Economic Backwardness in Political Perspective

DARON ACEMOGLU *Massachusetts Institute of Technology*
JAMES A. ROBINSON *Harvard University*

We construct a simple model where political elites may block technological and institutional development, because of a "political replacement effect." Innovations often erode elites' incumbency advantage, increasing the likelihood that they will be replaced. Fearing replacement, political elites are unwilling to initiate change and may even block economic development. We show that the relationship between blocking and political competition is nonmonotonic: elites are unlikely to block development when there is a high degree of political competition or when they are highly entrenched. It is only when political competition is limited and also when their power is threatened that elites will block development. Blocking is also more likely when political stakes are higher, for example, because of land rents enjoyed by the elites. External threats, on the other hand, may reduce the incentives to block.

Government policies and institutions shape economic incentives, and via this channel, have a first-order impact on economic development. Why, then, do many societies adopt policies that discourage investment and maintain institutions that cause economic backwardness? Perhaps, politically powerful groups (elites) are not in favor of economic growth. But why? It would appear that economic growth would provide more resources for these groups to take over or tax, increasing their economic returns. So why don't powerful groups always support economic development?

In this paper, we develop a theory of inefficient government policies and institutions. All else equal, politically powerful groups would welcome superior institutions and technologies. But in practice all else is not equal, because superior institutions and technologies may reduce their political power and make it more likely that they will be replaced. At the center of our theory is therefore the idea that changes in institutions or the introduction of new technologies often create turbulence, eroding the political advantages and future economic rents of incumbent elites. Alternatively, new technologies may enrich competing groups, increasing their threat to incumbents. These considerations make politically powerful groups fear losing power and oppose economic and political change, even when such change will benefit society as a whole.

To understand the mechanism at work and its potential applications, consider a concrete example: industrialization in the nineteenth century. Bairoch (1982) estimates that between 1830 and 1913, world manufacturing output increased by a factor of 5 (see Table 1 Panel A). Nevertheless, this process was highly uneven across regions and countries. Bairoch also calculates that over the same period manufacturing output in developed countries (Europe and North America) increased by a factor of over 10, whereas it declined in the Third World. Among developed countries, there were also marked differences: while Britain and the U.S. adopted new technologies and industrialized rapidly, Russia, Austria-Hungary, and Spain lagged behind. Why did these countries fail to adopt new technologies that would have increased their incomes?

These differences in performance motivated Gerschenkron's famous essay, *Economic Backwardness in Historical Perspective* (1962), which focused on how relatively backward economies lacking the economic prerequisites for industrialization could compensate in different ways. However, in later work Gerschenkron recognized that the desire to promote the institutions necessary for industrialization varied considerably across countries. Indeed, in the countries that lagged the most, rather than actively promoting industrialization, political elites opposed it. Gerschenkron argued that in the case of Austria-Hungary, not only did the state fail to promote industrialization but also

> . . . economic progress began to be viewed with great suspicion and the railroads came to be regarded, not as welcome carriers of goods and persons, but as carriers of the dreaded revolution. Then the State clearly became an obstacle to the economic development of the country. (1970, 89)

So the problem of understanding why industrialization was rapid in some countries, whereas in others it did not get off the ground, is closely related to understanding why in some countries the state encouraged industrialization, whereas in others it did not. More explicitly: why did the state and the political elites in some societies not only fail to encourage industrialization, but also go even as far as blocking the introduction of new technologies and economic institutions necessary for industrialization, such as the production of well-functioning factor markets, property rights, and legal systems?

Our answer emphasizes the *political replacement effect*: political elites will block beneficial economic and institutional change when they are afraid that these changes will destabilize the existing system and make it more likely that they will lose political power and future rents. More specifically, everything else equal, political elites are less likely to be replaced when they adopt technologies and institutional changes that

Daron Acemoglu is Professor, Department of Economics, Massachusetts Institute of Technology, 50 Memorial Drive, Cambridge MA 02142 (daron@mit.edu).

James A. Robinson is Professor, Department of Government, Harvard University, 1737 Cambridge Street, Cambridge MA 02138 (jrobinson@gov.harvard.edu).

TABLE 1

Panel A: Per-Capita Levels of Industrialization (UK 1900 is 100)[a]

	1750	1800	1860	1913
Austria-Hungary	7	7	11	32
France	9	9	20	59
Germany	8	8	15	85
Italy	8	8	10	26
Russia	6	6	8	20
Spain	7	7	11	22
United Kingdom	10	16	64	115
United States	4	9	21	126
Japan	7	7	7	20
China	8	6	4	3

Panel B: Per-Capita GDP Levels[b]

	1820	1870	1900	1913
Austria	28	41	63	76
France	27	40	62	75
Germany	25	43	68	86
Italy	24	32	38	55
Russia	16	23	27	33
Spain	23	28	44	49
United Kingdom	38	71	100	110
United States	28	53	89	115
Japan	16	16	25	29
China	12	12	14	15

[a] *Source:* Bairoch 1982.
[b] *Source:* Maddison 1995. Maddison's data covers only Austria. Because Austria and Vienna were by far the richest parts of the Empire, these numbers severely overstate the prosperity of Austria-Hungary.

increase output (e.g., because they will be more popular). Moreover, such changes will also benefit elites by increasing future output and their revenues. So all else equal, the elites prefer technological change. All else is not equal, however, because such change may erode their political advantages relative to other groups that are benefiting from the changes or weaken their ability to control political challenges. As a result, in certain circumstances, institutional and technological change will increase the likelihood that the elites will lose power, creating the political replacement effect. This effect introduces a tradeoff for elites between the likelihood of maintaining power and rents conditional on maintaining power, and may induce them to block change. The presence of the political replacement effect implies that a Coase Theorem type of logic, maintaining that investments that increase the size of the social pie will always be carried out, does not apply. There is no (credible) way of compensating ex post the political elites who lose their power (Acemoglu 2003).

In the context of nineteenth-century industrialization, our model suggests that the elites, the monarchy and landowning interests, opposed industrialization and the necessary institutional changes, precisely because these changes were likely to erode their political power. In fact, in most cases, the rise of markets and industrialization have been associated with a shift of political power away from traditional rulers and landowners toward industrial and commercial interests, and ultimately to popular interests and the masses. For example, in Russia, the Tzar and political elites were initially strongly opposed to industrialization, or even to the introduction of railways. When industrialization in Russia finally got underway after the Crimean War, the fears of the elites were confirmed: industrialization brought social turbulence in urban centers, and political and social change, culminating in the 1905 Revolution. This is the idea underlying our political replacement effect. Even though the political elites in Russia may have preferred industrialization if they could be sure of maintaining power and taxing the proceeds, in practice they did oppose it because they were afraid of losing their political power.

In addition to proposing a mechanism for why countries may fail to adopt superior technologies and institutions, our framework also gives a number of comparative static results that provide interpretations of the historical evidence. The impact of political competition on blocking is nonmonotonic. Both political elites that are subject to competition and those that are highly entrenched are likely to adopt new technologies. With intense political competition, elites prefer to innovate, because otherwise they are likely to be replaced. With a high degree of entrenchment, incumbents are willing to innovate, because they are not afraid of losing political power. Instead, it is elites that are somewhat entrenched but still fear replacement that will block innovation. This nonmonotonicity result provides an interesting interpretation of the cross-country differences in industrialization. New technologies were rapidly adopted in Britain and subsequently Germany where the political elites—the landed aristocracy—were sufficiently entrenched. In contrast, in Russia and Austria-Hungary, where the monarchy and the aristocracy controlled the political system, but feared replacement, they were firmly against industrialization. Instead, they continued to rely on the existing system of production, including the feudal relations between lords and serfs.

Our analysis also shows that economic change is more likely to be blocked when there are greater rents to political elites from staying in power. This suggests that another factor contributing to stagnation in Russia and Austria-Hungary may have been the substantial rents obtained by the landed aristocracy from the more feudal labor relations in the agricultural sector of these countries. Rents were also influenced by the political institutions. At the dawn of the nineteenth century, both Russia and Austria-Hungary were ruled by absolute monarchies who were unconstrained by representative political institutions. In Britain, political institutions were very different. The absolute monarchy had been to a large extent emasculated by the Glorious Revolution of 1688 and had lost many prerogatives. Therefore, an important determinant of attitudes toward change will be the preexisting political institutions: when these institutions limit political rents, elites will be more favorable toward change.

This reasoning on the role of rents also suggests that differences in the level of human capital may be

important in shaping the elites' attitudes toward industrialization; because human capital is complementary to industrial activity, a high level of human capital makes future gains from industrialization larger relative to the rents from preserving the existing system, thus discouraging blocking by the elites.

Finally, we show that external threats often make incumbents more pro-innovation, because falling behind technologically makes counties vulnerable to foreign invasion. This insight may explain why the Russian defeat in the Crimean war or the American blockade of Japan changed political elites' attitudes toward industrialization and modernization.

Our paper is most closely related to the literature on interest group politics, where existing powerful interest groups may block the introduction of new technologies in order to protect their economic rents. In the context of development economics, this idea was first discussed by Kuznets (1968), developed at length by Olson (1982) and Mokyr (1990), and formalized by Krusell and Ríos-Rull (1996) and Parente and Prescott (1999). Although the idea that monopolists, or other interest groups, may block technical change at first appears similar to the thesis in this paper, it is fundamentally different. We argue that what is important is *not* economic rents that will be destroyed by the introduction of new technologies, but the erosion in the political power of the elites. After all, if the groups that have the political power to block change were to maintain their political power after the change is implemented, why wouldn't they be able to use the same power to redistribute some of the gains to themselves? This reasoning suggests that whether certain groups will lose economically or not is not as essential to their attitudes towards change as *whether their political power will be eroded*. This view is consistent with the fact that British landed aristocracy, which maintained its political power, supported industrialization despite its adverse effects on land values. Issues of "blocking" also arise in the literature on economic reform, for example, Fernández and Rodrik (1991), Alesina and Drazen (1991), or Hellman (1998) though with nothing analogous to the analysis here.

Finally, this paper is closely related to our previous work, Acemoglu and Robinson (2000a,b), and to Bourguignon and Verdier (2000) and Robinson (1997). In particular, Acemoglu and Robinson (2000a) suggested the idea that the greater impediment to economic development was not groups whose economic interests were adversely affected by economic change, but those whose political power were threatened. This paper formalizes this idea by introducing the political replacement effect in the context of a forward-looking dynamic political economy model, and obtains the novel result that the relationship between political competition and the desire of political elites' to block innovation can be nonmonotonic (see Bueno de Mesquita and Smith 2004 for a related nonmonotonicity). It also uses this framework to interpret cross-country differences in industrialization during the nineteenth century.

THE BASIC MODEL

We now discuss a simple model to illustrate the political mechanism preventing the introduction of superior technologies and institutions.

The Environment

Consider an infinite horizon economy in discrete time consisting of a group of citizens, with mass normalized to 1, an incumbent ruler, and an infinite stream of potential new rulers. All agents are infinitely lived, maximize the net present discounted value of their income and discount the future with discount factor, β. Whereas citizens are infinitely lived, an incumbent ruler may be replaced by a new ruler, and from then on receives no utility.

There is only one good in this economy, and each agent produces:

$$y_t = A_t,$$

where A_t is the state of "technology" available to the citizens at time t. A_t should be thought of as technology broadly construed, so that it also captures the nature of economic institutions critical to production. For example, a change in the enforcement of property rights such as the creation of new legal institutions, or the removal of regulations that prevent productive activities, or any kind of political and economic *reform* that encourages investment would correspond to an increase in A_t. In light of this, we use the terms "innovate" and "adopt new technologies and institutions" interchangeably.

When a new technology is introduced or there is beneficial institutional change, A increases to αA, where $\alpha > 1$. The cost of adopting the new technology or initiating institutional change is normalized to 0. In addition, if there is political change and the incumbent ruler is replaced, this also affects the output potential of the economy as captured by A. In particular, when the incumbent does not adopt a new technology, the "cost of political change"—that is, the cost of replacing the incumbent—is zA, whereas this cost is $z'A$ when he introduces the new technology. Notice that this "cost" can be negative; it may be less costly to replace the incumbent ruler than keep him in place, for example, because he is "incompetent."

Therefore, more formally:

$$A_t = A_{t-1}((1-p_t)(1+(\alpha-1)x_t)) + p_t(1+(\alpha-1)\widehat{x}_t - x_t z' - (1-x_t)\,z)), \quad \textbf{(1)}$$

where $x_t = 1$ or 0 denotes whether the new technology is introduced ($x_t = 1$) or not ($x_t = 0$) at time t by the incumbent ruler, whereas $\widehat{x}_t = 1$ or 0 refers to the innovation decision of a new ruler. Also, $p_t = 1$ denotes that the incumbent is replaced, while $p_t = 0$ applies when the incumbent is kept in place. (Notice that if the incumbent is replaced, what matters is the innovation decision of the newcomer. So even when the incumbent has chosen $x_t = 1$, if the newcomer chooses $\widehat{x}_t = 0$, the new technology will not be introduced. This assumption is inconsequential, however, because we will see

in the following that the newcomer will always choose $\widehat{x}_t = 1$.)

Because this equation is crucial for the analysis, it is worth dwelling on it. First focus on the case when $x_t = 0$, so that the incumbent ruler has not innovated. In this case, we have $A_t = A_{t-1}((1 - p_t) + p_t(1 + (\alpha - 1)\widehat{x}_t - z))$. Therefore, if citizens choose $p_t = 0$ and do not replace the ruler, there is no change in productivity; that is, $A_t = A_{t-1}$. Alternatively, citizens could choose $p_t = 1$, incurring the cost z. In this case, whether there is innovation or not then depends on the decision of the new ruler, $\widehat{x}_t$. Alternatively, when $x_t = 1$, the cost of replacing the ruler is z' and we have $A_t = A_{t-1}((1 - p_t)\alpha + p_t(1 + (\alpha - 1)\widehat{x}_t - z'))$.

The most important feature of this equation is that it allows us to model the notion that costs of political change depend on whether the new technology has been adopted. When the new technology is not introduced, the position of the incumbent is relatively secure, and it will be more costly to replace him. When the new technology is adopted, there is political uncertainty and *turbulence*, and part of the advantages of the incumbent are eroded. As a result, the cost of replacing the incumbent may be lower.

More explicitly, we assume that z and z' are random variables, enabling stochastic changes in rulers along the equilibrium path. The distribution function of these two shocks differ: z is drawn from the distribution F^N and z' is drawn from F^I, which is first-order stochastically dominated by F^N, capturing the notion that the introduction of a new technology creates turbulence and erodes part of the incumbency advantage of the initial ruler.

The assumption that costs (or opportunities) of replacing rulers are different following certain economic and institutional changes is essential for our argument. Without this, voters are always less likely to replace a ruler who adopts the new technology and provides greater output, and the ruler obtains greater returns with the new technology; therefore, there would never be any blocking. There are a number of reasons why costs of replacing rulers will indeed be affected by economic and institutional change in practice, and there are various ways of modeling these issues. For example:

Often, there is a contest for political power, and those with greater economic power are more likely to obtain it. New technologies often benefit not the rulers, but some of the competing groups. This is clearly the case in the example of nineteenth-century industrialization, where the bourgeoisie was the main beneficiary of economic growth and naturally used its new economic powers to gain political strength. This feature can be incorporated into our model in a number of ways. The simplest would be to assume that a disproportionate share of the benefits from new technology go to the candidate new ruler, who uses all of its income to contest power (this would be the case as long as returns from coming to power are sufficiently large). Then we can think of the cost of replacing rulers, z, as drawn from a cumulative probability distribution $F(z \mid Z)$, where Z is the total amount spent by the potential new ruler. A higher Z leads to a first-order stochastically dominated shift of the function F. Therefore, new technologies will enrich new groups, increase Z, and reduce expected cost of replacing rulers. This model directly maps into our setup. This approach is also consistent with the instances in which landed elites opposed industrialization because they feared political power moving away from themselves to the bourgeoisie.

Typically, political elites maintain their position by using military power. Imagine that there are K regions (or groups), and the ruler will be replaced if anyone of these regions has a successful insurrection. The ruler has some budget (or military personnel) M to allocate for control at the beginning of each period, and it will allocate this to minimize the probability of successful insurrection anywhere. Moreover, suppose that $N < K$ of these regions pose a threat, and the probability of insurrection in the other regions is 0. In the N regions, this probability is $Q(m)$ where m is military resources allocated to that region, and naturally $Q' < 0$. If a region poses a greater threat, more resources will be allocated there. As long as the society has the same organization of production and institutional features, there will be a high degree of persistence in which regions and groups oppose the greatest threat. For simplicity, suppose that if no new technology is introduced, the same regions continue to pose the threat, so the ruler knows which regions are dangerous at the time of allocating its resources. Then, he will allocate $m = M/N$ to each region that poses a threat, and the probability of replacement will be $q_{NI} = 1 - [1 - Q(M/N)]^N$. In contrast, the outcomes of new technologies, in terms of which segments of the society and which regions will be losers and winners and therefore in which regions there will be additional turbulence, are uncertain. Assume that after the new technology is introduced, there is a totally new draw of which regions pose the threat. Thus, the optimal strategy for the ruler after the introduction of new technology is to evenly distribute its resources across regions, that is, M/K in each region. Hence, the probability of replacement will be $q_I = 1 - [1 - Q(M/K)]^N > q_{NI}$ because $M/K < M/N$, and the ruler is not concentrating its resources in the dangerous areas. Therefore, economic and institutional change will create turbulence and increase the probability that the ruler will be replaced. It is straightforward to generalize this model by making the probability of replacement also a function of citizens' income, as in our baseline model, for example, by making $Q(m)$ not directly the probability of replacement, but the mean of the distribution of the cost of replacement, $F(z)$. With this generalization, this approach maps exactly into our current model. Notably, this approach is consistent with the historical instances, like Russia and Austria-Hungary, where the main fear of the political elites was revolutionary challenges to their power coming from the emergent proletariat in new industrial areas.

Rulers are in power because, by definition, they have managed to come to power and successfully fought challenges. We can think of some characteristic, ζ, which corresponds to the ability of the rulers to deliver public

goods to citizens or fight challenges. This characteristic will typically depend on the ruler and the environment; for example, $\zeta_r(e)$, where r denotes the ruler and e the environment. Suppose that the ruler will remain in power as long as $\zeta_r(e) \geq \zeta_c(e)$, where c denotes the challenger and $\zeta_c(e)$ can be thought of as a draw from a distribution G_c. Plausibly, $\zeta_r(e)$ remains constant as long as e remains constant, but when there is an innovation and the environment changes, say to e', there is a new draw from a distribution G_r, and the ruler maintains power if $\zeta_r(e') \geq \zeta_c(e')$. This model also maps into our reduced form setup with a different distribution of costs (or probability) of replacement, because by virtue of having previously survived in power, $\zeta_r(e)$ is already above a certain threshold (i.e., it can be thought of as a draw from a truncated-below version of the distribution function G_r), so is greater than the expected new draw from G_r. Intuitively, the ruler is in power because he is "selected" as a good match to the current environment, and by innovating, he would destroy this advantage. To make this model map into our current setup, we need to make the probability of replacement not simply a function of the innovation decision, but also of the incomes of the citizens, which is again straightforward.

Here, rather than pursue any one of these three, or other possible, specific models, we simply adopt the reduced form assumption that the costs of replacement come from the two different distribution functions, F^I and F^N, depending on whether there is innovation or not. Furthermore, to simplify the algebra, we assume that F^I is uniform over $[\mu - \frac{1}{2}, \mu + \frac{1}{2}]$, whereas F^N is uniform over $[\gamma\mu - \frac{1}{2}, \gamma\mu + \frac{1}{2}]$, where $\gamma \geq 1$. In this formulation, μ is an inverse measure of the degree of political competition: when μ is low, incumbents have little advantage, and when μ is high, it is costly to replace the incumbent. Note that μ can be less than $\frac{1}{2}$, and in fact, we will focus much of the discussion on the case in which $\mu < \frac{1}{2}$, so that citizens sometimes replace rulers. The case of $\mu = 0$ is of particular interest, because it implies that there is no incumbency advantage, and z is symmetric around zero.

On the other hand, γ is a measure of how much the incumbency advantage is eroded by the introduction of a new technology: when $\gamma = 1$, the costs of replacing the ruler are identical irrespective of whether a new technology is introduced or not. A new entrant becomes the incumbent ruler in the following period after he takes control, and it will, in turn, be costly to replace him. A higher γ, all else equal, also implies a lower probability of replacement for the ruler without innovation, thus makes the position of noninnovating rulers more secure.

Citizens replace the ruler if a new ruler provides them with higher utility. This assumption is made for simplicity, and similar results are obtained if citizens' replacement decision translates into stochastic replacement of rulers (e.g., via revolution, coup, or simple shifts of power). The important feature is that citizens are more likely to replace a ruler that provides them with less income, but their decisions are also influenced by costs of replacing rulers. These costs, in turn, depend on whether there are changes that erode the incumbency advantage of rulers.

We also assume that if an incumbent is replaced then whether or not innovation takes place in that period depends on what the new ruler does. Thus, if the incumbent innovates but is replaced the new ruler can decide not to innovate and this implies that there is no innovation (though as we shall see along the equilibrium path a new ruler always innovates).

Finally, rulers levy a tax T on citizens. We assume that when the technology is A, citizens have access to a nontaxable informal technology that produces $(1 - \tau)A$. This implies that it will never be optimal for rulers to impose a tax greater than τ.

It is useful to spell out the exact timing of events within the period.

1. The period starts with technology at A_t.
2. The incumbent decides whether to adopt the new technology, $x_t = 0$ or 1.
3. The stochastic costs of replacement, z_t or z'_t, are revealed.
4. Citizens decide whether to replace the ruler, p_t.
5. If they replace the ruler, a new ruler comes to power and decides whether to adopt the new technology $\widehat{x}_t = 0$ or 1.
6. The ruler in power decides the tax rate, T_t.

Social Planner's Solution

We start by characterizing the technology adoption and replacement decisions that would be taken by an output-maximizing social planner. This can be done by writing the end-of-period Bellman equation for the social planner, $S(A)$. As with all value functions, we use the convention that $S(A)$ refers to the end-of-period value function (after step 6 in the timing of events above). By standard arguments, this value function can be written as:

$$\begin{aligned} S(A) = A + \beta\Bigg[& x^S \int \left[\left(1 - p_I^S(z')\right)S(\alpha A) + p_I^S(z') \right. \\ & \left. \times \left(\widehat{x}^S S((\alpha - z')A) + (1 - \widehat{x}^S)S((1 - z')A)\right)\right] dF^I \\ & + (1 - x^S) \int \left[\left(1 - p_N^S(z)\right)S(A) + p_N^S(z) \right. \\ & \left. \times \left(\widehat{x}^S S((\alpha - z)A) + (1 - \widehat{x}^S)S((1 - z)A)\right)\right] dF^N \Bigg], \end{aligned} \tag{2}$$

where x^S denotes whether the social planner dictates that the incumbent adopts the new technology, while $\widehat{x}^S$ denotes the social planner's decision of whether to adopt the new technology when he replaces the incumbent with a new ruler. $p_I^S(z') \in \{0, 1\}$ denotes whether the planner decides to replace an incumbent who has innovated when the realization of the cost of replacement is z', whereas $p_N^S(z) \in \{0, 1\}$ is the decision to replace an incumbent who has not innovated as a function of the realization z.

Intuitively, when technology is given by A, the total output of the economy is A, and the continuation value depends on the innovation and the replacement decisions. If $x^S = 1$, the social planner induces the incumbent to adopt the new technology, and the social value when he is not replaced is $S(\alpha A)$. When the planner decides to replace the incumbent, there is a new ruler and the social planner decides if he will adopt the new technology, $\widehat{x}^S$. In this case, conditional on the cost realization, z', the social value is $S((\alpha - z')A)$ or $S((1 - z')A)$ depending on whether the new technology is adopted. Notice that if $\widehat{x}^S = 1$ and the newcomer innovates, this affects the output potential of the economy immediately, hence the term $(\alpha - z')A$. The second line of (2) is explained similarly following a decision by the planner not to innovate. The important point in this case is that the cost of replacement is drawn from the distribution F^N not from F^I.

By standard arguments, $S(A)$ is strictly increasing in A. This immediately implies that $S((\alpha - z')A) > S((1 - z')A)$ since $\alpha > 1$, so the planner will always choose $\widehat{x}^S = 1$. The same reasoning implies that the social planner would like to replace an incumbent who has innovated when $S((\alpha - z')A) > S(\alpha A)$, that is, when $z' < 0$. Similarly, she would like to replace an incumbent who has not innovated when $S((\alpha - z)A) > S(A)$, that is, when $z < \alpha - 1$. Substituting for these decision rules in (2), the decision to innovate or not boils down to a comparison of

Value from innovating

$$= \left(\int_0^{\mu+\frac{1}{2}} S(\alpha A)\, dz' \right) + \left(\int_{\mu-\frac{1}{2}}^{0} S((\alpha - z')A)\, dz' \right)$$

and

Value from not innovating

$$= \left(\int_{\alpha-1}^{\gamma\mu+\frac{1}{2}} S(A)\, dz \right) + \left(\int_{\gamma\mu-\frac{1}{2}}^{\alpha-1} S((\alpha - z)A)\, dz \right).$$

In the Appendix, we show that the first expression is always greater. Therefore, the social planner always innovates. Intuitively, the society receives two benefits from innovating: first, output is higher; second, the expected cost of replacing the incumbent is lower. Both of these benefits imply that the social planner always strictly prefers $x^S = 1$. For future reference, we state (for a formal proof see Acemoglu and Robinson, 2002):

Proposition 1. *The social planner always innovates, that is,* $x^S = 1$.

Equilibrium

We now characterize the decentralized equilibrium of this game. We will limit attention to pure strategy Markov Perfect Equilibria (MPE) of this repeated game. The strategy of the incumbent in each stage game is simply a technology adoption decision, $x \in [0, 1]$, and a tax rate $T \in [0, 1]$ when in power, the strategy of a new entrant is also similarly, an action, $\widehat{x} \in \{0, 1\}$ and a tax rate $\widehat{T}$. The strategy of the citizens consists of a replacement rule, $p(x, z, z') \in \{0, 1\}$, with $p = 1$ corresponding to replacing the incumbent. The action of citizens is conditioned on x, because they move following the technology adoption decision of the incumbent. At this point, they observe z, which is relevant to their payoff, if $x = 0$, and z', if $x = 1$. An MPE of this game consists of a strategy combination $\{x, T, \widehat{x}, \widehat{T}, p(x, z, z')\}$, such that all these actions are best responses to each other for all values of the state A.

We will characterize the MPEs of this game by writing the appropriate Bellman equations. Let us denote the end-of-period value function of citizens by $V(A)$ (once again this is evaluated after step 6 in the timing of events), with A inclusive of the improvement due to technology adoption and the losses due to turbulence and political change during this period. With a similar reasoning to the social planner's problem, we have:

$$\begin{aligned} V(A) = A(1 - T) + \beta \Bigg[& x \int [(1 - p_I(z'))V(\alpha A) + p_I(z') \\ & \times (\widehat{x}V((\alpha - z')A) + (1 - \widehat{x})V((1 - z')A))]\, dF^I \\ & + (1 - x) \int [(1 - p_N(z))V(A) + p_N(z) \\ & \times (\widehat{x}V((\alpha - z)A) + (1 - \widehat{x})V((1 - z)A))]\, dF^N \Bigg], \end{aligned} \quad \textbf{(3)}$$

where $p_I(z')$ and $p_N(z)$ denote the decisions of the citizens to replace the incumbent as a function of his innovation decision and the cost realization. Intuitively, the citizens produce A and pay a tax of TA. The next two lines of (3) give the continuation value of the citizens. This depends on whether the incumbent innovates or not, $x = 1$ or $x = 0$, and on the realization of the cost of replacing the incumbent. For example, following $x = 1$, citizens observe z' and decide whether to keep the incumbent. If they do not replace the incumbent, $p_I(z') = 0$, then there is no cost, and the value to the citizens is $V(\alpha A)$. In contrast, if they decide $p_I(z') = 1$, that is, they replace the incumbent, then the value is $V((\alpha - z')A)$ when the newcomer innovates, and $V((1 - z')A)$ when he doesn't. The third line is explained similarly as the expected continuation value following a decision not to innovate by the incumbent.

The end-of-period value function for a ruler (again evaluated after step 6 in the timing of the game, so once he knows that he is in power) can be written as

$$\begin{aligned} W(A) = TA + \beta \Bigg[& x \int (1 - p_I(z'))W(\alpha A)\, dF^I \\ & + (1 - x) \int (1 - p_N(z))W(A)\, dF^N \Bigg]. \end{aligned} \quad \textbf{(4)}$$

The ruler receives tax revenue of TA, and receives a continuation value which depends on his innovation decision x next period. This continuation value also depends on the draw z' or z, indirectly through the replacement decisions of the citizens, $p_I(z')$ and $p_N(z)$.

Standard arguments immediately imply that the value of the ruler is strictly increasing in T and A. Because, by construction, in an MPE the continuation value does not depend on T, the ruler will choose the maximum tax rate $T = \tau$.

Next, consider the innovation decision of a new ruler. Here, the decision boils down to the comparison of $W((1-z)A)$ and $W((\alpha - z)A)$. Now the strict monotonicity of (4) in A and the fact that $\alpha > 1$ imply that $\widehat{x} = 1$ is a dominant strategy for the entrants.

The citizens' decision of whether or not to replace the incumbent ruler is also simple. Again by standard arguments $V(A)$ is strictly increasing in A. This is an important point and emphasizes that citizens will be happier with and less likely to replace a ruler that provides them with greater income. Thus all else equal, greater income (and better technology) further helps the ruler by increasing his chances of remaining in power. Nevertheless, adoption of new technology not only increases income but also creates greater uncertainty, eroding the political advantages of the ruler. This erosion is the source of the tradeoff facing the ruler in deciding whether or not to innovate.

More specifically, citizens will replace the incumbent ruler whenever $V(A) < V(A')$, where A is the output potential under the incumbent ruler and A' is the output potential under the newcomer. Now consider a ruler who has innovated and drawn a cost of replacement z'. If citizens keep him in power, they will receive $V(\alpha A)$. If they replace him, taking into account that the new ruler will innovate, their value is $V((\alpha - z')A)$. Then, their best response is:

$$p_I(z') = 0 \quad \text{if } z' \geq 0 \quad \text{and} \quad p_I(z') = 1 \quad \text{if } z' < 0. \qquad \textbf{(5)}$$

Next, following a decision not to innovate by the incumbent, citizens compare the value $V(A)$ from keeping the incumbent to the value of replacing the incumbent and having the new technology, $V((\alpha - z)A)$. So:

$$p_N(z) = 0 \quad \text{if } z \geq \alpha - 1 \quad \text{and} \quad p_N(z) = 1 \quad \text{if } z < \alpha - 1. \qquad \textbf{(6)}$$

It is noteworthy that replacement rule of the citizens is identical to the one used by the social planner above. This shows that the only source of inefficiency in the model stems from the innovation decision by the incumbent ruler.

Finally, the incumbent will decide whether to innovate by comparing the continuation values. Using the decision rule of the citizens, the return to innovating is $\int_{\mu-\frac{1}{2}}^{\mu+\frac{1}{2}} (1 - p_I(z')) \cdot W(\alpha A) dF^I$, and the value to not innovating is given by the expression $\int_{\gamma\mu-\frac{1}{2}}^{\gamma\mu+\frac{1}{2}} (1 - p_N(z)) \cdot W(A) dF^N$. Now incorporating the decision rules (5) and (6), and exploiting the uniformity of the distribution function F^I, we obtain the value of innovating as

$$\text{Value from innovating} = [1 - F^I(0)]W(\alpha A) = P\left[\frac{1}{2} + \mu\right] W(\alpha A), \qquad \textbf{(7)}$$

where the function P is defined as follows: $P[h] = 0$ if $h < 0$, $P[h] = h$ if $h \in [0, 1]$, and $P[h] = 1$ if $h > 1$, making sure that the first term is a probability (i.e., it does not become negative or greater than 1). Similarly, the value to the ruler of not innovating is

$$\begin{aligned} &\text{Value from not innovating} \\ &= [1 - F^N(\alpha - 1)]W(A) \\ &= P\left[\frac{1}{2} + \gamma\mu - (\alpha - 1)\right] W(A), \end{aligned} \qquad \textbf{(8)}$$

which differs from (7) for two reasons: the probability of replacement is different, and the value conditional on no-replacement is lower.

It is straightforward to see that if $P[\frac{1}{2} + \gamma\mu - (\alpha - 1)] < P[\frac{1}{2} + \mu]$, so that the probability of replacement is higher after no-innovation than innovation, the ruler will always innovate—by innovating, he is increasing *both* his chances of staying in power and his returns conditional on staying in power. Therefore, there will only be blocking of technological or institutional change when

$$P\left[\frac{1}{2} + \gamma\mu - (\alpha - 1)\right] > P\left[\frac{1}{2} + \mu\right]; \qquad \textbf{(9)}$$

that is, when innovation, by creating "turbulence," increases the probability that the ruler will be replaced. For future reference, note that by the monotonicity and continuity of the function $P[.]$ there exists a $\bar{\gamma}$, such that (9) holds only when $\gamma > \bar{\gamma}$. Therefore, as long as $\gamma \leq \bar{\gamma}$, there will be no blocking of new technologies or institutional change.

To fully characterize the equilibrium, we now conjecture that both value functions are linear, $V(A) = v(x)A$ and $W(A) = w(x)A$. The parameters $v(x)$ and $w(x)$ are conditioned on x, because the exact form of the value function will depend on whether there is innovation. (More generally, one might want to write $v(x, \hat{x})$ and $w(x, \hat{x})$, but we suppress the second argument, because in any MPE, we have $\hat{x} = 1$.) Note however that $w(x)$ and $r(x)$ are simply parameters, independent of the state variable, A. It is straightforward to solve for these coefficients (see the Appendix). Here, the condition for the incumbent to innovate, that is, for (7) to be greater than (8), can be written simply as:

$$\begin{aligned} w(x)\alpha A P\left[\frac{1}{2} + \mu\right] &\geq w(x) A P\left[\frac{1}{2} + \gamma\mu - \left(\alpha - 1\right)\right] \\ &\Longleftrightarrow \\ \alpha P\left[\frac{1}{2} + \mu\right] &\geq P\left[\frac{1}{2} + \gamma\mu - (\alpha - 1)\right]. \end{aligned} \qquad \textbf{(10)}$$

When will the incumbent adopt the new technology? First, consider γ. A higher γ always discourages innovation. This is intuitive, because a higher level of γ increases the security of the ruler in the absence of innovation; hence, it implies a greater *erosion* of entrenchment.

Next, consider μ, which affects the extent of entrenchment both before and after change and hence

can be thought of as to measure of the degree of political competition. Now imagine the case $\mu = 0$, where there is no incumbency advantage (i.e., the cost of replacing the incumbent is symmetric around 0). In this case, there is "fierce" competition between the incumbent and the rival. Condition (10) then becomes $\alpha P[\frac{1}{2}] > P[\frac{1}{2} - (\alpha - 1)]$, which is always satisfied because $\alpha > 1$. Therefore, when $\mu = 0$, the incumbent will always innovate; that is, $x = 1$. By continuity, for μ low enough, the incumbent will always innovate. Intuitively, when μ is low, because the rival is as good as the incumbent, citizens are very likely to replace an incumbent who does not innovate. As a result, the incumbent innovates in order to increase his chances of staying in power. The more general implication of this result is that incumbents facing fierce political competition, with little incumbency advantage, are likely to innovate because they realize that if they do not innovate they will be replaced.

Next, consider the polar opposite case where $\mu \geq 1/2$; that is, there is a very high degree of incumbency advantage. In this situation $P[\mu + \frac{1}{2}] = 1 \geq P[\frac{1}{2} + \gamma\mu - (\alpha - 1)]$, so there is no advantage from not innovating because the incumbent is highly *entrenched* and cannot lose power. This establishes that highly entrenched incumbents will also adopt the new technology.

The situation is different, however, for intermediate values of μ. Inspection of condition (10) shows that for μ small and γ large, incumbents will prefer not to adopt the new technology. This is because of the *political replacement effect*, which operates in the case where $\gamma > \bar{\gamma}$: the introduction of new technology increases the likelihood that the incumbent will be replaced, effectively eroding his future rents. As a result, the incumbent may prefer not to innovate in order to increase the probability that he maintains power. The reasoning is similar to the replacement effect in industrial organization emphasized by Arrow (1962): incumbents are less willing to innovate than entrants because they will be partly replacing their own rents. Here this replacement refers to the rents that the incumbent is destroying by increasing the likelihood that he will be replaced.

To determine the parameter region where blocking happens, note that there can only be blocking when both $P[\frac{1}{2} + \mu]$ and $P[\frac{1}{2} + \gamma\mu - (\alpha - 1)]$ are between 0 and 1, hence respectively equal to $\frac{1}{2} + \mu$ and $\frac{1}{2} + \gamma\mu - (\alpha - 1)$. Then from (10), it is immediate that there will be blocking when

$$\gamma > \alpha + \frac{3}{2}\frac{\alpha - 1}{\mu}. \qquad \textbf{(11)}$$

Hence, as $\alpha \to 1$, provided that $\gamma > 1$, there will always be blocking. More generally, a lower gain from innovation; that is, a lower α makes blocking more likely.

Clearly, because the social planner always adopts new technologies, whenever the incumbent ruler decides not to adopt, there is inefficient blocking of beneficial technological and institutional change.

Finally, also note that condition (10) does not depend on A. Therefore, if an incumbent finds it profitable to block change, all future incumbents will also do so. There will still be increases in A, as incumbents are sometimes replaced and newcomers undertake innovations, but there will never be a transition to a political equilibrium with no blocking.

We now summarize the main results of this analysis:

Proposition 2. *A higher γ always discourages innovation. The effect of μ is ambiguous*: *when μ is sufficiently small or large* (*political competition very high or very low*), *the elites will always innovate. For intermediate values of μ, economic change may be blocked.*

As emphasized above, elites will block change because of the political replacement effect: in the region where blocking is beneficial for the incumbent ruler, the probability that he will be replaced increases when there is economic change. This implies that the incumbent ruler fails to fully internalize future increases in output, making him oppose change.

Perhaps the most interesting results is the nonmonotonic relationship between political institutions, as captured by μ, and economic change. Because μ is the only measure of political competition in our model, a low level of μ corresponds both to limited incumbency advantage and to lack of political threats, and more generally, to an environment where the masses have some degree of control over political elites. For example, we think of a society like the United States in the nineteenth century with weak political elites tightly constrained by institutions and high levels of political participation as corresponding to low μ, whereas Germany and Britain where the landed aristocracy, through the House of Lords and the Coalition of Iron and Rye, were highly entrenched correspond to a high value of μ. Moreover, changes in domestic or foreign situations can correspond to changes in μ. For example, the defeat of Russia in the Crimean War is likely to have increased the political threat to the monarchy, and via this channel, to have reduced μ.

Political competition is often viewed as a guarantee for good political outcomes, and this view has motivated many constitutions to create a level playing field. Our model partly confirms this view; with low μ new technologies will be adopted, because citizens will remove incumbents who do not innovate. And yet, it also highlights potential costs from political competition under different conditions (for other ranges of parameters): whereas highly entrenched political elites, that is, those with very high levels of μ adopt beneficial economic change, and those with intermediate values of μ fear replacement and are likely to resist change.

POLITICAL STAKES AND DEVELOPMENT

So far we have considered a model in which the only benefit of staying in power was future tax revenues from the same technology that generated income for the citizens. There are often other sources of (pecuniary and nonpecuniary) rents for political elites, which will affect the political equilibrium by creating greater

"stakes" from staying in power. This relates to an intuition dating back to Madison, Hamilton, and Jay (1987) that emphasizes the benefits of having limited political stakes. We now introduce these additional sources of rents for political elites, enabling us to formalize this intuition: when rents from political power, "political stakes," are large, for example, because of rents from land and natural resources, or because existing political institutions do not constrain extraction by rulers, political elites will be more likely to block development. We will also use this extended model to discuss the importance of human capital in affecting the political equilibrium and show that high human capital will make blocking less likely.

We model these issues in a simple way by allowing income at date t to be $A_t h$, where h represents the exogenous stock of human capital. We assume that the structure of taxation is as before so that now the ruler gets tax income of $\tau A_t h$, and we additionally assume that a rent of R accrues to the ruler in each period. The two important assumptions here are: first, the political rent to the incumbent does not grow linearly with technology, A. This implies that a higher A makes the political rent less important. This is reasonable in our context, because in the applications that follow we would like to think of R as related to rents from preindustrial production relations. Second, human capital is more complementary to technology than to the other assets in the economy that are generating the political rents. This is again plausible since we consider $A_t h$ as income from new sectors, industry and commerce.

Let us now write the value function for the citizen, denoted $\widehat{V}(Ah)$:

$$\begin{aligned}\widehat{V}(Ah) = Ah(1-T) + \beta\Bigg[x\int[(1-p_I(z'))\widehat{V}(\alpha Ah) + p_I(z') \\ \times(\widehat{x}\widehat{V}((\alpha-z')Ah) + (1-\widehat{x})\widehat{V}((1-z')Ah))]\,dF^I \\ + (1-x)\int[(1-p_N(z))\widehat{V}(Ah) + p_N(z) \\ \times(\widehat{x}\widehat{V}((\alpha-z)Ah) + (1-\widehat{x})\widehat{V}((1-z)Ah))]\,dF^N\Bigg].\end{aligned} \tag{12}$$

Equation (12) is very similar to (3). The value for the incumbent ruler, $\widehat{W}(Ah, R)$, is

$$\begin{aligned}\widehat{W}(Ah, R) = TAh + R + \beta\Bigg[x\int(1-p_I(z')) \\ \times\widehat{W}(\alpha Ah, R)\,dF^I + (1-x) \\ \times\int(1-p_N(z))\widehat{W}(Ah, R)\,dF^N\Bigg],\end{aligned}$$

whose interpretation is immediate from (4). A major difference from before is that whether blocking is preferred by the incumbent ruler will now depend on the value of A.

Again let us start with the decision of citizens. As before, $\widehat{V}(Ah)$ is strictly increasing, so the citizens will use the same replacement rules as before, (5) and (6). Then, with a similar reasoning, the value to the incumbent ruler of innovating and not innovating at time t are given by:

$$\begin{aligned}&\text{Value from innovating} \\ &= [1-F^I(0)]\widehat{W}(\alpha A_t h, R) \\ &= P\left[\frac{1}{2}+\mu\right]\widehat{W}(\alpha A_t h, R)\end{aligned} \tag{13}$$

and

$$\begin{aligned}&\text{Value from not innovating} \\ &= [1-F^N(\alpha-1)]\widehat{W}(A_t h, R) \\ &= P\left[\frac{1}{2}+\gamma\mu-(\alpha-1)\right]\widehat{W}(A_t h, R),\end{aligned} \tag{14}$$

Notice that although, via the effect of A_t, the value functions, the $\widehat{W}$'s, depend on time, the probabilities of staying in power do not, because the decision rules of the citizens do not depend on time.

Next, again by standard arguments $\widehat{W}$ is strictly increasing in both of its arguments. This implies that if $[1-F^I(0)]\widehat{W}(\alpha A_t h, R) > [1-F^N(\alpha-1)]\widehat{W}(A_t h, R)$, then it is also true that $[1-F^I(0)]\widehat{W}(\alpha A' h, R) > [1-F^N(\alpha-1)]\widehat{W}(A' h, R)$, for all $A' \geq A_t$. Because innovations increase A_t, this implies that once an incumbent starts innovating, both that incumbent and all future incumbents will always innovate.

This implies that we can characterize the condition for innovation as follows: first determine the value function for the ruler under the hypothesis that there will always be innovations in the future, and then check whether the one-step ahead deviation of not innovating in this period is profitable. To do this, let us make the natural conjecture that $\widehat{V}(Ah) = \widehat{v}(x)Ah$ and $\widehat{W}(Ah, R) = \widehat{w}(x)Ah + \widehat{r}(x)R$, where we have explicitly allowed the coefficients of these value functions to depend on whether there will be innovation in the future.

By a similar reasoning to that above, the incumbent ruler innovates if

$$\begin{aligned}&P\left[\frac{1}{2}+\mu\right](\widehat{w}(x=1)\alpha Ah + \widehat{r}(x=1)R) \\ &\geq P\left[\frac{1}{2}+\gamma\mu-(\alpha-1)\right](\widehat{w}(x=1)Ah + \widehat{r}(x=1)R),\end{aligned} \tag{15}$$

where $\widehat{w}(x=1)$ and $\widehat{r}(x=1)$ are the coefficients of the value functions when there will always the innovation in the future and are simple functions of the underlying parameters.

Let us first focus on the main comparative statics of interest. As before, condition (15) can only be violated when $P[\frac{1}{2}+\gamma\mu-(\alpha-1)] > P[\frac{1}{2}+\mu]$, that is, when innovation reduces the likelihood that the ruler will remain in power. Then, in this relevant area of the

parameter space where blocking can occur, the coefficient of R on the right-hand side, $P[\frac{1}{2}+\gamma\mu-(\alpha-1)]$, is greater than the corresponding coefficient on the left-hand side, $P[\frac{1}{2}+\mu]$, so an increase in R makes blocking more likely (i.e., it makes it less likely that (15) holds). Conversely, an increase in h, the human capital of the labor force, makes blocking less likely. Intuitively, a higher level of R implies a greater loss of rents from relinquishing office, increasing the strength of the political replacement effect. In contrast, the higher level of h increases the gains from technology adoption relative to R, making technology adoption more likely.

More explicitly, condition (15) implies that, as long as $P[\frac{1}{2}+\mu]\alpha - P[\frac{1}{2}+\gamma\mu-(\alpha-1)] > 0$, the ruler will innovate at time t if

$$A_t \geq A^*(R/h) \equiv \frac{\left(P\left[\frac{1}{2}+\gamma\mu-(\alpha-1)\right]-P\left[\frac{1}{2}+\mu\right]\right)}{\left(P\left[\frac{1}{2}+\mu\right]\alpha-P\left[\frac{1}{2}+\gamma\mu-(\alpha-1)\right]\right)} \cdot \frac{1-\beta\alpha P\left[\frac{1}{2}+\mu\right]}{1-\beta P\left[\frac{1}{2}+\mu\right]} \cdot \frac{R}{\tau h}. \quad \textbf{(16)}$$

The inequality $P[\frac{1}{2}+\mu]\alpha - P[\frac{1}{2}+\gamma\mu-(\alpha-1)] > 0$ is imposed because if it did not hold, the incumbent would never innovate irrespective of the value of A, so in this case we set $A^*(R/h)=\infty$. Condition (16) states that the incumbent will innovate if the current state of technology is greater than a threshold level A^*. The greater is R/h, the higher is this threshold level, implying that innovation is less likely (or will arrive later).

Next suppose, instead, that the incumbent would like to block innovation. Then as long as he remains in power $A_{t+1}=A_t$. This enables a simple characterization of the value functions, again using the natural linearity conjecture (see the Appendix). We then obtain that the incumbent will block if

$$P\left[\frac{1}{2}+\gamma\mu-(\alpha-1)\right](\widehat{w}(x=0)Ah+\widehat{r}(x=0)R) \geq P\left[\frac{1}{2}+\mu\right](\widehat{w}(x=1)\alpha Ah+\widehat{r}(x=1)R), \quad \textbf{(17)}$$

where the right-hand side features $\widehat{w}(x=1)$ and $\widehat{r}(x=1)$, because if the ruler finds it profitable to innovate this period, he will also do so in the future. This condition will be satisfied if only if $A \leq A^*(R/h)$ as given by (16); that is, only if A is lower than the critical threshold characterized above. On reflection, this result is not surprising, because given the best responses of the citizens, the decision problem of the ruler is characterized by a standard dynamic programming problem, and has a unique solution.

Overall, the ruler will innovate when $A_t \geq A^*(R/h)$ and block whenever $A_t < A^*(R/h)$. This result has another interesting implication. Before, the innovation decision was independent of A, so an economy that had "adverse" parameters would always experience blocking. Although there would still be some improvements in technology as incumbents were replaced, incumbents would always block change whenever they could. Here, because A_t tends to increase over time (even when there is blocking, because incumbents are being replaced and newcomers innovate), eventually A_t will reach the threshold $A^*(R/h)$ as long as $A^*(R/h)<\infty$, and from this point onwards, incumbents would no longer block innovations. Therefore, a possible development path implied by this analysis is as follows: first, incumbents block change, but as many of these incumbent rulers are replaced and some economic and political change takes place, the society eventually undergoes a *political transition*—it reaches the threshold where even incumbent rulers are no longer opposed to change. Of course, the arrival of such a political transition may be very slow.

Summarizing the main implication of this analysis:

Proposition 3. *Political elites are more likely to block economic change when political rents, R, are high and human capital of the workforce, h, is low.*

This proposition is important for our discussion below because it implies that elites are more likely to block change when political stakes, as captured by R, are greater. As a result, in this model we can think of two distinct roles of preexisting political institutions: first, they determine μ, the degree of political competition, and affect the likelihood of economic change via this channel; and second, they affect the political stakes, R, and determine the gains to the elites from staying in power and their willingness to block development.

Finally, it is interesting to note that although we have so far treated h as given, the same forces that determine whether incumbent rulers want to block change will also determine whether they want to invest in the human capital of the population. A greater human capital of the labor force is likely to increase output, but may make it easier for the masses to organize against the ruler, and hence may erode the incumbency advantage of the ruler (see Bourguignon and Verdier 2000). Therefore, the political replacement effect may also serve to discourage rulers from investing in human capital or even block initiatives to increase the human capital of the masses.

EXTERNAL THREATS AND DEVELOPMENT

Political elites' attitudes toward industrialization changed dramatically in Russia after the defeat in the Crimean war and in Austria-Hungary after the 1848 Revolution. Similarly, Japanese elites started the process of rapid industrialization after they felt threatened by the European powers and the United States. One can also argue that the potential threat of communism was an important influence on the elites' attitudes toward development in South Korea and Taiwan. It therefore appears that external threats may be an important determinant of whether elites want to block technical and institutional change. In this section, we extend our model to incorporate this possibility.

To model these issues in the simplest possible way, suppose that at time t, rulers find out that there is a one-period external threat at $t+1$, which was unanticipated before. In particular, another country (the perpetrator) with technology B_t may invade. If an invasion takes place, the ruler is kicked out of power and gets zero utility from that point on. Whether this invasion will take place or not depends on the state of technology in two countries, and on a stochastic shock, q_t. If $q_t \phi B_t > A_t$, the perpetrator will successfully invade and if $q_t \phi B_t \leq A_t$, there will be no invasion. Hence, $\phi \geq 0$ parameterizes the extent of the external threat: when ϕ is low, there will only be a limited threat. This formulation also captures the notion that an economy that produces more output will have an advantage in a conflict with a less productive economy.

For simplicity, suppose that there will never be an invasion threat again in the future, and assume that q_t is uniformly distributed on $[0, 1]$. Suppose also that $B_t = \delta A_{t-1}$. This implies that there will be an invasion if

$$q_t > \frac{1 + x_t(\alpha - 1)}{\phi\delta},$$

where recall that x_t is the decision of the incumbent to innovate. Using the fact that q_t is uniform over $[0, 1]$, and the same definition of the function $P[\cdot]$, we have the probability that the ruler will not be invaded at time t, conditional on x_t, as

$$P\left[\frac{1 + x_t\,(\alpha - 1)}{\phi\delta}\right].$$

The important point here is that the probability of invasion is higher when $x_t = 0$ because output is lower.

Let us now return to the basic model presented above with $R = 0$. The same reasoning as before immediately establishes that at time t the ruler will innovate if

$$\alpha P\left[\frac{1}{2} + \mu\right] P\left[\frac{\alpha}{\phi\delta}\right] \geq P\left[\frac{1}{2} + \gamma\mu - (\alpha - 1)\right] P\left[\frac{1}{\phi\delta}\right]. \quad \textbf{(18)}$$

This condition differs from the basic condition we previously derived, (10), because of the probability of invasion. In particular, when $P[\frac{1}{\phi\delta}] \in (0, 1)$, external threats make blocking less attractive, because a relatively backward technology increases the probability of foreign invasion. Therefore, the emergence of an external threat might induce innovation in a society that would otherwise block change. In fact, an increase in δ or ϕ will typically make blocking less likely. For example, when $\delta \to 0$ or $\phi \to 0$, we have $P[\frac{1}{\phi\delta}] \to 1$, so the threat of invasion disappears and we are back to condition (10). For future reference, we state this result as a proposition:

Proposition 4. *Political elites are less likely to block development when there is a severe external threat (high ϕ) and when the perpetrator is more developed (high δ).*

The intuition for both comparative statics is straightforward. With a more powerful external threat or a more developed perpetrator, the ruler will be "forced" to allow innovation so as to reduce the likelihood of an invasion.

HISTORICAL EVIDENCE AND INTERPRETATION

We now use our analysis so far to provide an "interpretation" of the different industrialization experiences during the nineteenth century. As the data on output and industrial production from Maddison (1995) and Bairoch (1982) show (Table 1 Panels A and B), whereas some countries, including Britain and the United States, industrialized rapidly, others, such as Japan, Russia, and Austria-Hungary, lagged behind. Even Germany, though a famous example of rapid industrial catch-up, did not really take off until after 1850. We provide historical evidence suggesting that a proximate cause of this divergence is that in some countries political elites did not want to introduce economic institutions encouraging entrepreneurs to adopt new technology and innovate, and in fact, actively tried to block industrialization (see Acemoglu, Johnson, and Robinson 2002 for econometric evidence). Moreover, the evidence suggests that the primary reason why elites blocked such change was because they feared losing their political power. In addition our theory also provides an interpretation for why there were such adverse attitudes toward change in some countries, and not in others. It suggests that the political elites in Britain and subsequently Germany did not strongly oppose industrialization and the associated institutional changes because they were sufficiently entrenched and political rents were relatively low. In Britain this was true throughout the eighteenth and nineteenth centuries, whereas in Germany it was not until the second half of the century that political elites forged the coalition that entrenched their political power. We also suggest that external threats from the European powers and the United States were important in changing the attitudes of the Japanese elites toward industrialization and modernization, spurring rapid industrialization there.

In contrast, in Russia and Austria-Hungary, the political elites were powerful enough to block development, and because their political power was not totally secure, they feared technological and institutional change. We also suggest that because of the more feudal land/labor relations and the persistence of the absolutist monarchy into the nineteenth century, political stakes in Russia and Austria-Hungary were substantial for the landed aristocracy, encouraging them to oppose industrialization to protect their rents.

Needless to say, such interpretations are necessarily speculative and more conclusive evidence requires proper statistical testing of the ideas we develop here. We regard the main contribution of this section as showing that there is direct historical evidence that the mechanism which is the central focus of this paper was important to nineteenth-century industrialization.

Britain

At the end of the eighteenth century, the political system in Britain was controlled by a rich, primarily landowning aristocracy. The British elites at the start of the next century faced an ongoing process of industrialization which, by creating new groups of wealthy businessmen and finally a powerful working class, forced the aristocracy to concede political power.

This process happened incrementally through the three Reform Acts, the first of which was in 1832, the others in 1867 and 1884. A crucial policy change was the 1846 repeal of the Corn Laws. Although the extension of the franchise that was also introduced by these reforms was certainly fought for many years (e.g., in the 1840s the Chartist movement was successfully undermined), the political elites in Britain did not block the processes set in force by the first industrial revolution. Indeed, as Mokyr (1990, 243) argues about Britain "the landowning elite, which controlled political power before 1850, contributed little to the industrial revolution in terms of technology or entrepreneurship. It did not, however, resist it." It seems that the battle over the extension of the franchise was more relevant for determining how much of the gains from industrialization would be redistributed to the poorer segments of the society, rather than over whether industrialization should proceed or not (see Acemoglu and Robinson 2000b, 2005 on the extension of the franchise).

British political elites were not always in support of industrialization. For example, Christopher Hill (1981, 22) describes the hostile attitude of the landed aristocracy to modernization during the early seventeenth century. However, the rise of parliament and the commercialization of British society during the following centuries overcame these forces and paved the way for industrialization. The Glorious Revolution of 1688, often emphasized as the final step in the rise of parliament over the monarchy (North and Weingast 1989), also represented the final step in a much longer process of evolution. Not only were the political powers of the monarchy and traditional aristocracy relatively muted in Britain compared to other European countries, but also economic institutions were much more modernized. Feudalism and servile labor were almost completely gone and most of the landed elite had become commercial farmers (see Moore 1966).

Why were British elites, on balance, not opposed to economic and institutional development? Three reasons, highlighted by our model, may have been important. First, the political settlement which had emerged from the Glorious Revolution meant that the landed aristocracy in Britain, though holding only relatively limited powers compared to some other European aristocracies, did not face severe threats to its position and power in society. In particular, the House of Lords guaranteed the security of landed interests until the Liberal government of Asquith after 1906. Second, the transition from aristocratic to popular rule was a prolonged one. Although relatively universal male suffrage came after 1867, aristocratic power was strong in government until well into the present century. Therefore the British political elite, by adopting a strategy of gradual concessions, were able to control the political equilibrium and maintain power for at least a century following the onset of the political impact of industrialization. In terms of our model, both of these factors correspond to a high value of μ, reducing the opposition of existing elites toward institutional and technical change. In addition, the long history of Britain as a trading nation and mercantile power meant that many aristocrats had relatively diversified wealth, and many of the feudal land relations had long disappeared (see Cain and Hopkins 2000; Saville 1994). Therefore, the elites could benefit from industrialization, and had less to lose in terms of political rents. Moreover, the political institutions which emerged following the Glorious Revolution restricted predation not only by the monarchy against parliament but also by parliament against commoners (Thompson 1975). These institutional characteristics of the British society further reduced political rents, R in our model, making the elites less likely to be oppose change.

Germany

Industrialization occurred in Germany in the context to the rise of the Prussian state within the German federation of states and the creation of the Empire in 1871. The resulting political institutions ensured the entrenchment of the elites, in particular the landed aristocracy, the Junkers. For example, the Junkers forged the coalition of 'Iron and Rye' with the rising industrial class to secure their economic interests. Gerschenkron (1943, 49) describes this coalition as "a compromise between modern industry and the feudal aristocratic groups in the country." And Eley (1984, 153–54) notes that "the option of the German bourgeoisie's leading fractions for a politics of accommodation with the landowning interests . . . was fully compatible with the pursuit of bourgeois interests . . . The bourgeoisie entered the agrarian alliance . . . as the best means of securing certain political goals."

However, before the 1848 revolution and the emergence of this coalition, the landed elites did not uniformly support industrialization. For example, Tracey (1989, 106) writes: "there was relatively little industrial development in the east, because of lack of natural resources and also as a result of deliberate opposition to industrialization by the Junkers and the Bund der Landwirte, who feared the spread of socialism and also did not want the Polish proletariat to participate in industrialization."

Tipton (1974, 962) argues that in the first half of the nineteenth century the political elites "adamantly opposed plans for eastern industrialization on the grounds that the danger of socialism would increase with the expansion of employment in factories" (see also his 1976 book). Trebilcock (1981, p. 76) makes similar arguments noting "the Prussian state . . . was attracted only to a particular type of industrial development, that with military utility. Outside this area, the authorities contributed little in the way of investment

or encouragement to private entrepreneurs." Indeed, "they expressed hostility to major innovations in industry or transport, and they were notably suspicious of the railways at the outset." He continues that as late as the midcentury "the political preferences of the Junker groups definitely restricted the scope for economic advance."

Yet things began to change in the 1850s "a new alliance formed, combining authoritarianism with bourgeois elements, against the menace of peasant and proletariat. By modifying the vested interests of the previous four of five decades, it created a climate more favorable to industrial advance" (Trebilcock 1981, 76). The threat from the rapidly industrializing Britain and France and from the 1848 wave of revolutions may have also been important for the change in the attitudes toward industrialization, adding some element of defensive modernization to the German case.

Another factor facilitating the emergence of this more positive attitude toward change may have been that, despite the important role of the Junker elite, the political stakes were also relatively limited for the landed aristocracy. This was mostly because of the reforms induced by the Napoleonic wars. Blackbourn (1997, 71) notes that in the parts of Germany that they occupied, the French rule amounted to a "crash course in modernization that removed the institutions of the old regime, separated church and state, rebuilt the administrative bureaucracy on a new basis, and made possible the relatively untrammeled accumulation and disposition of property that is one hallmark of a modern civil society." Where the French did not rule, as in Prussia, their impact was to induce defensive reform and modernization. However, there is a consensus that these reforms did not have the revolutionary effects that they were once claimed to have had. Although the serfs were freed in Prussia in 1807, Trebilcock (1981, 34) notes, "the small peasantry, immensely more numerous but holding only a fraction of the peasant land, the rural masses between the Elbe and the Vistula, had to wait until the 1850s and 1860s before the miraculous cloak of emancipation swept over them." Labor relations were certainly less feudal than in Russia or Austria-Hungary, though they were probably less modernized than in Britain.

Political reforms after the 1848 Revolution and the emergence of parliamentary institutions in Germany appear to have been strategically designed, as in Britain, to give a sufficient degree of representation to the Junker elites. For example, the legislature was bicameral with a federal council composed of delegates from the states (the Bundesrat) and a national elected parliament (the Reichstag). Prussia had 17 of the Bundesrat's 58 votes and "the conservative Prussian elite could essentially block proposed national legislation that was contrary to its interests (Berman, 2001, 439). After the 1870s, the Junkers were able to gain protection for their output, insulating themselves economically from the worst effects of industrialization—such as falling land rents. Therefore, in Germany the continued political power of the Junkers, once the coalition of Iron and Rye had been formed, allowed them to compensate for the adverse direct economic effects of industrialization. So in terms of our model, we can see the German case as one where, after the 1850s, the political elites were relatively entrenched, that is, high μ and the political stakes, R, were limited. This combination of elite entrenchment and low political rents made it unprofitable for the elites to block change. Rapid industrialization among its main rivals may have also contributed to the favorable attitudes towards industrialization in Germany.

Japan

Japan industrialized and modernized rapidly in the second half of the nineteenth century. Although the seeds of industrialization could be traced back to the Tokugawa era (e.g., Macpherson 1987), rapid industrialization appears to have been related to the emergence of a serious external threat. The overwhelming British victory against the Chinese in the Opium War of 1842, the imposition of an "open door" to world trade on Japan by European powers and the United States, and perhaps most importantly, the arrival of the American fleet in Tokyo Bay in 1853 made it clear to the Japanese elites that they were facing a serious external threat.

Before the emergence of the external threat from the West, Japan was under the control of the Tokugawa shogunate which was a coalition of large landowning interests. Although Japan had been a relatively prosperous country since at least the fifteenth century, it was not always open to commerce, innovation, and foreign trade. For example, the elites did not welcome foreign missionaries, and foreign trade was seriously limited and controlled; or in the words of Macpherson (1987, p. 38), "...[they]...virtually prohibited overseas trade." In terms of our model, this makes sense as a calculated conservatism to maximize the longevity of the regime. In fact, the main aim of the Tokugawa shogunate was to bring peace and stability to Japan following an era of prolonged infighting and civil war, and many of the institutional changes needed to promote industry would have created turbulence and strengthened competing groups.

The Tokugawa equilibrium was shattered by the emergence of the external threat from the West, culminating in the arrival of the American fleet in Tokyo Bay. These changes eventually led to the Meiji Restoration of 1868. Although the Restoration installed the Meiji Emperor, this was purely symbolic, and the main drive to industrialization had already started before the Restoration as an explicit strategy of defensive modernization in response to these external threats. Curtin (2000, 163) describes this as follows: "The two sides were so similar that the brief but crucial fighting that ended the Tokugawa era was a struggle between competing military oligarchies seeking to control a new centralizing government, which would probably have sought to carry out similar policies, no matter which side won."

It is interesting that the drive for modernization in Japan took a special form, strengthening the centralized government and increasing the entrenchment of bureaucratic elites. In terms of our model, this can be viewed as a strategy to industrialize while also minimizing the probability of replacement, somewhat reminiscent to the industrialization experience in Britain and Germany where the nonindustrial elites maintained their political power despite the process of industrialization. In Japan, the Restoration, despite its emphasis on Japanese traditions, quickly wiped out the powers of the *daimyo* (the great lords), the main threat to the power of the centralized state. At the same time, much of industrial activity was delegated to a core group of wealthy families, known as the *Zaibatsu*, which was in close contact with the government, so the threat from economic change to the existing political regime was minimized. The choice of Japanese constitution also reflected the same desires. They adopted the Prussian constitution, which gave the appearance of representative government, but retained the oligarchy in control via the bicameral system with the upper house reserved largely for the ruling elite. The constitution also gave the military sweeping powers.

Overall, the Japanese experience can be interpreted as an example of defensive modernization and industrialization in response to an external threat, reminiscent to the results we derived earlier, and the pattern of industrialization following the change of attitudes can be interpreted as an example of adopting technological and institutional change, while strengthening the control of the oligarchy on centralized power.

Russia

Russia provides stark contrast to the cases we have examined so far. During the reign of Nikolai I between 1825 and 1855 (in the wake of the Decembrist putsch) only one railway line was built in Russia. Economic development was opposed since, as Mosse (1992, 19) puts it, "Economic development—elsewhere in Europe this was the age of early industrialization and railway construction—was deliberately held back," since "it was understood that industrial development might lead to social and political change." In a similar vein, Gregory (1991, 74) argues: "Prior to the about face in the 1850s, the Russian state feared that industrialization and modernization would concentrate revolution minded workers in cities, railways would give them mobility, and education would create opposition to the monarchy."

It was only after the defeat in the Crimean War that Nikolai's successor, Alexsandr II, initiated a large-scale project of railway building and an attempt to modernize the economy (among other things, by introducing a Western legal system, decentralizing government, and freeing the serfs). The reasons underlying this industrial drive appear defensive: Alexsandr II, most probably correctly, perceived that Russia's technological inferiority left it vulnerable to foreign threat. Alexsandr's reforms led to rapid industrialization (Portal 1965), supporting the notion that state policies before the Crimean War were important in blocking development. The sudden change of attitudes in the face of foreign threat is also consistent with our emphasis on external threats inducing innovation.

This period of industrialization also witnessed heightened political tensions, consistent with the view that times of rapid change destabilize the system (McDaniel 1988; Mosse 1958, 1992). Mosse (146) argues: "early industrialization . . . resulted in an acceleration of change and an increased dynamism in a previously static society. Russia . . . was transformed from a backward (or underdeveloped) into a developing country. She had entered the railway age. Society experienced a gradual transformation. Although the landed gentry was in a state of terminal decline, the bureaucracy recruited from various social strata, had begun to replace it as the ruling class. The liberal professions and the entrepreneurial bourgeoisie were gaining in numbers and importance. Early industrialization had created a small but growing proletariat. By the turn of the century, the social changes set in motion by perestroika were beginning to have an impact on public affairs."

The history of industrialization in nineteenth-century Russia therefore illustrates the contradictions that political elites faced in promoting innovation. Until the impetus of the Crimean War, industrialization was blocked. The defeat of the Crimean war is therefore the turning point in the attitudes of the Russian state to economic development.

Why was the Tzar so opposed to institutional and technological change in the period before the Crimean war? One possibility suggested by our analysis is the high level of the political rents, R, generated by the state of land/labor relations in Tzarist Russia. The feudal social structure in nineteenth-century Russia generated high rents for political elites and implied that the landed aristocracy had few commercial interests, and was not associated with industrial groups. So the primary beneficiaries of industrialization would have been groups outside the landed aristocracy. Moreover, because land is relatively easy to expropriate, the elites, especially the Tzar, had a lot to lose from political changes. These factors increased the political stakes for the elites, making them fear industrialization more than in Britain or Germany. Furthermore, the poor level of human capital of most of the workforce also implied that the gains from industrialization were lower relative to land rents that the elites obtained under the *ancien regime*. Another important factor was the tight control of the state by the Tzar, who had perhaps even more to lose from political transition. No policy could be made without the Tzar's agreement and all government ministers were personally appointed by him. Here Russia was very different from the European countries, such as Britain, where the monarchy staged a long, carefully orchestrated withdrawal from political power. In line with this McDaniel (1991, 32) notes that "The struggle between kings and burghers

so characteristic of much of western European history had few parallels in Russia."

The Habsburg Empire

In the nineteenth century, the Habsburg Empire was known as "Europe's China" or the "sick man on the Danube" (see Good 1984, 1991) and was generally regarded as having fallen far behind the other industrializing countries of Europe. Historians typically argue that this was what led to the weakness and disintegration of the empire during and after the First World War. The consensus view among historians now appears to be that the main explanation for the slow growth of Austria-Hungary in the nineteenth century is the opposition of the state. For instance Gross (1973) argues: "In domestic as well as foreign policy the *Vormärz* regime, from 1815 to 1848, was determined to prevent another French Revolution anywhere in Europe. From this principle Francis I derived not only his opposition to the growth of industry (and with it the Proletariat) . . . but his general reluctance to permit any change whatsoever."

The analysis of Freudenberger (1967) is similar. He notes (498–99): "In the 1790s, fear of the French Revolution added a new dimension to government policy. High officials in the government, with the young Emperor Francis I in strong sympathy, felt that industrialization would create an industrial proletariat which to them was the carrier of revolutionary ideas and for that reason . . . not only opposed large-scale enterprises but also favored a policy that kept the population agrarian."

As with the Tzar, the Habsburg emperors opposed the building of railways and infrastructure and there was no attempt to develop an effective educational system. Blum (1943, 26) pointed to the pre-modern institutional inheritance as the major blockage to industrialization arguing that "these living forces of the traditional economic system were the greatest barrier to development. Their chief supporter was . . . Emperor Francis. He knew that the advances in the techniques of production threatened the life of the old order of which he was so determined a protector. Because of his unique position as final arbiter of all proposals for change he could stem the flood for a time. Thus when plans for the construction of a steam railroad were put before him, he refused to give consent to their execution 'lest revolution might come into the country'."

The creation of the first railway line had to wait until Francis' death in 1835, yet even after that the government under Metternich kept to the same policies. It was the revolution of 1848 that perturbed this stasis. Eduard Marz places "the beginning of the industrial age in the 1850s . . . when the Ancien regime ceased to exist" (quoted in Blum 1948; Good 1984, 40–41). As in Russia after the Crimean, the response of the domestic elites was peasant emancipation and agrarian reform followed by a switch in economic policy towards a rather vigorous promotion of industry (see Eddie 1989).

In addition, as in Russia, Austria-Hungarian elites received substantial rents from unreformed feudal land/labor relations. Furthermore, the fact that they were landowners meant that they could be easily expropriated in the event of political transition. Another possibly important factor in the case of Austria-Hungary was the heterogeneity of the empire. The Austrian aristocracy thought that modernization would destroy the social glue which kept the empire together. Poor human capital also again lowered the incentive to industrialize by increasing the importance of land rents relative to income from industrial activity.

CONCLUSION

In this paper, we constructed a simple model where political elites may block technological and institutional development, because of a "political replacement effect." Innovations often erode political elites' incumbency advantage, increasing the likelihood that they will be replaced. Fearing replacement, political elites are unwilling to initiate economic and institutional change. We show that elites are unlikely to block development when there is a high degree of political competition, or when they are highly entrenched. It is only when political competition is limited and also the elites' power is threatened that they will block development. We also show that such blocking is more likely to arise when political stakes are higher, and in the absence of external threats. We argue that this model provides an interpretation for why Britain industrialized first and Germany followed relatively soon during the nineteenth century, while the monarchy and the landed aristocracy in Russia and Austria-Hungary blocked development.

There are many interesting areas for future research, both empirical and theoretical. At the empirical level, we need to develop quantitative measures of the degree of political competition and elites' attitudes toward technological change both for today and in the past, and investigate the relationship between competition and the likelihood of blocking. At the theoretical level, it may be informative to derive different (potentially testable) implications from models where the fear of replacement comes from different sources (challenges from new groups, fear of revolution, or threats from other subgroups within the elite). More important would be to model political competition more carefully, using a setup that nests both insurrections and party competition (unfortunately, such a setup does not currently exist).

Finally, our account suggests that the relative security of the British and German elites was important in the development trajectories of these countries. But the security was, at least in the case of Germany, and also in part in the British case, the outcome of a coalition that the elites formed. Therefore, the approach here needs to be complemented with a theory of coalition-formation between different groups. We view this as a very difficult, but exciting area for future research.

APPENDIX

Derivation of the Value Functions Leading to Equation (10)

Here for completeness, we solve for the value functions of the citizens and incumbent ruler. Using the conjecture, $V(A) = v(x)A$ and $\widehat{x} = 1$,

$$v(x)A = A(1-\tau) + \beta v(x)A\left[x\left(\alpha - \int_{\frac{1}{2}-\mu}^{0} z'\,dz'\right) + (1-x)\left(\int_{\alpha-1}^{\frac{1}{2}+\gamma\mu} dz + \int_{\frac{1}{2}-\gamma\mu}^{\alpha-1}(\alpha - z)\,dz\right)\right]. \quad \textbf{(19)}$$

The undetermined constant is found to be

$$v(x) = \frac{(1-\tau)}{1 - \beta x\left(\alpha - \int_{\frac{1}{2}-\mu}^{0} z'\,dz'\right) - \beta(1-x)\left(\int_{\alpha-1}^{\frac{1}{2}+\gamma\mu} dz + \int_{\frac{1}{2}-\gamma\mu}^{\alpha-1}(\alpha - z)\,dz\right)}$$

For the ruler, the same type of argument leads to a value function,

$$wA = \tau A + \beta w A\left[x\alpha\int_{0}^{\frac{1}{2}+\mu} dz + (1-x)\int_{\alpha-1}^{\frac{1}{2}+\gamma\mu} dz\right]. \quad \textbf{(20)}$$

Hence,

$$w(x) = \frac{\tau}{1 - \beta\left(xP\left[\frac{1}{2}+\mu\right]\alpha + (1-x)P\left[\frac{1}{2}+\gamma\mu-(\alpha-1)\right]\right)}.$$

Value Functions Leading to Equation (15)

First consider the situation where there is always innovation in the future. Then, we have the following recursion defining $\widehat{w}(x=1)$ and $\widehat{r}(x=1)$:

$$\widehat{w}(x=1)Ah + \widehat{r}(x=1)R = \tau Ah + R + \beta(\widehat{w}(x=1)\alpha Ah + \widehat{r}(x=1)R)\int_{0}^{\frac{1}{2}+\mu} dz'.$$

The undetermined coefficients are obtained as

$$\widehat{w}(x=1) = \frac{\tau}{1 - \beta\alpha P\left[\frac{1}{2}+\mu\right]}$$

and

$$\widehat{r}(x=1) = \frac{1}{1 - \beta P\left[\frac{1}{2}+\mu\right]}.$$

Now using these expressions, condition (15) can be rewritten as

$$P\left[\frac{1}{2}+\mu\right]\left(\frac{\tau\alpha Ah^*(R/h)}{1-\beta\alpha P\left[\frac{1}{2}+\mu\right]} + \frac{R}{1-\beta P\left[\frac{1}{2}+\mu\right]}\right) = P\left[\frac{1}{2}+\gamma\mu-(\alpha-1)\right]\left(\frac{\tau Ah^*(R/h)}{1-\beta\alpha P\left[\frac{1}{2}+\mu\right]} + \frac{R}{1-\beta P\left[\frac{1}{2}+\mu\right]}\right), \quad \textbf{(21)}$$

which defines $A^*(R/h)$. This solves for the critical threshold of the state of technology as

$$A^*(R/h) = \frac{\left(P\left[\frac{1}{2}+\gamma\mu-(\alpha-1)\right] - P\left[\frac{1}{2}+\mu\right]\right)}{\left(P\left[\frac{1}{2}+\mu\right]\alpha - P\left[\frac{1}{2}+\gamma\mu-(\alpha-1)\right]\right)} \cdot \frac{1-\beta\alpha P\left[\frac{1}{2}+\mu\right]}{1-\beta P\left[\frac{1}{2}+\mu\right]} \cdot \frac{R}{\tau h},$$

which is the expression in (16) in the text. Note that in (21) we must have that $P[\frac{1}{2}+\gamma\mu-(\alpha-1)] > P[\frac{1}{2}+\mu]$ and $P[\frac{1}{2}+\mu]\alpha - P[\frac{1}{2}+\gamma\mu-(\alpha-1)] > 0$—if the first inequality did not hold, the incumbent would strictly prefer to innovate, as discussed in the text, and if the second inequality did not hold, the incumbent would strictly prefer to block. These inequalities immediately imply that $A^*(R/h)$ is increasing in R/h as claimed in the text.

Next, consider the situation where a ruler does not innovate. Then the recursion for the value function can be written as

$$\widehat{w}(x=0)Ah + \widehat{r}(x=0)R = \tau Ah + R + \beta(\widehat{w}(x=0)Ah + \widehat{r}(x=0)R)\int_{\alpha-1}^{\frac{1}{2}+\gamma\mu} dz,$$

which is

$$\widehat{w}(x=0) = \frac{\tau}{1 - \beta P\left[\frac{1}{2}+\gamma\mu-(\alpha-1)\right]}$$

and

$$\widehat{r}(x=0) = \frac{1}{1 - \beta P\left[\frac{1}{2}+\gamma\mu-(\alpha-1)\right]}.$$

Now using these expressions and condition (17), we have

$$P\left[\frac{1}{2}+\mu\right]\left(\frac{\tau\alpha Ah^N}{1-\beta\alpha P\left[\frac{1}{2}+\mu\right]} + \frac{R}{1-\beta P\left[\frac{1}{2}+\mu\right]}\right) = P\left[\frac{1}{2}+\gamma\mu-(\alpha-1)\right]\left(\frac{\tau Ah^N}{1-\beta P\left[\frac{1}{2}+\gamma\mu-(\alpha-1)\right]} + \frac{R}{1-\beta P\left[\frac{1}{2}+\gamma\mu-(\alpha-1)\right]}\right), \quad \textbf{(22)}$$

which solves for $A^N = A^*(R/h)$, establishing the claim in the text that the incumbent ruler will block whenever $A_t < A^*(R/h)$, and innovate whenever $A_t \geq A^*(R/h)$.

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