Vol. 15, No. 1 (2020) | doi:10.15355/epsj.15.1.58

Strategic choices by the incumbent and challenger during revolution and civil war

Kjell Hausken and Mthuli Ncube

Kjell Hausken is Professor of Economics, Faculty of Social Sciences, University of Stavanger, Stavanger, Norway. He can be reached at kjell.hausken@uis.no. Mthuli Ncube is Professor of Economics and, Managing Director, Head of Research, Quantum Global Research Lab Ltd, Bahnhofstrasse 2, in Zug, Switzerland (on leave). Professor Ncube can be reached at m.ncube@quantumglobalgroup.com.

Abstract

A game is developed where an incumbent chooses between benefits provision to the population, which decreases the probability of revolution endogenously, and fighting with a challenger. Thereafter the challenger chooses a degree of fighting, which determines rent sharing. A successful revolution enables the challenger to replace the incumbent. An unsuccessful revolution preserves the status quo, or causes standoff or coalition. The four possibilities of incumbent replacement, status quo, standoff, or coalition combine with the incumbent either repressing (providing benefits below a threshold) or accommodating (providing benefits above a threshold) the population, for a total of eight outcomes. Such a rich conceptualization of eight outcomes of civil war is missing in the literature. We show how an advantaged versus disadvantaged incumbent deters or fights with a challenger, and provides versus does not provide benefits to the population. The eight outcomes are mapped to 87 revolutions 1961-2011.

We consider a stationary situation during revolution and civil war where the incumbent and challenger face each other under the threat that the revolution may be successful (in which case the challenger replaces the incumbent). The incumbent chooses strategically in period 1 the amount of benefits provision to the population, which affects whether the revolution is successful, and chooses whether to fight the challenger fiercely or less fiercely; benefits provision below a low threshold means repression (sticks). Benefits provision above a low threshold means accommodation (carrots). Reacting to the incumbent, the challenger determines strategically in period 2 how to fight the incumbent, which affects both parties' expected utilities, rent distribution, and which of eight possible outcomes arises.[1]

The probability of successful revolution depends on the country's characteristics and is endogenized in the sense that it is maximal when the incumbent represses, and zero at the limit when the incumbent accommodates (by providing infinitely many benefits to the population). If the revolution is successful, the challenger becomes the new incumbent. Conversely, if the revolution is unsuccessful, three outcomes are logically possible: the incumbent remains in power, a standoff ensues, or a coalition is formed. This causes eight possible outcomes (see the boxes in Figure 1). The model presented in this article captures the tradeoffs and the range of possible outcomes more clearly than what is available in the literature.

The model is especially applicable for cases where the incumbent's incentives to accommodate the population hinge on the incumbent's interaction with the challenger, and the challenger has limited or no ability to organize the population in a revolutionary uprising. This is most common during civil war and revolution. Incumbents have learned to somehow coexist with the population, and often do not last otherwise. In contrast, challengers

ISSN 1749-852X

may come and go, and may have more fluid preferences, with limited capacity or resources to influence the population.

We abstract away from the coordination problem in order to focus on the strategic interaction between the incumbent and the challenger, affected by the population which may or may not revolt. Strategic choices of the incumbent and challenger may either generate, or not generate, a revolution. Others focus on revolutions as threats to explain concessions from the elite to the working class. Some of these forces are present in a reduced way in this article. For example, the coordination problem is captured, in our model, by the endogenized probability of a successful revolution. Other forces are modeled more explicitly. For example, the incumbent's behavior depends on the threat of revolution. Plausible functional forms are assumed to enable empirical testing.

Modeling revolutions means addressing the chicken and egg problem of who moves first. In this article we choose a novel approach which we believe has not been chosen before, namely, that a revolution is sparked by how an incumbent and thereafter a challenger fight each other.[2]

The model uses eight categories of outcome based on an analysis of eighty seven revolutions from 1961 to 2011. While this article concentrates upon the model itself, the analysis leading to these categorizations has been published in a companion article in this journal.[3]

Literature review

A contest between an incumbent and a challenger has also been analyzed by Besley and Persson (2011), assuming simultaneous choices of the sizes of the armies by the two players, which determines who becomes the new incumbent. After that determination, the new incumbent determines public goods provision and revenue transfers. They predict a hierarchy from peace via repression to civil war and show that violence is associated with shocks that can affect wages and aid. Esteban, Morelli, and Rohner (2015) consider the role of incumbents in sequential conflict decisions. They find that mass killings increase with natural resources, polarization, institutional constraints on rent sharing, and low productivity.[4]

This article considers a stationary situation during revolution and civil war where the incumbent and challenger face each other under the threat that the revolution may be successful. It introduces a model intended to capture the tradeoffs and the range of possible outcomes better than what is currently available in the literature. A novel approach is chosen where a revolution is sparked by how an incumbent and thereafter a challenger fight each other.

Besley and Persson (2010) focus on conflict within the context of state capacity and development. Foran (1993) suggests modeling the economic, political and cultural processes in revolutions. Indeed, the literature on revolutions is multifarious, more of the background and the extant literature are detailed in the companion article.[3]

The following sections, present the model, solve the model, conduct a comparative static analysis, analyze the conditions for deterrence and benefits, map the model outcomes to the observed revolutions, and conclude.

The model

The model's full list of notational symbols is given in Appendix A. We start with three definitions.

Definition 1. The incumbent is the governing player with executive power, i.e., the dictator in autocratic regimes, often with absolute sovereignty.

Definition 2. The challenger is either the elites within the regime opposing the incumbent, or some other kind of opposition. The challenger may be less organized than the incumbent (and may consist of factions with irreconcilable differences), but is at least partly united in a desire to replace the incumbent. The challenger's interaction with the population is not so strong that it can organize the population's uprising in the revolution.

Definition 3: The term fighting is interpreted broadly to capture all forms of struggle occurring during civil war and revolution such as, conflict, battle, and violence, and is additionally interpreted as a metaphor. For this latter interpretation Hirshleifer (1995, p. 28) considers fighting as a subcategory of competition. He writes, "falling also into the category of interference struggles are political

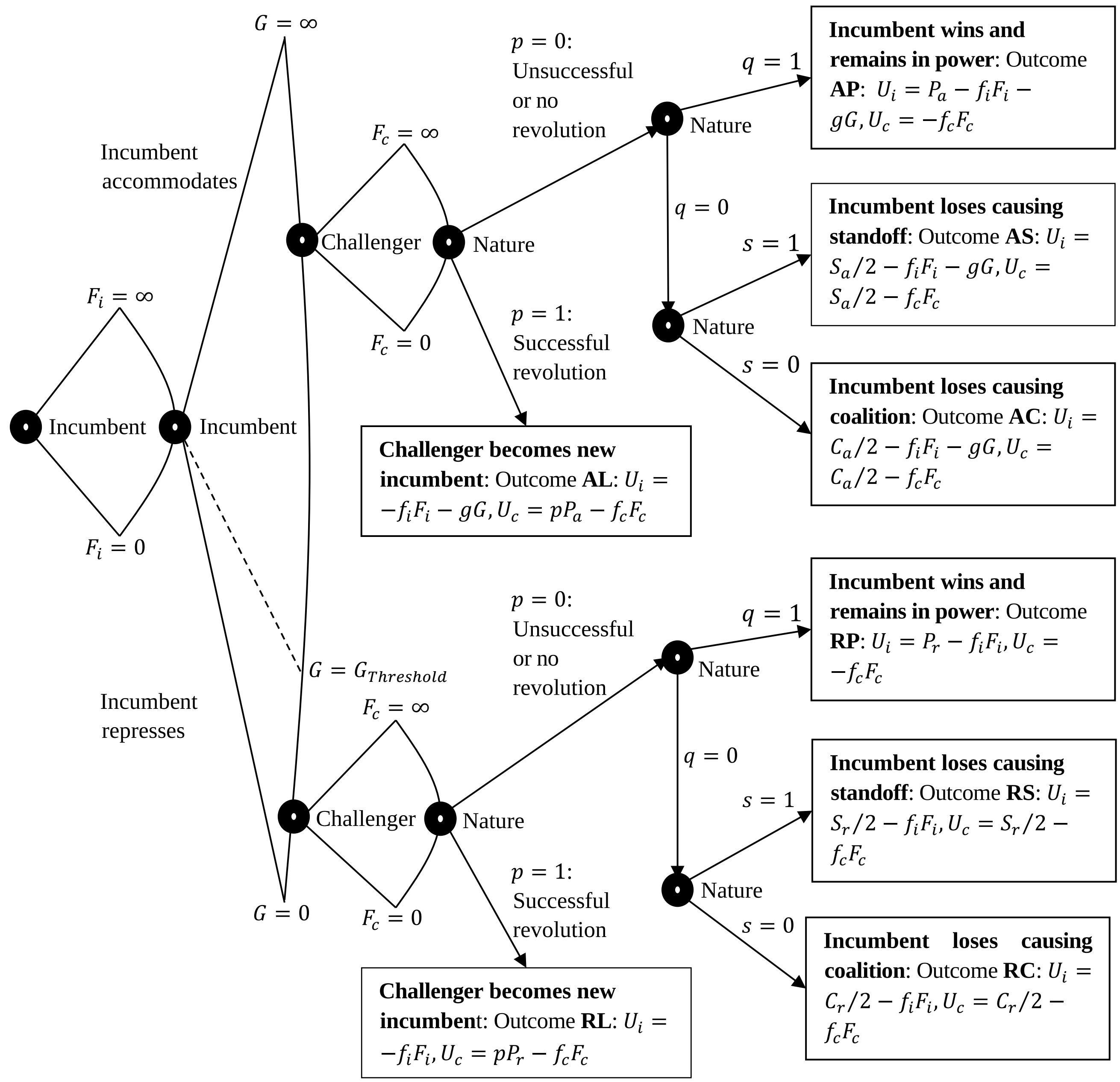

Figure 1: Revolution outcomes as a tree structure for the strategic form three-period game. Each of the eight outcomes is followed by the incumbent's and challenger's expected utilities U_i and U_c.
Note: For an explanation of the notation, see Appendix A.

campaigns, rent-seeking maneuvers for licenses and monopoly privileges , commercial efforts to raise rivals' costs, strikes and lockouts, and litigation—all being conflictual activities that need not involve actual violence" (references suppressed).

Consider the extensive form three-period game in Figure 1 starting at the left node. The two strategic risk neutral players, the incumbent and challenger, choose

ISSN 1749-852X

their strategies in period 1 and 2, respectively. Nature chooses its strategy in period 3, i.e., chooses probabilities which depend on the exogenous parameters and the strategies chosen by the incumbent and challenger. The game has complete and perfect information. All parameters are common knowledge. In period 1 the incumbent chooses two strategies simultaneously, reflecting a stationary situation with no need, opportunity, or relevance of choosing one strategy before the other. The first is the incumbent's fighting with the challenger. Fighting is a continuous choice variable which may vary between the two extremes $F_i=0$ and $F_i=\infty$ shown with two lines protruding from the incumbent's first decision node. The arc between the end points of the two lines illustrates that the incumbents can choose infinitely many fighting levels between 0 and ∞. The incumbent's second strategy is benefits provision to the population, which is also a continuous strategy between $G=0$ and $G=\infty$, illustrated with an arc. For illustrative purposes, fighting is depicted before benefits provision in Figure 1, but no other player chooses a strategy in period 1, so the sequence is irrelevant.

We define benefits as those beyond ordinary GDP-enhancing benefits that the incumbent provides to the population with no objective of decreasing the probability of successful revolution. Examples of such benefits are public goods, socio-economic and human rights, employment. All governments provide minimal benefits to the population. Benefits provision below a low threshold, $G_{Threshold}$, determined empirically through expert judgment to be extremely insufficient, means repression (sticks). Benefits provision above that threshold means accommodation (carrots). Thus repression and accommodation are labels assigned to the amount of benefits provision. Repression is the limiting case obtained by decreasing benefits provision below the low threshold. The very idea of accommodation is that the challenger experiences the incumbent as providing something of value for the population, here interpreted with the free choice benefit provision variable G (providing a suitable distinction between repression and accommodation). Since the incumbent has to fight with the challenger under all circumstances, and accommodation is directed toward the population, no contradiction exists between fighting and accommodation. Whether the revolution is successful depends on the incumbent's benefits provision, which gets determined in period 1.[5]

The challenger observes the incumbent's choices of the fighting level F_i and amount of benefits provision G. After these observations, in period 2, the challenger chooses fighting F_c, as one continuous choice variable. The two extremes $F_c=0$ and $F_c=\infty$ are shown with two lines protruding from the challenger's decision node, and an arc between the end points. We consider a stationary situation, but the challenger is interpreted as reacting to the incumbent. Analogously in the defense and attack literature, the defender usually moves first, and the attacker moves second (Hausken and Levitin, 2012).

In period 3, Nature chooses among four strategies simultaneously, making any one of eight outcomes possible since the incumbent may accommodate or repress in period 1. If the revolution is successful, with probability p=1, the incumbent loses and the challenger becomes the new incumbent. This follows from historical evidence. Successful revolutions always demand the incumbent's removal. Unsuccessful revolutions include the possibility that the population does not revolt. If the revolution is unsuccessful, with probability p=0, three outcomes are possible: The incumbent wins against the challenger with probability q=1 and remains in power, or the incumbent loses against the challenger with probability q=0. For this latter event, a standoff ensues with probability s=1 where the incumbent and challenger disagree as to who should be in power, or a coalition is formed with probability s=0 where the incumbent and challenger share power.

A standoff is a costly stalemate or draw where the incumbent and challenger do not agree who is and should be in power, despite the incumbent officially losing. The rest of the country and world, including the military, do not know who is in power and may support one player or the other. The government apparatus is severely limited in its functioning since its various parts may support one player or the other, or may cease functioning since it is uncertain whose direction to follow. In contrast, a

ISSN 1749-852X

Vol. 15, No. 1 (2020) | doi:10.15355/epsj.15.1.58

coalition is less costly and means that the incumbent and challenger, despite their differences, agree to cooperate and compromise in a coalition. They may, for example, appoint ministers representing both the incumbent and challenger to the various government departments. They may choose some policies favored by the incumbent and other policies favored by the challenger. For a coalition everyone knows who is in power, i.e., both the incumbent and challenger through cooperation. Modeling endogenously the process by which standoff or coalition follows is extremely challenging and possibly impossible. Such a process may depend on sociological, psychological, religious, cultural, and economic factors. The personalities of the incumbent and challenger leaders, national and international political pressures, lobbying by interest groups and the business community, may also affect the outcome. Thus we assume an exogenous probability s for standoff, and 1–s for coalition. Hence the game has the eight outcomes shown in Figure 1. The eight logically possible outcomes also reflect empirically common outcomes.

We consider a rent-seeking model where the incumbent and challenger fight, exerting efforts F_i and F_c at unit costs f_i and f_c, for a rent which is allocated to the player who is incumbent after period 2. If the incumbent chooses repression, we assume that fighting is all it does. If the incumbent chooses accommodation, we assume that the incumbent, additionally, incurs a cost of providing benefits G at unit cost g to the population.

Revolution is the main fear for an incumbent involved in repression. Without benefits G, assume that the incumbent estimates the probability of successful revolution as $1/\alpha$, where α is a country-specific parameter accounting for a ruler's attempt to suppress revolts applying methods such as spies, bribes, punishments for treason, and so on (Tullock 1971, 1974). A large α decreases the probability of successful revolution. One predominant example of a country-specific characteristic increasing the probability of successful revolution, through decreasing α, is the degree of inequality exemplified by high unemployment (especially among the youth population), the population's level of education, the size of the middle class, ethnic fractionalization, the lack of institutional development, former colonialist currents in the political environment, and the country's endowments (for example, in terms of natural resource) which can make an autocrat more recalcitrant. Such factors may determine to what degree a revolution is likely and whether it is successful.

The population observes the incumbent's period 1 choice of benefits provision. The population's choice of whether to start a revolution depends probabilistically on the incumbent's period 1 choice. Often a realistic scenario, this also prevents the complexity of modeling the choices of individual citizens, and it enables focusing on the incumbent and challenger as the influential players. Thus we suppress the collective action problem analyzed extensively elsewhere for revolutions, and assume that the population makes no strategic choice.

In addition to the parameter α, assume that the incumbent can decrease the probability of successful revolution by providing benefits G. We model the probability of successful revolution, p, causing the incumbent to be replaced with the challenger, as

$$(1) \quad p = p(G) = \frac{1}{\alpha + \gamma G} ,$$

where α and γ are parameters specific for a given country. The parameter γ weighs benefits against country-specific characteristics increasing the probability of successful revolution α. The parameter γ captures the degree of accommodation expressed with benefits $G>0$ as opposed to repression where benefits $G=0$. If $\gamma>0$, providing incentives for the incumbent to choose $G>0$, then the incumbent accommodates, providing benefits to the population. Conversely, if $\gamma=0$, then the incumbent represses causing no benefits for the population, $G=0$. Comparing $\gamma > 0$ with $\gamma=0$ means comparing the case when there are increasing strategic effects (as γ increases) through benefits provision in the likelihood of revolution, against the case when there is no strategic effect. The usefulness of this distinction reflects the usefulness of distinguishing between endogenous and exogenous probability p of successful revolution. Endogeneity $\gamma>0$ offers a role for the incumbent to incentivize the population to refrain from

ISSN 1749-852X

revolting through benefits provision G, whereas exogeneity $\gamma=0$ offers no such role.

When both, attempts to suppress revolution and benefits are low ($\alpha=1$ and $G=0$), a successful revolution is guaranteed. Most countries have $\alpha>1$, and as G increases, the probability of successful revolution decreases. Revolution is less likely when suppression, and benefits versus suppression and benefits (α, γ, and G) are large. If the revolution is unsuccessful, with probability 1–p, the incumbent and the challenger fight for the rent. We use the common ratio form contest success function (Skaperdas, 1996; Tullock, 1980). The incumbent wins with probability

(2) $$q = \frac{F_i}{F_i + F_c},$$

earning the incumbent rent P_x, where x=R means repression and x=A means accommodation. The incumbent loses against the challenger with the remaining probability $1-q = F_c/(F_i + F_c)$, in the sense of causing a standoff with utility $S_x/2$ to each player with probability s and coalition with utility $C_x/2$ to each player with probability 1–s where s is an exogenously determined parameter, i.e.,

(3) $$K_x = sS_x/2 + (1-s)C_x/2 .$$

Hence the incumbent and challenger share the standoff and coalition utilities equally. Coalition formation is costly, and standoff is even more costly, i.e., $P_x>C_x>S_x$. Conversely, if the revolution is successful, with probability p, the incumbent loses, and the challenger who represents the population wins. When the incumbent loses, the rent gets transferred in its entirety to the challenger. As an example, former Tunisian President Zine El Abidine Ben Ali fled to Saudi Arabia on 14 January 2011, 28 days after the 17 December 2010 uprising, losing his rent.

The three probabilities p, q, and s determine the eight outcomes in Figure 1. Combining these three probabilities with the utilities P_x, C_x, and S_x dependent on which outcome occurs, the incumbent's expected utility U_i is

(4) $$U_i = (1-p)(qP_x + (1-q)K_x) - f_iF_i - gG ,$$

where p is given by (1), q is given by (2), and K_x is given by (3). When p=1, the first term with 1–p is 0 since the incumbent loses the revolution, gains nothing, but incurs expenditures f_iF_i+gG. Conversely, when p=0, the incumbent earns P_x when q=1 due to remaining in power and winning against the challenger. When p=q=0, the incumbent loses against the challenger causing a standoff (s=1) with benefit $S_x/2$ or coalition (s=0) with benefit $C_x/2$. The incumbent in (4) strikes a balance between benefits (the positive terms) and costs (the two negative terms). This balance is more realistic than a budget constraint on the optimization which would decrease from two strategic choice variables to one strategic choice variable. Such a reduction would imply that more fighting F_i would give less benefits provision, and vice versa. We consider the incumbent to make these two choices separately.

Analogously, the challenger's expected utility U_c is

(5) $$U_c = (1-p)(1-q)K_x + pP_x - f_cF_c ,$$

where p is given by (1), q is given by (2), and K_x is given by (3). When p=1, the first term with 1–p is 0 since the incumbent loses the revolution and the challenger gets the rent P_x with expenditure f_cF_c. Conversely, when p=0, the challenger gets no benefit when losing against the incumbent (q=1). But, when winning against the incumbent, p=q=0, the challenger gets $S_x/2$ when a standoff occurs (s=1), and gets $C_x/2$ when a coalition occurs (s=0). The challenger in (5) also strikes a balance between benefits (the positive terms) and costs (the one negative term), which is more realistic than a budget constraint which would eliminate strategic choice for the challenger.

In (4) and (5) repression is characterized with x=R and $\gamma=0$ causing G=0, and accommodation is characterized with x=A and $\gamma>0$. If α is large, the incumbent can rely on fighting to earn a large fraction of the rent. If α is small, the incumbent additionally has to provide benefits G to earn a large fraction of the rent. The incumbent's expected utility U_i reflects the fact that revolution is repelled (the revolution does not succeed). In that case its expected utility derives from expected rents from a subsequent standoff, coalition, or outright win, but

ISSN 1749-852X

dampened by fighting costs and public goods provision. The challenger's expected utility U_c reflects the expected rents from a coalition, standoff, or outright success of the revolution, all dampened by fighting costs. The model implicitly reflects that the incumbent's rent P_x from winning a conflict with the challenger is discontinuous in the incumbent's benefits provision G to the population at the threshold $G_{Threshold}$, which is a low value above zero. That discontinuity follows intuitively since the population reacts differently when it decides that the incumbent represses as opposed to accommodates. That reaction by the population affects the contest between the incumbent and the challenger.

Summing up, the incumbent chooses the two strategies fighting F_i and benefits provision G in period 1. The challenger chooses fighting F_c in period 2. The probability of revolution decreases as benefits provision G increases. The game has eight outcomes shown in Figure 1.

Solving the model

We solve the model for the optimal levels of fighting for the incumbent and challenger, F_i and F_c, and benefits provision, G, that maximize the expected utilities in (4) and (5).

This section provides a narrative description of five theorems, their details and proofs can be found in Appendix B.

Theorems 1 and 2

Theorem 1 provides the equilibrium optimal levels of fighting F_i and F_c, benefits provision G, and the probability p of successful revolution, depending on the size P_x of the incumbent's rent.

Theorem 2 specifies how the incumbent deters the challenger without benefit provision G when the incumbent's rent P_x is large, provides benefits G without deterrence when the rent P_x is intermediate, provides neither benefits G nor deterrence when the rent P_x is small, and represses the population when the weight γ of benefits provision is zero.

Five insights are provided by Theorems 1 and 2. First, when the incumbent's rent P_x from winning a conflict with the challenger is greater or equal to the lower rent K_x of losing causing standoff or coalition (once the costs of fighting have been factored in), the incumbent is in an advantaged or superior position (since a large rent P_x is advantageous for the incumbent), a position described as

$$P_x \geq \left(2\frac{f_i}{f_c}+1\right)K_x \,.$$

This inequality provides two understandings about when the incumbent deters. One is that the incumbent deters when P_x is large compared with K_x, which means that the incumbent is motivated by the large rent of winning and remaining in power compared with the lower rent of losing causing standoff or coalition. This means that a large P_x may be quite detrimental for a country in that it can induce an incumbent to suppress all opposition. The other is, intuitively, that the incumbent deters when its unit cost f_i of fighting is low compared with the challenger's unit cost f_c of fighting. Furthermore, an advantaged incumbent does not provide benefits, and the revolution probability $p=1/\alpha$ is at its maximum. Thus, benefits provision and whether or not a revolution occurs is of no concern for the incumbent when choosing whether or not to deter the challenger. Deterrence is a matter between the incumbent and the challenger, where the population plays no role. Consequently, this inequality does not depend on benefits provision. Summing up, the incumbent is advantaged, deters the challenger, and does not care about the population.

The second insight is that when the incumbent's rent is in an intermediate position. In this case, the incumbent is not sufficiently advantaged to deter the challenger (as described in insight 1 above), but can (and does) provide benefits G since it fears the consequences of a revolution by the population, a position described as

$$K_x + 2\sqrt{\frac{f_i K_x(g\alpha^2-\gamma K_x)}{f_c\gamma}} \leq P_x < \left(2\frac{f_i}{f_c}+1\right)K_x$$

and $\gamma>0$.

The third insight is that where the incumbent is so disadvantaged that it can neither deter the challenger nor provide benefits to the population. Therefore, the incumbent tries instead, as best it can, to survive from day to day with a fighting challenger and an unsupportive population, a position described as

$$P_x < K_x + 2\sqrt{\frac{f_i K_x (g\alpha^2 - \gamma K_x)}{f_c \gamma}}.$$

The fourth insight is that mathematically the two inequalities in the second insight (describing the lower and upper bound of the incumbent's rent P_x) pull in different directions.

The rightmost inequality is satisfied when the lower rent of losing causing standoff or coalition K_x is large, the incumbent's unit cost of fighting f_i is large, and the challenger's unit cost of fighting f_c is small. Conversely, the leftmost inequality is satisfied when K_x is small, f_i is small, f_c is large, unit cost of benefits provision to the population g is small, α is small, and γ is large. The rightmost inequality specifies whether or not to deter the challenger, and thus f_i, f_c, K_x are present. The leftmost inequality specifies whether or not to provide benefits G to the population, and thus all the parameters are present. The upper bound is often larger than the lower bound allowing benefits provision, but not necessarily. For example, benefits are not provided when f_i, K_x, or γ is very low, or f_c, g, or α is very large.[6]

Fifth, if the weight of benefits provision relative to country-specific factors is zero, this guarantees repression since benefits provision entails no value.

Comparative static analysis

Theorem 3

With no benefits provision G, challenger fighting and incumbent fighting, Theorem 3 shows how the incumbent fights less if a revolution is probable. For the challenger the results are mixed, with less fighting as challenger-detrimental country-specific factors decrease (provided that the rent P_x is low). The incumbent fights more if the rent is valuable. A more valuable rent causes the incumbent to fight more, while the challenger fights less if the rent initially is sufficiently valuable. Conversely, higher value K_x for coalition and standoff causes less incumbent fighting, whereas an initially low K_x causes challenger fighting.

Theorem 4

With no benefits provision G, no challenger fighting but incumbent fighting occurs. Theorem 4 confirms Theorem 3 where the incumbent fights less if a revolution is probable. However, higher value K_x for coalition and standoff causes higher incumbent fighting. This result, opposite to Theorem 3, follows since the challenger is already deterred and benefits provision G does not occur.

Theorem 5

With some benefits provision, challenger fighting, and incumbent fighting, Theorem 5 shows that increasing the weight of benefits provision G to country-specific factors (such as high youth unemployment) α, increases G when α is large, and increases incumbent fighting F_i. In contrast, increasing α causes lower G. An increasingly valuable rent causes more benefits provision, a less probable revolution, and more incumbent fighting if the coalition and standoff value K_x is sufficiently low. An increasing value for coalition and standoff causes less benefits provision and a more probable revolution when the rent is sufficiently high. As the incumbent's unit cost of fighting increases, benefits provision decreases and a revolution becomes more probable. Conversely, as the challenger's unit cost of fighting increases, benefits provision increases and a revolution becomes less probable.

Analyzing conditions for deterrence and benefits provision

In this section we analyze the conditions for deterrence and benefits provision. To enhance our insight Figure 2 plots three regions in two-dimensional parameter space for the benchmark parameter values $f_i=f_c=g=\gamma=K_x=1$ and $\alpha=1.1$.

The incumbent's rent P_x is especially interesting and varies vertically, and one of the six parameters varies horizontally while the other five parameters are kept at their benchmark values. Thus, when P_x is large, i.e., more than $2\frac{f_i}{f_c}+1$ times as great as the rent K_x which weighs

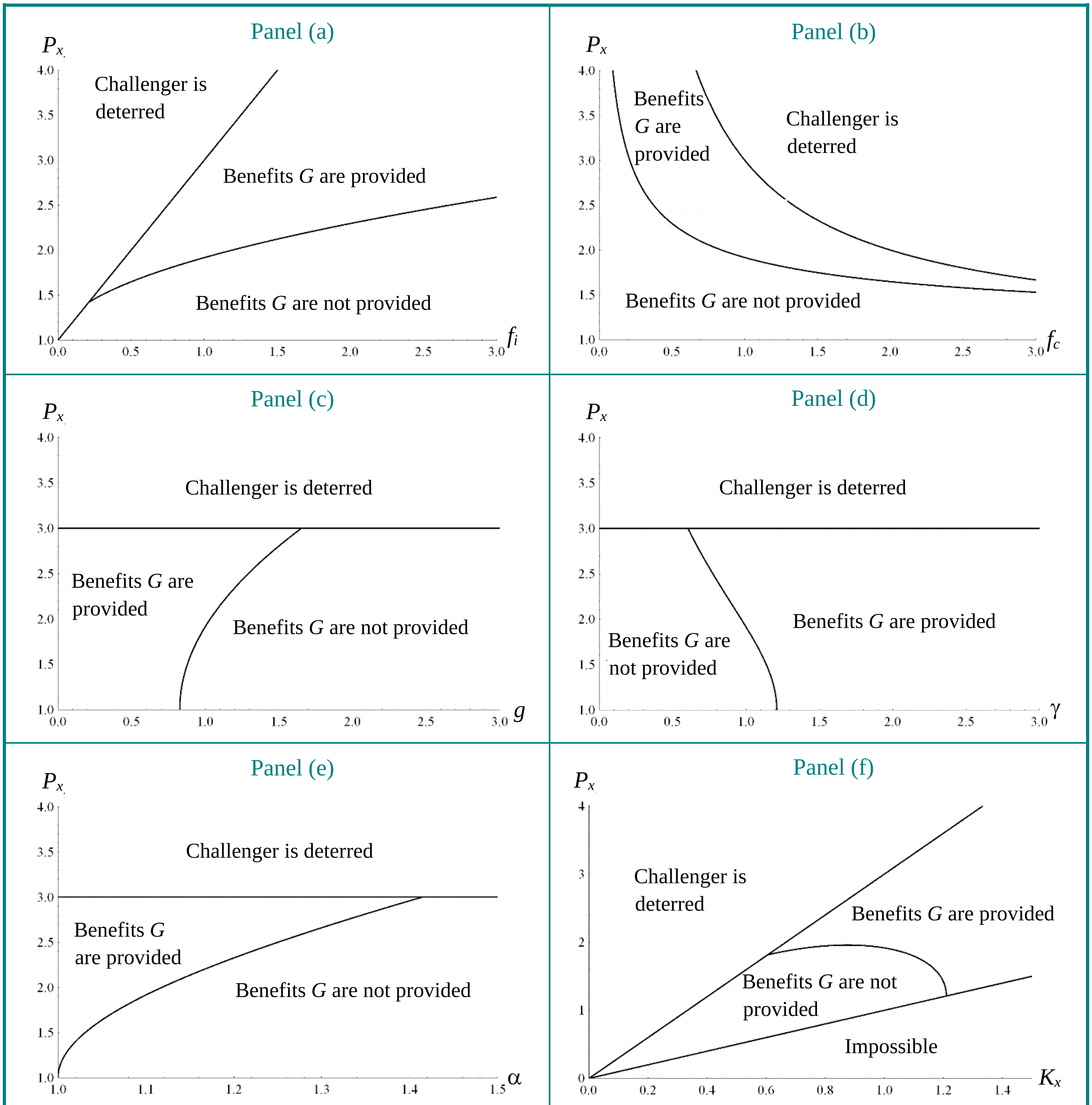

Figure 2: Three regions in parameter space for when the challenger is deterred and when benefits G are provided versus not provided, with benchmark parameter values $f_i=f_c=g=\gamma=K_x=1$ and $\alpha=1.1$.

standoff and coalition, the challenger is deterred (Theorems 1 and 2). The expression $2\frac{f_i}{f_c}+1$ increases when the ratio $\frac{f_i}{f_c}$ of the incumbent's unit fighting cost divided by the challenger's unit fighting cost increases.

Hence, when the incumbent is disadvantaged with a high unit fighting cost relative to the challenger ($\frac{f_i}{f_c}$ is high), then $2\frac{f_i}{f_c}+1$ is high and deterring the challenger is unlikely unless P_x is very large, i.e. $P_x \geq \left(2\frac{f_i}{f_c}+1\right)K_x$. When P_x is intermediate, benefits G are provided to the population and the challenger is not deterred (Theorem 2). When P_x is small, benefits G are not provided to the population and the challenger is not deterred (Theorem 2). In Figure 2, panel (a), a low unit cost f_i of fighting combined with a large incumbent rent P_x enables the advantaged incumbent to deter the challenger. As f_i increases or P_x decreases, the incumbent provides benefits G to the population to ensure its support and decrease the probability of revolution, while fighting with the challenger. As f_i increases or P_x decreases further, the disadvantaged incumbent does not provide benefits G to the population but does fight with the challenger.

In Figure 2, panel (b), the challenger is deterred when P_x is large and the challenger suffers a large unit cost f_c of fighting. As f_c decreases or P_x decreases, the incumbent provides benefits G. For low f_c or low P_x, the incumbent provides no benefits G.

In Figure 2, panel (c), the challenger is deterred when $P_x>3$, independently of g. A low unit cost g of benefits provision G induces the incumbent to provide benefits. Conversely, a large g causes no benefits which are too expensive. The indifference curve between providing versus not providing benefits increases when g increases since a large rent P_x, $P_x<3$, provides additional incentives to the incumbent to provide benefits to prevent a revolution.

In Figure 2, panel (d), the challenger is also deterred when $P_x>3$, but the indifference curve decreases in γ. Furthermore, benefits G are not provided when γ is low. Conversely, when g is large, benefits G are provided.[7]

In Figure 2, panel (e), the challenger is deterred when $P_x>3$. When α has its minimum value $\alpha=1$, a successful revolution is guaranteed when G=0, and thus the incumbent is guaranteed to provide benefits G. As α increases above 1, a low rent P_x induces the incumbent not to provide benefits. When $\alpha > \sqrt{2} \approx 1.14$ benefits are never provided since the probability of revolution is low and decreasing the probability further is not worthwhile for the incumbent.

In Figure 2, panel (f), the challenger is deterred when $P_x>3K_x$. The event $P_x<K_x$ is excluded by assumption since the rent P_x is preferable to standoff and coalition. Between these two sectors, the incumbent provides benefits G when P_x is large, and does not provide benefits when P_x is small.

Mapping the model outcomes to observed revolutions

Revolutions:1961-2011

Table C1 (in Appendix C) lists the 87 largest and most well-known revolutions during 1961-2011, linked to the theoretical analysis in the previous sections by categorization into the eight outcomes shown in column 3 from the left in Figure 1, i.e., incumbent wins and remains in power (RP), incumbent loses causing standoff (RS), incumbent loses causing coalition (RC), challenger becomes new incumbent (RL), incumbent wins and remains in power (AP), Incumbent loses causing standoff, (AS), Incumbent loses causing coalition (AC), and Challenger becomes new incumbent (AL). RL occurs 46 times (53%), RP 21 times (27%) RC 12 times (15%), AL seven times (4%), and AC once (1%), and RS, AP, AS never, i.e., 46+21+12+7+1=87. The route of each revolution is traced through the tree structure in Figure 1. Revolutions are considered where the population and/or challenger seek to replace the incumbent. The authors and research assistants researched each revolution and agreed on each outcome. It was determined whether the incumbent is repressive (letter "R" in the outcome). The 15 Arab Spring revolutions started by the population perceiving a repressive incumbent. The 2011 Egypt revolution is RL since the incumbent Hosni Mubarak was replaced with the challenger Mohamed Hussein Tantawi on February 11, 2011. During 1961-1990 in South Africa the incumbent repressed the population through apartheid policies, causing anti-apartheid, replacement of the incumbent, and RL. An accommodative incumbent gives the letter "A" in the outcome. For the 1964 Zanzibar

ISSN 1749-852X

Revolution in Tanzania the incumbent (Sultan of Zanzibar and his mainly Arab government) was accommodative. The mainly African Afro-Shirazi Party and left-wing Umma Party mobilized a revolution 12 January 1964, influenced by parliamentary under-representation despite winning 54% in the July 1963 election. The incumbent was replaced with the challenger, Abeid Karume, causing AL.[8]

Table C1 assumes the parameter values $f_i=f_c=g=K_R=K_A=1$, which are the same benchmark parameter values used in the previous section and Figure 2. We assume $P_R=2$ since the incumbent's rent when repressing is larger than the rent for standoff or coalition. We assume $P_A=2.9$ since the incumbent's rent when accommodating is larger than the incumbent's rent when repressing.[9]

Column 4 from the left in Table C1 shows the FSI (Fragile States Index) scaled from 0 to 120. The FSI is inversely proportional to α in equation (1) since revolutions are more likely to be successful in fragile countries. Column 5 shows α defined as $\alpha \equiv 240/FSI$ which gives scaling from $\alpha=2$ when FSI=120 to $\alpha=\infty$ when FSI=0. Using equation (1), the value $\alpha=2$ gives $p=1/2$ when $G=0$, which gives 50% probability of successful revolution in a maximally fragile state where the incumbent does not provide benefits. This range for α is estimated to be descriptive. In contrast, $\alpha=\infty$ gives $p=0$ regardless of G, which gives 0% probability of successful revolution in a minimally fragile state regardless of benefits provision. The highest FSI in column 4 is FSI=112.3 for the Second Sudanese Civil War and the Darfur Rebellion, causing $\alpha=2.137$. The Lowest FSI in column 4 is FSI=18.6 for The Troubles (Northern Ireland), causing $\alpha=12.903$.[10]

Column 6 shows GDP per capita in current 2019 US$ in the given country in the year when the revolution started. That is, the GDP per capita in the year the revolution started was determined, and was converted into the 2019 US$ value by adjusting for inflation. We assume that GDP per capita affects γ in equation (1). The effect cannot be proportional since GDP per capita varies from 56.535 for Malawi to 48268.591 for Kuwait. Column 7 shows γ defined as $\gamma \equiv 2\log_{10}(GDP/capita)$ which gives scaling from $\gamma=3.505$ for Malawi to $\gamma=9.637$ for Kuwait.[11]

Using equations (4), (5), and (6) for each of the 87 revolutions, the rightmost six columns in Table C1 show the equilibrium levels of fighting F_i and F_c, benefits provision G, the probability p of successful revolution, and the expected utilities U_i and U_c. The value of p is typically larger for countries with low to α, low γ, and low G. Table C1 illustrates how incumbents, challengers, populations, policy makers, and others can analyze how various conditions affect various outcomes.

Conclusion

The article analyzes revolutions, revolutionary uprisings, and civil war. We model both the reasoning processes of the incumbent and challenger (affected by the probability that the population revolts) and the outcomes. The incumbent chooses benefits provision to the population, which determines the probability of revolution endogenously. Benefits provision below a threshold means repression, with high probability of revolution. Increasing benefits provision above the threshold means accommodation, with decreasing probability of revolution. The incumbent also chooses the level of fighting with the challenger. The challenger observes the incumbent's choices of benefits provision and fighting, and chooses a fighting level, which determines how rents are divided between the incumbent and challenger.

The game has eight possible outcomes. If the revolution is successful, the challenger becomes the new incumbent. Conversely, if the revolution is unsuccessful, three events are possible: the incumbent remains in power, a standoff ensues, or a coalition is formed. The incumbent weighs the benefit of obtaining low probability of revolution against the effort costs, i.e., fighting and providing benefits to the population. The incumbent does not want to obtain low probability of revolution at any cost. Thus a frequent outcome, such as repression combined with losing the revolution, may arise because it gives the incumbent the highest expected utility.

We show that the incumbent fights less if a revolution is probable. An advantaged incumbent can deter the challenger and can ignore benefits provision to the population when the population does not pose a revolutionary threat. An intermediately advantaged incumbent fights with the challenger and provides benefits to the population to the extent these benefits decrease the revolutionary threat. A disadvantaged incumbent fights with the challenger and does not provide benefits to the population and thus the probability of revolution increases. The model is applicable as a tool adjusting the many parameters to determine the outcome of revolutions.

Notes

The authors acknowledge the assistance of Kate Ryan and Habiba Ben-Barka, in data-handling and research assistance. The authors thank two anonymous referees of this journal and the editors for useful comments.

1. We do not model the armed forces as a separate player since so many possibilities exist for how it operates. Most commonly the incumbent controls the army, or the army chooses to be loyal to the incumbent. Examples also exist where the armed forces support the population. It is also possible, at least in theory, that the armed forces may support the challenger. Our approach allows all these three interpretations.

2. If the incumbent moves first a reason may exist, e.g., financial depression (caused, for instance, by depletion of natural resources) causing the incumbent to tax the population which in turn may cause a revolution. A second possibility is that the challenger moves first, but for the challenger to gain momentum some precondition is needed. Third, if the population moves first by rioting, they do so for a reason, e.g., an oppressive regime.

3. See Hausken and Ncube (2019) for a companion article detailing more of the background and the extant literature.

4. See e.g., Dixit (1987) for comparisons of simultaneous and sequential moves.

5. Many of the countries in which revolts take place are places in which public services are not provided at high levels, partly because of low GDP and partly because of form of government. Olson (1965) suggests that dictators will provide GDP increasing levels of public services but not others. Benefits to the population thus exceed zero regardless of whether a revolt occurs, simply because it is in the rulers' interest to provide them.

6. For further detail see equation (11) in Appendix B where the square root in the left inequality is positive when $g\alpha^2 > \gamma K_x$ which provides a constraint for these four parameters.

7. Since the multiplicative term γG in the denominator in equation (5) is then too small which does not decrease the probability of revolution sufficiently.

8. Thus, e.g., the 1994 Rwandan genocide is not included since it was initiated by the Hutu majority incumbent slaughtering the Tutsi. The first and second Congo wars, since 1995, are not included since they were initiated by the neighboring Rwanda and Uganda invading Congo. In contrast, the May 1968 French rebellion, which does not qualify as a civil war, is included since it was initiated by student protests against capitalism, traditional institutions, consumerism, American imperialism, and values and order more generally, spreading to strikes involving 11 million workers in factories for about two weeks.

9. We assume $P_A<3$ to ensure $P_A < \left(2\frac{f_i}{f_c}+1\right)K_A$ in equation (6) in Appendix B.

10. The FSI, https://fragilestatesindex.org/, is available yearly 2006-2019. For Table C1, the actual year has been chosen when possible. For revolutions before 2006, the 2006 numbers have been used. These may be inaccurate for revolutions in, e.g., 1961, but are estimated to be better than using other proxies.

11. https://data.worldbank.org/indicator/ny.gdp.pcap.cd, https://countryeconomy.com/gdp. For missing data, the earliest year of available data has been used.

References

Besley, T. and T. Persson. 2010. "State Capacity, Conflict, and Development." *Econometrica*. Vol. 78, No. 1, pp. 1-34. https://doi.org/10.3982/ECTA8073

Besley, T. and T. Persson. 2011. "The Logic of Political Violence." *Quarterly Journal of Economics*. Vol. 126, No.3, pp. 1411-1445. https://doi.org/10.1093/qje/qjr025

Dixit, A. 1987. "Strategic Behavior in Contests." *American Economic Review*, Vol. 77, No. 5, pp. 891-898.

Esteban, J., M. Morelli, and D. Rohner. 2015. "Strategic Mass Killings." *Journal of Political Economy. Vol.* 123, No. 5, pp. 1087-1132. https://doi.org/10.1086/682584

ISSN 1749-852X

Vol. 15, No. 1 (2020) | doi:10.15355/epsj.15.1.58

Foran, J. 1993. "Theories of Revolution Revisited: Toward a Fourth Generation?" *Sociological Theory*. Vol. 11, No. 1, pp. 1-20. https://doi.org/10.2307/201977

Hausken, K., and G. Levitin. 2012. "Review of Systems Defense and Attack Models." *International Journal of Performability Engineering*, Vol. 8, No. 4, pp. 355-366.

Hausken, K., and M. Ncube. 2019. "The Incumbent, Challenger, and Population During Revolution and Civil War." *The Economics of Peace and Security Journal*. Vol. 14, No. 2, pp. 32–41. https://doi.org/10.15355/epsj.14.2.32

Olson, M. 1965. *The Logic of Collective Action: Public Goods and the Theory of Groups* (Vol. 124). Cambridge, MA: Harvard University Press.

Skaperdas, S. 1996. "Contest Success Functions." *Economic Theory*. Vol. 7, No. 2, pp. 283-290. https://doi.org/10.1007/s001990050053

Tullock, G. 1971. "The Paradox of Revolution." *Public Choice*. Vol 11, No. 1, pp. 89-99. https://doi.org/10.1007/BF01726214

Tullock, G. 1974. *The Social Dilemma: The Economics of War and Revolution*. Blacksburg, VA: University Publications.

Tullock, G. 1980. "Efficient Rent-Seeking." pp. 97-112 in J. M. Buchanan, R. D. Tollison, and G. Tullock, eds. *Toward a Theory of the Rent-Seeking Society*. College Station: Texas A. and M. University Press.

ISSN 1749-852X

Appendix A: Notation

Free choice variables

- F_i Incumbent's fighting
- G Incumbent's benefits provision to the population
- F_c Challenger's fighting

Dependent variables

- p Probability of successful revolution
- q Probability that the cumbent wins the fight with the challenger
- U_i Incumbent's expected utility
- U_c Challenger's expected utility

Parameters

- f_i Incumbent's unit cost of fighting
- g Incumbent's unit cost of benefits provision to the population
- f_c Challenger's unit cost of fighting
- $1/\alpha$ Probability of successful revolution without benefits provision G
- γ Weight of benefits provision G relative to α
- P_x Incumbent's rent dependent on x, x=R,A, when winning against the challenger
- $S_x/2$ Rent to each player dependent on x, x=R,A, when standoff
- $C_x/2$ Rent to each player dependent on x, x=R,A, when coalition
- $x=R$ Incumbent represses defined as $0 \leq G \leq G_{Threshold}$
- $x=A$ Incumbent accommodates defined as $G > G_{Threshold}$
- s Probability of standoff
- K_x $sS_x/2+(1-s)C_x/2$
- $G_{Threshold}$ Incumbent's threshold for benefits provision to the population

ISSN 1749-852X

Appendix B: Theorems and Proofs

Theorem 1 Detail

The equilibrium optimal levels of fighting and benefits provision, and the probability of successful revolution, are

(6)
$$F_i=\begin{cases}\dfrac{f_c(P_x-K_x)^2(\alpha+\gamma G-1)}{4f_i^2K_x(\alpha+\gamma G)} & when\ P_x<\left(2\dfrac{f_i}{f_c}+1\right)K_x\\ \dfrac{K_x(\alpha+\gamma G-1)}{f_c(\alpha+\gamma G)} & otherwise\end{cases}$$

$$G=\begin{cases}\dfrac{1}{2}\sqrt{\dfrac{f_c(P_x-K_x)^2+4f_iK_x^2}{f_igK_x\gamma}}-\dfrac{\alpha}{\gamma} & when\ K_x+2\sqrt{\dfrac{f_iK_x(g\alpha^2-\gamma K_x)}{f_c\gamma}}\le P_x<\left(2\dfrac{f_i}{f_c}+1\right)K_x\ and\ \gamma>0\\ 0 & otherwise\end{cases}$$

$$F_c=\begin{cases}\dfrac{\big(2f_iK_x-f_c(P_x-K_x)\big)(P_x-K_x)(\alpha+\gamma G-1)}{4f_i^2K_x(\alpha+\gamma G)} & when\ P_x<\left(2\dfrac{f_i}{f_c}+1\right)K_x\\ 0 & otherwise\end{cases}$$

$$p=\begin{cases}\dfrac{2\sqrt{f_igK_x}}{\sqrt{\gamma}\sqrt{f_c(P_x-K_x)^2+4f_iK_x^2}} & when\ K_x+2\sqrt{\dfrac{f_iK_x(g\alpha^2-\gamma K_x)}{f_c\gamma}}\le P_x<\left(2\dfrac{f_i}{f_c}+1\right)K_x\ and\ \gamma>0\\ \dfrac{1}{\alpha} & otherwise\end{cases}$$

Proof:

We solve the game with backward induction starting with period 2. Differentiating the challenger's expected utility in (5) and equating with zero gives

(7)
$$\frac{\partial U_c}{\partial F_c}=\frac{F_iK_x(\alpha+\gamma G-1)}{(F_i+F_c)^2(\alpha+\gamma G)}-f_c=0\Rightarrow F_c=\begin{cases}\sqrt{\dfrac{F_iK_x(\alpha+\gamma G-1)}{f_c(\alpha+\gamma G)}}-F_i & when\ \dfrac{K_x(\alpha+\gamma G-1)}{f_c(\alpha+\gamma G)}>F_i\\ 0 & otherwise\end{cases}$$

Inserting (7) into (4) to determine the incumbent's period 1 expected utility gives

(8)
$$U_i=\begin{cases}\sqrt{\dfrac{\alpha+\gamma G-1}{\alpha+\gamma G}}\left(\dfrac{\sqrt{F_if_c}(P_x-K_x)}{\sqrt{K_x}}+\sqrt{\dfrac{\alpha+\gamma G-1}{\alpha+\gamma G}}K_x\right)-f_iF_i-gG & when\ \dfrac{K_x(\alpha+\gamma G-1)}{f_c(\alpha+\gamma G)}>F_i\\ \dfrac{\alpha+\gamma G-1}{\alpha+\gamma G}P_x-f_iF_i-gG & otherwise\end{cases}$$

where $P_x>K_x$ since $P_x>C_x>S_x$ and $0\le s\le 1$. Differentiating (8) and equating with zero yield

ISSN 1749-852X

https://www.EPSJournal.org.uk
For permissions, email: ManagingEditor@EPSJournal.org.uk

(9)
$$\frac{\partial U_i}{\partial F_i}=\begin{cases}\frac{\sqrt{f_c}(P_x-K_x)}{2\sqrt{F_iK_x}}\sqrt{\frac{\alpha+\gamma G-1}{\alpha+\gamma G}}-f_i=0 \ when \ \frac{K_x(\alpha+\gamma G-1)}{f_c(\alpha+\gamma G)}>F_i\\ -f_i \ otherwise\end{cases}$$

$$\frac{\partial U_i}{\partial G}=\begin{cases}\frac{1}{2(\alpha+\gamma G)^2}\left(2\gamma K_x-\frac{\sqrt{F_if_c}(P_x-K_x)\gamma\sqrt{\alpha+\gamma G}+2g\sqrt{K_x}\sqrt{\alpha+\gamma G-1}(\alpha+\gamma G)^2}{\sqrt{K_x}\sqrt{\alpha+\gamma G-1}}\right)=0\\ \quad when \ \frac{K_x(\alpha+\gamma G-1)}{f_c(\alpha+\gamma G)}>F_i\\ -g \ otherwise\end{cases}$$

which are solved to yield (6) where F_c follows from inserting G and F_i into (7), and the inequality simplifies to

(10) $$\frac{K_x(\alpha+\gamma G-1)}{f_c(\alpha+\gamma G)}>F_i=\frac{f_c(P_x-K_x)^2(\alpha-1)}{4f_i^2K_x\alpha}\Rightarrow P_x<\left(2\frac{f_i}{f_c}+1\right)K_x$$

which is independent of γ and G. The second order conditions and Hessian matrix are

(11)
$$\frac{\partial^2 U_i}{\partial F_i^2}=\begin{cases}\frac{\sqrt{f_c}(P_x-K_x)}{4F_i^{3/2}\sqrt{K_x}}\sqrt{\frac{\alpha+\gamma G-1}{\alpha+\gamma G}} \ when \ P_x<\left(2\frac{f_i}{f_c}+1\right)K_x\\ 0 \ otherwise\end{cases}$$

$$\frac{\partial^2 U_i}{\partial G^2}=\begin{cases}-\frac{\gamma^2\left(8\sqrt{F_if_c}K_x^{3/2}(\alpha+\gamma G-1)^{3/2}\sqrt{\alpha+\gamma G}+F_if_c(P_x-K_x)(\alpha+\gamma G)(4\alpha-3+4\gamma G)\right)}{4\sqrt{F_if_cK_x}(\alpha+\gamma G-1)^{3/2}(\alpha+\gamma G)^{7/2}}\\ \quad when \ P_x<\left(2\frac{f_i}{f_c}+1\right)K_x\\ 0 \ otherwise\end{cases}$$

$$\frac{\partial^2 U_i}{\partial F_i\partial G}=\frac{\partial^2 U_i}{\partial G\partial F_i}=\begin{cases}\frac{\gamma\sqrt{f_c}(P_x-K_x)}{4\sqrt{F_iK_x}\sqrt{\alpha+\gamma G-1}(\alpha+\gamma G)^{3/2}} \ when \ P_x<\left(2\frac{f_i}{f_c}+1\right)K_x\\ 0 \ otherwise\end{cases}$$

$$|H|=\begin{vmatrix}\frac{\partial^2 U_i}{\partial F_i^2} & \frac{\partial^2 U_i}{\partial F_i\partial G}\\ \frac{\partial^2 U_i}{\partial G\partial F_i} & \frac{\partial^2 U_i}{\partial G^2}\end{vmatrix}=\frac{\partial^2 U_i}{\partial F_i^2}\frac{\partial^2 U_i}{\partial G^2}-\frac{\partial^2 U_i}{\partial F_i\partial G}\frac{\partial^2 U_i}{\partial G\partial F_i}$$

$$=\left\{\begin{matrix}-\frac{\gamma^2(P_x-K_x)\sqrt{f_c}}{2F_i(\alpha+\gamma G)^3}\left(\frac{\sqrt{K_x}\sqrt{\alpha+\gamma G-1}}{\sqrt{F_i}\sqrt{\alpha+\gamma G}}+\frac{\sqrt{f_c}(P_x-K_x)(2\alpha-1+2\gamma G)}{4K_x(\alpha+\gamma G-1)}\right)\\ when \ P_x<\left(2\frac{f_i}{f_c}+1\right)K_x\\ 0 \ otherwise\end{matrix}\right\}\geq 0$$

ISSN 1749-852X

Vol. 15, No. 1 (2020) | doi:10.15355/epsj.15.1.58

The second order conditions are always satisfied as negative, and the Hessian matrix is always negative semi-definite, since $\gamma \geq 0$, $\alpha \geq 1$, and $P_x > K_x$, which cause $\alpha + \gamma G - 1 \geq 0$ and $2\alpha - 1 + 2\gamma G \geq 0$ regardless of $G \geq 0$.

The expected utilities U_i and U_c follow from inserting (6) into (4) and (5). In the first line of each equation in (6), the incumbent's fighting F_i is low and does not deter the challenger, i.e., $F_c > 0$. Conversely, in the second line, labeled "otherwise", F_i is large deterring the challenger, i.e., $F_c = 0$.

For simplicity and to ensure better comparison, we hereafter approximate benefits provision G below the threshold G, $0 \leq G \leq G_{Threshold}$, which means negligible benefits provision, with no benefits provision G=0. The actual benefits provision when $0 \leq G \leq G_{Threshold}$, is determined by replacing G with $G_{Threshold}$.

Theorem 2 Detail

The incumbent deters the challenger without benefit provision $F_c = G = 0$ when $P_x \geq \left(2\frac{f_i}{f_c} + 1\right) K_x$, provides benefits G>0 without deterrence $F_c > 0$ when $K_x + 2\sqrt{\frac{f_i K_x (g\alpha^2 - \gamma K_x)}{f_c \gamma}} \leq P_x < \left(2\frac{f_i}{f_c} + 1\right) K_x$ and $\gamma > 0$, provides neither benefits G=0 nor deterrence $F_c > 0$ when $P_x < K_x + 2\sqrt{\frac{f_i K_x (g\alpha^2 - \gamma K_x)}{f_c \gamma}}$, and represses causing G=0 when $\gamma = 0$.

Proof:
The proof is as for Theorem 1.

Figure B1 illustrates Theorem 2 dependent on the rent P_x when $\gamma > 0$.

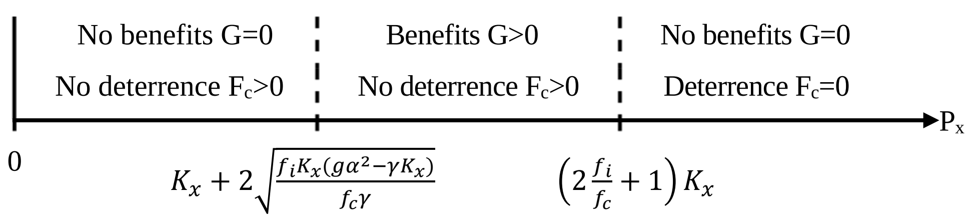

Figure B1: Illustration of Theorem 2 when $\gamma > 0$.

Theorem 3 Detail

No benefits provision G=0, challenger fighting $F_c > 0$, and incumbent fighting $F_i > 0$. In equilibrium, if $\gamma = 0$ and $P_x < \left(2\frac{f_i}{f_c} + 1\right) K_x$, or $\gamma > 0$ and $P_x < Min\left\{K_x + 2\sqrt{\frac{f_i K_x (g\alpha^2 - \gamma K_x)}{f_c \gamma}}, \left(2\frac{f_i}{f_c} + 1\right) K_x\right\}$,

then $\frac{\partial F_i}{\partial \alpha} > 0, \frac{\partial U_i}{\partial \alpha} > 0 \ if \ K_x < \frac{f_c P_x}{f_c + f_i}$,

$$\frac{\partial U_i}{\partial \alpha} > 0, \frac{\partial F_i}{\partial P_x} > 0, \frac{\partial F_c}{\partial P_x} < 0 \ if \ K_x < \frac{f_c P_x}{f_c + f_i}, \frac{\partial F_i}{\partial K_x} < 0, \frac{\partial F_c}{\partial K_x} > 0 \ if \ K_x^2 < \frac{f_c P_x^2}{f_c + 2f_i}, \frac{\partial F_i}{\partial f_i} < 0,$$

$$\frac{\partial F_c}{\partial f_i} > 0 \ if \ K_x < \frac{f_c P_x}{f_i + f_c}, \frac{\partial F_i}{\partial f_c} > 0, \frac{\partial F_c}{\partial f_c} < 0 .$$

ISSN 1749-852X

Vol. 15, No. 1 (2020) | doi:10.15355/epsj.15.1.58

Proof:

Differentiating (6) when γ=0 and $P_x < \left(2\frac{f_i}{f_c}+1\right)K_x$, or γ>0 and $P_x < Min\left\{K_x + 2\sqrt{\frac{f_iK_x(g\alpha^2-\gamma K_x)}{f_c\gamma}}, \left(2\frac{f_i}{f_c}+1\right)K_x\right\}$, gives

(12)

$$\frac{\partial F_i}{\partial \alpha} = \frac{f_c(P_x-K_x)^2}{4f_i^2K_x\alpha^2}, \quad \frac{\partial F_c}{\partial \alpha} = \frac{(2f_iK_x - f_c(P_x-K_x))(P_x-K_x)}{4f_i^2K_x\alpha^2}, \frac{\partial p}{\partial \alpha} = \frac{-1}{\alpha^2},$$

$$\frac{\partial U_i}{\partial \alpha} = \frac{4f_iK_x^2 + f_c(P_x-K_x)^2}{4f_iK_x\alpha^2}, \quad \frac{\partial U_c}{\partial \alpha} = \frac{(f_c^2P_x - (f_c+2f_i)^2K_x)(P_x-K_x)}{4f_i^2K_x\alpha^2},$$

$$\frac{\partial F_i}{\partial P_x} = \frac{f_c(P_x-K_x)(\alpha-1)}{2f_i^2K_x\alpha}, \quad \frac{\partial F_c}{\partial P_x} = \frac{-(f_cP_x - (f_c+f_i)K_x)(\alpha-1)}{2f_i^2K_x\alpha}, \frac{\partial p}{\partial P_x} = 0,$$

$$\frac{\partial U_i}{\partial P_x} = \frac{f_c(P_x-K_x)(\alpha-1)}{2f_iK_x\alpha}, \quad \frac{\partial U_c}{\partial P_x} = \frac{2f_i^2K_x + f_c(f_c(P_x-K_x) - 2f_iK_x)(\alpha-1)}{2f_i^2K_x\alpha},$$

$$\frac{\partial F_i}{\partial K_x} = \frac{-f_c(P_x-K_x)(P_x+K_x)(\alpha-1)}{4f_i^2K_x^2\alpha}, \quad \frac{\partial F_c}{\partial K_x} = \frac{(f_cP_x^2 - (f_c+2f_i)K_x^2)}{4f_i^2K_x^2\alpha}, \frac{\partial p}{\partial K_x} = 0,$$

$$\frac{\partial U_i}{\partial K_x} = \frac{-(f_cP_x^2 - (f_c+4f_i)K_x^2)(\alpha-1)}{4f_iK_x^2\alpha}, \quad \frac{\partial U_c}{\partial K_x} = \frac{-(f_c^2P_x^2 - (f_c+2f_i)^2K_x^2)(\alpha-1)}{4f_i^2K_x^2\alpha},$$

$$\frac{\partial F_i}{\partial f_i} = \frac{-f_c(P_x-K_x)^2(\alpha-1)}{2f_i^3K_x\alpha}, \quad \frac{\partial F_c}{\partial f_i} = \frac{(f_cP_x - (f_i+f_c)K_x)(P_x-K_x)(\alpha-1)}{2f_i^3K_x\alpha}, \frac{\partial p}{\partial f_i} = 0,$$

$$\frac{\partial U_i}{\partial f_i} = \frac{-f_c(P_x-K_x)^2(\alpha-1)}{4f_i^2K_x\alpha}, \quad \frac{\partial U_c}{\partial f_i} = \frac{-f_c(f_c(P_x-K_x) - 2f_iK_x)(P_x-K_x)(\alpha-1)}{2f_i^3K_x\alpha},$$

$$\frac{\partial F_i}{\partial f_c} = \frac{(P_x-K_x)^2(\alpha-1)}{4f_i^2K_x\alpha}, \quad \frac{\partial F_c}{\partial f_c} = \frac{-(P_x-K_x)^2(\alpha-1)}{4f_i^2K_x\alpha}, \frac{\partial p}{\partial f_c} = 0, \quad \frac{\partial U_i}{\partial f_c} = \frac{(P_x-K_x)^2(\alpha-1)}{4f_iK_x\alpha},$$

$$\frac{\partial U_c}{\partial f_c} = \frac{(f_c(P_x-K_x) - 2f_iK_x)(P_x-K_x)(\alpha-1)}{2f_i^2K_x\alpha}$$

Theorem 4 Detail

No benefits provision G=0, no challenger fighting F_c=0, and incumbent fighting F_i >0. In equilibrium, if γ=0 and $P_x \geq \left(2\frac{f_i}{f_c}+1\right)K_x \frac{\partial F_i}{\partial f_c}<0$, then $\frac{\partial F_i}{\partial \alpha}>0, \frac{\partial U_i}{\partial \alpha}>0 \ if \ K_x<\frac{f_c P_x}{f_i}, \frac{\partial F_i}{\partial P_x}=0, \frac{\partial F_i}{\partial K_x}>0, \frac{\partial F_i}{\partial f_i}=0, \frac{\partial F_i}{\partial f_c}<0$.

Proof:

Differentiating (6) when γ=0 and $P_x \geq \left(2\frac{f_i}{f_c}+1\right)K_x$ gives

$$\frac{\partial F_i}{\partial \alpha}=\frac{K_x}{f_c\alpha^2}, \frac{\partial p}{\partial \alpha}=\frac{-1}{\alpha^2}, \frac{\partial U_i}{\partial \alpha}=\frac{f_cP_x-f_iK_x}{f_c\alpha^2}, \frac{\partial U_c}{\partial \alpha}=\frac{-P_x}{\alpha^2}, \frac{\partial F_i}{\partial P_x}=\frac{\partial p}{\partial P_x}=0, \frac{\partial U_i}{\partial P_x}=\frac{\alpha-1}{\alpha}, \frac{\partial U_c}{\partial P_x}=\frac{1}{\alpha},$$

(13) $$\frac{\partial F_i}{\partial K_x}=\frac{\alpha-1}{f_c\alpha}, \frac{\partial p}{\partial K_x}=0, \frac{\partial U_i}{\partial K_x}=\frac{-f_i(\alpha-1)}{f_c\alpha}, \frac{\partial U_c}{\partial K_x}=0, \frac{\partial F_i}{\partial f_i}=\frac{\partial p}{\partial f_i}=\frac{\partial U_c}{\partial f_i}=0, \frac{\partial U_i}{\partial f_i}=\frac{-K_x(\alpha-1)}{f_c\alpha},$$

$$\frac{\partial F_i}{\partial f_c}=\frac{-K_x(\alpha-1)}{f_c^2\alpha}, \frac{\partial p}{\partial f_c}=\frac{\partial U_c}{\partial f_c}=0, \frac{\partial U_i}{\partial f_c}=\frac{f_iK_x(\alpha-1)}{f_c^2\alpha}$$

Theorem 5 Detail

Benefits provision G>0, challenger fighting F_c>0, and incumbent fighting F_i >0:

Define $Q \equiv \sqrt{f_c(P_x-K_x)^2+4f_iK_x^2}$ and $R \equiv \sqrt{f_igK_x}$. In equilibrium, if γ>0 and $K_x+2\sqrt{\frac{f_iK_x(g\alpha^2-\gamma K_x)}{f_c\gamma}} \leq P_x < \left(2\frac{f_i}{f_c}+1\right)K_x$,

then

$$\frac{\partial G}{\partial \gamma}>0 \ if \alpha>\frac{Q\sqrt{\gamma}}{4R}, \frac{\partial F_i}{\partial \gamma}>0,$$

$$\frac{\partial F_c}{\partial \gamma}<0 \ if \ \frac{f_cP_x}{2f_i+f_c}>K_x, \frac{\partial p}{\partial \gamma}>0, \frac{\partial G}{\partial \alpha}<0, \frac{\partial F_i}{\partial \alpha}=\frac{\partial F_c}{\partial \alpha}=\frac{\partial p}{\partial \alpha}=0, \frac{\partial G}{\partial P_x}>0,$$

$$\frac{\partial F_i}{\partial P_x}>0 \ if \ \frac{1}{f_i^2K_x}>\frac{g^2K_x(8f_iK_x^2+f_c(P_x-K_x)^2)}{Q^3R^3\sqrt{\gamma}},$$

$$\frac{\partial F_c}{\partial P_x}>0 \ if \ \frac{1}{f_i}>\frac{f_c(P_x-K_x)}{f_i^2K_x}+\frac{K_x(8K_x(P_x+K_x)R^4-g^2Q^4)}{(P_x-K_x)Q^3R^3\sqrt{\gamma}}, \frac{\partial p}{\partial P_x}<0,$$

$$\frac{\partial G}{\partial K_x}<0 \ if \ K_x^2<\frac{f_cP_x^2}{4f_i+f_c}, \frac{\partial p}{\partial K_x}>0 \ if \ K_x^2<\frac{f_cP_x^2}{4f_i+f_c}, \frac{\partial G}{\partial f_i}<0, \frac{\partial p}{\partial f_i}>0, \frac{\partial G}{\partial f_c}>0, \frac{\partial p}{\partial f_c}<0$$

Proof:

Define $V \equiv f_i g(P_x + K_x)$. Differentiating (6) when γ>0 and $K_x + 2\sqrt{\frac{f_i K_x(g\alpha^2 - \gamma K_x)}{f_c \gamma}} \leq P_x < \left(2\frac{f_i}{f_c} + 1\right) K_x$ gives

(14)
$$\frac{\partial G}{\partial \gamma} = \frac{-Q}{4R\gamma^{3/2}} + \frac{\alpha}{\gamma^2}, \frac{\partial F_i}{\partial \gamma} = \frac{f_c g^2 K_x (P_x - K_x)^2}{4QR^3\gamma^{3/2}}, \frac{\partial F_c}{\partial \gamma} = \frac{-g^2 K_x (f_c(P_x - K_x) - 2f_i K_x)(P_x - K_x)}{4QR\gamma^{3/2}},$$
$$\frac{\partial p}{\partial \gamma} = \frac{R}{Q\gamma^{3/2}}, \frac{\partial U_i}{\partial \gamma} = \frac{g\left(\sqrt{\gamma}\frac{Q}{R} - 2\alpha\right)}{2\gamma^2}, \frac{\partial U_c}{\partial \gamma} = \frac{g^2 K_x (f_c^2 P_x - (f_c + 2f_i)^2 K_x)(P_x - K_x)}{4QR\gamma^{3/2}},$$
$$\frac{\partial G}{\partial \alpha} = \frac{-1}{\gamma}, \frac{\partial F_i}{\partial \alpha} = \frac{\partial F_c}{\partial \alpha} = \frac{\partial p}{\partial \alpha} = \frac{\partial U_c}{\partial \alpha} = 0, \frac{\partial U_i}{\partial \alpha} = \frac{g}{\gamma},$$
$$\frac{\partial G}{\partial P_x} = \frac{f_c(P_x - K_x)}{2QR\sqrt{\gamma}}, \frac{\partial F_i}{\partial P_x} = \frac{f_c(P_x - K_x)}{2}\left(\frac{1}{f_i^2 K_x} - \frac{g^2 K_x (8f_i K_x^2 + f_c(P_x - K_x)^2)}{Q^3 R^3 \sqrt{\gamma}}\right),$$
$$\frac{\partial F_c}{\partial P_x} = \frac{1}{2}\left(\frac{1}{f_i} - \frac{f_c(P_x - K_x)}{f_i^2 K_x} - \frac{K_x(8K_x(P_x + K_x)R^4 - g^2 Q^4)}{(P_x - K_x)Q^3 R^3 \sqrt{\gamma}}\right), \frac{\partial p}{\partial P_x} = \frac{-2f_c(P_x - K_x)R}{Q^3\sqrt{\gamma}},$$
$$\frac{\partial U_i}{\partial P_x} = \frac{f_c(P_x - K_x)(Q\sqrt{\gamma} - 2R)}{2f_i K_x Q\sqrt{\gamma}},$$
$$\frac{\partial U_c}{\partial P_x} = \left(16f_i^3 K_x^3 R + f_c^3 (P_x - K_x)^3 (Q\sqrt{\gamma} - R) + 8f_c f_i^2 K_x^3 (2R - Q\sqrt{\gamma}) - 2f_c^2 f_i K_x (P_x - K_x)[4K_x R + (P_x - 3K_x)Q\sqrt{\gamma}]\right) \Big/ 2f_i^2 K_x Q^3 \sqrt{\gamma}$$

(15)
$$\frac{\partial G}{\partial K_x} = \frac{-f_i g (f_c P_x^2 - (4f_i + f_c)K_x^2)}{4QR^3\sqrt{\gamma}},$$
$$\frac{\partial F_i}{\partial K_x} = \frac{f_c(P_x - K_x)(f_c(P_x - K_x)^2 (P_x + K_x)R(R - Q\sqrt{\gamma}) + 4f_i K_x^2 [K_x + 3P_x - (P_x + K_x)Q\sqrt{\gamma}])}{4f_i^2 K_x^2 Q^3 \sqrt{\gamma}},$$
$$\frac{\partial F_c}{\partial K_x} = \frac{\left(f_c^2 (P_x - K_x)^3 (P_x + K_x) R (Q\sqrt{\gamma} - R) + 8f_i^2 K_x^4 (V - QR\sqrt{\gamma}) + 2f_c f_i K_x^2 (P_x - K_x)(3K_x + P_x)(QR\sqrt{\gamma} - V)\right)}{4f_i^2 K_x^2 Q^3 R \sqrt{\gamma}},$$
$$\frac{\partial p}{\partial K_x} = \frac{f_i g (f_c P_x^2 - (4f_i + f_c)K_x^2)}{R\sqrt{\gamma}Q^3}, \frac{\partial U_i}{\partial K_x} = \frac{f_i g^2 (f_c P_x^2 - (4f_i + f_c)K_x^2)R(2R - \sqrt{\gamma}Q)}{4R^5\sqrt{\gamma}Q},$$
$$\frac{\partial U_c}{\partial K_x} = \left(f_c^3 (P_x - K_x)^3 (P_x + K_x) R (R - Q\sqrt{\gamma}) - 16f_i^3 K_x^4 (V - QR\sqrt{\gamma}) + 4f_c^2 f_i K_x^2 (P_x - K_x)\left[f_i g (2K_x^2 + K_x P_x + P_x^2) - 2K_x QR\sqrt{\gamma}\right] + 4f_c f_i^2 K_x^2 [f_i g(-5K_x^3 - K_x^2 P_x - 3K_x P_x^2 + P_x^3) + (5K_x^2 - 2K_x P_x + P_x^2)QR\sqrt{\gamma}]\right) \Big/ 4f_i^2 K_x^2 Q^3 R \sqrt{\gamma}$$

ISSN 1749-852X

$$\frac{\partial G}{\partial f_i}=\frac{-f_c g K_x(P_x-K_x)^2}{4R^3\sqrt{\gamma}Q},\frac{\partial F_i}{\partial f_i}=\frac{f_c g(P_x-K_x)^2(f_c(P_x-K_x)^2(3R-2Q\sqrt{\gamma})+8f_iK_x^2(2R-Q\sqrt{\gamma}))}{4f_i^2Q^3R^2\sqrt{\gamma}},$$

$$\frac{\partial F_c}{\partial f_i}=g(P_x-K_x)\big(\big[16f_i^2K_x^3+3f_c^2(K_x-P_x)^3+2f_cf_iK_x(K_x-P_x)(9K_x-P_x)\big]R$$
$$\frac{+2[4f_iK_x^2+f_c(K_x-P_x)^2][f_cP_x-(f_c+f_i)K_x]Q\sqrt{\gamma}\big)}{4f_i^2Q^3R^2\sqrt{\gamma}},$$

$$\frac{\partial p}{\partial f_i}=\frac{f_c g K_x(P_x-K_x)^2}{R\sqrt{\gamma}Q^3},\frac{\partial U_i}{\partial f_i}=\frac{f_c g^2K_x(P_x-K_x)^2R(2R-\sqrt{\gamma}Q)}{4R^5\sqrt{\gamma}Q},$$

$$\frac{\partial U_c}{\partial f_i}=f_c g(K_x-P_x)\big(f_c^2(K_x-P_x)^3R(3R-2Q\sqrt{\gamma})+4f_cf_iK_x(K_x-P_x)R$$
$$\times\big[(5K_x-P_x)R+(-3K_x+P_x)Q\sqrt{\gamma}\big]$$
$$\frac{+4f_i^2K_x^2[f_ig(7K_x^2+2K_xP_x-P_x^2)-4K_xQR\sqrt{\gamma}]\big)}{4f_i^2Q^3R^3\sqrt{\gamma}}\tag{16}$$

$$\frac{\partial G}{\partial f_c}=\frac{(P_x-K_x)^2}{4R\sqrt{\gamma}Q},\frac{\partial F_i}{\partial f_c}=\frac{(P_x-K_x)^2-\dfrac{(-16f_i^2K_x^4+Q^4)R}{f_cQ^3\sqrt{\gamma}}}{4f_i^2K_x},$$

$$\frac{\partial F_c}{\partial f_c}=\frac{(P_x-K_x)^2(f_c(P_x-K_x)^2(R-Q\sqrt{\gamma})+2f_iK_x(3K_xR+P_xR-2K_xQ\sqrt{\gamma}))}{4f_i^2K_xQ^3\sqrt{\gamma}},$$

$$\frac{\partial p}{\partial f_c}=\frac{-R(P_x-K_x)^2}{4\sqrt{\gamma}Q^3},\frac{\partial U_i}{\partial f_c}=\frac{(P_x-K_x)^2(\sqrt{\gamma}Q-2R)}{4f_iK_x\sqrt{\gamma}Q},$$

$$\frac{\partial U_c}{\partial f_c}=(K_x-P_x)\big(-\big[3f_c^2(K_x-P_x)^3+4f_i^2K_x(7K_x^2+2K_xP_x-P_x^2)$$
$$+4f_cf_iK_x(5K_x^2-6K_xP_x+P_x^2)]R$$
$$\frac{+2[2f_iK_x+f_c(K_x-P_x)][4f_iK_x^2+f_c(K_x-P_x)^2]Q\sqrt{\gamma}\big)}{4f_i^2K_xQ^3\sqrt{\gamma}}$$

Appendix C: Revolutions 1961-2011

Table C1: Revolutions 1961-2011

	1	2	3	4	5	6	7	8	9	10	11	12	13
	Years	*Revolution*	*O*	*FSI*	*α*	*GDP/c*	*γ*	F_i	F_c	*G*	*p*	*Ui*	U_c
1	1961-70	First Kurdish-Iraqi War	RP	109	2.202	245.032	4.778	0.148	0.148	0.051	0.409	0.688	0.966
2	1961	Algiers Putsch	RP	77.8	3.085	213.486	4.659	0.169	0.169	0.000	0.324	0.845	0.817
3	1961-91	Eritrean War of Independence*	RL	83.9	2.861	152.987	4.369	0.163	0.163	0.000	0.350	0.813	0.862
4	1961-75	Angola War of Independence*	RL	88.3	2.718	664.118	5.644	0.158	0.158	0.000	0.368	0.790	0.894
5	1961-90	Anti-Apartheid Movement	RL	55.7	4.309	444.896	5.297	0.192	0.192	0.000	0.232	0.960	0.656
6	1962-74	Independence of Guinea-Bissau and Cape Verde*	RL	85.4	2.810	110.608	4.088	0.161	0.161	0.000	0.356	0.805	0.873
7	1962	Revolution in Northern Yemen	RL	96.6	2.484	468.367	5.341	0.153	0.153	0.019	0.387	0.748	0.927
8	1962-75	Dhofar Rebellion (Oman)	RP	43.8	5.479	101.259	4.011	0.204	0.204	0.000	0.183	1.022	0.569
9	1963-69	Bale Revolt in Southern Ethiopia	RP	91.9	2.612	202.792	4.614	0.154	0.154	0.000	0.383	0.771	0.920
10	1964	Zanzibar Revolution (Tanzania)	AL	78.3	3.065	219.372	4.682	0.608	0.032	0.000	0.326	1.282	0.948
11	1964-79	Rhodesian Bush War / Zimbabwe War of Liberation*	RL	109	2.204	285.053	4.910	0.137	0.137	0.000	0.454	0.683	1.044
12	1964-75	Mozambican War of Independence	RL	74.8	3.209	297.619	4.947	0.172	0.172	0.000	0.312	0.860	0.795
13	1965	March Intifada (Bahrain)*	RL	84	2.857	8537.929	7.863	0.170	0.170	0.035	0.319	0.816	0.808
14	1965	Malawi	AL	89.8	2.673	56.535	3.505	0.565	0.030	0.000	0.374	1.191	1.087
15	1965	Zambia	AL	79.6	3.015	303.883	4.965	0.603	0.032	0.012	0.325	1.277	0.946
16	1966-88	Namibia Struggle for Independence*	RL	70.7	3.395	2391.787	6.757	0.176	0.176	0.000	0.295	0.882	0.766
17	1967-70	Biafra (Nigeria)	RP	94.4	2.542	99.407	3.995	0.152	0.152	0.000	0.393	0.758	0.938
18	1968	May 1968 in France	RP	34.3	6.997	2532.315	6.807	0.214	0.214	0.000	0.143	1.071	0.500
19	1968	Prague Spring (Czechoslovakia)	RP	45.9	5.234	2392.730	6.758	0.202	0.202	0.000	0.191	1.011	0.584
20	1969-98	The Troubles (Northern Ireland)	RC	18.6	12.903	1291.350	6.222	0.231	0.231	0.000	0.078	1.153	0.386
21	1970-71	Black September (Jordan)	RP	77	3.117	372.094	5.141	0.170	0.170	0.000	0.321	0.849	0.811
22	1971	Bangladesh Liberation War**	RL	96.3	2.492	131.756	4.240	0.150	0.150	0.000	0.401	0.748	0.952
23	1974	Revolution in Ethiopia	RL	91.9	2.612	202.792	4.614	0.154	0.154	0.000	0.383	0.771	0.920
24	1975-91	Western Sahara War**	RL	82.2	2.921	430.366	5.268	0.164	0.164	0.000	0.342	0.822	0.849
25	1975-90	Lebanese Civil War	RP	80.5	2.981	1241.684	6.188	0.166	0.166	0.000	0.335	0.831	0.837
26	1975-02	Angola Civil War	RL	88.3	2.718	664.118	5.644	0.158	0.158	0.000	0.368	0.790	0.894
27	1977-92	Mozambican Civil War	RC	74.8	3.209	297.619	4.947	0.172	0.172	0.000	0.312	0.860	0.795
28	1978	Saur Revolution (Afghanistan)	RL	99.8	2.405	249.287	4.793	0.148	0.148	0.009	0.409	0.730	0.965
29	1978	Kurdish-Turkish Conflict	RP	74.4	3.226	1549.646	6.380	0.173	0.173	0.000	0.310	0.863	0.793

	1	2	3	4	5	6	7	8	9	10	11	12	13
	Years	*Revolution*	*O*	*FSI*	*α*	*GDP/c*	*γ*	F_i	F_c	*G*	*p*	*Ui*	U_c
30	1979	New Jewel Movement (Grenada)	AL	34.2	7.018	7804.762	7.785	0.774	0.041	0.000	0.143	1.631	0.415
31	1979	Iranian Revolution	RL	84	2.857	2426.454	6.770	0.164	0.164	0.008	0.344	0.813	0.852
32	1980	Coconut War (Republic of Vanuatu)	RP	84.6	2.837	770.466	5.774	0.162	0.162	0.000	0.353	0.809	0.867
33	1970-80	Zimbabwe	RL	109	2.204	364.054	5.122	0.137	0.137	0.000	0.454	0.683	1.044
34	1983-05	Second Sudanese Civil War**	RL	112	2.137	386.786	5.175	0.133	0.133	0.000	0.468	0.665	1.069
35	1986	People Power Revolution (Philippines)	AL	79.2	3.030	535.236	5.457	0.605	0.032	0.035	0.310	1.295	0.903
36	1987-91	First Intifada (Palestine)	RP	79.4	3.023	1201.582	6.160	0.167	0.167	0.000	0.331	0.836	0.829
37	1987	Singing Revolution (Estonia/Latvia/Lithuania)	RL	52.3	4.589	2514.150	6.801	0.196	0.196	0.000	0.218	0.978	0.631
38	1988	8888 Uprising (Burma / Myanmar)	RL	96.5	2.487	100.527	4.005	0.149	0.149	0.000	0.402	0.747	0.954
39	1989	Caracazo (Venezuela)	RP	81.2	2.956	2244.970	6.702	0.165	0.165	0.000	0.338	0.827	0.842
40	1989	Tiananmen Square Protests (China)	RL	82.5	2.909	310.882	4.985	0.164	0.164	0.000	0.344	0.820	0.852
41	1989	Velvet Revolution (Czechoslovakia)	RL	45.9	5.234	3130.910	6.991	0.202	0.202	0.000	0.191	1.011	0.584
42	1989	Peaceful Revolution (East Germany)	RL	39.7	6.045	17697.164	8.496	0.209	0.209	0.000	0.165	1.043	0.539
43	1989	Roman Revolution	RL	62.6	3.834	1817.902	6.519	0.185	0.185	0.000	0.261	0.924	0.706
44	1989	Hungary	RL	46.7	5.139	3349.770	7.050	0.201	0.201	0.000	0.195	1.007	0.591
45	1990	Poland	AL	47.9	5.010	2908.800	6.927	0.722	0.038	0.000	0.200	1.523	0.581
46	1990	Riots in Zambia	RL	79.6	3.015	409.258	5.224	0.167	0.167	0.000	0.332	0.835	0.830
47	1990-95	Log Revolution (Republic of Croatia)*	RL	61.9	3.877	4941.800	7.388	0.186	0.186	0.000	0.258	0.928	0.701
48	1990-95	First Touareg Rebellion in Mali and Niger	RP	80.8	2.970	313.202	4.992	0.166	0.166	0.000	0.337	0.829	0.839
49	1991	Shiite Uprising in Karbala (Iraq)	RP	109	2.202	10297.428	8.025	0.136	0.136	0.000	0.454	0.682	1.045
50	1991	Russia	AL	87.1	2.755	3485.056	7.084	0.599	0.032	0.129	0.272	1.312	0.795
51	1992-95	Bosnia War of Independence*	RL	88.5	2.712	318.020	5.005	0.158	0.158	0.000	0.369	0.789	0.895
52	1994	Zapatista Rebellion (Mexico)	RC	73.1	3.283	5715.410	7.514	0.174	0.174	0.000	0.305	0.869	0.783
53	1994-96	First Chechen War (Chechnya)*	RL	87.1	2.755	2663.395	6.851	0.165	0.165	0.025	0.342	0.798	0.848
54	1997-99	Rebellion in Albania	RL	68.6	3.499	717.380	5.711	0.179	0.179	0.000	0.286	0.893	0.750
55	1998	Kosovo Rebellion	RL	75.8	3.165	1675.910	6.449	0.171	0.171	0.000	0.316	0.855	0.803
56	1998	Bolivarian Rebellion (Venezuela)	AC	81.2	2.956	3874.982	7.177	0.601	0.032	0.103	0.271	1.342	0.790
57	1998	Indonesian Revolution	RL	89.2	2.691	463.969	5.333	0.157	0.157	0.000	0.372	0.785	0.900
58	1999-present	Second Chechen War (retake over by Russia)	RL	87.1	2.755	1330.751	6.248	0.161	0.161	0.006	0.358	0.796	0.876
59	2000-04	Second Intifada (Palestine)	RP	79.4	3.023	1476.172	6.338	0.167	0.167	0.000	0.331	0.836	0.829
60	2000	Bulldozer Revolution (Republic of Yugoslavia)	RL	69.2	3.467	2826.750	6.903	0.178	0.178	0.000	0.288	0.889	0.755

ISSN 1749-852X

Vol. 15, No. 1 (2020) | doi:10.15355/epsj.15.1.58

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
	Years	*Revolution*	*O*	*FSI*	*α*	*GDP/c*	*γ*	F_i	F_c	*G*	*p*	*Ui*	U_c
61	2001	Macedonia Conflict	RC	75.1	3.196	1815.920	6.518	0.172	0.172	0.000	0.313	0.859	0.798
62	2001	EDSA Revolution (Philippines)	RL	79.2	3.030	957.281	5.962	0.168	0.168	0.000	0.330	0.838	0.828
63	2001	Cacerolazo in Argentina	RL	40.8	5.882	7170.695	7.711	0.208	0.208	0.000	0.170	1.038	0.548
64	2003	Rose Revolution (Georgia)	RL	82.2	2.920	927.989	5.935	0.164	0.164	0.000	0.343	0.822	0.849
65	2003-present	Darfur Rebellion	RL	112	2.137	477.738	5.358	0.133	0.133	0.000	0.468	0.665	1.069
66	2004-05	Orange Revolution (Ukraine)	RL	72.9	3.292	1367.352	6.272	0.174	0.174	0.000	0.304	0.870	0.782
67	2005	Cedar Revolution (Lebanon)	RL	80.5	2.981	5390.208	7.463	0.168	0.168	0.010	0.327	0.831	0.823
68	2005	Tulip Revolution (Kyrgyzstan)	RL	90.3	2.658	476.552	5.356	0.156	0.156	0.000	0.376	0.780	0.908
69	2007-09	Tuareg Rebellion (Mali and Niger)	RP	83.4	2.879	444.098	5.295	0.163	0.163	0.000	0.347	0.816	0.858
70	2009	Malagasy Political Crisis (Madagascar)	RL	81.6	2.941	415.689	5.238	0.165	0.165	0.000	0.340	0.825	0.845
71	2010	Thai Political Protests (Thailand)	RP	78.8	3.046	5075.302	7.411	0.168	0.168	0.000	0.328	0.840	0.825
72	2010	Kyrgyzstani Revolution	RL	88.4	2.715	880.038	5.889	0.158	0.158	0.000	0.368	0.790	0.895
73	2010-	Arab Spring, Tunisia	RL	67.5	3.556	4140.152	7.234	0.180	0.180	0.000	0.281	0.898	0.742
74	2010-	Arab Spring, Algeria	RP	81.3	2.952	4463.395	7.299	0.167	0.167	0.009	0.331	0.827	0.829
75	2011-	Arab Spring, Jordan	RC	74.5	3.221	3807.324	7.161	0.172	0.172	0.000	0.310	0.862	0.793
76	2011-	Arab Spring, Mauritania	RP	88	2.727	1389.671	6.286	0.161	0.161	0.012	0.357	0.792	0.874
77	2011-	Arab Spring, Oman	RC	49.3	4.868	20986.085	8.644	0.199	0.199	0.000	0.205	0.993	0.609
78	2011-	Arab Spring, Saudi Arabia	RC	75.2	3.191	23770.747	8.752	0.174	0.174	0.013	0.302	0.859	0.779
79	2011-	Arab Spring, Egypt	RL	86.8	2.765	2747.480	6.878	0.165	0.165	0.024	0.341	0.799	0.847
80	2011-	Arab Spring, Yemen	RL	100	2.393	1349.420	6.260	0.146	0.146	0.000	0.418	0.728	0.981
81	2011-	Arab Spring, Iraq	RC	105	2.290	5854.614	7.535	0.141	0.141	0.000	0.437	0.704	1.014
82	2011-	Arab Spring, Bahrain	RC	59	4.068	22512.160	8.705	0.189	0.189	0.000	0.246	0.943	0.680
83	2011-	Arab Spring, Libya	RL	68.7	3.493	5602.549	7.497	0.178	0.178	0.000	0.286	0.892	0.751
84	2011-	Arab Spring, Kuwait	RC	59.5	4.034	48268.591	9.367	0.188	0.188	0.000	0.248	0.940	0.684
85	2011-	Arab Spring, Morocco	RC	76.3	3.145	3039.916	6.966	0.171	0.171	0.000	0.318	0.853	0.806
86	2011-	Arab Spring, Syria	RC	85.9	2.794	3292.240	7.035	0.166	0.166	0.024	0.337	0.804	0.840
87	2011-	Arab Spring, Lebanon	RP	87.7	2.737	8734.189	7.882	0.159	0.159	0.000	0.365	0.793	0.889

* Liberation Movement—liberation from outside powers, ** Liberation Movement—Resulting in secession and new state. Source: African Development Bank Statistics Department.

Notes: Column 3 header *O* means outcome using the acronym from Figure 1, i.e., incumbent wins and remains in power (RP), incumbent loses causing standoff (RS), incumbent loses causing coalition (RC), challenger becomes new incumbent (RL), incumbent wins and remains in power (AP), Incumbent loses causing standoff, (AS), Incumbent loses causing coalition (AC), and Challenger becomes new incumbent (AL). Column 4 header FSI means Fragile States Index, and column 5 header GDP/c means Gross Domestic Product per capita. Columns 7 to 13 header abbreviations are defined in Appendix A.