Developing Rotten Institutions

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Abstract

This paper models corruption as optimal parasitism in organizations where teams of agents are weakly restrained by principals. Each agent takes on part of the role of principal, choosing how much to invest in policing to repress corruption in others and how rapaciously to act when unpoliced opportunities arise. This simple model incorporates most of the factors stressed in empirical analyses of corruption, and gives rise to a wide variety of equilibria. Allow income to co-evolve with corruption, we show how adding corruption to a textbook exogenous growth model leads to a Lucas paradox. When income and corruption affect each other sufficiently strongly, economies converge to two corner equilibria despite diminishing returns to capital: a rich, clean corner and a poor, corrupt one; a pattern that appears to characterize international data.

1 Introduction.

To the fundamental question "Why are we so rich, and they so poor?" is increasingly given the answer "Because we have good institutions, and they bad ones." While the quality of institutions has moved to the centre of the empirical growth literature, less attention has been given to formal models of what determines this quality.

The obvious way for economists to understand the quality of institutions is through principal-agent models, where senior bureaucrats as agents choose how

conscientiously to act in response to the monitoring and incentives that they face. The problem in applying a principal-agent model to bureaucracies however is that there is often no obvious principal: most bureaucracies operate with little external monitoring. In the absence of effective principals then, what determines the quality of a country's institutions, and indeed how does any country manage to have institutions better than Nigeria's?

The basic idea of this paper is that agents in teams who are weakly controlled by a principal will each take on some of the role of the principal and police each other's behaviour. The degree of policing and the rapacity of agents when unpolicied opportunities present themselves determine the quality of the institution. Just as decentralized markets are ordered through the invisible hand of the price mechanism, so decentralized organisations are ordered through the invisible fist of mutual policing.

Corruption in organisations is analogous to parasitism in animals. A central question in parasitology is what restrains the virulence of unrelated parasites. The answer, and the motivation for the analysis here, is mutual policing: each unit can benefit by devoting resources to reducing the rapacity of its neighbours (Frank, 1995).

Our model is very simple. Each agent invests effort p_i to policing other agents. An average policing level of p means that each bureaucrat must devote a fraction p of his time to doing his job and can devote his remaining time to being dishonest. During the fraction $1 - p$ of the time when unpoliced opportunities occur the agent must choose r_i, how rapaciously to act. Rapacity can range from looking out the window to grand larceny. The amount of corruption reflects how much time each agent devotes to dishonesty and with what intensity: $c = (1 - p)r$.

Policing at intensity p_i costs the agent $C(p_i)$. The bureaucrat gets a return $D(r_i)$ from unpoliced activities and may have self-restraint that imposes a cost $S(r_i)$ on rapacity. Any loss of institutional efficiency from corruption imposes a cost of $E(c)$ on the agent through pressure from principals, loyalty to the institution, or fear of competing institutions. Given these costs and returns, the individual chooses optimal levels of policing and rapacity. This simple model can incorporate most of the factors included in informal analyses of corruption: colonial and legal

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origins, education, the curse of natural resources, competitive entry and formal career ladders, democracy, and press freedom.

Section 3 shows that the resulting equilibrium can be an internal one with intermediate levels of policing and rapacity; a corner with zero policing and low rapacity; or a corner with high rapacity repressed by heavy policing. Section 4 shows how the model can explain how corruption evolves through time, in particular the gradual fall of corruption in developed economies; and its rapid rise in former-colonial and Soviet economies.

Section 5 allows corruption and income to co-evolve. It shows that if corruption and income exert a sufficiently strong effect on each other, economies fall into two basins of attraction: one converging on a high income, low corruption steady state, the other converging to a low income, high corruption steady state. In other words, adding corruption to a standard Solow-Ramsey growth equation leads to a Lucas paradox: high and low income economies co-exist despite monotonically diminishing returns to capital. Section 6 finds that in international data, income and institutional quality appear to fall into two clusters, consistent with two basins of attraction.

2 Quis custodiet ipsos custodes?

In this section we develop a simple model of the behaviour of senior bureaucrats. Each chooses how much effort p_i to invest in policing other agents, and how rapaciously to act r_i when an unpoliced opportunity presents itself.

Policing here serves to deter corruption rather than to punish it.[1] If the average policing level of other agents is p_{-i}, the agent can engage in dishonest activities a fraction $1 - p_{-i}$ of the time. Policing involves not only direct monitoring of colleagues and subordinates but also developing and implementing better ways to control and audit activity.

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[1] Policing here is exactly analogous to repairing fences among Ellickson's (1986) Shasta County ranchers. Because policing deters corruption in others it has an immediate payoff, in contrast to punishment which requires costly action after someone has broken the rules, leading to second-order free rider problems (Panchanathan and Boyd, 2004).

To police others with an effectiveness p_i costs the agent $C(p_i)$ with $C_p > 0, C_{pp} > 0, C(0) = 0$. The cost of policing reflects the characteristics of individuals, and the norms and structures of the institutions in which they operate. Rauch and Evans (2000) find that the performance of bureaucracies is strongly predicted by the extent to which they are "Weberian": having open, competitive appointments and promotions through a clearly defined hierarchy. Career bureaucrats who have risen through the system through demonstrated ability and loyalty to institututional norms will be able to police more effectively than political appointees. Other factors affecting policing costs are the educational level of bureaucrats, the level of organizational technology, and, if differing legal systems require different degrees of procedural formalism, the origin of the legal code (La Porta et al., 1999).

An agent who exploits an opportunity for dishonesty with rapacity r_i receives a payoff of $D(r_i)$ with $D_r > 0, D_{rr} < 0, D(0) = 0$. Several factors considered in the empirical literature increase the payoff to dishonesty D: low salaries, and economic circumstances conducive to soliciting generous bribes or diverting funds for personal use: multilateral aid, big government, or the curse of natural resources (Ades and Di Tella 1999, Leite and Weidmann 2002).

The professionalism of bureaucrats not only affects how much they restrain the rapacity of each other, but how much they restrain their own rapacity. We suppose that exercising rapacity of r_i imposes a cost $S(r_i)$ on the agent where $S_r \geq 0, S_{rr} \geq 0, S(0) = 0$. What we call self-restraint resembles motivation in Besley and Ghatak (2004).

Finally, the average degree of corruption $c = (1 - p)r$ imposes a loss of $E(c)$ on the bureaucrat where $E_c > 0, E_{cc} > 0, E(0) = 0$. Losses reflect pressures from two sources: externally from the public, and internally from loyalty to the institution and fear of rival institutions. External pressure reflects the extent to which public dissatisfaction with low performance imposes costs on bureaucracy, in other words, the effectiveness of political agency. Societies with effective democracy and press freedom are more able to make life uncomfortable for corrupt bureaucrats than authoritarian ones (Adsera, Boix and Payne 2003, Besley and Prat 2004, Shleifer and Vishny 1993, Treisman 2000). The democracy and openness of societies reflect, in part at least, their historical evolution (Acemoglu, Johnson and

Robinson 2004, Engerman and Sokoloff 2005) and their levels of education and income (Glaeser et al 2004).

Personal loyalty to institution and colleagues aside, internal pressure reflects competition from other institutions: nothing generates altruism like fear of a common enemy. Rodger (2004) shows how Britain's drive to develop better institutions, particularly its navy, after the sixteenth century came from its fear of defeat by richer and more populous Catholic neighbours. Similarly, what distinguishes South Korea, Singapore, and Taiwan from the Philippines and Indonesia, is this sense of relentless competition with a potentially dangerous neighbour.

Most fundamentally, Berman (1983) argues that competition explains why formal institutions exist in the first place. Asking why rulers in the West, in contrast to China and Islam, came to limit their powers by recognising explicit laws and the jurisdiction of autonomous institutions, he argues that the essential factor in European legal development was the competition for resources between state and church starting in the eleventh century. Each was led each to develop explicit rules to improve its own competitiveness and, eventually, to recognise the legitimacy of the other.

We suppose that the individual's payoff V is the sum of the returns to unpoliced rapacity minus the cost of individual policing and rapacity, and the loss due to systemic inefficiency caused by corruption:

$$V = (1 - p_{-i}) D(r_i) - C(p_i) - S(r_i) - E[(1 - p)r]. \tag{1}$$

The model has one period: reputation building, punishment and other features of repeated games will play no role here. There are N senior bureaucrats. Each chooses a level of policing p_i and rapacity r_i to maximize V.[2] Differentiating V with respect to rapacity r_i and recognising that agents are identical so $p_i = p$ and

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[2]Concavity of V requires that $\partial^2 V/\partial r_i^2 = (1 - p_{-i})D_{rr} - S_{rr} - (1 - p)^2 \rho^2 E_c < 0, \partial^2 V/\partial p_i^2 = -C_{pp} - r^2 \rho^2 E_{cc} < 0$, which hold by the restrictions placed on D, C, S, E, and $\partial^2 V/\partial r_i^2 \partial^2 V/\partial p_i^2 - \left(\partial^2 V/\partial r_i \partial p_i\right)^2 = -\left((1 - p_{-i})D_{rr} - S_{rr} - (1 - p)^2 \rho^2 E_c\right)\left(C_{pp} + r^2 \rho^2 E_{cc}\right) - \left(\rho^2 r(1 - p)E_{cc}\right)^2 > 0$ which requires that E_{rr}, S_{rr}, C_{pp} be large relative to ρ and E_{cc}.

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$r_i = r$, gives the first order condition that the marginal cost of rapacity equals its marginal benefit

$$(1-p)D_r = S_r + (1-p)\rho E_c \qquad (2)$$

where $\rho = 1/N$ is the impact of individual on average actions. At a given level of policing, (2) implies that rapacity will be increasing in the marginal return to dishonesty D_r, and diminishing in individual influence ρ, marginal self-restraint S_r, and personal cost of systemic corruption E_c.

Similarly agents choose a level of policing $0 \le p_i \le \bar{p}$. The maximum level of policing $\bar{p} < 1$ so that opportunities for corruption are never entirely eliminated. (This eliminates problems with $1-p$ terms in denominators when S is positive.) For a level of policing in the interior of the range, the agent equates marginal cost and benefit

$$C_p = \rho r E_c. \qquad (3)$$

Bureaucrats police each other only when perceived efficiency losses from corruption E_c are positive.

At the $p = 0$ corner the marginal cost of policing can exceed its benefit $C_p \ge \rho r E_c$, and conversely at the maximum policing corner $\bar{p}$. For a given level of rapacity r, policing is increasing in marginal personal loss from corruption E_c and individual influence ρ, and diminishing in marginal policing cost C_p.

The combination of r and p satisfying the first order condition for rapacity (2) is termed the RR curve. This has slope

$$\left.\frac{dr}{dp}\right|_{RR} = \frac{\rho(1-p)rE_{cc} - S_r/(1-p)}{S_{rr} - (1-p)D_{rr} + (1-p)^2\rho E_{cc}}. \qquad (4)$$

Because the denominator is positive, the slope depends on the sign of the numerator. For zero marginal self-restraint $S_r = 0$ the numerator is positive everywhere. Otherwise it first rises and then falls as self restraint S_r asserts itself, reaching a maximum at $p = 1 - (S_r/\rho r E_{cc})^{1/2}$ which is increasing in individual influence ρ and convexity of loss to efficiency E_{cc}, and decreasing in marginal self restraint S_r. The intercept at $p = 0$, where rapacity is unrestrained by policing, occurs where $D_r = S_r + \rho E_c(r)$. This intercept rises with the marginal return to dishonesty D_r,

and diminishing in ρ, marginal self-restraint S_r, and the marginal cost of systemic inefficiency due to corruption E_c. For values of r above the RR curve, $V_r < 0$ giving an incentive to reduce rapacity.

The combinations of r and p satisfying the first order condition for policing (3) are called the PP curve. This has slope

$$\frac{dr}{dp}\bigg|_{PP} = \frac{r^2 E_{cc} + C_{pp}/\rho}{E_c + (1-p)rE_{cc}} \tag{5}$$

which is everywhere positive. The zero policing intercept occurs where $C_p(0) = \rho r E_c(r)$ which is increasing in marginal cost of policing, and diminishing in ρ and perceived efficiency loss E_c. For policing levels below the PP curve V_p is negative so the individual has an incentive to reduce policing.

For example, suppose that the payoff to dishonesty $D = dr_i^{1/2}$, the cost of policing $C = c_0 p_i + c_1 p_i^2$, the degree of self restraint $S = sr_i^2$, and the cost of systemic inefficiency $E = e((1-p)r)^2$. Then the equilibrium rapacity RR curve is

$$r = \left[\frac{(1-p)d}{4s + 4\rho e(1-p)^2}\right]^{\frac{2}{3}}$$

and the equilibrium policing PP curve is

$$r = \frac{c_0 + 2c_1 p}{2\rho e(1-p)}.$$

3   Equilibrium corruption.

The policing and rapacity curves give rise to the taxonomy of equilibria shown in Figure 1. In the first case the policing curve lies above the rapacity curve. This reflects low returns to dishonesty D_r, small numbers of senior bureaucrats leading to large ρ, and, possibly, high self-restraint S_r, combined with high marginal cost of policing C_p. The resulting equilibrium, at point A in the first panel of Figure 1, has zero policing and relatively low rapacity. This equilibrium, which resembles eighteenth century England, we refer to as "Old Corruption".

The opposite case occurs in the second panel of Figure 1 where the policing curve lies below the rapacity curve. This happens when high returns to dishonesty
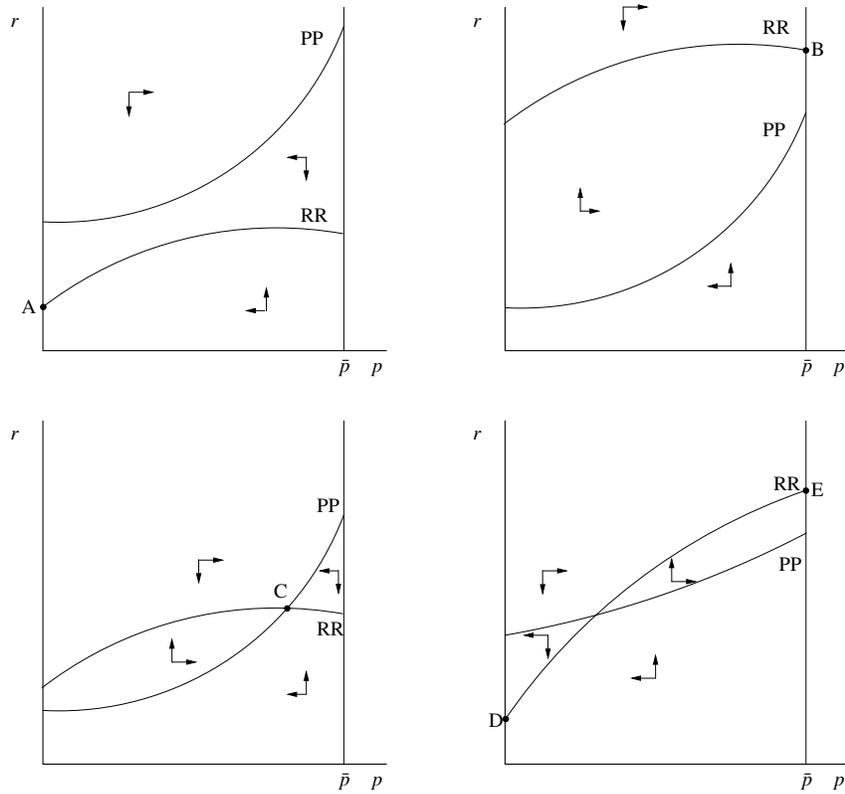
Figure 1: Equilibrium policing and rapacity. (a) Old corruption. (b) Hobbesian. (c) Internal equilibrium. (d) Saddle path stable.

D_r and low self restraint S_r meet a low cost of policing C_p. At the equilibrium point B, strong rapacity is repressed by strong policing. The harsh view of human nature underlying this equilibrium leads to its label "Hobbesian".

After the two corner solutions in the first two panels, the third panel shows a stable interior solution where the rapacity curve intersects the policing curve from above at point C. This requires the high returns to dishonesty D_r and low marginal policing cost $C_p(0)$ of the Hobbesian regime so that the rapacity curve starts above the policing curve.

The curves in this case can intersect either at low policing or high policing. The low policing intersection requires a steep policing PP curve (resulting from a rapid

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increase in the marginal cost of policing) leading to an outcome with low policing and high rapacity. The high policing equilibrium occurs when a flat policing curve (marginal cost of policing starts low and stays low) intersects the downward sloping part of the rapacity curve associated with high self restraint S_r. This regime matches Weber's ideal bureaucracy where conscientious officials intensively restrain themselves and each other.

The last possibility, shown in the fourth panel of Figure 1, is where the policing curve intersects the rapacity curve from above. The intersection point is saddle path stable so the r-p space is divided into two basins of attraction, one going towards the Old Corruption equilibrium D, the other going towards the Hobbesian equilibrium E.

The curves may, of course, intersect more than once. For example, when the policing curve intersects the rapacity curve first from above and then below, the outcome will be a stable equilibrium at the second, higher policing intersection, while the lower intersection is saddle path stable, falling towards either the higher internal equilibrium, or the Old Corruption corner.

We can view the equilibrium in two ways, either as Nash where each agent immediately jumps to his optimum, or as evolutionarily stable where less intelligent agents start at some level of policing and rapacity p_i, r_i and then grope in the direction of higher payoffs. These views of equilibrium are equivalent here but, in Section 5 when income and corruption jointly evolve through time, we shall stress the evolutionary interpretation.

4 Institutions evolving.

Equilibrium corruption changes as the policing and rapacity curves shift. A downward shift of the policing curve along a fixed rapacity curve, as a result of a fall in marginal cost of policing C_p for example, will increase policing. Along upward sloping sections of the rapacity curves (typically at low p) this downward shift in policing induces rapacity to rise, and conversely on downward sloping sections. Downward shifts in rapacity, caused by falls in the marginal returns to dishonesty D_r or greater self-restraint S_r for instance, reduce both rapacity and policing.
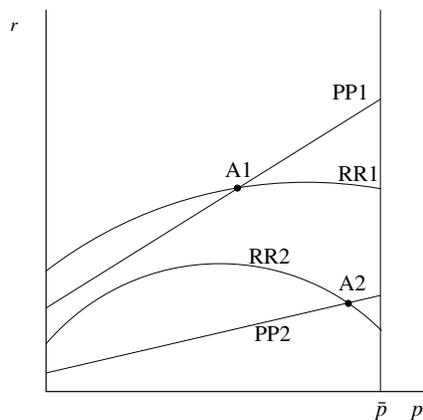
Figure 2: Evolution of corruption in industrialized economies: Falling rapacity and rising policing.

The level of corruption is $c = (1 - p)r$ making the proportional change in corruption approximately $dc/c = dr - dp/(1 - p)$. Falls in rapacity reduce corruption markedly at low levels of policing p, but matter less at high levels when changes in policing dominate. Consequently, at a low policing equilibrium where the curves intersect along a rising part of the rapacity curve, a rise in policing can increasee equilibrium corruption c; as can a reduction in rapacity at high policing levels.

Rises in concentration of power ρ and and in perceived losses caused by corruption E_c shift both curves downward, and, by reducing the net payoff to corruption V, cause equilibrium corruption to fall.

These curves allow a straightforward analysis of the gradual fall in corruption in developed economies; and the sudden rise of corruption in former colonial and post-Soviet states.

4.1 The waning of old corruption.

Industrialized economies have not always enjoyed high quality institutions. The British system of government before the 1830s is remembered as Old Corruption, that of the US before the 1880s as the spoils system. In both cases, reform centred on changing the composition of the civil service from political ap-
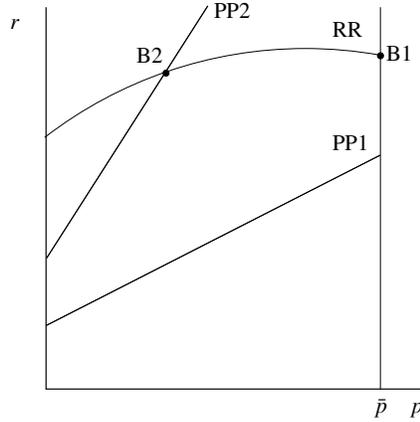
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Figure 3: Evolution of corruption in ex-colonial and former Soviet economies: rapacity no longer repressed by intensive policing.

pointees to salaried professionals recruited and promoted on a meritocratic basis. In the US this change centres on the Pendleton Civil Service Reform Act of 1883 (Hoogenboom, 1961) whereas the British process was more gradual(Harling, 1996).

Replacing temporary appointees loyal to their political patrons with competitively recruited professional bureaucrats loyal to the institution lowers policing costs C_p and C_{pp}, and increases self restraint S_r and aversion to corruption E_c. Paying regular salaries and linking promotion to performance lowers relative returns to dishonesty D_r. The result is that both policing and rapacity curves shift downwards. Falls in C_{pp}, the rate at which marginal cost of policing rises, cause the policing curve to flatten, while rising self-restraint S_r causes the rapacity curve to start sloping downwards at a lower policing level p.

The evolution of institutional quality in developed economies is shown in the first panel of Figure 2. The policing and rapacity curves shift down from PP1, RR1 to PP2, RR2, causing rapacity to fall and policing to rise from A1 to A2.

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4.2 Post-colonial corruption.

Studies of institutions (Ellickson 1986, Greif 1993 or North 1990, for example) are drawn to success stories. The analysis here applies equally to failures, most notably the rise in corruption in post-colonial and post-Soviet economies.

In colonial administrations a small number of colonists hold high positions and supervise natives in low positions. A colonial system therefore entails two sets of bureaucrats with payoffs V^c for colonists, V^n for natives. Corruption is now a weighted average of the corruption of each group $c = \beta(1 - p^c) r^c + (1 - \beta)(1 - p^n) r^n$ where β is the share of resources controlled by each group.

To the extent that native bureaucrats have low status, low education, and low attachment to colonial institutions, they will have a high marginal cost of policing C_p^n and see little personal loss E_c^n from systemic inefficiency. From the first order condition (3), their policing will be negligible, and all policing will be undertaken by the colonists. At the same time, low self-restraint S_r^n reflecting the absence of a belief in the legitimacy of the colonial government, and high returns to dishonesty D_r^n from poor pay and promotional prospects will result in a high rapacity locus.

For colonial administrators the marginal costs of policing natives is likely to be low: solicitude for subordinates or qualms about wrongly punishing the innocent are likely to lower than at home. The outcome shown in the second panel of Figure 3 is a Hobbesian equilibrium at B1 where high rapacity by native bureaucrats is restrained by vigorous policing by colonial administrators.

At independence, natives take over the senior positions held by colonists. If they retain their original rapacity but incur higher policing costs than colonial administrators, the policing curve will shift along the rapacity locus to B2. Rapacity remains high but policing falls, causing corruption to rise. A similar story can be told for the Soviet Union in its declining years where high rapacity fed by cynicism about the regime was kept in check by tough policing which disappeared with the collapse of communism.

This analysis shows what precisely is bad about the bad institutions that Acemoglu, Johnson and Robinson (2001) argue were left behind by colonizers in places with low European life expectancy. Long established, elaborately organized colonial bureaucracies gave natives opportunities to acquire the skills and outlook

of senior bureaucrats. Independence in India or Ireland meant leaving government in the hands of natives whose levels of education and probity were at least as those of the colonial administrators, whereas in Africa it meant giving power to army sergeants.

5   Co-evolution of Income and Institutions.

Income so far has been exogenous. We now look at what happens when income and institutional quality evolve together.

To keep our analysis in two dimensions after adding income, we fold the two institutional quality variables, policing and rapacity, into a single corruption variable. We assume that rises in income, and concomitant improvements in education and organizational ability, reduce corruption by shifting down the policing and rapacity curves in the manner of Section 4.1.[3] Adjustment to a new steady state occurs gradually rather than instantaneously: we assume an evolutionarily stable adjustment of bureaucratic behaviour rather than instantaneous Nash jumps. Letting y denote per capita income, the system is described by two equations

$$
\begin{aligned}
\frac{\dot{c}}{c} &= f(c,y) \\
\frac{\dot{y}}{y} &= g(c,y).
\end{aligned}
$$

We suppose that $f_y < 0$, income improves institutions; $g_c < 0$, corruption retards growth; and $f_c < 0$, $g_y < 0$ so that corruption and income converge to steady states. We work with a linearized version: the phase diagram of the general case being qualitatively similar.

$$
\begin{aligned}
\frac{\dot{c}}{c} &= c_0 - \alpha_c c - \alpha_y y \\
\frac{\dot{y}}{y} &= y_0 - \beta_c c - \beta_y y
\end{aligned}
\tag{6}
$$

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[3]Allowing more elaborate effects, such as a corruption Kuznets curve due, for instance, to the curse of natural resources, can add some steady states but will not change the analysis materially. Empirically, there is a strongly monotonic relationship between income and institutional quality, as Figure 5 below shows.
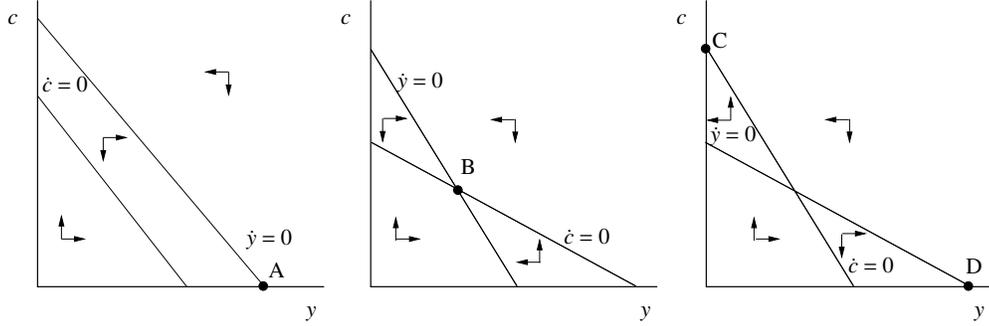
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Figure 4: Co-evolution of income and corruption. (a) Income dominates (b) Stable interior solution: weak interaction between income and corruption: $\alpha_c \beta_y > \alpha_y \beta_c$. (c) Corner solutions: strong interaction between income and corruption: $\alpha_c \beta_y < \alpha_y \beta_c$

In other words, we are simply adding corruption to a standard Solow-Ramsey exogenous growth model[4]

The three strands of the tropical underdevelopment literature reflect different beliefs about the relative magnitude of these coefficients. The institutions rule approach of Acemoglu, Johnson and Robinson (2001), Engerman and Sokoloff (2005) and others argues that the impact of institutions on growth β_c is large, and that, because the quality of institutions largely reflects history, α_y is small. The institutions reflect income approach of Glaeser et al. (2004) implies that causality flows from income to institutions so α_y is large and β_c is small. In the geography matters approach of Sachs (2001) β_c is negligible so equilibrium income is y_0/β_y where y_0 reflects the geographical endowment of the country.

In biological terms, the set of equations (6) represents corruption and income as two species competing for the same resources. It has 3 possible equilibria depicted in Figure 4. In the first, the isoclines do not intersect and the system tends to a zero corruption equilibrium (if the corruption isocline lies below the income one as shown) or zero income (if the income isocline is lower). Otherwise, the isoclines intersect at $c^* = \left(\beta_y c_0 - \alpha_y y_0\right)/\left(\alpha_c \beta_y - \alpha_y \beta_c\right), y^* = \left(\alpha_c y_0 - \beta_c c_0\right)/\left(\alpha_c \beta_y - \alpha_y \beta_c\right)$.

[4] Ehrlich and Lui (1999) add corruption to a considerably more complex endogenous growth model.

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The equilibrium then depends on which isocline is steeper. The income isocline is steeper when $\alpha_c/\alpha_y > \beta_c/\beta_y$. The intersection c^*, y^* is then globally stable as shown in the second panel of Figure 4.

Conversely, when $\alpha_c/\alpha_y < \beta_c/\beta_y$ the intersection c^*, y^* is saddle-path stable. The saddle path divides the diagram into two basins of attraction, one converging to wealth and probity at D; the other to poverty and malfeasance at C.

Given the convergence rates α_c, β_y of corruption and income, whether the internal equilibium is globally stable or saddle path stable depends on the size of the cross effect terms between income and corruption. If the product of the cross effects $\beta_c \alpha_y$ is small: institutions do not matter and/or income does not affect institutional quality, the interior equilibrium is globally stable. All countries will have middling levels of corruption and income, with differences reflecting their different values of c_0 and y_0. Conversely, when one or both of the cross effects between income and corruption are large, two groups of countries emerge: rich, clean ones and poor, corrupt ones.

When the cross effects are large then, we have a simple answer to Lucas's (1990) question "Why doesn't capital flow from rich to poor countries?" Despite growth's following a standard Solow-Ramsey model without any regions of increasing marginal product of capital economies fall into two steady states: those with high income and low corruption, and those with low income and high corruption.

This simple model can incorporate the "Great Divergence", the fact that incomes before 1800 were more equal than they are now. In a pre-industrial world where agriculture dominates output there is little scope for institutions to affect output. As a consequence β_c is small economies converge on an interior steady state. With the growing complexity of economic activity associated with industrialization, the ability of institutions to mess up economies increases. β_c rises and generates two corner equilibria with fortunate economies converging to the high income corner, and unfortunate ones pulled to the high corruption one.

Figure 5: Clustering in income and institutional quality.

6   Cluster Analysis.

The divergence of economies into two corner equilibria when the cross effects in equation (6) are sufficiently strong raises the question of how large these coefficients really are. Attempting to estimate (6) directly is problematic. Even if the coefficients of a cross section growth regression can be meaningfully estimated (Durlauf and Quah, 1999), it is hard to find suitable instruments, or even to measure the level and growth of corruption. Corruption indices of the sort put together by IRIS or Transparency International are essentially ordinal. If a country's Corruption Perceptions Index improves from 2 to 3, we can conclude that its institutions have improved somewhat, but not that they are fifty percent better.

Our approach is to look for clusters in the distribution of income and corruption. If corruption and income levels fall into a single cluster, we can conclude
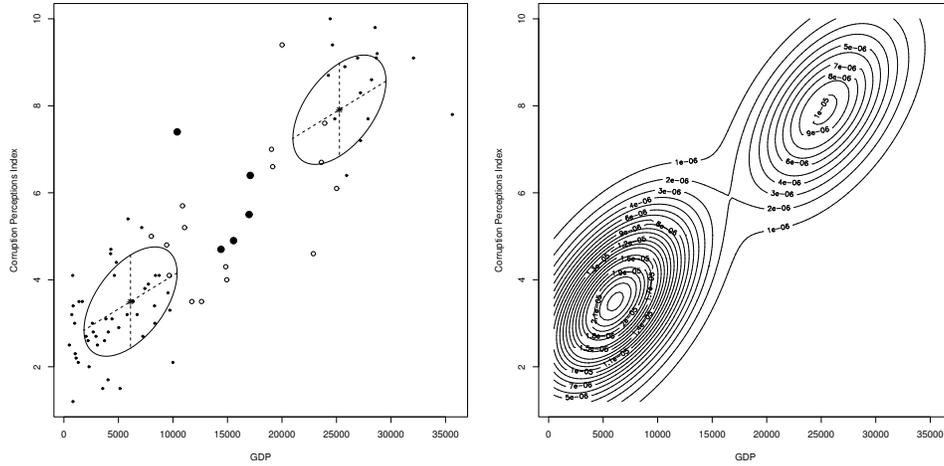
Figure 6: (a) Classification uncertainty. Large circles denote observations above the 95 percentile, open circles observations in the 75–95 percentile. (b) Contour plot of density of observations.

that there are weak cross effects in (6), while the appearance of two clusters is consistent with strong cross effects.

To identify groups of related observations in the data we use the model-based clustering approach of Fraley and Raftery (2002b). Each of the k clusters in the data has a multivariate normal distribution with mean μ_k and covariance Σ_k. Covariance matrices are parametrized through an eigenvalue decomposition, and the number of clusters and class of covariance matrix are chosen through a Bayesian Information Criterion approximation of the classification likelihood function.

Figure 4 plots per capita GDP from the Penn World Tables 6.1 against the Transparency International Corruption Perceptions Index (where higher scores correspond to lower corruption), both for 2000.[5] Using the Mclust algorithm (Fraley and Raftery 2002a), for the data in Figure 4, the Bayesian Information Criterion is maximised with two clusters that have equal, ellipsoidal covariance matrices. The high income, low corruption cluster, depicted by triangles, centres on Germany and

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[5]There are data available in both series for 83 countries. Luxembourg, which is a strong outlier for income, was excluded to make the scatterplots clearer. Including Luxembourg did not change the results of the cluster algorithm.

Austria; the low income, high corruption cluster, depicted by squares, centres on Bulgaria, Colombia and Turkey.

For each country we can estimate the uncertainty of its classification by subtracting the probability of the most likely group for each observation from 1. Only three observations have classification uncertainty above 4 percent: Slovenia (0.497), Portugal (0.227) and Greece (0.120). The left hand panel of Figure 6 shows the uncertainty associated with each observation. The right hand panel gives a contour plot, showing the density of observations around the twin peaks.

7   Conclusions.

Just as animals suffer from parasitism, so do institutions, and that parasitism is called corruption. This paper used insights from parasitology to look at how senior bureaucrats behave when weakly controlled by principals and showed that each will, in part, adopt the role of principal and police his peers and his won rapacity. We found that different regimes can lead to very different levels of policing and rapacity. Looking then at how corruption and income evolve together we saw that, if the interactions between them are sufficiently strong, a standard Solow-Ramsey model leads to a world of rich, well run countries, and poor, misgoverned ones.

The goal throughout was to work with extremely simple models, stripping the analysis down to its logical essentials. Anything beyond policing and rapacity that could be put into a black box was put into one. The natural continuation of this paper is to look more deeply at the organization of the bureaucracy in the manner of Besley and Ghatak (2004); and to explicitly add politicians and the public to the analysis in the manner of Banerjee (1997) and Alesina and Angeletos (2005).

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