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On the Timing of Political Regime Changes: Theory and Application to the Arab Spring

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Keywords: Political Transitions, Revolution, Natural Resources, Optimal Timing, Regime Switching, Dynamic Game
JEL Classification: C61, D74, Q34

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On the timing of political regime changes: Theory and application to the Arab Spring*

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August 27, 2014

Abstract

We develop a continuous time dynamic game to provide with a benchmark theory of Arab Spring-type events. We consider a resource-dependent economy with two interacting groups, the elite *vs.* the citizens, and two political regimes, dictatorship *vs.* a freer regime. Transition to the freer regime can only be achieved if citizens decide to revolt given the concession/repression policy of the elite. Departing from the related literature, the revolution optimal timing is an **explicit** control variable in the hands of citizens. The elite is the strategic leader: she ultimately chooses her policy knowing the reaction function of citizens. In this framework, we provide with a full equilibrium analysis of the political regime switching game and notably emphasize the role of the direct switching cost of the citizens and of the elite's self-preservation options. In particular, we show how the incorporation of explicit revolution timing may change the conventional wisdom in the related institutional change literature. Finally, we emphasize how the theory may help explaining some key features of the Arab Spring.

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1 Introduction

The Arab Spring, which started in Tunisia in late 2010, is arguably the most important event of the beginning of this century. While the political and geostrategic consequences of this event are not yet settled, it's enough to look a few months or years backward to realize how it is important and somehow striking: who could expect in early 2011 that fierce dictators and regimes as those of Benali or Mubarak will be ousted after quite a few weeks of heavy protests and demonstrations? Who could expect the cascade of events which have affected the whole Arab world after the Tunisian Jasmine revolution? A first puzzling aspect of the Arab Spring is henceforth the **timing**. Why did Arab populations wait 4 or 5 decades (after independence) before revolting? All these countries have in common the fact that they have been ruled for decades by elite controlling fiercely the rents deriving either from the exploitation of natural resources or from economic liberalization (like in Tunisia, celebrated as one of the most open Arab countries by the World Bank's *Doing Business* successive surveys prior to the Jasmine Revolution).[1] A key research question is consequently what does determine the decision of the opposition (that's the vast majority of the population) to go for a revolution and the inherent timing in a context where the ruling elite have all the economic and political powers in hands.

A second striking feature is **the large variety of outcomes** observed so far. In some cases, the ruling parties were eventually ousted (as in Tunisia or Egypt) after weeks of deadly demonstrations. In others, the same demonstrations have not been so successful and the incumbents remained in office as in Bahrain which ruling dynasty benefited from the external support of Saudi Arabia. A much less bloody case is Algeria: with a mixture of repression and redistribution, the elite have been able to retain the power (see Achy, 2011). Indeed, the January 2011 protests have led the Algerian government to markedly enlarge the scope of its food subsidy program and its youth employment support packages (see Boucekkine and Bouklia-Hassane, 2011).This variety of outcomes suggests the following research questions: to which extent the use of redistribution/repression by elite can explain this variety of outcomes observed? Incidentally, couldn't the elite, with all the powers in hands, systematically prevent the occurrence of such moves by taking the adequate decisions, either fierce/soft repression and/or massive/moderate redistribution of the rents, in the right time? The research questions stated above cannot be properly addressed without two key ingredients: in first place, the dynamic aspects to be able to fully understand the timing of the events, and in second place, the strategic aspects with ruling elite acting as a strategic leader in the initial non-democratic regime.

Our research can be related to two distinct streams of the literature. The first strand of literature deals with the roots of conflicts in fractionalized countries with abundant natural resources. Cross-country evidence suggests a positive

[1]Egypt was ranked in the Top 10 of the most reforming countries in the world by *Doing Business* in 2008/2009, and Tunisia was ranked 55th out of 183 in 2011 by *Doing Business ranking.*

correlation between rents from natural resources and civil wars. A major contribution along this line is the greed and grievance story told by Collier and Hoeffler (2004). The authors outline that rebellion and conflicts may be explained by severe grievances, such as high inequality, a lack of political rights, or ethnic and religious divisions in society. Several authors (see in particular Torvik, 2002, Hodler, 2006, Mehlum et al., 2006, and Gonzalez, 2007) have also pointed out that resource abundance induces political instability if competing factions try to obtain control over the associated rents. Resources cause rent seeking and fighting activities between rival groups, which weaken property rights and lead to a curse. In all this literature, there is no strategic structure (with leadership by the elite), which - we believe - is the first important feature of the Arab Spring. One exception is van der Ploeg and Rohner (2012) who analyze in a two period game the extraction policy of an incumbent government that is subject to a threat of rebellion. In such a situation, the government has an incentive to extract the resource much faster than under peace (or cooperation). This is coined the rapacious resource exploitation. But this is not a paper on political regime changes or revolutions.

Indeed, our work is more closely related to the second literature on political transitions. In a series of papers and a book, Acemoglu and Robinson (2000a,b, 2001 and 2006) present an analysis of the transition from dictatorships to democracies driven by the interaction between the rich elite and the poor citizens. Those two groups typically play a game where the sequence of moves is as follows: the elite first choose between different mutually exclusive strategies - repression, democratization or redistribution - and then the poor people decide whether they initiate a costly revolution. Even though democratization is costly (since it boils down to a transfer of power from the elite to the citizens), they show that it can be the elite's optimal strategy, given the threat of revolution. In these contributions however, the dynamic dimension is almost lacking, *i.e.* there is no accumulation of capital or management of a natural resource, and timing decisions are not considered.

In this paper, we develop a full-fledged dynamic game framework to provide with a benchmark theory of Arab Spring-type phenomena. In this framework, we first introduce the hierarchical dimension: Elite do act as a strategic leader. Second, the considered games explicitly distinguish between the pre-revolution regime (dictatorship of the elite) and the post-revolution regime (say, common access to resources). Finally and more importantly, the determination of (Markov perfect) equilibria includes the timing of the transition (if it occurs) from the first to the second regime. This ultimately leads to a methodological innovation as the latter requires merging dynamic games with multi-stage optimal control (see Boucekkine et al., 2013 for the use of multi-stage optimal control in a non-strategic model of technology adoption).[2]

In the first regime, the elite have full control on the resources (to be taken

[2]Two related papers are Boucekkine et al., 2011 and Long et al., 2014. But, among other notable differences, the former is only concerned with open-loop equilibria, and the latter does not have a strategic leader structure.

in a broad sense, they could either come from an – unmodeled – extraction sector or from globalization, *e.g.* from FDIs or import licenses for example) and decides about: i) how much resources to transfer to population (redistribution or concession), ii) how much to use for own consumption, iii) how much resources to employ for repression (modeled as a flow) and iv) how much to invest. The production function is AK to have a chance to extract (partial) analytical results. Of course, redistribution and/or repression are the instruments the elite may use (simultaneously or not, we examine both cases) to retain the power in exchange for own consumption and investment. From the point of view of the elite, neither redistribution nor repression makes sense in the absence of a revolution threat. Given the elite' policy, the opposition has to decide whether she rebels (or not) against the elite and **when** (if she does so). A key aspect in the opposition tradeoff is the *direct (political regime) switching costs* (DSC hereafter) faced. These costs depend either on the repression exerted by the elite and/or their allies (possibly foreign countries) or on the coordination costs inherent in any collective action. Knowing the resulting reaction function of the opposition, the elite as strategic leaders will then choose their optimal redistribution and/or repression policies.

In this framework, we make three distinct sets of contributions. On the technical ground, it's to the best of our knowledge the first analysis providing with an explicit characterization of the optimal timing of revolutions (in continuous time) in the growing literature of endogenous institutional change. This is far from a pure technicality. We do show that such a new dimension may change the typical wisdom in this literature stream (see just below for a first insight). As a second set of contributions, we deliver a comprehensive equilibrium analysis of the political regime switching game and notably emphasize the role of the direct switching cost of the citizens and of the elite's self-preservation options (redistribution and/or repression).[3] In the particular case where the elite make concession (only), which indirectly affects the citizens' uprising decision, we show that this instrument may not be sufficient to avoid a revolution. The direct switching cost is crucial in determining the equilibrium outcome. When this cost is low, a political regime switching always occurs. The key point is then to understand how the elite optimally adapt to the overthrow of their political power. Contrary to conventional wisdom, we find that the optimal strategy for the elite is to redistribute as many resources as possible to the people in the first dictatorial regime. This result clearly differs from the rapacious resource exploitation emphasized by van der Ploeg and Rohner (2012). It highlights the importance of the first striking aspect underlined above, *i.e.* the timing of events of our revolution game. Once this temporal dimension is taken into account, it comes at no surprise that making high redistribution levels is worthwhile since it allows the elite to lengthen the period of political and economic control. When the direct switching is high, the elite are able to provide sufficient transfers to the opposing citizens and choose the lowest level of redistribution compatible

[3]The situation where the elite use both concession and repression has not been explored in the literature.

with a permanent dictatorship. The same kind of results are obtained when the elite decide to keep the people under control through repressive means. Repression makes it possible to directly change the switching cost and generally implies that there is more room for self-preservation. In situations where neither repression (only) nor redistribution (only) prevent the elite from being removed, a policy-mix between these two instruments succeeds in maintaining the non-democratic regime. Based on the criterion of retaining power, there is a temptation to conclude that this policy-mix is the best strategy for the elite. However, it is not always true that the payoffs associated with an equilibrium featuring a permanent dictatorship are higher than those corresponding to a solution with a regime change. Finally, our third set of contributions concerns the understanding of the Arab Spring. We emphasize how the results of our theoretical model may help explaining why some countries have experienced a transition to (more) democratic political regimes while others are still stuck in dictatorships.

The article is organized as follows. Section 2 presents the details of our dynamic setup. Section 3 explains the problem faced by each player in the two possible regimes. It allows us to discuss the benchmark case when a revolutionary threat is absent. We formally examine the political game when the elite adopt a strategy based on concession for **given** DSC in Section 4. Section 5 then analyzes the other polar case where the elite repress the citizens in order to keep them under control when i/ repression is the unique determinant of the DSC and ii/ both instruments are used simultaneously. Section 6 discusses the implications of our analysis for the Arab Spring. Finally, Section 7 concludes.

2 The setup

We consider a modified AK growth model where the representative agent is replaced by two infinitely lived groups. We note them as the following players: the incumbent elite (E) and the opposition (P, for the poor citizens). These groups comprise a fractionalized society with a resource-dependent economy. We abstract from any assumption regarding the size of the population and each rival group. Emulating the framework of Lane and Tornell (1996), let K be the stock of resources and A the rate of return on this asset. *Resources* are defined in a broad sense and may refer to economic resources, or wealth and windfalls from natural resources.

There are two political or institutional regimes that describe the ways in which these groups interact: dictatorship (regime 1) and a freer regime with common access to the resources (regime 2), the switch from regime 1 to regime 2 being the result of a successful revolution by the citizens. The economy initially belongs to regime 1. In this regime, the elite have the full control over the economy and the economic resources and has to divide them between three different uses: self-preservation, consumption, and investment. In order to lengthen the dictatorial system, the elite may choose either to make concessions to the citizens or to rely on repression. Self-preservation through concessionary spending takes the form a transfer of a share $1 - u_E$ of the output AK to the opposition. More formally, the concession strategy of the elite is modeled as a choice $u_E \in [\underline{u}_E, \overline{u}_E]$, where u_E, the share of resources accruing to the elite, also represents the inequality in the access to economic resources. Alternatively or jointly, the elite may decide to opt for a repression strategy. The repression strategy consists of a flow of military expenditures $r_E \in [\underline{r}_E, \overline{r}_E]$, that can be interpreted as bribes paid to those who repress (or a periodic fixed cost to pay to benefit from the protection to get some military support).

Importantly enough, we model concession and repression as once-and-for-all strategies. Clearly these strategies are not standard continuous control variables because there is no instantaneous tradeoff related to their choices. They basically provide the elite with a set of instruments that can be used in order to affect the citizens' decision to revolt (think about the leader-follower structure of the problem). Now, one may allow the elite to revise these choices at some points in time, *i.e.* one may model u_E and r_E as discrete control variables. This would make sense in a changing institutional and economic environment (in regime 1), which is not the case here. That's why, for simplicity, we consider constant u_E and r_E and assume that the commitment mechanism of the elite is credible.

Let C_E be the elite's consumption at period t.[4] Then, the dynamics of the stock of economic resources are:

$$\dot{K} = u_E AK - C_E - r_E, \tag{1}$$

with $K(0) = K_0$, given.

Citizens' only source of wealth is from the elite's transfers, used for consumption: $C_P = (1 - u_E)AK$.[5] Concessions and repression affect the revolution strategy of the citizens in two different ways. From the expression of the citizens' consumption, one can easily see that concessions indirectly shape citizens' decisions by modifying the opportunity cost of the revolution. Other things equal, the higher the transfer (the lower u_E), the lower the incentive to revolt. In contrast, repression directly impinges upon the opposition. It is worth clarifying this point by describing the sequence of events leading to a regime change and its consequences. A switch from regime 1 to regime 2 results from a revolution by the opposition. A revolution (if any) succeeds with probability one.[6] A revolt is associated with a global cost $\chi > 0$. This is the continuous time

[4] When there is no risk of confusion, the time index is omitted.

[5] Leaving aside self-preservation, regime 1 is the one wherein the elite consume and invest, while the opposition only consumes. This structure shares similarities with the literature on the interaction between capitalists and workers (Lancaster, 1973, Hoel, 1978), except that in our framework citizens are completely passive and subject to the control of the elite.

[6] One may argue that uncertainty matters since it surrounds both the success of a revolution and the duration or stability of a successful revolution. To account for uncertainty, we may have assumed that the probability of success is less than one. We may also have considered that the second regime is not an absorbing state by adding the possibility to switch back from the second to the first regime. However, any tractable version of our problem with uncertainty would not bring much to the analysis.

analog of Acemoglu et al. (2012) who assume that a fixed amount of resource is destroyed when violent uprisings occur:

$$K(T^+) = K(T) - \chi, \tag{2}$$

which means that the state variable experiences a downward jump at the right of the switching time T, provided that T is finite. T represents the **switching strategy** of the citizens.

Besides the global cost for society, when conducting a revolt, the opposition incurs a direct switching cost (DSC), $\psi > 0$. This cost may capture efforts from collective action, *i.e.* the opposing citizens need to coordinate when trying to instigate conflict. Or, the magnitude of the DSC can also be interpreted as a measure of regime vulnerability. The higher is this cost, the more difficult it is for the opposition to lead a popular uprising against the ruling elite. A crucial issue concerns the **controllability** of the DSC by the elite. Indeed, one can classify factors that affect the DSC in terms of controllability. Among controllable factors are repression, the education policy or external support of the elite's regime. For example, one might think that the larger the education level of a country, the lower the coordination costs inherent in collective actions, and the larger the probability of revolts. If the education system is fully managed by the elite, this revolution channel is under control.[7] Uncontrollable factors include the globalized environment (communication networks, contagion effects etc.), demographic aspects and external intervention unsolicited by the elite. Also, any situation inducing massive grievance is likely to significantly ease coordination for a collective action against the elite. We shall mention mass youth unemployment in Arab countries as an example of such a situation in Section 6.

In our theoretical analysis, all factors except repression will be considered as exogenous. Thus, the DSC is supposed to be partially controllable through r_E and we will study the polar cases where the DSC is fully exogenous (Section 4) *vs* controllable (Section 5) via r_E. The influence of other factors will be further discussed in Section 6. Hereafter, we make an assumption that conveys the basic idea that repression makes the cost of revolting relatively higher.[8]

Assumption 1 *$\psi(r_E)$ from $[\underline{r}_E, \overline{r}_E]$ to $[\underline{\psi}, \overline{\psi}]$, with $0 < \underline{\psi} < \overline{\psi} < \infty$, $\psi'(r_E) > 0$ and $\psi''(r_E) \leq 0$.*

After a revolution, the system switches to regime 2 where common access to economic resources prevails. The dynamics of the stock K simply becomes:

$$\dot{K} = AK - C_E - C_P. \tag{3}$$

[7]Galor et al. (2009) is an excellent illustration of this mechanism in the context of the industrial revolution, in particular through the role of landowners in the late emergence of public education (in England for example).

[8]To echo footnote 7, we may have alternatively assumed that a revolution does not succeed with probability one and make the probability of success dependent on the level of repression. This would not change the general message delivered by the subsequent analysis.

Our view is that this second regime is characterized by more (political) freedom but may not be a well functioning democracy yet. Put differently, our groups engage in a political rent-seeking competition (Lane and Tornell, 1996): Both groups try to extract transfers from resource wealth in a non-cooperative manner. The elite are no longer a leader but survives to the revolution, *i.e.* continues to take decisions even after she loses the control of the economy. This assumption differs from what is usually done in the literature (Acemoglu and Robinson, 2006). We do believe however that it is relevant characteristic of Arab countries like Tunisia where the Arab Spring events have successfully overthrown the ruling dynasty or political elite but have failed to renew the economic elite, which basically remain the same.

The preferences of the two groups are the same and invariant with the regime. A logarithmic function is utilized, e.g. $U(C_i^j) = \ln(C_i^j)$ with $i = E, P$ and $j = 1, 2$. The rate of pure time preference is ρ and the time horizon is infinite.

The next sections are devoted to the analysis of the political regime change game under concessions and repression.

3 Interaction within the two-stage game

For the time being, let us take the leader-follower structure of our model as given and suppose a revolution takes place in finite time. The optimization problem can be decomposed into two subproblems, one for each regime. This is solved backward starting from the differential game that characterizes the second regime. All technical details are relegated in the appendix A.

3.1 Second regime: Post-revolution game

After the revolution, the two groups interact in a common-pool resource differential game. Indeed, regime 2 is characterized by the lack of strong institutions. It can be seen as reduced form model where each group has its own resource stock, with ability to appropriate part of the other's wealth (Lane and Tornell, 1996). Given the structure of the model described above, this game is symmetric. Using Markov-perfect equilibrium (MPE) as the solution concept and guessing linear feedback strategy for players, which implies that $C_j = a_j + b_j K$ with a_j, b_j two constants, player i solves:

$$\max_{\{C_i\}} \int_T^{\infty} \ln(C_i) e^{-\rho t} dt$$

subject to (3), given $K(T^+) = \tilde{K} - \chi$, where $\tilde{K}$ is the level of the capital stock at the instant of the revolution, and the guess formulated above. Direct manipulations of the necessary optimality conditions yield the value obtained by each player at the MPE (the superscript 2 refers to the second regime):

$$V_i^2(\tilde{K} - \chi) = \frac{1}{\rho} \left[\ln(\rho) + \ln(\tilde{K} - \chi) + \frac{A}{\rho} - 2 \right] \text{ for } i = E, P, \tag{4}$$

where ρ is the share of the capital stock "consumed" by each player and $A - 2\rho$ is the resulting growth rate of K. As far as growth prospects are concerned, a restriction on the parameters is imposed, which is necessary and sufficient to ensure that the regime following a revolution is compatible with non-negative growth:

Assumption 2 *The productivity parameter is high enough compared to the discount rate:* $A - 2\rho \geq 0$.

This assumption is the most relevant in our AK model where the analysis is conducted in terms of the balanced growth path.[9]

Using this value in (4) as the continuation payoff, the next subsection analyzes the problem faced by the elite in the autocratic regime.

3.2 First regime: Elite's control in autocracy

The analysis is conducted given self-preservation, (u_E, r_E), and revolution, T, strategies. It will be the purpose of the next section to solve the game in these specific strategies. The problem faced by the elite given the potential occurrence of a revolution at some date T can be expressed as follows:

$$\max_{C_E} \int_0^T \ln(C_E) e^{-\rho t} dt + e^{-\rho T} V_E^2(\tilde{K} - \chi)$$

subject to (1), $K(0) = K_0$, and given that $T \lesseqq \infty$. The level $K(T) = \tilde{K}$ is free if $T < \infty$ and the relevant transversality condition is also dependent on whether $T \lesseqq \infty$. In fact the crucial point is that the elite don't directly choose whether $T \lesseqq \infty$. However, in some circumstances, they will be able to influence the choice of the citizens to revolt or not.

For the time being, we can say a word about the particular case of a permanent autocratic regime. The fact that regime 1 lasts forever means that either the citizens choose not to revolt, i.e. adopt a never switching strategy $T = \infty$, or the elite face no threat of revolution. In any case, it is very simple to characterize the behavior of the elite having permanent control over both the political system and the economy. Solving the control problem above for $T = \infty$, the resulting present value, for the elite, is given by (superscript 1 is for regime 1):

$$V_E^1(u_E, r_E) = \frac{1}{\rho}\left[\ln(\rho) + \ln\left(K_0 - \frac{r_E}{u_E A}\right) + \frac{u_E A}{\rho} - 1\right]. \tag{5}$$

A pair of instruments (u_E, r_E) is said to be admissible if and only if it satisfies $K_0 > \frac{r_E}{u_E A}$. In the remainder of the paper, we'll pay attention to admissible pairs only (alternatively, we may impose $K_0 > \frac{\overline{r}_E}{\underline{u}_E A}$). The growth rate of the elite's consumption is equal to $g = u_E A - \rho$. As it is apparent from (5), modifying

[9] Allowing for negative post-revolution growth, as it is observed in Tunisia or Lybia following the Arab Spring revolutions, would only make sense in the transitional dynamics, *i.e.* in the short run, that are absent here.

the sharing rule is accompanied by a positive *growth effect*. By increasing u_E, the elite have more resources available for consumption and investment. This stimulates growth. In addition, there is also a positive scale effect. Given the level of repression, an increase in u_E also implies that the elite have more resources left for consumption. In the absence of revolution threat, the optimal choice of the elite is to set the sharing rule to the largest possible value, *i.e.* to $\overline{u}_E$. The repression decision only involves a negative scale effect. So, it is also clear that when the elite don't have any political challenger, there is no incentive to repress and the optimal repression level is $\underline{r}_E$. For simplicity, hereafter, we will take $\underline{r}_E = 0$. Finally, note that the present value earned by the citizens, in this case, is:

$$V_P^1(\overline{u}_E, 0) = \frac{1}{\rho}\left[\ln((1-\overline{u}_E)A) + \ln(K_0) + \frac{\overline{u}_E A}{\rho} - 1\right]. \tag{6}$$

While they also benefit from the growth effect associated with an increase in u_E, they incur a negative *rent capturing effect*. Increasing u_E means that the elite grab more resources at the expense of the opposition.

Of course, when a revolutionary threat is present, one logically expects that the elite will no longer be able to set their instruments to the levels $\overline{u}_E$ and $\underline{r}_E = 0$. In the subsequent section, we precisely address this issue by solving the two-stage game in self-preservation and timing strategies.

4 Equilibrium under the concession strategy

The purpose of the analysis is twofold. First, we want to discuss the conditions under which a revolution might occur or, on the contrary the elite might stay in power forever. Second in case of unavoidable uprising, we wonder what is the best strategy for the elite. Having set out the citizens' switching problem, we will pursue the equilibrium analysis in the particular case where the elite only use concessions. Equilibrium outcomes when the elite also may repress the citizens will be presented in Section 5. The proofs are displayed in the Appendix B.

4.1 Timing of the revolt

If the opposition finds it optimal to challenge political control by the elite, then she earns the following present value:

$$V_P(K_0, T) = \int_0^T \ln(C_P^1)e^{-\rho t}dt + e^{-\rho T}[V_P^2(\tilde{K} - \chi) - \psi(r_E)]. \tag{7}$$

The optimal condition for switching results from the maximization of (7) w.r.t T, which yields:

$$\ln(C_P^1(T)) - \rho V_P^2(\tilde{K} - \chi) = -\rho\psi(r_E).$$

This condition basically states that if there exists an optimal T for switching then the marginal benefit from delaying the switch (LHS) must be equal to the marginal direct switching cost at this instant (RHS). Given that $C_P^1(T) = (1-u_E)\Delta\tilde{K}$, this condition can be rewritten as:[10]

$$\ln\left(\frac{\tilde{K}}{\tilde{K}-\chi}\right) = \frac{\Delta}{\rho} - 2 + \ln\left(\frac{\rho}{[1-u_E]\Delta}\right) - \rho\psi(r_E). \tag{8}$$

Denote the RHS of (8) as $\omega(u_E, r_E)$ and define the critical threshold for the DSC as follows:

$$\tilde{\psi}(u_E) = \frac{1}{\rho}\left\{\frac{\Delta}{\rho} - 2 + \ln\left(\frac{\rho}{[1-u_E]\Delta}\right)\right\} \tag{9}$$

The ordering between the actual DSC, $\psi(r_E)$, and the threshold, $\tilde{\psi}(u_E)$, ultimately determines if it is optimal for people to instigate a revolution. Expression (9) illustrates that if redistribution doesn't affect the DSC directly, it does change the opportunity cost of switching. This is apparent when looking at the term in the log, which is the ratio between the share of K consumed by the people in the second (numerator) and first (denominator) regimes. An increase in u_E (meaning that the elite redistribute less) implies an increase in $\tilde{\psi}$, i.e. the opportunity cost of a revolution falls down.

Before going any further, it is worth mentioning that two polar cases can be considered, according to the controllability of the DSC. When the elite rely on redistribution only to keep the citizens under control, the DSC is said to be non controllable. On the contrary, the situation where the elite make use of repression (together or not with concessions) is referred to as the controllable DSC case. For the sake of exposure, in the remainder of this section we pay attention to the non controllable DSC case. In other words, we assume that the elite have to choose $u_E \in [\underline{u}_E, \overline{u}_E]$ and set $r_E = 0$, which implies that $\psi(r_E) = \underline{\psi}$. The analysis of the second case is postponed to section 5.

4.2 Citizens' regime switching strategy

In all this section the aim is to characterize the solution to the switching problem for $u_E \in [\underline{u}_E, \overline{u}_E]$ given. A first step towards this goal is to define the higher redistribution rate the elite are able to set, $\underline{u}_E$. To do so, let's go back to the situation of permanent autocracy in the absence of threat of revolution (as briefly exposed in Section 3.2). Here the basic idea we want to convey is that the elite should take advantage of a permanent autocratic regime by earning a value no lower than the one of the citizens:[11] $V_E^1(u_E, 0) \geq V_P^1(u_E, 0)$ for all $u_E \in [\underline{u}_E, \overline{u}_E]$. This leads us to impose:

[10] This is the necessary condition for the switching time. The sufficient optimality condition is satisfied if and only if $\dot{K}(T) \geq 0$. Assumption 2 and the forthcoming assumption 3 (Section 4.2) will be enough to get this point.

[11] Expression of the values are given in (5) and (6), when substituting $\overline{u}_E$ with u_E.

Assumption 3 *At the equilibrium with redistribution only, the lower bound of the domain of definition of* u_E *is defined such that* $V_P^1(\underline{u}_E) = V_E^1(\underline{u}_E)$*. This is equivalent to* $\underline{u}_E = 1 - \frac{\rho}{A}$*.*

Replacing u_E with $\underline{u}_E = 1 - \frac{\rho}{A}$ in (9) yields the expression of the threshold DSC that matters for the citizens' switching decision: $\tilde{\psi}(\underline{u}_E) = \tilde{\psi}_u = \frac{1}{\rho}\{\frac{A}{\rho} - 2\}$. Then, it can be established that:[12]

Lemma 1 *A necessary and sufficient condition for the existence of a solution to (8) is:* $\omega(u_E) > 0$*.*

1. *If* $\underline{\psi} < \tilde{\psi}_u$ ***(low DSC)*** *then,* $\omega(u_E) > 0$ *for all* $u_E \in [\underline{u}_E, \overline{u}_E]$*: There always exists a unique* $\tilde{K}(u_E)$ *for switching with,*

$$\tilde{K}(u_E) = \frac{\chi e^{\omega(u_E)}}{e^{\omega(u_E)} - 1}. \tag{10}$$

2. *Else,* $\underline{\psi} \geq \tilde{\psi}_u$ ***(high DSC)****, there exists a critical threshold* $\tilde{u}_E$ *such that* $\omega(u_E) > 0 \Leftrightarrow u_E > \tilde{u}_E$ *with,*

$$\tilde{u}_E = 1 - \frac{\rho}{A} e^{\rho(\tilde{\psi}_u - \underline{\psi})}, \tag{11}$$

this threshold is admissible i.e. $\tilde{u}_E > \underline{u}_E$*.*

Irrespective of the size of the global switching cost, χ, the occurrence of a political regime change is more likely when the DSC is low enough. For a high enough DSC, the decision to undertake a revolution will be bound to the sharing of resource fixed by the elite. So, the actual DSC and its position compared to the threshold $\tilde{\psi}_u$ is of crucial importance to understand the options available to the elite. Clearly, when the DSC is low, the elite can't avoid the revolution through concessions and the question is what is their best strategy given that the regime change is inevitable. By contrast, when the cost of switching regime is high enough, the elite seem to have the choice between making sizeable concessions in order to stay in power forever or grabbing a lot of economic resources in the first regime till a switch to regime 2 occurs.

To complete the characterization of the solution to the switching problem, we next prove that

Lemma 2 *The optimal switching time is implicitly given by*

$$K_0 e^{(u_E A - \rho)T} = \chi \left(\frac{1}{e^{\omega(u_E)} - 1} + e^{-\rho T} \right). \tag{12}$$

This equation has a unique solution, denoted by $T(u_E)$*, if and only if*

$$\tilde{K}(u_E) > K_0 \Leftrightarrow \frac{\chi e^{\omega(u_E)}}{e^{\omega(u_E)} - 1} > K_0. \tag{13}$$

where $\tilde{K}(u_E)$ *is defined in (10).*

[12] With a slight abuse of notation, we no longer make the dependance on $r_E = 0$ explicit.

Lemma 2 states that the switching level must be higher than the initial stock. This implies that the opposition allows the resource to accumulate first. This ensures that the remaining "cake" after the switch is high enough to compensate for the loss incurred during the regime change. This also guarantees that what is competed for in the common access regime is abundant.

Let's interpret the pair $(T(u_E), \tilde{K}(u_E))$ as the reaction function of the citizens. From (10) and (12), it appears that:

$$\begin{cases} \frac{\partial \tilde{K}}{\partial u_E} < 0; \ \frac{\partial \tilde{K}}{\partial \chi} > 0; \ \frac{\partial \tilde{K}}{\partial \psi} > 0; \\ \frac{\partial T}{\partial u_E} < 0; \ \frac{\partial T}{\partial K_0} < 0; \ \frac{\partial T}{\partial \chi} > 0; \ \frac{\partial T}{\partial \underline{\psi}} > 0. \end{cases}$$

As expected the desired switching level, for the citizens, is decreasing in u_E: The higher u_E, the lower the opportunity cost of switching. A high u_E implies that the first regime is painful for the citizens. In contrast, the higher the GSC or the DSC, the higher the desired switching level of resource. This is due to the cake size effect. Regarding the switching date, the revolution will occur more rapidly if the elite choose an unequal sharing rule during the first regime. The switching date decreases with the initial endowment too. The more abundant is the initial stock of natural resource in the economy, the more rapidly will conflict occur. With a higher initial stock, the resource level that triggers the revolt is achieved earlier. This observation is consistent with resource curse literature related to civil wars (see Hodler, 2006; Ploeg and Rohner, 2012 for detailed examples). Finally, the impact of a change in the switching costs on T is positive. To make the revolt valuable, the citizens must accept a longer phase of resource accumulation during the first regime in order to reach a larger $\tilde{K}(u_E)$ that will compensate for the cost.

Let's now turn to the analysis of the elite's problem of choosing a redistribution level given the reaction function defined above.

4.3 Elite's concession strategy

Assuming that a regime change will occur in finite time, we examine the choice of the sharing rule by the elite. The elite have to pick up a u_E from the right domain. According to Lemma 1, this domain varies depending on whether the DSC is low or high: The relevant interval is $[\underline{u}_E, \overline{u}_E]$ (resp. $(\tilde{u}_E, \overline{u}_E]$) when the DSC is low (resp. high). Whatever the case, this choice is made taking as given the reaction function. The value obtained by the elite in the equilibrium with an interior regime switching is:

$$V_E(u_E) = \int_0^{T(u_E)} \ln[C_E^1(u_E)]e^{-\rho t}dt + e^{-\rho T(u_E)} V_E^2[\tilde{K}(u_E) - \chi]. \qquad (14)$$

The derivative of V_E w.r.t. u_E is:

$$\frac{\partial V_E(u_E)}{\partial u_E} = \begin{cases} \int_0^{T(u_E)} \frac{\frac{\partial C_E^1(t;u_E)}{\partial u_E}}{C_E^1(t;u_E)} e^{-\rho t}dt \\ +T'(u_E)e^{-\rho T(u_E)}\{\ln[C_E^1(T(u_E))] - \rho V_E^2[\tilde{K}(u_E) - \chi]\} \\ +e^{-\rho T(u_E)} \frac{\partial V_E^2[\tilde{K}(u_E)-\chi]}{\partial K} \tilde{K}'(u_E) \end{cases} \qquad (15)$$

The first term represents the cumulative impact of a change in the redistribution rate on consumption. The second positive term states a comparison between the cost and benefit at the switching time $T(u_E)$. The term between the brace brackets is the marginal gain of delaying the switch. It is weighted by the derivate of the switching date w.r.t u_E, which is negative. It compares the discounted value of what the elite gain in the second regime, and her loss in utility (from consumption) during the switch. The third term exhibits the remaining cake size effect. This is always negative as $\tilde{K}'(u_E) < 0$. Simply put, this term indicates the loss due to resource destruction at the start of the second regime.[13] The exercise of signing the whole derivative leads to:

Lemma 3 *Let* $\sigma(T) = \frac{u_E T'(u_E)}{T(u_E)}$ *be the elasticity of the switching date with respect to the sharing rule* u_E. *If* $|\sigma(T)| \leq 1$ *for all admissible* u_E, *then* $\frac{\partial V_E(u_E)}{\partial u_E} < 0$.

It turns out that what is central to the elite's decision is the impact of a change in u_E on their consumption during the first regime. A change in u_E is associated with two different – growth and scale – effects. The first is a positive *growth effect.*[14] A larger u_E implies greater investment. This eventually translates into a higher consumption growth rate. The second scale effect is the combination of two opposing forces: When u_E increases, the elite are able to consume more simply because less resources are redistributed to the people. However, increasing u_E always decreases the time to go before the revolution $T(u_E)$, which increases the regime vulnerability and tends to impair consumption. If $|\sigma(T)| \leq 1$, the former effect dominates the latter and consumption, at any time in the first regime, is increasing in u_E. This condition states that the switching time chosen by the citizens is not too sensitive to the sharing rule. This is a relevant characteristic of resource-dependent economies with mediocre levels of social capital, e.g. awareness towards collective action.

We have now the key elements to summarize the properties of the equilibrium under redistribution only:

Proposition 1 *Under the conditions of Lemmas 1-3,*

- *When the DSC is low, there exists a unique equilibrium where the elite choose* $u_E^* = \underline{u}_E$ *and the revolution occurs in finite time* $T(\underline{u}_E)$.
- *When it is high, the unique equilibrium is the one where the elite stay in power forever* ($T = \infty$) *and set the redistribution to the critical rate* $\tilde{u}_E$.

[13] An alternative reading of the expression in (15) is that the impact of a change in u_E can be divided between three different effects, depending on the period during which the change is felt: The marginal impact of choosing u_E before the regime change (first term), the marginal impact at this instant of the regime change (second term) and the marginal impact of varying u_E after the political switch (last term).

[14] Under Assumptions 3 and 2, elite's consumption growth rate, $g = u_E A - \rho$, is positive in the autocratic regime.

Not surprisingly the magnitude of the DSC is crucial to determine the nature of the equilibrium. When the DSC is low, given that a revolt will occur in finite time, one may expect that the elite's optimal strategy is to set the sharing rule to the highest possible value $\overline{u}_E$ as this would allow them take advantage of their period of control. This is the kind of message delivered by the related literature (see for instance Ploeg and Rohner, 2012). It turns out that the optimal choice of the elite is the exact opposite, *i.e.* they choose to proceed to the largest concessions possible. This quite surprising result emphasizes the role of the **timing**, which is typically ignored by the literature. Once we account for the timing issue, it comes at no surprise that setting $\underline{u}_E$ is good to the elite. It allows her to delay the regime switching and to lengthen the duration in office.

With a high DSC, the elite have the capacity to influence the opposition's switching decision. The ex-ante trade-off is as follows: Either they make sufficient concessions by sharing the resource in such a way that citizens are not too harmed an don't instigate conflict. Or, they decide on a very unfair redistribution rule, which may trigger the revolution in finite time. Ex-post, it can be shown that the optimal decision is to set the redistribution rate to the lowest redistribution compatible with permanent autocracy. Indeed, when the DSC is high enough, avoiding the revolution doesn't cost so much to the elite. In order to stay in power, the elite have just to concede some resources (the lower the threshold, the lower the concession) to the citizens.

5 Beyond redistribution: The repressive option

From now on, the DSC is supposed to be controllable thanks to repression. We start with the other limit case where the elite use repression only and have to choose a $r_E \in [0, \overline{r}_E]$ given that $u_E = \overline{u}_E$ (no concessions). Next, we examine the most general (realistic) version of the model where the elite choose a mix of the two instruments. Given that the methodology is largely inspired from Section 4, we move to the results as quickly as possible.

5.1 Equilibrium under the repression strategy

In this section, the aim is to present and discuss the counterpart of Lemma 1 & 3 and proposition 1 in the case where the elite adopt the repressive option only (all the proofs are in the Appendix C). Suppose that u_E is fixed at the largest possible value, $\overline{u}_E$. Then from the citizens' switching problem and (9), we shall work with a new threshold value for the DSC: $\tilde{\psi}_r = \tilde{\psi}(\overline{u}_E) = \frac{1}{\rho}\left(\ln(\rho) - \ln[(1-\overline{u}_E)A] + \frac{A}{\rho} - 2\right)$.[15] We obtain

Lemma 4 *A necessary and sufficient condition for the existence of a solution to the switching problem of the citizens is:* $\omega(r_E) = \omega(r_E, \overline{u}_E) > 0$.

[15]Naturally we have $\tilde{\psi}_r > \tilde{\psi}_u$: Other things equal, when the elite don't provide any transfers to the citizens, they are willing to revolt for a relatively lower switching cost. The main difference with the first case is that now the elite can directly modify this switching cost.

1. *If $\underline{\psi} \geq \tilde{\psi}_r$ then dictatorship is necessarily permanent.*

2. *If $\overline{\psi} < \tilde{\psi}_r$ **(low returns to repression, RR)** then the revolution is unavoidable and occurs for a switching level $\tilde{K}(r_E) = \frac{\chi e^{\omega(r_E)}}{e^{\omega(r_E)}-1}$.*

3. *If $\overline{\psi} \geq \tilde{\psi}_r > \underline{\psi}$ **(high RR)** then there exists a critical repression level $\tilde{r}_E = \psi^{-1}(\tilde{\psi}_r)$ such that: Any $r_E < \tilde{r}_E$ will trigger a revolution in finite time whereas choosing $r_E \geq \tilde{r}_E$ is a means to avoid the revolution.*

The solution in the first case is trivial. From the discussion conducted in Section 3.2, in the absence of revolution threat, the optimal solution is $r_E^* = 0$. By analogy with Section 4, two interesting cases remain. On the one hand, when the RR are low, the elite are not able to keep the citizens under control and the political regime change is inevitable. On the other, the elite may avoid the revolution provided that the repression technology is efficient enough and by investing at least $\tilde{r}_E$ in military expenditures. Put differently, a permanent policy that consists in devoting a constant level of resources $\tilde{r}_E$ to the military budget protects the elite from an uprising of the citizens.

Working with r_E given, we next deal with the switching time $T(r_E)$, which is uniquely and implicitly defined by (see the Appendix C):

$$\left(K_0 - \frac{r_E}{\overline{u}_E A}\right) e^{(\overline{u}_E A - \rho)T} = \tilde{K}(r_E) - \chi + \left(\chi - \frac{r_E}{\overline{u}_E A}\right) e^{-\rho T},$$

with $\tilde{K}(r_E)$ defined in Lemma 4. The comparative statics are:

$$\frac{\partial T}{\partial r_E} > 0, \frac{\partial \tilde{K}}{\partial r_E} > 0; \frac{\partial T}{\partial \overline{u}_E} < 0, \frac{\partial \tilde{K}}{\partial \overline{u}_E} < 0; \frac{\partial T}{\partial \chi} > 0, \frac{\partial \tilde{K}}{\partial \chi} > 0 \text{ and } \frac{\partial T}{\partial K_0} < 0.$$

As far as the impact of repression on this solution is concerned, intuitively we obtain that increasing repression expenditures is a means to delay the revolution, which will occur for a larger stock of resource. Indeed, the larger r_E, the higher the cost of switching and the larger the compensation must be for the citizens. This compensation takes the form of the achievement of the second regime, whose profitability is determined by the difference $\tilde{K}(r_E) - \chi$ (the remaining cake size). Regarding the other parameters, the larger $\overline{u}_E$, *i.e.* the more unequal the country is in the absence of concessions by the elite, the lower the opportunity cost of switching and the sooner the political regime change. In addition, with a large $\overline{u}_E$, the citizens accept to start the second regime with a lower amount of economic resources. Finally, a larger initial stock of resources tends to expedite the decision to revolt.

Taking the reaction function $(T(r_E), \tilde{K}(r_E))$ as given, the next step goes through a measure of the impact of a change in repression on the elite's value in the first regime.

Lemma 5 *Let $\sigma(\tilde{K}) = \frac{r_E \tilde{K}'(r_E)}{\tilde{K}(r_E)}$ be the elasticity of the desired switching level w.r.t the repression level. If $\sigma(\tilde{K}) < -\frac{r_E \psi''(r_E)}{\psi'(r_E)}$ for all $r_E \in [0, \overline{r}_E]$ and $\frac{\partial C_E^1(t;r_E)}{\partial r_E}|_{r_E = \overline{r}_E} > 0$ then, $\frac{\partial V_E(r_E)}{\partial r_E} > 0$ for all admissible r_E.*

The following proposition finally summarizes our results in the two possible scenarios, low *vs.* high RR:

Proposition 2 *Under the conditions of Lemmas 4 and 5:*

- *In the low RR scenario, there is a unique equilibrium where the revolution occurs in finite time and the elite set* $r_E^* = \overline{r}_E$*.*
- *In the high RR scenario, the unique equilibrium features permanent dictatorship and* $r_E^* = \tilde{r}_E$*.*

Under the repression strategy, the trick consists once again in determining the sign of the derivative of the value function of the elite with respect to the r_E. This mainly boils down to determining how the consumption of the elite, in the first regime, responds to a change in the repression level. It appears that an increase in r_E has two opposing (scale) effects on the elite's consumption. The effects are more easily seen when rewriting consumption as:

$$C_E^1(t; r_E) = \rho \left[\tilde{K}_0 - \frac{r_E}{\overline{u}_E A} - \left(\chi - \frac{r_E}{\overline{u}_E A}\right) e^{-\overline{u}_E A T(r_E)}\right] e^{(\overline{u}_E A - \rho)t}$$

Both the initial condition and the global switching cost are reduced by an amount $\frac{r_E}{\overline{u}_E A}$. The resulting differences define the *true* values, or the values that matter to the elite when deciding how much to repress.[16] Then, the analysis runs as follows. Other things equal, more repression means that revolution will occur later and consequently the associated loss is felt less acutely, which stimulates consumption. However, at the same time, an increase in r_E implies that less resources are left for consumption and investment at every date in regime 1. This in turn tends to lower the elite's consumption. Now, it appears that if the elasticity of the desired switching level, $\tilde{K}(r_E)$, with respect to repression is low enough and lower than the sensitivity of the marginal switching with respect to this strategy, then the overall effect is positive: Regime 1 consumption is higher the larger r_E. Under this condition we finally obtain that the value function of the elite is strictly increasing in r_E when the political regime switch is inevitable. Therefore, in the low RR scenario, the elite will choose the highest level of repression in order to lengthen the first dictatorial regime. By contrast, when the RR are high, permanent dictatorship is the only possible equilibrium. In this case, and given that their present value is now decreasing with the level of repression, the elite set the repression level to the lowest possible value, $\tilde{r}_E$, compatible with the absence of regime switch.

5.2 Policy mix

The situation where the elite use both repression and redistribution deserves a lot of attention because this is actually what is observed in the Arab world.

[16]The term in square brackets is a rescaling of the true initial condition obtained by subtracting the true global cost incurred at the date of the revolution, $T(r_E)$, discounted from the initial period at the autonomous growth rate of the stock of economic resources.

From a technical point of view, it goes without saying that it is also the much more challenging case to study. In fact, to the best of our knowledge, there is no paper in the literature on political transitions that deals with the case where the elite have to choose a mix between redistribution and repression. In order to have a chance to get (partial) analytical results, and for a reason that will be clear in a moment, we restrict the analysis to the situation where the revolution is unavoidable when the elite use a single instrument. According to Lemmas 1 & 4, this is guaranteed for instance when the ordering between the thresholds and the boundaries of the domain of definition of the actual DSC is $\underline{\psi} < \tilde{\psi}_u < \overline{\psi} < \tilde{\psi}_r$.[17] First we state another technical Lemma which basically extends the conditions used in previous Lemmas to the situation where both u_E and r_E can vary in their respective domain of definition.

Lemma 6 *Let ζ be the set of combinations (r_E, u_E) that make the the autocratic regime permanent: $\zeta = \{(r_E, u_E) \in [\underline{u}_E, \hat{u}_E] \times [\hat{r}_E, \overline{r}_E] / r_E \geq \kappa(u_E)\}$, where $\kappa(u_E)$ is the relation obtained when solving $\omega(u_E, r_E) = 0$, with $(\hat{u}_E, \hat{r}_E)$ defined such that $\hat{u}_E = 1 - (1 - \overline{u}_E)e^{\rho(\tilde{\psi}_r - \overline{\psi})}$ and $\psi(\hat{r}_E) = \tilde{\psi}_u$. Let further assume that $\sigma(\kappa) = \frac{u_E \kappa'(u_E)}{\kappa(u_E)} < 1$, $\sigma(\tilde{K})|_{u_E = \underline{u}_E} < -\frac{r_E \psi''(r_E)}{\psi'(r_E)}$, $|\sigma(T)|_{r_E = \overline{r}_E} \leq 1$ and $T_{r_E u_E} > 0$ for all admissible (u_E, r_E).*

Then the following result can be shown (see the Appendix D):

Proposition 3 *Under the conditions of Lemma 6, there exists a unique equilibrium where the elite adopt the policy-mix $(\hat{u}_E, \overline{r}_E)$, which allows them to keep the citizens under control forever.*

The conditions of Lemma 6 may seem very difficult to interpret. As mentioned above, most of these conditions are strengthened versions of the ones used in Lemma 3 and 5 notably. They ensure that the fundamentals are quite stable and allow us to perform some comparisons between the elite's different options. In addition, we may abstract from most of these conditions except the first one. This would be enough to conduct the discussion to follow.[18]

Let us now go back to an important question raised by the paper: What is the best strategy for the elite? The answer to this question is not trivial in general and depends on the particular criterion one has in mind to evaluate the best outcome. At first glance, one may reply that the best strategy is the one

[17]The following reasoning can easily be extended to the other possible cases.

[18]Under this condition, the value of the elite is monotonically increasing in u_E in a permanent autocratic regime with a policy mix. As already observed in Section 3.2, a change in u_E is accompanied by positive growth and scale effects. There is now an additional negative scale that goes through the change in repression induced by the change in redistribution. In fact, the elite choose a combination (u_E, r_E) on the frontier of the set ζ, i.e. the elite choose for any u_E the minimum r_E that allows them to maintain the autocratic system: $r_E = \kappa(u_E)$. Thus any increase in u_E must be compensated by an increase in r_E in order to remain on the frontier. In some sense, the condition $\sigma(\kappa) < 1$ tells us that the elite should be relatively (more) efficient in repressing the people. The last (new) condition, that involves the cross derivative $T_{r_E u_E}$, basically means that when the elite make less concessions (u_E increases), the switching time chosen by the citizens becomes more sensitive to the level of repression.

that allows the elite to stay in power forever, if possible. Then, from what has been shown above in the particular case where $\underline{\psi} < \tilde{\psi}_u < \overline{\psi} < \tilde{\psi}_r$, the policy mix is the best option for the elite in the sense that it allows them to stay in power when a single strategy fails to do so. And the temptation is great to conclude that the policy-mix is intrinsically the best strategy. In concluding this discussion, we want however to emphasize a crucial point. If the success in keeping the political control is a first acceptable and relevant criterion to identify the best strategy, it may not always be so clear and forceful. Indeed, it may well be that the elite, by using an instrument only and accepting the regime change, are better off than by implementing a policy mix of the type discussed above. Put differently, the present value associated with the former strategy may be higher than the one yielded by the latter. Therefore, according to the criterion of (maximizing) the present value, accepting the revolution and adapting to this event may constitute the optimal strategy of the elite. Unfortunately, any attempt to go deeper into this discussion is vain. The comparison between the values provided by the different strategies appears to be a difficult exercise and doesn't allow us to identify the set of conditions under which this provocative result holds. As an illustration of the various conflicting (growth and scale) effects at stake, let's have a quick look at the comparison between the equilibrium with concession only – $(u_E, r_E, \mathcal{T}) = (\underline{u}_E, 0, \mathcal{T}(\underline{u}_E))$ – and the policy mix – $(u_E, r_E, \mathcal{T}) = (\hat{u}_E, \overline{r}_E, \infty)$. In this particular case, it can easily be shown that growth prospects are higher at the policy mix solution. But, how the scale effect exactly plays is unclear. If the elite redistribute much more resources at the solution with concession, they don't spend a penny to repress the citizens whereas, with the policy mix, they devote a lot of resources to the military budget. In general, it is possible neither to know which solution the scale effect benefit to, nor to conclude which effect prevails (when the scale effect pushes in the opposite direction as the growth effect).

6 Implications for the Arab Spring

We now show how our theory can be useful to understand some key aspects of a salient phenomenon like the Arab Spring. The theory essentially puts forward the so-called direct switching costs (DSC) faced by the opposition, and the repression/redistribution strategy followed by the elite. Applying it to any context therefore requires a certain knowledge of both aspects. Of course, it makes little sense to calibrate our highly stylized model, especially in the Arab context,[19] but it is worthwhile to check some key predictions of the model on a few countries using some available indicators of the DSC and repression/redistribution in these countries. A further complication is that the DSC, as outlined in Section

[19]Arab official statistics, particularly those related to redistribution and inequality, are almost systematically manipulated by the ruling governments. For example, as pointed out by Ali (2003), official statistics show a very clear decline in inequality - as measured by the Gini coefficient - in Arab countries throughout the 90s, in total contradiction with direct observations.

2, entail quite different components related either to the vulnerability of the elite or the coordination costs on the side of the opposition, some controllable by the elite and others no. To provide with a quick assessment of the theory, we shall measure repression by military expenditures (as a percentage of GDP) and redistribution by public expenditures in welfare services like health and education (in percentage of GDP), while the DSC will be tentatively captured by military expenditures again (for vulnerability) and education attainments and (skilled) unemployment rate (for coordination costs). It goes without saying that these indicators are far from exhaustive[20] but they do allow to see how the theory works. The inclusion of the unemployment rate, in particular among the skilled and young individuals, on the side of the coordination costs is worthwhile (and even necessary) to get through the Arab Spring. Indeed, beside the anti-democratic nature of ruling governments, Arab countries have in common high unemployment rates, in particular among young and graduate people, probably the highest in the world (see Masood, 2012). Given the age pyramid in these countries, this is a key issue from the political equilibrium point of view in these countries. So far, Arab governments have largely resorted to the public sector and some special programs to foster youth employment (see Boucekkine and Bouklia-Hassane, 2011, for the Algerian case). This is captured through the redistribution variable in our model. On the other side, the skilled unemployment problem has a potentially huge impact on the coordination costs, and thus on the DSC. First, in many Arab countries (see details below), the ed ucational attainments have been increasing over time, which lowers the DSC. Second, the associated skill mismatch problem in the labor markets and induced huge unemployment rates among the skilled is arguably a more decisive factor decreasing the DSC and pushing people to revolt.[21] Next, we will display some available statistics of the selected indicators. The specific cases of Tunisia, Bahrain and Algeria will be discussed in the light of our theory right after.

6.1 Some useful statistics

Concerning **repression** as captured by military expenditures as a percentage of GDP, there is a quite large variability among Arab countries. Before the Arab Spring, this ratio ranged from 1.3% in Tunisia to 8.6% in Saudi Arabia in 2010 according to the World Bank (the figures for Algeria and Bahrain being respectively 3.5% and 3%). Interestingly enough, this ratio has increased markedly after 2011 in these countries.[22]

Concerning **redistribution** as measured by welfare and education public expenditures, the picture is more involved. Arab public expenditures on health (as a percentage of GDP) are not strikingly high or low among developing countries; in particular, they are far from the Western world figures, even for the very rich

[20]For example, food subsidies is an interesting indicator of redistribution but we couldn't include it for data availability and reliability.

[21]Needless to say, for revolutions to get launched, a *triggering spark* is typically needed. Our model is about the deterministic forces leading to political transitions.

[22]See `http://data.worldbank.org/indicator/MS.MIL.XPND.GD.ZS/`

Gulf countries (in 2010, only 2.6% in Saudi Arabia or 1.6% is Qatar against 8.4% in the US or 3.4% in Togo to cite a developing country).[23] Jordan is by far the Arab country which spends the most on public health (5.7%) followed by Tunisia (3.8%), Algeria (3.3%) and Bahrain (3%).

Education is another key factor which is relevant to assess redistribution and does matter in the DSC as well (see below). From the former point of view, Tunisia is the Arab country which has invested the most in education: about 6.4% of the GDP went to public education in 2007, slightly above the French figure for example. Algeria and the the other oil exporters in the Gulf rank clearly behind: 4.4% for Algeria and 3.4% for Bahrain in 2007. Overall, Arab countries devoted around 4% of their GDP to education in that year, above the average of developing countries (see Breisinger et al., 2012). This effort, which started mostly after the independence of the Arab countries,[24] has significantly increased the number of years of schooling in these countries (5.3 years in average in 1999, ahead of South Asia for example and only one year behind East Asia and Latin America, see Masood, 2012).

Let's have a look now at the selected indicators for the coordination costs side of **the direct switching costs (DSC)**. One is educational attainments, which is not always perfectly correlated with public education spending. One relevant indicator in this respect is the literacy rate in the 15-24 years old population, given the age pyramid in the Arab countries (and the role of the youth in the street revolutions). For the three countries considered here below (Algeria, Bahrain and Tunisia), the figure is close to 100%, the lowest figures of the Arab world (close to 80%) being registered for countries like Egypt, Yemen or Morroco.[25]

If the educational attainment for the three countries as captured by the literacy rate of the youth is excellent, another quality indicator is much worse: as outlined by Masood (2012), education plays significantly against employment in all Arab countries (starting with Tunisia), which is clearly indicative of a major skill mismatch, and the unemployment rate of the youth in the MENA region is the highest in the world (10 percentage points above the world average in 2010). The extent of the skilled youth unemployment problem in this region is indeed huge ranging from 25% to 45% for those with tertiary education, a striking economic inefficiency and a major source of grievance in these countries.

6.2 Three country cases

To see how our theory may be used to understand the Arab Spring, notably the variety of outcomes observed, consider the cases of Tunisia, Bahrain and

[23] See `http://data.worldbank.org/indicator/SH.XPD.PUBL.ZS/`

[24] At the time, the education effort was seen as a way to complete independence, and by no way a self-preservation strategy by the elite.

[25] See `http:\data.worldbank.org/indicator/SE.ADT.1524.LT.ZS/`. These figures should not hide a significant illiteracy problem for older ages and a gender issue in several Arab countries as documented in Breisinger et al. (2012).

Algeria (which is to a certain extent close to other Gulf monarchies like Saudi Arabia) are illustrative enough. A key point in our application is the distinction between the actual DSC, $\psi(r_E, .)$, and the threshold levels, $\tilde{\psi}$, highlighted in our theoretical analysis. Recall that while redistribution does not affect the DSC directly, they do change the opportunity cost to revolt via the threshold $\tilde{\psi}$.

Tunisia- The Tunisian case is special for essentially two main reasons: it's the country with the lowest military expenditures (as a percentage of GDP) and at the same time it's the country with the best educational effort and attainment. Both elements already imply a lower value for the actual DSC, $\psi(r_E, .)$, with respect to the other Arab countries: from the double point of view of vulnerability and coordination costs, the actual Tunisian DSC look definitely more favorable to regime changes. Moreover, though mass (skilled) youth education is shared by all Arab countries, it is certainly especially acute in a country like Tunisia, involving a further larger impact on coordination costs and actual DSC.[26] Finally the margins of redistribution are much tighter in a country like Tunisia than in oil exporting countries: there is no way for this country to manipulate the threshold $\tilde{\psi}$ and bring it to low enough values compared to actual DSC.

Bahrain- Since his arrival in office in 1999, Sheikh Hamad has started a sequence of democratization and political liberalization steps leading many international organizations to believe that the country has definitely improved regarding protection of human rights. This relatively low level of repression shows up in the military expenditures statistics shown above: among the rich oil exporting countries like Saudi Arabia or Algeria ranked clearly behind in 2010. The distinctive feature of Bahrain is, however, what the religious majority of the country (the Shias) felt as an unfair redistribution of resources. In 2006, despite a per head income of close to \$20,000, a third of the native Bahraini workforce earns less than \$600 a month.[27]. In this context, our theory would predict a revolution and a regime change at finite time (relatively low actual DSC and relatively large threshold, $\tilde{\psi}$, due to unfair redistribution). Indeed, the Shias revolt took place in 2011 but the massive external intervention of Saudi Arabia to back the Khalifa dynasty changed the outcome. A large enough exogenous increase in the DSC through external intervention as in Bahrain would change the equilibrium to permanent dictatorship.[28]

Algeria- Algeria is a case where despite some early demonstrations, no regime change took place. It's interesting to compare it with the Tunisian neighbor. It's no question that the success of the Jasmine revolution did weaken the Algerian power.[29] However, up to now, no regime change has been observed in Algeria. Two main reasons could be invoked according to our theory. One is

[26]See for example `http://www.wider.unu.edu/publications/newsletter/articles-2012/en_GB/06-07-2012-Drine/`

[27]See `http://www.economist.com/node/8326066`

[28]In a straightforward extension of our model with random revolution success such as the probability of success is a decreasing function of total repression forces, we would get that the Shias would have not revolted if they would have anticipated the Saudi intervention.

[29]In this sense, contagion effects can be understood as driving down the actual DSC.

straightforward and has to do with actual DSC: the Algerian regime is much less vulnerable than the Tunisian in military and police terms, involving larger actual DSC. The second is definitely more interesting and has to do with the threshold, $\tilde{\psi}$: in contrast to Tunisia, a rich oil exporting country like Algeria can go for a massive redistribution of the rents (significantly decreasing $\tilde{\psi}$), therefore discouraging revolts. The same argument can be put forward to explain institutional stability of the Gulf monarchies during the 2011 events: Just like Algeria, these countries have spent a substantial part of their petrodollars to buy time.[30]

7 Conclusion

In this paper, we have provided with a benchmark dynamic game theory designed to capture the essential features of the Arab Spring. Beside several innovative technicalities, we have shown how incorporating explicit revolution timing decisions may considerably enrich the discussion, and in some cases, challenge the conventional wisdom in the related literature. It goes without saying, as one can infer from the previous section, that as any benchmark, some further refinements are needed to increase the relevance of the theory and its ability to explain the mechanisms behind the Arab Spring sequence. Part of the work to be done consists in endogenizing some key factors determining the DSC. In particular public education spending decisions by the elite and its impact on citizens' propensity to revolt are important to incorporate for a closer understanding of the timing and success of the revolts in Arab countries. Also, the analysis may be extended by allowing the elite to revise her repression and/or redistribution strategy in face of the threat of revolution and changing environments (either external geopolitical shocks like a military intervention in favor of one of the 2 groups, or economic shocks affecting the profitability of the resource economy). This would require a substantial technical upgrading. In this respect, the methodology developed by Long et al. (2014) may help.

Appendix

A Technical details: Section 3

• General solution in regime 2: Solving for the symmetric MPE by making use of the necessary optimality conditions (NOC), one obtains:

$$\begin{cases} K^2(t) = (\tilde{K} - \chi)e^{(A-2\delta)(t-T)}, \\ C_i^2(t) = \delta(\tilde{K} - \chi)e^{(A-2\delta)(t-T)}. \end{cases}$$

Computing the integral of discounted consumption flows then yields the value reporter in (4).

[30]This said, in none of these cases, the status-quo seems sustainable, see for example the excellent recent book by Christopher Davidson (2013) on the sustainability of Gulf monarchies.

• From direct manipulations of the NOC corresponding to regime 1, one has:

$$\begin{cases} K^1(t) = \phi e^{u_E A t} + (K_0 - \phi) e^{(u_E A - \delta) t} \\ C_E^1(t) = \delta (K_0 - \phi) e^{(u_E A - \delta) t} \\ C_P^1(t) = (1 - u_E) A [\phi e^{u_E A t} + (K_0 - \phi) e^{(u_E A - \delta) t}] \end{cases} \tag{16}$$

with ϕ an unknown. When there is no threat of revolution ($T = \infty$), using the transversality condition, one finds:

$$\begin{cases} K(t) = (K_0 - \frac{r_E}{u_E A}) e^{(u_E A - \delta) t} + \frac{r_E}{u_E A} \\ C_E(t) = \delta \left(K_0 - \frac{r_E}{u_E A} \right) e^{(u_E A - \delta) t} \\ C_P(t) = (1 - u_E) A [(K_0 - \frac{r_E}{u_E A}) e^{(u_E A - \delta) t} + \frac{r_E}{u_E A}], \end{cases} \tag{17}$$

and the resulting present value, for the elite, is given by (5).

B Proof of Lemmas 2, 3 & Proposition 1

• Lemma 2: First, the left-continuity of the capital stock at the switching date T, the general expression of $K^1(t)$ for all $t \leq T$ being given in (16), implies

$$K^1(T) = \tilde{K}(u_E) \Leftrightarrow \phi e^{u_E A T} + (K_0 - \phi) e^{(u_E A - \rho) T} = \tilde{K}(u_E). \tag{18}$$

Second, the transversality condition associated with $T < \infty$ for the elite's problem in regime 1, is:

$$e^{-\rho T} \lambda_E^1(T) = e^{-\rho T} \frac{\partial V_E^2(.)}{\partial K} \Leftrightarrow (K_0 - \phi) e^{(u_E A - \rho) T} = \tilde{K}(u_E) - \chi. \tag{19}$$

Substituting the value of ϕ given by (18) in (19), one obtains

$$K_0 e^{(u_E A - \rho) T} = \chi \left(\frac{1}{e^{\omega(u_E)} - 1} + e^{-\rho T} \right),$$

which must be studied to show the existence of a strictly positive and finite switching date, u_E being given. Noticing that under Assumptions 2 & 3, we have $u_E A - \rho > 0$ for all u_E, then we obtain that there exists a unique $0 < T(u_E) < \infty$ iff $\tilde{K}(u_E) > K_0$. Given that $\tilde{K}'(u_E) < 0$, $\tilde{K}(\bar{u}_E) > K_0$ is sufficient to ensure existence for all $u_E \in [\underline{u}_E, \bar{u}_E]$.

• Lemma 3: When $T(u_E) \in (0, \infty)$ exists, using the definition of $\tilde{K}(u_E)$, the expression of $V_E^2(.)$ and the solution valid is regime 1, which is

$$\begin{cases} K^1(t; u_E) = \chi e^{u_E A (t - T(u_E))} \left(1 + \frac{e^{-\delta(t - T(u_E))}}{e^{\omega(u_E)} - 1} \right), \\ C_E^1(t; u_E) = \frac{\delta \chi}{e^{\omega(u_E)} - 1} e^{(u_E A - \delta)(t - T(u_E))}, \\ C_P^1(t; u_E) = (1 - u_E) A K^1(t; u_E), \end{cases}$$

the derivative in (15) can be rewritten as

$$\frac{\partial V_E(u_E)}{\partial u_E}=\frac{1}{\rho}\left\{\begin{array}{l}\frac{1}{1-u_E}\left(\frac{(1-u_E)A}{\rho}-\frac{e^{\omega(u_E)}}{e^{\omega(u_E)}-1}\right)-AT(u_E)[1+\sigma(u_E)]+\rho T'(u_E)\\ -e^{-\rho T(u_E)}\left\{T'(u_E)\left[(1-u_E)A-\rho\right]+\frac{A}{\rho}\right\}.\end{array}\right.$$

Under Assumption 3, it's easy to check that if $u_E \geq \underline{u}_E = 1-\frac{\rho}{A}$ and $|\sigma(u_E)| \leq 1$ then $\frac{\partial V_E(u_E)}{\partial u_E} < 0$, with $\sigma(T) = \frac{u_E T'(u_E)}{T(u_E)}$, for all $u_E \in [\underline{u}_E, \bar{u}_E]$. Hence, the optimal choice is $u_E = \underline{u}_E$.

Discussion following Lemma 3: Elite's consumption can be rewritten as:[31]

$$C_E^1(t;u_E) = \rho\hat{K}_0(u_E)e^{(u_E A-\rho)t} \text{ with } \hat{K}_0(u_E) = K_0 - \chi e^{-u_E AT(u_E)}.$$

Its derivative w.r.t u_E is

$$\frac{\partial C_E^1(t;u_E)}{\partial u_E} = \rho\left[\hat{K}_0'(u_E) + At\hat{K}_0(u_E)\right]e^{(u_E A-\rho)t}, \tag{20}$$

with, $\hat{K}_0'(u_E) = \chi AT(u_E)e^{-u_E AT(u_E)}[1+\sigma(T)]$. The second term in (20) is a positive growth effect whereas the first term is as scale effect, which is positive only if $|\sigma(u_E)| \leq 1$.

• Proposition 1: The material in Lemma 1-3 together with the observation that the elite's value is increasing in u_E in a permanent autocratic regime (see (5)) are sufficient to state Proposition 1. As stated in Lemma 1, when the DSC is high (and such that $\omega(\underline{u}_E) < 0$), the elite has two options available. Either, they choose a sharing rule $u_E \in [\underline{u}_E, \tilde{u}_E]$, which implies that $\omega(u_E) \leq 0$: The unique equilibrium must be of the never switching type with $u_E^* = \tilde{u}_E$. Or, the elite can fix the sharing rule to a level $u_E \in (\tilde{u}_E, \overline{u}_E]$. In this case, the equilibrium candidate may exhibit a regime change. Given that the value of the elite is decreasing in u_E (Lemma 3), the optimal decision would be to set u_E to the lowest possible level. However, this critical redistribution rate, $\tilde{u}_E$, is not achievable because the interval corresponding to a solution with a regime change is open on the left. Since there is no solution to the elite's problem, there is no equilibrium featuring a transition between the two political regimes.

C Proof of Lemmas 4, 5 & Proposition 2

Upper bound of the domain of definition of r_E: Again, our argument is based on the principle that the elite's value should be at least as high as the citizens' one in a permanent autocracy. However, the citizens' value cannot be computed so easily (as we did in Section 3.2, see (6)) with positive repression. So, we resort to the condition that the elite's consumption is always higher than the citizens' consumption under permanent dictatorship. From (17), a sufficient

[31] Comparing this expression with the one in (17), with $r_E = 0$, it turns out that the growth rate of consumption is similar. The striking difference is the existence of a scale effect. Elite consumption is lower at the equilibrium with a regime change, u_E being given.

condition for this to hold is $C_E(0) > C_P(0) \Leftrightarrow r_E \leq \frac{\overline{u}_E AK_0(\rho-(1-\overline{u}_E)A)}{\rho}$. This in turn ensures that $V_E(r_E) > V_P(r_E)$. All this information is summarized in Assumption 4:

Assumption 4 *Under the repression strategy, the upper bound of the domain is defined by:* $\overline{r}_E = \frac{\overline{u}_E AK_0(\rho-(1-\overline{u}_E)A)}{\rho}$, *which implies that* $V_E(r_E) > V_P(r_E)$ *for all* $r_E \leq \overline{r}_E$.

• Citizens' switching problem (Lemma 4): From (7) with $u_E = \overline{u}_E$ (Section 4.1), the necessary optimal condition for switching is:

$$\ln\left(\frac{\tilde{K}}{\tilde{K}-\chi}\right) = \frac{A}{\rho} - 2 + \ln\left(\frac{\rho}{[1-\overline{u}_E]A}\right) - \rho\psi(r_E) \equiv \omega(r_E).$$

There exists a unique $\tilde{K}(r_E) = \frac{\chi e^{\omega(r_E)}}{e^{\omega(r_E)}-1}$ that solves this equation iff $\omega(r_E) > 0$. In addition, we can define a second critical threshold for the DSC:

$$\tilde{\psi}_r = \frac{1}{\rho}\left(\ln(\rho) - \ln[(1-\overline{u}_E)A] + \frac{A}{\rho} - 2\right).$$

This is sufficient to state Lemma 4.

• Switching time: From the transversality condition of regime 1 and the left continuity of the resource stock, T is implicitly given by:

$$\left(K_0 - \frac{r_E}{\overline{u}_E A}\right) e^{(\overline{u}_E A-\rho)T} = \tilde{K}(r_E) - \chi + \left(\chi - \frac{r_E}{\overline{u}_E A}\right) e^{-\rho T} \tag{21}$$

The condition $\tilde{K}(r_E) > K_0$ is sufficient for the existence of a unique solution $T(r_E)$ to this equation (for a given r_E). The solution corresponding to regime 1 then reads as follows:

$$\begin{cases} K^1(t;r_E) = \left(\chi - \frac{r_E}{\overline{u}_E A}\right) e^{\overline{u}_E A(t-T(r_E))} + (\tilde{K}(r_E)-\chi)e^{(\overline{u}_E A-\rho)(t-T(r_E))} + \frac{r_E}{\overline{u}_E A} \\ C_E^1(t;r_E) = \rho(\tilde{K}(r_E)-\chi)e^{(\overline{u}_E A-\rho)(t-T(r_E))} \\ C_P^1(t;r_E) = (1-\overline{u}_E)AK^1(t;r_E). \end{cases} \tag{22}$$

• Proof of Lemma 5: Let's assess the impact of a change in r_E on consumption (other comparative statics can easily be derived from the definition of $\tilde{K}(r_E)$ and (21)):

$$\frac{\partial C_E^1(t;r_E)}{\partial r_E} = C_E^1(t;r_E)\left(\frac{\tilde{K}'(r_E)}{\tilde{K}(r_E)-\chi} - (\overline{u}_E A-\rho)T'(r_E)\right),$$

with, from (21),

$$T'(r_E) = \frac{\tilde{K}'(r_E) + \frac{1}{\overline{u}_E A}\left(e^{(\overline{u}_E A-\rho)T(r_E)} - e^{-\rho T(r_E)}\right)}{(\overline{u}_E A-\rho)(\tilde{K}(r_E)-\chi) + \overline{u}_E A\left(\chi - \frac{r_E}{\overline{u}_E A}\right)e^{-\rho T(r_E)}}.$$

After straightforward manipulations, $\frac{\partial C_E^1(t;r_E)}{\partial r_E} > 0$ is equivalent to:

$$\frac{\overline{u}_E A}{\overline{u}_E A - \rho} \frac{\tilde{K}'(r_E)}{\tilde{K}(r_E) - \chi} \left(\chi - \frac{r_E}{\overline{u}_E A} \right) > \frac{1}{\overline{u}_E A} \left(e^{\overline{u}_E A T(r_E)} - 1 \right). \tag{23}$$

Define the RHS of (23) as $G(r_E)$. This function is increasing in r_E. If $-\frac{r_E \psi''(r_E)}{\psi'(r_E)} > \sigma(\tilde{K}) = \frac{r_E \tilde{K}'(r_E)}{\tilde{K}(r_E)} (> 0)$ for all $r_E \in [0, \overline{r}_E]$ then, the LHS of the inequality above, denoted by $F(r_E)$, is decreasing in r_E. Now, imposing $F(\overline{r}_E) > G(\overline{r}_E)$ is sufficient to conclude that $C_E^1(t; r_E)$ is increasing in r_E for all $t \geq 0$.

Optimal choice of the repression level $r_E \in [0, \overline{r}_E]$: The present value of the elite when the revolution occurs in finite time is:

$$V_E(r_E) = \int_0^{T(r_E)} \ln(C_E^1(t; r_E)) e^{-\rho t} dt + e^{-\rho T(r_E)} V_E^2(\tilde{K}(r_E) - \chi),$$

Taking the derivative w.r.t r_E, one obtains:

$$\frac{\partial V_E(r_E)}{\partial r_E} = \begin{cases} \int_0^{T(r_E)} \frac{\frac{\partial C_E^1(t;r_E)}{\partial r_E}}{C_E^1(t;r_E)} e^{-\rho t} dt \\ + \left(\ln(C_E^1(T(r_E); r_E) - \rho V_E^2(\tilde{K}(r_E) - \chi) \right) T'(r_E) e^{-\rho T(r_E)} \\ + \frac{\partial V_E^2}{\partial K} \tilde{K}'(r_E) e^{-\rho T(r_E)}. \end{cases}$$

Using the expression of $C_E^1(.)$ (see (22)), this derivative can be rewritten as:

$$\frac{\partial V_E(r_E)}{\partial r_E} = \frac{1}{\rho} \left(\frac{\tilde{K}'(r_E)}{\tilde{K}(r_E) - \chi} - \left(\overline{u}_E A - \rho + (A(1 - \overline{u}_E) - \rho) e^{-\rho T(r_E)} \right) T'(r_E) \right),$$

which is positive under the same two conditions that allow us to conclude that consumption is increasing in r_E.

• Proof of Proposition 2: A synthesis of the results set in Lemma 4 & 5 is sufficient to establish Proposition 2.

D Proof of Lemma 6 & Proposition 3

• From now on, we allow r_E and u_E to vary in their respective domains of definition, *i.e.* $[0, \overline{r}_E]$ and $[\underline{u}_E, \overline{u}_E]$ (Assumption 1-4 hold). Admissible pairs (u_E, r_E) must satisfy $r_E < u_E A K_0$. Adopting the same methodology as before, we can show that the switching problem of the citizens defines a unique $\tilde{K}(r_E, u_E)$ if and only if $\omega(r_E, u_E) > 0$ with:

$$\omega(r_E, u_E) = \frac{A}{\rho} - 2 + \ln \left(\frac{\rho}{[1 - u_E] A} \right) - \rho \psi(r_E).$$

Solving the equation $\omega(r_E, u_E) = 0$ boils down to solving $\psi(r_E) = \varphi(u_E)$. The function $\varphi(u_E) = \tilde{\psi}_r - \frac{1}{\rho}[\ln(1 - u_E) - \ln(1 - \overline{u}_E)] > 0$ for all u_E and satisfies

$\varphi'(u_E) > 0$, $\varphi(\underline{u}_E) = \tilde{\psi}_u$ and $\varphi(\overline{u}_E) = \tilde{\psi}_r$. Given the particular ordering considered, it's clear that $\psi(r_E) = \varphi(u_E)$ has a solution because we have $\underline{\psi} < \varphi(\underline{u}_E) < \overline{\psi} < \varphi(\overline{u}_E)$. Thus we can define $\hat{u}_E \in (\underline{u}_E, \overline{u}_E)$ such that $\varphi(\hat{u}_E) = \overline{\psi}$ and $\hat{r}_E \in (0, \overline{r}_E)$ such that $\psi(\hat{r}_E) = \tilde{\psi}_u$. Given that ψ is invertible, for any $u_E \in [\underline{u}_E, \hat{u}_E]$, the equation $\psi(r_E) = \varphi(u_E)$ can rewritten as a relationship $r_E = \kappa(u_E)$ with $\kappa(u_E) = \psi^{-1\prime}(\varphi(u_E))$, $\kappa'(u_E) > 0$ (and $\kappa''(u_E) > 0$), $\kappa(\underline{u}_E) = \hat{r}_E$ and $\kappa(\hat{u}_E) = \overline{r}_E$. By definition, any pair (r_E, u_E) belonging to this locus is such that $\omega(r_E, u_E) = 0$. Then, let ζ be the set such that for any pair taken in this set dictatorship is permanent because $\omega(r_E, u_E) \leq 0$:

$$\zeta = \left\{ (r_E, u_E) \in [\underline{u}_E, \hat{u}_E] \times [\hat{r}_E, \overline{r}_E] / r_E \geq \kappa(u_E) \right\},$$

the complementary set being denoted by $\overline{\zeta}$. For any pair in $\overline{\zeta}$, there might exist an equilibrium with a revolution in finite time.

• The second step consists in determining the optimal combination $(r_E, u_E) \in \zeta$ under permanent dictatorship: The elite's value is given by (5), which is decreasing in r_E and increasing in u_E. Thus, for any, u_E, the elite choose the lowest level of repression compatible with dictatorship. This means that the optimal combination necessarily lies in the frontier given by $r_E = \kappa(u_E)$. Then, the value can be rewritten as:

$$V_E(u_E, \kappa(u_E)) = \frac{1}{\rho}\left[\ln(\rho) + \ln\left(K_0 - \frac{\kappa(u_E)}{u_E A}\right) + \frac{u_E A}{\rho} - 1\right].$$

Taking the derivative w.r.t u_E, one obtains:

$$\frac{\partial V_E}{\partial u_E} = \frac{\kappa(u_E)}{u_E^2 A (K_0 - \frac{\kappa(u_E)}{u_E A})}(1 - \sigma(\kappa)) + \frac{A}{\rho^2} \text{ with } \sigma(\kappa) = \frac{u_E \kappa'(u_E)}{\kappa(u_E)},$$

and, for admissible $(u_E, \kappa(u_E))$, the condition $\sigma(\kappa) < 1$ is sufficient to have $\frac{\partial V_E}{\partial u_E} > 0$. This implies that the optimal combination is $(\hat{u}_E, \overline{r}_E)$.

• The third step shows that permanent dictatorship is indeed the unique equilibrium when the ordering is $\underline{\psi} < \tilde{\psi}_u < \overline{\psi} < \tilde{\psi}_r$. Our aim is to generalize the analyses of Sections 4 & 5.1 and to prove that under the conditions used in previous Lemmas (in particular 3 and 5), very few is needed to reach the conclusion.

Pick up a policy mix from $\overline{\zeta}$. This implies that the switching problem has a solution $(\tilde{K}(r_E, u_E), T(r_E, u_E))$, which is similar to the one characterized in Appendix C - see (21) and (22) - when one replaces $\overline{u}_E$ with any u_E provided that $(r_E, u_E) \in \overline{\zeta}$.[32] Let's see how the first period elite's consumption, $C_E^1(t; r_E, u_E)$ responds to changes in r_E and u_E given that:

$$C_E^1(t; r_E, u_E) = \rho(\tilde{K}(r_E, u_E) - \chi) e^{(u_E A - \rho)(t - T(r_E, u_E))},$$

with $\tilde{K}(r_E) = \frac{\chi e^{\omega(r_E, u_E)}}{e^{\omega(r_E, u_E)} - 1}$.

[32]Of course, the argument u_E now becomes apparent in the functions $\tilde{K}(.)$ and $T(.)$.

Partial derivative w.r.t r_E for any $u_E \in [\underline{u}_E, \hat{u}_E]$:[33]

$$\frac{\partial C_E^1(t; r_E, u_E)}{\partial r_E} = C_E^1(t; r_E, u_E)\left(\frac{\tilde{K}_{r_E}}{\tilde{K}(r_E, u_E) - \chi} - (u_E A - \rho)T_{r_E}\right).$$

We know that under the conditions of Lemma 5, this derivative is positive at $u_E = \overline{u}_E$. Given that $\frac{\tilde{K}_{r_E}}{\tilde{K}(r_E,u_E)-\chi} = \frac{\rho\psi'(r_E)\tilde{K}(r_E,u_E)}{\chi}$ is decreasing in u_E (because $\tilde{K}_{u_E} < 0$), we have $\frac{\tilde{K}_{r_E}}{\tilde{K}(r_E,u_E)-\chi}|_{u_E \leq \hat{u}_E} > \frac{\tilde{K}_{r_E}}{\tilde{K}(r_E,u_E)-\chi}|_{u_E = \overline{u}_E}$. Note also that $u_E A - \rho < \overline{u}_E A - \rho$ for all $u_E \in [\underline{u}_E, \hat{u}_E]$. Then the condition $T_{r_E u_E} > 0$ for all $(r_E, u_E) \in \overline{\zeta}$ is sufficient to conclude that $\frac{\partial C_E^1(t; r_E, u_E)}{\partial r_E} > 0$ provided that the conditions of Lemma 5, adapted to the case under scrutiny, hold. The first condition is $\sigma(\tilde{K}) < -\frac{r_E\psi''(r_E)}{\psi'(r_E)}$ where the RHS is independent of u_E and one can easily check that the LHS is decreasing in u_E. Thus, this condition must be strengthened to require that $\sigma(\tilde{K})|_{u_E = \underline{u}_E} < -\frac{r_E\psi''(r_E)}{\psi'(r_E)}$. The second technical condition is satisfied as well.

Moreover, by analogy with what has been done before, consumption can be rewritten as: $C_E^1(t; u_E, r_E) = \rho\hat{K}_0(u_E, r_E)e^{(u_E A - \rho)t}$ with

$$\hat{K}_0(u_E, r_E) = K_0 - \frac{r_E}{A u_E} - (\chi - \frac{r_E}{A u_E})e^{-u_E A T(u_E, r_E)}.$$

The partial derivative w.r.t u_E for any $r_E \in [\hat{r}_E, \overline{r}_E]$:

$$\frac{\partial C_E^1(t; u_E)}{\partial u_E} = \rho\left[\hat{K}_{0,u_E} + A t \hat{K}_0(u_E)\right]e^{(u_E A - \rho)t},$$

with,

$$\hat{K}_{0,u_E} = \frac{r_E}{A u_E^2}\left(1 - e^{-u_E A T(r_E, u_E)}\right) + \left(\chi - \frac{r_E}{u_E A}\right) A T(r_E, u_E)(1 + \sigma(T)),$$

where $\sigma(T) = \frac{u_E T_{u_E}}{T(r_E, u_E)}$ is increasing in r_E. Then, extending the condition of Lemma 3 to $|\sigma(T)|_{r_E = \overline{r}_E} \leq 1$ is sufficient to conclude that $\frac{\partial C_E^1(t; u_E)}{\partial u_E} > 0$.

Finally, under the conditions stated above, it's straightforward to show that the present value of the elite at a solution featuring a regime change is decreasing in u_E and increasing in r_E. Thus, there is no equilibrium with a political regime switching because one cannot find a pair (r_E, u_E) that maximizes the elite value. For instance, the elite would like to choose the highest concession level $\underline{u}_E$ but then it doesn't exist a repression level such that the pair of instruments belongs to $\overline{\zeta}$. In sum, when the ordering is $\underline{\psi} < \tilde{\psi}_u < \overline{\psi} < \tilde{\psi}_r$, there exists a unique equilibrium with permanent dictatorship.

[33] We will denote the derivates of $\tilde{K}$ and T w.r.t r_E as $\tilde{K}_{r_E}$ and T_{r_E}.

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