Incumbent policy, benefits provision, and the triggering and spread of revolutionary uprisings

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Abstract

This article analyzes revolutionary uprisings, such as the Arab spring of 2011. Revolutions occur with an inherent probability dependent on a country's characteristics. A country's incumbent leader can decrease this probability by providing benefits to a population, e.g., public goods such as necessities of life, health care, safety, and education. We equate the probability of revolution with Granovetter's equilibrium proportion of a population that joins a revolution. Decreased benefits provision increases the share of revolutionaries which, in turn, decreases the cost of revolt which helps resolve the free-rider problem implicit in revolting. The article quantifies how the incumbent chooses whether or not to provide benefits, and how many benefits to provide. We account for the unit cost of providing benefits and for the effects of the benefits provided, adjusted for whether the inherent revolution probability is low or high. Combining the modeling approaches, i.e., how revolutions spread and how the incumbent provides benefits, enriches our understanding of which factors affect revolutions and of how populations and their incumbent leaders interact. The model helps to understand the logic of revolutionary uprisings and how they can be curtailed.

We consider an incumbent leader's strategic benefits provision to a country's population. The population's choice of whether to initiate a revolution is first modeled probabilistically, endogenously affected by the incumbent's provision of benefits. To make individual involvement in revolution worthwhile, a sufficient number of people need to participate. A threshold has to be exceeded. The population's coordination problem is present, in part, in the revolution probability itself but we also model the coordination problem by assessing how a decrease in the incumbent's benefits provision increases the share of would-be revolutionaries, which would decrease citizens' average cost of revolting. Hence the free-rider problem, where citizens hope that others incur the cost of revolution, is alleviated.[1]

Since limits exist for what an incumbent can do, we distinguish between a country's characteristics and the incumbent's benefits provision. A country's characteristics, such as unemployment, inequality, ethnic fractionalization, institutional quality, presence of lack of human rights, implicit governmental repression, and so on, are given a parameter value which affects the revolution probability. Additionally, this probability depends on the incumbent's benefits provision. Benefits may be public goods such as health care and education, basic necessities of life, safety and security, political and socioeconomic rights, human rights, employment opportunities, education, or various privileges. Revolutions often, but not always, take place in countries where benefits such as these are not provided excessively, driven either by the form, nature, traditions and history of government, low GDP, or other factors. Mancur Olson argued that dictators provide public services only to the extent that GDP is increased. Accordingly, benefits provision is defined here as benefits exceeding GDP-enhancing benefits, with the objective of decreasing the revolution probability. The model intends to capture the tradeoffs and the range of possible outcomes better than does the current literature.[2]

Background and prior literature

Background

The Arab spring caused the eventual disposal of a number of autocratic leaders in the Middle East and North Africa (MENA) region. For many years, autocrats either held fraudulent elections (e.g., Tunisia) or no elections at all (e.g., Libya). In Tunisia, the population revolted and the autocrat relinquished power. A revolution may be sparked by how an incumbent reacts to an instigating event. Such an event lowers the cost of contribution for at least some rebels, may raise the benefits of contribution for at least some, may raise a rebel's potential share of the collective good, and may raise the probability of a successful revolution.

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Examples of instigating events are of a street vendor harassed by police and unleashing untapped frustration causing revolution (as in Tunisia on 17 December 2010), or any event where an incumbent has to decide whether to react with strategies such as no benefits provision or accommodation, or fraudulent elections generating results stirring the population. Such elections are typically held by autocrats and usually involve violence and manipulation.[3]

In 2012, Syria experienced economic disenfranchisement of young adults, including high youth unemployment. After the 2012 uprising the government was criticized, for instance, for repression and lack of human rights. Revolution has been described broadly as "any and all instances in which a state or a political regime is overthrown and thereby transformed by a popular movement in an irregular, extraconstitutional and/or violent fashion," and narrowly as entailing "not only mass mobilization and regime change, but also more or less rapid and fundamental social, economic and/or cultural change, during or soon after the struggle for state power." In Eastern Europe, the end of the cold war and the collapse of the Soviet Union brought a new wave of revolutions which saw the overthrow of the communist regimes in these countries. The revolutions during the cold war era and the collapse of the Soviet Union caused the decline of Marxist ideology, the liberalization of Eastern European countries from the communist system, and the introduction of market-oriented economic reforms. The 2014 Ukrainian revolution pertained to a struggle over orientation toward Moscow or Europe. Further East, the 2014 Thai revolution pertained to a desire for political reform.[4]

Literature

Although tentatively related approaches may have been made, the combined approach of the incumbent's benefits provision weighted against the probability of revolution appears not to have been considered in the literature in this manner. Grossman (1991) considers insurrections, and whether they can be deterred, as economic activities that compete with production for scarce resources. Accordingly, potential revolutionaries assess the time allocated to insurrection versus the time allocated to alternative activities, and they then choose an equilibrium with the highest expected income. Furthermore, Grossman (1999) assesses revolutions as kleptocratic rivalry where the incumbent chooses an optimal tax rate, striking a balance between production, funding soldiers, and suppressing revolutions, while assessing the revolutionaries' skills and preferences relative to the incumbent soldiers' skills. Grossman's (1999) choice of a tax rate has an impact similar to the incumbent's choice of benefits provision in this article, which affects whether or not revolutions occur.[5]

Revolutions occur with an inherent probability dependent on a country's characteristics. A country's incumbent leader can decrease this probability by providing benefits to a population. Decreased benefits increase the share of revolutionaries which, in turn, decrease the cost of revolt which helps resolve the free-rider problem implicit in revolting. The article quantifies how the incumbent chooses whether or not to provide benefits, and how many benefits to provide. The model helps to understand the logic of revolutionary uprisings and how they may be curtailed.

The literature on political revolutions is substantial and considers many facets. Kuran (1989) presents a theory of how political revolutions could occur in unanticipated ways. Examples include the 1789 French revolution, the 1917 Russian revolution, and the 1978–1979 Iranian revolution, all of which are often deemed to have come as a surprise. Bailyn (1992) considers the ideological origins of the 1765–1783 American revolution. More recently, the series of Arab spring revolutions were equally unanticipated. Beissinger (2007) develops an approach to understanding modular political phenomena such as revolutions, which occur as an emulation of the prior successful example of others, such as the post-communist revolutions of 2000–2006 and the Arab spring revolutions. Foran (1993) analyzes the earliest revolution theories and argues for the need to move to a new paradigm based on modeling economic, political, and cultural processes. Besley and Persson (2010) focus on conflict within the context of state capacity and development.[6]

Tullock (1971, 1974) made seminal contributions to our understanding of revolutions perceiving them mythical because of the free-rider dilemma (Olson, 1965) that an oppressed people will rise against a tyrannical ruler. A substantial literature has emerged explaining why and how revolutions nevertheless occur. If revolution is successful, the incumbent is replaced with someone else. For example, after 23 years in power, Tunisian President Zine El Abidine Ben Ali fled to Saudi Arabia on 14 January 2011, 28 days after the 17 December 2010 uprising.[7]

The following sections present our model, analyze how revolutionary uprisings are triggered and spread, and solve the model. The final section concludes.

The model

All incumbents fear revolution. We therefore consider an incumbent making a single strategic choice, namely, how many benefits, $G \geq 0$, where G is a real, noninteger number, to provide to the population while assessing the risk of revolution. The incumbent's unit cost of benefits provision is g. The incumbent

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is assumed to estimate the revolution probability, p, as

$$(1)\quad p=p(G)=\frac{1}{\alpha+\gamma G}, \frac{\delta p}{\delta \alpha}\leq 0,$$

with the first and second derivatives of G given by

$$(2)\quad \frac{\delta p}{\delta G}=\frac{-\gamma}{(\alpha+\gamma G)^2}, \frac{\delta^2 p}{\delta G^2}=\frac{2\gamma^2}{(\alpha+\gamma G)^3}.$$

Equation (1) reflects the inherent revolution probability, where $\alpha\geq 1$ and $\gamma\geq 0$ are parameters specific for a given country. Without benefits provision (i.e., when G=0), equation (1) simplifies to the benchmark p=1/α, where α is an average population satisfaction, well-being, prosperity, bliss, or societal happiness parameter. When α=1, people are unsatisfied, unhappy, and sometimes vengeful, resentful, vindictive, rebellious, and hostile, with the consequence that p=1, and revolution occurs with certainty. The more content the population, the larger is α, and therefore the smaller is the probability (p) of revolution.

The benchmark revolution probability p=1/α when G=0, is deemed high when unemployment, inequality, and ethnic fractionalization are high, institutional development is lacking, and implicit government repression is high. Further factors affecting 1/α are colonial origins and a country's resources, especially natural resource, the ready availability of which may make an incumbent less likely to adhere to the population's concerns. Included in α is the common occurrence that incumbents apply surveillance, supervision, indoctrination, spies, bribes, punishments for treason, and so on, to prevent revolutions (Tullock 1971, 1974).

The population observes the incumbent's choice of benefits provision, G. Whether the population chooses to start a revolution depends probabilistically on the incumbent's choice of G. (The next section considers the actual behavior of citizens.) Beyond 1/α, the incumbent is assumed to be able to decrease the revolution probability by providing benefits, G. The benefits impact parameter, γ, weighs benefits G against α and reflects the extent to which the incumbent's benefits provision affects the population in the sense of decreasing the revolution probability, p. The γ parameter also depends on the country's characteristics. For example, when γ=0, benefits provision, G, does not affect the revolution probability, p, a case that can be interpreted as extreme implicit government repression. More realistically, when γ>0, the country's situation is such that the incumbent may have incentives to choose positive benefits provision, G>0, although that depends on the total cost, gG, of benefits provision which has to be weighed against the incumbent's benefit of avoiding revolution. For the extreme events of α=1 and γ=0, or of α=1 and G=0 when γ>0 (since the incumbent cannot afford benefits provision), revolution is guaranteed. Commonly α>1, and when α increases as a country's situation improves, revolution becomes less likely. Similarly, when G increases, the revolution probability decreases. A revolution is less probable when α, γ, and/or G are large.

The incumbent benefits if no revolution occurs (or if it is unsuccessful). This occurs with probability 1–p. We assume that the incumbent benefits in proportion to 1–p. That is, if revolution is unsuccessful, the incumbent obtains benefit proportional to 1, and incurs a total cost, gG, of providing benefits to the population. In contrast, if the revolution is successful, with probability p, the incumbent obtains benefits proportional to 0, which corresponds to being ousted from government and being replaced with someone else, and incurs total cost, gG, of benefits provision to the population.

Accounting positively for the benefit 1–p of no revolution, and subtracting total cost, gG, of benefits provision to the population, the incumbent's expected utility, U, is given by

$$(3)\quad U=1-p-gG=1-\frac{1}{\alpha+\gamma G}-gG \text{ if } \frac{-\gamma g G^2+(\gamma-\alpha g)G+\alpha-1}{(\alpha+\gamma G)}\geq 0$$

and 0 otherwise, where g is the unit cost of benefits provision which then scales total cost, gG, against the probability, p. The if-condition in equation (3) follows from requiring positive expected utility $U\geq 0$. When G=0, the if-condition simplifies to 1–1/α ≥0, which is always satisfied since α≥1. Because of the quadratic term, $-\gamma g G^2$, the if-condition is not satisfied when G is arbitrarily large. Hence an upper limit exists for G. The if-condition in equation (3) can also be written so that the incumbent does not provide benefits, G, when $p\geq 1-gG$, i.e., when the revolution probability is high. However, increased G decreases the revolution probability. Later in the article we will see that provided that the incumbent has an incentive to choose positive $G\geq 0$, the expected utility cannot be negative.

When p=1 in equation (3), the first term with 1–p is 0 since the incumbent loses the revolution, gets no benefits, but incurs the cost, gG. In contrast, when p=ϵ>0, where ϵ is arbitrarily small but positive, which occurs when α is arbitrarily large, the incumbent earns 1–ϵ at the total cost of gG. If α is large, even modest benefits provision in the form of low G has the effect of lowering p. In contrast, if α is small, modest benefits provision G may increase p noticeably.

Summing up, the incumbent chooses benefits provision, G,

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to curtail the probability, p, of revolution. The revolution probability decreases as G increases, but providing G entails a cost, gG, which has to be weighed against the possible benefit of preventing the revolution.

How revolutionary uprisings are triggered and spread

Analysis and linkage to Granovetter

During a revolution, we observe participation by the population in riots or collective behavior which grows over time until the revolution succeeds or fails, and also depending on how the incumbent reacts. The dynamics of this collective behavior, analyzed by Granovetter (1978), can be linked directly to the parameters of the probability of a revolution. In Tunisia, the revolution began when vegetable vendor Mohammed Boazizi set himself on fire on 17 December 2010 in reaction to ill treatment by public officials and the police. President Ben Ali had earlier, in 2009, run fraudulent elections. In 2011, he then faced a revolution sparked by the eventual death of Mr. Boazizi from his burns.

We assume that the growth in the size of the participating crowds in the riots is proportional to the revolution probability, p, in equation (1). That is, growth is inversely proportional to the characteristics of the country captured by the parameter α, and inversely proportional to the incumbent's benefits provision, G, as moderated by parameter γ. When the denominator in (1) is low, and it cannot be below 1, then probability, p, of a revolution is high. If the country has high information and communication technology connectivity and developed media channels, then crowds have easier access to information and can mobilize more rapidly.

We now link our model to Granovetter's exposition. As mentioned, participation by the population in collective behaviors such as riots can grow over time until such time that it succeeds or fails depending on how the incumbent reacts. The bigger the crowd, the more likely is revolution. Therefore, we analyze how revolution can grow and spread within the country or region. The Arab spring revolutions of 2011 began in Tunisia and then spread to other parts of the MENA region, such as Bahrain, Egypt, Jordan, Libya, Morocco, Saudi Arabia, and Syria.

As in Granovetter (1978), consider the Boazizi incident which sparked the revolution. The revolutionaries reacted by taking to the streets demanding justice and, eventually, that President Ben Ali leave power. Denote the threshold for a revolutionary uprising by z. Then the frequency distribution is $f(z)$. The proportion of the population having a threshold less than or equal to z is given by a cumulative distribution function $F(z)$. Denote the point in time when a proportion of the population has joined the uprising with t, and let $r(t)$ be the proportion of the population which has joined at time t. Granovetter (1978) shows that the process of riot participating follows the difference equation

$$(4)\ r(t+1) = F[r(t)]$$

with an equilibrium at

$$(5)\ F(r) = r.$$

There then is a value of the probability of participation in a revolutionary riot, $F(r)=p$, at which the revolution succeeds. We thus link our model to Granovetter's analysis with the following definition.[8]

Definition: Assuming that the share of revolutionaries is proportional to the winning probability, p, the probability of participation in a revolutionary riot, $F(r)$, equals p when the revolution succeeds, i.e.,

$$(6)\ F(r)=r=p=\frac{1}{\alpha+\gamma G}.$$

Justification: Equation (6) follows from the argument above and from equations (4) and (5).

The definition reformulates Granovetter's (1978) approach using the terminology of this article. It shows how the incumbent, by adjusting benefits provision, G, can affect participation in a revolutionary riot. The riot spreads as described by Granovetter (1978) but, additionally, is affected by the inherent revolution probability, the incumbent's potential benefits provision, and the effect these benefits have on the population. Combining the two modeling approaches provides richer insights into how revolutions spread, and how incumbents can govern, amplify, suppress, or ignore their spread.

Incumbent's benefits provision and the free-rider problem

To show how a decrease in the incumbent's benefits provision, G, helps resolve the free-rider problem, we start with Figure 1 which uses equation (6) to plot the revolution probability, p, as a function of benefits provision, G. Due to irrelevance for the argument, scaling along the axes has been suppressed. (That said, Figure 1 uses equation (6) to plot p for α=1.2, γ=1, where G=high=3 and G=low=1.) Figure 1 and equation (6) illustrate that decreased benefits provision, G, increases the proportion $r=p$ of the population which has joined the revolution at time

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t. To show that this alleviates the free-rider problem we introduce the time dimension by considering three subsequent points in time, referred to as periods 1, 2, and 3.

In period 1, which may or may not be an equilibrium situation, the incumbent chooses high benefits provision, *G*, and the share of revolutionaries *r*=*p* happens to be low (see Figure 1). In period 2, we assume that the incumbent and a citizen in the population play the ordinal simultaneous move cooperation/defection 2x2 game in Table 1. Cooperation for the incumbent means to provide highly costly benefits, *G*=high, to the population, including the citizen. Conversely, the incumbent defects if *G*=low. If the incumbent chooses defection in period 2, we assume that the citizen's cost of revolting remains the same since the players choose their strategies simultaneously. This is realistic in practice since the share of revolutionaries does not change instantaneously from *r*=*p*=low to *r*=*p*=high when the incumbent changes from *G*=high to *G*=low. Period 2 is thus not depicted in Figure 1. Cooperation for the citizen means not to revolt, which is not costly, and the citizen defects when revolting, which is costly. Assume uncontroversially that each player prefers the other player to cooperate. That is, the incumbent prefers the citizen not to revolt, and the citizen prefers high benefits, *G*=high. Further assume that the parameters are such that the incumbent finds it more costly to provide high benefits, *G*=high, than low benefits, *G*=low, and overall prefers the latter to the former, regardless of whether the citizen revolts or not. Analogously, assume that the citizen finds it more costly to revolt than not to revolt, and overall prefers the latter to the former, regardless of whether the incumbent provides high or low benefits. The ordinal ranking of payoffs 4, 3, 2, and 1 from high to low for the two players are thus as in Table 1. The payoff before the comma in each cell is for the incumbent in the row. The payoff after the comma in each cell is for the citizen in the column.

The ordinally preferred payoff for each player for each possible strategy of the other player is shown in **bold type-font**, causing the Nash equilibrium 4,2 in the lower-left corner in period 2, i.e., payoffs 4 and 2 to the incumbent and citizen, respectively. This contrasts with period 1 depicted in the upper-left corner and payoffs 3,4 which are not an equilibrium in period 2. That is, in the transition from period 1 to period 2, the incumbent decreases his benefits provision from *G*=high to *G*=low, increasing his payoff from 3 to 4. The payoffs 4,2 in Table 1 constitute a Nash equilibrium in period 2 so long as the citizen continues not to revolt. As time elapses and we move to period 3, the period 2 Nash equilibrium becomes controversial since the incumbent's decrease of benefits provision, *G*, from high in period 1 to low in period 2 has consequences. More specifically, according to equation (6), decreasing *G* from high to low eventually increases the share *p* of revolutionaries from low to high causing point *B* in Figure 1.

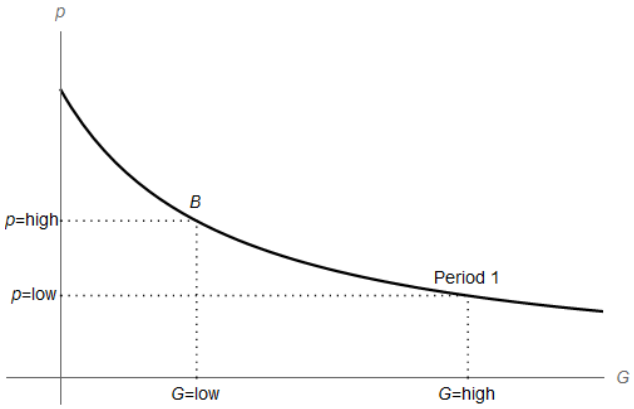

Figure 1: Revolution probability *p* as a function of benefits provision *G*.

Table 1: Cooperation/defection game between the incumbent and a citizen in a population

Citizen / *Incumbent*	*Cooperate (not revolt, which is not costly)*	*Defect (revolt, which is costly)*
Cooperate (provide highly costly benefits, G=high, to population)	3,**4**	1,3
Defect (provide less costly benefits, G=low, to population)	**4**,**2**	**2**,1

Table 2: Games between any two citizens 1 and 2 when *G*=high and *p*=low (left panel) and *G*=low and *p*=high (right panel)

	G=high; *p*=low		*G*=low; *p*=high	
Citizen 2 / *Citizen 1*	*Not revolt*	*Revolt*	*Not revolt*	*Revolt*
Not revolt	**2**,**2**	**4**,1	1,1	3,**2**
Revolt	1,**4**	3,3	**2**,3	**4**,**4**

To illustrate this phenomenon we proceed with the two games in Table 2. The ordinal 2x2 game on the left-hand side panel in Table 2 between any two citizens 1 and 2 in the

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population shows the game with high incumbent benefits provision, G=high, causing a low share $r=p$ of revolutionaries, as in period 1. Accordingly, the cost of revolting is high, in fact so high that each citizen prefers not to revolt regardless of whether the other citizen revolts or not. However, each citizen prefers that the other citizen incurs the high cost of revolting since a revolution may benefit both. Collectively, joint revolt is preferable to joint non-revolt. This gives the familiar prisoners' dilemma with the unique Nash equilibrium in the upper-left cell, where no citizen revolts.

In contrast, the ordinal 2x2 game on the right-hand side panel in Table 2 between citizens 1 and 2 assumes low incumbent benefits provision, G=low, causing a high share $r=p$ of revolutionaries, as in point B in Figure 1. We may assume that the high share, $r=p$, exceeds the critical k-threshold (Granovetter, 1978) for participation in the revolution. Since many other citizens, aside from the two in Table 2, have already started revolting, the costs of citizens 1 and 2 also joining the revolution is lower. In fact, assume that the cost of revolting is so low that each citizen in Table 2 prefers to revolt regardless of whether the other citizen revolts or not. This is possible when the benefits and probability of revolution are both high. Furthermore, each citizen prefers the other citizen to revolt regardless of whether oneself revolts. This gives the coordination game with the unique Nash equilibrium in the lower-right cell, where both citizens revolt. Table 2 illustrates how the incumbent's decrease of benefits provision from G=high to G=low helps overcome the free-rider problem inducing more citizens to join the revolution.

Social media and revolution

Social media enable revolutionaries to coordinate their activities quickly. The emergence of digital and social networking technology gradually overcomes various spatial divides in the spread of uprisings within a country or region. These media channels help swell the ranks of riots rather rapidly causing a likely unstoppable revolutionary situation for the incumbent. For example, Tunisia has a large population using mobile telephony, which facilitates communication.

The social networking capability also enables the information on an uprising in one geographic region to spread rapidly to other regions, thus engulfing an entire country. This ability also enables information to be transmitted to other countries in the neighborhood or with similar autocratic leadership, thus sparking a revolution in those countries as well. This describes what happened in the MENA region in 2011 and 2012. The spatial and temporal effects highlighted by Granovetter are lessened or altogether overcome by these technological enablers.

A literature has emerged in this regard. First, Starbird and Palen (2012) consider Twitter retweeting during the 2011 Egyptian uprising, revealing interaction between activists on the ground in Cairo and others elsewhere. Applying qualitative and statistical description, they show how the crowd expresses solidarity, and engages in recommendation and filtering, and how retweet-recommendations can be used together with other indicators from the ground to identify new information. Second, O'Leary (2016) analyzes cooperative retweeting settings, such as during the Arab spring revolutions, as games between retweeters, applying tit-for-tat strategies for retweeting, and considers retweet hijacking. Third, Pena-Lopez, Congosto, and Aragon (2014) consider networked citizen politics, involving decentralization and swarm-like Twitter action, among Spanish *Indignados* on 15 May 2011 and thereafter, one week prior to local and regional elections, and links to formal democratic institutions. Fourth, Lysenko and Desouza (2012) analyze the April 2009 Moldovian revolution. Initial mobilization occurred through social network and short-message services. Twitter was mostly used late in the revolution, to communicate locally and globally. They find that a successful revolution can occur with limited prior offline organization.

Solving the model

Having analyzed how revolutionary uprisings are triggered and spread, we now proceed to analyze the incumbent's optimal benefits provision.

Theorem 1: The incumbent's optimal benefits provision, G, revolution probability, p, and expected utility, U, are

$$G=\frac{\alpha}{\sqrt{\gamma g}}\left(\frac{1}{\alpha}-\sqrt{\frac{g}{\gamma}}\right) \text{ if } \sqrt{\frac{g}{\gamma}}\le\frac{1}{\alpha}, \text{ 0 otherwise;}$$

$$(7)\quad p=\sqrt{\frac{g}{\gamma}} \text{ if } \sqrt{\frac{g}{\gamma}}\le\frac{1}{\alpha}, \text{ } 1/\alpha \text{ otherwise;}$$

$$U=\left(1-\sqrt{\frac{g}{\gamma}}\right)^2+(\alpha-1)\frac{g}{\gamma} \text{ if } \sqrt{\frac{g}{\gamma}}\le\frac{1}{\alpha}, \text{ } 1-1/\alpha \text{ otherwise.}$$

Proof: The incumbent chooses the optimal G by differentiating U in (3) with respect to G. Equating the derivative with zero, solving, and inserting into (1) and (3), give (7). The second-order derivative is always satisfied as negative, i.e.,

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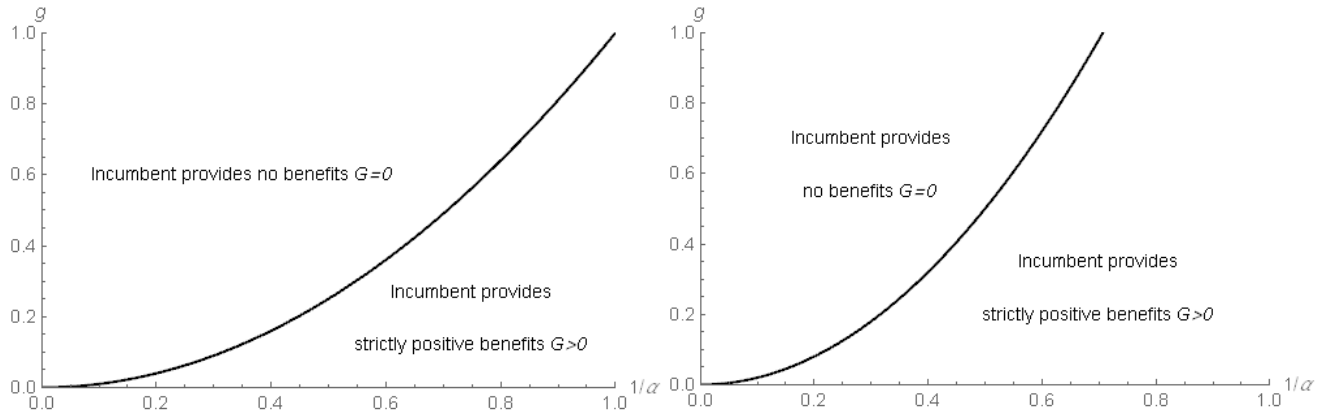

Figure 2: Two regions in the $(1/\alpha,\gamma)$ parameter space, separated by $g=\gamma/\alpha^2$, showing how the incumbent provides benefits when $g<\gamma/\alpha^2$, or does not provide benefits when $g\geq\gamma/\alpha^2$. Left-hand side panel: $\gamma=1$. Right-hand side panel: $\gamma=2$.

$$\frac{\delta U}{\delta G}=\frac{\gamma}{(\alpha+\gamma G)^2}-g=\gamma p^2-g=0 \text{ if } \sqrt{\frac{g}{\gamma}}\leq\frac{1}{\alpha}, \text{ 0 otherwise;}$$

(8)

$$\frac{\delta^2 U}{\delta G^2}=\frac{-2\gamma^2}{(\alpha+\gamma G)^3}<0 \text{ if } \sqrt{\frac{g}{\gamma}}\leq\frac{1}{\alpha}, \text{ 0 otherwise.}$$

The first-order derivative in equation (8) shows that for the incumbent's optimal benefits provision, G, the marginal benefit, γp^2, equals the marginal cost, g. This means that if the revolution probability, p, is low (high), squared, and multiplied with the benefits impact parameter, γ, then G is determined so that the marginal cost, g, is also low (high). Theorem 1 states that the square root of the ratio of the unit cost, g, and the benefits impact parameter, γ, has to be less than the inherent revolution probability, $1/\alpha$, for the incumbent to provide benefits, G, to the population. That is, providing benefits has to be sufficiently cheap, and/or the effect of the benefits has to be sufficiently large, for the incumbent to find it worthwhile to provide benefits. Provided that

(9) $G\geq 0 \Leftrightarrow \sqrt{g/\gamma}\leq 1/\alpha$,

the incumbent's expected utility, U, in equation (7) is always positive since it consists of a quadratic term and a positive term $(\alpha-1)g/\gamma$, where $\alpha\geq 1$.

Applying (7), Figure 2 shows two regions in the $(1/\alpha,\gamma)$ parameter space, separated by the curve $g=\gamma/\alpha^2$. When $g<\gamma/\alpha^2$, the first line in (7) applies, and the incumbent provides strictly positive benefits, $G>0$. That occurs when the unit cost, g, of benefits provision is low or the inherent revolution probability, $1/\alpha$, is high. Conversely, when $g\geq\gamma/\alpha^2$, the second line in (7) applies, and the incumbent provides no benefits, $G=0$. The left-hand side panel assumes $\gamma=1$, which gives a low curve with a large region for not providing benefits. The right-hand side panel assumes a γ twice as large, $\gamma=2$, causing the demarcation curve to increase more steeply, enlarging the region of benefits provision due to larger effect of benefits on curtailing the revolution probability.

Theorem 2: If $\sqrt{\frac{g}{\gamma}}\leq\frac{1}{\alpha}$ then

$$\frac{\delta G}{\delta\alpha}=\frac{-1}{\gamma}\leq 0,\ \frac{\delta p}{\delta\alpha}=0,\ \frac{\delta U}{\delta\alpha}=\frac{g}{\gamma}\geq 0,$$

$$\frac{\delta G}{\delta\gamma}=\frac{-\alpha}{\gamma^{3/2}\sqrt{g}}\left(\frac{1}{2\alpha}-\sqrt{\frac{g}{\gamma}}\right)\geq 0 \text{ if } \sqrt{\frac{g}{\gamma}}\leq\frac{1}{2\alpha},$$

(10)

$$\frac{\delta p}{\delta\gamma}=\frac{-\sqrt{g}}{2\gamma^{3/2}}\leq 0,\ \frac{\delta U}{\delta\gamma}=\frac{\sqrt{g\alpha}}{\gamma^{3/2}}\left(\frac{1}{\alpha}-\sqrt{\frac{g}{\gamma}}\right)\geq 0,$$

$$\frac{\delta G}{\delta g}=\frac{-1}{2g^{3/2}\sqrt{\gamma}}\leq 0,\ \frac{\delta p}{\delta g}=\frac{1}{2\sqrt{\gamma g}}\geq 0,\ \frac{\delta U}{\delta g}=\frac{-\alpha}{\sqrt{\gamma g}}\left(\frac{1}{\alpha}-\sqrt{\frac{g}{\gamma}}\right)\leq 0$$

Proof: Follows from differentiating (7).

Theorem 2 provides nine insights. *First*, and perhaps most

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crucial as advice to any incumbent, the incumbent's benefits provision, G, increases as the inherent revolution probability, $1/\alpha$, increases (i.e., the population's satisfaction parameter, α, decreases), driven by the incumbent's desire to prevent revolution by providing benefits. *Second*, and relatedly, the incumbent's expected utility, U, decreases as the inherent revolution probability, $1/\alpha$, increases. This result is driven, in part, by the cost to the incumbent to be located in a country with high $1/\alpha$, but also by that it is costly to provide benefits, G. *Third*, the incumbent's expected utility, U, increases as the benefits impact parameter, γ, increases. This follows since any given amount of benefits provision, G, now has larger effect on decreasing the revolution probability. Thus, *fourth*, the revolution probability, p, decreases as the benefits impact parameter, γ, increases. Hence, *fifth*, and conversely, the revolution probability, p, increases as the incumbent's unit cost, g, of benefits provision increases. This follows since, *sixth*, a larger g causes a lower G, which fails to decrease the revolution probability, p. Hence, *seventh*, the incumbent's expected utility, U, decreases as the unit cost, g, of benefits provision, G, increases. *Eighth*, the revolution probability, p, does not depend on the inherent revolution probability, $1/\alpha$, since when the incumbent provides benefits, these benefits depend on $1/\alpha$, and p depends only on g and γ. Finally, *ninth*, the benefits impact parameter, γ, has a mixed effect on the incumbent's benefits provision, G. When $\sqrt{g/\gamma} \leq 1/2\alpha$, which occurs when the unit cost, g, of benefits provision is low, or γ is large, or the inherent revolution probability, $1/\alpha$, is large, G increases asγ increases. This follows since when it is cheap to provide benefits, and the effect is large, and the inherent revolution probability is large, then increasing the impact parameter, γ, induces more benefits to be provided. However, this no longer holds when $\sqrt{g/\gamma} > 1/2\alpha$. In that case, increasing γ causes lower G. Hence, as $\sqrt{g/\gamma}$ increases from less than to greater than $1/2$, eventually G decreases as γ increases.[9]

Conclusion

This article analyzes revolutionary uprisings such as the Arab spring. An inherent revolution probability is considered, dependent on a country's characteristics. This probability is affected, and potentially decreased, by the incumbent leader of a country providing benefits to the population, e.g., public goods such as health care and security. We analyze how revolutionary uprisings are triggered and spread, incorporating Granovetter's (1978) model of collective behavior and riots. The proportion of the population that has joined the revolution at a given time is modeled as a difference equation. The equilibrium proportion is equated with the revolution probability, affected by the inherent revolution probability and the incumbent's benefits provision. We show how a decrease in the incumbent's benefits provision helps resolve the free-rider problem where citizens hope that others will incur the cost of revolting. Lower incumbent benefits provision increases the share of revolutionaries joining the revolution. When others already revolt, the cost of revolting for aditional citizens is lower.

The incumbent leader of the country can decrease the revolution probability by providing benefits to the population, e.g., public goods such as health care, education, and security. The reasoning process of the incumbent, affected by the probability that the population revolts, is modeled. The article quantifies the incumbent's various considerations.

The incumbent chooses strategically, at any point in time, or after an instigating event, how many benefits to provide to the population. Positive benefits mean accommodation. Examples of instigating events are fraudulent elections or mass demonstrations. The incumbent weighs the benefit of obtaining a low revolution probability against the cost of providing benefits, while accounting for the effect of benefits provision. The incumbent does not want to obtain a low revolution probability at any cost. Thus a frequently observed outcome, such as no benefits provision combined with losing the revolution, may arise because it gives the incumbent the highest expected utility.

We find that the incumbent, through adjusting benefits provision, can affect the participation in a revolutionary riot. The riot spreads as described by Granovetter (1978), and additionally is affected by the inherent revolution probability and the incumbent's benefits provision. Combining the two modeling approaches provides richer insights into how revolutions spread and how incumbents can govern or ignore their spread. Such insight is useful for incumbents, populations, revolutionaries, opponents of revolutionaries, policymakers, and leaders and actors in neighboring countries. Our model is applicable as a tool for adjusting the parameter values to determine the development and outcome of revolutions. Future research may search for data to support the comparative statics performed in this article.

Notes

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1. Probabilistically: 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. Yet examples also exist where the armed forces support the population. It is

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also possible, at least in theory, that the armed forces may support the challenger. Our approach allows for all of these interpretations. Threshold: See Granovetter (1978).

2. Olson: Olson (1965).

3. Instigating event: For a survey on the causes of civil war, see Blattman and Miguel (2010) who describe studies of cross-sectional inference using country-level data and panel-data studies accounting for within-country variation. Fraudulent elections: Reasons for why instigating events may emerge more easily in the Middle East have been explored by Kuran (2010, 2012). He argues (Kuran 2010) that the doctrine of Islamic economics is simplistic, incoherent, and largely irrelevant to present economic challenges, and that (Kuran 2012) what slowed the economic development of the Middle East was that, since around the tenth century, Islamic legal institutions started hampering the emergence of features such as private capital accumulation, corporations, large-scale production, and impersonal exchange. Violence and manipulation: See, e.g., Hermet, Rose, and Rouquié (1978) and Schedler (2007). The cost to the population of flawed elections involves loss of life, physical and mental injury, suppression of freedom of speech, and human rights violations. The election process can strengthen democratic institutions, but can worsen conflict (Collier 2009). The violent nature of election processes can have links to colonial roots (Acemoglu and Robinson 2006). Ellman and Wantchekon (2000) consider situations where one strong party controls sources of political unrest. This party likely wins with asymmetric information about its ability to cause unrest. Other related studies include Alesina (1988), Alesina and Rosenthal (1995), and Calvert (1985). See Lindberg (2006) for an analysis of democracy and elections in Africa. See Zimmermann (2012) for theories of violence and revolutions, and Migdal (2015) for revolutions and social change in the third world.

4. Syria: For a survey on the determinants of government repression and human rights violations, see Davenport (2007). The nexus of economic inequality, revolutions, and conflict has been analyzed by Besancon (2005). Revolution has been described: Goodwin (2001, p. 9).

5. Soldiers: Such funding is a delicate balance. Acemoglu, Vindigni, and Ticchi (2010) observe a common phenomenon after world war two where, in weakly institutionalized polities, civilian governments due to fear of military coups may choose weak armies that cannot end insurrections, thus prolonging civil wars. Revolutionaries' skills: See Casper and Tyson (2014) for elite coordination and popular protest in a *coup d' etat*, and Edmond (2013) for information manipulation, coordination, and regime change. Soldiers' skills: The interaction between revolutionaries and regime has also been analyzed by Angeletos, Hellwig, and Pavan (2007). They consider coordination among attackers over time and learning, e.g., about regime survival.

6. Russia: McFaul (2002) considers the Russian revolution to be unfinished.

7. A substantial literature: See, e.g., Kurrild-Klitgaard (2003) and Lichbach (1995) for reviews. Incumbent is replaced: A contest between an incumbent and a challenger is analyzed by Besley and Persson (2011) who assume 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.

8. In Definition 1 we have for simplicity ignored thresholds, and the share of revolutionaries may in practice be S-shaped as a function of the winning probability, p. That can be incorporated in future research.

9. Theorems 1 and 2 can be used to summarize the effect of parameters α, γ, and g on variables G, p, and U. A tabular presentation with the relevant mathematical expressions is available upon request from the corresponding author.

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