

MARKET STRUCTURE AND THE PROVISION OF CORRUPTION:
A THEORETICAL AND EMPIRICAL INVESTIGATION

By

CAMILLE MURA SOLTAU NELSON

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To the Faculty of Washington State University:

The members of the Committee appointed to examine the dissertation of
CAMILLE SOLTAU NELSON find it satisfactory and recommend that it be accepted.

Chair

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Abstract

by Camille Soltau Nelson, Ph.D.
Washington State University
August 2006

Chair: Mudziviri Nziramasanga

Corruption is defined as the misuse of a public office for private gain. Corruption is measured using survey techniques to determine the perceived level of corruption in a country. An overview and background on corruption are given. Theoretical models with numerical simulations are investigated to provide insight into the provision of corruption in an economy.

The provision of corruption is analyzed under three different market structures. First, the market for corruption is competitive when many public officials provide a supply of both a corrupt and a legal government good. Firms, who seek to avoid transaction costs associated with the legal government good, demand corruption. Equilibrium values of corruption decrease with an increased expected penalty for corruption and increase with increased transaction costs.

Second, the market for corruption functions as a monopoly when one public official provides the supply of corruption. Demand remains competitive. Again, equilibrium corruption is decreasing in expected penalty and increasing in transaction costs.

Finally, the provision of corruption occurs under a game theoretical framework when a single buyer and a single seller of corruption negotiate over the price of the bribe associated with a surplus. Corruption is eliminated when the value of the penalty for both agents exceeds the surplus.

The competitive market is examined empirically using corruption perception indexes and proxy variables for wages, probabilities of getting caught, penalties and transaction costs. Limited data availability makes drawing firm conclusions difficult.

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DEDICATION

For

Albie and Grace

Chapter 1: Introduction and Background on Corruption

Introduction

Corruption, defined as misusing a public office for private gain, is receiving a growing amount of attention. The international lending institutions (i.e. World Bank, IMF, etc.) focus on corruption as a serious impediment to successful lending and development programs. Recent literature has examined both the causes of corruption and the effect of corruption on an economy, specifically on economic growth.

The theoretical effects of corruption are mixed. In general, corruption is seen as negative and a hindrance to growth because it distorts market forces and the allocation of goods and services. Corruption reduces a government's ability to institute corrective regulations for market failures. Bribes distort incentives. Corruption may reduce investment or other productive activities, as individuals must focus on corruption activities instead. It acts as a tax on individuals, which is random in nature, thus making it more costly than a fixed, predictable tax. Corruption reduces the role of government and reduces the legitimacy of a market economy and a democratic system. It may increase poverty because it reduces the income-earning potential of the poor. Corruption increases uncertainty, which is generally considered to reduce welfare.

In a second-best world, however, corruption may exhibit some positive characteristics as it can speed up a process hindered by regulations and reduce or

eliminate redtape. Corruption can skim rents by reallocating firms' economic profits to public officials, thereby forcing firms and the market to behave more competitively. Corruption may act as "grease in the wheels" during the regulation process, thus reducing bureaucratic delays. Black markets may improve consumer welfare—particularly if they provide goods and services to consumers that are not otherwise available. In addition, highly centralized corruption tends to be better than randomly distributed corruption as it increases the predictability of such acts. That is, if a country must have corruption, it is better to have predictable, organized corruption. Samuel Huntington said it well, "...the only thing worse than a society with a rigid, over-centralized, dishonest bureaucracy is one with a rigid, over-centralized honest bureaucracy."¹ The debate about the effects of corruption remains unresolved.

There is a vast literature addressing the causes of corruption. One vein of the literature has looked at theoretical underpinnings of corruption, following an approach similar to the crime literature. Principal agent models have been used to examine the relationship between low level civil servants and upper level government regulators (see, for example, Ades and Di Tella (1999)). The other approach has been to empirically test various exogenous factors to determine if they play a role in the perceived level of corruption in a country. The publication of several corruption indexes has allowed this area of research to flourish. Many exogenous factors appear to be statistically correlated with corruption, but causation is more difficult to establish.

We model the market for corruption under three different market structures: a competitive market, a market with a monopoly supplier of corruption and many buyers,

¹ For a discussion of the effects of corruption see Ades and DiTella (1999), Shleifer and Vishney (1993), Bardhan (1997), Tanzi and Davoodi (1997) and Acemoglu and Verdier (2000).

and a market with a single buyer and single seller. We then use sensitivity analysis to examine the responsiveness of equilibrium corruption to changes in exogenous parameters. We empirically test the competitive model. To the best of our knowledge no research has looked at general equilibrium levels of corruption within an economy. This research thus fills an important gap in the literature and takes a first step toward understanding why some countries have virtually no corruption, while others have rampant and widespread corruption.

1.1 Outline of Work

This dissertation proceeds in the following manner. First, theoretical models are developed to analyze the decision-making process that leads to an equilibrium level of corruption in an economy. We model three different market structures for corruption: a competitive market, a market with a monopoly supplier of corruption and many buyers, and a market with a strategic interaction between a single buyer and single seller.

There are two types of agents in each market; public officials who are willing to supply corruption by accepting bribes and firms who demand corruption and are thus willing to pay bribes. The markets differ in the number of players of each type, and by whether individual players can exert market power.

In the competitive model, the public official maximizes her utility over expected income, where expected income depends on the payoffs from market work, corruption work, and the probabilities of getting caught. Where transaction costs are large enough, the firm demands some level of corruption in order to maximize profits.

In the second model, the monopoly supplier seeks to maximize profits subject to the constraint of the firm's demand for corruption. Demand in this model is unchanged from the competitive framework; firms seek to bribe officials to shorten the queue or avoid transaction costs.

The third market structure is that of a single supplier of corruption facing a single buyer of corruption. These two players bargain over the allocation of a surplus generated by an illegal activity.

Second, we empirically analyze the competitive model using corruption perception data. We test the model under various exogenous measures of the supply and demand factors for corruption, and examine the fit of the competitive model to real world data.

This dissertation is organized in the following manner. Chapter 1 defines corruption and provides background to the problem. Chapter 2 provides a literature review, covering both the crime literature and the corruption literature. Chapter 3 describes the theoretical models, provides a sensitivity analysis of the models, and discusses the social planner's regulation options if equilibrium corruption is too high. Chapter 4 details the data, provides the empirical results and presents the conclusions of the research.

1.2 Measuring and Defining Corruption

Corruption can take many forms: paying a bribe to obtain a permit, giving a political candidate or elected official money in exchange for favorable legislation, giving a government contract to the highest briber instead of the low cost bidder, slipping a policeman money to avoid a speeding ticket, denying a permit unless a bribe accompanies the application, and many more. Corruption is defined by the World Bank as the misuse of a public office for private gain. Any government official or public servant who accepts money, or favors in exchange for granting special services is guilty of corruption. However, what is seen as corruption in some countries is not always considered corruption in others. A good example of this difference is the practice in the United States of giving political candidates or elected officials money in exchange for legislation favorable to the donating party. This is called a Political Action Committee (PAC) in the United States and is perfectly legal and not considered corruption. In many other countries, giving money to an elected official in exchange for a favorable law is considered a bribe and would be defined as corruption. Thus, clearly defining corruption is a challenging task and any cross-country measures of corruption must be careful to avoid cultural biases or differences.

Measuring corruption is even more challenging than defining it. By definition, it is an illegal activity and as such there are no annual figures or statistics on the number of bribes or the size of bribes recorded. In order for the government to maintain statistics measuring corrupt activities, there would have to be transparency of activities and perfect (or at least good) monitoring. Since public officials carry out corruption, those with the power to monitor illegal activities are often the ones engaged in them. You cannot go to

a government's website and find a figure for the number of public officials who took money outside the limits of their job last year. Furthermore, corruption does not leave a paper trail or an obvious sign of having occurred. (Unlike a burglary, there is no broken window or missing jewelry when a bribe is exchanged.)

Surveys attempt to quantify perceived amounts of corruption by asking questions such as, "How likely is it that someone in your line of work would have to pay a bribe?" or "How likely is it that someone in your line of work would receive a payment to issue a permit?". These surveys must then attempt to eliminate cultural biases in respondents' answers and calculate an overall level of perceived corruption in a country.

In recent years, several agencies have tried to measure these perceived levels of corruption and have compiled indices reflecting those measurements. These indices give us the ability to compare perceived corruption levels within a single country across time, between countries, within specific regions, and worldwide.

The most commonly used index measuring perceptions of corruption is the Corruption Perceptions Index, which is published by Transparency International on a yearly basis. The CPI ranks countries on a 0-10 scale, with a score of zero representing a perception of total corruption and a score of ten indicating that no corruption is perceived to exist in a country. The CPI uses a variety of surveys to determine the level of perceived corruption, drawing on both local and ex-patriot sources to avoid cultural biases.² The surveys are tested for correlation and only those measures that are highly correlated are included as valid perceptions of corruption.³

² 2004 CPI Sources: Columbia University, Economist Intelligence Unit, Freedom House, Information International, International Institute for Management Development, Merchant International Group, Political and Economic Risk Consultancy, Transparency International/Gallup International, World Bank/European Bank for Reconstruction and Development, World Economic Forum and World Markets Research Centre.

Perceptions of corruption vary across countries. It is possible to imagine two countries with the same number of corrupt acts perceiving their levels of corruption differently and thus receiving a different CPI score. The perception of corruption is certainly important and may play a larger role in some decisions than the actual level of corruption (for example, investment decisions may be more influenced by the perception of corruption than by actual corruption), however, corruption perception indexes are used as proxies for actual corruption in empirical work.

Transparency International tries to minimize the discrepancy between actual and perceived corruption by using surveys given to both domestic and foreign workers, business owners, politicians and other members of society. A large multinational firm that operates in many countries may have a better perspective on relative amounts of corruption between those countries than an individual who lives in only one place. However, the local individual may have a more complete picture of her home country and levels of corruption within it; thus using both responses gives a more rigorous and unbiased perception of corruption than simply interviewing one source.

Table 1.1 lists the ten perceived most corrupt and ten least corrupt countries in the world according to Transparency International's CPI for 2002 - 2005.

2005 CPI Sources: The State Capacity Survey by the Center for International Earth Science Information Network (CIESIN) at Columbia University, The Economist Intelligence Unit, Freedom House Nations in Transit, Information International, The International Institute for Management Development, Grey Area Dynamics Ratings by the Merchant International Group, The Political and Economic Risk Consultancy United Nations Economic Commission for Africa, African Governance Report 2005, The World Economic Forum, The World Markets Research Centre

³ For a more rigorous discussion of the CPI methodology see Lambsdorff (1999a) and Treisman (2000).

Table 1.1 Ten Most and Least Corrupt Countries according to the Corruption Perceptions Index: 2002 - 2005

<u>2002</u>		<u>2003</u>		<u>2004</u>		<u>2005</u>	
Ten Most Corrupt	CPI		CPI		CPI		CPI
Bangladesh	1.2	Bangladesh	1.3	Bangladesh	1.5	Bangladesh	1.7
Nigeria	1.6	Nigeria	1.4	Haiti	1.5	Chad	1.7
Angola	1.7	Haiti	1.5	Nigeria	1.6	Haiti	1.8
Madagascar	1.7	Paraguay	1.6	Myanmar	1.7	Myanmar	1.8
Paraguay	1.7	Myanmar	1.6	Chad	1.7	Turkmenistan	1.8
Indonesia	1.9	Angola	1.8	Paraguay	1.9	Cote d'Ivoire	1.9
Kenya	1.9	Azerbaijan	1.8	Azerbaijan	1.9	Equatorial Guinea	1.9
Azerbaijan	2.0	Cameroon	1.8	Angola	2.0	Nigeria	1.9
Uganda	2.1	Georgia	1.8	Georgia	2.0	Angola	2
Moldova	2.1	Tajikistan	1.8	Tajikistan	2.0	Congo	2.1
Ten Least Corrupt	CPI		CPI		CPI		CPI
Finland	9.7	Switzerland	9.7	Finland	9.7	Iceland	9.7
Denmark	9.5	Netherlands	9.6	New Zealand	9.6	New Zealand	9.6
New Zealand	9.5	Norway	9.5	Denmark	9.5	Finland	9.6
Singapore	9.4	Australia	9.5	Iceland	9.5	Denmark	9.5
Iceland	9.3	Singapore	9.4	Singapore	9.3	Singapore	9.4
Sweden	9.3	Sweden	9.3	Sweden	9.2	Sweden	9.2
Canada	9.0	New Zealand	8.9	Switzerland	9.1	Switzerland	9.1
Netherlands	9.0	Finland	8.8	Norway	8.9	Norway	8.9
Luxembourg	9.0	Denmark	8.8	Australia	8.8	Australia	8.8
UK	8.7	Iceland	8.8	Netherlands	8.7	Austria	8.7

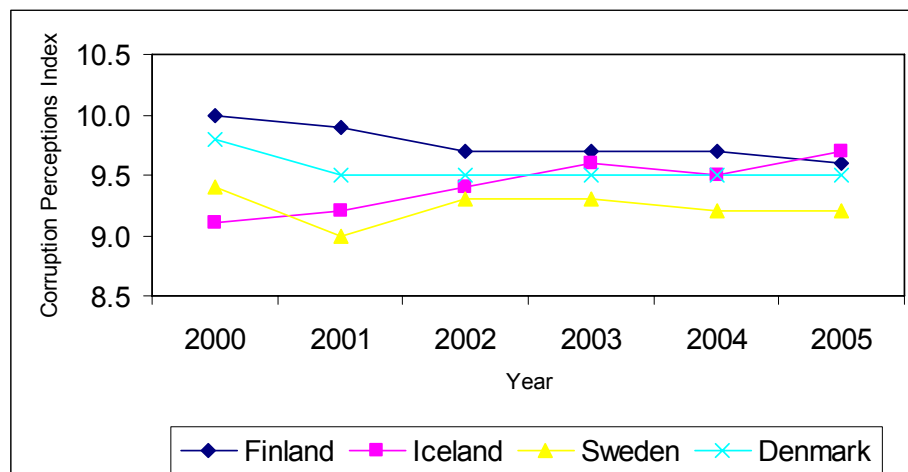
Many of the same countries make the lists (both most and least corrupt) each year. Nigeria and Bangladesh often lead the world in having the most perceived corruption. Haiti does not appear on the list until 2003, not because Haiti's corruption levels in 2002 did not put it in the top ten, but because Transparency International did not begin collecting data for Haiti until 2003. The countries in the top ten remain highly stable with only small ranking changes across time.

A striking observation about the lists is that all the countries in the ten most corrupt countries lie within the developing world and are primarily low income countries, while the ten least corrupt countries are all developed with a per capita income near the upper end of the world's range.

1.3 Regional Differences in Corruption

Examining perceived corruption by region yields interesting results. Corruption does not appear to be randomly distributed across the planet and perceived corruption levels show regional similarities. Whether this is due to cultural or economic convergence within the region or to some other factor is unclear, but the pattern is fairly strong. We report the CPIs for selected countries in Scandinavia, the former Soviet Bloc and Africa to look at geographical regional blocks of countries. We also report the CPI over time for the G-8. While not a geographic region, the G-8 represents the block of the largest economies in the world. The G-8 does not exhibit the cultural similarities of a common geography, but only the economic similarities attributable to relatively high wealth. This gives us a bit more perspective into why blocks have similar levels of corruption.

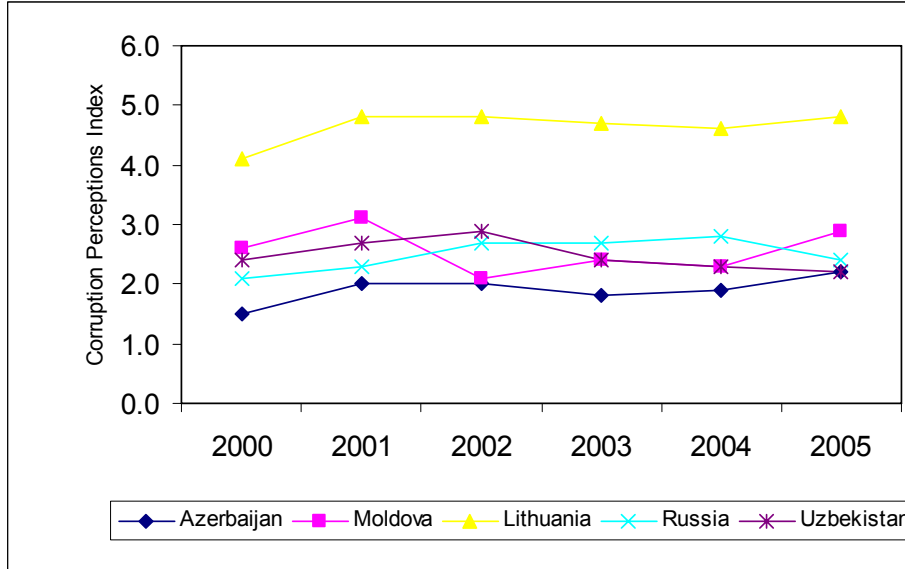
Figure 1.1
The CPI for Selected Scandinavian Countries, 2000-2005



The Scandinavian countries all tend to have very high CPI scores (i.e. very low levels of perceived corruption). Denmark, Sweden, Finland and Iceland all maintain very low, almost nonexistent levels of corruption. A country from this region almost always tops the CPI list as the “least corrupt” country for the year.

Looking at CPI data from these countries shows very little movement in the level of corruption over the last six years. Finland and Denmark have seen an increased perception of corruption from 2000 to 2005, but the change has been very small. Sweden’s score dipped slightly in 2001, but has otherwise remained stable across time. Iceland has seen a decreased perception of corruption over time. Changes in the perceived level of corruption for all four countries are very small across time - 0.3 or less on a 10 point scale.

Figure 1.2 The CPI for Russia and Selected Former Soviet Republics, CPI 2000-2005

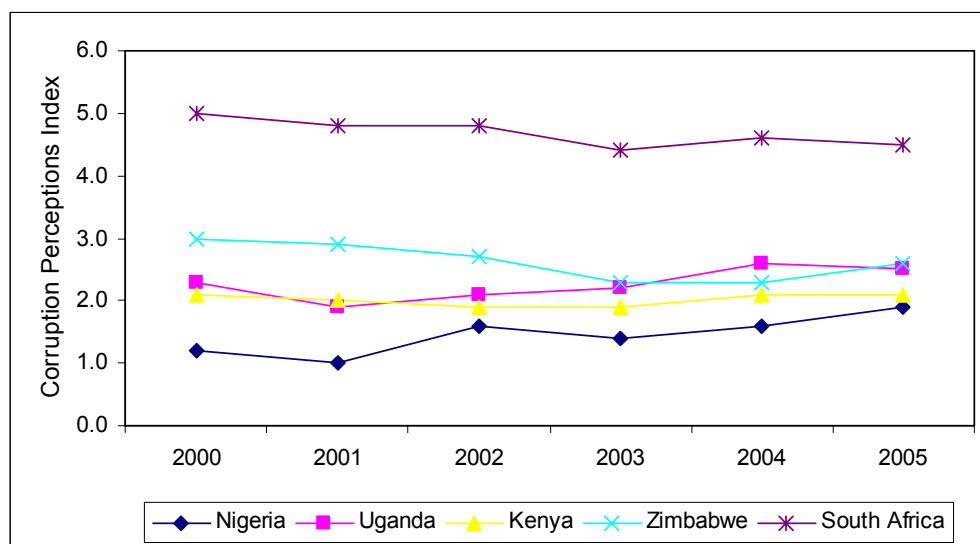


The breakaway, transitional economies of the former Soviet Union gained world attention for having very high levels of perceived corruption when Transparency International first published the indexes in the mid 1990's. Informal perception of Soviet corruption had been lower than reported CPI levels for many former bloc countries. Initial increases in corruption measures may have been attributable to more transparent monitoring once the countries emerged from behind the Iron Curtain. However, as these economies undergo the transition from a communist economic system to a capitalist one, we continue to observe high levels of perceived corruption. This may be explained, in part, by the nature of a transition economy. Large quantities of resources are newly available to private enterprises. Distributing those profits provides abundant opportunities for corruption to flourish. Murky or unclear commerce laws are relatively easy to bend or break for personal gain and it appears this may be the case in the breakaway republics (as well as Russia).

Despite the relatively bleak picture of high levels of perceived corruption in these countries, the last few years seem to show some small promise in reducing corruption. Looking at a selected sample of countries for the last six years, Azerbaijan, Lithuania (an outlier for the region) and Russia show small improvements in their CPI score. Moldova and Uzbekistan have seen perceived corruption fluctuate over time to a small degree.

Movements in perceived corruption for all five countries are very small (0.5 to 0.9 on a 10 point scale), suggesting that changes in perceived corruption levels occur very slowly and the former Soviet bloc countries have settled into established levels of corruption as they transition their economies to market based systems.

Figure 1.3 The CPI for Selected African Countries, 2000-2005

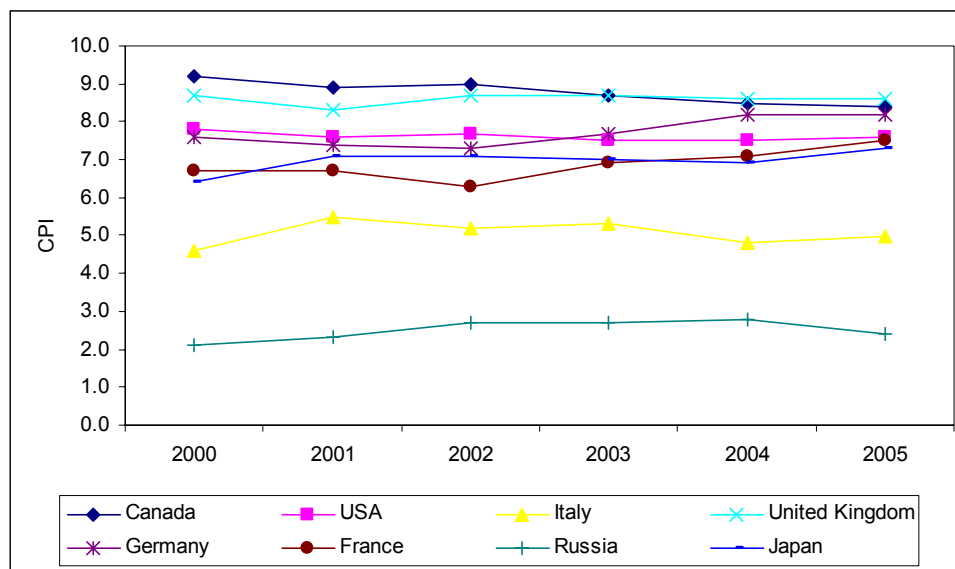


Looking at selected African countries we find that most have relatively high levels of corruption. In fact, Nigeria often tops the CPI as the worlds “most corrupt” country. Unlike the republics of the former Soviet Union, most African countries have not seen a dramatic change in their economic structure in the last 10 years, so the

explanation for high levels of corruption must lie elsewhere. One possible explanation is the legacy of colonialism with a system of endemic corruption and cronyism that persists to this day in most African countries. Preliminary empirical results suggest that colonial legacy plays a significant role in determining the level of perceived corruption. The outlier in the data is South Africa; with a differing colonial history and a significantly higher GNP per capita than the rest of the sample, this difference is not surprising.

Changes in perceived corruption in the region have been relatively small over time, with movements ranging between 0.2 and 0.4 on a 10-point scale. Perception of corruption has increased slightly in South Africa and Zimbabwe (a reduction in the CPI score), remained fairly stable in Kenya, and decreased slightly in Uganda and Nigeria.

As with the Scandinavian and former Soviet bloc countries, perceived corruption in Africa changes very little over time. The level of perceived corruption in Africa remains consistently high.

Figure 1.4 The CPI of the G-8, 2000-2005.

Perceived corruption in the G-8⁴ countries over the last six years shows trends very similar to our regional examinations of corruption. Each country has seen only very small movements in the perceived level of corruption over time. Italy and Russia are outliers with significantly higher levels of corruption than the other six countries. This is not a surprising finding given that Italy has frequent changes in its government and Russia is the only member of the G-8 undergoing a transformation of its economy from a centrally planned to market based system.

1.4 Economic Differences in Corruption

Corruption seems to be roughly negatively correlated with income levels. Table 1.1 lists the ten least and most corrupt countries in the world. The least corrupt countries in the world are all developed, rich nations while the most corrupt countries are all developing, poor nations. Higher GNP per capita seems to be linked to lower perceived

⁴ The G-8 is an organization of the largest eight economies in the world. The United States, the United Kingdom, Japan, Germany, France, Italy, Canada and Russia are all members. The definition is a bit misleading because one could argue that China has an economy that places it among the G-8 countries but it is not a member.

levels of corruption. This correlation is not a perfect relationship; the United States and Switzerland, the richest countries in the world, do not have the lowest levels of corruption, neither do Ethiopia or Nepal, the poorest countries in the world, make the list as the most corrupt countries; but the general trend seems to hold.

This observation raises the correlation versus causation question. If the relationship is purely one of randomly correlated variables and there is no real link between the per capita income and corruption, the discussion can end there. However, if some causation exists, then it is of interest to know which direction the causation travels. Do high levels of per capita income cause a country to have lower levels of corruption? Do lower levels of corruption cause an economy to function more smoothly and efficiently and therefore cause higher per capita incomes? Barro (1999) and Tanzi and Davoodi (1997) have argued that there is a causal link between the two, although the direction of that causality is unknown and most likely exhibits a circular relationship. We do not attempt to answer the question here but rather examine the relationship.

We plot perceived corruption against both GNP per capita and the Human Development Index to more clearly see this relationship.

Figure 1.5: 1999 GDP per capita and the 2005 Corruption Perceptions Index

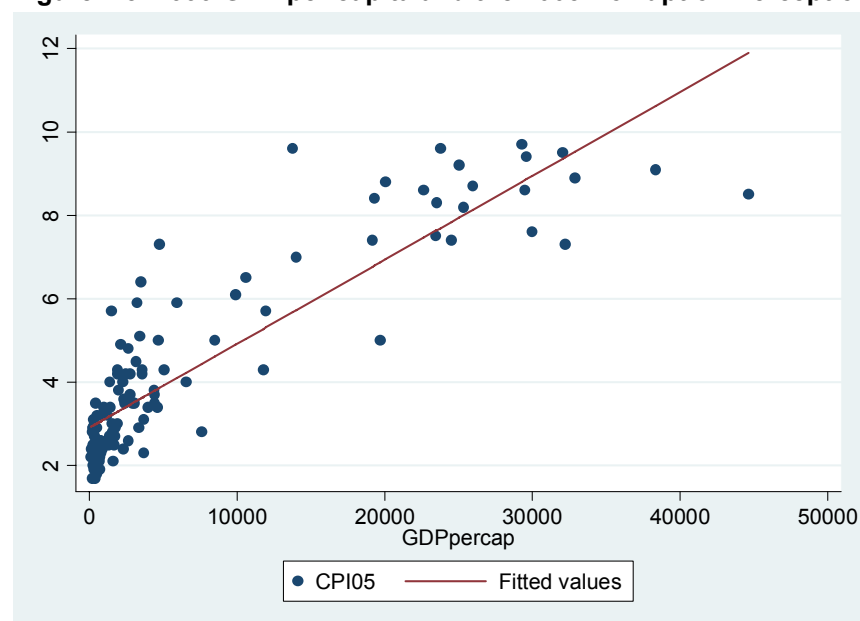


Figure 1.5 shows a positive relationship between GDP per capita and the CPI, which supports the hypothesis of a negative correlation between income and corruption. The data is densely bunched at very low levels of GNP per capita although the range of corruption is fairly widespread. The data is more scattered for higher values of the CPI. At very high values of the CPI, (i.e. above 9), income ranges from a low of \$13,780 in New Zealand to a high of \$44,640 in Luxembourg. If a causal relationship between income and corruption exists, it seems clear that income is not the only factor driving corruption.

The Human Development Index gives a broader picture of living standards, combining GDP per capita with measures of health and education.⁵ Graphing the relationship between the HDI and the CPI should give us a better understanding of the correlation between living standards and corruption.

⁵ The Human Development Index (HDI) is calculated as: $\frac{1}{3} (\text{GDP per capita}) + \frac{1}{3} (\text{life expectancy index}) + \frac{1}{3} (\text{schooling index})$, where the life expectancy index = $(\text{life expectancy} - 25) / (85 - 25)$ and the schooling index = $\frac{2}{3} (\text{literacy rate} / 100) + \frac{1}{3} (\text{school enrollment rate} / 100)$.

Figure 1.6: The 2004 Human Development Index and the 2005 Corruption Perceptions Index

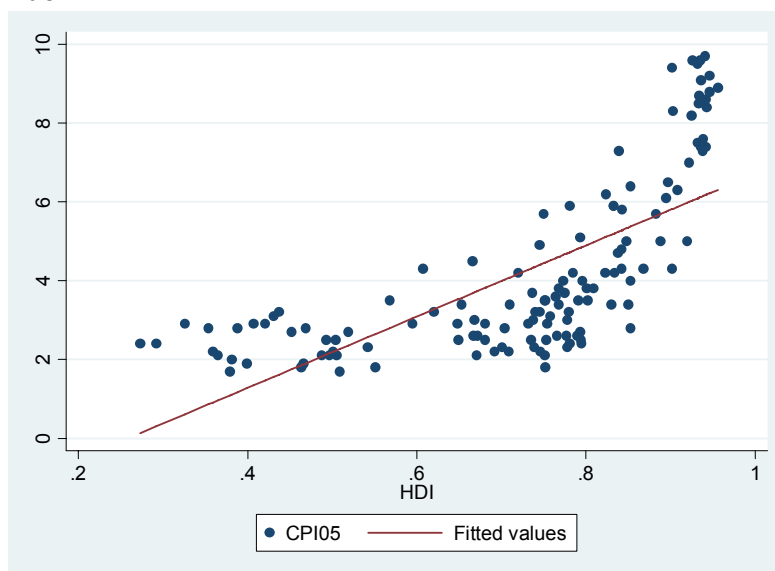


Figure 1.6 also has a broad upward trend line, clearly demonstrating a positive correlation between the HDI and the CPI, or a negative correlation between a broad standard of living and corruption in an economy. The data exhibits the opposite pattern as GDP per capita with CPI values below approximately 4.5 are associated with a much wider variance of levels of human development than at levels above 4.5. Above a CPI of 4.5 (with Botswana and Namibia as distinct outliers) most countries have a Human Development Index above 0.8, indicating a high level of human development.

Conclusions

Corruption is an increasingly important area of research. Recognition that good governance is fundamental to economic development has heightened awareness of the importance of understanding how corruption works. Measuring and defining corruption are important tasks.

Corruption is defined as the ‘misuse of a public office for personal gain’ by the World Bank and that definition is the standard view of what entails corruption. Determining which acts by public officials meet that definition is challenging. Differing job descriptions and cultural expectations between countries makes a standardized list of corrupt activities difficult to compile. Accepting money for a favorable decision is legal in some countries and illegal in others. One can think of many examples of public officials’ behavior that raises eyebrows in one country, but is considered acceptable in another.

Once a standard definition is agreed upon, measurement of corruption is also difficult. No direct measures of corrupt activities are compiled by the government officials who participate in bribe taking and outside observers cannot often see when such an exchange has taken place. Thus, empirical measures of corruption are based on the perception of how much corruption exists in a country. This perception may not, in fact, be identical to the actual amount of corruption in an economy. After a political scandal we often see a noticeable increase in the perception of corruption in a country, even though the actual incidence of corruption rises by only one bribe-taking incident. For example, Canada’s Liberal Party political scandal is reflected in the 2005 Canadian corruption figures in this way.⁶ However, if all countries experience a similar bias between perceived and reported corruption, using the perceived numbers still allows for comparisons between countries and over time.

⁶ Five Canadian advertising firms with links to the Liberal Party were “allegedly guaranteed a monopoly on government-sponsorship advertising at sporting and cultural events in the province and, as a result, are said to have made huge fortunes from contracts worth around C\$250m (\$200m)”. The Economist, April 7th 2005.

Transparency International compiles a Corruption Perceptions Index (CPI) for most countries that allows for quantitative measurement of corruption and comparison of corruption levels across time and between countries. The CPI addresses the potential bias between perceived corruption and actual corruption by using survey data from a variety of sources, both domestic and foreign, for each country.

Examining corruption across the world we see that corruption seems to follow geographic patterns. Looking at CPI data for selected countries from Scandinavia, the former Soviet bloc and Africa reveals that countries within geographic regions tend to have similar patterns of corruption. Furthermore, corruption appears to be fairly stable with only very small movements over time.

Corruption exhibits a negative correlation with income. Richer countries tend to have lower levels of perceived corruption. The level of human development in a country is also inversely related to the level of perceived corruption. The ten least corrupt countries according to the 2005 CPI are all from the developed world while the ten most corrupt countries are all classified as developing nations.

Chapter 2: Review of the Relevant Literature

“The PUBLIC GOOD ought to be the object of the legislator; GENERAL UTILITY ought to be the foundation of his reasonings. To know the true good of the community is what constitutes the science of legislation; the art consists in finding the means to realize that good.” Jeremy Bentham, 1887

Introduction

This chapter provides an overview of the relevant crime and corruption literature. Economic literature has explored crime both theoretically and empirically. Becker’s (1968) seminal paper argued that the decision to participate in criminal activities is rational, albeit for individuals with particular budget constraints. The foundations of thinking of crime as a rational decision greatly influence the way corruption is modeled and thought about. Corruption has primarily been modeled as a principal agent problem or investigated at the industry level. Empirical studies of corruption began with the publication of several corruption perception indices. Many papers have explored the empirical links between corruption and growth, and between factors thought to influence corruption and the level of corruption in a country.

To date very little literature looks at equilibrium levels of corruption, or attempts to model the market features of corruption. This review of the relevant literature provides an overview of what has been done, and demonstrates both where this research fits into

the literature and the importance of this area of research in examining the questions of corruption.

2.1 Crime Literature

Crime, criminal behavior, and legislation to control those activities were first examined under the economic lens in 1763 by Cesare Beccaria, an Italian economist and criminologist. *Dei Delitti e delle Pene* was the first work to look at the effects of punishment on societal welfare. Beccaria argued that the object of punishment was not to torment the perpetrator or undo a crime already committed, but rather “to prevent the criminal from injuring anew his fellow citizens and to deter others from committing similar injuries.” He further argued that the consistency and swiftness of punishment, rather than the severity of punishment, were the most effective deterrents to criminal activities. His arguments were widely read but largely ignored in terms of reforming the penal systems of eighteenth century Europe.

In 1802 the subject was again broached. Jeremy Bentham made a passionate plea in his work, *Theory of Legislation*, to base legal systems on the principles of utility rather than ascetics, sympathy or antipathy.⁷ Three conditions were necessary to make the change. “*First- To attach clear and precise ideas to the word utility...Second,-To establish the unity and the sovereignty of this principle, by rigorously excluding every other...Third,-To find the processes of a moral arithmetic by which uniform results may be arrived at.*” Bentham was greatly renowned and the details of his ideas were incorporated in the establishment of new laws. However, his general ideas of utility were

⁷ The Ascetic Principle is the idea that everything that “gratifies the senses is odious and criminal”, its followers viewed morality as the rejection of pleasurable things.

not fully accepted until 1822 when John Stuart Mill edited a collection of Bentham's works, and argued for analyzing behavior under the principle of utility.

Although the principles of utility were widely accepted and used after Mill, the ideas of applying those principles of utility to criminal behaviors were not considered again until the late 1960's. Economists shied away from looking at crime and criminal behavior as a rational, self-interested pursuit and, instead, generally viewed these actions as immoral and therefore beneath inquiry. Marshall spoke of gambling this way; "*the pleasures of gambling are ...'impure'; since experience shows that they are likely to engender a restless, feverish character, unsuited for steady work as well as for the higher and more solid pleasures of life.*" (Marshall 1961)

In 1968 the tide of thinking turned when Gary Becker published his seminal paper, "Crime and Punishment: An Economic Approach." Crime was considered a rational behavior, albeit one for persons with different constraints and preferences than the general population. Criminal behavior could be explained using a utility maximizing framework, and crime's effect on society could be analyzed with a social welfare framework. More startling was Becker's argument that some level of crime may be optimal for society, as the costs necessary to completely eliminate crime outweigh the benefits of a crime-free society. A framework of risk preference was developed and optimal private and public policies to combat crime derived. Importantly, real policies seemed to match these optimal conditions. As Beccaria had argued, Becker found that consistency of punishment and probability of getting caught played more strongly into the decision to commit a crime than did the severity of punishment. (Becker 1968)

After Becker's paper, it became acceptable to study criminal behavior in an economic context. Becker's work was directly expanded upon by Stigler (1970) to derive optimal marginal punishments to deter criminals from increasing the severity of crimes (i.e. to prevent a burglary from becoming a murder). Types of punishment - fines versus imprisonment versus probation (or some combination of punishments) - were examined by Polinsky and Shavell (1984) and Posner (1986). Both papers argued that fines are socially optimal in all cases except where the criminal poses a continued threat to society. This argument rests on fact that imprisonment is costly and therefore reduces social welfare. Fines increase welfare by reimbursing the victim, providing revenue to the government, and seem to be an effective deterrent for so-called 'white-collar' crimes. Additional research on deterrence effects of prison terms, conviction rates, and other variables was pioneered by Ehrlich (1973) and continues in many veins today.⁸

2.2 Corruption Literature

The corruption literature falls into two broad categories; theoretical modeling of corruption and empirical studies of factors correlated with corruption. We summarize the relevant papers in each.

2.2.1 Theoretical Models of Corruption

Attention to the rent skimming behavior of some criminal activities was drawn by Susan Rose-Ackerman in her 1975 paper, "The Economics of Corruption." Rent-skimming activities were studied using a principal agent framework. The principal (the top levels of government) wants to control the behavior of the agent (the low-level

⁸ A particularly popular avenue of research is the effect of the capital punishment on murder rates.

government official), who may take bribes from private individuals trying to influence some government policy or procure some government good. This line of research was simultaneously explored by Banfeild (1975), and later extended by Rose-Ackerman (1978), Klitgaard (1988, 1991), Besley and McLaren (1993) and Ades and Di Tella (1999).

Rose-Ackerman (1975) examined corruption under differing market structures. Of interest is her work on markets with one buyer and one seller; the bilateral monopoly case. She develops a model of bargaining based on work by Cross (1969). Cross uses the passage of time in the bargaining process as an explicit way to measuring bargaining strength between two agents. The two agents bargain over how a sum of money, M will be divided between them. Each demands a share, Z_i , of the money. If $Z_1 + Z_2 > M$, then at least one of the agents must modify her demands. A delay in the allocation of the money costs the first agent C_1 ; however, if the payout is delayed by one period, then Agent 2 is likely to lower her demand, Z_2 , by some fraction, r_2 . The larger is r_2 , the weaker the bargaining power of the second agent. Each agent chooses Z_i to maximize the present value of the share of M she receives. Agent 1's total present value of Z_1 is:

$$U_1^* = Z_1 e^{-aw} - \int_0^w C_1 e^{-at} dt \quad (2.1)$$

where a is a continuous discounting rate and w is the time required Agent 1's demand of Z_1 can be met; $w = (Z_1 + Z_2 - M) / r_2$. Agent 1's return is maximized where:

$$\left[Z_1 + \frac{C_1}{a} \right] \frac{a}{r_2} = 1 \quad (2.2)$$

Rose-Ackerman extends Cross' analysis to the case of a government official and an entrepreneur bargaining over both the quantity and size of bribes to determine the

allocation of a surplus, M . The entrepreneur determines the optimal offer, Z_1 , for any given bribe, chooses the size of the bribe, and finally assures that the present value of her return under the bribing scenario is greater than the present value of her return in the absence of a bribe. Given a cost $g(X)$ of making a bribe, the present value of the entrepreneur's total return is:

$$V_1^*(X) = U_1^*(X) - g^*(X) \quad (2.3)$$

Because the bribe is offered at initial contact, but is actually paid at w when both parties agree to the entrepreneur's offer of Z_1 , $g(X)$ must be discounted. Rose-Ackerman defines the present value for the entrepreneur as:

$$V^*(X) = [Z_1(X) - g(X)]e^{-aw(X)} + \frac{C_1}{a}e^{-aw(X)} - \frac{C_1}{a} \quad (2.4)$$

Equation (2.4) is maximized at:

$$\frac{r_2(X)}{a} = Z_1(X) - g(X) + \frac{C_1}{a} \quad (2.5)$$

The agent chooses the optimal size of the bribe such that (2.4) must hold for all values of X . Substituting (2.5) into (2.4), Rose Ackerman finds that:

$$g'(X) = W(X)r_2'(X) \quad (2.6)$$

which yields the optimal bribe, \bar{X} , as long as the second derivative is negative. The entrepreneur then verifies that $V_1^*(\bar{X}) - U_1^*(0) > 0$.

Rose-Ackerman finds that when the entrepreneur faces high costs of waiting, but the government official does not, the result is a high level of bribing.

A large body of literature looked at the relationship between the wages of a public officials and the level of corruption. The link between the level of public sector wages and corruption is well established in the literature. Raising the wages of bureaucrats was

generally argued to be the most effective way to ensure agent honesty, but the necessary wage to ensure honest public officials was considered prohibitively high.⁹ This analysis is known as efficiency wage theory.

Van Rijckeghem and Weder (1997, 2001) investigated this notion, arguing that if public officials maximize expected income as is in the convention in the literature, then the necessary wage to ensure honesty is very high. On the other hand, if agents are simply ‘satisficers’, the necessary wage may not be prohibitive.

Maximizing public officials seek to optimize expected income over two states of the world; one in which they are caught and punished for participating in bribe taking activities and one in which they are not. Expected income is defined as:

$$EI = (1 - P(C))(CB + W_g) + P(C)(W_p - f) \quad (2.7)$$

where P is the probability of getting caught and punished, C is the number of bribes or corrupt acts, B is the level or amount of the bribe, f is the penalty faced when caught and W_g and W_p are the government and private sector wages. The official is assumed to be fired if caught participating in corruption. Thus the penalty for getting caught is not only the fine directly paid, but the wage differential between the government and private sector. Van Rijckeghem and Weder assume the public official finds a private sector job after being fired. Agents are assumed to be risk neutral; therefore solving (2.7) for the wage in which the expected income in both states of the world is equal yields the number of corrupt acts in which the public official will participate.

$$C^* = \frac{B - P(W_g - W_p + f)}{2PB} \quad (2.8)$$

⁹ See Tanzi (1994) as a representative paper in this literature.

Satisficing public officials are motivated not by obtaining the maximum level of income, but rather by a notion of “fairness”. These officials exert effort such that their actual wage equates with a ‘fair wage’. If actual wages falls below perceived ‘fair wages’, workers will shirk on the job or seek nonpecuniary income to the extent that are ‘underpaid.’ That is:

$$e = f\left(\frac{EI}{EI^*}\right) \quad (2.9)$$

where e is effort, EI is the workers expected actual wage and EI^* is the fair wage. In a market with corruption, nonpecuniary income or shirking can be interpreted as bribe collecting and officials will seek bribes such that Equation 2.9 is satisfied. Satisficing public officials face the same penalties as maximizing officials - a fine, f , and loss of their government job at a cost of the wage differential between the public and private sectors. The probability of getting caught, P , is defined more simply as $P=pC$, where p is the probability of detection and C is the number of corrupt acts committed. Equation (2.7) then becomes:

$$EI = (1 - pC)(CB + W_g) + pC(W_p - f) \quad (2.10)$$

The satisficing agent solves equation 2.10 for C such that $EI = EI^*$, yielding:

$$C^* = \frac{B - p(W_g - W_p + f) - \sqrt{D}}{2pB} \quad (2.11)$$

where:

$$D = [B - p(W_g - W_p + f)]^2 - 4pB(EI - W_g)$$

When $W_g = EI^*$, $C^* = 0$, that is when workers are paid the fair wage, no corruption exists. When $W_g < EI^*$, corruption exists and increases with increasing values of EI^* . Neither of these results is surprising. If workers exert effort to collect bribes only when

they feel underpaid, they will not collect bribes when they are paid their perceived fair wage. On the other hand, the greater that gap between a worker's perceived fair wage and actual wage, the more the worker will seek to compensate for the difference through the collection of bribes.

Van Rijckeghem and Weder show that the theoretical wage necessary to ensure public official honesty is smaller when agents are satisficers than when they are maximizers. The model is tested empirically, but limited data did not allow for conclusive results.

A related approach looks at market structure and its effects on the collection of rents by government officials. Here, government officials are assumed to have different levels of market power (i.e. monopolists in the sale of a good or service versus competition). (Shleifer and Vishney (1993) and Ades and DiTella (1997, 1999)). Increased market power leads to increases in both the number and size of bribes made to public officials.

2.2.1 Empirical Studies of Corruption

Empirical studies of corruption were made possible by the publication of several indices measuring the perceived level of corruption within a country. Transparency International and the International Country Risk Services both produce annual measures of corruption.

The corruption literature has generally used corruption data to empirically explore the causes of corruption. These studies of the causes of corruption usually involve looking at a single exogenous variable and determining if it has a significant relationship to the level of corruption in a country. Factors that underlie a firms' demand for

corruption or a public officials' willingness to supply corruption have been investigated. Additionally, the link between corruption and cultural and institutional factors in an economy has been researched.

At the micro level, a public officials' willingness to participate in corruption can be modeled using the level of public sector wages (Swamy et al (1999)), Van Rijckeghem and Weder (1997, 2001)), merit based recruitment (Rauch and Evans (1997)) and measures of the strength of the judiciary or rule of law (Ades and DiTella (1996), Knack and Keefer (1995), Sali-i-Martin (1997)).

The level of public sector wages, measured as a multiple of per capita GDP or the manufacturing wage, reflect the public sector worker's opportunity cost. The lower these wages the less the worker has to lose when acting in a corrupt manner. Swamy et al, (1999) use average government wages as a multiple of per capita GDP (with the cross-country average being three) to measure this effect and find it be significant although not robust to the inclusion of percentage of women in the labor force. Rijckeghem and Weder (1997, 2001) test this hypothesis using public wages as a multiple of the manufacturing wage, arguing that low public sector are likely to increase incentives to supplement income with illegal bribe taking. They find it to be significant for a small sample (28) of low-income countries, although acknowledge that the causality is not clearly or easily defined.

The issue of merit-based recruitment may also have an effect on public sector workers' willingness to supply corruption, as merit based recruitment also reflects the opportunity cost of losing a job in the public sector. If public positions are awarded based on a merit system, they become more exclusive and will command a higher wage

premium. Thus, if a public sector worker was awarded her job based on her ability, we can hypothesize that she will be less likely to risk losing a ‘good’ job by committing corrupt acts. A variable measuring the percentage of civil service workers that entered their agency by passing a formal examination or by holding a university or post-graduate degree may factor into the supply of corruption. Rauch and Evans (1997) find that merit based recruitment has statistical significance and is the “most important structural feature for improving bureaucratic performance.”

Measuring the probability of getting caught when engaging in corrupt activities requires a look at the strength of the judiciary system. Ades and DiTella (1996) find a correlation between corruption and the independence of the judiciary system. The World Development Report (1997) found that the quality of the judiciary has a significant negative effect on the level of corruption in a country. Other factors that reflect the strength of the judiciary include the rule of law and the penalty system. Knack and Keefer (1995) define rule of law as a measure of citizens’ willingness to accept laws and regulations. Sali-i-Martin (1997) finds rule of law to be a significant and positive factor of growth. While the penalty system would seem to affect corruption, no reliable variable captures a penalty system. Any variable numbering cases before courts or convictions will have a sample bias because there is no way to calculate what percentages of criminal activities result in the perpetrators appearing before a court. Without this relative measure no information is gained from a caseload variable. It can be argued that percentage of convictions may to some degree reflect the quality of the penalty system but this is also problematic. More convictions do not necessarily reflect a fairer or more

accurate penalty system and it still tells us nothing about the relative convictions rate for all criminal acts.

The quality of institutions in an economy may also affect the probability of getting caught when participating in corrupt activities. Becker (1968) argued that the quality of institutions has an important effect on the level of crime or corruption.

One way of analyzing corruption is to look at the culture of corruption. One measure may be the behavior of the countries leadership (Tanzi 1998). If it is well known by the populace that those in power use corruption for personal gain, it seems likely that public officials at lower levels might imitate them. Another political factor of corruption is the number of revolutions and coups in a country. A country with a high degree of lawlessness stemming from uncertain power shifts will reflect a culture that is more tolerant of corruption and thus presents more opportunities for it.

Firms' demand for corruption, i.e. a willingness to pay a bribe to jump the queue, can be seen in measures of black market premiums (Sali-i-Martin (1997)), market openness (Brunetti and Weder (1998)), market structure (Ades and DiTella (1999)), level of imports (Treisman (2000)) and public investment (Tanzi (1998)).

Demand factors for corruption can be generally defined as market distortions that create additional transaction costs for firms. Firms look to avoid these additional costs by offering bribes to public officials. These demand factors result from market imperfections or distortions in the functioning of a free market. Regulations, tax structure, government spending decisions, and the provision of goods and services at below market prices are all factors that contribute to market distortions and thus may affect firms demand for paying bribes. (Tanzi, 1998)

Red tape measures the number of regulations and time spent dealing with a bureaucracy to accomplish a task. The greater this time period and the more officials needed to sign a permit the greater the possibility of a corrupt act taking place. Another factor that may influence the demand for corruption is the tax structure. An especially complicated tax structure that has large loopholes, or requires a contract between the taxpayer and tax collector, may offer increased opportunities for bribes or other forms of corruption.¹⁰

Black markets may arise for several reasons. If a country has restrictive trade policies there may be certain goods and services that are not widely available in the free market and a black market for these goods and services may be created. Thus, the level of openness (a measure of trade freedom) of a country may be correlated with the level of corruption. Openness also reduces corruption by increasing transparency at the global level. When the USSR was behind the Iron Curtain, levels of corruption were extremely high. Although still a problem in Russia and other breakaway republics¹¹, the increased world attention on the Russian economy is spotlighting corruption and making it more difficult to cover up.

Government provision of goods and services at below market prices can create a black market. Examples include government subsidized housing, electricity, water, or a rationed good (e.g. gasoline in the U.S. during the OPEC price shocks of the 1970's). The result of a shortage of goods and services is that some individuals may be willing to pay bribes to gain access to these goods, thus raising the level of corruption. Therefore, a

¹⁰ The wages of tax collectors may also influence the level of corruption but we treat this as a supply variable.

¹¹ Transition economies, by their very nature, are extremely susceptible to high levels of corruption.

measure of the below-market price availability of goods may prove useful in determining levels of corruption.

A limited number of empirical studies address these distortion factors. Brunetti and Weder (1998) look at the impact of openness and find it to be significant. Ades and DiTella (1999) investigate the links between market structure, rent skimming and corruption and find that countries where higher rents exist tend to have higher levels of corruption. Treisman (2000) also finds a weak correlation between the level of imports and corruption.

Public investment projects offer opportunities for corruption, especially if allocation of resources is arbitrary and/or left up to individual bureaucrats. In the short run capital spending may be highly discretionary, leading to corruption in public works projects. Tanzi (1998) argues that when public officials receive commissions for projects that are tied to the project cost, there are incentives to do larger projects, which may or may not serve the public interest. Thus, contractors may find themselves forced to outbid each other with commissions (bribes) to get contracts. In fact, in some countries it may be impossible to get a public works contract without paying bribes. Tanzi and Davoodi (1997) find statistically significance evidence against the rejection of the hypothesis that “other things being equal, high corruption is associated with high public investment.”

Social and cultural variables that may affect corruption include the percentage of women in the labor force (Swamy et al (1999), Dollar et al (1999)), the percentage of the population that is Protestant (La Porta et al (1997, 1999)), Treisman (2000)), the colonial history of the country (Treisman (2000), Swamy et al (1999), Acemoglu, Johnson and

Roninson (2001)), the freedom of the press (Brunetti and Weder (2003)) and a country's natural resource endowment (Weidemann (1999), Sachs and Warner (1997)).

Swamy et al (1999) looked at the effects of the percentage of women in the labor force and found it to be negatively correlated with level of corruption in a country. The authors posed no theoretical argument as to why this may be the case (i.e. it is not necessarily a biological phenomena and could be related to availability of corruption networks to women or other factors), but simply noted that the presence of women has a significant negative effect on corruption. Swamy et al (1999) propose that policies to increase women's participation in the labor force may help reduce corruption.

Another institutional factor may be the overall gender ratio of government. The percentage of females in parliament reflects this idea. Swamy et al (1999) test this relationship and find it be significant. Dollar et al (1999) also find significant results for the negative effects of women in the public sector on corruption.

Some religions, particularly Catholicism, Islam, and Eastern Orthodox, are hierarchical in nature and thus may discourage their followers from civic engagement or help foster a culture of unquestioned acceptance of higher ups. This social structure leads to higher levels of corruption than would a social structure supported by more individualistic religions (such as Protestantism.) La Porta et al (1997, 1999), look at the effects of the percentage of the population belonging to a hierarchical religion using a sample of 33 countries (1997) and 114 countries (1999) and find a significant positive relationship between religion and corruption. Treisman (2000) further investigates this relationship and finds countries with a Protestant tradition were significantly less corrupt than those countries with hierarchical religions.

Colonialism may influence the level of corruption. Although no studies have focused solely on this variable, several studies have used dummy variables for colonialism as control variables for other investigations. These studies (see for example Swamy et al (1999)) find that, *ceteris paribus*, former British colonies have significantly lower levels of corruption than countries that were not British colonies. Treisman (2000) also finds that countries that are former British colonies are less likely to be corrupt. He argues this occurs because countries that used to be under British rule adopted a common law governance system. Common law systems have been argued by La Porta et al (1999) to be superior legal systems. In addition, and perhaps more importantly, former British colonies have a culture of strict adherence to procedure and regulations that may cause officials to be more likely to turn in corrupt acts even when it threatens higher-ups. Thus, using dummy variables to account for colonialism may be a useful tool.

Ethno linguistic fractionalization may also contribute to corruption. When populations are highly fractionalized into separate language and culture groups, high levels of communication among different populations are unlikely to exist. A lack of communication may reduce political participation or, at the very least, reduce citizens' observance of actions taken by the government. Thus, a lack of information about political activities and corruption may create an environment where corruption is more prevalent. Additionally, it may indirectly affect corruption by slowing economic development, which then leads to higher levels of corruption. Treisman (2000) argues this latter relationship is more plausible because he finds ethno linguistic fractionalization to be insignificant in regressions that control for growth, but significant in those that do not.

An additional government structure that may influence the level of corruption is the level of federalism. Treisman (2000) argues that federal states should be more corrupt than unitary ones because ‘competition between autonomous levels of government to extract bribes may lead to overgrazing of the commons.’ He finds the relationship between corruption and federalism empirically significant.

Another institutional variable related to public investment and expenditure is the natural resource endowment of a country. Because natural resources tend to be centrally controlled, an abundance of them may lead to increased rent seeking behavior. Leite and Weidemann (1999) investigate this relationship and find it to be significant. Sachs and Warner (1997) look at the effect of natural resource richness on growth and reach the surprising conclusion that countries with greater natural resources tends to grow slower than countries with fewer resources. They hypothesize that this may occur because natural resources tend to be centrally controlled and have large rents associated with them that lead to increased opportunities for corruption.

The empirical literature suffers from endogeneity problems in the data. For example, Swamy et al (1999) and Dollar et al (1999) find the percentage of women in the labor force to be significantly positively correlated with a lower level of corruption. While this maybe the result of some moral superiority found in women that makes them impervious to corruption, it seems more likely to be the result of the fact that the percentage of women in the labor force is strongly correlated with GNP per capita which is strongly correlated with corruption. Many such issues arise in the data and any interpretation of causation between corruption and an independent variable is subject to such concern.

Micro level studies on corruption have been conducted by Svensson (2003) and Reinikka and Svensson (2004) using a World Bank data set on corruption among Ugandan firms and government programs. Svensson (2003) finds that firms vary in the whether or not they pay bribes and the value of bribes depending on the bargaining power of the firm and the firms' ability to pay. Reinikka and Svensson (2004) find that in a government transfer program for local education funding only 13% of funds on average reach their target schools. The remaining 87% are skimmed off by corrupt officials. Micro level data sets on corruption are rare and this avenue of research is just beginning.

Several papers present an overview of the issues surrounding corruption and summarize the research to date. (Shleifer and Vishney (1993), Bardhan (1997), Tanzi (1998) Jain (2001) Rose-Ackerman (2004) and Svensson (2005)) No studies to date examine how equilibrium levels of corruption are determined in a macroeconomy (Jain (2001)). Most of the empirical studies have focused on a single variable, testing for that variable's significance. It seems likely that some of those results may not be robust to the inclusion of all the variables thought to influence the level of corruption in a country. Additionally, the assumption has been that corruption is an all or nothing decision; a country will choose to be totally corrupt or not corrupt at all, and stick with that decision forever. No links between individual agents' motivations and equilibrium levels of corruption have been explored in a way that links a theoretical model with empirical results. Since it seems logical to analyze economic motivations for participating in corruption and empirical data does not reflect this all or nothing corruption decision, we feel this is an important area of research. This dissertation contributes to the debate by attempting to address this gap in the literature.

Chapter 3 Theoretical Models

Introduction

Corruption takes many forms and exists under varying market structures. We investigate three basic markets: a competitive market with many buyers and sellers, a monopoly supplier of corruption interacting with many buyers, and a single buyer and seller of corruption interacting in a strategic way.¹²

The market for corruption may be competitive, as is likely the case in low level or petty forms of corruption. An individual trying to obtain an identification card or a license to operate a business has many options for obtaining such a document. She can go to the office downtown or travel across town to several suburban offices; once at her office of choice, she has several windows to select from. She has the opportunity to interact with many different public officials and if she chooses, jump the queue by paying a bribe to a public official. The market she faces is competitive. On the reverse side of the market, the public official faces many such customers. Thus the market has many potential suppliers and buyers and operates in a competitive manner. The price of the bribes is exogenous to the individual players' decisions and equilibrium corruption in the

¹² Lambsdorff (2002) identifies two different kinds of corruption: market corruption, which involves a high degree of transparency and many buyers and sellers, and parochial corruption which is less transparent and involves a few buyers and sellers. We extend this to three specific cases; a competitive market with many buyers and sellers, a monopoly market with one supplier and many buyers and a strategic game with one buyer and one seller.

market is determined by the interaction of competitive supply and demand functions. Both public officials and firms have full information and no barriers to entry exist on either side of the market.

A market with only one supplier of corruption and many buyers can easily be imagined in the context of a public contract to build a road or dam. Many firms compete to be awarded the contract which is issued by a single agency or individual. If the bids are accompanied by a bribe or awarded based on bribes, corruption exists in the monopoly supplier context. The monopolist chooses the quantity of bribes to extract based on the firms' demand function for corruption. Market equilibrium is determined by the monopolist's maximization problem. Again, public officials and firms have full information but significant barriers to entry exist on the supply side of the market, such that only one public official can serve as the supplier of corruption. The demand side remains competitive.

The final type of market we imagine is one in which there is only one supplier of corruption interacting with a single buyer of corruption. We imagine this market as similar to a single supplier of a good in a single country or market. A single producer of a military good contracts with a single country to provide that good.¹³ The country is represented by an agency or public official who negotiates with the military producer and they agree on a contract for the provision of the good. The opportunity to introduce corruption into the market comes when the public official in charge seeks to extract a bribe from the firm or the firm offers a bribe. Border crossings provide another example. A lone customs official guards a border crossing. A firm seeking to illegally import a good meets this customs official. A bribe changes hands and the firm is allowed to come

¹³ For example, consider Halliburton and the awarding of military supply contracts in Iraq.

into the country with the illegal cargo. Buyers and sellers of corruption meet randomly in this model and bargain over the allocation of a surplus created by the illegal action. Given a sufficiently large surplus, both parties are better off if a transaction occurs within a range of bribes. The question becomes simply where in the range the bribe falls. The relative bargaining power of the firm and the public official dictate the size of the bribe given that a transaction occurs. The public official and the firms have full information about each player's bargaining power but the market is limited to two players.

The real world market for corruption is likely to be a mixture of these three extreme cases. Because corruption is an illegal activity, understanding of the market structure for corruption is limited by observations of actual corruption. As those observations may not be a random sample of all corrupt activities, it is informative to model differing market structures in order to gain better insight into how corruption is produced. Understanding differing market structures helps us to interpret the data and allows policy makers to make better informed decisions on how to best regulate corruption.

Chapter 3 proceeds as follows: Section 3.1 models and examines the competitive economy. Section 3.2 details the market with a monopoly supplier of corruption and many buyers. Section 3.3 looks at a market with a single buyer and a seller of corruption who interact in a strategic manner. Section 3.4 presents conclusions and policy ideas for regulating corruption.

3.1 A Competitive Market for Corruption

The first market structure we examine is one in which many buyers (firms looking to avoid a long queue) interact with many sellers of corruption (public officials willing to accept a bribe). Each actor in the market is too small to impact wages or policing and thus corrupt wages (the size of bribes) and the probability of getting caught are exogenous to individual decision makers.

We formally model a large competitive economy in which individual public officials provide needed government services, both legal and illegal. The supply of legal and illegal (corrupt) government services is determined by the public official's allocation of her scarce time between legitimate market work and illegal corrupt work. This allocation is based on the public officials' risk preferences, wages and potential punishments for participating in illegal activities. Firms in the economy provide the demand for corruption in their willingness to offer bribes to get around bureaucratic transaction costs. We specify supply and demand functions for the corrupt good and the legal government good based on the optimization decisions of public officials and firms. The model is numerically solved for equilibrium values of corruption under varying specifications.

3.1.1 Supply of Corruption: Public Officials Decision

We assume that the market for corruption operates under perfect competition. As long as the number of public officials willing to supply corruption and the number of firms demanding corruption are both large, it is likely that for any individual firm or public official the wage or size of the bribe is taken as given by the individual actor.

We use a utility maximizing framework to explore the public official's decision to supply corruption where the supply of corruption is equal to the number of hours an agent participates in corrupt work.¹⁴ The remaining hours available to the public official are then allocated to legal market work and constitute the supply of the legal government good.

We assume that public officials cannot simultaneously participate in market and corrupt work and therefore must allocate their time between the two. For example, if legal permit issuing is paid at a piece rate and the opportunity for extracting bribes comes from another source then the agent cannot overlap corrupt and market work, forcing a time allocation decision between the types of work. Or imagine a public official who issues legal building permits but also chooses to accept bribes to 'speed up the queue.' She cannot write the permit and accept the bribe at exactly the same time, thus forcing her to choose between the two at any given point in time. We may think of her as allocating her time between market work and corrupt work in small intervals. Even if the opportunities for extracting bribes come during legal permit issues, the public official cannot do both at exactly the same time and must allocate time discretely between the two activities. Thus competitive public officials face a market labor and corrupt labor tradeoff.

¹⁴ In reality, the number of corrupt acts possible in an hour of corrupt work is probably greater than one. Total corruption would then be measured by number of hours of work allocated to corruption times the number of corrupt acts possible during each hour of work. That is, an agent chooses the number of hours to devote to corrupt activities and the actual amount of corruption is then determined by the number possible in each hour. The number of corrupt activities possible in an hour depends on the social and institutional factors in an economy. A country with a 'culture of corruption' will have a greater number of opportunities for engaging in corruption. The leadership of a country may pattern a culture of corruption; many coups and revolutions would indicate a less stable system that is more open to corruption. Religious, ethnic and colonial backgrounds may all influence the opportunities for corruption. Countries with complex legal systems and tax codes or with lengthy permit processes all create greater number of opportunities for corruption to occur. However, for simplicity we assume that the number of corrupt acts possible in an hour is equal to one.

Corrupt activities pay some wage, w_c , but also impose a risk of prosecution and penalty if the agent is caught participating in such an activity. Thus the actual payoff to corrupt activities is tempered by the probability of being caught and facing a penalty. Legal market work pays a wage of w_m .

The official faces two states of the world, one in which she is caught participating in corrupt activities with probability ρ and faces a penalty (we assume for simplicity that being caught always results in a conviction and fine)¹⁵ and one in which she is not caught and faces no penalty with probability $1-\rho$. The public official earns wages from each activity, where w_m is equal to the wage for market work and w_c is the wage for corrupt work. Income in each state is defined as:

$$\text{If caught : } \tilde{Y} = w_m M + w_c C - \text{fine}C \quad (3.1.a)$$

$$\text{If not caught : } \hat{Y} = w_m M + w_c C \quad (3.1.b)$$

The agent knows with certainty the probability of getting caught, the size of the fine and the wages from both corrupt and legal work and takes all as given.

The public official maximizes expected utility over the following two states of the world: (1) she is caught participating in corruption and punished and (2) her corrupt activities go undetected. The maximization decision is constrained by time; the public official has only a limited number of hours in each day to spend on either market or corrupt work.¹⁶ Utility is defined as $U = Y^\alpha$. The agent's maximization problem can be written as:

¹⁵ The government faces a global solvency constraint such that all fines collected cannot exceed all wealth available but this constraint does not affect the individual agent's optimization choice. Thus the fine any individual agent may face is unrelated to the agent's own income.

¹⁶ We assume no moral or social costs of corruption to the individual public official.

$$\begin{aligned} \text{Maximize } EU &= \rho(w_m M + w_c C - \text{fine}C)^\alpha + (1 - \rho)(w_m M + w_c C)^\alpha \\ \text{s.t. } T &= C + M \end{aligned} \quad (3.2)$$

where T is total available hours, M is hours of market work and C is hours of corrupt work.¹⁷

An individual economic agent's risk preferences are measured by the shape of the utility function. Specifically, if an individual is risk averse, $EU(\text{gamble}) < U(E(\text{value of gamble}))$. For a risk neutral agent, $EU(\text{gamble}) = U(E(\text{value of gamble}))$, and for a risk loving agent, $EU(\text{gamble}) > U(E(\text{value of gamble}))$. Risk preference is measured by α , where α is defined as any non-negative number. Specifically: an $\alpha < 1$ implies risk aversion on the part of the public official, an $\alpha = 1$ implies risk neutrality, and an $\alpha > 1$ implies risk loving preferences.

Substituting the time constraint into the utility function gives us:

$$EU = \rho(w_m(T - C) + w_c C - \text{fine}C)^\alpha + (1 - \rho)(w_m(T - C) + w_c C)^\alpha \quad (3.3)$$

¹⁷ We can imagine an alternative model where T represents the total amount of the government good available for allocation as opposed to the number of hours available to the public official. Under such a model the public official can choose between selling her T units of the government good in the legal market for a price of w_m or selling them in the illegal market for a price of w_c . The public official must account for all T units of the good at the end of the day and provide the government with $w_m T$. If she sells some units illegally she pockets the difference $w_c - w_m (T - M)$. Selling units illegally carries a cost in the form of some probability of getting caught (ρ) and punished (*fine*). If she is caught, she is fined and fired. If the official has initial wealth, W, her utility function becomes:

$V(C) = \rho u(W - \text{fine}C) + (1 - \rho)u(W + (w_c - w_m)C)$. For the agent to supply corruption ($C > 0$),

$V'(C) > 0$. Evaluating $V'(C)$ at $C=0$ we find the black market premium for corruption to be

$w_c > w_m + \left(\frac{\rho}{1 - \rho}\right)\text{fine}$. When agents are risk neutral this premium will reduce to $w_c^* = w_m + \left(\frac{\rho}{1 - \rho}\right)\text{fine}$

in equilibrium. The supply of corruption is given by the solution to

$V'(C) = -\text{fine}\rho u'(W - \text{fine}C) + (w_c - w_m)(1 - \rho)u'(W + (w_c - w_m)C) = 0$. The supply of the legal

government good is then $M = T - C$. This model uses a fixed allocation of the government good to constrain the public official's decision as opposed to the time constraint in our model.

For an agent to choose to participate in corrupt activities the corrupt wage, w_c , must contain some premium over the market wage, w_m , to compensate for the increased risk of the activity (assuming the probability of getting caught is greater than zero). For this decision, the critical value of the corrupt wage depends on the degree of risk aversion of the agent. The costs associated with capture and punishment are exogenous to an individual agent but the reduction in utility for a particular agent due to these fixed costs depends on the shape of the utility curves, or the agents risk preferences.

The public official has the incentive to be corrupt if $EU'(0) > 0$.

$$\begin{aligned} \frac{\partial EU(C)}{\partial C} = \rho\alpha(w_c - w_m - fine)(w_m(T - C) + w_c C - fineC)^{\alpha-1} \\ + (1 - \rho)\alpha(w_c - w_m)(w_m(T - C) + w_c C)^{\alpha-1} > 0 \end{aligned} \quad (3.4)$$

Evaluating $EU'(C)$ at $C=0$ we get the condition for the agent to participate in corruption as:

$$\frac{\partial EU(C)}{\partial C} \Big|_{C=0} = w_c > w_m + \rho fine \quad (3.4.a)$$

The gain from participating in corruption (measured as the wage earned from corruption) discounted by the expected value of the fine, must be greater than the market wage rate. Thus the black market price of the illegal government good must account for the additional risk of providing corruption.

An agent is risk neutral if her expected utility of a gamble is equal to her utility of the expected value of a gamble; that is $EU(\text{gamble}) = U(E(\text{value of gamble}))$. For a risk-neutral agent the expected net payoffs for corrupt work must be non-negative. When agents are risk neutral and the market is competitive, the wage premium associated with corruption will fall until it reaches equilibrium at:

$$w_c^* = w_m + \rho fine \quad (3.5)$$

An agent is risk adverse if her expected utility of a gamble is less than her utility of the expected value of a gamble; that is $EU(\text{gamble}) < U(E(\text{value of gamble}))$.¹⁸ When agents are risk averse the black market premium must exceed the premium under the case when agents are risk neutral such that:

$$w_c^* + premium = w_m + \rho fine \quad (3.6)$$

Determining the level of corruption supplied by public officials requires knowledge of the distribution of risk preference among government workers. Risk preferences may depend on many factors. A public official's age, marital status, whether they have children and the level of their personal wealth may all influence risk preference. Knowledge of these demographics for public officials may be one way to identify or proxy risk preferences. If, for simplicity, all government workers were risk neutral, we could determine the supply of corruption for the economy by comparing the market and corrupt wages, and the probability of prosecution.

Assume public officials (agents) are homogeneous and are risk neutral actors. The agents face an exogenous probability of getting caught participating in corruption equal to ρ . Agents make two choices about how to spend their time: participating in market work for which they earn the wage, $w_m = 1$, or participating in corrupt work, earning the wage w_c . Agents cannot participate in both activities simultaneously and must

¹⁸ Public officials may also be risk loving such that $EU(\text{gamble}) > U(E(\text{value of gamble}))$. Thus, the risk loving agent is willing to accept an expected payoff to corrupt activities that is less than the market wage: $w_c - premium = w_m + \rho fine$. We ignore this case and focus only on risk averse and risk neutral agents.

allocate their time between the types of work. The wage for corrupt work, w_c , is not directly observed.

If we observe corruption, given that agents are risk neutral, we can assume that the wage associated with corruption must meet or exceed the agents' threshold wage. That is, if corruption exists, $w_c \geq 1 + \rho fine$.¹⁹ If we do not observe corruption in this country we can similarly assume that the wage is below the threshold level, that is, $w_c < 1 + \rho fine$.

We can make further observations about w_c by looking at the level of corruption. If corruption is positive but very small, it seems safe to assume that corrupt wages fall very close to $w_c = 1 + \rho fine$ so that the expected values of corrupt and market work are very close or equal. If corruption levels are relatively high, corrupt wages must fall somewhere above $1 + \rho fine$, so that the expected value of corrupt work is greater than the expected value of market work, inducing higher levels of corrupt work. When zero corruption exists, we observe a corner solution such that $C=0$. This occurs when the corrupt wage falls below $1 + \rho fine$.

Extending the model to allow for a heterogeneous distribution of risk preferences allows us to hypothesize about the relationship between observed levels of corruption, wages and distribution of risk aversion in a population.

Observed high levels of corruption in a country could be interpreted two ways with heterogeneous agents: if most agents are risk neutral (or in an extreme case, risk loving), bribes fall relatively close to the $1 + \rho fine$ threshold; if most agents are risk

¹⁹ Recall that we are assuming $w_m=1$. For a more generalized example, we would observe that if corruption exists, $w_c \geq w_m + \rho fine$.

averse corruption payoffs range upward from $1 + \rho fine$. A risk averse agent will only participate in corrupt activities if the expected payoff from such activities is strictly greater than the payoff from market work, thus corrupt wages must be strictly greater than $1 + \rho fine$. Observations of low or zero corruption could be interpreted either as a country with a very risk averse population or a country with a more normal distribution of risk aversion but corruption wages that fall very close or slightly below the $1 + \rho fine$ threshold.

Returning to our formal model we find the supply of corruption by differentiating the public official's utility function with respect to C and setting the derivative equal to 0. The first order condition with respect to C is:

$$EU' = \rho \alpha(w_c - w_m - fine)(w_m(T - C) + w_c C - fine C)^{\alpha-1} + (1 - \rho) \alpha(w_c - w_m)(w_m(T - C) + w_c C)^{\alpha-1} = 0 \quad (3.7)$$

Equation (3.7) states that the increase in expected utility when an additional hour is allocated to corrupt work is equal to the change in income in each state of the world. When the official is caught, the change in income is equal to the corrupt wage minus both the opportunity cost of missing a unit of market work and the increase in the expected value of the penalty, all weighed by the agents risk preference. When the official is not caught, the net change in income is equal to the corrupt wage minus the opportunity cost of missing a unit of market work, again weighed by the agents' risk preference. The tradeoff between these two states of the world must be equal. Solving (3.7) for C^* yields the supply function for corruption.

The second order condition for the public official's decision is:

$$\begin{aligned}
EU'' &= \rho(\alpha^2 - \alpha)(w_c - w_m - fine)^2 (w_m(T - C) + w_c C - fineC)^{\alpha-2} \\
&+ (1 - \rho)(\alpha^2 - \alpha)(w_c - w_m)^2 (w_m(T - C) + w_c C)^{\alpha-2} \leq 0
\end{aligned} \tag{3.8}$$

where $EU'' < 0$ if the public official is risk averse ($\alpha < 1$) and $EU'' = 0$ if the public official is risk neutral ($\alpha = 1$). Thus the expected utility function is concave for a risk averse public official and linear for a risk neutral official.²⁰

The time constraint can be rewritten such that:

$$M = T - C \tag{3.9}$$

allowing us to solve for the supply of market work (the legal government good) by first solving for corrupt work and allocating remaining time to market work. The supply function for the traditional government good becomes:

$$M^* = T - C^* \tag{3.10}$$

Using the implicit function theorem we investigate the comparative statics of the public official's decision problem and find the following:

$$\begin{aligned}
\frac{dC}{d\rho} &= \alpha(w_c - w_m - fine)[w_m(T - C) + w_c C - fineC]^{\alpha-1} \\
&- \alpha(w_c - w_m)[w_m(T - C) + w_c C]^{\alpha-1}
\end{aligned}$$

$$\begin{aligned}
\frac{dC}{dfine} &= -\rho\alpha [w_m(T - C) + w_c C - fineC]^{\alpha-1} \\
&+ fine(w_c - w_m - fine)[w_m(T - C) + w_c C - fineC]^{\alpha-2}
\end{aligned}$$

²⁰ For a risk loving official $EU'' > 0$ and her expected utility function is convex.

$$\begin{aligned}
\frac{dC}{d\alpha} &= \rho(w_c - w_m - fine)[w_m(T - C) + w_c C - fineC]^{\alpha-1} \\
&+ \alpha\rho(w_c - w_m - fine)[w_m(T - C) + w_c C - fineC]^{\alpha-1} \ln[w_m(T - C) + w_c C - fineC] \\
&+ (1 - \rho)(w_c - w_m)[w_m(T - C) + w_c C]^{\alpha-1} \\
&+ \alpha(1 - \rho)(w_c - w_m)[w_m(T - C) + w_c C]^{\alpha-1} \ln[w_m(T - C) + w_c C]
\end{aligned}$$

Increasing the probability of getting caught reduces the public official's supply of corruption, such that, $\frac{dC}{d\rho} < 0$ given that the fine is some positive number. When the fine

is equal to zero then $\frac{dC}{d\rho} = 0$. Changing the probability of getting caught does not

influence the supply of corruption when the penalty for participating in corruption is zero.

Changing the value of the fine decreases the supply of corruption such that $\frac{dC}{dfine} < 0$. Of

course, when $\rho=0$, then $\frac{dC}{dfine} = 0$. If the public official faces a zero percent chance of

getting caught the value of the penalty is irrelevant to the decision process. Decreasing

the public official's risk aversion measure (increasing values of α) increases the supply of

corruption such that $\frac{dC}{d\alpha} > 0$.

3.1.2 Demand for Corruption: The Firms' Decision

We make the assumption that demand for corruption is provided by firms seeking to make additional payments to secure a needed government input to production.

Production exhibits constant returns to scale and is dependant on two inputs; X, a composite good, and a government good which comes in two forms, G and B, where G is

the traditional government good and B is the corrupt government good. The firm is risk neutral.

Firms face the following production function:

$$Q = X^\sigma (G + \gamma B)^{1-\sigma} \text{ where } \gamma > 1 \quad (3.11)$$

Firms can utilize the official government input, G, by paying the listed price and standing in the appropriate queue. If a firm finds this traditional input too costly, they can procure a substitute government input, B, which is obtained by making an “additional payment” or bribe. Because B avoids the time costs associated with the conventional government good, G, one unit of B increases total production by more than one unit of G; as such B is weighted in the production function by γ , where $\gamma > 1$. However, using input B causes the firm to face the additional cost of some probability of getting caught participating in an illegal activity and incurring a fine. The size of the fine and the probability of getting caught are both known and exogenous to the firm’s decision.²¹ G and B are additive in the production function and firms can use any combination of the two government inputs that maximizes profits.²²

The cost function is:

$$Cost = pX + w_m G + (w_c + \rho fine)B \quad (3.12)$$

²¹ Each firm is too small to affect policing and thus the firm offering a bribe does not change the probability of detection in the market. The government faces a global solvency constraint such that all fines collected cannot exceed all wealth available but this constraint does not affect an individual firm’s optimization choice. Thus the fine any individual firm may face is unrelated to the firm’s own revenues or profits.

²² We imagine B and G to be complements in production and both to be substitutes for X. If instead we imagined G and X to be complements in production with B serving the substitute input we might model the firm’s production function as such: $Y = XG + \gamma B$ so that the firm’s profit function becomes:

$$\Pi = \rho(XG - pX - w_m G + (\gamma - w_c - fine)B) + (1 - \rho)(XG - pX - w_m G + (\gamma - w_c)B).$$

where p is the price of good X , w_m is the price of the conventional government good, w_c is the price of the corrupt government good and ρ and $fine$ are defined as before and are identical to the values the government agent faces. The full price the firms faces by using input B is the amount of the bribe plus the expected price of a fine (weighted by the probability of getting caught and having to pay the fine).

The firm seeks to maximize profits. The output price is the numeraire.

$$\text{Maximize } \Pi = X^\sigma (G + \gamma B)^{1-\sigma} - [pX + w_m G + (w_c + \rho fine)B] \quad (3.13)$$

subject to :

$$B \geq 0$$

$$G \geq 0$$

The first order conditions for the firm are:

$$\sigma X^{\sigma-1} (G + \gamma B)^{1-\sigma} - p = 0 \quad (3.14)$$

$$(1 - \sigma)(X^\sigma)(G + \gamma B)^{-\sigma} - w_m \leq 0 \quad (3.15)$$

$$G \geq 0 \quad (3.15.a)$$

$$G((1 - \sigma)(X^\sigma)(G + \gamma B)^{-\sigma} - w_m) = 0 \quad (3.15.b)$$

$$\gamma(1 - \sigma)(X^\sigma)(G + \gamma B)^{-\sigma} - (w_c + \rho fine) \leq 0 \quad (3.16)$$

$$B \geq 0 \quad (3.16.a)$$

$$B(\gamma(1 - \sigma)(X^\sigma)(G + \gamma B)^{-\sigma} - (w_c + \rho fine)) = 0 \quad (3.16.b)$$

The firm's demand for an input will equate the marginal product of adding another unit of that input with the cost of doing so. They will choose the profit maximizing quantity of each input such that the marginal (revenue) product of the input is equal to the price of the input good. Equations (3.14), (3.15) and (3.16) depict this decision for, respectively, X , the traditional government good, and the illegal government good.

The traditional government good and the alternative government good are substitutes in production and as such each can be optimized at a quantity of zero. Firms will not choose both $B=0$ and $G=0$ (just as they will not choose $X=0$) unless the profit maximizing quantity of output to produce is zero (the shut down rule). Firms may choose a quantity of G equal to zero if (3.15) is a strict inequality. Alternatively if the firm chooses $G>0$, (3.15) must hold with equality. Firms may choose a quantity of $B=0$ if (3.16) is a strict inequality. Again, alternatively, if the firms chooses $B>0$, (3.16) must hold with equality. Equations (3.16.a) and (3.16.b) ensure that these Kuhn-Tucker conditions are met.

Using the implicit function theorem the comparative statics of the firm's decision problem are:

$$\frac{dB}{d\rho} = \frac{X^{2\sigma-2} \text{fine} [(\sigma^2 - \sigma)^2 - (\sigma - \sigma^2)^2 (G + \lambda B)^{-2\sigma}]}{D}$$

$$\frac{dB}{d\text{fine}} = \frac{X^{2\sigma-2} \rho [(\sigma^2 - \sigma)^2 - (\sigma - \sigma^2)^2 (G + \lambda B)^{-2\sigma}]}{D}$$

$$\begin{aligned} & (\sigma^2 - \sigma)^2 (\sigma - \sigma^2)^2 \gamma B X^{3\sigma-4} (G + \lambda B)^{-\sigma} + (\sigma^2 - \sigma) (\sigma - \sigma^2) \gamma B X^{\sigma-3} (G + \lambda B)^{-3\sigma-1} \\ & + (\sigma^2 - \sigma)^2 (1 - \sigma) X^{3\sigma-2} (G + \lambda B)^{-3\sigma-1} + (\sigma^2 - \sigma) (\sigma - \sigma^2)^2 \gamma^2 X^{3\sigma-2} (G + \lambda B)^{-3\sigma-1} \\ & - (\sigma^2 - \sigma)^3 \gamma^2 B X^{3\sigma-2} (G + \lambda B)^{-\sigma-1} - (\sigma^2 - \sigma)^2 (1 - \sigma) X^{3\sigma-2} (G + \lambda B)^{-\sigma} \\ \frac{dB}{d\gamma} = & \frac{-2(\sigma^2 - \sigma) (\sigma - \sigma^2)^2 \gamma B X^{3\sigma-2} (G + \lambda B)^{-3\sigma-1}}{D} \end{aligned}$$

where D = determinant of the Jacobian matrix of the first partials.

Increasing the probability of getting caught and the size of the penalty will decrease firm's demand for the corrupt government good, such that $\frac{dB}{d\rho} < 0$

and $\frac{dB}{dfine} < 0$. Both conditions hold as long as $(\sigma^2 - \sigma)^2 < (\sigma - \sigma^2)^2 (G + \lambda B)^{-2\sigma}$.

Signing $\frac{dB}{d\gamma}$ is challenging and depends on the relative magnitude of the expressions in

the numerator. Theory predicts that $\frac{dB}{d\gamma} > 0$.

3.1.3 Equilibrium

Equilibrium occurs when the market for corruption and the market for the legal government good both clear. That is, the supply of corruption is equal to the demand for corruption,

$$C^* = B^* \tag{3.17}$$

and the supply of the legal government good is equal to the demand for the legal government good:

$$M^* = G^* \tag{3.18}$$

We now have seven equations ((3.7), (3.9), (3.14), (3.15), (3.16), (3.17) and (3.18)) and seven unknowns, in addition to the inequality constraints on the choice variables M, C, B, and G. For the system to be identified in equilibrium the ratio of the marginal products must be equal to the ratio of the input prices across all inputs. In an interior solution (3.14) and (3.15) both hold with a strict equality. A corner solution at either $C=T$ or $C=0$ is also possible. If transaction costs are very low, the firm's demand for B will be zero, driving the market equilibrium of corruption to zero. Additionally, on the supply side, if participating in corrupt activities is too costly (because the fine or

penalty are high) the public official's supply of corruption will fall to zero, again driving the market equilibrium of corruption to zero.

We can solve the above identified system of equations for our unknowns: C , M , X , G , B , w_c and w_m . Unfortunately, this system does not have a closed form solution and must be solved numerically. We are unable to definitively sign all the comparative static functions for the public official and first order conditions of the firm to determine the effect of changing values of exogenous parameters on corruption. We numerically simulate the model to gain testable hypothesis in addition to our mathematical comparative statics.

Section 3.1.4 Sensitivity Analysis

We have three parameters of interest for this system: ρ , the probability of getting caught participating in corruption γ , the value of using the non traditional government good (transaction cost) and the fine.²³ The probability of getting caught (ρ) ranges from 0 (a non existent probability of getting caught) to 1 (certainty of capture and punishment). The fine can take any non-negative value, with a higher number indicating a more severe penalty. We define the exogenous parameters for the system using standard values, where $\sigma = 1/2$, p , the price of the generic input good is 1 and the total time available to the public official to allocate between market and corrupt work, T , is 16 hours. We evaluate the

²³ The price of the other production input, p may change and thus affect the demand for corrupt and legal market goods, but this price is not a policy tool so we do not investigate it here. Additionally the total time available to the public official, T , may also change but the result would simply scale the supply curves up or down and would not affect the relative supply levels. Thus, we do not evaluate the impact of changing T in our system.

system for a risk neutral official, setting $\alpha=1$. Except where we directly investigate the impact of changing the parameter, we set the fine=10, $\gamma=10$ and $\rho=0.2$.

3.2.4.a: ρ

We first investigate the effect of probability of getting caught participating in corrupt activities on the equilibrium level of corruption produced in the market. We analyze the system for a range of values of ρ (0 to 1).

As expected, the equilibrium quantity of corruption falls as the probability of getting caught rises. Formally, $\frac{dC^*}{d\rho} < 0$; $\frac{dB^*}{d\rho} < 0$.

When the probability of getting caught is zero, the public official will allocate all her time to corrupt activities ($C=T$) and the market equilibrium occurs at $C^*=B^*=16$. As the probability of getting caught rises she reduces her supply of corruption. For example, when $\rho=0.6$, $C^*=B^*=0$ and $M^*=T=16$. Note that we are evaluating equilibriums, not estimating supply and demand curves. Thus differing values of C , B , M and G do not reflect movement along the supply and/or demand curves but rather shifts that result in new equilibrium values.

Table 3.1 Equilibrium corruption in a competitive market under changing probabilities of getting caught.

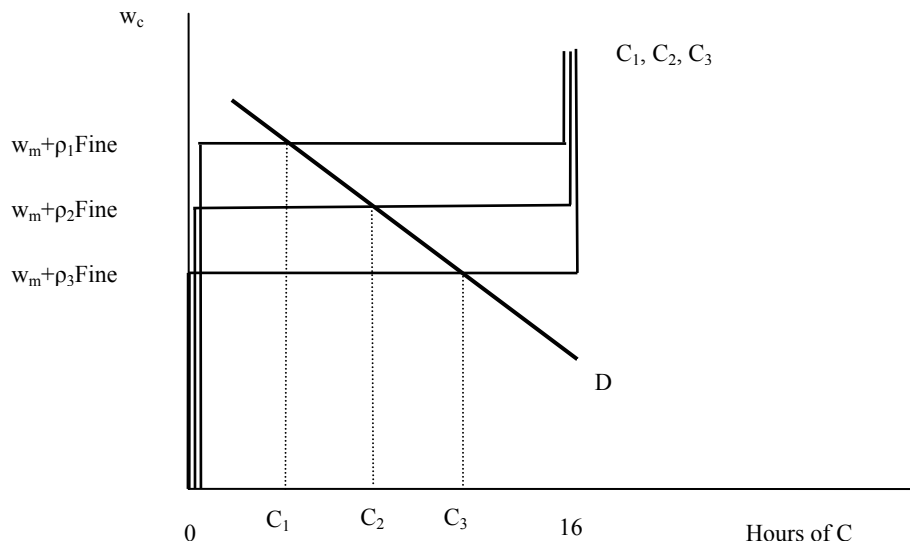
ρ	0	0.1	0.15	0.20	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	
X	18	35	63	98	100	101	102	102	103	104	105	113	
G	0	0.14	0.2	3	8.2	11.2	13	14.1	14.9	15.4	15.8	16	
B	16	15.86	15.8	13	7.8	4.8	3	1.9	1.1	0.6	0.2	0	
M	0	0.14	0.2	3	8.2	11.2	13	14.1	14.9	15.4	15.8	16	
C	16	15.86	15.8	13	7.8	4.8	3	1.9	1.1	0.6	0.2	0	
w_c	0.7	1.3	1.7	2.3	3	3.6	4.2	4.8	5.5	6	6.7	7.3	
w_m	0.7	0.3	0.7	0.3	0.5	0.6	0.7	0.8	1	1	1.2	1.3	
% Change in C		-0.1	-0.004	-0.2	-0.5	-0.5	-0.2	-0.5	-0.4	-0.6	-1	-2	-0.5
% Change in M		2	0.4	1.8	0.9	0.3	0.2	0.1	0.1	0.03	0.03	0.01	0.5
% Change in w_c		0.6	0.3	0.3	0.3	0.2	0.15	0.13	0.1	0.1	0.1	0.1	0.2
% Change in w_m		-0.8	0.8	-0.8	0.5	0.2	0.15	0.13	0.4	0	0.2	0.1	0.1
													average change

Note: Exogenous parameter values are set at: $\text{fine}=10$, $\gamma=10$, $\alpha=1$, $\sigma=1/2$, $\rho=1$, $T=16$.

The equilibrium quantity of corruption decreases as the probability of getting caught rises. Figure 3.1 illustrates this relationship in a supply and demand framework. The public official has a discontinuous supply function such that when the corrupt wage falls below $w_m + \rho \cdot \text{fine}$, the supply of corruption is zero. At $w_c = w_m + \rho \cdot \text{fine}$, the risk neutral public official is willing to supply any quantity of corruption between 0 and T (she is indifferent between corrupt and market work). The time constraint limits the supply of corruption to T regardless of price.

Changing the probability of getting caught increases the wage premium associated with corrupt work where $w_c = w_m + \rho \cdot \text{fine}$ holds. In Figure 3.1 the supply curve C_1 is associated with a probability, ρ_1 , while C_2 is associated with the probability ρ_2 , where $\rho_2 > \rho_1$. As the supply curve shifts upward (due to increasing ρ), the quantity demanded of corruption decreases and equilibrium corruption falls.

Figure 3.1 The provision of corruption under a supply and demand framework in a competitive market with changing ρ



3.2.4.b: Fine

The fine associated with getting caught participating in an act of corruption is exogenous to the public official's and firm's decisions. Increasing the value of the fine makes the choice to participate in corruption more costly to both parties. As such, increasing the fine should decrease the amount of corruption the public official is willing to supply (or raise the price at which they are willing to supply it) and decrease the amount of corruption the firms will demand, resulting in a lower equilibrium quantity of corruption.

As expected, the equilibrium quantity of corruption falls as the value of the fine increases. Formally, $\frac{dC^*}{dfine} < 0$; $\frac{dB^*}{dfine} < 0$. When the value of the fine is zero (i.e. there is no punishment associated with getting caught participating in corruption), the market

produces corruption such that $C^*=B^*=16$. Public officials allocate all their time to corrupt activities ($C=T$) and firms will choose $B=16$, $G=0$ to maximize profits.

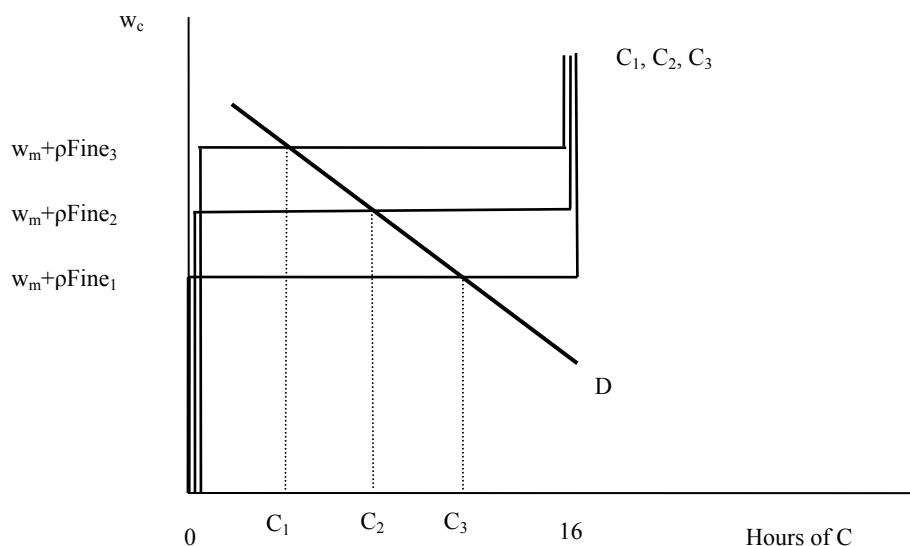
Table 3.2 Equilibrium corruption in a competitive market under changing fines.

Fine	0	10	12	15	20	30	
X	18	98	100	101.4	102.4	113.1	
G	0	2.6	7.3	11.2	14.1	16	
B	16	13.4	8.7	4.8	1.9	0	
M	0	2.6	7.3	11.2	14.1	16	
C	16	13.4	8.7	4.8	1.9	0	
w_c	1.7	2.4	2.8	3.6	4.9	7.3	
w_m	0.7	0.4	0.4	0.6	0.9	1.3	
% Change in C		-0.1	-4.3	-0.6	-3.1	-5	-1.8
% Change in M		2	1	0.42	1.1	1	1.1
% Change in w_c		0.3	.01	0.25	1.2	1.1	0.6
% Change in w_m		1	0	0.4	0.8	0.3	0.5
							average change

Note: Exogenous parameter values are set at: $\gamma=10$, $\rho=0.2$, $\alpha=1$, $\sigma=1/2$, $\rho=1$, $T=16$.

Changing the value of the penalty associated with corruption has the same intuitive explanation as changing the probability of getting caught. An increase in either variable increases the expected value of the punishment associated with corruption. Again, the supply curve of the risk neutral public official is discontinuous and depends the relationship between the corrupt wage w_c and $w_m + \rho * \text{fine}$. Increasing the fine increases the corrupt wage in equilibrium, making corruption more expensive, thus reducing the quantity demanded. Equilibrium corruption falls with an increase in the fine.

Figure 3.2 The provision of corruption under a supply and demand framework in a competitive market with changing fine



3.2.4.c: Transaction costs, γ

Firms are willing to pay bribes to obtain the government input in its illegal form, if the price of the traditional government good is high. The price of the traditional government good may be considered high if the transaction costs associated with using the good become large. Transaction costs are measured in our model by γ , the value using the government good in the illegal form in production. The higher the value associated with the illegal good (i.e. the higher the coefficient on B in production) the more costly it must be to use the traditional government good, signaling higher transaction costs in obtaining or using the traditional good. Changing the value of γ allows us to examine the changing equilibrium values for G and B , the traditional and illegal government goods, respectively.

The equilibrium quantity of corruption rises as transaction costs increase. Formally, $\frac{dB^*}{d\gamma} > 0$. When transaction costs are eliminated ($\gamma=0$), the firm uses only the legal government input, G , in production. The market equilibrium is then $G^*=M^*=16$, and $B^*=C^*=0$. Public officials allocate all their time to producing the traditional government good ($M=T$). As transaction costs rise, the allocation of government inputs moves towards increased use of B and away from G . When transaction costs reach 15, the firm uses only the illegal government good and none of the legal input. In equilibrium, the public official supplies $C=T$ of the illegal government good and $M=0$ of the legal good.

Table 3.3 Equilibrium corruption in a competitive market under changing transaction costs.

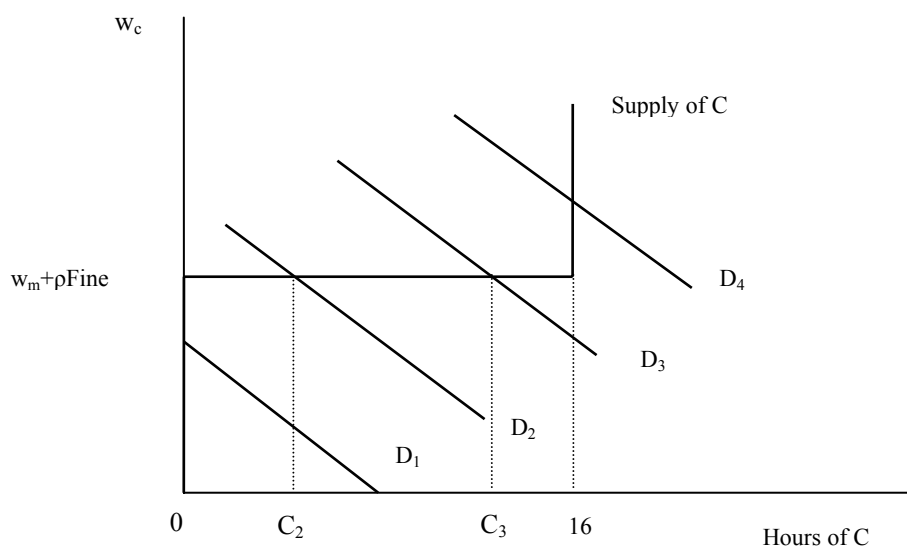
γ	0	6	8	10	12	
X	100	101	99	98	94	
G	16	10.6	6.3	2.6	0	
B	0	5.4	9.7	13.4	16	
M	16	10.6	6.3	2.6	0	
C	0	5.4	9.7	13.4	16	
w_c	0	2.7	2.5	2.4	2.3	
w_m	0	0.7	0.5	0.4	0.3	
% Change in B		2	0.6	0.3	0.2	0.6
% Change in w_c		2	0.1	0.04	0.04	0.42
% Change in w_m		2	-0.3	-0.2	-0.3	0.25
						average change

Note: Exogenous parameter values are set at: $\rho=0.2$, $\text{fine}=10$, $\alpha=1$, $\sigma=1/2$, $\rho=1$, $T=16$.

The supply and demand analysis of the impact of changing transaction costs associated with the legal government good is shown in Figure 3.3. The risk neutral public official retains their discontinuous supply curve. The firm's demand for corruption is a function of transaction costs and shifts to the right as transaction costs increases (i.e. the firm demands more corruption when the legal good is more costly). This shifting demand

curve intersects the supply function at different points resulting in differing quantities of corruption in equilibrium. When transaction costs are low the firm's demand curve is D_1 and zero corruption is produced in the market. As transaction costs rise demand rises to D_2 and equilibrium corruption increases to C_2 . Given the public official's supply curve, equilibrium corruption cannot rise above sixteen units ($T=16$) regardless of demand.

Figure 3.3 The provision of corruption under a supply and demand framework in a competitive market with changing transaction costs (γ)



Note that in Tables 3.1 through 3.3, we observe the predicted wage relationship, $w_c = w_m + \rho fine$ where the black market premium is equal to the expected value of punishment. In Tables 3.1 and 3.2 when ρ and the fine increase the black market premium associated with the corrupt wage also rises.

Tables 3.1 through 3.3 give us testable hypotheses of the impact on the market equilibrium of the probability of getting caught, the fine and transaction costs. The numerical simulations show that:

$$\frac{dC^*}{d\rho} < 0, \quad \frac{dB^*}{d\rho} < 0, \quad \frac{dC^*}{dfine} < 0, \quad \frac{dB^*}{dfine} < 0, \quad \frac{dB^*}{d\gamma} > 0$$

Section 3.2 A Market with One Seller and Many Buyers: A Monopolist Supplier Problem

We now turn to a market with one supplier of corrupt services, a single public official who issues government contracts, and many buyers of corruption, firms willing to pay a bribe.

It is easy to imagine the existence of such a market in the case of a government contract to build government services, such as roads or dams. Many firms submit bids, some with accompanying bribes, to a single government official in charge of issuing the contracts. The government official awards the contracts differentially based on whether a firm bribes or not. The government official acts as a monopoly supplier of corruption who faces many buyers.

The supply side of the market is analogous to a monopolist producer while the demand side of the market remains competitive. Identical to the competitive model framework, firms seek to pay bribes to avoid transaction costs and a long queue or to be awarded a government contract. We present the public official's and firm's decision problems and the numerical simulations for the equilibrium price and quantity of corruption produced in the market.

3.2.1 Monopoly Supply of Corruption

The single public official acts as a monopoly supplier of corruption in the market. The public official seeks to maximize expected utility over two states of the world; one in

which she is caught participating in corruption and punished and one in which she is not caught. Income in each state is each subject to the firm's demand for corruption. The agent is caught participating in corruption with probability ρ and gets away with it with probability $(1 - \rho)$. This decision problem is similar to a monopoly firm seeking to maximize expected profits, but with an added measure of the risk preferences of the public official. The risk preference is noted in the exponent of the utility function, (α) , where $U = Y^\alpha$. When $\alpha < 1$, the public official is risk averse, when $\alpha = 1$, risk neutral, and when $\alpha > 1$, risk loving. The monopolist public official's income is defined as:

$$Y = w_c(B)B - c(B) \quad (3.19)$$

where $w_c(B)$, the firms' conditional inverse demand function for corruption is defined as:

$$w_c(B) = \gamma(1 - \sigma)(X^\sigma)[\gamma B + G]^{-\sigma} - \rho \text{fine} \quad (3.20)$$

and the cost function the public official faces, $c(B)$, is the probability that the public official will be caught participating corruption and subsequently be required to pay a fine. Costs are defined as:

$$c(B) = \rho(\text{fine}B) + (1 - \rho)0 \quad (3.21)$$

The public official's maximization problem can be written as:

$$\begin{aligned} \text{Max} EU &= \rho \left[(1 - \sigma) X^\sigma (G + \gamma B)^{-\sigma} - \rho \text{fine} - \text{fine} \right] B^\alpha \\ &+ (1 - \rho) \left[(1 - \sigma) X^\sigma (G + \gamma B)^{-\sigma} - \rho \text{fine} \right] B^\alpha \end{aligned} \quad (3.22)$$

The first order condition for the monopolists' problem with respect to C can be written as:

$$\begin{aligned} EU' &= \rho * \alpha \left[B(\gamma(1 - \sigma)(X^\sigma)[\gamma B + G]^{-\sigma} - \rho \text{fine} - \text{fine}) \right]^{\alpha-1} * \\ &(\gamma(1 - \sigma)(X^\sigma)[\gamma B + G]^{-\sigma} - \rho \text{fine} - \text{fine} + \gamma^2 B(-\sigma + \sigma^2)(X^\sigma)[\gamma B + G]^{-\sigma-1}) \\ &+ (1 - \rho) * \alpha \left[B(\gamma(1 - \sigma)(X^\sigma)[\gamma B + G]^{-\sigma} - \rho \text{fine}) \right]^{\alpha-1} * \\ &(\gamma(1 - \sigma)(X^\sigma)[\gamma B + G]^{-\sigma} - \rho \text{fine} + \gamma^2 B(-\sigma + \sigma^2)(X^\sigma)[\gamma B + G]^{-\sigma-1}) = 0 \end{aligned} \quad (3.23)$$

Equation (3.23) states that the marginal increase in utility associated with an increase in income from selling an additional unit of corruption must be equal to the marginal cost associated with participating in another unit of corrupt activities. Solving (3.23) for B^* gives us the equilibrium level of corruption in the market. We can then use the firm's conditional inverse demand curve, (3.20), to determine equilibrium price in the market.

3.2.2 Demand for Corruption

The demand for corruption is determined by the production decisions of firms in the market. We assume the same firm production characteristics as in the competitive model.

Firms face the following production function:

$$Q = X^\sigma (G + \gamma B)^{1-\sigma} \text{ where } \gamma > 1 \quad (3.11)$$

where X is the composite input, G is the traditional government good and B is the illegal government good. The cost function for the firm is defined as:

$$Cost = pX + w_m G + (w_c + \rho fine)B \quad (3.12)$$

where p is the price of X , w_m is the price of the conventional government good, w_c is the price of the corrupt government good, and ρ and $fine$ are the probability of getting caught and the cost of the penalty. The firm is risk neutral, and seeks to maximize profits:

$$\text{Maximize } \Pi = X^\sigma (G + \gamma B)^{1-\sigma} - [pX + w_m G + (w_c + \rho fine)B] \quad (3.13)$$

Solving the firm's decision problem gives us the following first order conditions:

$$\sigma X^{\sigma-1}(G + \gamma B)^{1-\sigma} - p = 0 \quad (3.14)$$

$$(1 - \sigma)(X^\sigma)(G + \gamma B)^{-\sigma} - w_m \leq 0 \quad (3.15)$$

$$\gamma(1 - \sigma)(X^\sigma)(G + \gamma B)^{-\sigma} - (w_c + \rho fine) \leq 0 \quad (3.16)$$

The interpretation of the firm's first order conditions is the same as for the competitive model. For each input, at the optimal level of use the increased marginal product from an additional unit of the input must be equal to the cost of that input. We assume interior solutions for all inputs. The input demand of interest here is the firm's demand for the illegal government good, B. Solving 3.16 for B we find:

$$B(w_c) = \frac{\left[\frac{w_c + \rho fine}{\gamma(1 - \sigma)(X^\sigma)} \right]^{-\frac{1}{\sigma}} - G}{\gamma} \quad (3.16.a)$$

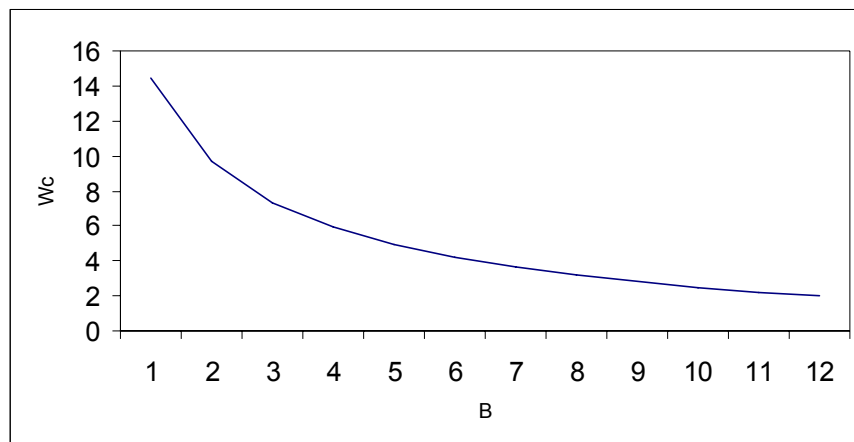
Rewriting the demand function as the conditional inverse demand yields:

$$w_c(B) = \gamma(1 - \sigma)(X^\sigma)[\gamma B + G]^{-\sigma} - \rho fine \quad (3.19)$$

3.3.3 Equilibrium

As with the competitive market, this model must be solved numerically as there is no closed form solution to the problem. We have four unknowns, X, G, B and w_c and four equations (3.14), (3.15), (3.16), and (3.22). We generate a conditional sample demand curve for corruption as shown in Figure 3.1 and find that firms demand higher quantities of corruption as the price of corruption falls given fixed quantities of the other production inputs, X and G. We numerically simulate the model to gain testable hypothesis in place of mathematical comparative statics.

Figure 3.4: Conditional demand curve for B; the corrupt government good.



Note: Parameter values set at: $X=100$, $G=10$, $\gamma=10$, $\sigma=1/2$, $\rho=0.2$, fine =10

3.3.3 Sensitivity Analysis

We examine the monopolist model to investigate how sensitive equilibrium is to changes in the exogenous parameters. For a risk neutral official, we change values of ρ (the probability of getting caught participating in corruption), γ (the benefit of using the illegal government good in production), and the size of the fine and examine the resulting equilibrium price and quantity of corruption. Recall that a value of $\alpha = 1$ indicates risk neutrality. We define the exogenous parameters for the system using standard values, where $\sigma = 1/2$ and p (the price of the generic input) is 1. Except where we directly investigate the impact of changing the parameter, we set the fine at 10, $w_m = 1$, $\gamma = 10$ and $\rho = 0.2$.

We find that the equilibrium values of corruption behave as expected. Corruption is reduced both when the probability of getting caught increases and the fine associated with getting caught increases. Likewise, when transaction costs increase, corruption increases.

3.3.3.a: ρ

Raising the probability of getting caught participating in corruption reduces firm's demand for corruption and decreases the public officials' willingness to supply corruption. Higher values of ρ increase the costs associated with illegal bribes for both groups. We report both the equilibrium price and quantity for corruption, but note that the results represent differing equilibrium quantities from shifting supply and demand curves and should not be interpreted as a demand curve.

As the probability of getting caught increases, the equilibrium quantity of corruption falls. Formally, $\frac{dB^*}{d\rho} < 0$. When there exists a zero percent chance of getting caught, equilibrium corruption is 135 units. Increasing the probability of getting caught to thirty percent ($\rho=0.3$) causes B to fall to zero. The average percentage change in B given a change in ρ is -0.9, while the price response is 0.4%.

Table 3.4 Equilibrium corruption in a monopoly market under various probabilities of getting caught.

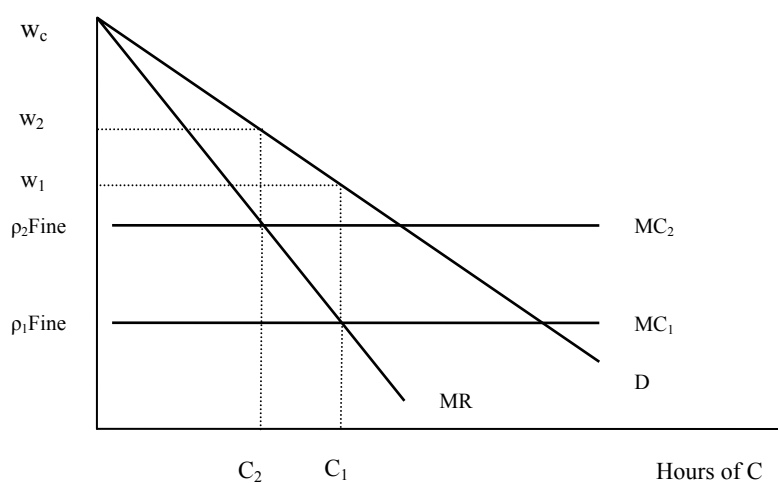
ρ	0	0.1	0.15	0.2	0.25	0.3	
X	165	259	185	196	201	158	
G	0	0	100	100	100	110	
B	135	40	15	8	4	0	
w_c	1.8	3	2.8	3.2	3.4	3	
% change in B		-1.1	-0.9	-0.6	-0.7	-1	-0.9
% change in w_c		0.5	0.1	0.13	0.15	0.4	0.4
							average change

Note: Exogenous parameter values are set at: $\text{fine}=10$, $\gamma=10$, $\alpha=1$, $\sigma=1/2$, $p=1$, $w_m=1$.

A monopolist produces where marginal revenue equals marginal cost. The public official's marginal cost function is constant and equal to $\rho \cdot \text{fine}$, or the expected value of

the punishment associated with participating in corruption. Increasing the probability of getting caught increases marginal cost. As marginal cost rises from MC_1 to MC_2 the equilibrium quantity of corruption produced in the market falls from C_1 to C_2 . This relationship is depicted in Figure 3.4.

Figure 3.5 The provision of corruption in a cost and revenue framework under a monopoly supplier market with changing ρ .



3.3.3.b: Fine

Just as increasing the probability of getting caught makes corruption more costly for firms and public officials, so does increasing the punishment. In our framework, the punishment is in the form of a fine. Raising the value of the fine should decrease the equilibrium quantity of corruption.

As predicted, when the fine increases the equilibrium quantity of corruption falls.

Formally, $\frac{dB^*}{dfine} < 0$.

When the fine is zero (there is no punishment associated with participating in corruption, even if the public official is caught doing so) the market will produce approximately 125 units of corruption, while raising the fine to 15 eliminates corruption in the market. The quantity of corruption produced in equilibrium responds to a one percent increase in the fine with approximately a -1 percent drop, while the equilibrium price rises approximately 0.4 percent in response to the same change in the fine.

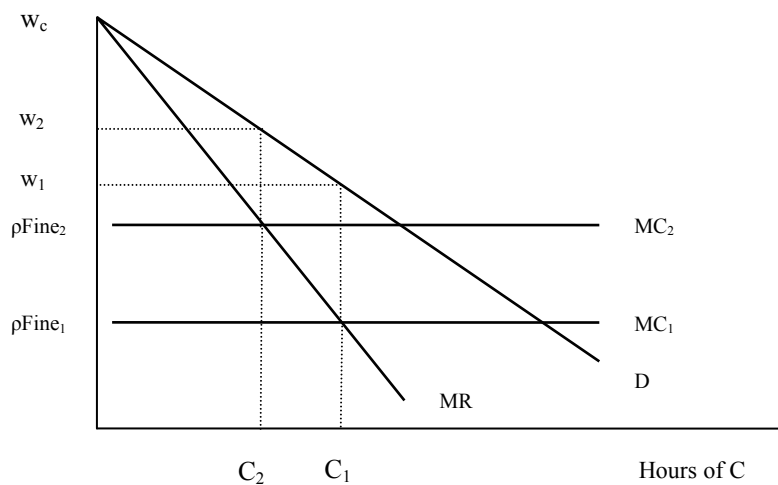
Table 3.5 Equilibrium corruption in a monopoly market under changing fines.

Fine	0	5	8	10	12	15	
X	165	259	187	196	199	174	
G	0	0	100	100	100	121	
B	125	40	13.3	8.3	5	0	
w_c	1.7	3	2.9	3.2	3.4	3	
% change in B		-1	-1	-0.5	-0.4	-2	-1
% change in w_c		0.6	0.03	0.1	0.06	1.3	0.4
							average change

Note: Exogenous parameter values are set at: $\rho=0.2$, $\gamma=10$, $\alpha=1$, $\sigma=1/2$, $p=1$, $w_m=1$.

Increasing the fine paid increases the marginal cost curve faced by the monopolist public official. When marginal costs rises, the equilibrium quantity of corruption falls. Figure 3.6 illustrates this relationship. Increasing the marginal cost from MC_1 to MC_2 , as the fine rises from $Fine_1$ to $Fine_2$, reduces the equilibrium quantity of corruption from C_1 to C_2 .

Figure 3.6 The provision of corruption in a cost and revenue framework under a monopoly supplier market with a changing Fine.



3.3.3.c: Transaction Costs, γ

Transaction costs in obtaining the legal government input decrease profitability of firms. Therefore, they may demand some alternative to the legal avenue and offer a bribe or extra payment to avoid such costs. Higher transaction costs lead to greater quantity and price of bribes offered by the firm to avoid them. Thus, as transaction costs rise we should see rising equilibrium quantities of corruption due to increasing demand.

Formally, $\frac{dB^*}{d\gamma} < 0$. Equilibrium corruption rises 0.6 % given a 1% increase in transaction

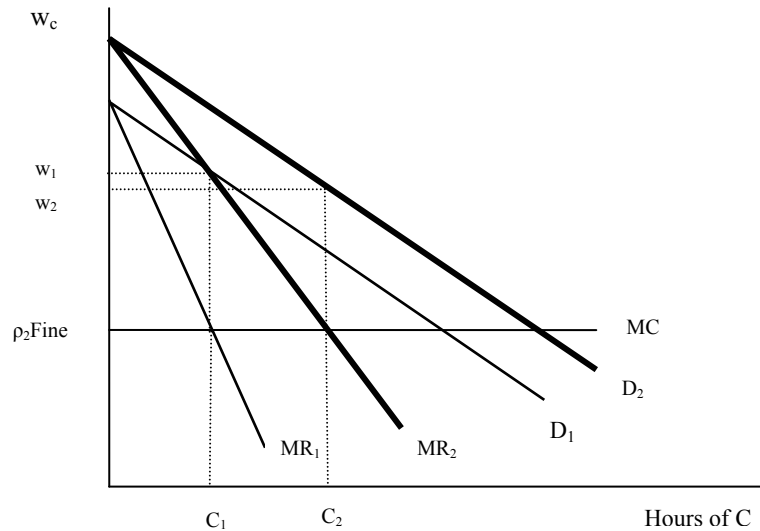
costs. The price response is smaller, with a 0.2% increase.

Table 3.6 Equilibrium corruption in a monopoly market under changing transaction costs.

γ	5	8	10	12	14	16	18	
X	216	201	196	191	189	265	285	
G	85	107	100	100	100	17	0	
B	0	5.2	8.3	10.4	12.2	17.5	20	
w_c	2	2.7	3.2	3.5	3.8	5.6	6	
% change in B		2	0.5	0.2	0.16	0.4	0.13	0.6
% change in w_c		0.3	0.2	0.1	0.1	0.4	0.1	0.2
								average change

Note: Exogenous parameter values are set at: $\rho=0.2$, $\text{fine}=10$, $\alpha=1$, $\sigma=1/2$, $\rho=1$, $w_m=1$.

An increase in transaction costs is depicted in Figure 3.7. This increase shifts demand from D_1 to D_2 . Corruption is produced where marginal revenue is equal to marginal cost. As demand shifts rightward, marginal revenues increase, increasing equilibrium corruption from C_1 to C_2 .

Figure 3.7 The provision of corruption in a cost and revenue framework under a monopoly supplier market with changing transaction costs.

Tables 3.4 through 3.6 give us testable hypothesis of the impact on market equilibrium of changing the probability of getting caught, the fine and transaction costs.

We find that for the monopoly supplier market:

$$\frac{dB^*}{d\rho} < 0, \quad \frac{dB^*}{dfine} < 0, \quad \frac{dB^*}{d\gamma} > 0$$

3.4 A Single Buyer, Single Seller Market for Corruption

The third market structure we examine is one in which the market consists of a single buyer and single seller of corruption. This market structure can be seen in an example of a single supplier of a good in a single country or market. Buyers (firms willing to pay a bribe) and sellers (a public official willing to accept a bribe) meet randomly in a one time transaction. If the buyer and seller can agree on the price of the bribe, both parties are better off. If the buyer and seller cannot agree to a bribe price, the transaction does not occur.

We examine a game played between a single supplier of corruption and a single buyer of corruption. Suppose a firm wishes to import an illegal good. That firm randomly meets the customs official on duty at the time and place of proposed entry. The two negotiate over the size of the bribe allowing the firm to cross the border. The firm has a known surplus or profit associated with illegally importing the goods. It is this surplus the firm and customs official bargain to allocate. The firm would prefer to pay a low bribe and retain most of the surplus while the customs official would like to receive a large bribe thus allocating most of the surplus to herself. If the two parties cannot reach a decision about the allocation the surplus disappears and each receives nothing. The firm has to turn around at the border and thus does not profit from importing the good. The customs official does not receive a bribe for allowing the firm to cross.

Following Cross (1969) and Eichberger (1993), we model the bargaining problem as follows. In a two period game, two players must allocate a set sum of money, S ,

between them. Player 1 begins and offers a proposed allocation, $(x_1, S - x_1)$. Player 2 can accept the offer, at which time the game ends and S is divided up $(x_1, S - x_1)$, or reject the offer. If Player 2 rejects the offer, she then proposes her own allocation, $(x_2, S - x_2)$. Player 1 can accept the offer with the resulting allocation $(x_2, S - x_2)$ or reject it. If Player 1 rejects Player 2's offer, then the game ends with each player receiving zero. In the second period the payoffs are discounted by each player's discount rate: δ_1 and δ_2 respectively. We assume Player 1 is the customs official and Player 2 is the firm.²⁴

The game can be solved through backward induction to find the Subgame Perfect Nash Equilibrium. In the second period Player 1 accepts any offer by Player 2, $x_1 \geq 0$. Thus, it is in Player 2's best interest to always offer $x_1 = 0$ in the second period. Player 2 then receives a payoff of $\delta_2 S$ in the second period if she rejects Player 1's offer in the first period. Player 2 will accept any first period offer, $(x_1, S - x_1)$ if $S - x_1 \geq \delta_2 S$. Player 1 knows the payoffs to Player 2 and so offers x_1 such that $S - x_1 = \delta_2 S$, or $x_1 = S(1 - \delta_2)$. Player 2's best interest is to accept this offer. As such the game ends in the first round with Player 2's acceptance of Player 1's offer of $x_1 = S(1 - \delta_2)$.

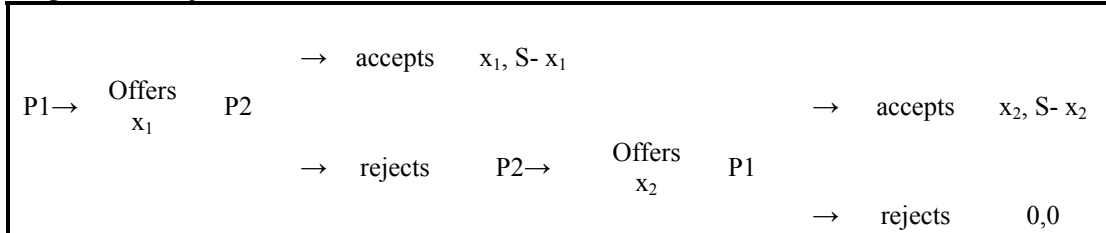
The relative allocation of the surplus depends on the degree of time sensitivity for Player 2. When δ_2 is small and Player 2 is impatient, then Player 1 is allocated a larger share of the surplus. However, when Player 2 is patient and δ_2 is large, then the share of S that Player 1 receives is relatively small.²⁵ Thus the relative bargaining power of the players depends on Player 2's discount rate. If the firm faces a discount rate greater than

²⁴ The role of the customs official and firm could be reversed with the firm making the original bribe offer.

²⁵ For example, assume $S=10$. When $\delta_2=0.9$, Player 1 receives 1 unit of the surplus. However, when $\delta_2=0.1$, then Player 1 receives 9 units of the surplus.

$\frac{1}{2}$, a greater share of the surplus will be allocated to the customs official. On the other hand, if $\delta_2 < \frac{1}{2}$, a greater share of the surplus will be allocated to the firm.

Figure 3.2 Payoff Tree



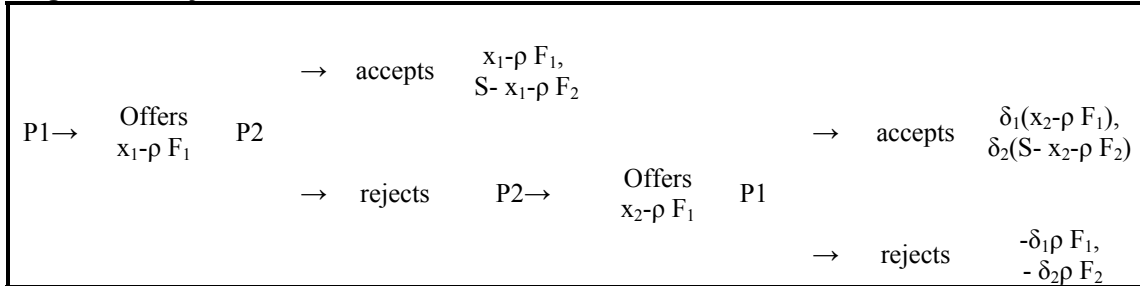
We can extend the game by including some probability of getting caught and punished when the two players bargain over the surplus. If the customs official allows the firm to illegally import goods, both face some chance that these actions will be detected and they will be punished for participating in corruption. The payoffs under such a game are reduced by the expected value of the punishment, where the probability of getting caught for each player is ρ , Player 1 faces a fine of F_1 , and Player 2 faces a fine of F_2 .

The game becomes the following. Player 1 offers a proposed allocation $(x_1 - \rho F_1, S - x_1 - \rho F_2)$. Player 2 can accept the offer, at which time the game ends and S is divided up $(x_1 - \rho F_1, S - x_1 - \rho F_2)$, or reject the offer. If Player 2 rejects the offer, she then proposes her own allocation, $(x_2 - \rho F_1, S - x_2 - \rho F_2)$. Player 1 can accept the offer with the resulting allocation $(x_2 - \rho F_1, S - x_2 - \rho F_2)$ or reject the offer. If Player 1 rejects Player 2's offer then the game ends with each player receiving, respectively, $(-\rho F_1)$ and $(-\rho F_2)$. Again, the second period payoffs are discounted by each player's discount rate, δ_1 and δ_2 .

The Subgame Perfect Nash Equilibrium in this game is for Player 1 to offer x_1 such that $S - x_1 - F_2 = \delta_2 S - \delta_2 F_1$, or $x_1 = S(1 - \delta_2) + \delta_2 F_1 - F_2$ given $x_1 \geq F_1$. Player 2

accepts this offer, since she is indifferent between accepting or rejecting and offering $\delta_2 F_1$ in the second period.

Figure 3.3 Payoff Tree with Penalties



When $S(1 - \delta_2) > (1 - \delta_2)F_1 + F_2$ the game proceeds as above. However, when $S(1 - \delta_2) \leq (1 - \delta_2)F_1 + F_2$, neither player is willing to participate in the game and no corruption exists in the market. This market produces corruption in an all or nothing fashion. If the value of the surplus is high enough, $S(1 - \delta_2) > (1 - \delta_2)F_1 + F_2$, the customs official and the firm will engage in a bargaining process to determine the size of the bribe and the market will produce one unit of corruption. When the public official moves first, the bribe will be large when the discount rate of the firm is high. When the firm moves first, the bribe will be large when the discount rate of the public official is high. If the value of the surplus is small, $S(1 - \delta_2) \leq (1 - \delta_2)F_1 + F_2$, no interaction takes place and no units of corruption are produced.

Increasing the size of the fine faced by Player 1, will increase x_1 while increasing the size of the fine faced by Player 2, will decrease x_1 . If both fines are increased equivalently, x_1 will remain constant, given that the increase in the fines does not result in $S(1 - \delta_2) \leq (1 - \delta_2)F_1 + F_2$.

3.4 Policy Tools and Conclusions

We model the level of corruption in an economy under three market structure specifications, a competitive market with many sellers and buyers of corruption, a market with a monopoly supplier of corruption who interacts with many buyers and market where a single buyer and a single seller interact strategically.

We first model a large competitive economy where individual public officials cannot influence the size of bribes and bribe values are determined exogenously. These public officials provide the supply of corruption to the market which varies with the risk preferences of the officials. Firms demand corruption to avoid redtape or transaction costs. Together these supply and demand factors give us an equilibrium level of corruption that we are able to evaluate numerically. We solve the model for the equilibrium level of corruption under varying specifications. We find that equilibrium corruption is decreasing in the probability of getting caught and the fine and increasing in transaction costs.

Second, we model a market with many buyers of corruption and a single monopoly supplier. Firms demand corruption with the same production characteristics as in the competitive market. The public official maximizes expected income subject to the firms' demand for the illegal government good. We numerically solve the model with varying exogenous parameters to analyze the sensitivity of the results to changes in those parameters. Again, we find that equilibrium corruption is decreasing in the probability of getting caught and the fine, and increasing in transaction costs.

Third, we use a simple game to model a market with a single buyer and a single seller of corruption. These two players bargain over a surplus generated by the firm in using the illegal government good. The relative bargaining power of the firm versus the public official depends on their relative discount rates. Corruption is produced in this market if the surplus is large enough to offset the expected values of the punishment for both the public official and the firm.

Under each market structure the government may find the equilibrium level of corruption to be socially sub-optimal and seek to regulate the market.²⁶ Since corruption is an illegal activity, the government cannot simply put a tax, quota or price restriction on the market to bring the quantity down. Instead the government must seek to change the supply and demand factors to reduce corruption. The government is able to set the fine associated with getting caught participating in corruption and indirectly affect the probability of getting caught through policing efforts and legal system funding.

The size of the transaction cost represents how well government works. If government is efficient and there is no queue associated with government services, the demand for corruption will fall to zero. Thus, the government can target efficiency as a way to reduce the transaction costs faced by firms and therefore reduce the demand for corruption.

²⁶ In a first best world, the optimal level of corruption is zero, as corruption is a rent seeking activity and thus has no economic value. However, in a second best world it may be optimal to allow some positive level of corruption. The social planner faces a tradeoff between the costs of reducing corruption and the costs of corruption to society. By spending more money on efforts to catch and punish corrupt agents, the government will reduce corruption levels, but at the expense of higher policy costs. If, on the other hand, the government allows corruption to exist, they save on the costs of catching criminals but society incurs the costs of corruption. Additionally, corruption can be argued to have beneficial effects if second best market conditions exist. That is, if market restrictions and impediments reduce economic growth or activity and corruption allows the removal of some of the impediments, then reducing corruption to a zero level may not be the optimal choice.

The impact of changing the probability of getting caught and the fine is different when corruption is produced in a competitive framework versus a monopolist market. In a competitive market, a 1% increase in the probability of getting caught will reduce corruption by 0.5%, while the same change in the monopoly market will reduce corruption by 0.9%. Increasing the probability of getting caught has a larger negative impact on corruption when corruption is supplied by a single public official rather than by many. Conversely the impact of changing the size of the fine is larger in the competitive case. Increasing the size of the fine by 1% reduces corruption in the competitive market by 1.8%, as compared to 1% in the monopolist market. Reducing transaction costs has the same effect in both markets, with a 1% reduction in transaction costs reducing equilibrium corruption by 0.6%. This result is expected as firms remain competitive under both market structures.

Knowledge of the market structure for the provision of corruption allows the government to better target policies when seeking to reduce corruption. If public officials are competitive, increasing the size of the fine will have a significantly larger impact than increasing the probability of getting caught and the government should focus their efforts on increasing fine size. When corruption is supplied by a single public official, the difference in changing the fine versus the probability of getting caught is minimal and both variables present similar policy targets. Regardless of the market structure, reducing transaction costs will reduce corruption.

Chapter 4 Empirical Results

Introduction

Corruption is measured empirically by several indexes that use survey questions to assess citizens' perception of corruption in both their home country and other countries. The survey results are then turned into quantitative indices which allow us to empirically test corruption hypothesis. We investigate our competitive model hypotheses using these corruption indexes.

Empirically investigating our monopolist supplier and single buyer, single seller models would provide useful insight into corruption in the real world and allow us to investigate which model most closely mimics corruption around the world. However the limited nature of the data does not allow us to test these models. Furthermore, an empirical measure of risk preferences would allow us to investigate the effects of increasing degrees of risk aversion on equilibrium quantities of corruption, but again such data is not available. We are therefore limited in our empirical study to simply investigating our testable hypotheses from the competitive model.

We examine these relationships using proxy measures to capture the probability of getting caught, the market and corrupt wages, and transaction costs.

The chapter proceeds as follows: Section 4.1 presents the basic model, 4.2 discusses the econometric strategy, 4.3 details the variables and provides descriptive statistics for the data, and 4.4 presents the results. Section 4.5 concludes the analysis.

4.1 Basic Specification

We investigate the relationship between the level of perceived corruption in a country and the probability of getting caught, the market and corrupt wages, and transaction costs in an economy. The level of perceived corruption is measured on a 0 to 10 scale with higher values reflecting lower perceived corruption. The basic specification of our empirical model is:

$$\begin{aligned} \text{Corruption} = & \alpha_1 + \alpha_2 \text{probability of getting caught} + \alpha_3 \text{market wages} \\ & + \alpha_4 \text{corrupt wages} + \alpha_5 \text{transaction costs} + \alpha_6 \text{controls} + \varepsilon \end{aligned} \quad (4.1)$$

We hypothesize that $\hat{\alpha}_2 > 0$, $\hat{\alpha}_3 > 0$, $\hat{\alpha}_4 < 0$, $\hat{\alpha}_5 < 0$. We use varying proxies for corruption and the right hand side variables and report the results in Tables 4.3 and 4.4.

We also examine the relationship between the size of the bribe and transaction costs using the following specification:

$$\text{CorruptWages} = \beta_1 + \beta_2 \text{TransactionCosts} + \beta_3 \text{Controls} + \nu \quad (4.2)$$

We hypothesize that $\hat{\beta}_2 > 0$. We use two proxies for corrupt wages and several transaction cost proxies to estimate our model and report the results in Table 4.5.

4.2 Econometric Strategy

We face several econometric issues in our estimation. First, perceived corruption may or may not perfectly mimic actual corruption in an economy, and it is unclear if the perception of corruption exhibits any systematic lags to actual corruption. We estimated the regressions using the CPI from various years and did not find any significant differences in the results. As such, we use the 2005 CPI as the standard proxy for corruption.

Second, correlation between the independent variables is common in the set of variables frequently used to estimate corruption. The literature deals with this problem by ignoring it (see for example Treisman 2000). We use a limited number of controls to minimize such issues. Additionally, identifying the causality of the relationship between corruption and an independent variable is difficult. To identify causality we need an instrumental variable that is highly correlated with the independent variables but uncorrelated with corruption. We are unaware of any such variables for any of our exogenous parameters.

Third, the measure of perceived corruption represents an equilibrium level of corruption in an economy. We are unable to separately estimate the theoretical supply and demand functions for corruption as we only observe the intersecting equilibrium points for each curve. However with simulation results we are most interested in the responsiveness of equilibrium levels of corruption to changes in the exogenous parameters. Thus, regressing the exogenous parameters against equilibrium corruption gives us estimates for just such responsiveness measures. We do not interpret the coefficients as estimating the supply and demand curves but as estimating the change in

the equilibrium level of corruption given a change in the quantity of an exogenous parameter.

Fourth, the available data is highly limited. Few countries have observations for each proxy measure and the numbers of observations in our regressions are low. As such, rejecting or failing to reject our hypotheses is challenging. The coefficient on a variable may be insignificant because the underlying relationship does not support significance or simply because the number of observations is too low to accurately calculate the relationship. Expanding the available data is an important step in further corruption research.

4.3 Data

We have a cross country panel data set, with a variety of measures of corruption and a large collection of variables representing our exogenous factors. Corruption is measured as an index of perceived corruption using survey data. We have indexes of corruption from Transparency International, Weder and Brunetti and the ICRG's Country Risk Guide. The exogenous variables come from the World Bank, the Penn World Tables, the United Nations and Treisman (1999).

4.3.1 Measures of Corruption

Measuring corruption is difficult for many reasons. Prominently, corruption by definition, is illegal and therefore often unreported. In order to measure corrupt activities there must be a uniform definition of what constitutes corruption. However, cultural differences in definitions of what constitutes corruption are common. Additionally, because public officials are the ones who carry out corruption, those with the power to

monitor illegal activities are often the ones engaged in them. As a result, a quantitative measure of actual corruption is currently unavailable. Instead, corruption is quantified across nations based on the perception of corruption in a country (as opposed to actual corruption).

The most commonly used measure of perceived corruption is the Corruption Perceptions Index (CPI), which is compiled yearly by Transparency International. Additional corruption indices include the Weder and Brunetti World Development Report index and the International Country Risk Guide (ICRG).

The CPI measures perceived corruption on a 0 to 10 scale. A score of 0 represents the perception of total corruption, while a score of 10 represents the perception of a complete absence of corruption. The CPI is calculated using survey data from both domestic and international sources. The CPI was first published in 1995 and measured perceived corruption for 41 countries. It has been expanded each year and the 2005 CPI includes 159 countries.

Weder and Brunetti (1997) studied corruption perceptions for the World Bank using surveys of business owners. They asked a series of questions like: “It is common for firms in my line of business to have to pay some irregular ‘additional payments’ to get things done”, scaled from 1 (always) to 6 (never). They tabulated the responses to produce a corruption scale from 1 (representing corruption existing “always”) to 6 (corruption existing “never”). This index was published in the World Development Report for 1997 and is only available for one year.

International Country Risk Guide publishes a yearly measure of corruption. We use the rescaled version calculated by La Porta, Lopez-De-Silanes, Shleifer, and Vishney

(1999). This index is scaled between 0 and 10 with low ratings indicating “high government officials are likely to demand special payments” and “illegal payments are generally common throughout lower levels of government” and high ratings indicating “high government officials are unlikely to demand special payments” and “illegal payments are generally uncommon throughout lower levels of government”. This index is reported as a single value representing the average monthly response between 1982 and 1995.

Correlations between the Weder and Brunetti, ICRG and the 2004 and 2005 CPI corruption indexes are shown in Table 4.1. We primarily use the CPI for our regression analysis and check for robustness with the Weder WDR and the ICRG data.

Table 4.1 Correlation between leading corruption indices.

	Weder and Brunetti: WDR	ICRG	Corruption Perception Index: 2004	Corruption Perception Index: 2005
Weder and Brunetti: WDR	1	0.6662	0.8645	0.8666
ICRG	0.6662	1	0.7868	0.7691
Corruption Perception Index: 2004	0.8645	0.7868	1	0.9960
Corruption Perception Index: 2005	0.8666	0.7691	0.9960	1

4.3.2 Independent Variables: w_m , w_c , γ , ρ , fine, controls

The rest of the data are used as proxies for the exogenous supply and demand factors. For most of these variables we have several data series. Our data set combines data from the Sala-i-Martin, Weder and Brunetti, Barro and Lee, and La Porta, Lopez-De-Silanes, Shleifer, and Vishney data sets along with data from the World Bank, the United Nations, Sachs and Warner, Treisman (1999) and the Penn World Tables.

To better understand the data, we fit regression lines for each of our independent variables against corruption. Figures 4.1 through 4.10 show the relationships between the 2005 CPI and varying measures used as proxies for ρ , w_m , w_c , and γ .

4.3.2.a: ρ

We are aware of no data that measures the probability of getting caught if a public agent participates in corruption. Data measuring case loads or convictions for corruption exists for some countries but because there is no measure of how many corrupt acts are committed each year, this data is not ideal. A measure of the number of suspects to face trial tells us little, if anything, about the probability of getting caught. Similarly, the percentage of suspects who face trial and are convicted tells us only the percentage convicted if tried, not the number of convictions relative to the number of corrupt acts. Successful corruption does not leave a trail. There is no obvious sign that a bribe has been offered or taken or that a rule has been bent or ignored in return for a favor. Thus, to empirically test for the probability of getting caught if a public agent participates in corruption, we must use a proxy variable.

The main difficulty in calculating corruption prosecutions is that corruption leaves no trail. Murder, however, does leave an obvious trail: a dead body. We can calculate the

probability of conviction if an individual commits a murder by comparing the total number of murders committed each year with the total number of convictions. In the same way we can calculate a measure of probability of conviction when the crime was a theft, as theft also leaves a visible trail. The total number of theft convictions per year can be measured against total thefts and the likelihood of being caught calculated. One issue of concern is that there may exist a delay between the time a crime was committed and the prosecution of that theft. However, as long as crime rates and the criminal justice system remain relatively steady over time, using concurrent year crimes and convictions gives us a reasonably accurate measure of the probability of getting caught when committing a particular crime.

Interpol publishes international crime statistics, and lists both the total number of murders and thefts per year and the total number of murder and theft convictions per year for 156 countries. We calculate the probability of getting caught for both types of crime and use those measures as an upper and lower bound proxy for the probability of getting caught for participating in corruption.

It is reasonable to argue that murder is the most serious of crimes, thus the largest share of resources should be devoted to those cases, giving us an upper bound on the probability of getting caught for committing any crime in a society. Theft is a less serious crime than murder and a smaller share of policing resources is likely devoted to catching thieves. Using theft data gives us a lower bound measure for the probability of getting caught committing a crime. We assume the probability of getting caught participating in corruption is most likely to mimic that of stealing, as corruption is likely to be an equivalent social deviation to theft.

As predicted, using murder conviction rates from Interpol data as a proxy for ρ , we see that as the probability of getting caught decreases, the amount of perceived corruption in a country decreases. However, when the probability of getting caught is measured using theft conviction rates, the data exhibits the opposite relationship. We have two concerns with the data. First, the Interpol data presents some irregularities with several countries reporting one hundred percent conviction rates for theft or murder while other countries report zero percent conviction rates. We suspect errors in both conviction levels, but are unwilling to drop these observations from the data as it is not clear that these are the only misreported data. Should we trust a country that reports a murder conviction rate of 99%, while throwing out a country with a 100% conviction rate? Second, the non-hypothesized relationship between corruption and theft conviction rates leads us to suspect that conviction rates for the theft variable are misreported or measured. To accurately measure theft conviction rates one must have a count of all thefts that occurred within a country in a given year. It is easy to imagine that this number is unknown or misreported. Murder rates are likely to have more accurate reporting being both lower in absolute number than thefts and more socially prominent and alarming. The empirical relationship between murder conviction rates and the CPI supports this notion. Therefore, we use the murder conviction rate as our proxy in the empirical work.

Figure 4.1: The relationship between the CPI and the probability of getting caught, using murder conviction rates as a proxy for ρ .

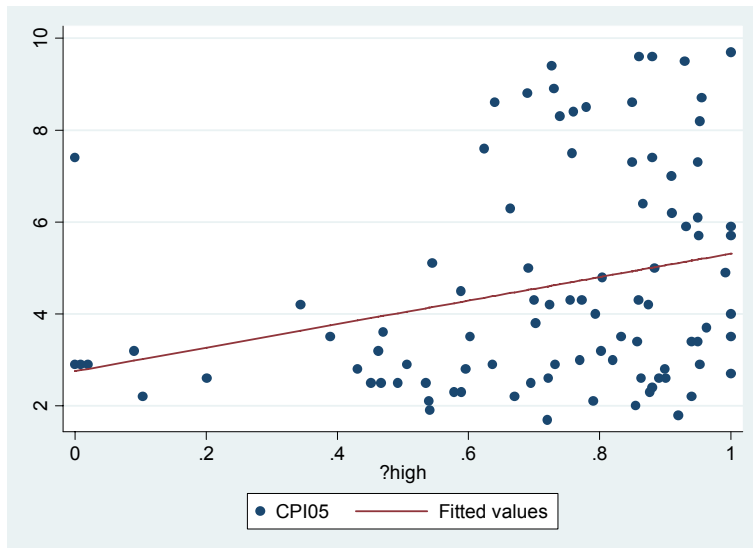
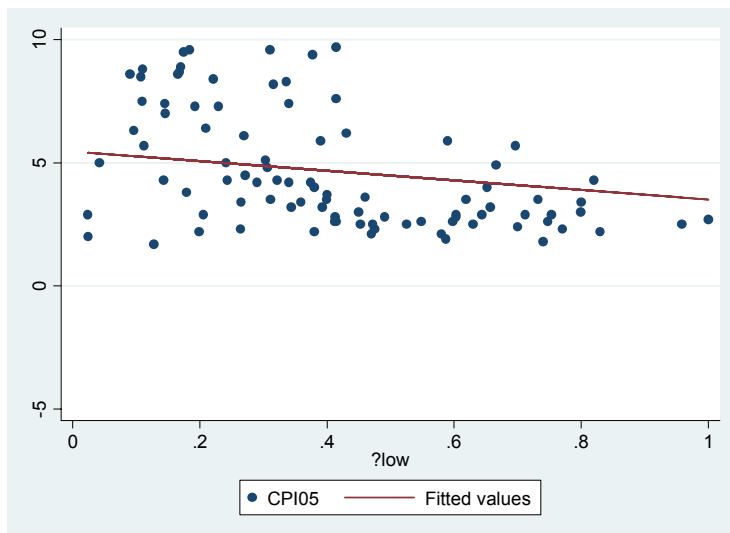


Figure 4.2: The relationship between the CPI and the probability of getting caught, using theft conviction rates as a proxy for ρ .



4.3.2.b: W_c

Measuring the wage paid to a government official for their participation in a corrupt activity or measuring the size of a bribe offered by a firm in exchange for said activity is difficult. No paper trail, tax return or profit statement reports these illegal

payments. Given that no reliable cross country data on the average size of bribes or wages for corrupt officials exists, we must identify another way to measure the value of w_c .

The World Development Report 2005 (World Bank 2005) has a ‘Doing Business’ data set that approximates the cost or size of bribes using survey questions. We have two measures that attempt to proxy the costs of a bribe: sales and contract. The variable ‘Sales’ measures what percentages of sales do firms pay in ‘unofficial payments’ to get things done’. ‘Contract’ measures what percentage of the contract is the ‘value of the gift expected to secure such a government contract’.

Self reporting of these payments to researchers in survey form is problematic for a number of reasons. The firm may not trust that the information will remain private or may not want information about bribes to be made public, regardless of the anonymity of the bribe maker. Additionally, survey respondents may not be randomly selected as those individuals who choose to fill out the survey may reveal some sample selection by their choice. However, such survey data is the best available option to date.

Both proxy measures of the illegal corruption wage exhibit the hypothesized relationship with the CPI. As the price of corruption rises, the equilibrium quantity falls. We use both measures of corrupt wages in our empirical work.

Figure 4.3: The relationship between the CPI and illegal corrupt wages, using survey data measuring the percentage of sales paid by firms to 'get things done' as a proxy for w_c .

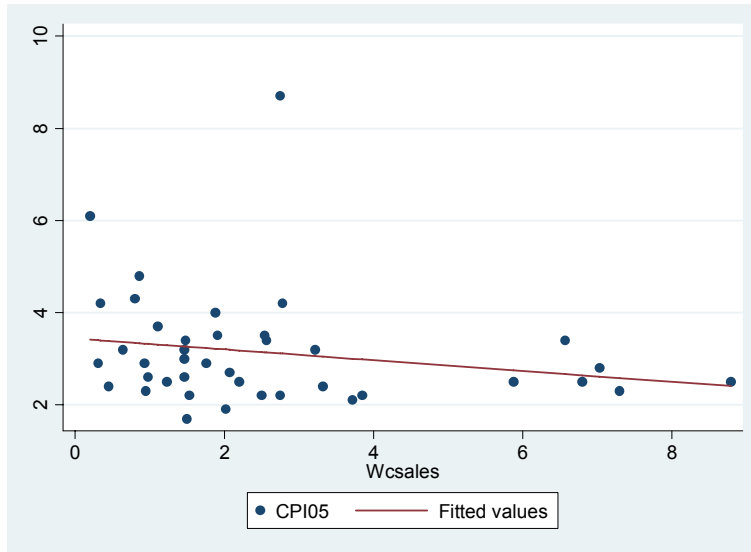
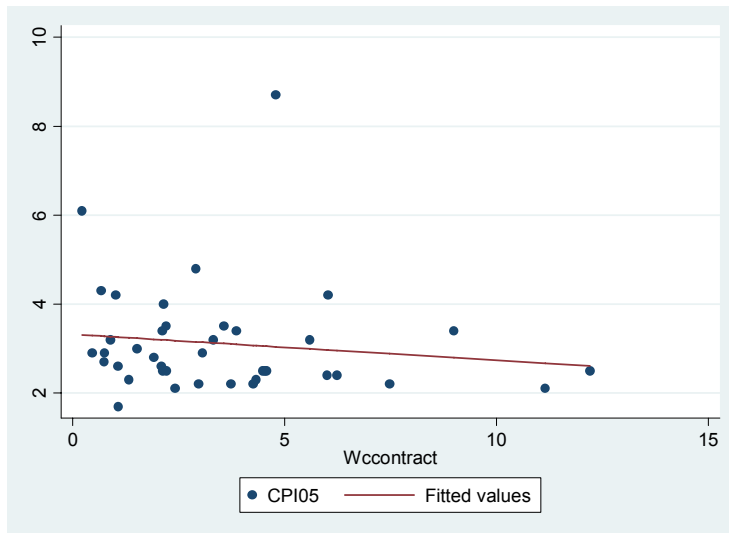


Figure 4.4: The relationship between the CPI and illegal corrupt wages, using survey data measuring the percentage of a contract paid by firms to secure the contract as a proxy for w_c .



4.3.2.c: W_m

The hypothesized relationship between government wages and corruption says that as the government wage rises, corruption should fall due to rising opportunity costs of losing a government job. The relevant measure of the value of the government wage is

the next best alternative a worker might face as compared with the government wage. This can be measured in two ways: the ratio of government wages to GNP per capita or the ratio of government wages to average manufacturing wages. It is reasonable to assume that the next best alternative to a government job is a manufacturing job. Agricultural jobs are generally low skilled work while both manufacturing and government work assume some human capital. Using these ratios ensures that the value of a government job does not appear higher in richer countries, where all wages are higher, but instead reflects only the relative differences in the value of a government job between countries.

We have two proxies for the government wage, the ratio of government wages to GNP per capita and the ratio of government wages to manufacturing wages. The ratio of government wages to manufacturing wages exhibits a positive relationship with the CPI. As the ratio of wages rises perceived corruption falls. (Figure 4.4) On the other hand, when government wages are measured as the ratio to GNP per capita the opposite relationship with the CPI appears. (Figure 4.3) However, the ratio of government wages to GNP per capita is higher for very poor countries where GNP per capita is very low thus distorting this measure as a true reflection of government wages. We use the ratio of government wages to manufacturing wages in the empirical estimates although doing so limits our regression results as we only have observations for 39 countries.

Figure 4.5: The relationship between the CPI and legal government wages, using the ratio of government wages to GNP per capita as a proxy for w_m .

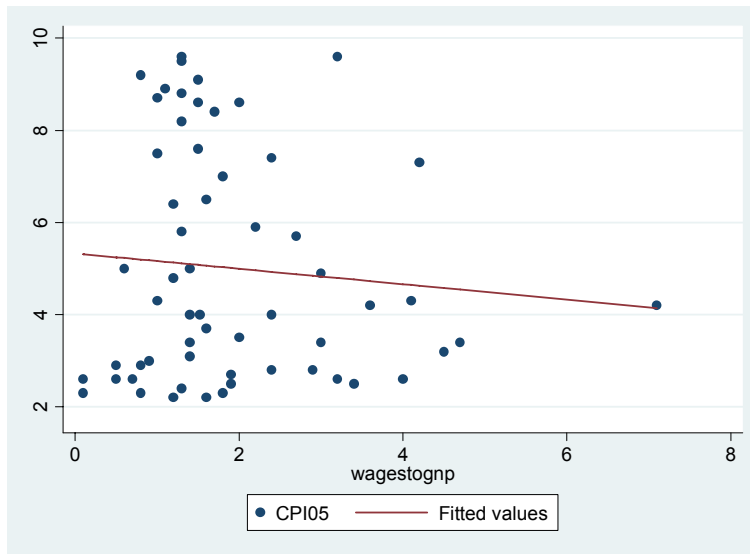
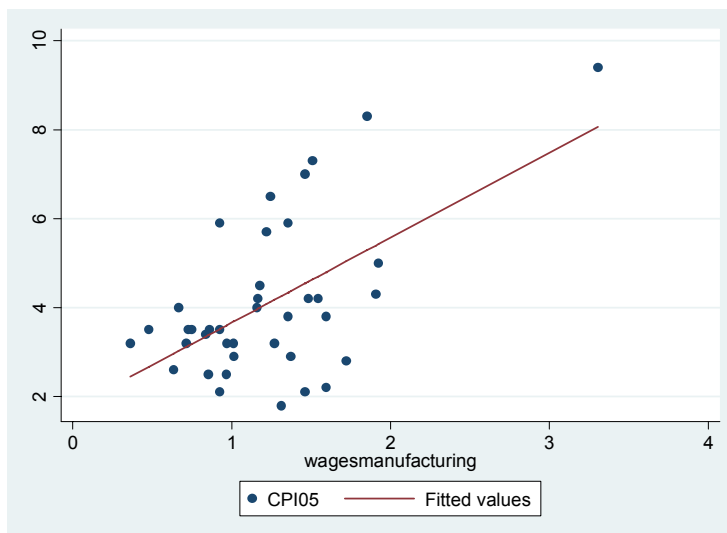


Figure 4.6: The relationship between the CPI and legal government wages, using the ratio of government wages to manufacturing wages as a proxy for w_m .



4.3.2.d: γ

The ease with which business can be conducted in a country helps determine a firm's demand for corruption. If few regulations exist and queues are short, firms are

likely to obtain necessary government permits or contracts through legal channels. However, if regulations are costly, in either time or money, or if bureaucratic delays are frequent and queues are long, firms may seek to avoid these transaction costs and circumvent the legal market by offering a bribe. Measuring these transaction costs is necessary to empirically test out model, but no perfect single measure exists. Thus, we again rely on survey data and proxies to quantitatively measure transaction costs.

The World Development Report 2005's (World Bank 2005) 'Doing Business' survey also questioned business leaders about transaction costs. Survey questions asked about the number of days firms spent in meetings with tax officials (days) and the percentage of senior management's time that was spent dealing with requirements of regulations (management time).

The Weder and Brunetti WDR survey also looked at transaction costs and reports two measures, each scaled between 1 (high regulations) and 6 (no regulations). The survey asked "how costly to your firm are regulations for starting business or new operations" (business) and "how costly to your firm are tax regulations and/or high taxes" (taxes).

Three of the measures of transaction costs- percentage of time senior officials spend dealing with regulations, difficulty of dealing with regulations in starting a business and difficulty of dealing with tax regulations- all exhibit the hypothesized relationship. As transaction costs increase, perceived corruption increases.

The measure of the number of days a firms must spend dealing with public officials does not have the hypothesized relationship with the CPI. (Figure 4.9) As days increase (increasing transaction costs), we expect corruption to increase as firms will

have a greater incentive to pay bribes to avoid costly time delays. However, the data exhibits the opposite result. We use all four measures in the empirical work.

Figure 4.7: The relationship between the CPI and transaction costs, using survey data measuring the number of days senior officials spend dealing with the requirements of regulations as a proxy for γ .

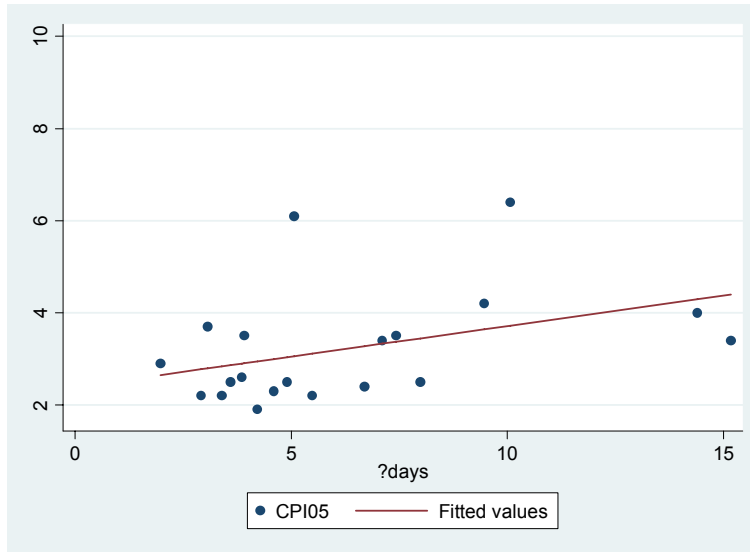


Figure 4.8: The relationship between the CPI and transaction costs, using survey data measuring the percentage of their time senior officials spend dealing with the requirements of regulations as a proxy for γ .



Figure 4.9: The relationship between the CPI and transaction costs, using survey data measuring the difficulty of starting a business as a proxy for γ . Scale 1 (high regulations) to 6 (no regulations).

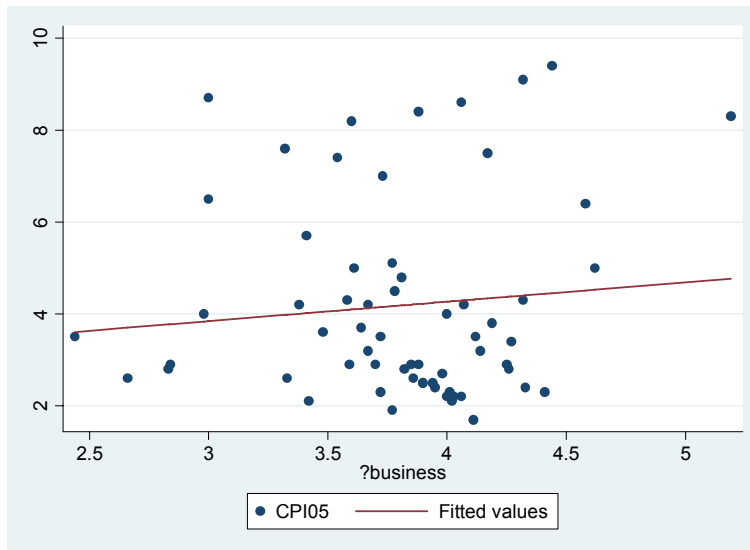
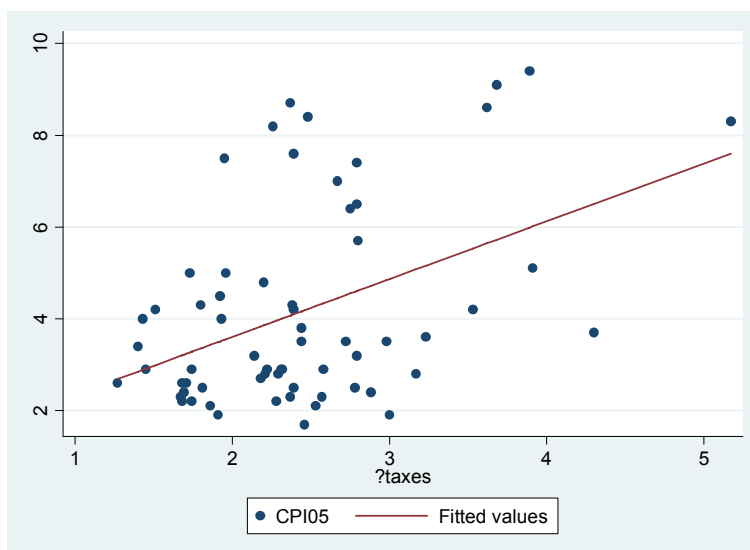


Figure 4.10: The relationship between the CPI and transaction costs, using survey data measuring the measuring the difficulty of dealing with tax regulations as a proxy for γ . Scale 1 (high regulations) to 6 (no regulations).



4.3.2.e: Fine

The average value of the fine paid by public sector employees and firms, when they are caught and convicted of participating in corruption, is an important theoretical

variable. Unfortunately, to the best of our knowledge, no such data exists nor do any reasonable proxies. Therefore, we do not include the fine in our empirical work.

4.3.2.f: Controls

The general culture and climate of a country may affect overall corruption.

Variables that control for economic and cultural differences are included for robustness.

GNP per capita and the Human Development Index are positively correlated with lower levels of corruption in a country. The level of school enrollment and literacy rates give us information about how informed the population is and may be linked to corruption. (Van Rijckeghem and Weder (1997, 2001)) Ethnolinguistic fractionalization (Treisman (2000)), the colonial history (Treisman (2000), Swamy et al (1999), Acemoglu, Johnson and Robinson (2001)), and the religious makeup of a country (La Porta et al (1997, 1999)), Treisman (2000)), have all been linked to corruption.

Measures of political culture, such as the number of revolutions and coups, the number of political assassinations and the example of the countries leadership may influence corruption. If a public official or firm observes corrupt behavior among high level officials, they may view corruption as more acceptable and thus may be more likely to participate in corruption. Strength of the judiciary and the rule of law, (Ades and DiTella (1996), Knack and Keefer (1995), Sali-i-Martin (1997)) give us an additional measure of the probability of getting caught participating in corruption. Black market premiums (Sali-i-Martin (1997)), market openness (Brunetti and Weder (1998)) and public investment (Tanzi (1998)) all provide information on how well the market functions and thus may indirectly measure transaction costs.

4.3.3 Descriptive Statistics

Descriptive statistics for the data are provided in Table 4.2. Table 4.3 provides a full variable list with descriptions and data sources for each variable.

Table 4.2 Data Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
CPI 04	131	4.2	2.26	1.5	9.7
CPI 05	138	4.2	2.25	1.7	9.7
Weder	65	3.8	0.93	2.36	5.96
Lopez-de-Silanes	108	5.9	2.26	1.01	10
ρ high	92	0.73	0.24	0	1
ρ low	92	0.41	0.23	0.02	1
Gov't wages to GNP per capita	59	1.9	1.29	0.1	7.1
Gov't wages to average manufacturing wages	39	1.2	0.52	0.36	3.31
Sales	40	2.5	2.15	0.2	8.79
Contract	40	3.5	2.79	0.22	12.21
Days	20	6.3	3.65	1.97	15.17
Management time	40	9.2	4.24	2.8	19.63
Business	63	3.8	0.49	2.44	5.19
Taxes	64	2.4	0.74	1.27	5.17
Adult Literacy	134	83.9	19.73	17.1	100
School Enrollment	134	72.1	19.3	19	114
GDP per capita	122	6701.3	10117	100	44640
log GDP per capita	78	3.6	0.46	2.6	4.3
GDP per capita PPP	134	10245	10638	520	61190
HDI	134	0.73	0.18	0.27	0.96
UK colony	133	0.28	0.45	0	1
French colony	133	0.44	0.5	0	1
Revolutions and Coups	90	0.21	0.26	0	1.19
Leader Example	108	0.10	0.19	0	1.28
Assassinations	85	0.02	0.05	0	.253
Market Open	90	0.39	0.35	0	1
Black Market	85	45.8	93.7	0.001	588.63
Rule of Law	84	0.54	0.33	0	1
Percent Protestant	91	14.4	23.98	0	97.8
Ethnolinguistic Fractionalization	76	36.5	29.55	0	93
Public Investment	100	3.7	2.87	0	10

Table 4.3. Variable Definitions and Data Sources

Variable	Definition and Source
CPI04/ CPI05	Corruption Perceptions Index 2004, 2005 (Transparency International)
Weder	"It is common for firms in my line of business to have to pay some irregular 'additional payments' to get things done" Scale from 1 (always) to 6 (never). (Weder WDR)
Lopez-de-Silanes	Corruption in government index. Low ratings indicate "high government officials are likely to demand special payments" and "illegal payments are generally expected thought (sic?) lower levels of government" Scale from 0 to 10. Average of the months of April and October in the monthly index between 1982 and 1995. (Lopez-de-Silanes)
ρ high	Percentage of reported murder convictions out of all reported murders. (Interpol)
ρ low	Percentage of reported theft convictions out of all reported thefts. (Interpol)
Gov't Wages to GDP per capita	The ratio of average wages of central government to per capita GDP in each country. Certain non-wage benefits are not included in the estimate of the average central government wage. (Lopez-de-Silanes)
Gov't Wages to manufacturing wages	Ratio of average government wages to average manufacturing wages, 1982-1994. (Von Rijckeghem and Weder (1997, 2001))
Sales	Unofficial payments for firms to get things done (% of sales) (World Bank)
Contract	Value of gift expected to secure government contract (% of contract) (World Bank)
Days	Time firms spent in meetings with tax officials (days). (World Bank)
Management Time	Percentage of senior management's time spent dealing with the requirements of regulations. (World Bank)
Business	Regulations for starting business/new operations as obstacle. Scale from 1 (no) to 6 (very strong) (Weder WDR)
Taxes	Tax regulations and/or high taxes as obstacle. Scale from 1 (no) to 6 (very strong) (Weder WDR)

Table 4.3 continued: Variable Definitions and Data Sources

Variable	Definition and Source
Adult Literacy	Percentage of the population over the age of 15 able to read and write (World Bank)
School Enrollment	Percentage of the school age population enrolled in school, Primary, Secondary and Tertiary levels. (World Bank)
GDP per capita	1999 GDP per capita (World Bank)
HDI	2002 Human Development Index (World Bank)
UK Colony	Dummy Variable for British colony
French Colony	Dummy Variable for French colony
Revolutions and Coups	Number of military coups and revolutions (Sala-I-Martin)
Leader Example	Measure of political instability (assassinations *revolutions) (Sala-I-Martin)
Assassinations	Number of political assassinations (Sala-I-Martin)
Market Open	Index of degree in which economies favor capitalist forms of production "EcOrg" is the Type of Economic Organization variable reported by the Freedom House (1994). "Capitalist" countries have a value of 4 or 5. (Sala-I-Martin)
Black Market	Log of (1 + Black Market Premium) (Sala-I-Martin)
Rule of Law	Subjective index of the extent of maintenance of the rule of law. Scaled from 0 (worst maintenance) to 1 (best). From Knack and Keefer: "reflects the degree to which the citizens of a country are willing to accept the established institutions to make and implement laws and adjudicate disputes". Lower score indicates "a tradition of depending on physical force or illegal means to settle claims." Original name in ICRG is "law and order tradition". (Sala-I-Martin)
Percent Protestant	Percentage of the Population which is Protestant (Treisman (2000))
Ethnolinguistic Fractionalization	Degree of fractionalization, scaled 1 to 100 with higher values representing higher degrees of fractionalization. (Treisman (2000))
Public Investment	Public Sector Investment as Share of Economy 1990 (World Bank)

4.4 Results

Table 4.4 reports regression results for the basic model using three alternative measures of corruption. We first regress a proxy the exogenous variables against the 2005 CPI.²⁷ In Column 1, the coefficients on murder conviction rates, contract and senior management time all have a predicted positive sign. Murder rates and senior management time are statistically significant. We then add GNP per capita and school enrollment as controls in Column 2 which causes the sign on murder rates and management time to become negative and statistically insignificant.

Columns 3 and 4 repeat the same estimation but use the Weder and Brunetti corruption index as the dependant variable. The coefficients on murder, contract, and senior management time are all positive (the theoretically predicted sign), but none are statistically significant. Adding controls in Column 4 reverses the sign for murder conviction rates and does not change the significance for any of the variables.

Columns 5 and 6 use the ICRG corruption index as the dependant variable. Murder conviction rates, contract and management time all have the theoretically predicted sign but none are statistically significant. Adding controls causes the coefficient on management time to become negative and again none of the variables are statistically significant.

We cannot conclude from the lack of statistical significance in the regressions that our exogenous variables are not related to corruption. Rather, the limited nature of the

²⁷ Including a proxy for government wages severely limits the degrees of freedom. However, the explanatory power of the regressions is much higher when using the government wages. We do not include government wages in our regression analysis but a clear avenue for further research is greater wage data availability.

data prevents us from drawing any firm conclusions. However, we can look at the R^2 for the equations for some intuition into the explanatory power of the model. Using the CPI as the measure of corruption yields an $R^2=0.23$, which increases to 0.85 when the controls are added. The specification explains the Weder and Brunetti corruption variable at a similar level with an $R^2=0.36$, which rises to 0.7 with the addition of GNP per capita and school enrollment as controls. The ICRG is less well explained by the model with an $R^2=0.19$, although this rises to 0.41 when controls are added.

Table 4.4 Determinates of corruption with differing measures of corruption

	CPI 2005		Weder and Brunetti		ICRG	
	(1)	(2)	(3)	(4)	(5)	(6)
Murder conviction rates	1.87* (-.85)	-.347 (-.55)	.74 (.53)	-.5 (0.6)	2.35 (1.35)	.304 (1.8)
% of contract firms pay to secure government contract	-.002 (-.09)	-.093 (.04)	.048 (.05)	.02 (.04)	-.098 (.15)	-.156 (.138)
% of Senior Management time spent dealing with regulations	-.113* (-.06)	.013 (.03)	-.06 (.03)	-.02 (.03)	-.083 (.098)	.053 (.104)
R^2	.23	.85	.26	.7	.19	.41
Obs	31	31	18	18	22	22
Controls		Y		Y		Y

Notes: Standard errors in parenthesis. * denotes significance at the 5% level. Controls in columns 2, 4 and 6 are school enrollment and GDP per capita.

Table 4.5 examines which explanatory variable has the largest impact on corruption. Using the CPI 2005 as the dependant variable, we isolate the exogenous factors and run regressions using all proxies of each factor against corruption. We then add GNP per capita as a control to each regression.

We have five proxies that can reasonably stand in for the probability of getting caught: the murder conviction rate, the theft conviction rate, a measure of the rule of law, the number of revolutions and coups and the number of assassinations. The murder and theft rates directly measure the probability of getting caught when committing a crime, while rule of law, revolutions and coups, and assassinations measure the general strength of the judiciary. Murder conviction rates and rule of law are statistically significant with positive coefficients. The coefficient on revolutions and coups has the correct theoretical sign, but is not significant. Theft conviction rate and assassinations both have negative coefficients where theory would predict positive ones but they are not significant. The explanatory power of this set of variables is quite high with an $R^2=.81$. Adding controls does not affect the significance or sign of any of the coefficients but raises R^2 to .87.

We have two proxies for the market wages rate: the ratio of government wages to GNP per capita and the ratio of government wages to manufacturing wages. As expected, the coefficient on the ratio of government wages to GNP per capita is negative, while the coefficient for the ratio of government wages to manufacturing wages is positive, but neither is significant. Adding controls in Column 4 does not change the sign or significance of either variable. The explanatory power of market wages in explaining corruption is low with an $R^2=.19$ without controls and $R^2=.30$ with controls.

The size of the bribe is measured with two indices, one asking what percentage of sales firms must pay to 'get things done' and the other what percentage of a contract must the firm spend as a bribe to secure the contract. In Column 5 the coefficient on contract has the predicted positive sign, but neither variable is significant and the explanatory

power of corrupt wages is even lower than market wages with an $R^2=0.04$ without controls.

Transaction costs are measured by three different proxies: the percentage of senior management's time spend dealing with regulations, the difficulty of the number of regulations needed to start a business, and the difficulty of dealing with tax regulations as challenges for doing business. The expected coefficient for management time is negative, while business and taxes are measured on an inverse scale and so are expected to have a positive coefficient. Management time and taxes have their expected sign while taxes has a positive coefficient, but are all three are insignificant. The sign for management time and taxes remains the same, while business flips to the predicted positive coefficient but all three remain insignificant when controls for GNP per capita and school enrollment are added in Column 8. The explanatory power of transaction costs is very low with an $R^2=0.1$ but increases to $R^2=.74$ when the controls are added.

Given available data, the probability of being caught has the highest explanatory power. It may be that market and corrupt wages, and transaction costs are relatively less important, or it may be that our measures for these variables are flawed.

Table 4.5 Determinates of Corruption

		CPI 2005							
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ρ	Murder conviction rates	2.95*	1.55*						
		(.765)	(.722)						
	Theft conviction rates	-1.36	-.234						
		(1.01)	(.908)						
	Rule of law	4.86*	2.99*						
	(.699)	(.90)							
W_m	Revolutions and coups	-1.14	-1.05						
		(.727)	(.634)						
	Assassinations	10.58	7.11						
	(6.74)	(5.84)							
W_m	Gov't wages to GNP per capita			-423	-.075				
				(.389)	(.519)				
W_m	Gov't wages to manufacturing wages			1.49	.032				
				(1.10)	(1.69)				
W_c	Sales					-.14	-.08		
						(.110)	(.05)		
W_c	Contract					.05	-.04		
						(.12)	(.05)		
γ	Management Time						-.08	-.02	
							(.08)	(.05)	
	Taxes						.38	.152	
							(.7)	(.41)	
	Business						-.51	.07	
							(.72)	(.52)	
	R ²	0.81	0.87	0.19	0.3	0.05	0.82	0.1	0.74
	Obs	53	52	15	15	38	38	24	24
	Controls		Y		Y		Y		Y

Notes: Standard errors in parenthesis. * denotes significance at the 5% level. Controls in columns 2, 4, 6 and 8 are school enrollment and GDP per capita.

Table 4.6 looks at the relationship between corrupt wages and transaction costs. Columns 1 and 2 measure corrupt wages as the percentage of sales firms pay in bribes. Each of the measures of transaction costs has a positive coefficient and management time and taxes are significant. However, theory predicts taxes to have a negative relationship to bribes. When GNP per capita is added as a control the sign and significance of the coefficients remains the same. The explanatory power $R^2=0.42$ without the control and $R^2=0.44$ with controls.

Columns 3 and 4 have the same specification as 1 and 2, but use the percentage of a contract firms have to pay to secure the contract as a proxy for bribe size. Management time and taxes have the predicted sign but are insignificant. Business has a negative and insignificant coefficient. Adding GNP per capita retains the sign and significance of the coefficients. $R^2=.19$ without controls and 0.22 with controls.²⁸

In the full specifications, the explanatory power of the exogenous variables is high, but limited observations make drawing conclusions about relationships difficult. Eliminating days raises the number of observations but reduces the explanatory power of the regression.

Table 4.6 Determinates of price of bribes

	W _c : Sales		W _c : Contract	
	(1)	(2)	(3)	(4)
Management Time	0.17* (0.08)	0.18* (0.08)	0.11 (0.13)	0.14 (0.14)
Business	0.15 (0.76)	0.38 (0.85)	-0.4 (1.3)	-0.08 (1.46)
Taxes	1.91* (0.66)	1.84* (0.68)	2.15 (1.12)	2.06 (1.16)
R ²	0.42	0.44	0.19	0.2
Obs	21	21	22	22
Control		Yes		Yes

Notes: Standard errors in parenthesis. * denotes significance at the 5% level. The control in Columns 2 and 4 is GDP per capita.

²⁸ We have an additional proxy for transaction costs in the number of days a firm must spend dealing with public officials. However, limited observations of this variable limit its usefulness in regression analysis as including days reduces the number of observation to 7 for columns 1 and 3. However, when days is included the explanatory power of the regressions is large. Expanding the availability of this data would be useful for further research.

4.5 Conclusions

Corruption is defined as misusing a public office for personal gain. Corruption exists in most of the world, but is particularly prevalent in developing countries. Corruption serves as a large impediment to development. In recent years a large amount of attention has been focused on corruption and ways to reduce its impact on economy and society. This dissertation contributes to that body of research by both theoretically and empirically examining the market for corruption.

This dissertation provides a theoretical examination of the markets for corruption. Public officials willing to accept a bribe supply corruption while firms willing to pay a bribe seek to buy corruption. These sellers and buyers of corruption come together in three different possible market structures. A competitive market with many buyers and sellers, a monopoly market with a single seller and many buyers, and a market with a single buyer and seller of corruption are modeled.

The competitive market occurs where individual public officials and firms cannot influence the size of bribes, and bribe values are exogenous to individual decision makers. Public officials provide the supply of corruption to the market. Firms demand corruption to avoid redtape or transaction costs. Together these supply and demand factors give us an equilibrium level of corruption that we are able to evaluate numerically. We solve the model for the equilibrium level of corruption under varying specifications. We find that equilibrium corruption is decreasing in the probability of getting caught and the fine and increasing in transaction costs.

The monopoly market occurs where barriers to entry are high so that a single public official serves as the supplier of corruption. Firms demand corruption with the same production characteristics as in the competitive market. The single public official maximizes expected income subject to the firms' demand for the illegal government good, B . We numerically solve the model with varying exogenous parameters to analyze the sensitivity of the results to changes in those parameters. We again find that equilibrium corruption is decreasing in the probability of getting caught and the fine and increasing in transaction costs.

The single buyer, single seller market for corruption occurs when only two players are allowed to participate in a strategic game. These two players bargain over a surplus generated by the firm in using the illegal government good. The relative bargaining power of the firm versus the public official depends on their relative discount rates. Corruption is produced in this market if the surplus is large enough to offset the expected values of the punishment for both the public official and the firm.

We empirically investigate our competitive model hypothesis, $\frac{\partial C^*}{\partial \rho} < 0$, $\frac{\partial B^*}{\partial \rho} < 0$, $\frac{\partial C^*}{\partial fine} < 0$, $\frac{\partial B^*}{\partial fine} < 0$, $\frac{\partial B^*}{\partial \gamma} > 0$, using indexes of perceived corruption and proxy variables to measure the probability of getting caught, market and corrupt wages and transaction costs. Empirical results are inconclusive due to the limited nature of available data. However, the explanatory power of expected punishments, in the form of the probability of getting caught, and transaction costs faced by firms in determining the level of corruption is high.

With a monopoly market structure, the social planner who wishes to reduce corruption should target policing policies at increasing the probability of catching a firm or public official who pays or receives a bribe and increasing the size of the fine. When the market for corruption is competitive, the social planner should focus efforts on increasing the size of the fine. Under either market structure, the social planner should focus efforts on eliminating transaction costs associated with obtaining government goods and services as a way to reduce corruption.

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Appendix A: Corruption Data

Table A.1: CPI Data 2000-2005

<u>Country</u>	2000 CPI Score	2001 CPI Score	2002 CPI Score	2003 CPI Score	2004 CPI Score	2005 CPI Score
Afghanistan						2.5
Albania			2.5	2.5	2.5	2.4
Algeria				2.6	2.7	2.8
Angola	1.7		1.7	1.8	2.0	2
Argentina	3.5	3.5	2.8	2.5	2.5	2.8
Armenia	2.5			3.0	3.1	2.9
Australia	8.3	8.5	8.6	8.8	8.8	8.8
Austria	7.7	7.8	7.8	8.0	8.4	8.7
Azerbaijan	1.5	2.0	2.0	1.8	1.9	2.2
Bahrain				6.1	5.8	5.8
Bangladesh		0.4	1.2	1.3	1.5	1.7
Barbados					7.3	6.9
Belarus	4.1		4.8	4.2	3.3	2.6
Belgium	6.1	6.6	7.1	7.6	7.5	7.4
Belize				4.5	3.8	3.7
Benin					3.2	2.9
Bolivia	2.7	2.0	2.2	2.3	2.2	2.5
Bosnia and Herzegovina				3.3	3.1	2.9
Botswana	6.0	6.0	6.4	5.7	6.0	5.9
Brazil	3.9	4.0	4.0	3.9	3.9	3.7
Bulgaria	3.5	3.9	4.0	3.9	4.1	4
Burkina Faso	3.0					3.4
Burundi						2.3
Cambodia						2.3
Cameroon	2.0	2.0	2.2	1.8	2.1	2.2
Canada	9.2	8.9	9.0	8.7	8.5	8.4
Chad					1.7	1.7
Chile	7.4	7.5	7.5	7.4	7.4	7.3
China	3.1	3.5	3.5	3.4	3.4	3.2
Colombia	3.2	3.8	3.6	3.7	3.8	4
Congo, Democratic Republic					2.0	2.1
Congo, Republic				2.2	2.3	2.3
Costa Rica	5.4	4.5	4.5	4.3	4.9	4.2
Cote d'Ivoire	2.7	2.4	2.7	2.1	2.0	1.9
Croatia	3.7	3.9	3.8	3.7	3.5	3.4
Cuba				4.6	3.7	3.8
Cyprus				6.1	5.4	5.7
Czech Republic	4.3	3.9	3.7	3.9	4.2	4.3
Denmark	9.8	9.5	9.5	9.5	9.5	9.5
Dominican Republic		3.1	3.5	3.3	2.9	3
Ecuador	2.6	2.3	2.2	2.2	2.4	2.5
Egypt	3.1	3.6	3.4	3.3	3.2	3.4

<u>Country</u>	2000 CPI Score	2001 CPI Score	2002 CPI Score	2003 CPI Score	2004 CPI Score	2005 CPI Score
El Salvador	4.1	3.6	3.4	3.7	4.2	4.2
Equatorial Guinea						1.9
Eritrea					2.6	2.6
Estonia	5.7	5.6	5.6	5.5	6.0	6.4
Ethiopia	3.2		3.5	2.5	2.3	2.2
Fiji						4
Finland	10.0	9.9	9.7	9.7	9.7	9.6
France	6.7	6.7	6.3	6.9	7.1	7.5
Gabon					3.3	2.9
Gambia				2.5	2.8	2.7
Georgia			2.4	1.8	2.0	2.3
Germany	7.6	7.4	7.3	7.7	8.2	8.2
Ghana	3.5	3.4	3.9	3.3	3.6	3.5
Greece	4.9	4.2	4.2	4.3	4.3	4.3
Guatemala		2.9	2.5	2.4	2.2	2.5
Guyana						2.5
Haiti			2.2	1.5	1.5	1.8
Honduras		2.7	2.7	2.3	2.3	2.6
Hong Kong	7.7	7.9	8.2	8.0	8.0	8.3
Hungary	5.2	5.3	4.9	4.8	4.8	5
Iceland	9.1	9.2	9.4	9.6	9.5	9.7
India	2.8	2.7	2.7	2.8	2.8	2.9
Indonesia	1.7	1.9	1.9	1.9	2.0	2.2
Iran				3.0	2.9	2.9
Iraq				2.2	2.1	2.2
Ireland	7.2	7.5	6.9	7.5	7.5	7.4
Israel	6.6	7.6	7.3	7.0	6.4	6.3
Italy	4.6	5.5	5.2	5.3	4.8	5
Jamaica			4.0	3.8	3.3	3.6
Japan	6.4	7.1	7.1	7.0	6.9	7.3
Jordan	4.6	4.9	4.5	4.6	5.3	5.7
Kazakhstan	3.0	2.7	2.3	2.4	2.2	2.6
Kenya	2.1	2.0	1.9	1.9	2.1	2.1
Kuwait				5.3	4.6	4.7
Kyrgyzstan				2.1	2.2	2.3
Laos						3.3
Latvia	3.4	3.4	3.7	3.8	4.0	4.2
Lebanon				3.0	2.7	3.1
Lesotho						3.4
Liberia						2.2
Libya				2.1	2.5	2.5
Lithuania	4.1	4.8	4.8	4.7	4.6	4.8
Luxembourg	8.6	8.7	9.0	8.7	8.4	8.5
Macedonia				2.3	2.7	2.7
Madagascar			1.7	2.6	3.1	2.8

Country	2000 CPI Score	2001 CPI Score	2002 CPI Score	2003 CPI Score	2004 CPI Score	2005 CPI Score
Malawi	4.1	3.2	2.9	2.8	2.8	2.8
Malaysia	4.8	5.0	4.9	5.2	5.0	5.1
Mali				3.0	3.2	2.9
Malta					6.8	6.6
Mauritius	4.7	4.5	4.5	4.4	4.1	4.2
Mexico	3.3	3.7	3.6	3.6	3.6	3.5
Moldova	2.6	3.1	2.1	2.4	2.3	2.9
Mongolia					3.0	3
Morocco	4.7		3.7	3.3	3.2	3.2
Mozambique	2.2			2.7	2.8	2.8
Myanmar				1.6	1.7	1.8
Namibia	5.4	5.4	5.7	4.7	4.1	4.3
Nepal					2.8	2.5
Netherlands	8.9	8.8	9.0	8.9	8.7	8.6
New Zealand	9.4	9.4	9.5	9.5	9.6	9.6
Nicaragua		2.4	2.5	2.6	2.7	2.6
Niger					2.2	2.4
Nigeria	1.2	1.0	1.6	1.4	1.6	1.9
Norway	9.1	8.6	8.5	8.8	8.9	8.9
Oman				6.3	6.1	6.3
Pakistan		2.3	2.6	2.5	2.1	2.1
Palestine				3.0	2.5	2.6
Panama		3.7	3.0	3.4	3.7	3.5
Papua New Guinea				2.1	2.6	2.3
Paraguay			1.7	1.6	1.9	2.1
Peru	4.4	4.1	4.0	3.7	3.5	3.5
Philippines	2.8	2.9	2.6	2.5	2.6	2.5
Poland	4.1	4.1	4.0	3.6	3.5	3.4
Portugal	6.4	6.3	6.3	6.6	6.3	6.5
Qatar				5.6	5.2	5.9
Romania	2.9	2.8	2.6	2.8	2.9	3
Russia	2.1	2.3	2.7	2.7	2.8	2.4
Rwanda						3.1
Saudi Arabia				4.5	3.4	3.4
Senegal	3.5	2.9	3.1	3.2	3.0	3.2
Serbia and Montenegro	1.3			2.3	2.7	2.8
Seychelles					4.4	4
Sierra Leone				2.2	2.3	2.4
Singapore	9.1	9.2	9.3	9.4	9.3	9.4
Slovakia	3.5	3.7	3.7	3.7	4.0	4.3
Slovenia	5.5	5.2	6.0	5.9	6.0	6.1
Somalia						2.1
South Africa	5.0	4.8	4.8	4.4	4.6	4.5
South Korea	4.0	4.2	4.5	4.3	4.5	5
Spain	7.0	7.0	7.1	6.9	7.1	7

<u>Country</u>	2000 CPI Score	2001 CPI Score	2002 CPI Score	2003 CPI Score	2004 CPI Score	2005 CPI Score
Sri Lanka			3.7	3.4	3.5	3.2
Sudan				2.3	2.2	2.1
Suriname					4.3	3.2
Swaziland						2.7
Sweden	9.4	9.0	9.3	9.3	9.2	9.2
Switzerland	8.6	8.4	8.5	8.8	9.1	9.1
Syria				3.4	3.4	3.4
Taiwan	5.5	5.9	5.6	5.7	5.6	5.9
Tajikistan				1.8	2.0	2.1
Tanzania	2.5	2.2	2.7	2.5	2.8	2.9
Thailand	3.2	3.2	3.2	3.3	3.6	3.8
Trinidad and Tobago		5.3	4.9	4.6	4.2	3.8
Tunisia	5.2	5.3	4.8	4.9	5.0	4.9
Turkey	3.8	3.6	3.2	3.1	3.2	3.5
Turkmenistan					2.0	1.8
Uganda	2.3	1.9	2.1	2.2	2.6	2.5
Ukraine	1.5	2.1	2.4	2.3	2.2	2.6
United Arab Emirates				5.2	6.1	6.2
United Kingdom	8.7	8.3	8.7	8.7	8.6	8.6
Uruguay		5.1	5.1	5.5	6.2	5.9
USA	7.8	7.6	7.7	7.5	7.5	7.6
Uzbekistan	2.4	2.7	2.9	2.4	2.3	2.2
Venezuela	2.7	2.8	2.5	2.4	2.3	2.3
Vietnam	2.5	2.6	2.4	2.4	2.6	2.6
Yemen				2.6	2.4	2.7
Zambia	3.4	2.6	2.6	2.5	2.6	2.6
Zimbabwe	3.0	2.9	2.7	2.3	2.3	2.6

Appendix B: Matlab Programs

Competitive Model

Competitive

```
function [fval]=competitivemodelwg(x,param)
```

```

sigma = param(1);
rho   = param(2);
tau   = param(3);
gamma = param(4);
p     = param(5);
T     = param(6);
alfa  = param(7);

% unknowns are X,G,B,M,C,wc, wm
X     = sqrt(x(1)^2);
G     = sqrt(x(2)^2);
B     = sqrt(x(3)^2);
M     = sqrt(x(4)^2);
C     = sqrt(x(5)^2);
wc    = sqrt(x(6)^2);
wm    = sqrt(x(7)^2);

e1    = C-B;
e2    = T-C-M;
e3    = (rho*alfa*(wc-wm-tau)*(wm*(T-C)+wc*C-tau*C)^(alfa-1))+((1-rho)*alfa*(wc-wm)
        *(wm*(T-C)+wc*C)^(alfa-1));
e4    = sigma*(X^(sigma-1))*((G+gamma*B)^(1-sigma))-p;
e5    = (1-sigma)*(X^sigma)*(G+gamma*B)^(-sigma)-wm;
e6    = gamma*((1-sigma)*(X^sigma)*(G+gamma*B)^(-sigma))-wc-(rho*tau);
e7    = M-G;

fval  = [e1;e2;e3;e4;e5;e6;e7];

fval  = fval*fval;
fval  = abs(fval);
if isnan(fval)==1
    x
    rho
    X
    G
    B
    wc
    wm
    [e1 e2 e3 e4 e5 e6 e7]
    pause
end

if isreal(fval)==0
    [X G B M C wc wm]
    error('unknowns are complex')
end

```

Call Competitive

```

sigma = 1/2;
rho   = 0.2;
tau   = 10;
gamma = 10;
p     = 1;
T     = 16;
alfa  = 1;

param = [sigma;rho;tau;gamma;p;T;alfa]

% unknowns are X,G,B,M,C,wc,wm
M0    = 8;
C0    = T-M0;
X0    = 100;
G0    = 8;
B0    = C0;
wc0   = 10;
wm0   = 10;

x0    = [X0;G0;B0;M0;C0;wc0;wm0];

A     = [];
b     = [];
Aeq   = [];
beq   = [];
nonlcon = [];
LB    = [0;0;0;0;0;0;0];
UB    = [Inf;Inf;Inf;Inf;Inf;Inf;Inf];

options = optimset('LevenbergMarquardt','on','Display','iter','TolFun',1e-
12,'MaxFunEvals',1000000000, 'MaxIter', 1000000);

[x,fval] = fmincon(@competitivemodelwg,x0,A,b,Aeq,beq,UB,nonlcon,options,param);

disp('*****')
disp('Solution')
disp('*****')

X     = x(1)
G     = x(2)
B     = x(3)
M     = x(4)
C     = x(5)
wc    = x(6)
wm    = x(7)

```

Monopolist Model

Monopolist

```
function [fval]=monopolist(x,param)
```

```
sigma = param(1);
rho    = param(2);
tau    = param(3);
gamma  = param(4);
p      = param(5);
g      = param(6);
wm     = param(7);
alfa   = param(8);
```

```
%unknowns are X,G,B,wc
```

```
X      = sqrt(x(1)^2);
G      = sqrt(x(2)^2);
B      = sqrt(x(3)^2);
wc     = sqrt(x(4)^2);
```

```
e1     = rho*(alfa*(B*gamma*(1-sigma)*(X^sigma)*((gamma*B+G)^(-sigma))-rho*tau-tau)^(alfa-1)*(gamma*(1-sigma)*(X^sigma)*((gamma*B+G)^(-sigma))-rho*tau-tau)+(gamma^2)*B*(-sigma+sigma^2)*(X^sigma)*((gamma*B+G)^(-sigma-1)))+(1-rho)*(alfa*(B*gamma*(1-sigma)*(X^sigma)*((gamma*B+G)^(-sigma))-rho*tau)^(alfa-1))*(gamma*(1-sigma)*(X^sigma)*((gamma*B+G)^(-sigma))-rho*tau)+(gamma^2)*B*(-sigma+sigma^2)*(X^sigma)*((gamma*B+G)^(-sigma-1)))
e2     = sigma*(X^(sigma-1))*((G+gamma*B)^(1-sigma))-p
e3     = (1-sigma)*(X^sigma)*(G+gamma*B)^(-sigma)-g
e4     = gamma*((1-sigma)*(X^sigma)*(G+gamma*B)^(-sigma))-wc+rho*tau
```

```
fval   = [e1;e2;e3;e4];
fval   = fval'*fval;
fval   = abs(fval);
```

Call Monopolist

```

sigma = 1/2;
rho = 0.2;
tau = 100;
gamma = 10;
p = 1;
g = 10;
wm = 10;
alfa = 1;

param = [sigma;rho;tau;gamma;p;g;wm;alfa]

%unknowns are X,G,B,wc

X0 = 100;
G0 = 100;
B0 = 100;
wc0 = 10;
x0 = [X0;G0;B0;wc0];

A = [];
b = [];
Aeq = [];
beq = [];
nonlcon = [];
LB = [0;0;0;0];
UB = [Inf;Inf;Inf;Inf];

options = optimset('LevenbergMarquardt','on','Display','iter','TolFun',1e-
12,'MaxFunEvals',1000000000, 'MaxIter', 1000000);

[x,fval] = fmincon(@monopolist,x0,A,b,Aeq,beq,LB,UB,nonlcon,options,param);

disp('*****')
disp('Solution')
disp('*****')

X = x(1)
G = x(2)
B = x(3)
wc = x(4)

```