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Corruption across countries and regions: Some consequences of local osmosis ☆

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Abstract

Large and persistent differences in corruption across comparable countries is a challenging research issue. Even more intriguing are such differences across regions within the same country, because the typically considered socioeconomic and governance characteristics are generally more similar across such regions than across different countries.

This paper's principal theme is that individuals' perceptions of their environments are influenced by the realities that they have faced in the past; these perceptions affect their current and future actions; which in turn influence the current and future realities. An articulation and analysis of these dynamics yields significant observations concerning individuals' behavior and societal outcomes.

JEL classification: D73; H83; D83; C61; N10

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☆This is a revised version of Sah (1988).
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1. Introduction

The phenomenon of corruption has perhaps existed since the earliest organized societies, almost regardless of the structure of the societal organization; see, for example, Darling (1996, Chapter VIII), Miller (1992), Lovell et al. (2000), Lui (1979), and Waquet (1992). Those with an understanding of multiple societies have often noted that there are large differences in the levels of corruption across different societies. Such differences between many developing and more modern economies are particularly salient. In many developing societies, almost every kind of transaction between a citizen and the government usually entails at least some degree of corruption and illegality. Since the 1990s, various indices of corruption across countries have become available; for example, those published by Transparency International (various years). With their many limitations, some of which are noted below, such indices also indicate large differences in the levels of corruption across countries. A positive analysis of such differences, across countries and across regions within a country, is a primary motivation of this paper.

A history of not understanding such differences has perhaps had deleterious effects on economic theory and policymaking concerning developing economies. The phenomenon of corruption was almost altogether missing from the formal discourses in development economics until the late 1980s. A concrete example is Chenery and Srinivasan (1988 and 1989) which contains reviews of the conceptual frameworks of that era. Such intellectual blind spots seem primarily to reflect fads and fashions of research paradigms, rather than political or methodological biases of researchers. Widespread corruption is an issue, in different ways, for a conservative or a liberal, a traditional price theorist or a behavioral economist, and so on. Since hard data on corruption is generally unavailable (more on this later), such fads and fashions may also be influenced by the researcher's own exposures and experiences. A researcher in Chicago is likely to be aware of the rich lore of corruption in the city of Chicago. Likewise, a policymaker in Washington, DC is likely to be aware of the long history of corruption in Washington, DC. Such individuals may have some inadvertent predisposition to view the levels of corruption in the rest of the world through the lenses of their own experiences, without adequately recognizing that, during the same time period, corruption in many other parts of the world has been at altogether different levels of magnitude and pervasiveness. Similar intellectual blind spots regarding corruption have also existed in numerous developing countries, as well as in international organizations, in the policies and projects that they supported, financially or otherwise. Some openness in the discussion of these issues has been seen since the 1990s, though it is unclear whether there is any substantive change. An open question for future research, which is not a concern of this paper, is the extent to which the problems that developing countries have accumulated in the post-colonial period are attributable to the intellectual blind spots of the kind noted in this paragraph.

An understanding of the large and persistent differences in corruption across countries is a challenging research issue. An even more challenging issue is the understanding of such differences across different regions or sub-economies within the same country. This is because: (i) the level of corruption is generally believed to reflect in part the nature of governance structures, the laws and their enforcements, and so on; and (ii) different countries are usually, but not in every case, more different concerning the aspects just noted than different regions within a country. An example of sustained intra-country differences in Europe is that between northern and southern Italy. An example in India is that between the neighboring provinces of Bihar and West Bengal. At least since the mid-1600s, these two provinces, with changing geographical configurations, have been under nearly the same systems of federal governance or non-governance. There are many examples of intra-country differences in other parts of the world.

To say that one country has more corruption than another entails issues of measurement (throughout the paper, the phrases 'country' or 'economy' can be interpreted, depending on the context, as 'region' and 'sub-economy', respectively). The nature of corruption is such that direct data on corruption will perhaps never be available with a high degree of hardness and abundance, comparable to, say, electronically captured data on individuals' purchases in modern supermarkets. It is therefore likely that subjectivities, including those inherent in the indices of corruption mentioned earlier, will perhaps continue to play a role in the assessment of inter-country or intra-country differences in corruption.[1] The present paper acknowledges this subjectivity.

As conceptual overviews of corruption have rightly pointed out, there are different categories of corruption, even though there are typically considerable overlaps among them; see Aidt (2003), Andvig (1991), Bardhan (1997), Rose-Ackerman (1999), and Jain (2001). One category of corruption is organized, in relatively centralized ways, by combinations of such elements as an autocratic ruler, his (her) family and cronies, and one or more groups of oligarchs. Such corruption typically targets the de facto control of financial institutions, natural resources, and other specific sectors of the economy. Suharto's Indonesia is an example of this category of corruption. A different category of corruption, which can coexist with the previous one, is that of 'diffused' and demographically-widespread corruption undertaken by a large proportion of bureaucrats, including those at the lowest levels, in their day-to-day transactions with citizens. Among numerous examples of such transactions are: (i) assessment and payment of various kinds of taxes and government fees; (ii) trying to receive everyday public services; (iii) protecting one's property rights, such as preventing an unauthorized occupation of one's property or getting a delinquent tenant evicted from one's property; (iv) a transaction between a food adulterer and an official who is responsible for food safety; or even something as ordinary as (v) getting a vehicle registered or a passport issued. Corruption of this kind is not centrally organized or coordinated in any significant manner by anyone, including the politicians, even though they usually share its proceeds. Such corruption is a defining aspect of the routine of life in South Asia, where it coexists with the

[1] There have been noteworthy recent innovations in inferring misconduct from indirect but available data; see Duggan and Levitt (2002) and Jacob and Levitt (2003).

manifestations of oligarchic corruption mentioned earlier. This diffused and demographically widespread category is the focus of this paper.[2]

A principal theme of this paper is that an individual's perceptions of his environment are influenced by the realities of the past. These influences arise from a large number of sources: personal experiences, experiences of others in the individual's personal environment, media, education, and so on. These perceptions influence individuals' current actions, which in turn influence the realities that will exist in the present and future. At each stage in this process, human perceptions and actions are affected by a variety of factors including biases, imperfections of information and inference, and chance. Since this process is intrinsically dynamic, I construct an explicitly dynamic model. In addition to realism, this model has several advantages, including that many of its predictions concerning individual and group behavior could not have been obtained without a dynamic analysis.

The formal models presented in this paper translate the above theme in particular ways, while recognizing that there might be other ways to do the same. For concreteness, the formal analysis in this paper uses a particular set of simplifying assumptions. I present comments on how these assumptions can be modified without altering the main theme of the analysis.

The key components of the formal analysis are as follows. Within the setting of overlapping generations, a new cohort of citizens becomes active in the economy in each time period. This cohort has diverse initial perceptions concerning the 'level of corruption' (that is, the fraction of bureaucrats who are corrupt), and the cohort remains active for a finite number of periods. Likewise, a new cohort of bureaucrats, with diverse initial perceptions concerning the level of cheating by citizens, enters the economy in each period. Here, 'cheating' is a shorthand for a citizen's activities that are ex ante more beneficial to him if he were to ex post encounter a bureaucrat who is corrupt rather than one who is not. The 'level of cheating' is the fraction of citizens who cheat. The diversity of initial beliefs can arise from a variety of sources, including intrinsic characteristics of individuals, as well as familial and social influences during childhood.

As he progresses through his life, each individual revises his perceptions. These revisions are based on his own past experiences, as well as on all other information, often partly erroneous, that he has gathered intentionally or otherwise. As will be seen later, any mild form of learning-from-experience, including but not limited to Bayesian updating, is sufficient for our analysis. Based on his current perceptions and on other considerations, including preferences and pecuniary trade-offs, a citizen chooses, in each period, whether or not to cheat, and a bureaucrat chooses whether or not to be corrupt.

The choices just described, in turn, influence the future perceptions of individuals, which influence their future choices. Through these dynamic relationships, future

[2]An aspect of such corruption is that it involves a large part of the population, and this involvement is ongoing rather than episodic. Its welfare costs, inclusive of deadweight burdens, could therefore be larger than those of oligarchic corruption. Such important questions of welfare analysis are not pursued in this paper.

levels of cheating and corruption in the economy become explicitly linked to past levels of cheating and corruption, as well as to the fundamentals of the economy (that is, the parameters describing the economy). I use this framework to examine some qualitative properties of: (a) individuals' choices; (b) the economy-wide dynamic evolution of cheating and corruption; and (c) the effects of some of the economy's parameters on the levels of cheating and corruption. Some of the conclusions, discussed in detail later, are as follows.

(i) Similar individuals will in general differ in their perceptions and choices. Consequently, the perceptions of many individuals can be noticeably different from the reality. For example, two citizens may have quite different perceptions (one believing that corruption is extensive, while the other assessing it as negligible), even though they belong to the same cohort, face the same economic trade-offs, and have started their active lives with identical initial perceptions. Bardhan (1997, pp. 1333–1334) summarizes some of the evidence from developing countries which supports this conclusion. For instance, Neher (1977, p. 485) finds diversity in citizens' beliefs concerning the extent of corruption in a Thai province. Oldenberg (1987) studies similar matters at the grass-root level in Northern India.[3]

(ii) A greater prevalence of cheating *or* corruption in the past induces a greater prevalence of cheating *and* corruption in the future. Two economies whose current economic fundamentals are comparable can have different levels of cheating and corruption. These conclusions are consistent with the large inter-country and intra-country differences in corruption discussed earlier.

(iii) There are many instances in which societal and political leaders have undertaken campaigns, often highly publicized but short-lived, to eliminate corruption. Such efforts are unlikely to alter the long-term levels of cheating and corruption in the economy. This is because the effects of the past can be long lasting and can easily overwhelm the effects of transitory and incremental campaigns. However, sustained changes in policies and institutions can have lasting effects which become magnified with time.

(iv) Roughly speaking, older cohorts of bureaucrats are likely to exhibit higher or lower levels of corruption than younger cohorts, depending on whether the economy-wide incidence of cheating is high or low. An analogous relationship holds for older versus younger cohorts of citizens.

(v) Some bureaucrats are not corrupt even in economies that are viewed as extreme examples of corruption. Conversely, some bureaucrats are corrupt even in economies that are viewed as extreme examples of the absence of corruption. The present analysis predicts this pattern. In other words, under plausible

[3]An example from a different context is the Gallup Poll on how citizens rate the honesty and ethical standards of local political officeholders in the United States; see Gallup (1977–1986). This multi-year survey shows a large variance in the cross-section of responses. This variance is substantial even among respondents who are homogeneous with respect to characteristics such as income, occupation, race, and gender; see Gallup (1972–1976, Vol. 2, pp. 823–50).

assumptions, it is not possible that an economy will be totally corrupt or totally free from corruption. Likewise, it is not possible that all citizens in an economy will cheat or that no citizen will cheat. These conclusions suggest that the present analysis is more realistic than those that predict that either all or none of the bureaucrats will be corrupt; for example, see Andvig (1991, p. 71). It is separately noteworthy that these conclusions do not rely on differences in individuals' preferences or pecuniary trade-offs.

I now highlight some key points of departure of the present paper in relation to the literature. Much of the existing economic analysis of corruption is based, directly or indirectly, on frameworks arising from Becker (1968). Depending on the context, this framework can be enriched by such constructs as agency theory (Aidt, 2003), industrial organization (Shleifer and Vishny, 1993), incomplete contracts, and so on. Much has been learned from such approaches and will continue to be learnt in the future. The present analysis is entirely consistent with Becker-style choices of individuals. The focus of this analysis is on endogenous human perceptions and their consequences. Such perceptions (including, for example, those concerning the probability that a corrupt bureaucrat will be detected and punished) are typically exogenous parameters in the literature noted above. This contrast is roughly analogous to general equilibrium analyses of endogenous prices versus analyses of microeconomic choices taking prices as exogenously specified parameters.

Another departure from the literature is as follows. Multiple equilibria have long been present in economics literature; for example, in Walrasian models, in tipping models, and in variations of these and other models. Among the early tipping models of corruption are those by Cadot (1987), Andvig and Moene (1990), and Andvig (1991). In these models, there is no link between individuals' choices and the emergence of one versus another equilibrium. More generally, these models do not attempt to understand why one particular equilibrium arises in one situation and yet a different one in a comparable situation. Also, these models do not shed light on the processes through which one or more of the multiple equilibria change over time. In the present analysis, there are no agents or forces within the economy which deliberately or otherwise can bring about an equilibrium. Instead, the only basic characterization is that of an economy evolving over time, including due to endogenous forces resulting from individuals' actions, and there are no outside assumptions concerning the nature of this evolution. As a part of the analysis of this evolution, I examine its steady-states, which are derived explicitly from the dynamics of the economy.

To keep the paper tractable and within a reasonable length, as well as to maintain its focus, I have adopted several boundaries on the analysis, including the following: (i) The present analysis is a positive one. I take as given the economy's legal and administrative rules and structures, which are represented through exogenous parameters. I trace the effects of changes in some of these parameters (or, alternatively, the consequences of differences in these parameters between two economies) on individual and social behavior. The paper does not deal with such normative issues as how to set up governments' structures concerning compensation, monitoring, investigations, and punishments; see Besley and McLaren (1993), Mookherjee and Png (1995), Prendergast (2000), and the references therein. (ii) I do not examine the relationship between corruption and aspects such as growth (Ehrlich and Lui, 1999; Mauro, 1995) and efficiency and welfare (Aidt, 2003). (iii) Recall the earlier discussion of diffused and demographically widespread corruption, which is the focus of this paper, versus oligarchic corruption. An aspect of the former category is that citizens and bureaucrats typically participate in it as faceless entities because, for example, there are many of them, and the turnover of bureaucrats, including their transfers to different locations, is significant. A natural assumption to make then is that, in this category of corruption, strategic considerations are not perhaps as central in the interactions between individuals as they are, say, in the interactions among the primary participants in oligarchic corruption. Accordingly, the analysis presented in this paper abstracts from strategic considerations. I depict atomistic interactions among a large number of individuals, in a manner similar to price-taking behavior of atomistic consumers and firms. (iv) The dynamic relationships of the kind described here, including the formation and consequences of perceptions, play a role in understanding many other societal phenomena besides corruption. A full discussion of these is outside the scope of this paper; see Sah (1991a) for an analysis of crime, and Lazear (2000) for some methodological observations.

There are several important literatures which provide perspectives which are complementary to but different from those presented in this paper. Since a full discussion of these literatures will take us far afield, I present some brief remarks: (i) In the literature on herding and informational cascades, individuals take actions sequentially. An individual's action is based on his information and on the history of actions taken by the individuals preceding him. An elegant example in Avery and Zemsky (1998, p. 725) describes the basic mechanism; Bikhchandani et al. (1998) provide an overview. In this literature, the same history of actions by previous individuals is available to all subsequent individuals. For example, consider two individuals, respectively, the fourth and the fifth to choose actions. Both observe the same history of actions by the first three individuals. In contrast, in the present paper, individuals do not observe any common history. As outlined earlier, and discussed in detail later, each individual has his own separate set of observations, based on his own experiences and other knowledge which he can gather. This representation is arguably better for studying cheating and corruption of the kind which is the focus of this paper. (ii) This paper's abstract depiction of the nature of interactions between citizens and bureaucrats appears to me to be natural, in the sense of being of first-order importance, for studying routine transactions between individuals belonging to these two groups. There are many other ways in which social influences are created and felt by individuals, and the relative importance of these ways depends partly on the context at hand. Glaeser and Scheinkman (2000) present a rich taxonomy of such influences, with many resulting insights. (iii) A branch of this taxonomy consists of models of interactions adapted from statistical physics; Durlauf and Blume (2001) provide a summary of such models and their potential applications. (iv) Tirole (1996) and Zucker (1977) have studied alternative mechanisms of intertemporal persistence.

1.1. Organization of the paper

Section 2 presents a simplified version of individuals' choices and analyzes some of their properties. Section 3 derives and analyzes dynamic relationships between past and future levels of cheating and corruption. Section 4 analyzes the effects of some of the parameters of the economy on cheating and corruption. For simplicity, the preceding analysis assumes that citizens begin their active lives with homogeneous initial beliefs, and that the same holds for bureaucrats. This assumption is removed in Section 5. Section 6 presents some extensions of the preceding analysis. Section 7 concludes with some speculative remarks.

2. Individuals' choices

This section provides building blocks for the rest of the paper. It describes the choices of a citizen and a bureaucrat, and presents some properties of these choices. The simplifying assumptions made in this section are relaxed or discussed in later parts of the paper.

In each time period, a new cohort of bureaucrats and citizens become active in the economy. Each cohort consists of a large number of bureaucrats, and an even larger number of citizens. An individual is active for L periods. Depending on the context, a 'period' can be defined arbitrarily, such as a week, month or a year. The value of L is large but finite because human life is finite. Citizens begin their active lives with initial beliefs concerning the level of corruption in the economy. Likewise, bureaucrats begin their active lives with initial beliefs concerning the level of cheating in the economy. Individuals revise their beliefs as they progress through life, which, as will be seen, makes their subsequent beliefs heterogeneous, regardless of whether or not their initial beliefs were heterogeneous. In reality, individuals begin their active lives with diverse initial beliefs. However, an artificial set-up in which individuals' initial beliefs are identical provides a simpler framework for understanding some of the key themes of this paper. I begin with this simpler framework. A more realistic model of the economy, in which individuals begin their active lives with diverse initial beliefs, is discussed in Section 5.

In each period, a citizen encounters one bureaucrat, and a bureaucrat encounters M citizens, where $M>1$; alternative assumptions in this regard as well as the role of other sources of information that might affect an individual's beliefs are discussed later. In each period, a citizen's choice is to cheat or not to cheat. Likewise, a bureaucrat's choice is to be corrupt or not to be corrupt. The participants in different encounters are determined stochastically. There is an equal probability that a particular citizen will encounter any one of the bureaucrats during a given period. Similarly, there is an equal probability that any citizen will belong to the subset of citizens whom a particular bureaucrat encounters during a given period. Thus, neither a bureaucrat nor a citizen knows in advance who will constitute his counterparty in a particular period. An individual must make his choice before the encounter. The individual's choice is therefore determined by the individual's current beliefs and his gains and losses from the alternative choices.

2.1. A citizen's choices

For a citizen who chooses to cheat in a particular period, the (expected) utility is u_{00} if he encounters a corrupt bureaucrat, and the utility is u_{01} if he encounters a bureaucrat who is not corrupt. The corresponding utilities for a citizen who chooses not to cheat are u_{10} and u_{11}. The only assumptions concerning the payoffs are that $u_{00} > u_{10}$, and $u_{11} > u_{01}$. The first inequality says that having cheated is better for a citizen than not having cheated if he encounters a corrupt bureaucrat. The second inequality says that not having cheated is better for a citizen than having cheated if he encounters a non-corrupt bureaucrat. Both of these assumptions are reasonable.[4]

The above structure of payoffs accommodates a variety of possible configurations. One such configuration is that a citizen who does not cheat has the same payoff whether he encounters a corrupt or a non-corrupt bureaucrat. That is, $u_{10} = u_{11}$. This configuration is consistent with my assumptions on the payoffs stated in the previous paragraph. Another configuration is that a citizen who has chosen not to cheat is worse-off if he encounters a corrupt rather than a non-corrupt bureaucrat. That is, $u_{11} > u_{10}$. This configuration is also consistent with my assumptions on the payoffs. Separately, this configuration illustrates that my definition of cheating is based solely on the ex ante choice of a citizen. For instance, in this configuration, the citizen chooses ex ante not to cheat (and undertakes associated actions; for example, filing honest tax returns), and, ex post, the corrupt bureaucrat forces an illegal transfer of resources from this citizen to himself. In my nomenclature, this transfer represents, depending on the context, such phenomena as extortion and predation, but not cheating. Finally note that I do not make any assumptions concerning the relative magnitudes of u_{00} and u_{11}; that is, whether having cheated and encountered a corrupt bureaucrat is better or worse for a citizen than not having cheated and encountered a non-corrupt bureaucrat. These relative magnitudes will depend partly on the surplus from cheating and corruption, and how this surplus is divided between the citizen, the bureaucrat, and the deadweight loss. Accordingly, these relative magnitudes will vary across different situations of corruption. The present paper abstracts from the causes and consequences of this variation.

The choice made by a citizen in each period depends on his mean estimate of the level of corruption in the economy. This is because this estimate represents the citizen's assessment of the probability of encountering a corrupt bureaucrat. Now,

[4]The above description of payoffs is quite general concerning aspects such as individuals' risk aversion, benefits from cheating, bribes to the bureaucrats, and fines and punishments from the detection of cheating. As an illustration, consider the configuration in which a non-cheating citizen is treated identically by a corrupt and a non-corrupt bureaucrat. Define the following: I is the non-cheating citizen's full income including the benefits received from the interaction with a bureaucrat, p is the probability that cheating will be detected, Z_{benefit} is the extra benefit from cheating, Z_{fine} is the net fine that a cheating citizen pays if a non-corrupt bureaucrat detects the cheating, Z_{bribe} is the net bribe that a cheating citizen pays if a corrupt bureaucrat detects the cheating, and v is the citizen's utility function. Then, $u_{00} \equiv pv(I + Z_{\text{benefit}} - Z_{\text{bribe}}) + (1-p)v(I + Z_{\text{benefit}})$, $u_{01} \equiv pv(I + Z_{\text{benefit}} - Z_{\text{fine}}) + (1-p)v(I + Z_{\text{benefit}})$, and $u_{10} = u_{11} \equiv v(I)$. As mentioned earlier, this paper does not deal with efficiency aspects of corruption. As a part of this boundary, I do not compare the efficiency of alternative forms of the full compensation of bureaucrats in the presence or absence of corruption.

consider a citizen at the beginning of period T, who began his active life in period t. Let a denote the vector of his characteristics. As will be seen, depending on the issues at hand, particular economic meanings can be attached to the elements of a. Let $s(t,T)$ denote the number of corrupt bureaucrats that this citizen has encountered during periods t to $T-1$. Let $q(s(t,T),a)$ define his mean estimate of the level of corruption at the beginning of period T. Then, this citizen's choice in period T will be:[5]

$$\text{Cheat if and only if: } q(s(t,T),a) \geqslant u, \tag{1}$$

where $u \equiv (u_{11} - u_{01})/\{(u_{00} - u_{10}) + (u_{11} - u_{01})\}$. The summary parameter u can be viewed as the 'relative cost of cheating' because it is increasing in u_{11} and u_{10}, and decreasing in u_{01} and u_{00}. Our assumptions concerning the payoffs imply that $1 > u > 0$.

2.2. A bureaucrat's choices

If a bureaucrat is corrupt during a particular period, then his utility is linearly increasing in the number of citizens, denoted by m, who have chosen to cheat among those whom this bureaucrat encounters during this period. The idea here is that a corrupt bureaucrat's 'catch' is larger if he ends up dealing with a larger number of cheating citizens. The utility of a corrupt bureaucrat is thus described by $U_0(m) \equiv U_{01} + mU_{00}$, where U_{00} is positive, and $M \geqslant m \geqslant 0$. The utility of a bureaucrat who is not corrupt is denoted by U_1. I assume that $U_0(M) > U_1 > U_0(0)$. That is, the utility of a bureaucrat who is not corrupt lies between a corrupt bureaucrat's maximum possible utility, which arises when all of the citizens whom he encounters have chosen to cheat, and the minimum possible utility, which arises when none of the citizens whom he encounters have chosen to cheat.

A bureaucrat's choice is analogous to that of a citizen's choice described earlier. For brevity, therefore, I leave out the details. Consider a bureaucrat at the beginning of period T, who began his active life in period t, and whose characteristics are denoted by vector A. Let $Q(S(t,T),M,A)$ denote the mean of the level of cheating in the economy, as estimated by this bureaucrat if he has found $S(t,T)$ citizens to be cheating among those whom he has encountered during the past $T-t$ periods. Then, this bureaucrat's choice in period T will be:

$$\text{Be corrupt if and only if: } Q(S(t,T),M,A) \geqslant U, \tag{2}$$

[5]To derive (1), note that the utility from cheating is $qu_{00} + (1-q)u_{01}$ and the utility from not cheating is $qu_{10} + (1-q)u_{11}$. This yields (1). It is assumed that an individual chooses to cheat if he is indifferent between cheating and not cheating. The analysis remains unchanged if the opposite assumption is made. Separately, note a generalization of (1) in which $s(t,T)$ is not a scalar but instead a vector, $(\varsigma(t), \varsigma(t+1), \ldots, \varsigma(T-1))$, such that $\varsigma(i)$ is 1 if this citizen encountered a corrupt bureaucrat in period i, and it is 0 otherwise. This generalization is clearly desirable because it is formally more comprehensive. However, I have not adopted it; partly for brevity in presentation and, more importantly, because it is unlikely to add much to the qualitative insights toward which this paper aims. An analogous comment applies to the behavior of bureaucrats described later.

where the parameter $U \equiv (U_1 - U_{01})/MU_{00}$ represents the 'relative cost of corruption' because it is increasing in U_1 and decreasing in U_{01} and U_{00}. Also, it follows from the assumptions concerning the payoffs that $1 > U > 0$.

2.3. Some properties of individuals' choices

It should be apparent from the above subsection that individuals' beliefs will in general be heterogeneous at the beginning of every period of their active lives, except at the beginning of their respective initial periods, because each individual's observations come from a different random draw. This subsection shows how this heterogeneity of beliefs translates into heterogeneity of choices. For specificity, I consider Bayesian updating of individuals' beliefs, and assume that their initial beliefs are represented by a non-degenerate beta distribution.[6] Let $a_1 > 0$ and $a_2 > 0$, which are the first two elements of vector a, denote the parameters of the beta distribution for a citizen. Let $A_1 > 0$ and $A_2 > 0$, which are the first two elements of the vector A, represent the corresponding parameters for a bureaucrat. Then

$$q(s(t,T),a) = \{a_1 + s(t,T)\}/\{a_1 + a_2 + (T-t)\} \tag{3}$$

and

$$Q(S(t,T),M,A) = \{A_1 + S(t,T)\}/\{A_1 + A_2 + (T-t)M\}; \tag{4}$$

see DeGroot (1970, pp. 40 and 160).

Now, consider a bureaucrat who was corrupt in the last period. Then, the decision rule (2) can be shown to imply that this bureaucrat will also be corrupt in the current period if MU or more citizens cheated among the M citizens whom he encountered in the last period. Likewise, a bureaucrat who was not corrupt in the last period will not be corrupt in the current period if MU or fewer citizens cheated among the M citizens whom he encountered in the last period. The reason is intuitive. If an individual's decision-relevant beliefs are sufficiently reinforced by his experience in a particular period, then he will not alter his behavior in the next period. These conclusions, and analogous ones for a citizen, are summarized below and proven in the Appendix.

Proposition 1. (a) *A citizen who cheated* (*did not cheat*) *in the last period will not alter his behavior in the current period if he encountered a corrupt* (*non-corrupt*) *bureaucrat in the last period.* (b) *A bureaucrat who was corrupt* (*non-corrupt*) *in the last period will not alter his behavior in the current period if a sufficiently large* (*small*) *proportion of the citizens whom he encountered in the last period cheated.*

[6] These assumptions are not necessary for the analysis, presented later, of the economy-wide evolution of cheating and corruption. Instead, any mild form of learning-from-experience is sufficient; for example, that a citizen who has encountered a larger number of corrupt bureaucrats in the past believes that the probability of encountering a corrupt bureaucrat in the current period is larger. Also, the assumption of a beta distribution is not particularly restrictive because other types of initial beliefs can be approximated to a reasonable degree by this distribution with appropriately chosen parameters.

2.4. Effects of an individual's initial beliefs on his behavior

One would expect initial beliefs to play a more significant role in an individual's choices in the earlier phase of his active life. At the same time, one would expect an individual's initial beliefs to continue to exert some effect on his choices throughout his active life. This is indeed the case, as will be seen later when we consider diversity in initial beliefs.

3. Evolution of cheating and corruption

As described earlier, the number of corrupt bureaucrats that a citizen has encountered in the past is random. The same is true for the number of cheating citizens that a bureaucrat has encountered in the past. Thus, recalling (1), the probability that a citizen who started his active life in period t will cheat in period T can be expressed as

$$f(t,T,u,a) \equiv \text{prob}\{q(s(t,T),a) \geqslant u\}. \tag{5}$$

From (2), the corresponding probability for a bureaucrat to be corrupt is

$$F(t,T,U,M,a) \equiv \text{prob}\{Q(S(t,T),M,A) \geqslant U\}. \tag{6}$$

I assume for now that citizens have identical characteristics, including their initial beliefs, and that the same holds for the bureaucrats; diversity in individuals' characteristics is considered later. The level of cheating in period T for the cohort of citizens which began its active life in period t is the proportion of citizens in this cohort who cheat. This proportion is random in general. However, given the large number of individuals, I use the Central Limit Theorem and approximate it as non-random. This proportion is thus given by f, defined in (5).[7] Likewise, the corresponding level of corruption is F, defined in (6), and it is also non-random. It is assumed throughout the paper that the level of cheating in each cohort of citizens, and the level of corruption in each cohort of bureaucrats, is greater than zero and smaller than one. Some of the reasons underlying this assumption are presented later in Section 5.

Let $c(T)$ and $C(T)$, respectively, denote the economy-wide levels of cheating and corruption in the current period T. Then, from the aggregation of (5) and (6) over all of the cohorts that are currently active

$$c(T) = \frac{1}{L} \sum_{t=T-L+1}^{\mathrm{T}} f(t,T,u,a), \tag{7}$$

[7] A derivation is as follows. Let $j = 1$ to J denote the citizens in a cohort. Let the Bernoulli variable X_j take the value of 1 if the jth citizen cheats and of 0 otherwise. From (5), the probability that the citizen will cheat is f. Hence, the variance of X_j is $f(1-f)$. The variables $X_1, X_2, \ldots, X_J$ are independent and identically distributed. Define $Y \equiv \sum_j X_j$ as the number of citizens, out of J, who cheat. The Central Limit Theorem implies that, as $J \to \infty$, Y tends to a normal random variable with mean fJ and variance $f(1-f)J$. In turn, the proportion of citizens who cheat, represented by Y/J, tends to a normal random variable with mean f and variance $f(1-f)/J$. Since J is large, I use the approximation that Y/J equals f and is not random.

and

$$C(T) = \frac{1}{L} \sum_{t=T-L+1}^{\mathrm{T}} F(t, T, U, M, A). \tag{8}$$

Next, consider the effects of the past on the current behavior of citizens; the effects on the current behavior of bureaucrats are analogous. Suppose that the level of corruption was higher in any of the past $L-1$ periods. This implies a larger probability that each citizen who was active in that period will have encountered a corrupt bureaucrat. Therefore, from (5) and (7), the current level of cheating will be higher. Thus,

$$\partial c(T)/\partial C(\tau) > 0 \quad \text{and} \quad \partial C(T)/\partial c(\tau) > 0 \quad \text{for } \tau = T-L+1 \text{ to } T-1. \tag{9}$$

For brevity in later use, (7) and (8) can be re-expressed in reduced-form as

$$c(T) = g(C(T-1), \ldots, C(T-L+1), u, a, \text{ other parameters}) \tag{10}$$

and

$$C(T) = G(c(T-1), \ldots, c(T-L+1), U, M, A, \text{ other parameters}). \tag{11}$$

These two expressions describe the dynamic evolution of the economy-wide level of cheating and corruption. Further, given (9), the dynamic interactions between expressions (10) and (11) yield

$$\partial c(T)/\partial c(\tau) > 0 \quad \text{and} \quad \partial C(T)/\partial C(\tau) > 0 \quad \text{for } \tau = T-L+1 \text{ to } T-2. \tag{12}$$

Expressions (9) and (12) yield

Proposition 2. *A higher level of cheating or corruption in the past results in a higher level of cheating as well as a higher level of corruption in the future.*

3.1. A summary of the nature of knowledge of individuals

I briefly summarize here the nature of individuals' knowledge depicted in the analysis presented thus far, and how and why this knowledge is different from the data which may exist in the economy but, given the nature of the economic phenomenon under consideration, is unavailable to individuals. For brevity, I discuss here only the citizens; the summary for the bureaucrats is analogous.

In the present simplified version of the model, citizens have homogenous initial beliefs, and they are homogenous in all of their other characteristics. Consequently, their actions are homogenous in the initial period of their respective lives. Consider the next period. Each citizen in a cohort collects observations which come from a different random draw. Their beliefs are therefore heterogeneous, as seen explicitly in the Bayesian illustration in (3). The choice of a citizen in this period is binary; to cheat or not cheat. Since the beliefs of citizens are heterogeneous, their choices are heterogeneous. These choices are described in (1) as outcomes of a binary random variable. The same heterogeneity of beliefs and choices is present in each cohort of citizens in all periods after the initial periods of their respective lives. This heterogeneity is consistent with the empirical evidence summarized in the introductory section.

Now consider the economy-wide levels. Recall from above that the choices made by the citizens in a cohort are represented by a binary random variable. Since the number of citizens in a cohort is large, I use the Central Limit Theorem as an approximation. Consequently, the level of cheating in this cohort (that is, the proportion of citizens who chose to cheat in this cohort) in a period is non-random. This non-random level of cheating is stated as (5). Aggregating across the cohorts of citizens, the economy-wide level of cheating, represented by $c(T)$ in (7), is also non-random. Analogous reasoning concerning the beliefs and choices of bureaucrats yields that the economy-wide level of corruption, represented by $C(T)$ in (8), is non-random.

The above depiction of $c(T)$ and $C(T)$ as non-random is for analytical convenience only. More important is the premise that no individual in the economy knows the precise magnitudes of $c(T)$ and $C(T)$. This is consistent with the empirical findings noted earlier concerning the heterogeneity in individuals' beliefs. Further, there are no public or market entities which do or can obtain these magnitudes and make them available to individuals, even at a cost to the latter. This is consistent with the heterogeneity reflected in the surveys of experts' beliefs about the levels of corruption. Even the abstract feasibility of a public or market entity being able to provide to citizens the magnitudes of $c(T)$ and $C(T)$ is doubtful. This is because, in such a situation, the ultimate sources of information (namely, the citizens and the bureaucrats) as well as the aggregators of information (namely, a public or private entity) are both naturally subject to such issues as incentives, truthfulness, verifiability and legitimacy.

Now, consider a citizen once again. Given that the value of $C(T)$ is not known to him, he uses all of the information that he has, from his own experiences and from other sources discussed earlier. The phrase 'osmosis' in the title of this paper additionally underscores this central aspect of the present analysis; in life-sciences, the ultimate locus of osmosis is almost always local rather than global. At each stage of his life, an individual's choices are based on the information which he has as of that date. Finally note that, for the case of Bayesian updating, I have shown that an individual's choices are fully consistent with the information which he has. Thus, while other behavioral assumptions (for example, bounded rationality) can be accommodated within the present analysis, it does not necessarily require them.

4. Steady-states and comparative statics

I now analyze the steady-states of the dynamic system described by (10) and (11). Here, a steady-state is a hypothetical situation in which the period-to-period changes in the levels of cheating and corruption are negligible. We look at only those steady-states that are locally stable, that is, the 'sinks' of the dynamic system (see Hirsch and Smale, 1974, p. 280, for a definition). If the economy is close to such a steady-state, and receives small shocks, from whatever sources, then the economy will in the future return to the same steady-state. It is important to emphasize that a steady-state is not an equilibrium, because there are no agents or forces in this economy who can, or who wish to, bring it to an equilibrium. Instead, a steady-state here is simply a stylized depiction, derived from dynamic analysis, that can be potentially helpful in studying certain qualitative properties of the economy.

Let c and C, respectively, denote the economy-wide levels of cheating and corruption at a steady-state. For brevity, let ϕ denote any parameter that affects the function g in (10), such as any element of a. Likewise, let Φ denote any parameter that affects the function G in (11), such as U, M, or any element of A. Then, from (10) and (11), a solution of the equation system

$$c = h(C, \phi) \quad \text{and} \quad C = H(c, \Phi) \tag{13}$$

defines a steady-state value of c and C.

Sah (1991b) presents more than one statement of the conditions that are necessary and/or sufficient for a particular (C, c) to be stable. Roughly stated, a common method is to: (i) convert the underlying higher-order dynamic system (10) and (11) to a first-order system; (ii) obtain the gradient matrix (which is sometimes referred to as the 'companion' matrix) of the preceding first-order system; (iii) evaluate this matrix at the (C, c) under consideration; and (iv) calculate the maximum of the absolute values of the eigenvalues of the matrix just evaluated. If this maximum is smaller than one, then (C, c) is stable. These steps are formally stated in Sah (1991b). Hirsch and Smale (1974) is a classic source of background material on discrete dynamic systems.

The equations in (13) are highly non-linear, as will be seen later. Hence, these equations will in general admit multiple steady-states. Therefore, recalling Proposition 2, we can state

Proposition 3. *Consider two economies with identical current economic fundamentals. These economies can have different steady-state levels of cheating and corruption. An economy with higher steady-state levels of cheating and corruption will have had at least some history of higher levels of cheating or corruption or both.*

The historical process described earlier allows us to understand how different steady-states might be reached. For instance, two economies with identical current parameters may reach two different steady-states if they have faced different kinds of shocks in the past, or if they have faced similar shocks but at different times in the past. No matter what the reason, once the levels of cheating and corruption in these two economies begin to diverge significantly, there may not be forces in these economies that will eliminate or even reduce these differences.

4.1. Bayesian steady-states

In this subsection, I briefly present a special case of the steady-state system (13) in which individuals' learning is characterized by Bayesian updating. The sole purpose of this special case is to provide illustrations. Hence, it is not necessary here to go into the strengths and limitations of Bayesian updating as a paradigm of human learning.

Let $\ell \equiv T - t$ represent the number of periods for which a citizen has been active. Recalling (1), define $\bar{r}(\ell, u, a)$ through the equality $q(\bar{r}(\ell, u, a), a) = u$. From (1) and (3), it follows that

$$\bar{r}(\ell, u, a) \equiv (a_1 + a_2 + \ell)u - a_1. \tag{14}$$

Next define $r(\ell, u, a)$ as the smallest integer that is greater than or equal to $\bar{r}(\ell, u, a)$. That is,

$$r(\ell, u, a) \equiv [\bar{r}(\ell, u, a)]_+, \tag{15}$$

where $[\,]_+$ is the rounding-off function just described. It then follows from (1) and (3) that a citizen who has lived for ℓ periods will choose to cheat in the $(\ell + 1)$st period of his active life if and only if he has encountered $r(\ell, u, a)$ or more corrupt bureaucrats in the past. Hence, we refer to $r(\ell, u, a)$ as the 'reservation level' of a citizen.

Let $b(j, \ell, C) \equiv \binom{\ell}{j}(C)^j(1 - C)^{\ell - j}$ denote the binomial probability of j successes out of ℓ trials where the probability of success in each trial is C. Let $B(r, \ell, C) \equiv \sum_{j=0}^{r} b(j, \ell, C)$ denote the cumulative binomial distribution. Now consider the cohort that has been active for ℓ periods. It follows that this cohort's level of cheating in the $(\ell + 1)$st period of its life, denoted by $c^{\ell+1}$ (where $\ell + 1$ is a superscript), will be

$$c^{\ell+1} \equiv 1 - B(r(\ell, u, a) - 1, \ell, C). \tag{16}$$

Further, the economy-wide level of cheating will be

$$c = h(C, \phi) \equiv \frac{1}{L}\sum_{\ell=0}^{L-1} c^{\ell+1}. \tag{17}$$

Since the description of the bureaucrats' behavior is analogous, I leave out the details, and state the corresponding expressions:

$$\bar{R}(\ell, U, M, A) \equiv (A_1 + A_2 + \ell M)U - A_1, \tag{18}$$

$$R(\ell, U, M, A) \equiv [\bar{R}(\ell, U, M, A)]_+, \tag{19}$$

$$C^{\ell+1} \equiv 1 - B(R(\ell, U, M, A) - 1, \ell M, c) \tag{20}$$

and

$$C = H(c, \Phi) \equiv \frac{1}{L}\sum_{\ell=0}^{L-1} C^{\ell+1}. \tag{21}$$

To recapitulate some of what has been done thus far, recall the dynamic system described by (10) and (11). For brevity, I will refer to it as the 'general dynamic system.' Expression (13) is obtained by adding to (10) and (11) the definition of the steady-state that $C(T) = C$ and $c(T) = c$, for all T. I will refer to (13) as the 'general steady-state system.' The set of equations (14)–(21) is the Bayesian special case of the general steady-state system (13). I will refer to this set of equations as the 'Bayesian steady-state system.' In the above presentation, the preceding system has been obtained by directly inserting the Bayesian updating assumptions into the general steady-state system, (13). A different but equally valid method to reach (13) entails the following two steps. First, the Bayesian updating assumptions are inserted into (10) and (11) to obtain what might be referred to as the 'Bayesian dynamic system.' Second, the definition of the steady-state (namely, that $C(T) = C$ and $c(T) = c$, for all T) is added to the just-mentioned Bayesian dynamic system to obtain the Bayesian steady-state system (14)–(21). To keep this paper within a reasonable length, I do not here describe this two-step method.

I now briefly present three remarks on the numerical analysis of the Bayesian special case. First, the nature of the dynamic systems under consideration here suggests that they should, in general, admit multiple steady-states for the same set of parameter values. The numerical analysis confirms this. Second, consider the stability of steady-states. Analysis of stability requires the use of the Bayesian dynamic system described in the previous paragraph, and of methods such as those presented earlier in this section. For a range of parameter values which I have examined, the numerical analysis yields one or more stable steady-states. Third, there are several other potentially important facets of stability analysis. One such facet is to obtain analytical restrictions on the parameters of the Bayesian special case which will guarantee that at least one stable steady-state exists. These facets are related, but only distantly so, to the qualitative focus of the present paper. Hence, full analyses of these facets might be treated as a matter for future research.

4.2. Comparative statics of the steady-states

Let a letter subscript denote the parameter with respect to which a partial derivative is being taken; for example, $h_\phi \equiv \partial h(C, \phi)/\partial \phi$. I use (9) and perturb the system (13) around a steady-state. I use some results presented in Sah (1999). This yields

$$\operatorname{sgn}\{\mathrm{d}c/\mathrm{d}\phi\} = \operatorname{sgn}\{\mathrm{d}C/\mathrm{d}\phi\} = \operatorname{sgn}\{h_\phi\}, \tag{22}$$

$$\operatorname{sgn}\{\mathrm{d}C/\mathrm{d}\Phi\} = \operatorname{sgn}\{\mathrm{d}c/\mathrm{d}\Phi\} = \operatorname{sgn}\{H_\Phi\}, \tag{23}$$

$$|\mathrm{d}c/\mathrm{d}\phi| > |h_\phi| \quad \text{and} \quad |\mathrm{d}C/\mathrm{d}\Phi| > |H_\Phi|. \tag{24}$$

To interpret these expressions, note that h_ϕ can be viewed as the first-round effect of a change in a parameter on the level of cheating. The levels of cheating and corruption in future periods are affected not only by the preceding parameter change but also by a sequence of indirect dynamic effects. Accordingly, $\mathrm{d}c/\mathrm{d}\phi$ and $\mathrm{d}C/\mathrm{d}\phi$, respectively, represent the full effects of a sustained change in parameter ϕ on the steady-state levels of cheating and corruption. Analogous interpretations apply to H_Φ and its impacts, $\mathrm{d}c/\mathrm{d}\Phi$ and $\mathrm{d}C/\mathrm{d}\Phi$, on the steady-state.

Proposition 4. *Consider a sustained change in a parameter that affects either the level of cheating or the level of corruption.* (a) *The effect of this change on the steady-state levels of cheating as well as corruption has the same sign as that of the first-round effect* *of the parameter change*. (b) *The magnitude of change in the steady-state level of cheating (corruption) is larger than that of the first-round effect of a parameter change that affects the level of cheating (corruption)*.

4.3. Some effects of changes in the costs of cheating and corruption

To see an illustration of the above proposition, consider a sustained increase in the relative cost of corruption, U. The first-round impact of an increase in U is to lower the level of corruption, because being corrupt is now less attractive to some bureaucrats than not being corrupt.[8] Because of this, citizens will in future periods encounter fewer corrupt bureaucrats leading to a reduced level of cheating. In turn, bureaucrats will in future periods encounter fewer cheating citizens. Thus, the indirect effects will reinforce the direct effect. Consequently, the steady-state level of cheating as well as corruption will be lower. Further, the decrease in the steady-state level of corruption will be larger in magnitude than the first-round reduction in the level of corruption. Using identical reasoning, it can be seen that a sustained increase in the relative cost of cheating will lead to lower steady-state levels of cheating as well as corruption, and that the steady-state level of cheating will decline by a larger magnitude than that of the first-round effect of this parameter change.

4.4. Some effects of the sources of information that influence individuals' beliefs

To simplify the analysis, I have thus far used the abstraction that, in each period: (i) a citizen encounters one bureaucrat; (ii) a bureaucrat encounters M citizens; and (iii) these are the only sources of information which influence individuals' beliefs. I also assumed a particular format of interactions between citizens and bureaucrats, including that each pair of participants in the interaction is chosen randomly in each period. Such assumptions were made for brevity. The main point here is that an individual learns, at times erroneously, from a variety of sources. For instance, an individuals' friends and relatives might be additional sources of information, but such sources may contain errors, perhaps prompting an individual to place more weight on one's own observations than on those of the others. Rumors and hearsay are another error-laden source of information. Likewise, the mass media may not contain information that is highly meaningful for decision-making because of its usual focus on a few high-profile cases. From an economic viewpoint, a given number of additional observations containing errors is nearly the same as fewer additional error-free observations.

To examine the effects of additional observations, consider an increase in the number of citizens that a bureaucrat encounters in each period. Suppose that this number is $M+1$ instead of M. Then, a bureaucrat's: (i) sample size increases

[8] This can be seen as follows; for brevity, I leave aside some minor details. Note from (18) and (19) that R is non-decreasing in U. Assume that the increase in U induces an increase in R for at least one of the relevant values of ℓ. From (20), $C^{\ell+1}$ is decreasing in R because B is increasing in R. Hence, from (21), H is decreasing in U.

because he has obtained one more observation in each of the past periods in which he was active, and (ii) reservation level will likely increase because he now requires greater evidence of cheating (that is, a larger number of past encounters with cheating citizens) to be convinced that it is in his interest to be corrupt.

It is intuitive to expect that if the current level of cheating is high, then a larger M will increase the probability of a bureaucrat being corrupt. This is because a larger M will make it more likely that the increased reservation level is satisfied. In this case, the level of cheating and corruption in the economy will likely increase. On the other hand, a low level of cheating is likely to have the opposite effect. This intuition is supported by the result stated below which is derived in the Appendix A. A similar result holds for an increase in the number of bureaucrats that a citizen encounters in each period.

Proposition 5. *Suppose that the youngest cohorts of bureaucrats are indifferent between being corrupt and not corrupt. Then, increased interactions between citizens and bureaucrats result in increased (decreased) level of cheating as well as an increased (decreased) level of corruption in the economy if the current level of cheating is larger (smaller) than the relative cost of corruption.*

5. Diversity of initial beliefs

It is natural to posit that individuals begin their active lives with diverse initial beliefs, even though, for simplicity, I have thus far assumed otherwise. The incorporation of this diversity requires a small modification in the preceding analysis and it yields several insights. Let $w_1(a_1)$ and $w_2(a_2)$ denote the distribution functions of a_1 and a_2, and let $W_1(A_1)$ and $W_2(A_2)$ denote the distribution functions of A_1 and A_2. Then, instead of (17) and (21), the expressions for the steady-states are

$$\begin{aligned} c = h(C, \phi) &\equiv \frac{1}{L} \sum_{\ell=0}^{L-1} c^{\ell+1} \\ &= \frac{1}{L} \sum_{\ell=0}^{L-1} \int_{a_1} \int_{a_2} \{1 - B(r(\ell, u, a) - 1, \ell, C)\} \, \mathrm{d}w_1(a_1) \, \mathrm{d}w_2(a_2) \end{aligned} \tag{25}$$

and

$$\begin{aligned} C = H(c, \Phi) &\equiv \frac{1}{L} \sum_{\ell=0}^{L-1} C^{\ell+1} \\ &= \frac{1}{L} \sum_{\ell=0}^{L-1} \int_{A_1} \int_{A_2} \{1 - B(R(\ell, U, M, A) - 1, \ell M, c)\} \, \mathrm{d}W_1(A_1) \, \mathrm{d}W_2(A_2). \end{aligned} \tag{26}$$

Now recall an earlier assertion that the initial beliefs of an individual exert some influence on his choices throughout his life. A simple way to illustrate this is to compare the behavior of a bureaucrat who, given his initial beliefs, was initially not corrupt to that of a bureaucrat who was initially corrupt. The following result is derived in the Appendix A. An analogous result holds for citizens.

Proposition 6. *An initially corrupt bureaucrat cannot have a smaller probability of being corrupt in any subsequent period than a bureaucrat who was not initially corrupt.*

5.1. Extremes of cheating and corruption

Is it possible that all bureaucrats in an economy are corrupt, or that no bureaucrat is corrupt? Likewise, is it possible that all citizens in an economy cheat, or that no citizen cheats? The analysis below shows that, under plausible assumptions, the answer is no.

Consider the possibility of a steady-state in which no bureaucrat is corrupt; that is, of the 'corner' steady-state in which $C = 0$. Such a steady-state obviously requires the youngest cohorts of bureaucrats to be non-corrupt. However, this steady-state is not sustained if even a few members of the youngest cohorts of citizens choose to cheat. The arrival of these few citizens into the economy in each period will eventually cause at least some bureaucrats, among those who happen to encounter one or more of these cheating citizens, to believe that it is in their interest to be corrupt. The choice of these bureaucrats to be corrupt will, in turn, cause more citizens to cheat in the future. The resulting steady-state must therefore entail at least some cheating and some corruption.

Analogous reasoning suggests the infeasibility of other corner steady-states, in which all bureaucrats are corrupt, and in which all or none of the citizens choose to cheat. These conclusions, proven in the Appendix A, are summarized below. As shown in the Appendix A, a sufficient condition for these results is that the number of periods for which the individuals are active in the economy is not too small, so that the dynamics initiated by a small subset of individuals do not die out before they have had an opportunity to affect the economy.

Proposition 7. (a) *At least some bureaucrats will be corrupt, even if all bureaucrats begin their lives not being corrupt, provided that at least a few citizens begin their lives choosing to cheat.*

(b) *At least some bureaucrats will not be corrupt, even if all bureaucrats begin their lives being corrupt, provided that at least a few citizens begin their lives choosing not to cheat.*

(c) *At least some citizens will cheat, even if all citizens begin their lives choosing not to cheat, provided that at least a few bureaucrats begin their lives choosing to be corrupt.*

(d) *At least some citizens will choose not to cheat, even if all citizens begin their lives choosing to cheat, provided that at least a few bureaucrats begin their lives choosing not to be corrupt.*

5.2. Some effects of the nature of initial beliefs

The initial beliefs of a bureaucrat are represented by the parameters (A_1, A_2). Substituting $t = T$ and $S(t, T) = 0$ into (4), it is easily ascertained that a bureaucrat with a larger A_1 or a smaller A_2 begins his active life with a larger estimate of the mean level of cheating in the economy. Consider a first-order stochastic improvement in the distribution of A_1, or a first-order stochastic worsening in the distribution of A_2. Each of these two perturbations imply that a larger fraction of the youngest cohorts of bureaucrats believes that there is a greater prevalence of cheating in the economy. Likewise, a first-order stochastic improvement in the distribution of a_1, or a first-order stochastic worsening in the distribution of a_2, implies that a larger fraction of the youngest cohorts of citizens believe that there is a greater prevalence of corruption in the economy.

All of the four perturbations just mentioned have similar implications. A first-order stochastic improvement in the distribution of A_1 will lead to at least a few more bureaucrats choosing to be corrupt. This, in turn, will initiate a dynamics inducing more citizens to cheat and more bureaucrats to be corrupt. Thus, the new steady-state to which the economy will settle will have higher levels of cheating and corruption. The effects of the other three perturbations can be traced similarly. These conclusions are summarized below, and are derived in the Appendix A.

Proposition 8. *If a larger fraction of the youngest cohorts of bureaucrats believe that the level of cheating is higher in the economy, or if a larger fraction of the youngest cohorts of citizens believe that the level of corruption is higher in the economy, then the actual level of cheating as well as that of corruption in the economy will be higher.*

6. Some extensions

This section presents some extensions of the analysis presented earlier. Each extension is considered separately from the others.

6.1. Heterogeneity in individuals' characteristics

The only source of heterogeneity in individuals' characteristics in the preceding analysis is that due to their initial beliefs. To see how other kinds of heterogeneity can be incorporated, consider the case in which the benefits to a citizen from alternative actions (that is, from cheating or not cheating) depend partly on his wealth. One can then characterize the steady-states of the economy for any given distribution of wealth in the economy. Moreover, one can establish intuitive results of the following kind: *If a citizen's relative cost of cheating is decreasing in his wealth, then a first-order stochastic improvement in the distribution of wealth will result in higher steady-state levels of cheating as well as corruption.* The effects of other types of heterogeneity (such as those in individuals' preferences for cheating or corruption) can be examined similarly.

6.2. A bureaucrat's trade-offs

In the earlier analysis, a bureaucrat's trade-off was as follows. The gain to a bureaucrat from being corrupt was $U_0(m)$, which was linearly increasing in m, where

m denoted the number of cheating citizens that the bureaucrat encounters in a period. Now suppose that U_0 is increasing in m but not in a linear fashion. Then, the decision rule (2) will get redefined, but it will still be the case that a bureaucrat is more likely to be corrupt if he has encountered a larger number of cheating citizens in the past.

6.3. Individuals' payoffs

A possible extension is to incorporate the effects of the levels of cheating and corruption on individuals' payoffs. For example, a higher level of corruption may reduce the benefits from corruption, because of increased dissipation of the surplus from corruption. The opposite effect may arise if a higher level of corruption leads to increasingly larger parts (for example, sectors and regions) of the economy becoming subject to corruption. I do not study here the nature of these effects and their consequences, which will depend partly on the context of corruption.

7. Some speculative remarks

In the last two thousand years of recorded history, pervasive and persistent corruption has been the norm in human societies rather than the exception. It is unlikely that 'good old days' ever existed except locally and temporarily. Perhaps the most notable large-scale exception is the decline, in relation to its previous very long-term past, in corruption in northwestern Europe, beginning roughly in the mid 19th century, and the sustained low levels thereafter. In a historical sense, as well as in comparison to the rest of the contemporaneous world, this change was monumental. The present understanding of the fundamental causes and processes of these changes is quite limited; see Glaeser and Goldin (2004) for their pioneering work on the United States and for a summary of the insights from related work.

There are several informal hypotheses concerning corruption which are potentially important but whose causal structures have not been adequately articulated. Among these are the possible roles of religion and democracy. An example of the hypothesis concerning religion is that Protestantism, as in Scandinavia, encouraged and continues to encourage lower corruption in contrast with Catholicism, as in Spain. Among the examples which suggests that religious differences may not be central are those mentioned earlier for regions within Italy and India. One argument concerning the role of democracy is that citizens' participation reduces corruption. However, there are several counter-examples. For instance, among postcolonial societies, corruption was nearly eliminated in Singapore by the authoritarian government of Lee Kuan Yew, whereas it is pervasive in the democracy of India. The analysis presented in this paper accommodates heterogeneity of individuals' preference, and this can partly capture the role of factors such as religion. Likewise, this analysis accommodates a variety of parameters which might be different in democracies versus autocracies, including those describing detection and punishment of those who cheat or are corrupt. A causal analysis of the hypotheses noted in this paragraph will require, at the minimum, specifications of how particular religions and forms of governance are reflected in the parameters describing individuals' perceptions, preferences and opportunities.

Another hypothesis, of which the causal structure is unclear, is that the level of corruption declines when a society reaches some high level of income and wealth. The reverse possibility is that lower levels of corruption induce higher level of incomes. If this hypothesis is predicated upon the notion that the poor have a higher willingness to live with corruption, then it is unclear whether this is because of their preferences or because they have more limited alternatives. These two perspectives will likely have quite different implications, especially for the welfare costs of corruption.

Yet another hypothesis is that a smaller role of government results in lower levels of corruption. A key idea here, which has obvious strength, is that a smaller role of government means fewer opportunities for corruption, which results in less overall corruption. It is unlikely however that this hypothesis, by itself, can explain experiences such as those noted at the beginning of this section concerning northwestern Europe. During the period under consideration (namely, beginning roughly in mid 19th century), the role and the size of government has increased in these countries almost continuously until the late 20th century. These and other puzzles await answers.

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Appendix A

Proof of Proposition 1. Consider a bureaucrat who was corrupt in period T. From (2) and (4), thus, $A_1 + S(t,T) \geqslant [A_1 + A_2 + (T-t)M]U$. Suppose that MU or more citizens out of M whom he encountered in period T had cheated. That is, $S(t, T+1) \geqslant S(t,T) + MU$. The preceding two inequalities imply that $A_1 + S(t,T+1) \geqslant [A_1 + A_2 + (T-t+1)M]U$. From (2) and (4), therefore, this bureaucrat will be corrupt in period $T+1$. Analogous proofs apply to the behavior of: (a) a bureaucrat who was not corrupt in the previous period; (b) a citizen who cheated in the previous period; and (c) a citizen who did not cheat in the previous period. □

Proof of Proposition 5. We: (i) treat M as a continuous variable; (ii) ignore the distinction between $\bar{R}$ and R, described respectively in (18) and (19); and (iii) approximate the binomial distribution function in the right-hand side of (20) by a normal distribution function. Then, from (20),

$$C^{\ell+1} = 1 - \mathrm{N}[(\bar{R} - \ell Mc)\{\ell Mc(1-c)\}^{-1/2}], \tag{A.1}$$

where N[ ] represents the distribution function of the unit normal variate, and $\bar{R}$ is given by (18). The derivative of the right-hand side of (A.1), with respect to M, can be rearranged to yield

$$\mathrm{sgn}\{\mathrm{d}C^{\ell+1}/\mathrm{d}M\} = \mathrm{sgn}\{\ell M(c-U) + A^*\}, \tag{A.2}$$

where $A^* \equiv (A_1 + A_2)U - A_1$. Next, note from (2) and (4) that the youngest cohorts of bureaucrats (for whom $t = T$ and $S(t, T) = 0$) are indifferent between being corrupt and non-corrupt if $A^* = 0$. Hence, the desired result follows from (A.2). □

Proof of Proposition 6. Let the parameters A_1^j and A_2^j denote the initial beliefs of two bureaucrats represented by the superscript $j = 1, 2$. Now suppose that bureaucrat 1 was initially corrupt and bureaucrat 2 was not. Then, the substitution of $\ell = 0$ into (18) yields: $[(A_1^2 + A_2^2)U - A_1^2] > 0 \geqslant [(A_1^1 + A_2^1)U - A_1^1]$. Adding ℓMU to all terms in the preceding expression and using (18), we obtain $\bar{R}(\ell, U, M, A_1^2, A_2^2) > \bar{R}(\ell, U, M, A_1^1, A_2^1)$. In turn, from (19),

$$R(\ell, U, M, A_1^2, A_2^2) \geqslant R(\ell, U, M, A_1^1, A_2^1) \quad \text{for all } \ell. \tag{A.3}$$

The probability that the bureaucrat j will be corrupt in a subsequent period of his life (that is, for $\ell = 1$ to $L - 1$) is $1 - B(R(\ell, U, M, A_1^j, A_2^j) - 1, \ell M, c)$. Since B is increasing in R, the desired result follows from (A.3). □

Proof of Proposition 7. The following properties of the binomial cumulative distribution, $B(r, \ell, C)$, are used below. If $0 < C < 1$, then: (i) $B = 0$ if $r < 0$; and (ii) $B = 1$ if $r \geqslant \ell$. If $C = 0$, then: (i) $B = 0$ if $r < 0$; and (ii) $B = 1$ if $r \geqslant 0$. If $C = 1$, then: (i) $B = 0$ if $r < \ell$; and (ii) $B = 1$ if $r \geqslant \ell$.

We prove here part (a) of Proposition 7; the proofs of the other parts are analogous. Since $c^1 > 0$, it follows from (25) that

$$c > 0. \tag{A.4}$$

Recalling (26), and noting that $C^1 = 0$, the condition for $C = 0$ is that

$$1 - B(R(\ell, U, M, A) - 1, \ell M, c) = 0 \tag{A.5}$$

for each $\ell \geqslant 1$, and for each value of (A_1, A_2). Now, recall the properties of the binomial distribution function noted earlier. Given (A.4), the condition (A.5) can be satisfied only if

$$R(\ell, U, M, A) - 1 \geqslant \ell M. \tag{A.6}$$

We ignore the distinction between $\bar{R}$ and R, described in (18) and (19). Using (18), the condition (A.6) can be restated as

$$(A_1 + A_2)U - (A_1 + 1) \geqslant \ell M(1 - U).$$

Since $U < 1$, the preceding condition cannot be satisfied (and, hence, C cannot be zero) if ℓ is sufficiently large. □

Proof of Proposition 8. Assuming that the end-points of A_1 are fixed, let the distribution function of A_1 be denoted by $W_1(A_1, \Phi)$, such that a larger value of the parameter Φ represents a first-order stochastic improvement in the distribution of A. That is, $\partial W_1/\partial\Phi \leqslant 0$ and the inequality is strict for at least some values of A_1. Recalling (18) and (19), and ignoring the distinction between $\bar{R}$ and R, it follows from (18) that

$$\partial R/\partial A_1 < 0. \tag{A.7}$$

Next, consider (26), and, for brevity, define $Z \equiv 1 - B(R(\ell, U, M, A) - 1, \ell M, c)$. Hence, $\partial Z/\partial R \leqslant 0$. Combining this with (A.7), we get $\partial Z/\partial A_1 \geqslant 0$. To avoid unnecessary details, we assume that there is at least one set of values of ℓ and A_1 for which the preceding inequality is strict and $\mathrm{d}W_1/\mathrm{d}\Phi$ is strictly negative. From (26) and a standard result on first-order stochastic dominance, then, $H_\Phi > 0$. In turn, from (23), $\mathrm{d}c/\mathrm{d}\Phi > 0$ and $\mathrm{d}C/\mathrm{d}\Phi > 0$. Analogous reasoning yields the results concerning the stochastic changes in the distributions of A_2, a_1, and a_2. $\square$

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