\varphi_t} \tag{3.27}$$

One can combine equation (3.5) and equation (3.26) to derive equations (3.12) and (3.13). Equation (3.16) follows from equation (3.27).

Dynamics of α_t^*. We can rewrite equation (3.12) as follows:

$$\eta'(\alpha_t^*) = \frac{1}{\theta\left(\frac{A^L_{t-1,1}(1+g)}{A_{t-1,1}+\eta(\alpha^*_{t-1})\left(A^L_{t,1}-A_{t-1,1}\right)} - 1\right)} \tag{3.28}$$

From equation (3.28) we notice that when the denominator of the following expression

$$\frac{A^L_{t-1,1}(1+g)}{A_{t-1,1}+\eta(\alpha^*_{t-1})\left(A^L_{t-1,1}-A_{t-1,1}\right)}$$

increases more than its numerator as a result of investing the share of income α^*_{t-1}, i.e. when the domestic level of technology grows faster than g, the economy approaches the leading technological frontier, and therefore the gap between the level of local technology and the leading frontier, i.e. $\frac{A^L_{t,1}}{A_{t,1}}$, reduces. As $\frac{A^L_{t,1}}{A_{t,1}}$ positively affects the level of α_t^*, this implies that α_t^* reduces as well, and therefore $\alpha_t^* < \alpha^*_{t-1}$.

When, on the contrary, the denominator of

$$\frac{A^L_{t-1,1}(1+g)}{A_{t-1,1}+\eta(\alpha^*_{t-1})\left(A^L_{t-1,1}-A_{t-1,1}\right)}$$

increases less than its the numerator, i.e. when the level of domestic technology grows slower than the world frontier, then the distance to technological frontier increases, which reverses the inequality, i.e. α_t^* becomes larger than α^*_{t-1}.

Finally, when the numerator of

$$\frac{A^L_{t-1,1}(1+g)}{A_{t-1,1}+\eta(\alpha^*_{t-1})\left(A^L_{t-1,1}-A_{t-1,1}\right)}$$

increases as fast as does its denominator, i.e. at the rate g, the gap between the level of local technology and the leading frontier remains constant, and therefore it follows that $\alpha_t^* = \alpha^*_{t-1}$.

Uniqueness of α_t^*. We take a derivative of $\frac{\alpha_{t+1}^*}{\alpha_t^*}$ with respect to α_t^*:

$$\frac{\partial\left(\frac{\alpha_{t+1}^*}{\alpha_t^*}\right)}{\partial\alpha_t^*} = \frac{\frac{\partial\alpha_{t+1}^*}{\partial\alpha_t^*}\alpha_t^* - \alpha_{t+1}^*}{\left(\alpha_t^*\right)^2} < 0$$

The latter inequality follows as $\frac{\partial\alpha_{t+1}^*}{\partial\alpha_t^*} < 0$, which we established in the previous section of the current Appendix. $\frac{\partial\left(\frac{\alpha_{t+1}^*}{\alpha_t^*}\right)}{\partial\alpha_t^*} < 0$ implies that $\frac{\alpha_{t+1}^*}{\alpha_t^*}$ decreases when the value of α_t^* increases. α_t^* reaches its steady-state level when the following results hold: $\frac{\alpha_{t+1}^*}{\alpha_t^*} = 1$, $\frac{\partial\alpha_{t+1}^*}{\partial\alpha_t^*} = 1$, and therefore $\frac{\partial\left(\frac{\alpha_{t+1}^*}{\alpha_t^*}\right)}{\partial\alpha_t^*} = 0$. As $\frac{\alpha_{t+1}^*}{\alpha_t^*}$ always decreases when α_t^* instead becomes larger, the steady-state is unique.

Global stability of the steady-state level of α_t^*. We write down the first order condition for the representative firm which imitates technologies from the leading frontier:

$$\eta'(\alpha_t^*) = \frac{1}{\theta\left(\frac{A_{t,1}^L}{A_{t,1}} - 1\right)} \tag{3.29}$$

As $\eta'(\alpha_t^*)$ is monotonically decreasing in α_t^*, we can rewrite equation (3.29) as follows:

$$\alpha_t^* = (\eta')^{-1}\left(\frac{1}{\theta\left(\frac{A_{t,1}^L}{A_{t,1}} - 1\right)}\right) \tag{3.30}$$

Since $\eta(\alpha_t^*)$ is concave, which implies that $\eta''(\alpha_t^*) < 0$, the inverse of $\eta'(\alpha_t^*)$, which is $(\eta')^{-1}$, is also a decreasing function of its argument, i.e $\left((\eta')^{-1}\right)' < 0$.

To prove global stability, we consider $\alpha_t^* \in (\alpha^*, \alpha_0^*)$, where α^* is a steady-state level of α_t^*, and α_0^* is the level of initial share which is invested by generation $t = 0$.

We can use equation (3.30) to show that for all $\alpha_t^* \in (\alpha^*, \alpha_0^*)$

$$\alpha_{t+1}^* - \alpha^* = (\eta')^{-1}\left(\frac{1}{\theta\left(\frac{A_{t+1,1}^L}{A_{t+1,1}(\alpha_t^*)} - 1\right)}\right) - (\eta')^{-1}\left(\frac{1}{\theta\left(\frac{A_{t,1}^L}{A_{t,1}(\alpha^*)} - 1\right)}\right) =$$

$$= -\tfrac{\alpha_t^*}{\alpha^*}\left((\eta')^{-1}\right)' > 0 \tag{3.31}$$

The latter inequality follows from $\left((\eta')^{-1}\right)' < 0$. We therefore conclude that $\alpha_{t+1}^* > \alpha^*$.

As we showed that $\frac{\alpha_{t+1}^*}{\alpha_t^*}$ decreases when $\alpha_t^* \in (\alpha^*, \alpha_0^*)$, we can now derive the following result:

$$\frac{\alpha_{t+1}^*}{\alpha_t^*} - 1 < \frac{\alpha^*}{\alpha^*} - 1 = 0 \tag{3.32}$$

Equation (3.31) together with equation (3.32) establish that for all $\alpha_t^* \in (\alpha^*, \alpha_0^*)$, it follows that $\alpha_{t+1}^* \in (\alpha^*, \alpha_t^*)$. A similar argument can be used to show that for all $\alpha_t^* \in (\alpha_0^*, \alpha^*)$, $\alpha_{t+1}^* \in (\alpha_t^*, \alpha^*)$. Therefore, $\{\alpha_t^*\}_0^\infty$ monotonically converges to α^* and is globally stable.

Adoption function is increasing in α_t^*. To show that the following expression

$$R_t = (1 - \varphi(\alpha_t^*))^{1-\theta}\left[1 - \alpha_t^* + \frac{1 + \varphi(\alpha_t^*)}{1 - \varphi(\alpha_t^*)}\right]$$

is increasing with respect to α_t^*, we first rewrite this equation as follows:

$$R_t = \left(\frac{A_{t,2} + A_{t,1}}{A_{t,1}} - \alpha_t^*\right)\left(\frac{2A_{t,1}}{A_{t,2} + A_{t,1}}\right)^{1-\theta}$$

and then differentiate the above expression with respect to α_t^*:

$$\left(\frac{1}{\theta} - 1\right)\left(\frac{2A_{t,1}}{A_{t,2} + A_{t,1}}\right)^{1-\theta} -$$

$$-(1-\theta)\left(\frac{2A_{t,1}}{A_{t,2} + A_{t,1}}\right)^{-\theta}\left(\frac{2A_{t,1}}{A_{t,2} + A_{t,1}}\right)\frac{A_{t,1}}{\theta\left(A_{t,2} + A_{t,1}\right)}\left(\frac{A_{t,2} + A_{t,1}}{A_{t,1}} - \alpha_t^*\right) =$$

$$= \left(\frac{1}{\theta} - 1\right)\left(\frac{2A_{t,1}}{A_{t,2} + A_{t,1}}\right)^{1-\theta} \alpha_t^* \frac{A_{t,1}}{A_{t,2} + A_{t,1}} > 0$$

which establishes the result

3.5.2 Appendix B

In the case of corruption, we consider the following inequality:

$$(1-\gamma)\left[(1-\alpha_t^*)\,\beta A_{t,1}^{\theta}\left(h_{t,1}\left(1-\varphi(\alpha_t^*)\right)m_t\right)^{1-\theta} + \beta A_{t,2}^{\theta}\left(h_{t,1}\left(1+\varphi(\alpha_t^*)\right)m_t\right)^{1-\theta}\right] \geq$$

$$\geq \beta A_{t,1}^{\theta}\left(h_{t,1}m_t\right)^{1-\theta} + \beta A_{t,1}^{\theta}\left(h_{t,1}m_t\right)^{1-\theta}$$

which reduces to

$$(1-\gamma)\left(1-\varphi(\alpha_t^*)\right)^{1-\theta}\left[1-\alpha_t^* + \frac{1+\varphi(\alpha_t^*)_t}{1-\varphi(\alpha_t^*)}\right] \geq 2$$

From this result inequality (3.20) follows immediately.

3.5.3 Appendix C

The cost of market concentration

A common solution to the problem of low investment is a subsidy, as it reduces the cost of investment for a firm and thus increases the profitability of an investment project. However, if the fiscal system is underdeveloped, which is likely to be the case for many developing economies, an alternative solution is to restrict competition. For instance, Aghion and Griffith (2008) argue that after WWII Mexico, Peru, Brazil, several South-East Asian countries, Japan and a number of European economies introduced restrictions on competition and favored the creation of domestic monopolies. Acemoglu, Aghion and Zilibotti (2006) also argue that to induce firms to increase the level of investment, the government could impose restrictions on competition, and a similar argument was also put forward by Gerschenkron (1962). In this section we show how restricted competition can help the economy to leave the non-convergence trap.[34]

We assume that the government introduces restrictions on competition to induce firms to invest more in the acquisition of new technologies.[35] As a result of restricted competition, the number of firms reduces, while the number of workers employed at the representative firm, becomes instead larger. In particular, we assume that a typical firm becomes K times larger than before, and therefore the number of employees in the representative firm increases from m to Km. We also assume that larger restrictions on competition translate in a higher value of K. Finally, we assume that the government does not limit competition unconditionally: if firms do not invest into the acquisition of new technologies in period $j = 1$, then the government does not limit competition any longer. As a result, equation (3.21), which reflects the case when the owner is indifferent between investing into a new technology or retaining the old one, can be rewritten as follows:

$$\gamma = 1 - \frac{1 + \frac{1}{K^{1-\theta}}}{\left[1 - \widehat{\alpha}^{*} + \frac{1+\varphi(\widehat{\alpha}^{*})}{1-\varphi(\widehat{\alpha}^{*})}\right]\left(1 - \varphi(\widehat{\alpha}^{*})\right)^{1-\theta}} \tag{3.33}$$

, where $K > 1$ represents the number of firms which were transformed into one large firm as a result of a higher level of market concentration. For the derivation of equation (3.33), see Appendix D.1.

We remind that $\widehat{\alpha}^{*}$ reflects the value of α_t^{*} at which the payoffs from investing into a new technology and acquiring the storage technology are identical. As it follows from equation (3.33), when $\widehat{\alpha}^{*}$ is equal to 0, and when $K > 1$, indicating that competition

[34] One can pose the following question: why is the state interference a necessary way out? Why can't firms voluntarily merge to overcome the negative effect caused by corruption?

To answer this question, assume that K firms merged and created one large firm with K shareholders. We assume that whenever two (or more) small firms merge, the new big firm employs everyone from the two (or more than two) smaller firms. It is easy to check that in this case equation (3.21) holds again. Intuitively, if corruption affects the incentives of K different owners who own K comparatively small firms, then it equaly affects the incentives of K shareholders who own one large firm. Then, if the number of owners stays the same, a voluntary merger can not result in an improvement.

[35] To this end, the government can introduce higher licensing standards, nationalize firms, etc.

is restricted, the level of γ, representing a share of the owner's income taken by a bureaucrat, is equal to $\frac{1-\frac{1}{K^{1-\theta}}}{2} > 0$. The latter implies that if the level of corruption γ does not exceed $\frac{1-\frac{1}{K^{1-\theta}}}{2}$, then the representative firm is better off investing into a new technology at any $\alpha_t^* \geq 0$, and therefore corruption does not affect the level of investment in the acquisition of a new technology. The latter was not the case for the competitive economy with corruption, which was considered in Section 3. Intuitively, a higher level of market concentration generates a higher level of income per firm, and. as a result, the representative firm's incentives to invest into the acquisition of new technologies become larger even in the presence of corruption, whereas investment into the storage technology becomes instead less attractive.

We are now ready to formulate the following proposition:

Proposition 5. *If the government restricts competition, the representative owner invests more in the acquisition of new technologies and, as a result, the distance to the leading technological frontier reduces. Moreover, the government can introduce a sufficiently large level of restrictions to induce the economy to move as close to the leading technological frontier, as to be able to substitute imitation with innovation. As a result of a higher market concentration, the level of investment into human capital also becomes higher.*

Proof. From equation (3.33) it follows that the value of $\widehat{\alpha}^*$ corresponding to particular γ becomes smaller compared to the level of $\widehat{\alpha}^*$ which we obtained from equation (3.21).[36] According to equation (3.12), a lower level of $\widehat{\alpha}^*$ corresponds, in turn, to

[36] To show that tht latter result is the case, we subtract equation (3.21) from equation (3.33), which results in the following expression:

$$\frac{2}{(1-\varphi(\widehat{\alpha}_1^*))^{1-\theta}\left[1-\widehat{\alpha}_1^*+\frac{1+\varphi(\widehat{\alpha}_1^*)}{1-\varphi(\widehat{\alpha}_1^*)}\right]}-\frac{1+\frac{1}{K^{1-\theta}}}{(1-\varphi(\widehat{\alpha}_2^*))^{1-\theta}\left[1-\widehat{\alpha}_2^*+\frac{1+\varphi(\widehat{\alpha}_2^*)}{1-\varphi(\widehat{\alpha}_2^*)}\right]}=0 \qquad (3.34)$$

where $\widehat{\alpha}_1^*$ corresponds to equation (3.21) and $\widehat{\alpha}_2^*$ instead corresponds to equation (3.33). The numerator of the first term of the upper expression is larger than the numerator of its second term, as $2 > 1+\frac{1}{K^{1-\theta}}$ whenever $K > 1$. To satisfy equation (3.34), the denominator of the first term should therefore be larger a lower distance to technological frontier $\frac{A^L_{t,1}}{A_{t,1}}$, and therefore it follows that a higher market concentration let the economy move closer to the leading frontier.

It is also possible to choose a sufficiently large level of K such that the economy can move to the leading frontier close enough to substitute imitation with innovation. To see this, suppose that the economy substitutes imitation with innovation when $\alpha^*_t = \alpha^*$. From equation (3.33) it follows that given a particular value of γ, we can choose K such that $\alpha^*_t = \alpha^*$ will satisfy equation (3.33).
Let's assume that the value of α^* is, for instance, sufficiently low. As a consequence, the denominator of the second term on the right-hand side of equation (3.33) is low as well. As a result, the ratio on the right-hand side of equation (3.33) is large, and, therefore, the entire right-hand side of equation (3.33) instead is low. If γ, reflecting the level of corruption, is large, then equation (3.33) can not be satisfied, which implies that the owner will prefer to retain the old technology, and not to invest into a new one. The government, however, can restrict competition, i.e. it can choose a larger level of K such that equation (3.33) is satisfied, as a higher K results in a higher level of the right-hand side of equation (3.33). As a result of restricted competition, the owner will therefore change his decision in favor of investment into a new technology. ■

We can illustrate the working of Proposition 3 in Figure 5:

than the denominator of the second term. As the value of $(1-\varphi(\widehat{\alpha}^*))^{1-\theta}\left[1-\widehat{\alpha}^*+\frac{1+\varphi(\widehat{\alpha}^*)}{1-\varphi(\widehat{\alpha}^*)}\right]$ is larger when the level of $\widehat{\alpha}^*$ is higher, it thus follows that $\widehat{\alpha}^*_1 > \widehat{\alpha}^*_2$.

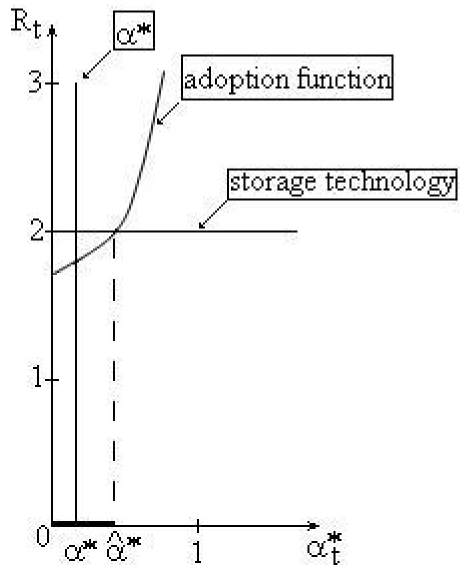

Figure 5. The steady-state level of investments in the economy with corruption and limited competition.

As a larger firm generates higher income, after the firm pays the respective share γ of this income to a bureaucrat, the remaining income is comparatively large, and, as a result, the representative owner has higher incentives to invest in the acquisition of new technologies. As investment into the storage technology becomes instead relatively less attractive, the horizontal line $R_t = 1 + \frac{1}{K^{1-\theta}}$ representing the payoff from the storage technology is shifted down. Algebraically, instead of $R_t = 2$, as is on the right-hand side of equation (3.33), now the payoff from the storage asset corresponds to $R_t = 1+\frac{1}{K^{1-\theta}}$,which is less than 2 whenever $K > 1$. The latter results in a new intersection point between the horizontal line and the adoption function.. If we project this new intersection point on the horizontal axis, we can see that the corresponding point on the α_t^*-axis, i.e. point $\widehat{\alpha}^*$, is located closer to zero than a similar point in the case of free competition, reflected in Figure 3. The latter implies that the *non-convergence set*, which is again depicted as a bold section of the horizontal axis, becomes smaller.

A larger restriction on competition corresponding to a higher value of K, results in a larger increase in the level of the representative firm's incomes. The latter further reduces the attractiveness of investing into the storage asset. Algebraically, a higher level of K results in a smaller value of $R_t = 1+\frac{1}{K^{1-\theta}}$, and graphically this corresponds to a larger downward shift of the horizontal line which reflects the payoff from the storage asset. Therefore, when K is high, owners tend to invest more into a new technology, and therefore the economy moves closer to the frontier technology.

At the same time, we emphasize that the government should not choose K arbitrarily, since, as we show in the following section, market concentration results in significant costs for the economy. A larger value of K corresponding to a higher level of restrictions results in a higher level of costs. Therefore, to minimize these costs, the government should select a minimal level of K which induces firms to invest into adoption as much, as to be able to reach the steady-state level of α_t^*. The horizontal line $R_t = 1 + \frac{1}{K^{1-\theta}}$ therefore should intersect the adoption function exactly at point $\widehat{\alpha}^* = \alpha^*$, where the adoption function itself intersects with the vertical line reflecting the innovation stage, and where the economy substitutes imitation with innovation, as it is shown in Figure 5.

The cost of market concentration

To determine the level of costs resulting from a higher level of market concentration, we need to compare the level of production under the limited competition regime with the output level which is produced when competition is instead unrestricted. To eliminate the effect of corruption, we temporarily assume that the level of corruption is zero, i.e. $\gamma = 0$.

In Appendix D.2 we show that the comparison between the output levels produced in a less competitive and a more competitive economies reduces to comparison between 1 and K^{θ}, where $K > 1$. As the latter is larger than the former, it follows that a less competitive economy produces a lower level of output, and therefore a larger K

representing the level of market concentration, results in a lower level of production.

In the presence of corruption, however, restrictions on competition can benefit the economy. To show this result, we compare the following two expressions:

$$Y_t^R = (1 - \varphi(\alpha_t^*))^{1-\theta} \left[1 - \beta\alpha_t^* + \frac{1 + \varphi(\alpha_t^*)}{1 - \varphi(\alpha_t^*)}\right] \tag{3.35}$$

and

$$Y_t^{NR} = 2K^\theta \tag{3.36}$$

where Y_t^R denotes the owner's normalized payoff when competition is restricted, and Y_t^{NR} denotes the owner's normalized payoff in the absence of restrictions on competition. For the derivation of equations (3.35) and (3.36), see Appendix D.2.

As soon as the government restricts competition, the level of output reduces as a result of a higher level of market concentration. These costs, however, can be compensated if in the less competitive economy firms invest into new technologies, and employees acquire additional human capital, i.e. when α_t^* and therefore $\varphi(\alpha_t^*)$ are both positive. Assume that two economies are identical but in country A the government limits competition, and, as a result, the level of output declines, while in B competition remains unrestricted. However, as more limited competition induces firms to acquire new technologies, the level of technology in A evolves faster and moves closer to the leading frontier. The latter also results in a faster accumulation of human capital. As the level of technology increases and the stock of human capital becomes larger, the level of output in A increases as well. On the contrary, in country B competition is free, however, in the presence of corruption the local technology does not converge to the leading frontier. Both, the level of human capital and the level of technology in B increase slowly, and, as a result, B lags behind economy A considering the level of technology and the stock of human capital. Therefore, starting from a particular point, the level of production in A becomes larger than the level of output in B. The latter occurs as soon as the following expression holds:

$$\left(\frac{A_{t,1}^{A}}{A_{t,1}^{B}}\right)^{\theta}\left(\frac{h_{t,1}^{A}}{h_{t,1}^{B}}\right)^{1-\theta}(1-\varphi(\alpha_t^*))^{1-\theta}\left[1-\beta\alpha_t^*+\frac{1+\varphi(\alpha_t^*)}{1-\varphi(\alpha_t^*)}\right]\geq 2K^{\theta} \qquad (3.37)$$

where $A_{t,1}^{A}$ and $h_{t,1}^{A}$, correspondingly, denote the level of technology and human capital stock in less competitive A, and $A_{t,1}^{B}$and h_t^B reflect technology and human capital levels in country B, where environment is instead more competitive. For derivation of inequality (3.37) see Appendix D.2.

One can notice that expression (3.37) contains a scalar $\left(\frac{A_{t,1}^{A}}{A_{t,1}^{B}}\right)^{\theta}\left(\frac{h_{t,1}^{A}}{h_{t,1}^{B}}\right)^{1-\theta}$, which is larger whenever a higher market concentration results in faster evolution of technology and human capital accumulation. As was showed in section 3, a competitive economy can fail to reach the steady-state, as it does not converge to the world frontier, and therefore it can stay in the adoption stage forever. At the same time, since a less competitive economy has a higher potential to reach the innovation stage, its technology develops faster.[37] Thus, a less competitive economy reaches higher levels of technological development and human capital than a more competitive one.

We therefore conclude that market concentration has an important limitation, as a higher level of monopolization results in a lower level of production. This limitation arises because as a policy, consolidation deals with negative effects of corruption, but not with the level of corruption per se. It helps the economy move closer to the leading technological frontier and acquire more human capital, but as it can not solve the problem of corruption, the latter finds a different channel to produce a negative effect on the economy. This is the key difference between market concentration and anti-corruption campaign, as, to result in a higher level of investment, the latter does not require to impose restrictions on competition, and therefore the level of output does not become lower.

[37]This is because if it falls down into a non-convergence trap, a competitive economy grows as fast as does the leading frontier, i.e. at a rate g. The latter, by assumption, is lower than the growth rate of an innovating economy.

We also emphasize another potential problem which might arise when the authority restricts the level of competition in the economy. So far, we assumed that the share of income which a bureaucrat diverts from the owner, i.e. γ, remains constant. However, in response to a larger income which the representative firm receives under restricted competition, a bureaucrat might increase the level of γ. In the latter case, a higher market concentration will enrich the bureaucracy instead of a increasing the pace of technological evolution and human capital accumulation. As a result, not only the level of production will decline below its potential, but also the economy will not be able to leave the non-convergence trap. Therefore, if the level of corruption increases, the economy might end up being worse off as a result of restricted competition.

Finally, we show that the positive effect of restricted competition is stronger when the difference between the level of $\widehat{\alpha}^*$ corresponding to equation (3.21), and the level of α^*, corresponding to the steady-state, is low. In this case, even though firms need additional incentives to move from point $\widehat{\alpha}^*$ to the steady-state point, the level of required additional incentives is low. Therefore, the government does not need to introduce large restrictions on competition, which implies that the level of K is low, and, as a result, the level of costs associated with a lower level of competition is low as well. We can show this result graphically.

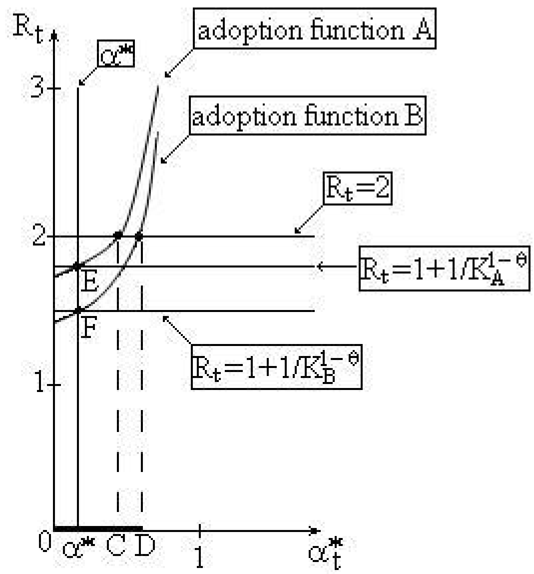

Figure 6. The necessary level of restrictions on competition in two economies with different levels of corruption.

Assume that two economies, A and B, have different levels of corruption, but are otherwise identical. Assume that the value of γ^B, the share of income which bureaucrats divert in country B, is larger than the level of γ^A, corresponding instead to the level of corruption in A. From equation (3.21) it follows that a higher level of corruption in B results in a larger downward shift of the adoption function and, as a consequence, a larger non-convergence set in this economy. The non-convergence set in B is equal to the distance between 0 and point D on the horizontal axis. The non-convergence set in economy A is instead smaller and equals to the distance between 0 and point C, which is shorter than the distance between 0 and D. Therefore, in economy B firms need higher additional incentives to move to the steady-state, and thus the government needs to introduce larger restrictions on competition, which results in a larger level of K. Therefore, as $K_B > K_A$, in country B the payoff from investing into storage asset $R_t = 1 + \frac{1}{K_B^{1-\theta}}$ intersects the vertical line, representing innovation stage, at point F, which is located below point E, the intersection point between $R_t = 1 + \frac{1}{K_B^{1-\theta}}$, corresponding to the payoff from acquiring the storage asset in economy A, and the vertical line. A higher value of K_B, reflecting the level of restrictions on competition, results in a larger reduction in the level of output in country B. In economy A the required level of K_A is instead smaller, which results in a lower reduction in the level of production. We therefore conclude that, if the authority implements an industrial policy in order to increase the pace of technological evolution, a higher value of γ results in larger restrictions on competition, and as a consequence, leads to a larger reduction in the level of output.

Educational reform and market concentration

We thus showed how a higher level of market concentration can encourage the owners to invest more in the acquisition of new technology. As a result of restricted competition, the domestic technology might improve, and therefore employees have higher incentives to acquire human capital. Thus, in the presence of a higher market concentration, new educational opportunities brought about by an educational reform might become more demanded by employees.

3.5.4 Appendix D.1

For an arbitrary level of γ the following expression should hold:

$$(1-\gamma)\left((1-\alpha_t^*)\,\beta A_{t1}^{\theta}\left(h_{t,1}\left(1-\varphi(\alpha_t^*)\right)Km_t\right)^{1-\theta}+\beta A_{t,2}^{\theta}\left(h_{t,1}\left(1+\varphi(\alpha_t^*)\right)Km_t\right)^{1-\theta}\right)=$$

$$=\beta A_{t,1}^{\theta}\left(h_{t,1}Km_t\right)^{1-\theta}+\beta A_{t,1}^{\theta}\left(h_{t,1}m_t\right)^{1-\theta}$$

After we divide it over β, it transforms to the following result:

$$(1-\gamma)\left((1-\alpha_t^*)\,A_{t,1}^{\theta}\left(h_{t,1}\left(1-\varphi(\alpha_t^*)\right)Km_t\right)^{1-\theta}+A_{t,2}^{\theta}\left(h_{t,1}\left(1+\varphi(\alpha_t^*)\right)Km_t\right)^{1-\theta}\right)=$$

$$= (1+r)\, A_{t,1}^{\theta} \left(h_{t,1} K m_t\right)^{1-\theta} + A_{t,1}^{\theta} \left(h_{t,1} m_t\right)^{1-\theta}$$

Finally, after we simplify the above expression, we receive the following result:

$$(1-\gamma)\, K^{1-\theta} \left(1-\varphi(\alpha_t^*)\right)^{1-\theta} \left[1-\alpha_t^* + \frac{1+\varphi(\alpha_t^*)}{1-\varphi(\alpha_t^*)}\right] = K^{1-\theta} + 1$$

From this expression equation (3.33) follows immediately

3.5.5 Appendix D.2

We, first, compare the level of production under the limited competition regime with the output level which is produced when competition is instead unrestricted. To eliminate the effect of corruption, we temporarily assume that the latter is zero, i.e. $\gamma = 0$.

As in the absence of corruption the level of investment into a new technology is the same for the less and the more competitive economies, we can reduce the above comparison to the following two expressions:

$$Y_{t,1}^{R} = A_{t,1}^{\theta} \left(h_{t,1} K m_t\right)^{1-\theta} \tag{3.38}$$

and

$$Y_{t,1}^{UR} = K A_{t,1}^{\theta} \left(h_{t,1} m_t\right)^{1-\theta} \tag{3.39}$$

Equation (3.38) corresponds to the level of output produced by the representative firm in a less competitive economy in period $j = 1$, while equation (3.39) reflects the level of output produced by K firms in a more competitive economy within the same period $j = 1$. The representative firm in the less competitive economy employs as many individuals as K firms in the more competitive one. We divide equations (3.38) and (3.39) over $A_{t,1}^{\theta} \left(h_{t,1} K m_t\right)^{1-\theta}$, and as a result, we have to compare 1, corresponding to the normalized output level under restricted competition, and K^{θ}, reflecting instead the level of production in the economy without restrictions. As $K \geq 1$, we conclude that $K^{\theta} \geq 1$, implying a higher level of production in the economy with a lower level of market concentration.

We turn to the situation when the level of corruption is positive, i.e. $\gamma > 0$, and we consider the case when the level of production in the economy with restricted competition becomes larger than the level of output in the economy with free competition. In the presence of corruption, the latter occurs when the following expression holds:

$$A_{t,1}^{\theta}\left(h_{t,1}\left(1-\varphi(\alpha_t^*)\right)Km_t\right)^{1-\theta}\left(\beta\left(1-\alpha_t^*\right)+\left(1-\beta\right)\right)+A_{t,2}^{\theta}\left(h_{t,1}\left(1+\varphi(\alpha_t^*)\right)Km_t\right)^{1-\theta}\geq$$

$$\geq 2KA_{t,1}^{\theta}\left(h_t m_t\right)^{1-\theta}$$

or after simplification

$$K^{1-\theta}\left(\beta\left(1-\alpha_t^*\right)+\left(1-\beta\right)+\frac{1+\varphi(\alpha_t^*)}{1-\varphi(\alpha_t^*)}\right)\geq 2K \tag{3.40}$$

Equation (3.35) directly follows from equation (3.40).

Consider the following inequality again:

$$A_{t,1}^{\theta}\left(h_{t,1}\left(1-\varphi(\alpha_t^*)\right)Km_t\right)^{1-\theta}\left(\beta\left(1-\alpha_t^*\right)+\left(1-\beta\right)\right)+A_{t,2}^{\theta}\left(h_{t,1}\left(1+\varphi(\alpha_t^*)\right)Km_t\right)^{1-\theta}\geq$$

$$\geq 2KA_{t,1}^{\theta}\left(h_t m_t\right)^{1-\theta}$$

Let $A_{t,1}^{A}$ and $h_{t,1}^{A}$ represent the level of technology and human capital under restricted competition, and let $A_{t1}^{B}$and h_t^B instead correspond to technology and human capital levels in the more competitive economy, $A_{t,1}^{A}\neq A_{t,1}^{B}$, and $h_{t1}^{A}\neq h_t^B$. Substitute $A_{t,1}^{A}$ and $h_{t,1}^{A}$ into the left-hand side of the above inequality, and $A_{t,1}^{B}$and h_t^B into its right-hand side. Then, after minor manipulations, we arrive at inequality (3.37).

Chapter 4

Growth Alone is not Enough

4.1 Introduction

In October 2012, after 8 years of profound institutional reforms which resulted in a substantial reduction in the level of bureaucratic corruption, a higher effectiveness of the national energy sector, the emergence of modern public finance system and professional and transparent bureaucracy, Georgian president Saakashvili's United National Movement lost an election against the Georgian Dream, a political alternative established by a billionaire Bidzina Ivanishvili. Despite high growth rates, which reached double-digit levels in particular years and on average a nearly double-digit level between 2004 and 2007, Saakashvili's rule was also characterized by low level of income redistribution and relatively high poverty. Growth was not followed by an adequate job creation, while the wages of employed individuals were instead increasing substantially. High-educated citizens reaped significant benefits from economic growth, whereas most of low-educated Georgians stayed poor. Overall, the level of poverty declined from 28.5% in 2003 to 24.7% in 2009, which was not proportionate to the speed of economic growth within the same period. According to the World Bank (2011), "Economic growth in Georgia has not been pro-poor... ". Unfavorable distribution of benefits from economic growth induced poor individuals not to support Saakashvili and his reforms, but instead to grant their votes to alternative political force, which they considered as potentially less reformist, but also as more redistributing and therefore pro-poor.

This recent episode can be considered as a part of a broader context which, since 1980s, has been affecting the mainstream development roadmaps, as, for instance, the Washington or the Post-Washington Consensuses. Both of them emphasized the importance of growth-enhancing policies, leaving, however, a peripheral role to income redistribution. The lack of redistribution concerns as an important inadequacy of a development plan was also indicated by Joseph Stiglitz (2004) in his critical review of the Post-Washington Consensus:

> ”Is a society in which the vast majority of its citizens are becoming worse off - but in which a few at the top are doing so well that average incomes are rising - better off than one in which the vast majority are doing better? While there may be disagreements - and those at the very top may well stress that average income is the appropriate measure - the possibility that increases in GDP may not benefit most individuals means that we cannot simply ignore issues of distribution. Some economists argued that distribution concerns could be ignored because they believed in trickle down economics - somehow everybody would benefit; a rising tide would lift all boats. But the evidence against trickle down economics is now overwhelming, at least in the sense that an increase in average incomes is not sufficient to raise the incomes of the poor for quite prolonged periods. Some economists argued that distribution concerns could and should be ignored, because such concerns were outside the province of economics; economists should focus on efficiency and growth alone. Distribution was a matter for politics”.

We argue that the lack of income redistribution concerns is an important flaw of modern development practices. As the presence of a large disadvantaged cohort which is disconnected from fast growing sectors[1] is a feature of many developing societies, economic growth alone might therefore not be very helpful for reducing the level of poverty. It thus should be complemented with a redistribution policy, which, as long as the poor cohort is separated from rapidly developing economic activities, might play an important role for mitigating the most severe consequences of poverty.

That economic growth can play a limited role in reducing the level of poverty is recognized by modern development practices, as, for instance, Inclusive Growth. However, instead of implementing direct redistribution, the latter suggests to expand the disadvantaged cohort's opportunities to participate in fast-growing economic activities, as it follows from the World Bank (2009):

> ”While absolute pro-poor growth can be the result of direct income redistribution schemes, for growth to be inclusive, productivity must be improved and new employment opportunities created. In short, inclusive growth is about raising the pace of growth and enlarging the size of the economy, while levelling the playing field for investment and increasing productive employment opportunities” and ”Inclusive Growth focuses on productive employment rather than income redistribution”.

We argue though that as the main effects of such a policy might realize after a long time, it thus can not substitute income redistribution in the short term. For instance, a reform which increases the accessibility of education in order to enhance social mobility, can achieve its goals years later, as transferring human capital is inherently a long-term process. Therefore, before the main effects of this reform are realized, the disadvantaged cohort can remain poor and thus sensitive to income redistribution policies. If the latter are not implemented, poor individuals might support a political regime which practices income transfers, even though this regime's growth-enhancing policies are, at the same time, potentially less effective. It is therefore essential to

[1] As, for instance, individuals who are self-employed in subsistance farming.

incorporate income redistribution into development policies, as otherwise the latter might become politically unfeasible.

To introduce this intuition in the form of a model, we consider a non-overlapping generation developing economy where high-educated and low-educated individuals combine their human capital with evolving technology to produce output.

We incorporate institutions into the model and show that the pace of technological evolution and economic growth are larger under the high-quality institutions, and they are instead small in the opposite case of low-quality institutions.

We assume that, as opposed to the large group of low-educated individuals, a relatively small high-educated cohort controls a larger share in output, and therefore its representative member derives comparatively high benefits from economic growth. The less educated individuals' share in output is instead low, and, as a result, their benefits from economic growth are low as well. As a consequence, a high level of poverty might sustain even in the presence of high growth rates.

To link these features with political outcomes, we consider two alternative political regimes. A clientelistic regime derives benefits if the quality of institutions remains low, and therefore it has incentives to retain low-quality institutions as long as possible. As low-quality institutions are broadly recognized as a key impediment to economic growth (see, for instance, Blume, Rubinfeld and Shapiro 1984, Kaplow 1986, and Epstein 2008), growth rates remain low as long as the clientelistic regime keeps power. However, as staying in power requires retaining a certain level of popularity, the clientelistic regime implements a redistribution policy which benefits low-educated individuals and thus earns their political sympathies. A reformist regime instead improves the quality of institutions, which increases the pace of technological evolution, accelerates human capital accumulation, and results in faster economic growth. We show, however, that the latter might be insufficient for sustaining political popularity, as the low-educated cohort, which makes up a majority of individuals, might be comparatively more sensitive to income redistribution, than to economic growth. Therefore, complementing an institutional reform with income redistribution policy might be a key to winning political competition. The central role in politics transits from economic growth to redistribution as long as the economy becomes more developed, and thus growth rates decline. We conclude that the reformist regime might loose political competition against the clientelistic alternative, if it ignores income redistribution.[2] As a result, growth-enhancing policy can be reversed and the economy might end up in a non-convergence trap.

As an alternative to income redistribution, a part of the low-educated cohort can transit to the high-educated group if the authority, instead of redistributing incomes, implements a reform which increases the accessibility of education. As a result of the latter reform, the level of output becomes larger, as well as the size of the middle class, and thus the number of individuals who benefit from economic growth increases. We therefore follow Muller and Shavit, (1998), as we assume that a broader access to high-quality educational services enhances the attainment of the middle-class occupations, which results in the emergence of a larger middle class. Our key assumption, however, suggests that the time which is required for the acquisition of additional human capital is comparatively long, and, as a consequence, the educational reform might impact only the following generation of low-educated individuals, without affecting the current one.[3] As is argued in Tiongson (2012) "...Education policy reforms have long term effects on poverty and income distribution...". As a result, inclusive growth can

[2]Even though it is associated with slow growth, the clientelistic regime, nevertheless, might earn substantial political popularity among the low-educated group, as income transfers which it provides might be more important for the low-educated individuals than economic growth.

[3]At the same time, we assume that much less time is needed to improve the quality of institutions in a particular economy. Moreover, economic effect of improved institutions might also realize relatively fast.

For instance, Georgia needed 3 years to increase its FDI inflow from 500 million USD in 2004 to 2 bln USD in 2007, as a result of its anti-corruption efforts which were implemented within the same years.

Another illustration is a successful anti-corruption campaign which was implemented in Liberia. The latter made a substantial progress in reducing the level of corruption, as it had been ranked 137 out of 158 countries according to Transparency International's Corruption Perseption Index in 2005, but ended up at the 87th position out of 178 economies in 2010 (see Transparency International, 2011).

By contrast, economic effect of an educational policy is intrinsically more delayed, as years are required to implement the reform, to educate individuals, to employ them, etc.

not substitute income redistribution in the short term, as the current generation of low-educated individuals can still have low sensitivity to economic growth. Its dependence on income redistribution, by contrast, remains comparatively high.

The remainder of the chapter is organized as follows. Section 2 reviews the literature and provides the model outline. Section 3 addresses the problem of low-quality institutions in the context of our benchmark growth model, and shows how does its presence result in a non-convergence trap. In Section 4, we introduce political competition as an opportunity to remove low-quality institutions, and show how this opportunity can remain unemployed if an institutional reform is not complemented with income redistribution. In the extension to our chapter, which we present in Section 5, we argue that the effect of investing into human capital, which we consider as a potential alternative to income redistribution policy, realizes only in the long-run, and therefore can not reduce the level of income inequality in the short term. Section 6 provides a summary.

4.2 Literature Review and Model Outline

Our model brings together different strands of the literature. First, our argument is related to the extensive literature which studies the link between growth and inequality.

For instance, Alesina and Rodrik (1994), Persson and Tabellini (1994) and Alesina (1994) argue that polarization is an obstacle to economic growth, as it shifts political focus from economic growth to income redistribution. As a result, a larger political pressure for redistribution discourages investment and therefore reduces the pace of economic growth.

Another set of arguments related to income polarization, as the ones of Loury (1981) or Galor and Zeira (1993), focuses on credit market imperfections as an important flaw which reduces poor individuals' investment opportunities and therefore lowers growth rates. As a result of a low accessibility of credit, poor individuals might be restricted from undertaking the optimal level of investment. In the presence of decreasing returns, their underfunded projects, however, are characterized by higher marginal product, and therefore, as redistribution might compensate the lack of investment credit, economic growth can become faster. In this context, Galor and Zeira (1993), for instance, argue that a society with high income inequality has a small middle class. The poor class is instead large and facing a binding liquidity constraint, which reduces its opportunities to accumulate human capital, thus resulting in a lower level of production.

There is also a literature which links income inequality and security of property rights. In the presence of a widening gap between rich and poor, the latter have motivation to expropriate assets from the former, and thus as investing becomes less secure, incentives to invest decline (see, for instance, Grossman, 1991, 1994, Acemoglu, 1995, Tornell and Velasco, 1992, Benhabib and Rustichini, 1996).

Finally, Adelman and Morris (1967) and Landes (1998), provide historical evidence for the importance of the middle class, and therefore lower inequality, for economic development in Europe.

Even though we also link inequality and economic growth, our focus is, however, different. We argue that, as inequality results in a higher popularity of income redistribution, it therefore might enhance political survival of ineffective and corrupt regimes, thus negatively affecting the long-term growth. For instance, even though a rent-seeking regime can cause a substantial slowing down in economic growth, it might, nevertheless, remain popular if it provides income transfers to the poor. We therefore emphasize that income redistribution might be a key ingredient for political success, and thus it should also be implemented by reformist regimes to enhance their political sustainability.

Our work is also related to political science literature which addresses the issue of persistence of clientelistic policies (see, for instance, Kitschelt, 2000). Brusco et al (2004) and Calvo and Murillo (2004) argue that poor voters in Argentina are more willing to support Peronists as the latter deliver clientelistic policies. Robinson and Verdier (2003) show that poor and less productive societies practice clientelism more often. This literature, however, focuses on popularity of clientelistic regimes among poor voters, without, by contrast to our argument, linking the latter with economic growth.

Finally, a vast literature considers education as an important link between individuals' social origin and their later social destination. Acemoglu (2002), Aghion et al (1999) and Katz and Murphy (1992) indicate that education and skills play an important role in wage differentials, therefore implying that a more accessible education system will result in a lower income inequality and a larger middle class. We refer to this literature, as we consider a policy which enhances the availability of education for the poor in order to integrate the latter into fast growing economic activities. This literature does not, however, link income redistribution with political sustainability. and economic growth.

In our setting a firm which is owned by the representative capitalist combines technology and human capital to produce output. Following Lucas (1988), Acemoglu (1994) and Redding (1996), we consider a non-overlapping generations economy where output is shared between the capitalist and two groups of employees, a low-educated group and a high-educated one. When young, each employee receives a particular endowment of human capital from the previous generation and becomes a high-educated individual if the level of human capital endowment is large, or a low-educated individual in the opposite case of a low intergenerational transfer of human capital. High- and low-educated individuals then decide how to allocate their human capital endowments between production and acquisition of additional human capital. Their decision is affected by the capitalist, who invests a part of his revenue from production into the acquisition of a new technology. The capitalist and employees share the same information, and thus the employees can perfectly foresee how much output does the capitalist plan to invest in a new technology. When the capitalist invests more into technological evolution, both groups of employees also prefer to acquire more human capital, since in this case the latter will earn a higher return. Higher educational attainments and investment into a new technology result, respectively, in a larger human capital stock and a more advanced technology, which are used to produce output when the capitalist, high-educated and low-educated employees become old.

We incorporate the quality of institutions into the model, and consider it as an important determinant of the level of investment into new technologies. When the quality of institutions is high, the economy develops faster, as the representative capitalist invests more into technological evolution, imitating technologies from the leading economy and thus letting domestic technology converge to the world technological frontier. However, as empirical evidence suggest that convergence with more developed countries did not take place in the case of many developing economies (see, for instance, Acemoglu, 2008), we also consider the case of low-quality institutions, and show how the latter reduce the capitalist's incentives to invest into new technologies. Since production factors are complements, both groups of employees reduce their investments into human capital in response to a slower pace of technological advancement.

We then introduce political competition into our model and consider it as an opportunity to replace low-quality institutions with the high-quality ones. We assume that a reformist regime pursues a growth-enhancing policy, and, to this end, it improves the quality of institutions. As the latter results in higher growth rates and therefore makes the capitalists and the employees better off, the reformist regime should acquire a broad political support, while its clientelistic opponent, which instead practices rent seeking and thus maintains low-quality institutions, should become extremely unpopular. As we show, the latter, however, is not necessarily the case if most of the current generation's employees belong to the low-educated group. As in this case less educated individuals acquire low benefits from economic growth, their support to growth-enhancing policy remains low as well. On the contrary, a sufficiently generous redistribution policy can increase the low-educated cohort income level more substantially. If the reformist regime does not transfer incomes to the low-educated employees, while its clientelistic opponent instead does, the political survival of the former, and therefore the implementation of institutional reform, becomes less feasible. Therefore, to win political competition, the reformist regime should combine institutional reform with income redistribution.

Finally, we consider the working of a particular growth policy[4] which helps low-educated employees transit to the high-educated group. We assume that the reformist regime, instead of using tax revenues to redistribute incomes, can improve the quality of education and transfer more human capital to the less educated cohort, therefore decreasing its size and increasing instead the size of the high-educated group. We suppose, however, that the former effect realizes in the long run, benefiting the next generation of low-educated employees, but not the current one. The latter implies that in the short term the educational policy can't substitute income redistribution, which remains an important determinant of the reformist regime's political survival.

4.3 The Benchmark Model of Economic Growth

In this section we introduce our baseline growth model, where two representative groups of employees and the representative capitalist, all belonging to a particular generation, combine, respectively, human capital and technology in order to produce output. Moreover, the employees acquire additional human capital, and the capitalist instead improves upon the technology which he inherited from the previous generation. After the current generation passes away, the human capital stock and technology are transferred to the next generation.

Incentives to acquire new technologies and human capital are affected by the quality of institutions. In the presence of low-quality institutions, the representative capitalist invests less into a new technology, while the employees, in turn, accumulate less human capital. As a result, the economy fails to catch up with a more developed reference country, and stays behind the latter as long as the quality of institutions remains low.

[4] As, for instance, Inclusive Growth

4.3.1 Production

Following Redding (1996), we consider two non-overlapping generations economies,[5] D and F,[6] where every generation lives for two periods 1 and 2. We focus our analysis on country D, while country F is instead introduced as a reference economy.

In period 1 a new generation t is born, it produces output $Y^i_{t,1}$, $i = D, F$, invests a particular share of $Y^i_{t,1}$ in the acquisition of new technologies and accumulates human capital. In the following period, i.e. in period 2, the same generation t produces output $Y^i_{t,2}$ and passes away.

We assume for simplicity that the size of population in D does not change over time, and it is as large as the size of population in country F. Each generation is made up of $L\left(n^i + 1\right)$ individuals, where L represents the number of capitalists in economy $i = D, F$ and $n^i = n^i_1 + n^i_2$ corresponds to the number of employees working for a typical capitalist in economy $i = D, F$. A group of employees of size n^i_1 working for the representative capitalist receives a large per capita human capital endowment $h^{i,1}_{t,1}$, while in the other group of size n^i_2 a typical employee inherits instead a low level of human capital $h^{i,2}_{t,1}$, which implies that $h^{i,1}_{t,1} > h^{i,2}_{t,1}$, $i = D, F$.

The representative capitalist owns a firm, where technology, which belongs to the capitalist, is combined with human capital, belonging instead to the employees, in order to produce the final output $y^i_{t,1}$, $i = D, F$. In both periods $j = 1, 2$, the representative firm in each economy produces a particular level of output according to the following production function:

$$y^i_{t,j} = \left(A^i_{t,j}\right)^{1-\theta_1-\theta_2} \left(h^{i,1}_{t,j} n^i_1\right)^{\theta} \left(h^{i,2}_{t,j} n^i_2\right)^{\theta_2} \tag{4.1}$$

where $i = D, F$ and $j = 1, 2$.

Therefore, within periods 1 and 2, the representative firm in economy $i = D, F$

[5] We do not use a standard overlapping generations approach, as we need to make sure that investing in two factors of production takes place synchronically. The latter is possible if the owners of the respective production factors make up the same generation.

[6] Where D and F correspond to ”Domestic ” and ”Foreign” respectively.

produces as much output as follows:

$$y_t^i =_{j=1}^{2} \left(A_{t,j}^i\right)^{1-\theta_1-\theta_2} \left(h_{t,j}^{i,1} n_1^i\right)^{\theta_1} \left(h_{t,j}^{i,2} n_2^i\right)^{\theta_2} \tag{4.2}$$

where y_t^i is the level of output which is produced by the representative firm belonging to generation t in economy i, $A_{t,j}^i$ is the level of technology belonging to the representative capitalist in country $i = D, F$ in period $j = 1, 2$, $h_{t,j}^{i,1}$ and $h_{t,j}^{i,2}$ reflect, respectively, the amount of human capital per the representative employee from the more and the less educated groups in country $i = D, F$ in period $j = 1, 2$, and n_1^i and n_2^i represent the number of employees per firm, belonging to the more and the less educated groups correspondingly.

We assume that $\theta_1 > \theta_2$, which implies that high-educated employees are more important for production.

In both periods $j = 1, 2$ the representative employee belonging to the more educated group and employed at a typical firm receives a wage rate $w_{t,j}^{i,1}$, while her counterpart from the less educated group receives instead $w_{t,j}^{i,2}$, $i = D, F$. The equilibrium wage rate $w_{t,j}^{i,1}$ is equal to the marginal productivity of employing n_1^i individuals from the more educated group:

$$w_{t,j}^{i,1} = \theta_1 \left(A_{t,j}^i\right)^{1-\theta_1-\theta_2} \left(h_{t,j}^{i,1}\right)^{\theta_1} \left(h_{t,j}^{i,2} n_2^i\right)^{\theta_2} \left(n_1^i\right)^{\theta_1-1} \tag{4.3}$$

while the rate $w_{t,j}^{i,2}$ corresponds to the marginal productivity of n_2^i employees belonging to the less educated group

$$w_{t,j}^{i,2} = \theta_2 \left(A_{t,j}^i\right)^{1-\theta_1-\theta_2} \left(h_{t,j}^{i,1} n_1^i\right)^{\theta_1} \left(h_{t,j}^{i,2}\right)^{\theta_2} \left(n_2^i\right)^{\theta_2-1} \tag{4.4}$$

In total, the high-educated and the low-educated groups working at a typical firm, receive the following income in period $j = 1, 2$:

$$I^i_{t,j} = n^i_1 w^{i,1}_{t,j} + n^i_2 w^{i,2}_{t,j} \tag{4.5}$$

The representative capitalist therefore acquires the remaining part of output:

$$W^i_{t,j} = Y_{t,j} - n^i_1 w^{i,1}_{t,1} - n^i_2 w^{i,2}_{t,1} = (1 - \theta_1 - \theta_2)\, Y^i_{t,j} \tag{4.6}$$

In both economies, D and F, a new generation inherits technology and human capital from the previous generation. Therefore, when a new generation is young, it uses the following technology to produce output:

$$A^i_{t,1} = A^i_{t-1,2} \tag{4.7}$$

where $A^i_{t-1,2}$ is the level of technology a new generation t inherited from its predecessor, generation $t - 1$. In economy D, each generation can invest in the acquisition of new technologies, therefore increasing the level of technology it inherited from the previous generation.

In the benchmark model we assume that the level of technology in country F, i.e. A^F, is a constant.[7] We also assume that the initial generation $t = 0$ in country D owns a technology which is less developed than the one in economy F, i.e. $A^H_{0,1} < A^F$.

Following Lucas (1988), we also assume that, similar to the level of technology, the human capital stock $H^i_{t-1,2}$ is transferred from the previous generation $t - 1$ to the current one, i.e. to t. We assume that the more educated group of employees receives a larger per capita share $0 < \delta_1 < 1$ in the total human capital stock $H^i_{t-1,2}$, while per capita share in the less educated cohort, δ_2, is instead smaller. Within each group the level of human capital endowment is, however, identical for all the members belonging

[7] However, we relax this assumption in Appendix D, as a constant level of the leading technological frontier represented by A^F is not a realistic assumption. Adding a possibility of evolution of the world technological frontier does not, however, affect our key results.

to a particular cohort, which reflects equal distribution of wealth in each cohort.[8]

Similarly to the level of A^F, we also assume that the total human capital stock in country F is constant. Finally, we assume that $H_{0,1}^D < H^F$ which implies that for the initial generation $t = 0$ the stock of human capital in D is lower than the one in economy F.

Given that employees are identically distributed between high-educated and low-educated cohorts in both D and F, i.e. $n_1^D = n_1^F$ and $n_2^D = n_2^F$,[9] these two assumptions, i.e. $A_{0,1}^D < A^F$ and $H_{0,1}^D < H^F$, together with production function $y_{t,1}^i = \left(A_{t,1}^i\right)^{1-\theta_1-\theta_2} \left(h_{t,1}^{i,1} n_1^i\right)^{\theta_1} \left(h_{t,1}^{i,2} n_2^i\right)^{\theta_2}$, imply that for the initial generation $t = 0$, in period $j = 1$, the level of output produced by the representative firm in country F is larger than the one produced in economy D.

4.3.2 Investment

At the end of the first period, $j = 1$, the representative capitalist in D decides whether to improve upon $A_{t,1}^D$, the level of technology D inherited from the previous generation $t - 1$, or to invest in a storage technology.

The storage technology is available in both economies, D and F, and pays a return $r = 0$ in period $j = 2$ if the capitalist invests his income in this technology in period $j = 1$. We introduce the storage technology to capture a possibility of non-convergence trap, which emerges when D fails to catch up with country F. The representative firm in D invests in the storage asset if the payoff from improving upon $A_{t,1}^D$ is negative. In the latter case, the capitalist in D stops investing into technological progress, and therefore the economy stays with the same level of technology.

The representative capitalist can improve upon the old technology, i.e upon $A_{t,1}^D =$

[8]Adifferent assumption would result in a more complicated aggregation of our key variables, and the whole analysis of the model would become more complicated as well, without delivering, at the same time, any interesting and important insights.

[9]We will relax this assumption later, when we discuss the Inclusive Growth policy.

$A^D_{t-1,2}$, in the following way:

$$A^D_{t,2} = \eta(x_t) A^F + (1 - \eta(x_t)) A^D_{t,1} \tag{4.8}$$

Equation (4.8) reflects a possibility of *adoption* from the leading technological frontier, which is represented by A^F, the level of technology in country F. As a result of adoption, the level of technology in economy D in period $j = 2$, i.e. $A^D_{t,2}$, becomes larger and contains two parts: first, this is $A^D_{t,1}$, the level of technology the capitalist inherited from the previous generation $t - 1$ and uses to produce output in period $j = 1$, and second, this is an additional part, which the capitalist adopts from the leading frontier A^F.[10] $0 \leq x_t \leq 1$ corresponds to the share of the capitalist's income $(1 - \theta_1 - \theta_2) y^D_{t,j}$ in period $j = 1$, invested into a new technology. $\eta(x_t)$ satisfies the following properties: $0 \leq \eta(x_t) \leq 1$, $\eta'(x_t) > 0$, $\eta''(x_t) < 0$, $\eta(0) = 0$, it also follows the Inada conditions, i.e. $\eta'(\infty) = 0$ and $\eta'(0) = \infty$.

In period $j = 1$, the capitalist invests a share x_t of his income $(1 - \theta_1 - \theta_2) y^D_{t,1}$ into a new technology, and the return is realized in period $j = 2$. Therefore, the capitalist receives $(1 - x_t)(1 - \theta_1 - \theta_2) y^D_{t,1}$ in period $j = 1$ and $(1 - \theta_1 - \theta_2) y^D_{t,2}$ in the following period, $j = 2$.

In period $j = 1$, the more and the less educated employees, working at the representative firm in economy D, receive, correspondingly, $\theta_1 y^D_{t,1}$ and $\theta_2 y^D_{t,1}$, and in the next period, $j = 2$ these groups' incomes change to $\theta_1 y^D_{t,2}$ and $\theta_2 y^D_{t,2}$. A member of the more educated group can invest a fraction φ^1_t of her human capital endowment to augment her human capital stock, while a typical employee from the less educated group can instead invest a fraction φ^2_t of her human capital endowment to have more human capital in period $j = 2$. For simplicity, we assume that in both groups human capital is created according to a one-to-one technology, and therefore in period $j = 2$

[10] We can rewrite $A^D_{t,2}$, corresponding to the left-hand side of equation (4.8) as the level of the old technology which is represented by $A^D_{t,1}$ plus a part of the distance between the old technology and the leading frontier, i.e.: $A^D_{t,2} = A^D_{t,1} + \eta(x_t)\left(A^F - A^D_{t,1}\right)$

an employee from the more educated group receives $(1+\varphi_t^1)\,h_{t,1}^{1,D}$ in case she invested $\varphi_t h_{t,1}^{1,D}$ in period $j=1$, while her counterpart from the less educated group receives $(1+\varphi_t^2)\,h_{t,1}^{2,D}$ if $\varphi_t^2 h_{t,1}^{2,D}$ was invested in period $j=1$.[11]

4.3.3 Institutions

In this subsection, we incorporate institutions into the model. We show how the presence of low-quality institutions, which is a feature of many developing economies, reduces country D's opportunities to catch up with more developed economy F. Following Blume, Rubinfeld and Shapiro (1984), Kaplow (1986), and Epstein (2008), we argue that the presence of low-quality institutions, which we model as a positive probability p of expropriation of the firm belonging to the representative capitalist, results in slower economic growth. In particular, we show that expropriation reduces the pace of technological evolution and human capital accumulation, therefore leading to a non-reducible distance between the level of technology in D and the world technological frontier.

We assume that the ruling regime can either maintain low-quality institutions, which corresponds to a positive level of probability of expropriation p, or, alternatively, it can choose high-quality institutions resulting in $p=0$. In the presence of low-quality institutions, the regime can expropriate the firm from the representative capitalist. We assume that the ruling regime has no skills to run the firm profitably, and, as a consequence, it never expropriates it in period $j=1$, as if instead the firm is expropriated in the following period $j=2$, the regime will receive at least as much as it can receive in period $j=1$. The latter is a result of a higher level of output in period $j=2$, i.e. a higher $y_{t,2}^D$, as in period $j=2$ the return on investment into a new technology and human capital is realized. When the regime expropriates the firm in period $j=2$, it keeps the capitalist's income $(1-\theta_1-\theta_2)\,y_{t,2}^D$ and then shuts the firm

[11] A different assumption would cost us algebraic and geometric convenience, including explicit algebraic solutions and their geometric counterparts, without producing any tangible benefits and additional insights.

down. In $t+1$ a new capitalist establishes a new firm and the same story repeats again.

If the quality of institutions is instead high, p equals to zero, and therefore the representative owner receives $(1-\theta_1-\theta_2)\, y_{t,2}^D$ in period $j=2$.

4.3.4 Equilibrium

We write down the capitalist's payoff function, which, according to equation (4.6), takes the following form:

$$W_t^D = (1-x_t)\, W_{t,1}^D + W_{t,2}^D =$$

$$= (1-x_t)\,(1-\theta_1-\theta_2)\, y_{t,1}^D + (1-p)\,(1-\theta_1-\theta_2)\, y_{t,2}^D \tag{4.9}$$

where the level of output produced at the representative firm in period $j=1$ is as large as the following:

$$y_{t,1}^D = \left(A_{t,1}^D\right)^{1-\theta_1-\theta_2} \left(h_{t,1}^{D,1} n_1^D \left(1-\varphi_t^1\right)\right)^{\theta_1} \left(h_{t,1}^{D,2} n_2^D \left(1-\varphi_t^2\right)\right)^{\theta_2}$$

while in the next period $j=2$ the level of output is equal to:

$$y_{t,2}^D = \left(A_{t,2}^D\right)^{1-\theta_1-\theta_2} \left(h_{t,1}^{D,1} n_1^D \left(1+\varphi_t^1\right)\right)^{\theta_1} \left(h_{t,1}^{D,2} n_2^D \left(1+\varphi_t^2\right)\right)^{\theta_2}$$

Considering the employees, in the more educated group, the representative employee's payoff function corresponds to the following expression:

$$w_{t,1}^{D,1} + w_{t,2}^{D,1} \longrightarrow \max_{\varphi_1} \tag{4.10}$$

where $w_{t,1}^{D,1}$ is a wage rate which an employee belonging to the more educated group receives in period $j = 1$:

$$w_{t,1}^{D,1} = \theta_1 \left(A_{t,1}^{D}\right)^{1-\theta_1-\theta_2} \left(h_{t,1}^{D,1}\left(1-\varphi_t^1\right)\right)^{\theta_1} \left(h_{t,1}^{D,2} n_2^D \left(1-\varphi_t^2\right)\right)^{\theta_2} \left(n_1^D\right)^{\theta_1-1} \quad (4.11)$$

while $w_{t,2}^{D,1}$ is a wage she acquires in the following period, i.e. $j = 2$:

$$w_{t,2}^{D,1} = \theta_1 \left(A_{t,2}^{D}\right)^{1-\theta_1-\theta_2} \left(h_{t,1}^{D,1}\left(1+\varphi_t^1\right)\right)^{\theta_1} \left(h_{t,1}^{D,2} n_2^D \left(1+\varphi_t^2\right)\right)^{\theta_2} \left(n_1^D\right)^{\theta_1-1} \quad (4.12)$$

A typical employee from the less educated group maximizes instead the following income:

$$w_{t,1}^{D,2} + w_{t,2}^{D,2} \longrightarrow \max_{\varphi_2} \quad (4.13)$$

where $w_{t,1}^{D,2}$ is a wage rate which an employee from the less educated cohort earns in period $j = 1$:

$$w_{t,1}^{D,2} = \theta_2 \left(A_{t,1}^{D}\right)^{1-\theta_1-\theta_2} \left(h_{t,1}^{D,1} n_1^D \left(1-\varphi_t^1\right)\right)^{\theta_1} \left(h_{t,1}^{D,2} n_2^D \left(1-\varphi_t^2\right)\right)^{\theta_2} \left(n_2^D\right)^{\theta_2-1} \quad (4.14)$$

and $w_{t,2}^{D,2}$ is instead her wage in period $j = 2$

$$w_{t,2}^{D,2} = \theta_2 \left(A_{t,2}^{D}\right)^{1-\theta_1-\theta_2} \left(h_{t,1}^{D,1} n_1^D \left(1+\varphi_t^1\right)\right)^{\theta_1} \left(h_{t,1}^{D,2} n_2^D \left(1+\varphi_t^2\right)\right)^{\theta_2} \left(n_2^D\right)^{\theta_2-1} \quad (4.15)$$

In period $j = 1$, the capitalist makes a decision about the level of investment into a new technology, while the employees instead decide how much human capital to acquire.

Maximization of equations (4.9), (4.10) and (4.13) with respect to x_t, φ_t^1 and φ_t^2 correspondingly, and combining the respective FOCs, results in the following expression:

$$\eta'(x_t^*) = \frac{1}{\left(1-\theta_1-\theta_2\right)\left(1-p\right)\left(\frac{A_{t,1}^F}{A_{t,1}^D}-1\right)} \quad (4.16)$$

From equation (4.16) we can conclude that a larger importance of technology for production, i.e. a higher level of $1-\theta_1-\theta_2$, a larger distance to the leading frontier $\frac{A^F_{t,1}}{A^D_{t,1}}$, and a lower probability of expropriation p, all result in a higher level of investment into a new technology.

Employees instead search for the optimal share of human capital φ_t which they invest in education. Maximizing equations (4.10) and (4.13) with respect to φ^1_t and φ^2_t correspondingly, produces the following first order condition:

$$\varphi^*_t = \varphi^1_t = \varphi^2_t = \frac{A^D_{t,2} - A^D_{t,1}}{A^D_{t,2} + A^D_{t,1}} \tag{4.17}$$

See Appendix A for a detailed derivation of equations (4.16) and (4.17).

The right-hand side of equation (4.17) is lower than 1 and declines over time as the difference between $A^D_{t,2}$ and $A^D_{t,1}$ reduces.[12] The fraction of human capital endowment φ^k_t, $k=1,2$ which is used to acquire additional human capital, is higher the higher is the level of $A^D_{t,2}$. As we will see shortly, $A^D_{t,2}$ is larger, the further away is the level of technology in D from the leading frontier A^F.

We are now ready to formulate our first result.

Proposition 1.

1. *The level of technology in economy D converges to the unique steady-state. The latter corresponds to the leading technology A^F when the quality of institutions is high, i.e. when the probability of expropriation p is equal to zero. However, the steady-state level of technology is below the world technological frontier A^F if the quality of institutions is instead low, i.e. when the probability of expropriation p is positive. Moreover, a larger p results in a higher level of technological backwardness corresponding to a higher distance to technological frontier $\frac{A^F}{A^D_{t,1}}$.*

[12] To show that the latter is indeed the case, we represent equation (4.17) as follows:
$\varphi^1_t = \varphi^2_t = \frac{A^D_{t,2}+A^D_{t,1}-2A^D_{t,1}}{A^D_{t,2}+A^D_{t,1}} = 1 - \frac{2A^D_{t,1}}{A^D_{t,2}+A^D_{t,1}}$
The right-hand side of the upper expression is approaching 0 as soon as $A^D_{t,2}$ is getting closer to $A^D_{t,1}$, and it is close to 1 when $A^D_{t,2}$ is instead significantly larger than $A^D_{t,1}$.

2. *Furthermore, the distance to the leading frontier* $\frac{A^F}{A^D_{t,1}}$ *and the measure of importance of technology for production* $1-\theta_1-\theta_2$*, both affect the level of investments into technology and human capital accumulation positively. By contrast, the probability of expropriation* p *reduces the representative capitalist's incentives to imitate technologies from Foreign. The latter also lowers the optimal level of human capital acquisition* φ^*_t*.*

3. *Low-educated and high-educated employees invest the same fraction* φ^*_t *of their human capital endowment in the acquisition of additional human capital.*

Proof. To prove the first part of Proposition 1, we lag equation (4.8) one step back, such that it corresponds to generation $t-1$. We use equation (4.7) to show that as $A^D_{t,1}$ is a function of x^*_{t-1}, the more the previous generation, i.e. generation $t-1$, invested into a new technology, i.e. the higher was the level of x^*_{t-1}, the larger becomes the level of technology which was inherited from generation $t-1$, i.e. the higher is $A^D_{t,1}$. As a result of a higher level of domestic technology $A^D_{t,1}$ in period $j = 1$, the distance between $A^D_{t,1}$ and the leading technological frontier A^F reduces. From the expropriation-free, i.e. $p = 0$, version of equation (4.16) corresponding to the following expression

$$\eta'(x^*_t) = \frac{1}{(1-\theta_1-\theta_2)\left(\frac{A^F_{t,1}}{A^D_{t,1}}-1\right)} \tag{4.18}$$

it follows that x^*_t becomes smaller when the distance to frontier $\frac{A^F}{A^D_{t,1}}$ declines. It therefore follows that x^*_{t-1} is larger than x^*_t. Nevertheless, as x^*_t is positive, the level of technology in economy D moves closer to the leading frontier technology A^F. When the level of technology in country D, i.e. $A^D_{t,1}$, converges to A^F entirely, the denominator of the right-hand side of equation (4.18) becomes equal to zero, and the whole right-hand side of this expression therefore becomes equal to infinity. As $\eta'(0) = \infty$ by assumption, the level of x^*_t thus equals to 0, which corresponds to the steady-state level of investment into a new technology in the absence of expropriation, i.e. when $p = 0$. As A^F is a constant, the steady-state level of technology in economy D also

remains a constant, as there is nothing to adopt from economy F any longer.[13]
From equation (4.17) it follows that the steady-state level of investment into human capital equals to zero as well.

In the presence of low-quality institutions, probability of expropriation p is instead positive. If the capitalist invests into a new technology, his payoff function corresponds to equation (4.9), which we reproduce below for convenience:

$$W_t^D = (1 - x_t)(1 - \theta_1 - \theta_2)\, y_{t,1}^D + (1 - p)(1 - \theta_1 - \theta_2)\, y_{t,2}^D$$

where in period $j = 1$ the level of output produced at the representative firm is as large as the following:

$$y_{t,1}^D = \left(A_{t,1}^D\right)^{1-\theta_1-\theta_2} \left(h_{t,1}^{D,1} n_1^D \left(1 - \varphi_t^1\right)\right)^{\theta_1} \left(h_{t,1}^{D,2} n_2^D \left(1 - \varphi_t^2\right)\right)^{\theta_2}$$

while in the next period $j = 2$ the level of output is instead equal to:

$$y_{t,2}^D = \left(A_{t,2}^D\right)^{1-\theta_1-\theta_2} \left(h_{t,1}^{D,1} n_1^D \left(1 + \varphi_t^1\right)\right)^{\theta_1} \left(h_{t,1}^{D,2} n_2^D \left(1 + \varphi_t^2\right)\right)^{\theta_2}$$

Investing into the storage technology results in the following payoff:

$$S_t^D = (1 - \theta_1 - \theta_2)\, y_{t,1}^D + (1 - \theta_1 - \theta_2)(1 - p)\, y_{t,1}^D \tag{4.19}$$

where, as, following the capitalist's decision not to invest into a new technology, high-educated and low-educated employees do not acquire additional human capital, the level of $y_{t,1}^D$ is as large as the following:

$$y_{t,1}^D = \left(A_{t,1}^D\right)^{1-\theta_1-\theta_2} \left(h_{t,1}^{D,1} n_1^D\right)^{\theta_1} \left(h_{t,1}^{D,2} n_2^D\right)^{\theta_2}$$

From equations (4.9) and (4.19) it follows that the capitalist is indifferent between

[13] We complete the proof of uniqueness and global stability of the steady-state in Appendix A.

acquiring a new technology and investing into the storage asset when the following equality holds:

$$(1-\varphi(x_t^*))^{\theta_1+\theta_2}\left[1-x_t^*+(1-p)\,\frac{1+\varphi(x_t^*)}{1-\varphi(x_t^*)}\right]=2-p \qquad (4.20)$$

In Appendix B we show that the left-hand side of equation (4.20) equals to $2-p$ when $x_t^*=0$, it becomes lower than $2-p$ when x_t^* is located between 0 and p, attains a minimum level when $x_t^*=p$, and it starts growing when the value of x_t^* is larger than p. Therefore, for a particular set of values of x_t^* the left-hand side of equation (4.20) is lower than $2-p$, corresponding instead to the right-hand side of equation (4.20). The latter implies that the capitalist receives a higher payoff when he invests into the storage technology.

Equation (4.20) has two solutions, $\widehat{x}_t^1=0$ and $\widehat{x}_t^2>0$. The former solution occurs when the level of technology in economy D converges to the one in country F, i.e. when $\frac{A^F}{A_{t,1}^D}$ equals to 1. However, the presence of expropriation reduces country D's opportunities to converge to A^F. To see this, consider the second solution of equation (4.20), $\widehat{x}_t^2>0$. As $\widehat{x}_t^2$ is positive, from equation (4.8) it follows that the level of technology in economy D becomes larger. As a result of a higher level of technology in D, the distance to technological frontier instead becomes lower, which, according to equation (4.16), results in a lower share of income the representative capitalist belonging to generation $t+1$ invests into a new technology, i.e. a lower x_{t+1}^*. However, as the level of x_{t+1}^* is lower than $\widehat{x}_t^2>0$, which is the positive solution of equitation (4.20), the left-hand side of equation (4.20) becomes lower than its right-hand side. In this case, the representative capitalist prefers investing into the storage asset instead of investing into a new technology. Therefore, the actual level of x_{t+1} equals to 0, and thus the level of technology in economy D remains constant.

In Appendix C we show that the level of $\widehat{x}_t^2>0$, a positive solution to equation (4.20), becomes larger when the probability of expropriation p becomes higher. According to equation (4.16) a higher level of $\widehat{x}_t^2$ corresponds to a larger distance to the leading technological frontier $\frac{A^F}{A^D_{t,1}}$. Therefore, a large value of p results in a higher level of technological backwardness $\frac{A^F}{A^D_{t,1}}$. Intuitively, in the presence of expropriation, the capitalist has incentives to invest into a new technology if the latter results in a sufficiently high level of return, which, according to equation (4.16), is the case when the level of $\frac{A^F}{A^D_{t,1}}$ is large.

The proof of the second and the third parts of the proposition follows directly from equations (4.16) and (4.17).

■

To transit to a graphical representation of these results, we introduce a number of important definitions which we will also be using throughout the chapter.

We start from comparing the capitalist's payoffs from investing into a new technology and the storage asset. The former is at least as large as the latter when the following inequality holds:

$$\left(A^D_{t,1}\right)^{1-\theta_1-\theta_2}\left(h^{D,1}_{t,1}n^D_1\right)^{\theta_1}\left(h^{D,2}_{t,1}n^D_2\right)^{\theta_2}(1-\varphi(x^*_t))^{\theta_1+\theta_2}\left[1-x^*_t+(1-p)\frac{1+\varphi(x^*_t)}{1-\varphi(x^*_t)}\right]\geq$$

$$\geq(2-p)\left(A^D_{t,1}\right)^{1-\theta_1-\theta_2}\left(h^{D,1}_{t,1}n^D_1\right)^{\theta_1}\left(h^{D,2}_{t,1}n^D_2\right)^{\theta_2} \tag{4.21}$$

We divide both sides of inequality (4.21) over $\left(A^D_{t,1}\right)^{1-\theta_1-\theta_2}\left(h^{D,1}_{t,1}n^D_1\right)^{\theta_1}\left(h^{D,2}_{t,1}n^D_2\right)^{\theta_2}$ in order to transform it into the following expression:

$$(1-\varphi(x^*_t))^{\theta_1+\theta_2}\left[1-x^*_t+(1-p)\frac{1+\varphi(x^*_t)}{1-\varphi(x^*_t)}\right]\geq 2-p \tag{4.22}$$

We call the left-hand side of inequality (4.22) the *adoption function*, as it reflects the capitalist's payoff from investing in the adoption of new technologies. The right-hand side of inequality (4.22) instead corresponds to the payoff from investing into the *storage technology*.

We also divide the level of output produced in country F by generation t, which corresponds to the following equation:

$$Y^F = 2L\left(A^F\right)^{1-\theta_1-\theta_2}\left(h^{F,1}n_1^F\right)^{\theta_1}\left(h^{F,2}n_2^F\right)^{\theta_2} \tag{4.23}$$

over the output level which is produced in economy D by the same generation t in period $j = 1$, i.e. over $Y_{t,1}^D = L\left(A_{t,1}^D\right)^{1-\theta_1-\theta_2}\left(h_{t,1}^{D,1}n_1^D\right)^{\theta_1}\left(h_{t,1}^{D,2}n_2^D\right)^{\theta_2}$. As we temporarily assume that $n_1^D = n_1^F$ and $n_2^D = n_2^F$, we receive the following ratio:

$$\frac{Y^F}{Y_{t,1}^D} = 2\left(\frac{A^F}{A_{t,1}^D}\right)^{1-\theta_1-\theta_2}\left(\frac{h^{F,1}}{h_{t,1}^{D,1}}\right)^{\theta_1}\left(\frac{h^{F,2}}{h_{t,1}^{D,2}}\right)^{\theta_2} \tag{4.24}$$

We call the latter expression *the output gap function*, as it reflects the gap in income levels between economies D and F.

As it follows from Proposition 1, when the probability of expropriation p is equal to 0, the level of domestic technology, i.e. $A_{t,1}^D$, entirely converges to the leading frontier A^F, and, as a result, $\frac{A^F}{A_{t,1}^D}$ equals to one in the steady-state. If, at the same time, high-educated and low-educated employees in economy D become as educated as their foreign counterparts, $\frac{h^{F,1}}{h_{t,2}^{D,1}}$ and $\frac{h^{F,2}}{h_{t,2}^{D,2}}$ both equal to one as well, and then equation (4.24) reduces to $\frac{Y^F}{Y_{t,1}^D} = 2$, which implies that the output gap between D and F disappears.

We replicate these results in the following figure.

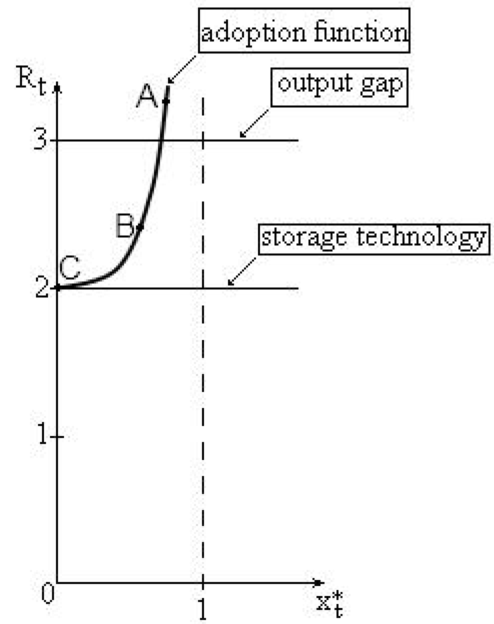

Figure 1. In the absence of expropriation economy D converges with country F.

In Figure 1, the share of income which the capitalist invests in a new technology x_t^* is placed along the horizontal axis, while R_t is instead placed along the vertical one and represents either a payoff from investing into a new technology, or instead a payoff from investing into the storage asset, corresponding respectively, to the left-hand and to the right-hand sides of inequality (4.22). In Figure 1, *the adoption function* corresponds to the expropriation-free, i.e. $p = 0$, version of the left-hand side of inequality (4.22), which equals to the following expression:

$$R_t = (1 - \varphi(x_t^*))^{\theta_1 + \theta_2} \left[1 - x_t^* + \frac{1 + \varphi(x_t^*)}{1 - \varphi(x_t^*)}\right] \tag{4.25}$$

In Appendix A we show that equation (4.25) is a monotonically increasing function of x_t^*. Moreover, as we know from equation (4.16), a larger value of x_t^* corresponds to a larger distance to the leading frontier $\frac{A^F}{A^D_{t,1}}$. Therefore, as equation (4.25) is larger when x_t^* is higher, it thus is also larger when the distance to the leading frontier $\frac{A^F}{A^D_{t,1}}$ is higher. As a result, the value of equation (4.25) declines when the distance to the leading frontier becomes smaller. Therefore, since a larger value of x_t^* corresponds to a higher level of $\frac{A^F}{A^D_{t,1}}$, a point on the adoption function which is close to the dashed line, as point A, reflects a lower stage of technological development. On the contrary, a point as point B, which is instead relatively far away from the dashed line, corresponds to a lower share of income which the capitalist invests into a new technology x_t^* and thus to a smaller distance to the leading frontier $\frac{A^F}{A^D_{t,1}}$. The economy thus becomes more developed as long as it moves along the adoption function towards the steady-state point C. In point C the share x_t^* equals to 0, reflecting the absence of investment into a new technology. As a result, the left-hand side of inequality (4.24) becomes equal to 2, which indicates that the level of output in country D totally converges with the one in economy F.

The horizontal line which is called "*storage technology*", reflects the payoff from investing into the storage asset. As this line intersects the vertical axis in $R_t = 2$, corresponding to expropriation-free, i.e. $p = 0$, version of the right-hand side of inequality (4.22), it follows that the payoff from investing into the storage technology is lower than the payoff from investing into a new technology as long as $x_t^* > 0$, which is the case when $\frac{A^F}{A_{t,1}} > 1$. The latter follows from equation (4.25), as its right-hand side, representing the payoff from investing into a new technology, is larger than 2 as long as $x_t^* > 0$. Therefore, in the absence of expropriation, the capitalist always chooses investment into a new technology, leaving instead the opportunity to invest into the storage asset unexploited.

When economy D reaches the steady-state level of technology, technological gap between D and F reduces to zero, i.e. $\frac{A^F}{A^D_{t,1}} = 1$, and therefore D does not adopt new technologies any longer. Nor, according to equation (4.17), it invests into the acquisition of additional human capital, as, when $x_t^* = 0$, the level of technology remains constant, i.e. $A^D_{t,1} = A^D_{t.2} = A^F$, and, as it follows from equation (4.17), the share of human capital which is used to acquire additional capital is thus $\varphi_t^1 = \varphi_t^2 = \varphi(x_t^*) = 0$.

As long as D converges to economy F, the output gap between these two economies reduces, which results in a downward shift of the *output gap function*. Form Proposition 1, equation (4.24), and the assumption that the high-educated and low-educated employees in economy D become as educated as their foreign counterparts, i.e. $\frac{h^{F,1}}{h^{D,1}_{t,2}} = \frac{h^{F,2}}{h^{D,2}_{t,2}} = 1,$ it follows that the output gap between country D and economy F disappears in the steady-state, i.e. $\frac{Y^F}{Y^D_{t,1}} = 2$.

We now consider the case when p is instead positive. According to Proposition 1, as a result of a positive probability of expropriation p, the level of technology in economy D, i.e. $A^D_{t,1}$, fails to catch up with the world technological frontier A^F. We illustrate this result in the following figure:

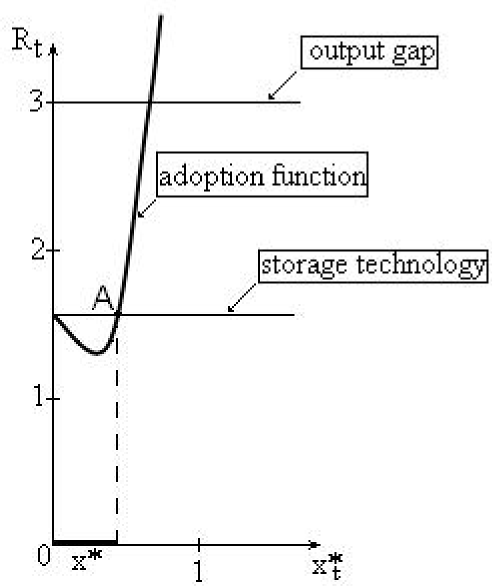

Figure 2. Non-convergence trap.

The presence of expropriation changes the shape of adoption function. In Appendix B, we show that as long as $p > 0$, the adoption function has a minimum point at $x^*_t = p \geq 0$ instead of $x^*_t = 0$ as in the case of $p = 0$. As a result, a part of the adoption function is now located below the horizontal line representing the payoff from the storage technology, which was not the case in the absence of expropriation. We call the set of values of x^*_t corresponding to this part of the adoption function as "*non-convergence set*". This set is represented as a bold section on the horizontal axis.

In point A the capitalist is indifferent between acquiring a new technology or investing into the storage asset. Therefore, this point corresponds to the share $x_t^* > 0$ satisfying equation (4.20), which we reproduce below for convenience:

$$(1 - \varphi(x_t^*))^{\theta_1 + \theta_2} \left[1 - x_t^* + (1 - p) \frac{1 + \varphi(x_t^*)}{1 - \varphi(x_t^*)} \right] = 2 - p$$

As in the case of $x_t^* > 0$ the level of technology becomes higher, from equation (4.16) it follows that the next generation $t+1$ will choose $x_{t+1}^* < x_t^*$. As x_{t+1}^* does not satisfy equation (4.20), the right-hand side of this expression becomes larger than its left-hand side. The latter implies that the storage technology will thus pay a higher return to the capitalist belonging to generation $t+1$, and, as the result, the capitalist does not have incentives to invest into a new technology. Therefore, the level of technology in Home $A_{t,1}^D$ remains lower than the world technological frontier A^F.

From equation (4.17) it follows that expropriation also lowers the rate of human capital accumulation. As expropriation reduces investment into a new technology, employees, correspondingly, reduce their investments into human capital. The latter implies that, in addition to a non-reducible technological gap $\frac{A^F}{A_{t,1}^D}$, expropriation also results in a constant educational gap between economies D and F, reflected in $\frac{h_t^{F,1}}{h_{t,1}^{D,1}} > 1$ and $\frac{h^{F,2}}{h_{t,1}^{D,2}} > 1$. Therefore, a positive probability of expropriation p also leads to educational backwardness.

From equation (4.24) it follows that technological and educational gaps translate into a non-reducible output gap. Therefore, in the presence of expropriation the output gap between economies D and F always remains positive, which implies that $\frac{Y_t^F}{Y_{t,1}^D} > 2$.

4.4 Political Equilibrium

As expropriation results in a lower pace of technological development, slower human capital accumulation, and, as a consequence, lower rate of economic growth, an institutional reform which reduces the risk of expropriation, might help the economy to transit to its expropriation-free version. The implementation of this policy therefore should gain substantial popularity, as it makes everyone, apart from the corrupt regime, better off.

To show why the latter might be the case, we combine equations (4.17), (4.14) and (4.15) to derive the optimal life-time labor incomes belonging to typical individuals from high-educated and low-educated groups, which, respectively, correspond to the following expressions:

$$w_{t,1}^{D,1} + w_{t,2}^{D,1} =$$

$$= \theta_1 \left(A_{t,1}^{D}\right)^{1-\theta_1-\theta_2} \left(h_{t,1}^{D,1}\right)^{\theta_1} \left(h_{t,1}^{D,2} n_2^D\right)^{\theta_2} \left(n_1^D\right)^{\theta_1 - 1} \frac{2}{\left(1-\varphi_t\right)^{1-\theta_1-\theta_2}} \tag{4.26}$$

$$w_{t,1}^{D,2} + w_{t,2}^{D,2} =$$

$$= \theta_2 \left(A_{t,1}^{D}\right)^{1-\theta_1-\theta_2} \left(h_{t,1}^{D,1} n_1^D\right)^{\theta_1} \left(h_{t,1}^{D,2}\right)^{\theta_2} \left(n_2^D\right)^{\theta_2 - 1} \frac{2}{\left(1-\varphi_t\right)^{1-\theta_1-\theta_2}} \tag{4.27}$$

As, according to equation (4.17), a higher pace of technological evolution results in a larger φ_t, from equations (4.26) and (4.27) it follows that a faster technological progress increases the level of life-time income for both groups of employees. Therefore, as an institutional reform results in faster technological development, it benefits all the employees, as well as the capitalist. As a consequence, a political regime which eliminates expropriation should earn substantial popularity, and thus the presence of political competition should help to solve the problem of expropriation, as individuals receive an opportunity to replace the regime which practices expropriation with the one which instead will eliminate it. We show, however, that low-educated employees might not support the reformist policy, and therefore regardless the harm the expropriating regime produces for the economy, it can nevertheless be politically survivable.

In this section, we incorporate political competition into the model and introduce two political regimes. We assume that under the rule of clientelistic regime the quality of institutions remains low, which is reflected in a positive level of probability of expropriation p, while the reformist regime instead chooses high-quality institutions resulting in $p = 0$. As we show, even though the policy of the reformist regime results in faster economic growth, the latter might play little role for the representative low-educated employee.[14] On the contrary, income transfers can make the current generation of low-educated individuals substantially better off. Therefore, if low-educated employees make up a majority of population and thus play an important political role, providing income redistribution might become a key to political success.

4.4.1 The Reformist Regime

We, first, consider a policy which is implemented by the reformist regime. We assume that the latter eliminates expropriation, and therefore the probability of expropriation p becomes equal to 0. As a result, inequality (4.22) changes to the following expression:

$$(1-\varphi(x_t^*))^{\theta_1+\theta_2}\left[1-x_t^*+\frac{1+\varphi(x_t^*)}{1-\varphi(x_t^*)}\right]\geq 2 \tag{4.28}$$

As we show in Appendix A, when $p = 0$, the left-hand side of inequality (4.28)

[14] This is a consequence of a low labor income of the representative employee belonging to the low-educated cohort. The income level is low as the output share belonging to the less educated group, i.e. θ_2, is small, and, moreover, the number of low-educated employees is instead large, which lowers this group's per capita labor income even further. As a consequence, even fast economic growth might result in a too small increase in per capita income level of the representative employee belonging to the low-educated cohort.

becomes a monotonic function of x_t^*, which is reflected in Figure 1 in the previous section. From Figure 1 it follows that in the absence of expropriation the adoption function is placed above the storage technology line as long as $x_t^* > 0$. The latter implies that the payoff from investing into a new technology is always at least as large as the one from investing into the storage asset, and therefore the capitalist acquires new technologies until economy D entirely converges to the world technological frontier.

As x_t^* remains positive as long as economy D converges to the leading frontier, from equation (4.17) it follows that high-educated and low-educated employees acquire additional human capital, i.e. $\varphi_t = \varphi_t^1 = \varphi_t^2 > 0$. As investment into new technologies and human capital remains positive along economy D's path towards the leading technological frontier, the output gap function, corresponding to the following equation

$$\frac{Y^F}{Y_{t,1}^D} = 2\left(\frac{A^F}{A_{t,1}^D}\right)^{1-\theta_1-\theta_2}\left(\frac{h^{F,1}}{h_{t,1}^{D,1}}\right)^{\theta_1}\left(\frac{h^{F,2}}{h_{t,1}^{D,2}}\right)^{\theta_2}$$

moves down and for a particular generation t it becomes equal to 2, which implies that the output level in D entirely converges to the one in economy F.

We therefore conclude that the reformist policy results in faster economic growth and lets economy D reach substantially larger level of income, benefiting all the employees.

4.4.2 The Clientelistic Regime

Even though higher-quality institutions, corresponding to $p = 0$, result in faster growth, its benefits might be inequally allocated among the employees. To show this, we again consider labor incomes which are earned by the more educated and the less educated groups working at the representative firm. The high-educated group employed at a typical firm receives the following income:

$$n_{t,1}^D\left(w_{t,1}^{D,1} + w_{t,2}^{D,1}\right) = \theta_1 y_t^D \tag{4.29}$$

while the labor income of low-educated employees is instead as large as the following:

$$n_{t,2}^{D}\left(w_{t,1}^{D,2}+w_{t,2}^{D,2}\right)=\theta_2 y_t^D \tag{4.30}$$

The representative capitalist receives the remaining part of income, i.e. $(1-\theta_1-\theta_2)\,y_t^D$.

We notice that, given our assumption about income shares, i.e. $\theta_1 > \theta_2$, form equations (4.29) and (4.30) it follows that per capita income level in the more educated group is larger than the one in the low-educated cohort whenever $n_{t,1}^D \leq n_{t,2}^D$, i.e. when the size of the less educated group is at least as large as the size of the more educated one. The latter result follows directly after we divide equations (4.29) and (4.30), over $n_{t,1}^D$ and $n_{t,2}^D$ respectively, such that they transform into per capita labor incomes:

$$w_{t,1}^{D,1}+w_{t,2}^{D,1}=\frac{\theta_1 y_t^D}{n_{t,1}^D} \tag{4.31}$$

$$w_{t,1}^{D,2}+w_{t,2}^{D,2}=\frac{\theta_2 y_t^D}{n_{t,2}^D} \tag{4.32}$$

From equation (4.32) it follows that a low θ_2 and a high $n_{t,2}^D$, both lead to a low level of per capita income in the less educated group. As a consequence, even fast economic growth can add too little to the level of per capita income within the low-educated cohort. Less educated employees can therefore be sensitive to redistribution policy, as the latter might result in a larger increase in the level of per capita income. Therefore, even though the clientelistic regime can not compete with the reformist one regarding economic growth, it can, however, provide larger income transfers to the low-educated cohort.

We assume that under the rule of the clientelistic regime, the share of the low-educated cohort in output is as large as $\beta_t^{C,2} \geq \theta_2$, while under the rule of the reformist regime it is instead equal to $\beta_t^{R,2} \geq \theta_2$.

4.4.3 Political Competition

We assume that the low-educated cohort forms a majority in economy D, and, therefore, the representative employee from this group plays a pivotal role in politics.[15] To earn political sympathies of a typical employee from the low-educated cohort, the clientelistic regime should implement redistribution policy which makes the employee's income larger than the one which she would receive under the reformist regime's rule. The latter is reflected in the following expression:

$$w_{t,1}^{C} + w_{t,2}^{C} \geq w_{t,1}^{R} + w_{t,2}^{R} \tag{4.33}$$

where $w_{t,1}^{C}+w_{t,2}^{C}$ is the representative low-educated employee's labor income under the clientelistic regime rule, while $w_{t,1}^{R} + w_{t,2}^{R}$ corresponds instead to the level of her labor income in the economy where the reformist regime is in power. We denote the lowest $\beta_{t}^{C,2}$ satisfying inequality (4.33) as $\beta_{t,\min}^{C,2}$,[16] and therefore at point $\beta_{t}^{C,2} = \beta_{t,\min}^{C,2}$ inequality (4.33) transforms into the following equation:

$$\beta_{t,\min}^{C,2} \frac{2}{(1-\varphi_t(p))^{1-\theta_1-\theta_2}} = \beta_{t}^{R,2} \frac{2}{(1-\varphi_t)^{1-\theta_1-\theta_2}} \tag{4.34}$$

We notice that $\beta_{t,\min}^{C,2}$ should be less than 1, as if $\beta_{t,\min}^{C,2}$ is instead equal to 1 then neither the capitalist, nor the employees belonging to the other group receive a positive income.[17]

After rearranging, equation (4.34) turns into the following expression:

$$\beta_{t,\min}^{C,2} = \left(\frac{1-\varphi_t\left(p\right)}{1-\varphi_t} \right)^{1-\theta_1-\theta_2} \beta_{t}^{R,2} \tag{4.35}$$

[15] The latter assumption holds for developing economies, where the level of education is comparatively low.

[16] We consider the minimum level of redistribution $\beta_{t,\min}^{C,2}$ as the ruling regime receives $p\left(1-\beta_1-\beta_2\right)Y_{t,2}$ and therefore it has incentives to minimize the level of β_2, as the latter results in a higher level of regime's income.

[17] We assume that all the employees and the capitalists receive a strictly positive income.

We notice that the share of human capital endowment which is invested in the acquisition of additional human capital, i.e. φ_t, is positively linked with the rate of economic growth: a larger level of φ_t results in faster growth in economy D. We therefore can use φ_t to measure the pace of output growth.

From equation (4.35) it follows that a large difference between growth rate under the reformist regime rule and the one under the rule of clientelistic alternative, reflected in $\frac{1-\varphi_t(p)}{1-\varphi_t}$, and a higher share in output $\beta_t^{R,2}$ of a typical employee from the low-educated group under the rule of the reformist regime, both result in a higher level of $\beta_{t,\min}^{C,2}$, the representative employee´s share in output when the clientelistic regime is in power.

Regarding the difference in growth rates reflected in $\frac{1-\varphi_t(p)}{1-\varphi_t}$, a positive probability of expropriation $p > 0$ under the clientelistic regime rule results in a lower level of investment in the acquisition of new technologies, a slower speed of human capital accumulation and, as a consequence, a smaller pace of economic growth compared to the case when expropriation is instead absent. A higher level of p results in a larger difference between growth rates under the rule of reformist and clientelistic regimes, reflected in a larger value of $\frac{1-\varphi_t(p)}{1-\varphi_t}$. Moreover, if economy D ends up in a non-convergence trap, then no investment into new technology and human capital takes place, and, as a result, $\varphi_t\left(p\right) = 0$, i.e. economy D does not grow at all.

From equation (4.27) it follows that a higher probability of expropriation p also translates into slower growth of a low-educated employee's labor income $w_{t,1}^C + w_{t,2}^C$. To compensate for a slower growth of the representative low-educated employee's income, i.e. $w_{t,1}^C + w_{t,2}^C$, the clientelistic regime needs to transfer more output to a typical low-educated employee, which results in a higher level of $\beta_{t,\min}^{C,2}$.

A higher share in output belonging to the representative employee from the low-educated group under the reformist regime´s rule, i.e. a higher $\beta_{t,2}^R$, also induces the clientelistic regime to redistribute more output towards the employees.

Therefore, if under the reformist regime rule the economy is growing at a high rate, compared to the rate under the rule of the clientelistic regime, and, moreover, employees benefit from growth, from equation (4.35) it follows that $\beta_{t,\min}^{C,2}$ should be large to let the clientelistic regime win the political competition against the reformist opponent. As the maximum value of $\beta_{t,\min}^{C,2}$ is strictly lower than 1, the reformist regime can therefore choose the share $\beta_t^{R,2}$ such that winning political competition becomes impossible for the clientelistic regime. From equation (4.35) it follows that for the latter to be the case, the lowest value of $\beta_t^{R,2}$ should be equal to the following expression:

$$\beta_{t,\min}^{R,2} = \left(\frac{1 - \varphi_t}{1 - \varphi_t(p)} \right)^{1-\theta_1-\theta_2} \tag{4.36}$$

as, if equation (4.36) holds, the level of $\beta_{t,\min}^{C,2}$ is equal to 1, which contradicts our assumption that the largest $\beta_{t,\min}^{C,2}$ should be instead strictly less than 1. From equation (4.36) it follows that a larger difference between growth rates under the reformist and clientelistic regimes rules results in a lower right-hand side of equation (4.36), and therefore the reformist regime needs to redistribute comparatively less income to win political competition against the clientelistic alternative. The difference between growth rates is large when the probability of expropriation p is high, as in this case $\varphi_t(p)$ is low compared to φ_t. On the contrary, the difference between growth rates is comparatively low if the clientelistic regime is less corrupt, or when D becomes more matured economy, as in the latter case, according to equation (4.17), φ_t is relatively low, and therefore the difference between φ_t and $\varphi_t(p)$ is low as well. The latter result implies that as soon as D becomes more developed, the level of redistribution which is implemented by the reformist regime should increase. We, therefore, notice the important difference between policies in the less developed economies and the more developed ones: in the latter, redistribution plays a comparatively more important role in political competition than in the former.

If, however, the reformist regime redistributes less than what is implied by equation (4.36), as, for instance, $\beta_{t,2}^{R} = \theta_2$, corresponding to the case of no redistribution, then political opportunities of the clientelistic regime become larger.

We summarize our findings in the following proposition:

Proposition 2. *A high difference between growth rates under the rule of the reformist and the clientelistic regimes, reflected in a large distance between φ_t and $\varphi_t(p)$, and a large share in output belonging to the representative employee under the reformist regime's rule $\beta_t^{R,2}$, all reduce the clientelistic regime's political opportunities.*

Proof. From equation (4.35) it follows that a larger distance between φ_t, reflecting the rate of growth under the reformist regime, and $\varphi_t(p)$, corresponding to growth rate when instead the clientelistic regime is in power, and a higher $\beta_t^{R,2}$ reflecting the output share of the representative employee from the low-educated group under the reformist regime, all result in a higher level of $\beta_{t,\min}^{C,2}$, the output share belonging to a typical employee when the clientelistic regime is in office. As $\beta_{t,\min}^{C,2}$ should be strictly lower than 1, there is less chance that $\beta_{t,\min}^{C,2}$ corresponding to equation (4.35) will meet the latter requirement, when the difference between φ_t and $\varphi_t(p)$, as well as the level of $\beta_t^{R,2}$, are large. ■

4.4.4 Discussion

We therefore conclude that redistribution might be important for political survival of the reformist regime. If the difference between growth rates provided by two regimes is comparatively low, income redistribution might be a key to political feasibility of growth enhancing policy.

What are the alternatives to the policy of income redistribution? Is there another policy which, on one hand, is effective for enhancing political popularity of the reformist regime, but can also capitalize resources which are invested into it? As we argue, even though such a policy exists, its benefits, however, are realized in the long run. Within a shorter period of time, income redistribution is still necessary to facilitate political survival of the reformist regime.

Notice that political survival of the clientelistic regime also becomes low when the representative employee belongs to the high-educated group. In this case, equation (4.35) changes to the following expression:

$$\beta_{t,\min}^{C,2} = \left(\frac{1 - \varphi_t(p)}{1 - \varphi_t} \right)^{1-\theta_1-\theta_2} \theta_1 \tag{4.37}$$

As $\frac{1-\varphi_t(p)}{1-\varphi_t}$ is larger than 1, and θ_1 is large compared to θ_2, $\beta_{t,\min}^{C,2}$ should also be sufficiently large. As $\beta_{t,\min}^{C,2}$ is strictly lower than 1 by assumption, there is little chance that the clientelistic regime will win the political competition.

However, for the high-educated group to make up a majority, the ruling regime should implement an educational policy, which, at a particular cost, transfers a larger per capita share δ_1 of the aggregate human capital stock $H_{t-1,2}^{D}$ to the majority of young individuals. The latter reform corresponds to the Inclusive Growth policy, which we briefly mentioned in the introductory part of the chapter. The policy aims to increase the level of productivity in a developing society, in order to enhance the effect of economic growth: "While absolute pro-poor growth can be the result of direct income redistribution schemes, for growth to be inclusive, productivity must be improved and new employment opportunities created. In short, inclusive growth is about raising the pace of growth and enlarging the size of the economy, while levelling the playing field for investment and increasing productive employment opportunities".[18]

In the extension to our chapter, which we present in the following subsection, we show that, regardless the benefits this policy brings about to economy D, as, for instance, "enlarging the size of the economy", "raising the pace of growth" or increasing the size of the high-educated cohort, it still might be less popular than the conventional income redistribution policy which can be implemented by the clientelistic regime. The key assumption which leads to this result is that the implementation of this policy might take a lot of time, as, for instance, transferring human capital is typically a long-term process, and therefore the main benefits of it will impact the following, but not the current generation of the low-educated employees, who instead will stay unaffected. Inclusive growth thus can not be a substitute for income transfers in the short

[18]The World Bank (2009).

run. As a result, the current generation of low-educated individuals remains sensitive to income transfers, and if the latter are not provided by the reformist regime, then political chances of the clientelistic alternative become higher.

4.5 Extension: Inclusive Growth and Redistribution

As we mentioned in the previous subsection, economic growth alone might be insufficient to deliver benefits to a broad cohort of individuals, as in the presence of a large disadvantaged group, benefits from the implementation of the institutional reform will not be equally distributed. A typical employee belonging to the high-educated cohort will derive substantial benefits from the introduction of the reform, which, however, will not be the case for the representative employee from the low-educated group. This, however, can be changed if the ruling regime transfers more human capital to employees, therefore increasing the size of the high-educated group.[19] At the same time, we assume that this policy affects the next generation of employees, but not the current one.

To show how does this reform can be implemented, we maximize equations (4.10) and (4.13) with respect to φ_t^1 and φ_t^2 again, which, as was shown in Section 3, results in the following expression:

$$\varphi_t^2 = \varphi_t^1 = \frac{A_{t,2}^H(x_t) - A_{t,1}^H}{A_{t,2}^H(x_t) + A_{t,1}^H} \tag{4.38}$$

We combine equations (4.38), (4.10) and (4.13) to derive labor incomes belonging to the representative employees from the high-educated and the low-educated groups.

As a result, we receive that the representative individual belonging to the more

[19]This is, of course, the reformist regime which implements this policy, as the clientelistic one does not have insentives to introduce such a reform.

educated cohort earns the following income:

$$w_{t,1}^{D,1} + w_{t,2}^{D,1} = \theta_1 \frac{\left(h_{t,1}^{D,1}\right)^{\theta_1}}{\left(n_1^D\right)^{1-\theta_1}} \left(A_{t,1}^H\right)^{\theta_1} \left(h_{t,1}^{D,2} n_2^D\right)^{\theta_2} \frac{2}{\left(1-\varphi_t^1\right)^{1-\theta_1-\theta_2}} \tag{4.39}$$

The equilibrium level of labor income of her counterpart from the less educated group is instead as large as:

$$w_{t,1}^{D,2} + w_{t,2}^{D,2} = \theta_2 \frac{\left(h_{t,1}^{D,2}\right)^{\theta_2}}{\left(n_2^D\right)^{1-\theta_2}} \left(A_{t,1}^H\right)^{\theta_1} \left(h_{t,1}^{D,1} n_1^D\right)^{\theta_1} \frac{2}{\left(1-\varphi_t^1\right)^{1-\theta_1-\theta_2}} \tag{4.40}$$

The ratio between equation (4.39) and equation (4.40) reflects the wage gap between two groups of employees:

$$\frac{w_{t,1}^{D,1} + w_{t,2}^{D,1}}{w_{t,1}^{D,2} + w_{t,2}^{D,2}} = \frac{\theta_1}{\theta_2} \frac{n_2^D}{n_1^D} \tag{4.41}$$

As was shown in the previous subsection, from equation (4.41) it follows that a larger number of employees belonging to the less educated group, reflected in higher n_2^D, and a low importance of this group for production, which is mirrored in a low level of θ_2, both result in a smaller $w_{t,1}^{D,2} + w_{t,2}^{D,2}$, the labor income of a typical individual from the low-educated group, compared to $w_{t,1}^{D,1} + w_{t,2}^{D,1}$, the labor income of the representative individual belonging to the high-educated cohort.

As a consequence, the implementation of a policy which eliminates expropriation and therefore enhances economic growth, might produce a limited effect on the low-educated group. Even fast economic growth might result in a too small increase in per capita income level of the representative employee belonging to the less educated cohort. The positive effect of a reform which reduces the risk of expropriation can, however, become more substantial for the low-educated group if such a reform is complemented by an educational policy which results in transferring the high per capita share δ_1 of the aggregate human capital stock $H_{t-1,2}$ to a larger group of employees.

As a result of the educational policy, the number of low-educated employees reduces, while the size of the high-educated cohort instead increases. Therefore, $\frac{n_2^D}{n_1^D}$ reduces, and thus according to equation (4.41) the wage gap becomes lower. To implement this policy, the reformist regime needs to spend a particular amount of output which it receives from taxing the capitalist.

We assume that this reform does not, however, affect the current generation of employees. Instead, it impacts individuals belonging to generation $t+1$.[20] As a result of this reform, a high level of human capital endowment $h_{t+1,1}^{D,1}$ is transferred to a broader group of individuals belonging to generation $t+1$, and therefore the size of the high-educated group increases. As a consequence, a reform which eliminates the risk of expropriation will benefit a larger number of employees, as the more educated employees' labor income is higher compared to the one of the low-educated workers.

We show in Appendix F, that the optimal number of high-educated employees belonging to generation $t+1$, $n_{t+1,1}^*$ is derived from maximization of the following expression:

$$y_{t+1,1}(n_1^D) + y_{t+1,2}(n_1^D) \longrightarrow \max_{n_{t+1,1}^D} \tag{4.42}$$

and satisfies the following condition:

$$\frac{\theta_1}{\theta_2}\frac{n_{t+1,2}^*}{n_{t+1,1}^*} = 1 \tag{4.43}$$

We notice that from equations (4.43) and (4.41) it follows that if the number of employees belonging to the more educated group is defined optimally, the labor incomes of two groups of employees become identical:

$$w_{t+1,1}^{D,1} + w_{t+1,2}^{D,1} = w_{t+1,1}^{D,2} + w_{t+1,2}^{D,2} \tag{4.44}$$

As $\theta_1 > \theta_2$ by assumption, which implies that the high-educated group is more

[20]The rest of employees from generation $t+1$ are provided with the low per capita share δ_2 in aggregated human capital stock $H_{t-1,2}$, $\delta_2 < \delta_1$.

important for production, from equation (4.43) it therefore follows that in the optimum the number of low-educated employees $n^*_{t+1,2}$ should be lower than the size of the high-educated cohort, i.e. $n^*_{t+1,1}$. As a result, economic growth will benefit a larger number of employees, as the low-educated cohort becomes smaller, while the high-educated, and better paid one instead becomes larger.

We combine identity $n^D = n^D_{t+1,1} + n^D_{t+1,2}$ with equation (4.43) to receive the following solutions:

$$n^*_{t+1,1} = n^D \frac{\theta_1}{\theta_1 + \theta_2} \tag{4.45}$$

and

$$n^*_{t+1,2} = n^D \frac{\theta_2}{\theta_1 + \theta_2} \tag{4.46}$$

From equations (4.45) and (4.46) it follows that a larger importance of the high-educated group for production reflected in a higher level of θ_1 results in a larger optimal number of high-educated individuals $n^*_{t+1,1}$.

We summarize our findings in the following proposition:

Proposition 3. *If high-educated employees are more important for production, i.e. if $\theta_1 > \theta_2$, then the optimal size of the more educated group belonging to generation $t+1$ will be larger than its low-educated counterpart, i.e. $n^*_{t+1,1} > n^*_{t+1,2}$.*

Proof. If the high-educated group is more important for production than the low-educated one, i.e. if θ_1 is larger than θ_2, then according to equations (4.45) and (4.46) the number of high-educated individuals $n^*_{t+1,1}$ is larger than $n^*_{t+1,2}$, reflecting instead the size of the low-educated group. This establishes the result ■

As the labor incomes within the high-educated and the low-educated cohorts are the same when equation (4.43) holds, i.e. $w^{D,1}_{t+1,1} + w^{D,1}_{t+1,2} = w^{D,2}_{t+1,1} + w^{D,2}_{t+1,2}$, both groups of employees equally benefit from economic growth. Moreover, $w^{D,2}_{t+1,1} + w^{D,2}_{t+1,2}$ satisfying equation (4.44) is larger than the level of labor income belonging to the representative low-educated employee in the case of non-optimally large size of the less educated group. This implies that the less educated cohort can derive higher benefits from economic growth and therefore the institutional reform which was considered in the previous subsection, not only results in higher rates of economic growth, but also benefits a larger cohort of employees.[21]

Our findings are consistent with the resent history of Georgia, where in October 2012, after 8 years of reforms, president Saakashvili's United National Movement lost elections against the Georgian Dream, a populist alternative established by a billionaire Bidzina Ivanishvili. Despite the reforms which resulted in a substantial improvement in the public sector quality, corresponding, in terms of our model, to a lower p, and higher growth rates reflected in a larger φ_t, Saakashvili's rule was also characterized by a low level of redistribution and relatively high poverty. Growth was not followed by an adequate job creation, while, by contrast, wages of employed individuals were increasing substantially. In terms of our model, employed Georgians can be considered as individuals with a high level of human capital endowment $h_{t,1}^{D,1}$, while poor Georgians instead correspond to those employees who inherited a low human capital

[21]We also notice that if the number of high-educated individuals in economy D is lower than the level $n_{t+1,1}^{*}$ corresponding to equation (4.45), then the output gap between countries D and F remains positive even if the level of technology and the human capital stock in economy D catch up with the ones in country F. To show this, we normalize equation (4.23) which reflects the level of output produced by generation $t+1$ in economy F in the absence of technological development:

$$Y_{t+1}^{F} = 2L^{F}\left(A_{t+1,1}^{F}\right)^{1-\theta_1-\theta_2}\left(h_{t+1,1}^{F,1} n_{t+1,1}^{F}\right)^{\theta_1}\left(h_{t+1,1}^{F,2} n_{t+1,2}^{F}\right)^{\theta_2} \tag{4.47}$$

over the level of output produced by generation $t+1$ in country D in period $j=1$ if the level of technology in D also remains constant

$$Y_{t+1}^{D} = L^{H}\left(A_{t+1,1}^{H}\right)^{1-\theta_1-\theta_2}\left(h_{t+1,1}^{D,1} n_{t+1,1}^{D}\right)^{\theta_1}\left(h_{t+1,1}^{D,2} n_{t+1,2}^{D}\right)^{\theta_2} \tag{4.48}$$

which, if technology and human capital stocks are the same in F and D, results in the following expression:

$$\frac{Y_{t+1}^{F}}{Y_{t+1}^{D}} = 2\left(\frac{n_{t+1,1}^{F}}{n_{t+1,1}^{D}}\right)^{\theta_1}\left(\frac{n_{t+1,2}^{F}}{n_{t+1,2}^{D}}\right)^{\theta_2} \tag{4.49}$$

As it follows from equation (4.49), if the number of high-educated employees $n_{t+1,1}^{F}$ in economy F is chosen optimally, while in country D the size of the high-educated cohort $n_{t+1,1}^{D}$ is lower than it is optimally required, then, as $\theta_1 > \theta_2$, the output gap remains positive, i.e. $\frac{Y_{t+1}^{F}}{Y_{t+1}^{D}} > 2$, even if technology and the level of human capital in economy D are as large as the ones in country F.

level $h_{t,1}^{D;2}$. As poor individuals did not benefit from growth, their incentives to vote for Saakashvili and his reforms were low. Instead, they granted their votes to a political force which was characterized by a larger corruption potential, but promised to provide more redistribution.

4.6 Conclusion

We consider a non-overlapping generations economy where individuals combine human capital and technology to produce output. Each generation lives for two periods and is made up of capitalists who own a technology, and two groups of employees, possessing instead the human capital stock. Each capitalist employs a particular number of individuals from both groups in order to produce output. Using a possibility of adoption from exogenously given leading technological frontier, the representative capitalist improves upon a technology which he inherited from the previous generation.

In our setting, high-educated employees inherit a large human capital endowment, while their low-educated counterparts, by contrast, receive a low level of human capital stock from the previous generation. Both groups of employees, a high-educated and a low-educated one, invest in the acquisition of additional human capital. As human capital and technology are complementary factors of production, employees accumulate more human capital if the pace of technological evolution is larger. The latter occurs when the capitalist invests more in the acquisition of a new technology.

According to our assumption, the high-educated cohort is more important for production, and therefore it acquires a larger share in output and thus receives higher benefits when the latter increases. The share of the low-educated group is instead smaller, and, if this cohort makes up a majority of population, the level of per capita income in this group, as well as benefits from economic growth, are low.

We also introduce low-quality institutions into the benchmark economy and show how do bad institutions result in a lower level of investment into a new technology, slower accumulation of human capital stock and a smaller pace of economic growth.

In the presence of low-quality institutions the economy can not converge to the leading technological frontier and therefore remains a technological laggard.

We then assess under which circumstances a reform which improves the quality of institutions, increases the pace of economic growth, and thus makes all the employees, as well as the capitalists, better off, might be politically infeasible. To this end, we incorporate political competition into the model and consider two political regimes, one of them practicing expropriation and therefore maintaining the quality of institutions at a low level, while the other, by contrast, improving the quality of institutions. In order to gain political popularity, the former implements income redistribution, making transfers to the low-educated cohort. If less educated individuals make up a majority of population, their per capita income level is low, and so are their benefits from economic growth. As a result, the low-educated group's sensitivity to income redistribution remains high. We conclude that the alternative regime should complement its institutional reform with income redistribution policy to become more popular than its clientelistic opponent. If instead the redistribution policy is neglected by the reformist regime, its popularity might be low, and therefore the institutional reform can become less politically feasible.

As an alternative to income redistribution, we consider a policy which, instead of redistributing incomes, transfers more human capital to employees in order to enhance social mobility, enlarge the high-educated cohort and therefore broaden the group of employees benefiting from economic growth. We assume, however, that the latter effect realizes in the long run, therefore affecting the next generation, but not the current one. As a result, this policy might substitute income redistribution in the long run, however, in the short run income transfers remain an important component of political competition. We suggest to replace income transfers with growth enhancing policy gradually, redistributing less to those individuals who transited to the high-educated cohort and continuing transferring incomes to those ones who instead remain poor.

4.7 Appendices

4.7.1 Appendix A

Appendix A.1. Derivation of equations (4.16), (4.86), (4.17). In period $j = 1$ a typical employee belonging to the more educated group receives the following wage:

$$w_{t,1}^{D,1} = \theta_1 \left(A_{t,1}^{D}\right)^{1-\theta_1-\theta_2} \left(h_{t,1}^{D,1}\left(1-\varphi_t^1\right)\right)^{\theta_1} \left(h_{t,2}^{D,1} n_2^D \left(1-\varphi_t^2\right)\right)^{\theta_2} \left(n_1^D\right)^{\theta_1 - 1} \tag{4.50}$$

and in period $j = 2$ the same employee receives instead the wage rate which is equal to:

$$w_{t,2}^{D,1} = \theta_1 \left(A_{t,2}^{D}\right)^{1-\theta_1-\theta_2} \left(h_{t,1}^{D,1}\left(1+\varphi_t^1\right)\right)^{\theta_1} \left(h_{t,2}^{D,1} n_2^D \left(1+\varphi_t^2\right)\right)^{\theta_2} \left(n_1^D\right)^{\theta_1 - 1} \tag{4.51}$$

Similarly, in period $j = 1$ an employee from the more educated cohort receives the following wage:

$$w_{t,1}^{D,2} = \theta_2 \left(A_{t,1}^{D}\right)^{1-\theta_1-\theta_2} \left(h_{t,1}^{D,1} n_1^D\left(1-\varphi_t^1\right)\right)^{\theta_1} \left(h_{t,2}^{D,1} \left(1-\varphi_t^2\right)\right)^{\theta_2} \left(n_2^D\right)^{\theta_2 - 1} \tag{4.52}$$

and in period $j = 2$ the same employee receives the wage rate which is equal to:

$$w_{t,2}^{D,2} = \theta_2 \left(A_{t,2}^{D}\right)^{\theta_1} \left(h_1 n_1^D \left(1+\varphi_t^1\right)\right)^{\theta_1} \left(h_2 \left(1+\varphi_t^2\right)\right)^{\theta_2} \left(n_2^D\right)^{\theta_2 - 1} \tag{4.53}$$

An employee from the more educated group solves the following problem:

$$w_{t,1}^{D,1} + w_{t,2}^{D,1} \longrightarrow \max_{\varphi_t^1} \tag{4.54}$$

While her counterpart from the less educated group instead maximizes the following payoff function:

$$w_{t,1}^{D,2} + w_{t,2}^{D,2} \longrightarrow \max_{\varphi_t^2} \tag{4.55}$$

The capitalist maximizes his payoff, which is equal to the following expression:

$$(1-x_t)\left[y_{t,1}^D - n_1^D w_{t,1}^{D,1} - n_2^D w_{t,1}^{D,2}\right] + (1-p)\left[y_{t,2}^D - n_1^D w_{t,2}^{D,1} - n_2^D w_{t,2}^{D,2}\right] \longrightarrow \max_{x_t} \tag{4.56}$$

where

$$y_{t,1}^D = \left(A_{t,1}^D\right)^{1-\theta_1-\theta_2}\left(h_{t,1}^{D,1} n_1^D \left(1-\varphi_t^1\right)\right)^{\theta_1}\left(h_{t,1}^{D,2} n_2^D \left(1-\varphi_t^2\right)\right)^{\theta_2}$$

and

$$y_{t,2}^D = \left(A_{t,2}^D\right)^{1-\theta_1-\theta_2}\left(h_{t,1}^{D,1} n_1^D \left(1+\varphi_t^1\right)\right)^{\theta_1}\left(h_{t,1}^{D,2} n_2^D \left(1+\varphi_t^2\right)\right)^{\theta_2}$$

After taking derivatives and rearranging we receive the following first order conditions:

$$\left(\frac{A_{t,2}^D(x_t)}{A_{t,1}^D}\right)^{1-\theta_1-\theta_2}\left(\frac{1+\varphi_t^1}{1-\varphi_t^1}\right)^{\theta_1} = \left(\frac{1+\varphi_t^2}{1-\varphi_t^2}\right)^{1-\theta_2} \tag{4.57}$$

or

$$\left(\frac{A_{t,2}^D(x_t)}{A_{t,1}^D}\right)^{1-\theta_1-\theta_2}\left(\frac{1+\varphi_t^2}{1-\varphi_t^2}\right)^{\theta_2} = \left(\frac{1+\varphi_t^1}{1-\varphi_t^1}\right)^{1-\theta_1} \tag{4.58}$$

and

$$\left(\frac{A_{t,2}^D(x_t)}{A_{t,1}^D}\right)^{1-\theta_1-\theta_2}\left(\frac{1+\varphi_t^1}{1-\varphi_t^1}\right)^{\theta_1}\left(\frac{1+\varphi_t^2}{1-\varphi_t^2}\right)^{\theta_2} = \frac{A_{t,2}^D}{\left(1-\theta_1-\theta_2\right)\left(1-p\right)\frac{\partial\left(A_{t,2}^D(x_t)\right)}{\partial x_t}} \tag{4.59}$$

Dividing equation (4.57) over equation (4.58) results in the following expression:

$$\frac{1+\varphi_t^2}{1-\varphi_t^2} = \frac{1+\varphi_t^1}{1-\varphi_t^1} \tag{4.60}$$

which, after rearranging, leads to the following result:

$$\varphi_t^2 = \varphi_t^1 \tag{4.61}$$

Substituting equation (4.60) into equation (4.59) and equation (4.58) results in the following expression:

$$\frac{A^D_{t,2}\left(x_t\right)}{A^D_{t,1}} = \frac{1+\varphi^2_t}{1-\varphi^2_t} = \frac{1+\varphi^1_t}{1-\varphi^1_t} \tag{4.62}$$

or, after rearranging:

$$\varphi^2_t = \varphi^1_t = \frac{A^D_{t,2}\left(x_t\right) - A^D_{t,1}}{A^D_{t,2}\left(x_t\right) + A^D_{t,1}} \tag{4.63}$$

From equations (4.59) and (4.60) results in the following expression:

$$\frac{\partial A^D_{t,2}}{\partial x_t} = \frac{A^D_{t,1}}{\left(1-\theta_1-\theta_2\right)\left(1-p\right)} \tag{4.64}$$

One can combine equation (4.64) with equation (4.8) or with equation (4.85) from Appendix D to derive equation (4.16) or equation (4.86) respectively.

Dynamics of x^*_t. We can rewrite equation (4.16) as follows:

$$\eta'(x^*_t) = \frac{1}{\left(1-\theta_1-\theta_2\right)\left(1-p\right)\left(\frac{A^F_{t-1,1}(1+g)}{A^D_{t-1,1}+\eta(x^*_{t-1})\left(A^F_{t-1,1}-A^D_{t-1,1}\right)} - 1\right)} \tag{4.65}$$

From equation (4.65) it follows that when the denominator of

$$\frac{A^F_{t-1,1}(1+g)}{A^D_{t-1,1}+\eta(x^*_{t-1})\left(A^F_{t-1,1}-A^D_{t-1,1}\right)}$$

increases more than its numerator, the economy approaches the leading technological frontier, and therefore the gap between the level of local technology and the leading frontier reduces.

As $\frac{A^F_{t,1}}{A^D_{t,1}}$ positively affects the level of x^*_t, this implies that $x^*_t < x^*_{t-1}$.

When, on the contrary, the denominator of

$$\frac{A^F_{t-1,1}(1+g)}{A^D_{t-1,1}+\eta(x^*_{t-1})\left(A^F_{t-1,1}-A^D_{t-1,1}\right)}$$

increases less than the numerator, then the distance to technological frontier increases as well, which results in $x_t^* > x_{t-1}^*$.

Finally, when the numerator of

$$\frac{A_{t-1,1}^F(1+g)}{A_{t-1,1}^D + \eta(x_{t-1}^*)\left(A_{t-1,1}^F - A_{t-1,1}^D\right)}$$

increases as much as does the denominator, $x_t^* = x_{t-1}^*$.

Appendix A.2. Uniqueness and global stability of the steady-state level of x_t^*.

First we show uniqueness:

$$\frac{\partial\left(\frac{x_{t+1}^*}{x_t^*}\right)}{\partial x_t^*} = \frac{\frac{\partial x_{t+1}^*}{\partial x_t^*}x_t^* - x_{t+1}^*}{\left(x_t^*\right)^2} < 0$$

The latter result holds as from equation (4.16) we know that $\frac{\partial x_{t+1}^*}{\partial x_t^*} < 0$. This implies that $\frac{x_{t+1}^*}{x_t^*}$ increases when x_t^* decreases. As $\frac{x_{t+1}^*}{x_t^*} = 1$ in the steady-state, and $\frac{x_{t+1}^*}{x_t^*}$ is everywhere increasing when x_t^* is decreasing, the steady-state is unique.

Global stability of the steady-state level of x_t^*.

$$\eta'(x_t^*) = \frac{1}{(1-\theta_1-\theta_2)(1-p)\left(\frac{A_{t,1}^F}{A_{t,1}^D} - 1\right)} \tag{4.66}$$

Since $\eta'(x_t^*)$ is monotonically decreasing in x_t^*, we can write the following expression:

$$x_t^* = (\eta')^{-1}\left(\frac{1}{(1-\theta_1-\theta_2)(1-p)\left(\frac{A_{t,1}^F}{A_{t,1}^D} - 1\right)}\right) \tag{4.67}$$

Since $\eta(x_t^*)$ is concave, which implies that $\eta''(x_t^*) < 0$, the inverse of $\eta'(x_t^*)$, which is $(\eta')^{-1}$, is also a decreasing function of its argument. To prove global stability, we consider $x_t^* \in (x^*, x_0^*)$, where x^* is a steady-state share in output x_t^*, and x_0^* is a share in output for the initial generation $t = 0$.

We use equation (4.67) to show that

$$x_{t+1}^* - x^* = (\eta')^{-1} \left(\frac{1}{(1-\theta_1-\theta_2)(1-p)\left(\frac{A_{t+1,1}^F}{A_{t+1,1}^D(x_t^*)} - 1\right)} \right) -$$

$$- (\eta')^{-1} \left(\frac{1}{(1-\theta_1-\theta_2)(1-p)\left(\frac{A_{t,1}^F}{A_{t,1}^D(x^*)} - 1\right)} \right) =$$

$$= -\tfrac{x_0^*}{x^*} \left((\eta')^{-1} \right)' > 0 \tag{4.68}$$

Since we proved that $\frac{x_{t+1}^*}{x_t^*}$ increases when x_t^* instead decreases, we can now derive the following result:

$$\frac{x_{t+1}^*}{x_t^*} - 1 = \frac{(\eta')^{-1} \left(\frac{1}{(1-\theta_1-\theta_2)\left(\frac{A_{t+1,1}^F}{A_{t+1,1}^D(x_t^*)} - 1\right)} \right)}{(\eta')^{-1} \left(\frac{1}{(1-\theta_1-\theta_2)\left(\frac{A_{t,1}^F}{A_{t,1}^D(x_{t-1}^*)} - 1\right)} \right)} - 1 < \frac{x^*}{x^*} - 1 = 0 \tag{4.69}$$

Equation (4.68) together with equation (4.69) establishes that for all $x_t^* \in (x^*, x_0^*)$ the following result holds: $x_{t+1}^* \in (x^*, x_t^*)$. Using a similar argument we can show that for all $x_t^* \leq x^*$, $x_{t+1}^* \in (x_t^*, x^*)$. Therefore, a sequence $\{x_t^*\}_0^\infty$ monotonically converges to x^* and is globally stable.

Appendix A.3. Adoption function is decreasing in x_t^* when $p = 0$. To show that $(1-\varphi(x_t^*))^{\theta_1+\theta_2} \left[1 - x_t^* + \frac{1+\varphi(x_t^*)}{1-\varphi(x_t^*)} \right]$ is increasing with respect to x_t^*, we first rewrite it as follows:

$$\left(\frac{A_{t,2}^D + A_{t,1}^D}{A_{t,1}^D} - x_t^*\right)\left(\frac{2A_{t,1}^D}{A_{t,2}^D + A_{t,1}^D}\right)^{\theta_1+\theta_2}$$

and then differentiate it with respect to

$$x_t^* : \left(\frac{1}{1-\theta_1-\theta_2} - 1\right)\left(\frac{2A_{t,1}^D}{A_{t,2}^D + A_{t,1}^D}\right)^{\theta_1+\theta_2} -$$

$$-\left(\theta_1+\theta_2\right)\left(\frac{2A_{t,1}^D}{A_{t,2}^D + A_{t,1}^D}\right)^{\theta_1+\theta_2} \frac{A_{t,1}^D}{\left(1-\theta_1-\theta_2\right)\left(A_{t,2}^D + A_{t,1}^D\right)}\left(\frac{A_{t,2}^D + A_{t,1}^D}{A_{t,1}^D} - x_t^*\right) =$$

$$= \left(\frac{1}{1-\theta_1-\theta_2} - 1\right)\left(\frac{2A_{t,1}^D}{A_{t,2}^D + A_{t,1}^D}\right)^{\theta_1+\theta_2} x_t^* \frac{A_{t,1}^D}{A_{t,2}^D + A_{t,1}^D} > 0$$

which establishes the result

4.7.2 Appendix B

We take a derivative of the adoption function R_t with respect to x_t^*. First we use $\varphi(x_t^*) = \frac{A_{t,2}^D - A_{t,1}^D}{A_{t,2}^D + A_{t,1}^D}$ to rewrite the adoption function

$$R_t = \left(1-\varphi(x_t^*)\right)^{\theta_1+\theta_2}\left[1 - x_t^* + (1-p)\frac{1+\varphi(x_t^*)}{1-\varphi(x_t^*)}\right] \tag{4.70}$$

as follows

$$R_t = \left(\frac{2A_{t,1}^D}{A_{t,2}^D + A_{t,1}^D}\right)^{\theta_1+\theta_2}\left[\frac{A_{t,2}^D}{A_{t,1}^D}(1-p) + 1 - x_t^*\right] \tag{4.71}$$

Taking a derivative of equation (4.71) with respect to x_t^* results in the following expression:

$$\frac{\partial R_t}{\partial x_t^*} = -\left(\theta_1+\theta_2\right)\left(\frac{2A_{t,1}^D}{A_{t,2}^D + A_{t,1}^D}\right)^{\theta_1+\theta_2-1} \frac{2A_{t,1}^D \frac{\partial A_{t,2}^D}{\partial x_t^*}}{\left(A_{t,2}^D + A_{t,1}^D\right)^2}\left(\frac{A_{t,2}^D}{A_{t,1}^D}(1-p) + 1 - x_t^*\right) +$$

$$+\left((1-p)\frac{\frac{\partial A^D_{t,2}}{\partial x^*_t}}{A^D_{t,1}}-1\right)\left(\frac{2A^D_{t,1}}{A^D_{t,2}+A^D_{t,1}}\right)^{\theta_1+\theta_2}= \tag{4.72}$$

From equations (4.8) and (4.16) it follows that $\frac{\partial A^D_{t,2}}{\partial x^*_t}=\frac{A^D_{t,1}}{(1-\theta_1-\theta_2)(1-p)}$. We therefore can rewrite equation (4.72) as follows

$$\frac{\partial R_t}{\partial x^*_t}=\left(\frac{2A^D_{t,1}}{A^D_{t,2}+A^D_{t,1}}\right)^{\theta_1+\theta_2}$$

$$\left[-\frac{\theta_1+\theta_2}{1-\theta_1-\theta_2}\frac{A^D_{t,1}}{(1-p)\left(A^D_{t,2}+A^D_{t,1}\right)}\left(\frac{A^D_{2,t}}{A^D_{1,t}}(1-p)+1-x^*_t\right)+\frac{\theta_1+\theta_2}{1-\theta_1-\theta_2}\right]=$$

$$=\left(\frac{2A^D_{t,1}}{A^D_{t,2}+A^D_{t,1}}\right)^{\theta_1+\theta_2}\frac{\theta_1+\theta_2}{1-\theta_1-\theta_2}$$

$$\left[-\frac{A^D_{t,2}(1-p)}{\left(A^D_{t,2}+A^D_{t,1}\right)(1-p)}-\frac{A^D_{t,1}(1-x^*_t)}{(1-p)\left(A^D_{t,2}+A^D_{t,1}\right)}+\frac{(1-p)\left(A^D_{t,2}+A^D_{t,1}\right)}{(1-p)\left(A^D_{t,2}+A^D_{t,1}\right)}\right]=$$

$$=\left(\frac{2A^D_{t,1}}{A^D_{t,2}+A^D_{t,1}}\right)^{\theta_1+\theta_2}\frac{\theta_1+\theta_2}{1-\theta_1-\theta_2}\frac{A^D_{t,1}}{(1-p)\left(A^D_{t,2}+A^D_{t,1}\right)}(x^*_t-p) \tag{4.73}$$

From equation (4.73) it follows that equation (4.70) reaches its minimum when $x^*_t=p$, it increases whenever $x^*_t>p$ and declines whenever the opposite occurs.

We now show that the minimum point of equation (4.70) declines when p increases. We substitute $x^*_t=p$ into equation (4.70)

$$R_t=(1-\varphi(p))^{\theta_1+\theta_2}\left[1-p+(1-p)\frac{1+\varphi(p)}{1-\varphi(p)}\right]=(1-p)\frac{2}{(1-\varphi(p))^{1-\theta_1-\theta_2}} \tag{4.74}$$

and take a derivative of equation (4.74) with respect to p:

$$\frac{\partial R_t}{\partial p} =$$

$$\frac{-2\left(1-\varphi(p)\right)^{1-\theta_1-\theta_2}+2\left(1-\theta_1-\theta_2\right)\left(1-\varphi(p)\right)^{-\theta_1-\theta_2}\left(1-p\right)\frac{\partial\varphi(p)}{\partial p}}{\left(1-\varphi(p)\right)^{2(1-\theta_1-\theta_2)}} =$$

$$= \frac{2}{\left(1-\varphi(p)\right)^{1-\theta_1-\theta_2}}\left[\frac{\left(1-\theta_1-\theta_2\right)\left(1-p\right)\frac{\partial\varphi(p)}{\partial p}}{1-\varphi(p)}-1\right] \tag{4.75}$$

We substitute $\varphi(x_t^*) = \frac{A_{t,2}-A_{t,1}}{A_{t,2}+A_{t,1}}$ into equation (4.75) and use equation (4.16) to receive the following result:

$$\frac{\partial R_t}{\partial p} = \frac{2\left(A_{t,2}^D+A_{t,1}^D\right)^{1-\theta_1-\theta_2}}{\left(2A_{t,1}^D\right)^{1-\theta_1-\theta_2}}\left[\frac{A_{t,1}^D}{A_{t,2}^D+A_{t,1}^D}-1\right] =$$

$$-\frac{2\left(A_{t,2}^D+A_{t,1}^D\right)^{1-\theta_1-\theta_2}}{\left(2A_{t,1}^D\right)^{1-\theta_1-\theta_2}}\frac{A_{t,2}^D}{A_{t,2}^D+A_{t,1}^D} < 0 \tag{4.76}$$

Expression (4.76) implies that a larger p reduces the minimum point of R_t.

4.7.3 Appendix C

We now show that a larger p results in a larger x_t^* corresponding to the intersection between equation (4.70) and $2-p$.

At the intersection point, equation (4.70) equals to $2-p$:

$$R_t = \left(1-\varphi(x_t^*)\right)^{\theta_1+\theta_2}\left[1-x_t^*+(1-p)\frac{1+\varphi(x_t^*)}{1-\varphi(x_t^*)}\right] = 2-p \tag{4.77}$$

As, according to equation (4.16), x_t^* is a function of p, we can rewrite equation

(4.77) as follow

$$(1-\varphi(x_t^*(p)))^{\theta_1+\theta_2}\left[1-x_t^*(p)+(1-p)\frac{1+\varphi(x_t^*(p))}{1-\varphi(x_t^*(p))}\right]-2+p=0 \qquad (4.78)$$

We use $\varphi(\alpha_t^*)=\frac{A_{t,2}^D-A_{t,1}^D}{A_{t,2}^D+A_{t,1}^D}$ together with the implicit function theorem to derive the following result:

$$-(\theta_1+\theta_2)\left(\frac{2A_{t,1}^D}{A_{t,2}^D(x_t^*(p))+A_{t,1}^D}\right)^{\theta_1+\theta_2-1}\frac{2A_{t,1}^D\frac{\partial A_{t,2}^D}{\partial x_t^*}}{\left(A_{t,2}^D(x_t^*(p))+A_{t,1}^D\right)^2}\frac{\partial x_t^*}{\partial p}$$

$$\left[\frac{A_{t,2}^D(x_t^*(p))}{A_{t,1}^D}(1-p)+1-x_t^*(p)\right]+$$

$$+\left(\frac{2A_{t,1}^D}{A_{t,2}^D(x_t^*(p))+A_{t,1}^D}\right)^{\theta_1+\theta_2}\left[\frac{\partial x_t^*}{\partial p}\frac{\frac{\partial A_{t,2}^D}{\partial x_t^*}}{A_{t,1}^D}(1-p)-\frac{A_{t,2}^D(x_t^*(p))}{A_{t,1}^D}-\frac{\partial x_t^*}{\partial p}\right]+1=0 \qquad (4.79)$$

We can simplify the upper expression in order to receive the following result (most derivations replicate the ones from Appendix B):

$$\frac{\partial x_t^*}{\partial p}=\frac{\frac{A_{t,2}^D(x_t^*(p))}{A_{t,1}^D}-\left(\frac{A_{t,2}^D(x_t^*(p))+A_{t,1}^D}{2A_{t,1}^D}\right)^{\theta_1+\theta_2}}{\frac{A_{t,1}^D(x_t^*(p)-p)}{(1-p)\left(A_{t,2}^D(x_t^*(p))+A_{t,1}^D\right)}\left(\frac{\theta_1+\theta_2}{1-\theta_1-\theta_2}\right)} \qquad (4.80)$$

To define the sign of equation (4.80) we have to find the sign of $x_t^*(p)-p$ and $\frac{A_{t,2}^D(x_t^*(p))}{A_{t,1}}-\left(\frac{A_{t,2}^D(x_t^*(p))+A_{t,1}^D}{2A_{t,1}^D}\right)^{\theta_1+\theta_2}$. Equation (4.77) holds for a value of $x_t^*(p)$ which is located to the right from the minimum point $x_t^*(p)=p$, i.e. $x_t^*(p)>p$, which implies that $x_t^*(p)-p>0$. We now rewrite $\frac{A_{t,2}^D(x_t^*(p))}{A_{t,1}}-\left(\frac{A_{t,2}^D(x_t^*(p))+A_{t,1}}{2A_{t,1}}\right)^{\theta_1+\theta_2}$ as follows:

$$\frac{\frac{A_{t,2}^D(x_t^*(p))}{A_{t,1}^D}\left(\frac{A_{t,2}^D(x_t^*(p))+A_{t,1}^D}{2A_{t,1}^D}\right)^{1-\theta_1-\theta_2}-\frac{A_{t,2}^D(x_t^*(p))+A_{t,1}^D}{2A_{t,1}^D}}{\left(\frac{A_{t,2}^D(x_t^*(p))+A_{t,1}^D}{2A_{t,1}^D}\right)^{1-\theta_1-\theta_2}}=$$

$$= \frac{\frac{A_{t,2}^D(x_t^*(p))}{A_{t,1}^D}\left[\left(\frac{A_{t,2}^D(x_t^*(p))+A_{t,1}^D}{2A_{t,1}^D}\right)^{1-\theta_1-\theta_2}-\frac{1}{2}\right]-\frac{1}{2}}{\left(\frac{A_{t,2}^D(x_t^*(p))+A_{t,1}^D}{2A_{t,1}^D}\right)^{1-\theta_1-\theta_2}} \tag{4.81}$$

The numerator of equation (4.81) is positive, since $\left(\frac{A_{t,2}^D(x_t^*(p))+A_{t,1}^D}{2A_{t,1}^D}\right)^{1-\theta_1-\theta_2} > 1$, which implies that $\left(\frac{A_{t,2}^D(x_t^*(p))+A_{t,1}^D}{2A_{t,1}^D}\right)^{1-\theta_1-\theta_2} > \frac{1}{2}$, and therefore, since $\frac{A_{t,2}^D(x_t^*(p))}{A_{t,1}^D} > 1$, $\frac{A_{t,2}^D(x_t^*(p))}{A_{t,1}^D}\left[\left(\frac{A_{t,2}^D(x_t^*(p))+A_{t,1}^D}{2A_{t,1}^D}\right)^{1-\theta_1-\theta_2}-\frac{1}{2}\right] > \frac{1}{2}$ as well.

Thus we conclude that $\frac{\partial x_t^*}{\partial p} > 0$.

4.7.4 Appendix D

In Section 3 we assumed that the level of A_t^F is constant, and, as imitation of technologies from country F was the only opportunity for economy D to improve upon its domestic technology, the steady-state level of technology in country D also remained constant. However, as a constant level of the world technological frontier is not a realistic assumption, in this Appendix we allow for a positive growth rate of the leading technology level, corresponding to A_t^F, which is the level of technology in country F. We therefore introduce a more natural assumption of evolving technological frontier, and assume that the level of technology in economy F grows at a constant rate g.

As it follows from equation (4.16), when the leading technology is growing at a constant rate g, the steady-state level of A_t^D also increases at the same rate. However, even in the absence of expropriation, i.e. when $p = 0$, the level of technology in country D can not entirely converge to the one in F. To show the latter, we use the following result:

$$A_{t,1}^D(1+g) = \eta\left(x^*\right)A_t^F + \left(1-\eta\left(x^*\right)\right)A_{t,1}^D \tag{4.82}$$

where x^* is the steady-state level of x_t^*. Equation (4.82) implies that the steady-state level of A_t^D increases at a rate g. After rearranging, equation (4.82) results in the following expression:

$$A_{t,1}^{D}=\frac{\eta\left(x^{*}\right)A_{t}^{F}}{g+\eta\left(x^{*}\right)} \tag{4.83}$$

As $\frac{\eta(x^*)}{g+\eta(x^*)}$ is less than 1, from equation (4.83) it follows that the steady-state level of $A_{t,1}^{D}$ always remains below A_t^F. Therefore, the level of output in economy D can not entirely converge to the one in country F. From equation (4.24) it follows that the output gap always remains positive, as $A_{t,1}^{D}$, and, as a result, $h_{t,1}^{D,1}$ and $h_{t,1}^{D,2}$ as well, do not catch up, correspondingly, with $A_{t,1}^{F}$, $h_{t,1}^{F,1}$ and $h_{t,1}^{F,1}$. It follows that $\frac{Y^F}{Y_{t,1}^D}=2\left(\frac{A^F}{A_{t,1}^D}\right)^{1-\theta_1-\theta_2}\left(\frac{h^{F,1}}{h_{t,1}^{D,1}}\right)^{\theta_1}\left(\frac{h^{F,2}}{h_{t,1}^{D,2}}\right)^{\theta_2}$, which is equation (4.24), is larger than 2. The latter implies that D does not catch up with economy F.[22]

Therefore, to converge to the leading frontier A_t^F, the level of technology in economy D should always grow at a rate which is higher than g. To allow for convergence, we thus assume that country D substitutes *imitation* of technologies with *innovation* as soon as the adoption-induced technological growth becomes sufficiently slow.[23]

If the capitalist in economy D invests into innovations, he spends a share x_t of his income in period $j=1$, which results in a higher level of technology $\lambda(x_t)A_{t,1}^D$ in period $j=2$ with probability $\mu>0$, where $\lambda(x_t)\geq 1$, $\lambda'(x_t)>0$, $\lambda''(x_t)<0$, $\lambda(0)=1$, $\lambda'(0)=\infty$ and $\lambda'(\infty)=0$. With probability $1-\mu$ investing into a new technology results instead in no improvement in the level of technology. Therefore, in period $j=2$ the level of technology in economy D equals to the following expression:

$$A_{t,2}^{D}=\mu\lambda(x_t)A_{t,1}^{D}+(1-\mu)\,A_{t,1}^{D} \tag{4.85}$$

[22] From the previous subsection we know that economy D converges to country F entirely when $\frac{Y_t^F}{Y_{t,1}^D}$ is, on the contrary, equal to 2

[23] Country D substitutes imitation with innovation when the following inequality holds:

$$\mu\geq\frac{g}{\lambda(x_t^*)-1} \tag{4.84}$$

Inequality (4.84) implies that starting from a particular level of x_t^* innovation results in a faster technological progress than adoption. As $A_{t,1}^D$ grows faster than A_t^F, the level of technology in economy D converges to the one in country F. If condition (4.84) instead does not hold, economy D imitates technologies forever, and therefore economy D never converges to F.

We then substitute this result into equations (4.9), (4.10) and (4.13). Maximizing equations (4.9), (4.10) and (4.13) with respect to x_t, φ_t^1 and φ_t^2 respectively and rearranging, results in the following expression:

$$\lambda'(x_t^*) = \frac{1}{(1-\theta_1-\theta_2)\,(1-p)\mu} \tag{4.86}$$

If the capitalist invests into innovations, the optimal level of x_t thus corresponds to equation (4.86). Therefore, equation (4.86) replaces equation (4.16) if the economy substitutes imitation with innovation. We notice that, as $(1-\theta_1-\theta_2)$, μ and p are constants, from equation (4.86) it thus follows that x_t^* is a constant as well.

We are ready to formulate our next proposition:

Proposition 3.

The rate of technological development in economy D converges to the unique steady-state, when the quality of institutions is high, i.e. when the probability of expropriation p is equal to zero. In the latter case, the representative capitalist transits from imitating of technology to innovating, As a result, the steady-state rate of technological evolution corresponds to the rate of technological innovations.
However, if the quality of institutions is instead low, i.e. when the probability of expropriation p is positive, the rate of technological progress in economy D is equal to g, the rate of evolution of technology in country F. In the latter case, the level of technology in economy D remains below the world technological frontier A_t^F.

Proof. We first consider the case when the probability of expropriation p is equal to zero. If the probability of successful innovation μ is at least as large as $\frac{g}{\lambda(x_t^*)-1}$, the representative capitalist substitutes imitation with innovation. In the latter case, the pace of technological evolution is defined from the expropriation-free version of equation (4.86), which corresponds to the following expression:

$$\lambda'(x_t^*) = \frac{1}{(1-\theta_1-\theta_2)\,\mu} \tag{4.87}$$

From equation (4.87) it follows that the optimal level of x_t^* is constant, as $(1-\theta_1-\theta_2)$ and μ are both constants, and therefore it corresponds to the steady-state rate of technological evolution.

We proceed with considering the case of low-quality institutions, when the probability of expropriation p is positive. We notice that if the capitalist invests into innovation, his optimal payoff function corresponds to the following expression:

$$W_C =$$

$$\left(A_{t,1}^D\right)^{1-\theta_1-\theta_2}\left(h_{t,1}^{D,1}n_1^D\right)^{\theta_1}\left(h_{t,1}^{D,2}n_2^D\right)^{\theta_2}(1-\varphi(x^*))^{\theta_1+\theta_2}\left[1-x^*+(1-p)\frac{1+\varphi(x^*)}{1-\varphi(x^*)}\right] \tag{4.88}$$

where $(1-\varphi(x^*))^{\theta_1+\theta_2}\left[1-x^*+(1-p)\frac{1+\varphi(x^*)}{1-\varphi(x^*)}\right]$ is a constant, as x^* is equal to a constant.

Normalizing equation (4.88) over $\left(A_{t,1}^D\right)^{1-\theta_1-\theta_2}\left(h_{t,1}^{D,1}n_1\right)^{\theta_1}\left(h_{t,1}^{D,2}n_2\right)^{\theta_2}$ results into the following expression:

$$R_t = (1-\varphi(x^*))^{\theta_1+\theta_2}\left[1-x^*+(1-p)\frac{1+\varphi(x^*)}{1-\varphi(x^*)}\right] \tag{4.89}$$

Equation (4.89) corresponds to the *innovation function*, which we also depict in the following Figure:

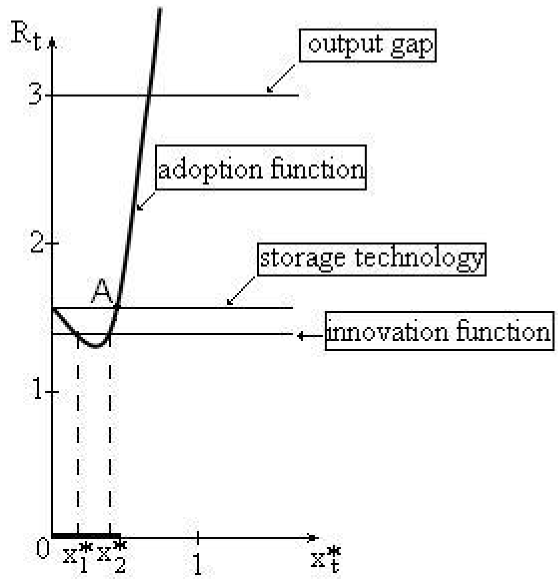

Figure 3. Non-convergence trap in the case with innovations.

We remind that according to equation (4.20), which we again reproduce below for convenience:

$$(1-\varphi(x_t^*))^{\theta_1+\theta_2}\left[1-x_t^*+(1-p)\,\frac{1+\varphi(x_t^*)}{1-\varphi(x_t^*)}\right]=2-p$$

the adoption function, corresponding to the left-hand side of equation (4.20), decreases when $0 \leq x_t^* < p$, attains its minimum at $x_t^* = p$, and increases when $x_t^* > p$. If the value of x_t^* belongs to the non-convergence set represented as interval $[0; \widehat{x}_t^2]$, where $\widehat{x}_t^2$ is a positive solution of equation (4.20) corresponding to point A in Figure 3, the respective value of the adoption function is less than $2-p$. As a consequence, the capitalist prefers not to invest into a new technology, which results in the absence of convergence with the leading frontier. In the example which is reflected in Figure 3, two points at which the innovation function intersects the adoption curve, correspond to x_1^* and x_2^* on the horizontal axis, both belonging to the bold section of the horizontal axis, reflecting the non-convergence set. The latter implies that economy D does not transit to the innovation stage.

We notice the important difference between the case of constant leading technology A^F, which we considered in the previous section, and the one of the current section, where $A^F_{t,1}$ instead grows at a rate g. In the previous subsection, ending up in the non-convergence trap resulted in the absence of growth. However, when the world frontier grows at a positive rate, the trapped economy develops at the same rate as well. To show the latter result, consider again, as in the previous subsection, point A, where the capitalist is indifferent between acquiring a new technology and investing into the storage asset. From equation (4.16) it follows that the next generation $t+1$ will choose $x^*_{t+1} < x^*_t$. As x^*_{t+1} does not satisfy equation (4.20), the right-hand side of this equation becomes larger than its left-hand side. The latter implies that the storage technology will thus pay a higher return to the capitalist belonging to generation $t+1$, and, as the result, the capitalist does not have incentives to invest into a new technology. As a result, the level of $A^D_{t+1,1}$ remains constant, while the level of the world technology A^F_t instead increases at a rate g. As a consequence, next generation $t+2$ inherits a technology which is more faraway from the leading frontier, i.e. the distance to the world frontier $\frac{A^F_{t+2,1}}{A^D_{t+2,1}}$ becomes larger. From equation (4.16) it follows that the level of x^*_{t+2} becomes larger as well. If the distance to the leading frontier $\frac{A^F_{t+2,1}}{A^D_{t+2,1}}$ and therefore the level of x^*_{t+2}, are sufficiently large, the left-hand side of equation (4.20) becomes larger than its right-hand side, which implies that investing into a new technology benefits the capitalist more than investing into the storage technology. As a result of investment into a new technology, the level of $A^D_{t+3,1}$ becomes larger, which reduces the distance to the leading frontier $\frac{A^F_{t+3,1}}{A^D_{t+3,1}}$. Because of a smaller $\frac{A^F_{t+3,1}}{A^D_{t+3,1}}$, the level of x^*_{t+3}, the optimal share of income the representative capitalist belonging to generation $t+3$ would invests into a new technology, becomes lower and therefore investing into a new technology might again be less beneficial for the capitalist. Thus, the level of technology in D develops when the distance to the world frontier becomes sufficiently large, and it instead does not evolve when the distance to the leading technology reduces. On average, the level of technology in economy D grows at the rate g, i.e. as fast as does the leading technology $A^F_{t,1}$. As a result, $A^D_{t,1}$, on average, remains a constant fraction of the world technological frontier, which implies that the level of technology in country D does not converge to the frontier technology. ■

We therefore conclude that the presence of expropriation reduces the rate of economic growth, which results in a non-diminishable distance between the level of technology in economies F and D.

4.7.5 Appendix E

We take a derivative of

$$R_t = (1-\varphi(x_t^*))^{\theta_1+\theta_2}\left[1 - x_t^* + (1-p)\frac{1+\varphi(x_t^*)}{1-\varphi(x_t^*)}\right] = 2 - p \tag{4.90}$$

with respect p. We use $\varphi_t = \frac{A_{t,2}^D(x_t)-A_{t,1}^D}{A_{t,2}^D(x_t)+A_{t,1}^D}$ to derive the following result:

$$-(\theta_1+\theta_2)\left(\frac{2A_{t,1}^D}{A_{t,2}^D(x_t^*(p))+A_{t,1}^D}\right)^{\theta_1+\theta_2-1}\frac{2A_{t,1}^D\frac{\partial A_{t,2}^D}{\partial x_t^*}}{\left(A_{t,2}^D(x_t^*(p))+A_{t,1}^D\right)^2}\frac{\partial x_t^*}{\partial p}$$

$$\left[\frac{A_{t,2}^D(x_t^*(p))}{A_{t,1}^D}(1-p)+1-x_t^*(p)\right]+$$

$$+\left(\frac{2A_{t,1}^D}{A_{t,2}^D(x_t^*(p))+A_{t,1}^D}\right)^{\theta_1+\theta_2}\left[\frac{\partial x_t^*}{\partial p}\frac{\frac{\partial A_{t,2}^D}{\partial x_t^*}}{A_{t,1}^D}(1-p)-\frac{A_{t,2}^D(x_t^*(p))}{A_{t,1}^D}-\frac{\partial x_t^*}{\partial p}\right] \tag{4.91}$$

The derivative of $2-p$ with respect to p equals to -1. We need to compare -1 with expression (4.91), or, alternatively

$$\frac{\partial x_t^*}{\partial p}\frac{A_{t,1}^D(x_t^*(p)-p)}{(1-p)\left(A_{t,2}^D(x_t^*(p))+A_{t,1}^D\right)}\left(\frac{\theta_1+\theta_2}{1-\theta_1-\theta_2}\right)-\frac{A_{t,2}^D(x_t^*(p))}{A_{t,1}^D} \tag{4.92}$$

with

$$\left(\frac{A^D_{t,2}(x^*_t(p)) + A^D_{t,1}}{2A^D_{t,1}}\right)^{\theta_1+\theta_2} \tag{4.93}$$

We have already shown that $\frac{A^D_{t,2}(x^*_t(p))}{A^D_{t,1}} > \left(\frac{A^D_{t,2}(x^*_t(p))+A^D_{t,1}}{2A^D_{t,1}}\right)^{\theta_1+\theta_2}$ which implies that $-\frac{A^D_{t,2}(x^*_t(p))}{A^D_{t,1}} < -\left(\frac{A^D_{t,2}(x^*_t(p))+A^D_{t,1}}{2A^D_{t,1}}\right)^{\theta_1+\theta_2}$. From $\lambda'(x^*_t) = \frac{1}{(1-\theta_1-\theta_2)\mu}$ we know that $\frac{\partial x^*_t}{\partial p} < 0$. Therefore, if $x^*_t(p) - p > 0$ expression (4.92) is smaller than expression (4.93).

4.7.6 Appendix F

The representative employee from the high-educated cohort receives the following income:

$$w^1_1 + w^2_1 = \theta_1 \frac{h^{\theta_1}_{t,1}}{n^{1-\theta_1}_{t,1}} \left(A^D_{t,1}\right)^{1-\theta_1-\theta_2} \left(h_{t,2} n^D_{t,2}\right)^{\theta_2} \frac{2}{(1-\varphi_t)^{\theta_1+\theta_2}} \tag{4.94}$$

while her counterpart from the low-educated group earns instead as much as:

$$w^1_{t,2} + w^2_{t,2} = \theta_2 \frac{h^{\theta_2}_{t,2}}{\left(n^D_{t,2}\right)^{1-\theta_2}} \left(A^D_{t,1}\right)^{1-\theta_1-\theta_2} \left(h_{t,1} n^D_{t,1}\right)^{\theta_1} \frac{2}{(1-\varphi_t)^{\theta_1+\theta_2}} \tag{4.95}$$

We divide equation (4.94) over equation (4.95) to receive the following result:

$$\frac{w^1_{t,1} + w^2_{t,1}}{w^1_{t,2} + w^2_{t,2}} = \frac{\theta_1}{\theta_2} \frac{n^D_{t,2}}{n^D_{t,1}} \tag{4.96}$$

The reformist regime maximizes the following expression with respect to $n_{t,1}$

$$y^D_{t,1} + y^D_{t,2} \longrightarrow \max_{n^D_{t,1}} \tag{4.97}$$

Maximization results in the following first order condition:

$$\theta_1 \frac{1}{n^D_{t,1}} - \theta_2 \frac{1}{n - n^D_{t,1}} + \theta_1 \frac{1}{n^D_{t,1}} \frac{1+\varphi^1_t}{1-\varphi^1_t} - \theta_2 \frac{1}{n - n^D_{t,1}} \frac{1+\varphi^1_t}{1-\varphi^1_t} = 0 \tag{4.98}$$

which simplifies to the following result:

$$\frac{\theta_1}{\theta_2}\frac{n^D_{t,2}}{n^D_{t,1}} = 1 \tag{4.99}$$

As $n^D_{t,1} + n^D_{t,2} = n$, and the total number of employees in economy D is equal to Ln^D we can derive the following results:

$$n^D_{t,1} = n^D \frac{\theta_1}{\theta_1 + \theta_2} \tag{4.100}$$

$$n^D_{t,2} = n^D \frac{\theta_2}{\theta_1 + \theta_2} \tag{4.101}$$

Finally, we combine equations (4.99) and (4.96) to receive the following expression:

$$\frac{w^1_{t,1} + w^2_{t,1}}{w^1_{t,2} + w^2_{t,2}} = 1 \tag{4.102}$$

Chapter 5

Nederlandse samenvatting (Summary in Dutch)

Dit proefschrift behandelt drie verschillende onderwerpen met betrekking tot het gebied van de politieke economie en Economische Ontwikkeling.

Het eerste hoofdstuk, ”Inleiding”, schetst de thesis.

In het tweede hoofdstuk, ”Extractieve instellingen, gesloten grenzen en Economische Ontwikkeling”, beschouw ik een autocratisch regime dat de toegang tot informatie over de buitenwereld beperkt, om te voorkomen dat burgers leren over de relatief slechte prestaties van de economie in hun thuisland. Ik analyseer het gebruik van censuur en modelleer het als een probleem van asymmetrische informatie, in het kader van een aangepast Solow groeimodel. Ik vind dat een hogere technologische achterstand, een lagere kwaliteit van de binnenlandse instituten, laag niveau van de inkomensongelijkheid en lage kosten van het verzamelen van informatie over de buitenlandse economieën leiden tot restrictievere en uitgebreidere censuur. Deze bevindingen komen overeen met de verhalen van de socialistische dictaturen, zoals de voormalige Sovjet-Unie of Noord-Korea, waar zeer restrictieve vormen van censuur werden/worden gebruikt. Ook verklaar ik waarom de meest restrictieve vormen van censuur, zoals politiek isolationisme, nu minder populair zijn. Ik betoog dat isolationisme de mogelijkheden voor de invoering van technologieën vermindert, wat resulteert in onderontwikkeling, een hogere kwetsbaarheid voor negatieve schokken, en potentieel hogere politieke turbulentie. Om dit te voorkomen, doet een regime er goed aan de meest strenge vormen van censuur niet te implementeren. Deze bevinding is in lijn met het censuur beleid dat wordt toegepast in hedendaags China.

In het derde hoofdstuk, ”Zijn onderwijsvernieuwingen noodzakelijk bevorderend voor groei? Zwakke instellingen als de oorzaak van beleidsmislukkelingen”, analyseer ik een ontwikkelende economie, waar een onderwijsvernieuwing die nieuwe mogelijkheden creëhoger niveau van menselijke kapitaal. Om dit probleem aan te pakken, introduceer ik een dynamisch model waarin de representatieve onderneming een productiefunctie heeft waarin menselijk kapitaal en het beschikbare niveau van de technologie complimentair zijn. Het bedrijf investeert in de aankoop van nieuwe technologie, terwijl werknemers beslissen hoeveel menselijk kapitaal zij verwerven. De snelheid van de accumulatie van menselijk kapitaal heeft een positief effect op de groei van de economie en als gevolg daarvan kan een hervorming die het onderwijssysteem verbetert leiden tot een snellere groei. Belangrijk is echter dat, indien eigendomsrechten zwak worden afgedwongen, bedrijven beperkte prikkels hebben om te investeren in de verwerving van nieuwe technologieën. Dit zou de vraag naar menselijk kapitaal beperken, en zorgt er potentieel voor dat een onderwijsvernieuwing mislukt. Als eigendomsrechten zwak worden beschermd, leidt een educatieve hervorming tot de keuze van een hoger niveau van onderwijs alleen als individuen hun menselijk kapitaal kunnen overdragen naar een andere economie, waar de vraag naar hun vaardigheden hoger is. Ik concludeer daarmee dat een verbetering van het school-systeem eenduidig tot een snellere groei leidt alleen als het gecombineerd gaat met een betere handhaving van het eigendomsrecht.

Tot slot, het vierde en het laatste hoofdstuk, ”Groei alleen is niet genoeg ”, is ingegeven door een van de meest intrigerende resultaten van de parlementsverkiezingen in Georgië van 2012: het economisch succes van een groeibevorderend beleid kan mogelijk niet worden omgezet in politieke populariteit. In het kader van een niet-overlappende generaties groeimodel met hoog- en laaggeschoolde werknemers, beargumenteer ik dat een mogelijke verklaring voor dit resultaat is dat een op groei gericht beleid het belang van inkomensherverdeling negeert. Hoewel de hervormingen economische groei vergroten, kan het zijn dat de hooggeschoolden profiteren van de groei, terwijl de laaggeschoolden nauwelijks beter af zijn. De laatste groep blijft daarom gevoelig voor inkomensoverdrachten. Indien deze niet worden geleverd door het zittende regime, daalt de politieke overlevingskans zelfs met positieve groeicijfers. Ik toon veder dat een beleid dat sociale mobiliteit bevordert (mogelijkheden genereren waarbij laaggeschoolden omhoog kunnen klimmen) op de lange termijn een vervanging kan zijn voor inkomensherverderling (maar niet op korte termijn).

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