Analyses of Corruption and Productivity with Empirical Study in Vietnam*

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Abstract

This paper develops a model to analyze bribery under heterogeneous firms' productivity. In the static setting, we show that there are four possible regimes in equilibrium where firms' bribery depends on their productivity and fundamental variables, including the state capacity. In the dynamic setting, we show that the regime in which more productive firms pay bribes converges to the regime with no bribery, while the regime where all firms pay bribes does not change. We also show that, unlike in the latter case, output increases over time in the former case. Finally, to test the validity of our theoretical results, we apply the methodology in Ackerberg et al. (2015) while including a bribery variable to a dataset of Vietnamese manufacturing firms between 2005 and 2015. We find a statistically significant and positive relationship between productivity and the likelihood of paying bribes, coinciding with one of the equilibrium regimes shown in our theoretical analysis.

Key Words: corruption, productivity.

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1 Introduction

Corruption constitutes one of the world's oldest problems, having persisted since the ancient world. Texts as old as Kautilya's *The Arthashastra* (Rangarajan, 1992), written between 300 B.C. and 150 A.D., refer to the problems of state officials harassing merchants for private gains. There are many definitions of corruptions, but the most generally accepted definition of corruption is "the abuse of entrusted power for private gain" (Transparency International, 2020). This broad definition may be divided into three types based on the scale and position of the corrupt official: grand, petty and political. Of those, petty corruption comes mostly from low to mid-level public officials, who demand or receive bribes from private citizens or firms in everyday interactions. Even though the bribery amount is typically much smaller than those of the remaining two types, the occurrences are much more frequent and have a more direct effect on both firms and citizens.

In this paper, we develop a model of corruption with heterogeneous firms' productivity. We consider firm productivity as a fundamental factor of economic growth and ask one key question: do more productive firms pay bribes or not? Another question that follows is how does bribery affect economic outcomes? In reality, we observe evidence of widespread corruption and poor economic development in most African countries (McArthur et al., 2002; Faruq et al., 2013); meanwhile, other East and Southeast Asian countries—such as Vietnam, Malaysia, China, and South Korea—are known for the "East Asian paradox," which refers to the simultaneous existence of high levels of corruption and economic growth (Campos et al., 1999). To see why we observe such different patterns of petty corruption and economic growth across nations, we further study how equilibrium outcomes in the static analysis change over time and see if the transition affects economic growth.

Our single period model works in the following way. Firms are heterogeneous in their productivity. The production output of the firm with the highest productivity level is termed the *production capability*. All firms' production output is bounded by this production capability. There are two kinds of technology that each firm can choose from: "good" and "bad" technology.[1] A good technology requires an investment cost and penalizes productivity. A bad technology requires no investment cost and does not incur any penalties. The government hires self-interested bureaucrats to conduct firm-level inspections and to enforce the adoption of good technology. If a firm is inspected and found to be using the bad technology, it must pay a bribe to the bureaucrat to avoid being reported to the government. The government conducts an audit with non-negative probability and this audit is costly. If the government audits, we assume that it can detect which firms are using the bad technology and which bureaucrats are receiving bribes, in which case those firms are penalized and those bureaucrats

[1] We borrow these terms from Acemoglu and Verdier (2000).

lose their jobs.

We then consider a dynamic setting, which is a series of single period model described in the static setting. In doing so, we examine the conditions under which more—or less—productive firms pay bribes in equilibrium. We then demonstrate how the equilibrium outcome changes over time. Finally, to see how our theoretical findings fit in reality, we use Vietnamese manufacturing data to study the relationship between bribes and productivity at a firm level.

The literature of theoretical analyses on corruption starts with Becker and Stigler (1974); Rose-Ackerman (1975) and Lui (1985). Some notable theoretical frameworks include a queueing model (Lui, 1985), general equilibrium models in both static (Acemoglu and Verdier, 1998, 2000) and dynamic settings (Blackburn and Forgues-Puccio, 2007), a three-player dynamic game (Harstad and Svensson, 2011), and a principal-agent model (Strîmbu and González, 2018). Of particular interest is Acemoglu and Verdier (2000), who analyze the alternatives of corruption and market failures. Our model borrows some features from Acemoglu and Verdier (2000). In particular, we adopt the notions of firms' homogeneous output with two choices of technology, one of which is considered "good" and generates a positive externality, as well as the presence of self-interested bureaucrats hired by the government to inspect the firms. Our model further accommodates productivity heterogeneity and incorporates the notion of state capacity as the inverse of the audit cost. In doing so, we obtain multiple equilibrium regimes and examine the conditions under which each regime arises.

In equilibrium, there are four possible regimes:

- In *Regime 1*, all firms use the good technology. This regime arises if the investment cost is sufficiently low and the production capability is sufficiently high.
- In *Regime 2*, all firms use the bad technology. This regime arises when the cost of audit is sufficiently high, when the probability of the government audit is low, or when the penalty to production or investment cost associated with the good technology is sufficiently high.
- In *Regime 3*, there is a productivity threshold such that a firm with productivity above the threshold chooses the good technology. This regime arises when the penalty to production is lower than the government's audit probability and the cost of audit is sufficiently low.
- In *Regime 4*, there is a productivity threshold such that a firm with productivity above the threshold chooses the bad technology. This regimes arises when the penalty to production is higher than the government's audit probability and the cost of audit is sufficiently low.

Our result in the static setting can be interpreted in the following way. The inverse of the cost of the government's audit can be thought of as the state capacity. When the state capacity is low, the cost of audit is high and then finding out all firms using a bad technology is expensive for the government. Hence all firms use the bad technology (i.e., the second regime). On the other hand, when the state capacity is high, the cost of audit is reasonably low. In addition, if the probability of an audit increases, some portion of firms may use the good technology (i.e., the third or fourth regime may arise).

Further, by studying a dynamic series of single period model described in the static setting and whether the starting regime continues to be an equilibrium regime in subsequent periods, we show how the equilibrium regime switches when the good technology generates positive production externalities. In particular, we show that a regime in which more productive firms pay bribes converges to one in which no firm pays bribes and all use the good technology. However, we also show that when an equilibrium regime starts at the one where all firms pay bribes, an equilibrium continues to be in this regime and there is no change to economic output.

In the literature there have been many works investigating potential causes of corruption. These range from a general context—such as inefficient institutions and public sector size (Lambsdorff, 2006)—in a more more specific contexts relating to geography, culture or history such as a region's religious traditions, history as a former British colony (Treisman, 2000), or—in the case of former Soviet countries—strength of democratic institutions (Peev and Mueller, 2012). Aidt (2003) lists three necessary conditions for corruption to exist: (i) the bureaucrat must have sufficient authority, (ii) which allows him to extract or create economic rents from the citizens or firms, (iii) under a weak government framework that creates an incentive for him to do so.[2] Indeed, the third condition measures the state capacity, where corruption can exist under a weak state capacity. We contribute to the literature on corruption by constructing a model that provides a better understanding of how main factors in our society such as state capacity and transparency affect bribery in equilibrium and how equilibrium outcomes change over time.

Besley and Persson have conducted a series of analyses on state capacity (Besley and Persson, 2008, 2009, 2010, 2011). In particular, they define state capacity as the ability to raise taxes and sustain markets, which includes the power to enforce regulations and contracts. They examine internal political conflicts (Besley and Persson, 2009, 2010), state fragility (Besley and Persson, 2011), and external wars (Besley and Persson, 2008) in relation to the level of state capacity. They show that when the state capacity is low, the nation continues to be poor.

In this paper, we provide a mechanism in which corruption plays a key role to determine two different outcomes under the same level of state capacity. In the static setting, we first show when

[2] His categorization of corruption then depends on the benevolence of the policy maker (i.e., the principal) and the state capacity.

the state capacity is low, either all firms engage in corruption (Regime 2) or more productive firms tend to engage in corruption (Regime 4). In the dynamic setting, we further show that even with the same low level of state capacity, different starting regimes lead to two different outcomes. Regime 4 transits to the regime where no firm engages in corruption (Regime 1), and economic output increases. However, Regime 2 stays the same, all firms continue to pay bribes in equilibrium and there is no change to economic output.

Our work presents a testable hypothesis about the relationship between productivity and bribery. To see how our theoretical findings fit in reality, in our empirical analysis, we study the relationship between petty corruption, revenue, and productivity at a firm level using data from the Vietnamese Small and Medium Enterprises (SME) Survey between 2005 and 2015. To measure the productivity term, we extend the model from Ackerberg et al. (2015) by including a bribery dummy variable in the first stage of estimation. We argue that a firm's productivity also affects its bribery, and thus, simultaneity bias between productivity and bribery also arises. Our main empirical findings show that, across all periods studied, a firm's decision to pay bribes is associated with a reduction in revenue. At the firm level, our estimates support the "sanding the wheel" hypothesis, which describes the detrimental effect of bribery on the economy at the firm level. More importantly, these empirical findings confirm the results from the previous chapter; namely, that there is a significant link between a firm's productivity and its bribery.

On the other hand, Faruq et al. (2013) uncover a negative relationship between a firm's productivity and its likelihood to engage in bribery, using a dataset comprising more than 900 firms in Ghana, Kenya, and Tanzania between 1991 and 2002. Also, Dal Bó and Rossi (2007) look at the efficiency of electricity distribution firms in thirteen Latin American countries between 1994 and 2001 and find that inefficient firms have a higher likelihood to engage in bribery. Their theoretical model shows that bribery diverts efforts of the managers from coordinating and supervising the production process to bribery. In contrast to these findings in Africa and Latin America, our empirical model demonstrates a positive relationship between firm productivity and bribery in Vietnam. Our theoretical model yields both of these empirical results in equilibrium, while our findings in the dynamic setting also indicate the difference in economic growth between Vietnam—a country within the East Asian paradox—and Ghana, Kenya and Tanzania (see Faruq et al., 2013).

The organization of the paper is as follows. Section 2 proposes a theoretical model in a static setting and presents an equilibrium analysis. Section 3 extends the model to a dynamic setting with positive externalities. Section 4 describes our data set, empirical methodology and empirical results. Section 5 concludes.

2 A Static Theoretical Model

2.1 The Setting

Let $\mathcal{F}$ denote a set of a continuum of firms with mass 1. Each firm is endowed with wealth $\bar{\omega} > 0$. We assume that firms differ in their productivity level, a_i, where $a_i \in [a_{\min}, 1]$ and $a_{\min} > 0$. Let A denote the distribution of a_i. Each firm has access to two types of technology: good (denoted by G) and bad (denoted by B). The good technology is costly to utilize; if firm i utilizes the good technology, it incurs a cost of implementation equal to its endowment, $\bar{\omega}$. In addition, firm i suffers a negative shock to productivity, captured by the coefficient $\gamma \in [0, 1]$. On the other hand, the bad technology does not incur any cost of implementation. Let $y \in \mathbb{R}_{++}$ denote the production capability. Then, for firm i, with productivity a_i, the good technology produces $\gamma a_i y$, while the bad technology produces $a_i y$.

In the next section, we consider the dynamic setting in which the use of the good technology generates a positive externality to production in subsequent periods. It is implicitly assumed that the society benefits from firms' adoption of the good technology. We assume that there is a regulation to make firms to use the good technology and bureaucrats are employed to inspect firms' adoption of the good technology. In particular, we assume a continuum of bureaucrats with mass $n \in [0, 1]$. Furthermore, suppose that all bureaucrats are self-interested and will accept a bribe if it is offered by a firm.

If a firm is using the bad technology and is inspected, it can choose to pay a bribe amount $b \geq 0$ to silence the bureaucrat. However, if it does not, the bureaucrat reports to the government and the firm is prohibited from producing. Suppose that the firm can continue to utilize the bad technology after paying the bribe. In this case, not paying a bribe results in a lower output than paying a bribe for the firm. Thus, if it is using the bad technology and is inspected, it always pays a bribe to the official. If, on the other hand, a bureaucrat observes a firm using the good technology, nothing happens. Finally, we assume that each bureaucrat inspects only one firm, so that the probability of inspection is n.

The government audits with probability θ. Suppose that if the government audits, it can successfully determine which firms are using the bad technology and which bureaucrats are corrupt. In the event of an audit, corrupt bureaucrats are laid off and those firms' endowments are confiscated.

Firm i's profits from using the good and bad technologies, respectively, are given by:

$$\pi_G^i = \gamma a_i y - \bar{\omega}, \tag{1}$$

$$\pi_B^i = (1-\theta) a_i y - \theta \bar{\omega} - nb. \tag{2}$$

For every $i \in \mathcal{F}$, denote $d_i \in \{G, B\}$ as firm i's technology choice. Firm i chooses the technology to maximize its profit, or d_i satisfies $\pi_{d_i}^i \geq \pi_{-d_i}^i$. Without loss of generality, suppose that firm i

chooses the good technology if both choices yield the same expected profit. We consider the difference between the profit levels of the good and the bad technologies, denoted by $D_i = \pi^i_G - \pi^i_B$. Then,

$$D_i = (\gamma - (1-\theta))a_i y - (1-\theta)\bar{\omega} + nb. \tag{3}$$

Thus, for firm i, $d_i = G$ if $D_i \geq 0$, and $d_i = B$ if $D_i < 0$. Now, let $s \in [0, 1]$ be the proportion of firms using the good technology.

Recall that if a bureaucrat misreports a firm utilizing the bad technology and the government audits, he loses his job. In this case, however, we assume that he still keeps the bribery amount. In addition, we also assume that bureaucrats can choose to be lazy and not inspect, giving an expected payoff of w_o. These assumptions yield the following constraint, where a bureaucrat is indifferent between being lazy and inspecting a firm:

$$w_o = (s + (1-\theta)(1-s))w_o + (1-s)b. \tag{4}$$

Note that the right hand side of this constraint denotes the bureaucrat's income from inspection. With probability s, the firm he inspects is using the good technology, and thus he receives his his full wage, w_o. On the other hand, if the inspected firm is using the bad technology with probability $1-s$, he only receives his wage w_o if there is no audit, which occurs with probability $1-\theta$. Suppose that if a bureaucrat is indifferent, he decides to inspect a firm.

Finally, the government decides on the bureaucrats' wage, w_o, so as to satisfy its budget constraint,

$$(1-s)\bar{\omega}\theta = \theta C + (s + (1-\theta)(1-s))nw_o, \tag{5}$$

where $C \geq 0$ is the government's monetary cost from conducting the audit. Recall that once the government audits, it can successfully detect all corrupt bureaucrats and those firms using the bad technology. In this regard, C can be interpreted as the inverse of the state capacity. That is, a government with high state capacity can easily conduct corruption investigations, possibly but not necessarily due to its inherently high transparency levels. Therefore, its associated cost, C, is low. On the other hand, countries with weak institutional frameworks may have difficulty detecting or even investigating corruption, possibly due to the presence of corruption at the highest level of government; one example is the presence of corruption at every level in the government hierarchy in Indonesia under Suharto (Vial and Hanoteau, 2010). For these countries, it is reasonable to expect a significantly high associated cost, C. In the case of these weak and ineffective institutions, Leff (1964) claims that corruption can be beneficial to economic growth. However, rather than focusing on the effects of corruption, in this paper, we instead examine why we observe different levels of corruption across countries.

We now formally define an equilibrium.

Definition 1. *An equilibrium consists of firms' choices of technology* $\{d_i^*\}_{i\in\mathcal{F}}$ *where for each* $i \in \mathcal{F}$, $d_i^* \in \{G, B\}$, *bribe amount* b^*, *the bureaucrat's wage* w_o^* *such that*

- *Given* b^*, $\pi^i_{d_i^*} \geq \pi^i_{-d_i^*}$ *for each* $i \in F$;
- *Given* b^* *and* $\{d_i^*\}_i$, w_o^* *satisfies the government's budget constraint* (5)*;*
- *Given* $\{d_i^*\}_i$, b^* *satisfies the bureaucrat's constraint* (4).

2.2 Summary of Results

In this section, we summarize our theoretical findings in the static setting. We find that there are four possible regimes that can arise in equilibrium. Formally, we define four regimes in the following way:

Definition 2.

- *In* Regime 1*, all firms use the good technology;*
- *In* Regime 2*, all firms use the bad technology;*
- *In* Regime 3*, there is a productivity threshold such that a firm with productivity levels above this threshold chooses the good technology;*
- *In* Regime 4*, there is a productivity threshold such that a firm with productivity levels above this threshold chooses the bad technology.*

Table 1 provides a summary of the conditions under which each regime arises in equilibrium. There are four determinants of the regime a country is in:

- The state capacity, represented by the inverse of C;
- The government transparency rate, which determines θ;
- The current technological progress, represented by γ and the inverse of $\bar{\omega}$;
- The production capability, represented by y.

Table 1: Summary and Comparison of Different Regimes

<table>
<tr><td colspan="3">If $(\gamma - (1-\theta))a_{\min}y \geq (1-\theta)\bar{\omega}$, all firms use the good technology;</td></tr>
<tr><td colspan="3">If $\gamma = 1-\theta$ and $(1-2\theta)\bar{\omega} + \theta^2 C > 0$, all firms use the bad technology; otherwise,</td></tr>
<tr><th></th><th>$\bar{\omega} \geq \theta C$</th><th>$\bar{\omega} < \theta C$</th></tr>
<tr><td rowspan="2">$\gamma > 1-\theta$</td><td>$(1-2\theta)\bar{\omega} + \theta^2 C \leq (1-\theta)(\gamma - (1-\theta))y$
Productive firms use the good technology</td><td>$(1-\theta)\bar{\omega} + \theta^2 C \leq (\gamma - (1-\theta))y$
Productive firms use the good technology</td></tr>
<tr><td>$(1-2\theta)\bar{\omega} + \theta^2 C > (1-\theta)(\gamma - (1-\theta))y$
All firms use the bad technology</td><td>$(1-\theta)\bar{\omega} + \theta^2 C > (\gamma - (1-\theta))y$
All firms use the bad technology</td></tr>
<tr><td rowspan="2">$\gamma < 1-\theta$</td><td>$(1-2\theta)\bar{\omega} + \theta^2 C \leq 0$
Productive firms use the bad technology</td><td rowspan="2">All firms use the bad technology</td></tr>
<tr><td>$(1-2\theta)\bar{\omega} + \theta^2 C > 0$
All firms use the bad technology</td></tr>
</table>

2.3 Equilibrium Analysis

In this section, we provide six propositions that describe the conditions for the four possible regimes in equilibrium. First, note that the bureaucrat's constraint, given in (4), simplifies to:

$$b = \theta w_o. \tag{6}$$

Intuitively, (6) indicates that the bribe is compensation for the job loss that results when the bureaucrat inspects a firm using the bad technology. Recall that nothing happens if the bureaucrat inspects a good firm; he does not lose his job even if the government audits. However, if a firm is using the bad technology, then with probability θ the government audits and he loses his wage. Therefore, as compensation, the bureaucrat requires the bribe amount b to be at least equal to this expected wage loss.

The first proposition provides sufficient conditions under which the first two regimes arise in equilibrium. In these two regimes, all firms use the same technology, regardless of their productivity.

Proposition 1. *All firms use the good technology, regardless of their productivity values, if*

$$(\gamma - (1-\theta))a_{\min}y \geq (1-\theta)\bar{\omega}. \tag{7}$$

All firms use the bad technology if

$$(\gamma - (1-\theta))y < \frac{(1-2\theta)\bar{\omega} + \theta^2 C}{1-\theta}. \tag{8}$$

All proofs are in Appendix A. Recall that D_i measures the difference in firm i's profits between using the good and bad technology. Therefore, if $D_i \geq 0$ for all i, all firms will use the good technology, and if $D_i < 0$ for all i, all firms will use the bad technology. Further, since $a_i \in [a_{\min}, 1]$, and D_i is increasing in a_i, when all firms use the good technology, it is held that $D_i \geq 0$ for $\min(a_i) = a_{\min}$. Similarly, when all firms use the bad technology, it is held that $D_i < 0$ for $\max(a_i) = 1$. These are the two conditions (7) and (8), respectively.

First, consider the case where $(\gamma - (1-\theta))a_{\min}y \geq (1-\theta)\bar{\omega}$. Then, $D_i \geq 0$ for all firms and, therefore, all firms use the good technology. Note that for this condition to hold, it must be the case that either (i) θ is sufficiently high; (ii) $\bar{\omega}$ is sufficiently low; or (iii) $a_{\min}$ is sufficiently high. Recall that θ is the probability of a government audit, in which case the government successfully detects all corrupt bureaucrats and those firms using the bad technology; in this regard, one can liken θ to a country's transparency rate. From the profit under the good technology given by (1), we see that $\bar{\omega}$ must be sufficiently low since it can be interpreted as a firm's initial investment cost when using the good technology.

From the next proposition, we provide necessary conditions under which each regime arises in equilibrium. Proposition 2 considers the case where $\gamma = 1 - \theta$ and presents the conditions under which all firms use the same technology, regardless of their productivity.

Proposition 2. *Suppose $\gamma = 1 - \theta$.*

- *If $\theta = 1$, all firms use the good technology.*
- *If $(1-2\theta)\bar{\omega} + \theta^2 C > 0$, all firms use the bad technology.*

If $\gamma = 1 - \theta$, D_i is independent of a_i, meaning D_i is identical across firms. Thus, all firms choose the same technology, irrespective of their productivity. Using Proposition 1, we solve for the necessary conditions for $s = 1$ and $s = 0$, which are the two scenarios detailed in Proposition 2.

The remaining four propositions consider the case where $\gamma \neq 1-\theta$. First, we solve for the critical value of productivity under which a firm is indifferent between the two technological choices. Let $\bar{a}_c$ satisfy $D_i(\bar{a}_c) = 0$. Then,

$$\bar{a}_c = \frac{\bar{\omega}}{(\gamma - (1-\theta))y} - \frac{\theta\bar{\omega} - \theta^2 C}{(1-\theta(1-s))(\gamma-(1-\theta))y}. \tag{9}$$

Now, let $\bar{a}$ denote the critical productivity value. Then,

$$\bar{a} = \begin{cases} a_{\min} & \text{if } \bar{a}_c < a_{\min}, \\ \bar{a}_c & \text{if } a_{\min} \leq \bar{a}_c \leq 1, \\ 1 & \text{if } \bar{a}_c > 1. \end{cases} \tag{10}$$

Then, since D_i is monotone in a_i, all firms with productivity levels above $\bar{a}$ will choose the same technology, while those with productivity levels below $\bar{a}$ will choose the other technology. Further, since $a_i \in [a_{\min}, 1]$ for any firm i, the critical productivity value must also lie in this range. Thus, if $\bar{a}_c > 1$ or $\bar{a} < a_{\min}$, then the critical value $\bar{a}$ must take the maximum and minimum value in A, respectively. In these cases firms choose the same technology, regardless of their productivity levels.

The next two propositions consider the case where $\gamma > 1 - \theta$. In particular, Propositions 3 and 4 study the cases where $\bar{\omega} \geq \theta C$ and $\bar{\omega} < \theta C$, respectively.

Proposition 3. *Suppose that $\gamma > 1 - \theta$ and $\bar{\omega} \geq \theta C$.*

- *If $(1 - 2\theta)\bar{\omega} + \theta^2 C \leq (1 - \theta)(\gamma - (1 - \theta))y$, then there exists $\bar{a} \in [a_{\min}, 1]$ such that for all firms with productivity levels $a_i \geq \bar{a}$, the good technology is adopted.*

- *If $(1 - 2\theta)\bar{\omega} + \theta^2 C > (1 - \theta)(\gamma - (1 - \theta))y$, all firms use the bad technology.*

If $\gamma > 1 - \theta$, the productivity penalty incurred from using the good technology is less than the probability of a government audit. Then, from a firm's perspective, their output is higher under the good technology. This is especially true for productive firms with a high productivity value. For these firms, there is more to lose from adopting the bad technology; this is expressed in the first scenario of Proposition 3. However, if $(1 - 2\theta)\bar{\omega} + \theta^2 C > (1 - \theta)(\gamma - (1 - \theta))y$, then $\bar{a}$ is higher than the maximum productivity value of 1; thus all firms use the bad technology. This inequality holds if either $\bar{\omega}$ or C is high. Recall that $\bar{\omega}$ is a firm's cost of investment in the good technology, while C is the inverse of the state capacity. Therefore, this inequality will hold if either the investment cost is too high, or the government is so ineffective that firms can generate higher profits by adopting the bad technology.

Proposition 4. *Suppose that $\gamma > 1 - \theta$ and $\bar{\omega} < \theta C$.*

- *If $(1 - \theta)\bar{\omega} + \theta^2 C \leq (\gamma - (1 - \theta))y$, then there exists $\bar{a} \in [a_{\min}, 1]$ such that for all firms with productivity levels $a_i \geq \bar{a}$, the good technology is adopted.*

- *If $(1 - \theta)\bar{\omega} + \theta^2 C > (\gamma - (1 - \theta))y$, all firms use the bad technology.*

The explanation for these cases follows the same analogy to the previous proposition. However, note that the condition $(1 - 2\theta)\bar{\omega} + \theta^2 C \leq (1 - \theta)(\gamma - (1 - \theta))y$ from Proposition 3 is more likely to hold than $(1 - \theta)\bar{\omega} + \theta^2 C \leq (\gamma - (1 - \theta))y$. This means that, all else held constant, s is higher if $\bar{\omega} \geq \theta C$ than if $\bar{\omega} < \theta C$. This reinforces the interpretation of C as the inverse of state capacity. For example, if C is low—as in Proposition 3—more firms adopt the good technology than the number that would under the scenario described in Proposition 4.

The next two propositions consider the case where $\gamma < 1 - \theta$. In particular, Propositions 5 and 6 study the cases where $\bar{\omega} \geq \theta C$ and $\bar{\omega} < \theta C$, respectively.

Proposition 5. *Suppose that $\gamma < 1 - \theta$ and $\bar{\omega} \geq \theta C$.*

- *If $(1 - 2\theta)\bar{\omega} + \theta^2 C \leq 0$, then there exists $\bar{a} \in [a_{\min}, 1]$ such that for all firms with productivity levels $a_i \geq \bar{a}$, the bad technology is adopted.*
- *If $(1 - 2\theta)\bar{\omega} + \theta^2 C > 0$, all firms use the bad technology.*

In contrast to Proposition 3 which assumes $\gamma \geq 1 - \theta$, in Proposition 5 which assumes $\gamma < 1 - \theta$, meaning firms have a lower potential output if they adopt the good technology, ceteris paribus. This occurs under these conditions because the productivity penalty is higher than the probability of an audit. Therefore, more productive firms tend to choose the bad technology. In addition, $(2\theta - 1)\bar{\omega} < \theta^2 C$ means that C is relatively high, particularly when compared to the alternate scenario where $(2\theta - 1)\bar{\omega} \geq \theta^2 C$. Thus, since the government is more inefficient, all firms adopt the bad technology.

Proposition 6. *If $\gamma < 1 - \theta$ and $\bar{\omega} < \theta C$, all firms use the bad technology.*

As in Proposition 5, a firm loses more in output if it chooses the good technology, ceteris paribus. Moreover, 6 assumes that $\bar{\omega} < \theta C$, meaning C is even higher than $\bar{\omega}$. A high value of C can be interpreted as an ineffective institution, which offers even more incentives for firms to adopt the bad technology while avoiding repercussions.

2.4 Further Discussion

Table 1 allows us to find the regime applicable to a country under certain conditions. For instance, suppose that country A is a developing country with low technology stock and an average level of state capacity. The low technology stock suggests that the cost of investment—captured by $\bar{\omega}$—is high. Further, given the the large transaction costs associated with training low-skill workers to adapt to new technology, the residual productivity after investment—captured by γ—is likely to be low. Country A's average level of state capacity suggests that C is not too high. Moreover, since developing countries are normally associated with low transparency rates (Transparency International, 2020), we can also infer that θ is relatively low. As such, we can safely assume for country A, that $\gamma < 1 - \theta$ and $\bar{\omega} \geq \theta C$. Therefore, if θ is sufficiently high, country A falls into the first regime of Proposition

5, where more productive firms tend to use the bad technology and the remaining firms use the good technology.

Now, suppose societal conditions are such that the regime in which all firms use the good technology holds (or when Proposition 1 holds). If this is the case, then it is more likely that we are in an advanced—rather than a developing—country. This can be seen by considering the three conditions outlined above in the discussion of Proposition 1. That is, more developed countries tend to be very transparent in the public sector, yielding relatively high θ values. In addition, given their higher base level of technology relative to less developed peers, it is likely that the costs incurred when investing in the good technology are lower. Further, it is likely that firms' productivity levels are also higher as a whole compared to those in developing countries. Together, this implies that these countries' $\bar{\omega}$ is lower and their $a_{\min}$ is higher than the corresponding values in developing countries. Thus, it is possible that we may only observe this scenario—where all firms use the good technology and there is no corruption—in highly developed and transparent countries.

In the context of developing countries, we can see that countries who are more transparent or have a higher state capacity level tend to fall into the bracket of Proposition 5, while countries with very low state capacity—and thus very high values of C—are more likely to be in the regime from Proposition 6, where all firms choose the bad technology and pay bribes.

Comparatively, we see that productive firms use the good technology if θ is high and C is low, which, as discussed prior, are the properties of developed countries. Consider two similarly developed countries, which differ only in their state capacity C; then, the country with a higher state capacity has a lower value of C, making it more likely to fall into the regime delineated in Proposition 3 and also more likely to satisfy the condition $(1-2\theta)\bar{\omega}+\theta^2 C \leq (1-\theta)(\gamma-(1-\theta))y$. Thus, ceteris paribus, a country with a higher state capacity tends to have more firms using the good technology. As such, we may conclude that developing countries are typically characterised by the regime listed in the row specified under the case $\gamma < 1-\theta$ of Table 1, while the conditions in countries with higher government transparency or higher state capacity levels are better described by the row specified under the case $\gamma \geq 1-\theta$.

In reality, however, it is very difficult to numerically measure these fundamental variables—such as state capacity or transparency—for comparative purposes. While there have been several attempts over the years to measure these variables, none can be considered perfect. Nonetheless, a very good measure of corruption is the Transparency International's Corruption Perception Index (Transparency International, 2020). In this index, a country's corruption level is estimated by aggregating multiple data sources that survey businesses' or country experts' perceptions of corruption in the public sector. Another indicator, the Global Innovation Index—a joint project by Cornell University, INSEAD, and the United Nations' World Intellectual Property Organization (Index, 2019)—can be considered a good indicator of the technological advances discussed above. The 2019 rankings and scores of the Corruption Perception Index as well as Global Innovation Index, for some selected countries, are presented in Table 2.

Table 2: Selected Countries' Rankings in 2019

Country	CPI		GII		Input Sub-Index	
	Rank	Score	Rank	Score	Rank	Score
Australia	12	77	22	50.34	15	64.35
China	80	41	14	54.82	8	66.69
Denmark	1	87	7	58.44	5	69.33
Germany	9	80	9	58.19	12	65.28
Indonesia	85	40	85	29.72	87	38.64
Japan	20	73	15	54.68	14	65.03
Norway	7	84	19	51.87	13	65.27
Sweden	4	85	2	63.65	4	70.43
The United Kingdom	12	77	5	61.30	6	68.22
The United States	23	69	3	61.73	3	70.85
Vietnam	96	37	42	38.84	63	43.75
Zimbabwe	158	24	122	22.30	123	29.22

Note: CPI stands for Corruption Perception Index, while GII stands for Global Innovation Index. The Input Sub-Index represents the component of the GII related to production inputs.

As Table 2 suggests, the scores for these countries—across both the Corruption Perception Index and the Global Innovation Index in 2019—vary significantly. Our theoretical model provides testable hypotheses on these values and offers regimes for the different degrees of corruption observed in each country. For example, consider those countries in the East Asian Paradox; the paradox describes the observation that some East (and Southeast) Asian countries—such as China, Vietnam, Indonesia and Thailand—have experienced both drastic economic growth and significant investment inflow, while simultaneously having a reputation as some of the most corrupt countries in the world, according to Transparency International (2020).

The East Asian Paradox has been examined in multiple articles including Campos et al. (1999), Wedeman (2002), Rock and Bonnett (2004) and Vial and Hanoteau (2010). In particular, Campos et al. (1999) focuses on corruption predictability, which measures the likelihood of favors or services being granted as a result of bribery. The authors find that countries that conform to the "sanding the wheel" hypothesis also have a high level of corruption unpredictability. On the other hand, the East (and Southeast) Asian countries in question have a higher level of predictability, thereby contributing to a positive correlation between corruption and economic growth.

For example, take Somalia and Indonesia. Both are developing countries where the cost of researching new technologies is high, while government transparency is low (Transparency International, 2020). As such, it is easy to imagine that both countries should conform to the regime described in the row specified under the case $\gamma < 1-\theta$ of Table 1. On the other hand, however, the state capacity in Indonesia can be considered higher than that of Somalia. This suggests that the value of C is lower in Indonesia than in Somalia. Therefore, a testable hypothesis here is whether Somalia can be characterized by the regime in proposition 6—where all firms use the bad technology (lower right cell of Table 1)—while Indonesia is better described by the regimes outlined in proposition 5 (lower left cell).

The literature examining the positive effects of corruption was first initiated by Leff (1964) and Huntington (1968). In particular, their arguments are founded on the assumption of ineffective governments, in which case bribery can speed up economic activities, thereby providing economic growth. Later work by Acemoglu and Verdier (2000) find that under some conditions, a certain level of corruption is still preferable to the alternative of market failures. In these cases, corruption can be considered a necessary evil to tackle market failures and thus is not entirely harmful.

3 Dynamics with Externalities

Our dynamic model is a series of single period model described in the static setting. What can change over time is the proportion of firms using the good technology, partly due to the existence of positive externalities. In the dynamic setting, time is discrete, so there are periods $t = 1, 2, \ldots$. Further, let s_t denote the proportion of firms using the good technology in period t, where $t = 1, 2, \ldots$. Now, suppose that the good technology's period-t profit is given by

$$\pi^i_{g,t}(s) = \gamma(s_{t-1})a_i y - \iota^i_t \bar{\omega}, \tag{11}$$

where $\iota^i_t \in [0, 1]$. In particular, if firm i uses the good technology in period $t-1$, then $\iota^i_t = \iota_0$, while if firm i uses the bad technology, then $\iota^i_t = \iota_1$. We assume that $\iota_0 < \iota_1$. This implies that once a firm has switched from using the good to the bad technology, re-switching to the good technology in the next period incurs an additional cost of $(\iota_1 - \iota_0)\bar{\omega} > 0$. The profit of a firm using the bad technology is unchanged from (2).

We assume that $\gamma(s)$ is increasing in s, the proportion of firms that use the good technology. Hence, $\gamma(s)$ can be interpreted as the increase in expertise—and thereby productivity—when more firms use the good technology and share their knowledge. Furthermore, we assume that $\gamma(0) \in [0, 1]$ and that there exists $\bar{s} \in [0, 1]$ such that $\gamma(\bar{s}) = 1$. In this sense, $\gamma(s)$ captures the positive externality that arises from using the good technology. In fact, when $s > \bar{s}$, the good technology generates higher productivity than the bad technology. Since there is a continuum of firms, we assume that each firm is small relative to the size of the market and selects only one type of technology given s_{t-1}.

Denote X_t^G and X_t^B as the sets of firms using the good and bad technology in period t, respectively, or $X_t^G = \{i \in \mathcal{F} | d_{i,t} = G\}$ and $X_t^B = \{i \in \mathcal{F} | d_{i,t} = B\}$. Finally, define Y_t as total output produced by all firms in period t. Then Y_t is given by

$$Y_t = \int_{i \in X_t^G} \gamma(s_t) a_i y \mathrm{d}i + \int_{i \in X_t^B} (1 - \theta) a_i y \mathrm{d}i. \tag{12}$$

A *dynamic equilibrium path* is a sequence $(s_t, Y_t)_t$ such that for each t, (s_t, Y_t) is obtained from equilibrium variables as described in Definition 1. The following lemma starts with the regime in which the more productive firms use the bad technology and pay bribes. We show that, given the presence of positive externalities, as time passes, more firms switch to using the good technology.

Lemma 1. *Suppose that $\gamma(s_t) < 1 - \theta$ and $\alpha(s_t)\bar{\omega} \geq \theta C$ and $(1 - 2\theta)\alpha(s_t)\bar{\omega} + \theta^2 C \leq 0$ in period t. Then, $s_t \geq s_{t-1}$ for every $t = 1, 2, \ldots$.*

This lemma implies that a key driver of an increased adoption of good technology in each period is the presence of positive externalities. In addition, the existence of the additional cost, ι_t^i, means that firms are less inclined to switch to the bad technology. Hence, more firms start switching to the good technology as time passes.

However, in the absence of externalities, firms have no incentives to switch to the good technology. This occurs if the initial regime is one in which all firms use the bad technology. In that case, $s_{t-1} = 0$, meaning $\gamma(s_t) = \gamma(s_{t-1})$, and so for any firm i, $\pi_{G,t}^i(0) = \pi_{G,t-1}^i(0)$, meaning that the firm does not change its behavior. Put differently, if all firms are using the bad technology in a given period, they will all continue to do so, meaning that $s_t = 0$ for all periods $t = 1, 2, \ldots$. We summarize this in the next lemma.

Lemma 2. *Suppose that $s_t = 0$ in period t. Then, $s_{t+1} = s_t = 0$ for every $t = 1, 2, \ldots$.*

We apply Lemma 1 in the following theorem to show that as time passes, if marginal externalities are high, then total production increases and eventually the regime converges to the one in which all firms use the good technology (Regime 1).

Theorem 1. *Suppose that $\gamma(s_t) < 1 - \theta$, $\bar{\omega} \geq \theta C$ and $(1 - 2\theta)\bar{\omega} + \theta^2 C \leq 0$ in period t.*

- *There exists $\bar{\gamma}_t > 0$ such that if $\gamma'(s) \geq \bar{\gamma}_t$ for every $s \in [s_{t-1}, s_t]$, then $Y_{t-1} < Y_t$.*
- *There exists a T such that if $T - t$ is large enough, $s_T = 1$ and $s_{T+t'} = 1$ for every $t' > 0$; that is, the regime converges to one in which all firms use the good technology.*

Theorem 1 suggests that there can be an increase in output with some levels of corruption. This supports the East Asian paradox. Recall the paradox refers to the simultaneous presence of drastic economic growth alongside high corruption levels in countries such as China, Vietnam, Indonesia and Thailand. On the other hand, rampant corruption in many African countries has been shown, in the literature, to be very detrimental to economic growth (McArthur et al., 2002; Faruq et al., 2013). This observation can be reconciled by Lemma 2, where the starting regime is one in which all firms are using the bad technology and paying bribes. This means that positive externalities do not appear and the situation does not change as time passes. Consequently, there is no economic growth. Thus, another testable hypothesis from our model is that in East (and Southeast) Asian countries, only productive firms pay bribes, while in African countries, all firms engage in corruption. In the next empirical section, we consider a specific country within the paradox—Vietnam—and confirm the positive relationship between bribery and productivity.

4 Empirical Analysis

4.1 Data Description

We use the data from the Vietnam SME Survey, which is explained in details in CIEM (2016). This survey is a joint project between the Central Institute for Economic Management (CIEM) and the Institute of Labour Science and Social Affairs (ILSSA) in Vietnam, the Development Economics Research Group (DERG) at the University of Copenhagen, and the United Nations University World Institute for Development Economics Research (UNU-WIDER). It was conducted biannually between 2005 and 2015 and consists of a sample of manufacturing firms in ten provinces spanning across all regions in Vietnam. The data has been used by various papers including Rand and Tarp (2012), Nguyen et al. (2014) and Sharma and Tarp (2018) who analyze firm-level corruption decisions, formalization and managerial behaviors, respectively.

The survey is comprised of three components: the main enterprise questionnaire, the economic accounts survey, and the employee questionnaire, the former two of which are used in our analysis. The main enterprise questionnaire contains a variety of firm-level data, including a firm's location and ownership type, its main products, and whether it exports. The questionnaire also asks whether a firm has a tax code, which in turn determines whether it can be classified as a formal firm.[3] The economic accounts survey asks for firms' economic positions and performances such as its total asset, debt values, revenue and wages paid in the previous two years.

There are three key details of this survey that distinguish it from other surveys in Vietnam. First, the survey does not cover either state-owned enterprises (SOEs) or joint ventures with foreign firms. Second, it includes informal and household enterprises that are not registered with the district authorities. Finally, the survey respondent of a firm is either its owner or manager, who is asked during the interview about bribery. In particular, both formal and informal firms are asked whether they have paid bribes or made informal payments in the previous year. If so, they are questioned about the frequency of the payment as well as the purpose of the bribe, and whether they expect the bribe amount to increase in the future.

The population of Vietnamese manufacturing firms is obtained from the Establishment Census in 2002, which contains data on both registered and non-registered enterprises (where the latter are considered households enterprises). Then, by comparing the firm identifications with those in the 2004–2006 Industrial Survey, a random sample is drawn using stratified sampling to ensure a sufficient number of firms of each ownership type and province combination are selected. Furthermore, informal firms that operate without a tax code are identified on site by the surveyors. The data collection begins in the autumn of each odd year, at which time surveyors directly interview the owners and managers during personal visits.

When analyzing data on sensitive topics such as informal payments, there is always a concern of the response bias where respondents might misreport their bribery, either because they are unaware or they want to avoid punishment from the authorities. However, we argue that the response bias is insignificant in this survey for four key reasons. First, given that for each firm, the interviewee is either the firm owner or manager, it is safe to assume that this interviewee would be informed of any actual firm bribery. Second, for each firm, the interviewee answers three sets of questions, the main set of which contains more than 100 questions, including various administrative and regulatory questions. As such, each session is a relatively long face to face interview between the owner/manager and the surveyor, thereby reducing the chance of dishonest responses to sensitive questions relating to informal payments. Third, as noted in Rand and Tarp (2016), prior to the main survey, the team also conducted a pilot survey where firms are instead asked an indirect question relating to bribery in

[3]Firms are also asked whether they have a Business Registration Code (hereafter BRC). However, while all firms with tax codes also have BRCs, the reverse is not true. We follow the convention from both Rand and Tarp (2012) and Nguyen et al. (2014) who consider a firm as formal if it has a tax code.

their location and sector.[4] The authors find that the responses are near identical to those of the main survey. Finally, the survey is a joint project between foreign (UNU-WIDER and DERG) and domestic (CIEM and ILSSA) institutes in Vietnam, where the latter two are institutes at the central government in Vietnam. Given that petty corruption is decentralized in Vietnam (Bai et al., 2019), and the ones to extract and collect bribes from SMEs are provincial government bureaucrats, it is reasonable to assume that firms are not subjected to retribution for their answers on bribery.

In general, the survey receives a very high response rate. Nguyen et al. (2014), who use the same dataset for the period between 2005 and 2011 to examine firms' formal status, report a response rate of 98% across the first four waves. One possible explanation for this high response rate is a cultural convention in Vietnamese business, where firms are expected to participate in surveys to improve policy outcomes.

Table 3 lists descriptive statistics for the bribery dummy variable and firm size. The bribery dummy variable takes a value of 1 if the firm has paid bribes in the previous year of the survey, and 0 otherwise. In general, half the firms have paid bribes in each, on average. This proportion has an increasing trend over the sample period, with the exception of a significant drop from 49.5% in 2004 to only 33.6% in 2006. One possible explanation for this marked decrease is the inception of an anti-corruption law in Vietnam in 2005.

Table 3: Descriptive Statistics

Year	# Obs	Bribe		Size		
		Mean	St.D.	Mean	Median	St.D.
2004	2105	0.4950	0.5001	22.21	8	61.00
2006	1894	0.3363	0.4726	22.30	8	58.71
2008	1830	0.4279	0.4949	18.13	7	32.19
2010	1795	0.4474	0.4974	16.79	7	29.38
2012	1809	0.5318	0.4991	16.42	6	47.71
2014	1830	0.5290	0.4993	17.59	6	38.39

The input and output values used in our analysis come from the economics accounts survey. The size of a firm is related to a head-count of the number of workers in a firm at the end of each fiscal year. Labor input is measured as the total wage bill paid by a firm, which includes total wages and other

[4]More specifically, the indirect question is "Do firms in your line of business (with the same location, size and sector) normally have to pay informal fees to public servants in order to get things done?" while the direct question in the main survey is "Do you have to pay informal/communication fees?"

employee-related costs such as social security, insurance, and other benefits. For the intermediate input, we include raw materials and other indirect costs such as fuel, stationary, and office supplies as well as telephone and internet costs. Capital is measured as the value of physical assets used in production. Finally, output is measured as total revenue from sales. All these variable values are adjusted for inflation using data from the World Bank.

In addition, it should be noted that we exclude data from those firms that did not continuously participated in the survey waves. This is done to ensure a balanced panel for our regression analysis. While this can potentially cause selection bias—as newly entered and shut down businesses are not accounted for—we do not anticipate this becoming a significant problem, since we are more concerned with finding the correlation between productivity and bribery. Ultimately, we conduct the analyses over three different periods, with 1001 firms reporting between 2005 and 2009, 974 firms reporting continuously between 2011 and 2015, and 457 firms who respond over all six waves of the survey.

4.2 Empirical Procedure

In this section, we outline the methodologies used to estimate the coefficients. To ensure the robustness of our results, we conduct two separate analyses, both of which are two-stage GMM processes that eliminate any simultaneity bias between the inputs and the productivity term. The first method is based on Ackerberg et al. (2015) (henceforth ACF), and the second method comes from its predecessor, contained in Levinsohn and Petrin (2003) (henceforth LP). For both methodologies, we extend the models to account for bribery, as we later confirm the existence of simultaneity bias between productivity and bribery.

We begin by describing the simultaneity bias. Consider the logarithmic form of a Cobb–Douglas production function for firm i at time t given by,

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \omega_{it} + \varepsilon_{it}, \tag{13}$$

where y_{it}, k_{it}, and l_{it} are the logs of output, capital input, and labor input, respectively. The composite error term in this regression consists of ω_{it} and ε_{it}, which represent observed and unobserved productivity shocks to the firm prior to input decisions, respectively. The former is also referred to as "total factor productivity" in the literature, while the latter can be interpreted as measurement error in the output variable. However, the ordinary least squares (OLS) estimate of β_k and β_l are biased and inconsistent due to endogeneity between the inputs, k_{it} and l_{it}, and the observed shock ω_{it}. This endogeneity arises due to a simultaneity problem; while the econometrician does not observe the productivity shock, ω_{it}, the profit maximizing firm does, and uses this information on productivity levels to inform their optimal input choices. There have been many attempts to solve for unbiased estimators, which can be broadly divided into two general approaches: using dynamic panel data—such as in Blundell and Bond (1998, 2000)—and using proxy variables—which includes Olley and Pakes (1996); Levinsohn and Petrin (2003); Wooldridge (2009); Ackerberg et al. (2015) and Kasahara et al. (2015). In particular both Levinsohn and Petrin (2003) and Ackerberg et al. (2015) use a two-stage GMM process with instruments, where the proxy variable is intermediate materials and capital stock is dynamic and decided in the previous period.

To account for corruption, we extend (13) to,

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \beta_b b_{it} + \omega_{it} + \varepsilon_{it}. \tag{14}$$

Though bribery is not a factor of production in a traditional Cobb–Douglas setting, we nonetheless include it in this regression, as intuitively, bribery can affect total revenue. Further, the addition of dummy, non-input variables into the production function regression is relatively common (see, for example, Cornwell et al., 1990; Battese et al., 1996; Yasar et al., 2006).

We argue here that the simultaneity bias not only extends to inputs, but also to bribery. Intuitively, as a firm becomes more productive, it is more likely to be hassled by government bureaucrats, which in turn adversely impacts ouput and ultimately profit. Thus, as productivity increases, a firm becomes more willing to pay bribes to bureaucrats to fully exploit the rise in its efficiency. The two methodologies—based on ACF and LP—used to eliminate this simultaneity bias are explained in detail in the Appendix B.

Then, to test the link between bribery and the productivity term, ω_{it}, we use both logit and probit regression frameworks. The logit linear model is given by

$$\Pr(b_{it} = 1) = \frac{e^{\gamma_0 + \gamma_\omega \omega_{it}}}{1 + e^{\gamma_0 + \gamma_\omega \omega_{it}}}, \tag{15}$$

while the probit linear model is given by

$$\Pr(b_{it} = 1) = \Phi(\gamma_0 + \gamma_\omega \omega_{it}), \tag{16}$$

where b_{it} is a dummy variable that takes a value of 1 if firm i engages in bribery at time t and 0 otherwise.

The list of explanatory variables used in these models includes productivity, firm size, and dummy variables indicating the following firm characteristics: if a firm exports, if the owner or manager is a member of the Vietnamese Communist Party, if the firm has borrowed from formal or informal sources, if the firm submits its financial reports to the government, and if the firm has a tax code. We also include a time dummy variable for the year 2006 to account for the significant drop in bribery rates between 2004 and 2006, as outlined in Table 3.

4.3 Empirical Results

The coefficients for all three approaches are given in Table 4. Except for the LP model's β_b between 2010 and 2014, all coefficients are statistically significant at a 95% confidence level. It should be noted here, however, that the OLS estimates of β_b for all three periods are statistically insignificant. We speculate that this difference can be attributed to the simultaneity bias, creating a downward bias for these estimators. We focus now on the coefficient β_b. For all three periods considered in this analysis, both the ACF and LP extended models confirm that the decision to pay a bribe is associated with a reduction in firm revenue. For the figures and analysis that follow, we use the results from the extended ACF model.

Table 4: Parameter Estimates for Three Different Periods, Using Two Methodologies

	2004 – 2014		2004 – 2008		2010 – 2014	
	ACF	LP	ACF	LP	ACF	LP
β_l	0.7283	0.6012	0.6875	0.5301	0.8313	0.6498
	(0.0217)	(0.0143)	(0.0253)	(0.0132)	(0.0246)	(0.0139)
β_k	0.2395	0.3073	0.2918	0.3846	0.1661	0.2668
	(0.0307)	(0.0326)	(0.0368)	(0.0386)	(0.0334)	(0.0342)
β_b	-0.0404	-0.0740	-0.0167	-0.0389	-0.0321	-0.0564
	(0.0029)	(0.0031)	(0.0036)	(0.0038)	(0.0034)	(0.0032)

Note: Standard errors are given in parentheses.

Figure 1 presents a scatter plot of the productivity term, ω_{it}, for the three periods. In each plot, we construct the smoothed blue line using weighted linear least squares with a second degree polynomial model. Overall, we see that the productivity distribution is relatively similar across different firm sizes. However, for all three sample sets, some middle to large-sized firms appear to be less productive relative to their peers. Conversely, the more productive firms tend to be small or middle-sized.

In the next three figures, we construct a smoothed line, again using weighted linear least squares with a second degree polynomial, of the bribery variable on the vertical axis and plot it against various firm characteristics. Using this line, we can comment on the likelihood of bribery given firm size (Figure 2), productivity level (Figure 3), and revenue (Figure 4), respectively.

Consider first the plot of bribery against firm size; there is a clear positive trend suggesting that larger-sized firms are more likely to pay bribes than their smaller peers. A positive trend is also apparent when considering the relationship between productivity and bribery in Figure 3. Finally, in analyzing the relationship between revenue and bribery in Figure 4, there appears to be a relatively consistent trend across all three periods; in particular, while there is evidence of a positive correlation between revenue and bribery likelihood for lower to medium-revenue firms, the likelihood of bribery appears to then decrease for the highest-revenue firms.

The results for the logit and probit regressions are given in Table 5. All coefficients are statistically significant at the 5% level. Of particular interest are the values of γ_ω, which are statistically significant and positive across all periods, implying that more productive firms are more likely to pay bribes. This result directly contrasts the finding in Faruq et al. (2013), which suggests that, in Africa, it is the less productive firms that are more likely to pay bribes. This distinction confirms the theorem of the theoretical model; that is, that there exists multiple regimes in which firms' bribery depend on their productivity levels.

It can be inferred from these results that productive firms are more likely to pay bribes, in turn reducing their expected revenue. Intuitively, this can be explained as follows: as a firm becomes more productive, it is more likely to be hassled by bureaucrats or, should it decide to grow, to dedicate more time to regulations. As a consequence, there is a higher chance this firm pays a bribe. Further, given the time spent dealing with these bureaucrats or resolving bribery-related issues, the firm will have less time for production, thereby reducing revenue. Thus, using this sample of Vietnamese manufacturing firms, we can infer that petty corruption acts as a deterrent to economic growth at a firm level in Vietnam between 2005 and 2015.

5 Conclusion

Corruption exists in many forms in countries all over the world. It has persisted since ancient times and thrived in many developing countries in particular, despite multiple attempts to combat and reduce it. In this paper, we focused on petty corruption and considered the question of how such different degrees of petty corruption have come to exist in equilibrium. In doing so, we examined, both theoretically and empirically, the relationship between firms' productivity – an important factor contributing to economic growth – and bribery. Theoretically, we built upon the general equilibrium framework from Acemoglu and Verdier (2000) to include heterogeneous productivity of firms. This model presents a testable hypothesis that is applicable to real-world countries, in both the static and dynamic settings. Further, we empirically tested our results using data from Vietnamese manufacturing firms between 2004 and 2014. We found that more productive firms are corrupt in Vietnam, which coincides with one of the equilibrium regimes found theoretically.

In the theoretical analysis, we first studied the model in a static setting where firms are faced with a choice between the good—but costly— technology, and the bad technology, which is free but requires bribes. We identified four potential regimes that may arise in equilibrium:

1. All firms use the good technology, and there is no corruption;
2. All firms use the bad technology and engage in bribery;
3. There exists a productivity threshold such that a firm with productivity above the threshold chooses the good technology;
4. There exists a productivity threshold such that a firm with productivity above the threshold chooses the bad technology.

In our model, the regime that arises in equilibrium depends on four fundamental variables, which can be interpreted as the state capacity, the transparency rate, the technological strength, and the production capability. For instance, the first regime —where all firms use the good technology— arises in countries with high state capacity, transparency, advanced technology levels, and very high production capability. Meanwhile, the second regime —where all firms engage in bribery— arises in countries with low transparency, weak state capacity, and low technological progress.

Our dynamic model is a series of single period models in which a firm's use of the good technology generates positive externalities in subsequent periods. We found that if a country starts in the regime where productive firms use the bad technology, due to the externalities, more firms start switching to the good technology in the following periods, and eventually the regime switches to one in which all firms use the good technology. At the same time, there is also an increase in total output. On the other hand, if the starting regime is one in which all firms use the bad technology, the externalities do not appear and that regime is stable in equilibrium. This provides testable hypothesis that the former scenario is descriptive of those countries in the East Asian paradox, where widespread corruption coexists with high economic growth. Meanwhile, the latter cab best describes many African countries, where there is little development and corruption is rampant.

We then tested the validity of our theoretical results using the Vietnam SME survey between 2005 and 2015. To find the unbiased productivity value, we adopted the two-stage GMM model from Ackerberg et al. (2015), one of the most recent methodologies developed to remove the simultaneity bias between productivity and inputs. To ensure the robustness of our results, we extended the model to include a bribery variable in both estimation stages. In doing so, we found a significant and positive relationship in our sample between productivity and the likelihood of bribes, which coincides with one equilibrium regime derived in our theoretical analysis. We also considered the contrast of this positive relationship between productivity and bribery with the results of Faruq et al. (2013), who find the same relationship to be negative for many African countries. Ultimately, this provides support for our theoretical analysis of multiple possible regimes arising in equilibrium.

The findings in this paper pose further research questions. For instance, one can further extend the theoretical model to account for bureaucrats' behavior. In our current setting, we assume that all bureaucrats accept bribes offered by firms using the bad technology. However, one could relax this assumption, allowing honest bureaucrats to reject the bribe, or even corrupt bureaucrats to demand bribes from firms using the good technology. It would be interesting in such a case to see which regime is most likely to arise in equilibrium. Another possible extension is to formally include varying production output. In our current setting, firms are bounded by the production capability, and output increases can only be measured via the positive externalities affecting the productivity of firms using the good technology. However, if we also allow firms to maximize profits not only by choosing the technology, but also by deciding on labor input, then we can have a comparative analysis on output under different regimes, even in a static setting.

In terms of the empirical analysis, we have so far only shown the relationship between productivity and bribery within the sample of Vietnamese manufacturing firms that we have studied. As discussed above, we contrasted these findings with those of Dal Bó and Rossi (2007) and Faruq et al. (2013). However, it should be noted that they measure firm-level efficiency, in contrast to our measures of productivity.[5] As such, it would be interesting to have a formal cross-country comparison using the same empirical methodology. Further, it would be very fruitful to confirm the relationship found in Vietnam with that in other countries within the East Asian paradox, such as China and Indonesia. Finally, aside from East (and Southeast) Asian and African countries, corruption is also rampant and actively discussed in many Latin American countries, such as Peru or Brazil. As such, it would be interesting to confirm which regime is applicable in these countries.

[5]Firm-level efficiency is measured as the distance to the production frontier, whereas ours is the total factor productivity in the literature (see Syverson, 2011).

Appendices

A Proofs for the Theoretical Analysis

A.1 Proofs of the results in Section 2

Proof of Proposition 1. First, consider if $s = 1$. Then, as all firms use the good technology, bureaucrats cannot extract any bribes; thus $b = 0$. In addition, note that for $s = 1$ to hold, we still need the condition $D_i \geq 0$ to hold for any $a_i \in [a_{\min}, 1]$. Then $s = 1$ holds if

$$(\gamma - (1-\theta))a_{\min}y \geq (1-\theta)\bar{\omega}. \tag{A-1}$$

We now examine if $s = 0$ can exist. In that case, all firms use the bad technology, which is equivalent to $D_i < 0$ for all $a_i \in (0, 1]$, or

$$(\gamma - (1-\theta))y < (1-\theta)\bar{\omega} - nb,$$

for the maximum value $a_i = 1$.

In addition, note that we also have $b = \theta w_o$ from the bureaucrats' constraint (4), and $w_o = \frac{(\bar{\omega}-C)\theta}{(1-\theta)n}$ from the government budget constraint (5). Thus, the inequality above is equivalent to

$$(\gamma - (1-\theta))y < \frac{(1-2\theta)\bar{\omega} + \theta^2 C}{1-\theta}.$$

□

Proof of Proposition 2. In this case D_i from (3) becomes

$$D_i = nb - (1-\theta)\bar{\omega},$$

which also means all firms use the same technology, regardless of their productivity. Thus, if $\gamma = 1 - \theta$, then either only $s = 0$ or $s = 1$.

Substituting the values of b and w_o from the bureaucrat's budget constraint and the government's budget constraint to the equation for D_i yields

$$D_i = \frac{-(1 + \theta s - 2\theta)\bar{\omega} - \theta^2 C}{s + (1-\theta)(1-s)}. \tag{A-2}$$

Then, all firms use the bad technology if $s = 0$, in which case

$$D_i = \frac{-(1-2\theta)\bar{\omega} - \theta^2 C}{1-\theta},$$

which happens if and only if $D_i < 0$, or $(1-2\theta)\bar{\omega} + \theta^2 C > 0$.

In addition, recall condition (7), which states that $s = 1$ if and only if $(1-\theta)\bar{\omega} \leq 0$. This only holds if $\theta = 1$, or the government always audits.

$\square$

Lemma A-1. *Suppose that $\gamma > 1-\theta$. In equilibrium,*

$$w_o = \frac{((1-s)\bar{\omega} - C)\theta}{(1-\theta(1-s))n}; \tag{A-3}$$

$$b = \frac{((1-s)\bar{\omega} - C)\theta^2}{(1-\theta(1-s))n}; \tag{A-4}$$

$$D_i = (\gamma - (1-\theta))a_i y + \frac{\theta\bar{\omega} - \theta^2 C}{1-\theta(1-s)} - \bar{\omega}. \tag{A-5}$$

Proof of Lemma A-1. Recall the profit difference D_i from (3). Denote the solution for $D_i = 0$ as $\bar{a}_c$. Then

$$\bar{a}_c = \frac{(1-\theta)\bar{\omega} - nb}{(\gamma - (1-\theta))y}. \tag{A-6}$$

We can consider $\bar{a}_c$ the critical productivity value, since if firm i's productivity score is $\bar{a}_c$ both technologies yield the same level of profit, or $\pi_G^i(\bar{a}_c) = \pi_B^i(\bar{a}_c)$. Then in terms of profitability, firm i prefers the good technology if $D_i \geq 0$ and the bad technology if $D_i < 0$.

Using the government's budget constraint (5), we calculate the equilibrium wage as (A-3). Then, using $b = \theta w_o$ from the bureaucrat's wage, we have the equilibrium bribery level as (A-4). From substituting b to the expression for D_i in (3), we obtain (A-5). $\square$

Lemma A-2. *Suppose that $\gamma > 1-\theta$. There exists $\underline{C}$ where if $(\gamma - (1-\theta))a_{\min} y \geq (1-\theta)\bar{\omega}$ and $C \leq \underline{C}$ all firms use the good technology. Suppose that $\gamma < 1-\theta$ and C is sufficiently high, all firms use the bad technology, or $s = 0$.*

Proof of Lemma A-2. Consider first the case $\gamma > 1-\theta$. Then if $\underline{C}$ is sufficiently small, $D_i(\underline{C}) > 0$, or $\pi_G^i > \pi_B^i$. This means that all firms enjoy higher profits when choosing the good technology, regardless of their productivity value. Thus all firms choose the good technology.

On the other hand, if $\gamma < 1-\theta$ and C is sufficiently high that (8) holds, $D_i < 0$ and also the condition for $s = 0$ in lemma 1 is satisfied, meaning that all firms experience higher profit if they choose the bad technology. $\square$

Lemma A-3. *Let $\bar{a}_c$ satisfy $D_i(\bar{a}_c) = 0$. Then*

$$\bar{a}_c = \frac{\bar{\omega}}{(\gamma - (1-\theta))y} - \frac{\theta\bar{\omega} - \theta^2 C}{(1-\theta(1-s))(\gamma-(1-\theta))y}. \tag{A-7}$$

Further,

- *If $\gamma > 1-\theta$, firms whose productivity $a_i \geq \bar{a}_c$ use the good technology.*
- *Otherwise, if $\gamma < 1-\theta$, firms whose productivity $a_i > \bar{a}_c$ use the bad technology.*

Proof of Lemma A-3. From (A-5), we can find the value of $\bar{a}_c$ as in (A-7). From (3), we see that $D_i \geq 0$ if and only if $(\gamma - (1-\theta))a_i y \geq (1-\theta)\bar{\omega} - nb$, which equals

$$(\gamma - (1-\theta))a_i y \geq \bar{\omega} - \frac{\theta\bar{\omega} - \theta^2 C}{1-\theta(1-s)}. \tag{A-8}$$

Recall that if $D_i \geq 0$, firm i uses the good technology. Then, if $\gamma > 1-\theta$, inequality (A-8) holds if and only if $a_i \geq \bar{a}_c$. Thus, firms whose productivity $a_i \geq \bar{a}_c$ use the good technology and the rest use the bad one as $D_i < 0$ for those firms.

Similarly, if $\gamma < 1-\theta$, inequality (A-8) becomes $a_i \leq \bar{a}_c$. Then, firms whose $a_i \leq \bar{a}_c$ use good technology and the remaining use the bad one. $\square$

Proof of Proposition 3. Suppose that $\gamma > 1-\theta$ and $\bar{\omega} \geq \theta C$. Then, from (A-10), $\bar{a}_c$ is increasing in $f(\bar{a})$ and is maximized when $f(\bar{a})$ is maximized at 1:

$$\bar{a}_c^{\max}(1) = \frac{(1-\theta)\bar{\omega} + \theta^2 C}{(\gamma-(1-\theta))y}.$$

When $f(\bar{a})$ is at its minimum value of 0, $\bar{a}_c$ is minimized at

$$\bar{a}_c^{\min}(0) = \frac{(1-2\theta)\bar{\omega} + \theta^2 C}{(1-\theta)(\gamma-(1-\theta))y}.$$

On the other hand, from Lemma A-3, we know $f(\bar{a})$ is decreasing in $\bar{a}$. Then, $f(\bar{a}) = 0$ when $\bar{a} = 1$ and $f(\bar{a}) = 1$ when $\bar{a} = a_{\min}$. To sum up, as $\bar{a}$ increases from $a_{\min}$ to 1, we know that $f(\bar{a})$ decreases from 1 to 0, and thereby $\bar{a}_c$ decreases from $\bar{a}_c^{\max}(1)$ to $\bar{a}_c^{\min}(0)$.

If $(1-2\theta)\bar{\omega} + \theta^2 C \leq (1-\theta)(\gamma-(1-\theta))y$, $\bar{a}_c^{\min}(0) \leq 1$ while $\bar{a}_c^{\max}(1) \geq 1$. Using the intermediate value theorem, there exists $\bar{a} \in [a_{\min}, 1]$ that satisfies $\bar{a} = \bar{a}_c(f(\bar{a}))$. If $(1-2\theta)\bar{\omega}+\theta^2 C > (1-\theta)(\gamma-(1-\theta))y$, $\bar{a}_c^{\min}(0) > 1$, meaning that $\bar{a} = 1$ as $\bar{a}_c > 1$ for any $f(\bar{a})$. In addition, note that the condition (8) is satisfied. Thus all firms use the bad technology and $f(\bar{a}) = 0$.

Finally, recall lemma A-2, and that we are consider the valuations with respect to 1. If we focus instead to $a_{\min}$, then if $(\gamma-(1-\theta))a_{\min}y \geq (1-\theta)\bar{\omega}$ and with sufficiently low value of C such that $\bar{a}_c^{\max}(1) < a_{\min}$, then it follows that $\bar{a} = a_{\min}$, meaning all firms use the good technology and $f(\bar{a}) = 1$. $\square$

Proof of Proposition 4. Suppose that $\gamma > 1-\theta$ and $\bar{\omega} < \theta C$. As its derivative is negative, $\bar{a}_c$ is decreasing in $f(\bar{a})$ and is maximized when $f(\bar{a})$ is minimized at 0:

$$\bar{a}_c^{\max}(0) = \frac{(1-2\theta)\bar{\omega}+\theta^2 C}{(1-\theta)(\gamma-(1-\theta))y}.$$

In addition, $\bar{a}_c$ is maximized at $f(\bar{a}) = 1$:

$$\bar{a}_c^{\min}(1) = \frac{(1-\theta)\bar{\omega}+\theta^2 C}{(\gamma-(1-\theta))y}.$$

From lemma A-3, $f(\bar{a})$ is decreasing in $\bar{a}$, as $\gamma > 1-\theta$. Then, $f(\bar{a}) = 0$ when $\bar{a} = 1$ and $f(\bar{a}) = 1$ when $\bar{a} = a_{\min}$. To sum up, as $\bar{a}$ increases from $a_{\min}$ to 1, $f(\bar{a})$ decreases from 1 to 0, and thereby $\bar{a}_c$ increases from $\bar{a}_c^{\min}(1)$ to $\bar{a}_c^{\max}(0)$.

If $(1-\theta)\bar{\omega}+\theta^2 C \leq (\gamma-(1-\theta))y$, $\bar{a}_c^{\min}(1) \leq 1$ while $\bar{a}_c^{\max}(0) > 1$. Using the intermediate value theorem, there exists $\bar{a} \in [a_{\min}, 1]$ that satisfies $\bar{a} = \bar{a}_c(f(\bar{a}))$. If $(1-\theta)\bar{\omega}+\theta^2 C > (\gamma-(1-\theta))y$, $\bar{a}_c^{\min}(1) > 1$, meaning that $\bar{a} = 1$ as $\bar{a}_c > 1$ for any $\bar{a}$. In addition, the condition (8) is also satisfied. Thus all firms use the bad technology and $f(\bar{a}) = 0$. $\square$

Proof of Proposition 5. Suppose that $\gamma < 1-\theta$ and $\bar{\omega} \geq \theta C$. Then, the critical value $\bar{a}_c$ from (A-7) becomes:

$$\bar{a}_c(f(\bar{a})) = \frac{\bar{\omega}}{(\gamma-(1-\theta))y} - \frac{\theta\bar{\omega}-\theta^2 C}{(1-\theta(1-f(\bar{a})))(\gamma-(1-\theta))y}. \tag{A-9}$$

The partial derivative of $\bar{a}_c$ with respect to $f(\bar{a})$ is given as

$$\frac{\partial \bar{a}_c(s)}{\partial f(\bar{a})} = \frac{(\bar{\omega}-\theta C)\theta^2}{(1-\theta(1-f(\bar{a})))^2(\gamma-(1-\theta))y}. \tag{A-10}$$

From (A-10), $\bar{a}_c$ is decreasing in $f(\bar{a})$ and is maximized when $f(\bar{a})$ is minimized at 0:

$$\bar{a}_c^{\max}(0) = \frac{(1-2\theta)\bar{\omega}+\theta^2 C}{(1-\theta)(\gamma-(1-\theta))y}.$$

In addition, $\bar{a}_c$ is maximized at $f(\bar{a}) = 1$, which is

$$\bar{a}_c^{\min}(1) = \frac{(1-\theta)\bar{\omega}+\theta^2 C}{(\gamma-(1-\theta))y}.$$

On the other hand, from lemma A-3, we know $f(\bar{a})$ is increasing in $\bar{a}$. Then, $f(\bar{a}) = 0$ when $\bar{a} = a_{\min}$ and $f(\bar{a}) = 1$ when $\bar{a} = 1$. To sum up, as $\bar{a}$ increases from $a_{\min}$ to 1, $f(\bar{a})$ increases from 0 to 1, and thereby $\bar{a}_c$ decreases from $\bar{a}_c^{\max}(0)$ to $\bar{a}_c^{\min}(1)$.

Note that $\bar{a}_c^{\min}(1) < 0$. Thus if $(1-2\theta)\bar{\omega} + \theta^2 C \leq 0$, $\bar{a}_c^{\max}(0) \geq 0$. Using the intermediate value theorem, there exists $\bar{a} \in [a_{\min}, 1]$ that satisfies $\bar{a} = \bar{a}_c(f(\bar{a}))$. If $(1-2\theta)\bar{\omega} + \theta^2 C > 0$, $\bar{a}_c^{\max}(0) < 0$ and therefore $\bar{a} = a_{\min}$. In addition, the condition (8) is also satisfied. Thus all firms use the bad technology, and $f(\bar{a}) = 0$. $\square$

Proof of Proposition 6. Suppose that $\gamma < 1-\theta$ and $\bar{\omega} < \theta C$. In this case, $\bar{a}_c$ is increasing in $f(\bar{a})$ and is maximized when $f(\bar{a})$ is maximized at 1:

$$\bar{a}_c^{\max}(1) = \frac{(1-\theta)\bar{\omega} + \theta^2 C}{(\gamma - (1-\theta))y}.$$

However, note that $\bar{a}_c^{\max}(1) \leq 0$, meaning that $\bar{a}_c \leq 0$ for any value of $\bar{a}$. Thus $\bar{a} = a_{\min}$. Coupled with condition (8) being satisfied, all firms use the bad technology, and $f(\bar{a}) = f(a_{\min}) = 0$. $\square$

A.2 Proofs of the results in Section 3

Proof of Lemma 1. Let τ denote the period that firm i adopts the good technology for the first time. Consider the decision by firm i. Now suppose that firm i has its threshold productivity in period τ such that by (A-8)

$$(\gamma(s_\tau) - (1-\theta))a_i y + \frac{\theta\bar{\omega} - \theta^2 C}{1-\theta+\theta s_\tau} = \iota_1 \bar{\omega}. \tag{A-11}$$

Then by (A-11) and $\gamma(s_\tau) < 1-\theta$, for every $a_h < a_i$, we have

$$(\gamma(s_\tau) - (1-\theta))a_i y + \frac{\theta\bar{\omega} - \theta^2 C}{1-\theta+\theta s_\tau} > \iota_1 \bar{\omega} > \iota_0 \bar{\omega}. \tag{A-12}$$

On the contrary, suppose $s_{\tau+1} < s_\tau$. Then, firm j with its productivity $a_j < a_i$ has a period $\tau+1$ threshold productivity such that

$$(\gamma(s_{\tau+1}) - (1-\theta))a_j y + \frac{\theta\bar{\omega} - \theta^2 C}{1-\theta+\theta s_{\tau+1}} = \iota_1 \bar{\omega}, \tag{A-13}$$

and all firms with higher productivity than a_j use the bad technology. However, because $\iota_1 > \iota_0$ and by the continuity of productivity, (A-13) implies that there is some firm h with its productivity $a_h \in (a_j, a_i)$ such that

$$(\gamma(s_{\tau+1}) - (1-\theta))a_h y + \frac{\theta\bar{\omega} - \theta^2 C}{1-\theta+\theta s_{\tau+1}} > \iota_0 \bar{\omega}. \tag{A-14}$$

By (A-12) and (A-14), firm h would choose the good technology in period $\tau + 1$, which contradicts the assumption that in period $\tau + 1$, firm j with $a_j < a_h$ has the threshold productivity and in this regime, all firms with higher productivity than a_j use the bad technology.

Finally, because τ and i are arbitrary, this completes the proof. $\square$

Proof of Theorem 1. We denote the threshold productivity in period t by $\bar{a}_t$. Suppose that $\gamma(s_t) < 1 - \theta$ and $\bar{\omega} \geq \theta C$ and $(1 - 2\theta)\bar{\omega} + \theta^2 C \leq 0$ in period t. Then by Proposition 5, there exists $\bar{a}_t \in [a_{\min}, 1]$ and firms whose productivity $a_i \geq \bar{a}_t$ use the bad technology. By Lemma 1, $\bar{a}_t$ and s_t increase over periods. The second statement is direct because once s_T reaches 1, by Lemma 1, $s_{T+t'} = s_T = 1$ for every $t' > 0$. Now we focus on the first statement.

To show the first statement, recall that from (12), the total output, Y_t, under the regime where productive firms use the bad technology becomes:

$$Y_t = \int_{i:a_i \in [\bar{a}_t, 1]} (1-\theta) a_i y \mathrm{d}i + \int_{i:a_i \in [a_{min}, \bar{a}_t]} \gamma(s_t) a_i y \mathrm{d}i.$$

By Lemma 1, $\gamma(s_t)$ is increasing over period t and $\gamma(s_t) - \gamma(s_{t-1}) > \bar{\gamma}(s_t - s_{t-1})$. Then, $Y_t - Y_{t-1}$ is given by

$$\begin{aligned}
Y_t - Y_{t-1} = & \int_{i:a_i \in [\bar{a}_t, 1]} (1-\theta) a_i y \mathrm{d}i - \int_{i:a_i \in [\bar{a}_{t-1}, 1]} (1-\theta) a_i y \mathrm{d}i \\
& + \int_{i:a_i \in [a_{min}, \bar{a}_t]} \gamma(s_t) a_i y \mathrm{d}i - \int_{i:a_i \in [a_{min}, \bar{a}_{t-1}]} \gamma(s_{t-1}) a_i y \mathrm{d}i \\
= & - \int_{i:a_i \in [\bar{a}_{t-1}, \bar{a}_t]} (1-\theta) a_i y \mathrm{d}i + [\gamma(s_t) - \gamma(s_{t-1})] \int_{i:a_i \in [a_{min}, \bar{a}_t]} a_i y \mathrm{d}i + \int_{i:a_i \in [\bar{a}_{t-1}, \bar{a}_t]} \gamma(s_{t-1}) a_i y \mathrm{d}i \\
= & - \int_{i:a_i \in [\bar{a}_{t-1}, \bar{a}_t]} (1-\theta-\gamma(s_{t-1})) a_i y \mathrm{d}i + [\gamma(s_t) - \gamma(s_{t-1})] \int_{i:a_i \in [a_{min}, \bar{a}_t]} a_i y \mathrm{d}i \\
= & [\gamma(s_t) - \gamma(s_{t-1})] \int_{i:a_i \in [a_{min}, \bar{a}_{t-1}]} a_i y \mathrm{d}i - \int_{i:a_i \in [\bar{a}_{t-1}, \bar{a}_t]} (1-\theta-\gamma(s_t)) a_i y \mathrm{d}i.
\end{aligned}$$

Let $\bar{\gamma} = \frac{\int_{i:a_i \in [\bar{a}_{t-1}, \bar{a}_t]} (1-\theta-\gamma(s_t)) a_i y \mathrm{d}i}{(s_t - s_{t-1}) \int_{i:a_i \in [a_{min}, \bar{a}_{t-1}]} a_i y \mathrm{d}i}$. Then, we obtain the desired result. $\square$

B Empirical Methodologies

B.1 Assumptions

There are five assumptions for the model, which outline the nature of dynamically optimizing firms.

Assumption 1 (Information Set)**.** *A firm i's information set I_{it} follows $I_{it} = \{\omega_{it}, \omega_{it-1}, ..., \omega_{i0}\}$. In addition, for any firm i, the unobserved shocks are i.i.d., and, $E[\varepsilon_{it} | I_{it}] = 0$.*

This assumption implies that the firm i's information set consists of all the current and past observable productivity shocks related to the firm, and so all firms know some part of the productivity shocks that happen in every period up to the current period.

Assumption 2 (First-Order Markov)**.** *The productivity shock ω_{it} follows a first-order Markov process, that is,*

$$p(\omega_{it}|I_{it-1}) = p(\omega_{it}|\omega_{it-1}).$$

This distribution is known to firms and stochastically increasing in ω_{it-1}.

As a result of the previous two assumptions, a firm does not know its future productivity shocks; it only knows its distribution, which depends solely on the previous period's value.

Assumption 3 (Timing of Capital and Labor Choices)**.** *Firm i's labor input l_{it} and bribery b_{it} is chosen at period t while its capital accumulation follows*

$$k_{it} = \kappa(k_{it-1}, i_{it-1}), \tag{A-15}$$

where investment i_{it-1} is chosen in period $t-1$.

Assumption 3 implies that a firm's capital is dynamic and its stock in period t is a result of the firm's previous capital stock k_{it-1} and investment decision from the previous period i_{it-1}. This is in direct contrast to the firm's labor decision, which are stationary. It should be noted here that Ackerberg et al. (2015) also allows for the case of dynamic labor decision; that is, l_{it} can also be chosen at period $t-c$, where $c \in [0, 1]$. However, because we are analyzing manufacturing industries, which arguably do not require extensive training or marketing for the jobs, we can relax the assumption and allow labor to be chosen during the same period. The stationary property can also hold for bribery, which can be thought of as an ad-lib to handle bureaucrats hassling the firms.

Assumption 4 (Scalar Unobservable)**.** *Firm i's intermediate input demand at time t follows*

$$m_{it} = \widetilde{f}_t(k_{it}, l_{it}, b_{it}, \omega_{it}). \tag{A-16}$$

This is the main departure from the model in Ackerberg et al. (2015), where (A-16) is given as

$$m_{it} = \widetilde{f}_t(k_{it}, l_{it}, \omega_{it}). \tag{A-17}$$

Thus, a firm's intermediate input is non-dynamic and chosen at the same time period as production and depends on a firm's capital, labor stocks, productivity level, as well as its bribery. As the intermediate input can be translated directly into output and thus revenue, it is clear intuitively that bribery is one important factor in the firm's decision. Gandhi et al. (2020) discuss that if intermediate input prices are constant, then this demand function is under-identified. However, inflation in Vietnam varies significantly over the period, thus it is safe to say that the identification problem does not apply to our analysis.

Assumption 5 (Strict Monotonicity)**.** *The demand function for intermediate input* $\widetilde{f}_t(k_{it}, l_{it}, b_{it}, \omega_{it})$ *is strictly increasing in* ω_{it}*.*

This assumption implies that the more productive a firm is, the more it wants to accumulate intermediate inputs and, through these, to increase production. It is required to invert the intermediate input demand function.

B.2 The procedure

Using Assumption 5, we can invert the input demand function (A-16) to

$$\omega_{it} = \widetilde{f}_t^{-1}(k_{it}, l_{it}, m_{it}, b_{it}), \tag{A-18}$$

which gives productivity as a function of the capital, labor and intermediate inputs. We substitute this into the production function:

$$\begin{aligned} y_{it} &= \beta_k k_{it} + \beta_l l_{it} + \beta_b b_{it} + \widetilde{f}_t^{-1}(k_{it}, l_{it}, m_{it}, b_{it}) + \varepsilon_{it} \\ &= \widetilde{\Phi}_t(k_{it}, l_{it}, m_{it}) + \varepsilon_{it}. \end{aligned} \tag{A-19}$$

This gives the first stage moment condition

$$E[\varepsilon_{it}|I_{it}] = E[y_{it} - \widetilde{\Phi}_t(k_{it}, l_{it}, m_{it}, b_{it})|I_{it}] = 0. \tag{A-20}$$

This stage can be simply represented as an OLS regression of the equation

$$y_{it} = \gamma_0 + \gamma_l l_{it} + \gamma_k k_{it} + \gamma_m m_{it} + \gamma_b b_{it} + \varepsilon_{it} = X_{it}\gamma + \varepsilon_{it}, \tag{A-21}$$

which we can estimate to find $\widehat{\widetilde{\Phi}}_t(k_{it}, l_{it}, m_{it}, b_{it})$.

In the second stage, we extend Assumption 2 and allow the productivity term to evolve in an AR(1) process according to the following equation:

$$\omega_{it} = \mathbb{E}[\omega_{it}|I_{it-1}] + \xi_{it} = \mathbb{E}[\omega_{it}|\omega_{it-1}] + \xi_{it} = g(\omega_{it-1}) + \xi_{it}, \tag{A-22}$$

where $\mathbb{E}[\xi_{it}|I_{it-1}] = 0$. This gives us the second stage moment condition:

$$\begin{aligned}\mathbb{E}[\xi_{it} + \varepsilon_{it}|I_{it-1}] =& \mathbb{E}[y_{it} - \beta_k k_{it} - \beta_l l_{it} - \beta_b b_{it} \\ & - g(\widetilde{\Phi}_{t-1}(k_{it-1}, l_{it-1}, m_{it-1}, b_{it-1}) \\ & - \beta_k k_{it-1} - \beta_l l_{it-1} - \beta_b b_{it-1})|I_{it-1}] = 0. \qquad \text{(A-23)}\end{aligned}$$

In particular, we look at the evolution equation of the form

$$\omega_{it} = \rho\omega_{it-1} + \xi_{it}. \qquad \text{(A-24)}$$

As a result, we have four moment conditions in the second stage that we can use to estimate the coefficients β_l, β_k and β_b in the original production function, as well as the evolution coefficient ρ of (A-24):

$$E\left[\left(y_{it} - \beta_k k_{it} - \beta_l l_{it} - \beta_b b_{it} - \rho\left(\widetilde{\Phi}_{t-1}(k_{it-1}, l_{it-1}, m_{it-1}) - \beta_k k_{it-1} - \beta_l l_{it-1} - \beta_b b_{it-1}\right)\right) \otimes \begin{pmatrix} k_{it} \\ l_{it-1} \\ b_{it-1} \\ \widetilde{\Phi}_{t-1}(k_{it-1}, l_{it-1}, m_{it-1}) \end{pmatrix}\right] = 0. \qquad \text{(A-25)}$$

B.3 An Alternate Procedure

To further test the robustness of our results, we perform the analysis using the empirical methodology from Levinsohn and Petrin (2003), which is also the base model which Ackerberg et al. (2015) extend from. The main difference between the two models is the consideration of labor when firms choose the intermediate input. In Levinsohn and Petrin (2003), firms' intermediate input decision depends only on its current capital stock and productivity level; we also modify this to include bribery. This can be shown in the new assumption, which is modified from assumption 4:

Assumption 4LP (Scalar Unobservable)**.** *Firm i's intermediate input demand at time t follows*

$$m_{it} = f_t(k_{it}, b_{it}, \omega_{it}). \qquad \text{(A-26)}$$

The first stage of the procedure is to perform an OLS estimation

$$\begin{aligned} y_{it} &= \beta_k k_{it} + \beta_l l_{it} + \beta_b b_{it} + f_t^{-1}(k_{it}, l_{it}, m_{it}, b_{it}) + \varepsilon_{it} \\ &= \beta_l l_{it} + \widetilde{\Phi}_t(k_{it}, m_{it}) + \varepsilon_{it}, \qquad \text{(A-27)}\end{aligned}$$

using the first moment condition

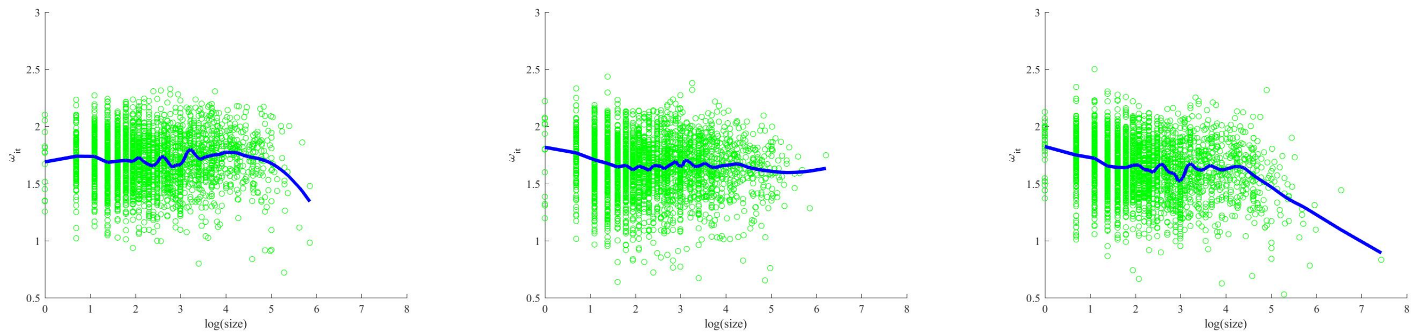
$$E[\varepsilon_{it}|I_{it}] = E[y_{it} - \beta_l l_{it} - \Phi_t(k_{it}, m_{it}, b_{it})|I_{it}] = 0. \tag{A-28}$$

In the first stage, we estimate $\hat{\beta}_l$ and $\hat{\Phi}_t(k_{it}, m_{it}, b_{it})$. Then we apply these estimates to the second stage moment condition:

$$\begin{aligned}\mathbb{E}[\xi_{it} + \varepsilon_{it}|I_{it-1}] =& \mathbb{E}[y_{it} - \beta_k k_{it} - \beta_l l_{it} - \beta_m m_{it} - \beta_b b_{it} \\ & - g(\Phi_{t-1}(k_{it-1}, m_{it-1}, b_{it-1}) - \beta_k k_{it-1} - \beta_b b_{it-1})|I_{it-1}] = 0,\end{aligned} \tag{A-29}$$

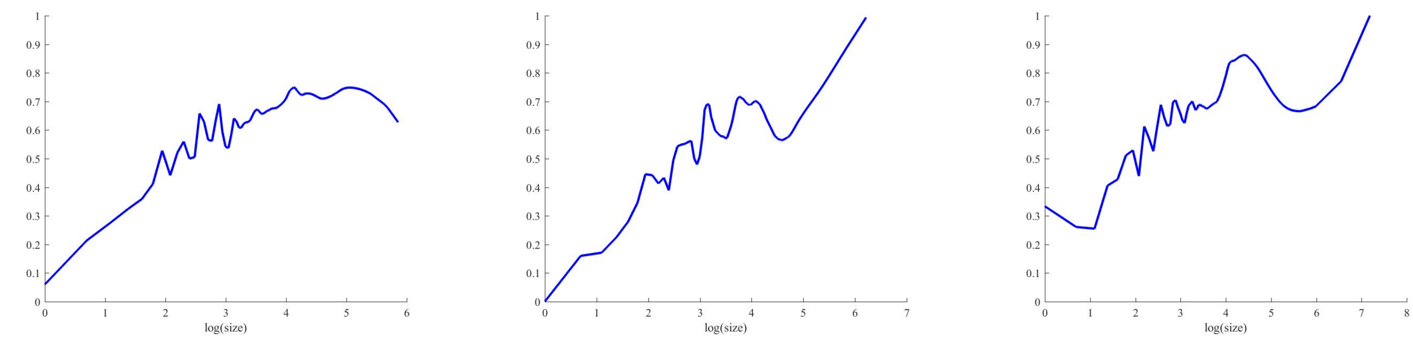
where we find the estimates for $\hat{\beta}_k$, $\hat{\beta}_b$ as well as the firm-specific productivity terms for each period.

C Tables and Figures



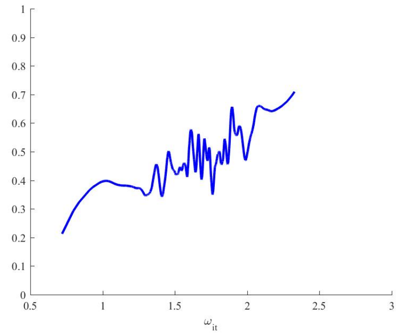
(a) 2004 – 2014 (b) 2004 – 2008 (c) 2010 – 2014

Figure 1: Distribution of Productivity Term across Different Firm Sizes

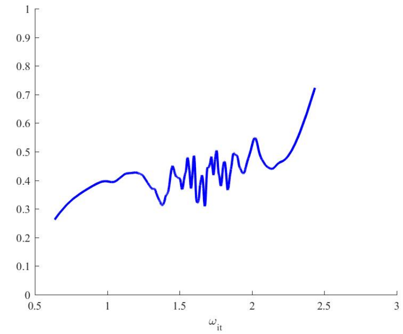


(a) 2004 – 2014 (b) 2004 – 2008 (c) 2010 – 2014

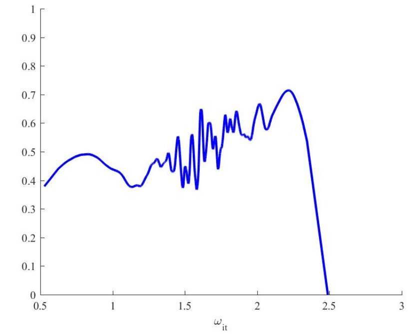
Figure 2: Bribery Likelihood across Different Firm Sizes



(a) 2004 – 2014

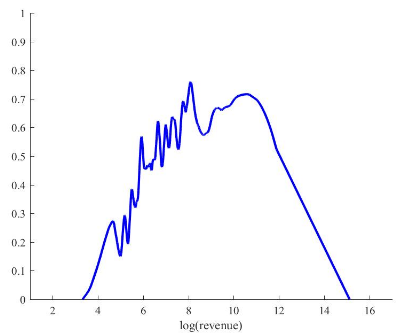


(b) 2004 – 2008

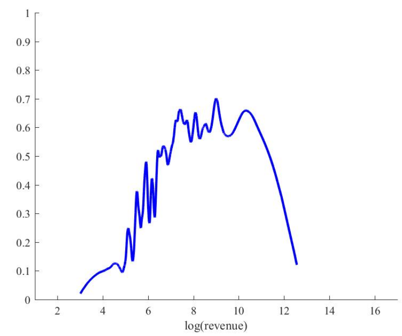


(c) 2010 – 2014

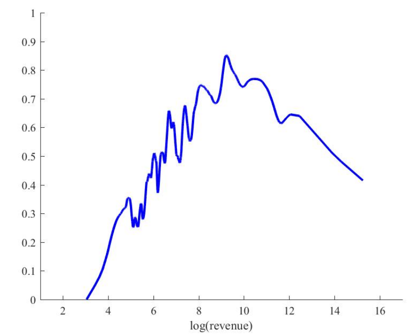
Figure 3: Bribery Likelihood across Productivity Distribution



(a) 2004 – 2014



(b) 2004 – 2008



(c) 2010 – 2014

Figure 4: Bribery Likelihood across Different Revenue Levels

Table 5: Results of the Logit and Probit models

Dependent variable:	2004 – 2014		2004 – 2008		2010 – 2014	
Bribe Incidence	Logit	Probit	Logit	Probit	Logit	Probit
Intercept	-1.8294***	-1.1185***	-1.6302***	-0.9939***	-1.9636***	-1.1995***
Productivity	0.1670***	0.1014***	0.0624**	0.0378**	0.2047***	0.1240***
Size	0.0052***	0.0029***	0.0050***	0.0029***	0.0057***	0.0033***
Export	0.2287	0.1433	-0.0614	-0.0334	0.2530*	0.1540*
Party	0.3535**	0.2160**	0.3469**	0.2108**	-0.0280	-0.0154
Formal Lending	0.0404	0.0255	0.2348***	0.1437***	0.0022	0.0024
Informal Lending	0.2989***	0.1837***	0.2770***	0.1697***	0.4066***	0.2504***
Government Report	0.8730***	0.5446***	0.7609***	0.4746***	1.0147***	0.6323***
Tax Code	0.3315***	0.2029***	0.5982***	0.3611***	0.1440*	0.0881*
2006	-0.8004***	-0.4889***	-0.5823***	-0.3556***		

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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