Does Economic Growth Reduce Corruption? Theory and Evidence from Vietnam[*]

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Abstract

Government corruption is more prevalent in poor countries than in rich countries. This paper uses cross-industry heterogeneity in growth rates within Vietnam to test whether growth leads to lower corruption. We begin by developing a model of government officials' choice of how much bribe money to extract from firms that is based on the notion of inter-regional tax competition, and consider how officials' choices change as the economy grows. We show that economic growth decreases the rate of bribe extraction under plausible assumptions, with the benefit to officials of demanding a given share of revenue as bribes outweighed by the increased risk that firms will move elsewhere. This logic suggests that growth is less effective at reducing bribes if firms are immobile, for example because they lack property rights over their land. Our empirical analysis uses survey data collected from over 13,000 Vietnamese firms between 2006 and 2010 and an instrumental variables strategy based on industry growth in other provinces. We find that, indeed, faster growing firms experience more rapid declines in bribe payments. Moreover, this pattern is particularly true for firms with strong land rights that could more easily relocate. Our results suggest that as poor countries grow, corruption could subside "on its own," and they demonstrate one type of positive feedback between economic growth and good institutions.

1   Introduction

A striking fact about government corruption is that, no matter how you measure it, it is higher in poor countries. For example, the 10 least corrupt countries in the 2009 Transparency International Corruption Perceptions Index, such as New Zealand, the Netherlands, and Canada, had an average real GDP per capita of \$36,700; the 10 most corrupt countries, such as Haiti, Turkmenistan, and Afghanistan, had an average real GDP per capita of \$5,100. This relationship is easy to see in the raw data: Figure 1 shows scatter plots of the two major corruption indices, the Transparency International Corruption Index and the World Bank Control of Corruption Index, plotted against real (i.e., PPP-adjusted) GDP per capita, and shows a clear downward-sloping relationship between corruption and GDP.

The strong correlation between economic development and corruption does not appear to be an artifact of misplaced perceptions. Data on individual bribe payments from household surveys conducted in several countries show the same pattern (e.g., Mocan (2004)), as do survey data collected from firms around the world. Figure 2 plots the fraction of firms surveyed by the Wolrd Bank Enterprise Surveys that reported they were expected to give gifts to public officials in order to "get anything done" against real GDP per capita, and once again, there is a downward-sloping relationship.

While there is a general consensus about the cross-sectional facts, we know relatively little about why corruption is lower in rich countries. One hypothesis is that this pattern reflects a negative causal effect of corruption on economic growth: Corruption discourages investment which, in turn, depresses growth (Mauro, 1995; Wei, 1999). Such a link suggests that rooting out corruption could be critical in achieving higher growth in developing countries.

However, the correlation between income and corruption could also reflect the reverse causal link: Economic growth may reduce corruption, so as countries grow, corruption naturally declines (Treisman, 2000). In this paper, we propose a mechanism through which this may occur, based on the idea of inter-regional competition. We model how economic growth affects the bribes that bureaucrats extract from firms, and then test the predictions using a data set of firms in Vietnam that includes information on the bribes the firms paid to government officials.

We begin by laying out a simple neoclassical model in which the government is able to extract an unlimited amount of bribes from a firm, for example, because it could shut down the firm if it does not comply. What puts a check on bribe extraction is that if the amount is too high, a firm will move elsewhere. Thus, the government chooses a percentage of a firm's

revenues to extract as bribes, trading off higher revenues generated by a higher bribe rate against the increase in the firm's incentive to leave.

The model predicts, under reasonable assumptions about firms' moving costs, that an exogenous increase in firm productivity reduces the proportion of firm revenues that are extracted as bribes. Specifically, the assumption needed is that moving costs are concave in firm size, which would be true for example if there is any fixed costs associated with moving. If this is true, then for a fixed bribe rate, a firm's net benefits of moving (reduced bribes minus moving costs) increase as the firm grows. To offset this greater incentive of firms to move, the government will respond by reducing the proportion of revenues that it extracts as bribes. Bribes become a smaller part of the economy with economic growth.

The model also predicts that if corrupt officials can price-discriminate among firms (as in, e.g., Svensson (2003)), this negative effect of growth on corruption will be heterogeneous, depending on individual firms' ability to move. Intuitively, if firms are completely tied to one region, then inter-regional competition as a check on the level of bribes vanishes. We show that this intuition also holds for how growth affects bribes (i.e., for the cross-partial): economic growth reduces corruption by a greater amount if firms are more able to move elsewhere.

We examine the relationship between economic growth and corruption, and test the predictions of the model, using within-country variation and firm-level data from Vietnam. We use the Provincial Competitiveness Index (PCI) survey (Malesky, 2011), an annual survey of firms that asked how much the firm paid in bribes to government officials as a percentage of their revenues. We construct a repeated cross-section across province-industries from 2006 to 2010, comprised of data on a total of about 13,000 individual firms, and examine how the bribe-paying rate varies as firms are predicted to grow.

An important feature of the PCI survey is that it is designed to study the investment environment across Vietnam's 63 provinces and therefore collects data on a representative sample of firms in each province. The survey instrument asks respondents to reflect specifically on their interactions with provincial officials, allowing us to treat each province as a jurisdiction in which bureaucrats determine how much to extract from local firms. The reason the PCI specifically asks about dealings with provincial officials is that bureaucratic corruption is largely decentralized in Vietnam, with provincial governments, as opposed to the central government, wielding the most power to extract bribes from firms (Meyer and Nguyen, 2005; Cung, Tuan, Van, and Dapice, 2004; Tran, Grafton, and Kompas, 2009). This

institutional feature informs our theoretical and empirical frameworks, in which we treat the province as the relevant geographic unit for bribe extraction and inter-provincial competition as a force that can keep corruption in check.

As shown in Figure 3, during the period from 2006 to 2010, nationally Vietnam was growing rapidly, and corruption as measured in the PCI was falling. These time trends are suggestive, but do not isolate the causal impact of growth on corruption. To test for a causal relationship, we use detailed micro data and track how shocks to predicted firm profitability affect the bribes that provincial officials extract from the firm. As a source of plausibly exogenous variation in a firm's economic performance, we predict a firm's size (employment level) using the aggregate size of the firm's industry in the rest of Vietnam, excluding the firm's province itself. This identification strategy is similar to the "shift-share" or Bartik approach that is commonly used (Bartik, 1991; Blanchard and Katz, 1992; Bound and Holzer, 2000). To construct this aggregate measure, we use a census of firms conducted by Vietnam's General Statistical Organization (GSO), which we match to the PCI data at the province-industry-year level. We show that industry-wide performance is indeed a strong predictor of a firm's performance.

Using this approach, we find that when an industry is predicted to grow, the rate of bribe extraction falls, consistent with the model's predictions. To the best of our knowledge, this provides the first within-country causal evidence that economic growth leads to lower corruption.

We then test for the heterogeneous patterns predicted by the model. To capture heterogeneity in moving costs, we focus on whether firms own a Land Use Rights Certificate (LURC), which gives them secure and transferable property rights over their land. These property rights make firms more mobile, since they increase their ability to sell their land and relocate should they wish to do so.[1] We test whether having more secure and transferable property rights enhances the negative effect of growth on corruption. We find that it indeed does. When a firm owns the plot of land on which it operates and has official permits for that land—so that it is presumably more mobile—economic growth has a stronger negative effect on bribes.

Our findings make several contributions to the literature on corruption in developing countries. First, we provide some of the first micro empirical evidence on the effect of

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[1]Several recent papers have documented an analogous positive effect of property rights over land on migration for individuals, showing that land titling in Mexico increased both domestic (de Janvry, Emerick, Gonzalez-Navarro, and Sadoulet, 2012) and international (Valsecchi, 2011) migration.

economic growth on corruption. Our finding that economic growth reduces bribery suggests that countries might "grow" their way out of corruption. In this case, it may not be necessary to root out corruption to spur growth, but rather corruption might subside as a country grows.[2]

Second, our findings contribute to the broader literature on the effects of economic growth on institutions, and provide the first empirical evidence that we know of for the idea that inter-regional competition could reduce corruption, and that this effect is greater for more mobile firms.[3] The literature on institutions and growth suggests that economic growth could improve the quality of political and economic institutions, and we confirm this hypothesis for the case of bureaucratic corruption (Acemoglu, Johnson, and Robinson, 2005; Glaeser, La Porta, Lopez-de Silanes, and Shleifer, 2004).

Third, our finding that better property rights for firms coupled with economic growth can reduce corruption by making firms more mobile suggests a more subtle interplay than just economic growth improving institutions. Strong theoretical and empirical evidence exists for the relationship between property rights, domestic investment, and growth (North, 1991; De Long and Shleifer, 1993; Weingast, 1995; Goldstein and Udry, 2008; Jones, 1981; Acemoglu and Johnson, 2005; Olson, 2000). Adapting this literature to the micro-level, De Soto (1989) and De Soto (2000) famously predicted that through the provision of land titles, entrepreneurs in the informal sector could be transformed into an important new source of economic growth in the developing world. Since the publication of that piece, convincing evidence has been found that allocation of land rights increases household investment (Galiani and Schargrodsky, 2010), belief in the power and fairness of the market (Di Tella, Galiant, and Schargrodsky, 2007), and the number of hours dedicated to productive work (Field, 2007). We provide a new dimension to literature on the economic benefits of property rights, by demonstrating how land titling can restrain the grabbing hand of local authorities

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[2]At the cross-country level, the most related work is Treisman (2000), who finds that per-capita income, instrumented by geography, negatively predicts corruption. Treisman (2007), however, notes that this relationship does not necessarily hold once one uses microdata-based measures of corruption of the sort we examine here.

[3]From a theoretical perspective, Shleifer and Vishny (1993) are among the first to argue that competition between bureaucrats can reduce corruption, though they consider a different framework than the one we see here. The closest analogue to the ideas developed here is Menes (2006), who noted in her qualitative study of US cities that the ability of firms to relocate to other jurisdictions was one potential reason why urban corruption in the pre-Progressive era was not more severe. Burgess, Hansen, Olken, Potapov, and Sieber (2012) show in the context of illegal logging in Indonesia that Cournot-style competition between jurisdictions can decrease the price of bribes, though in their context that actually leads to more corrupt activity, rather than less.

in the presence of economic growth.

Besides contributing to the literatures on corruption and property rights, our paper is also related to the literature on inter-regional tax competition. The decision problem we model of a bureaucrat setting a bribe rate is analogous to the problem of local governments setting tax rates (Epple and Zelenitz, 1981; Epple and Romer, 1991; Wildasin, 2003; Wilson, 1986). A recent study by Diamond (2012) uses a similar framework to study the effect of workers' migration elasticity on the magnitude of rent extraction by state and local governments . Where we differ from her study and many previous tax competition papers is in the comparative statics we are interested in: we derive (and test) not just the determinants of the level of tax (rents) but also the effects of economic growth in such an environment, something that, to our knowledge, has not been a focus of the tax literature but could also apply in that context.

The remainder of the paper is organized as follows. Section 2 presents the model. Section 3 describes our data and background information on Vietnam. Section 4 describes the empirical strategy and section 5 presents the results. Section 6 concludes.

2   Model

We consider a model in which governments choose how much to extract from firms to maximize their bribe revenue. Governments balance the revenues they raise from extracting higher bribes from firms with an increased risk that by extracting too much from firms in their jurisdictions, some firms may choose to relocate to other jurisdictions with lower corruption. For firms, a bribe is just an additional payment to government, analogous to a tax. The model is therefore similar to models of inter-regional tax competition, where we think of a bribe payment as a type of tax.

The basic idea that underlies most of the papers in the tax competition literature is that mobile factors can adjust their location to any inter-regional differentials in taxation or benefits. Local governments thus need to take into account such potential reaction when designing redistributive policies. Each local government chooses its tax parameters strategically trying to influence migration or capital movement. Models either assume that each region is a small economy among many, or that two regions (usually perfectly symmetric) play a Nash game, though the implications are generally robust to the choice of modeling approach. Cremer and Fourgeaud (1995) provide a comprehensive survey of this literature.

In this paper, we adopt the second approach and consider a two-region Nash equilibrium.

The key distinction of our model compared to the previous literature is that we focus not just on the equilibrium level of taxes/bribes, but also examine how the level of bribes changes with productivity shocks. It is this comparative static that generates predictions about how economic development affects the amount of corruption in the economy. We also derive how the relationship between productivity shocks and the equilibrium bribe rate varies based on the firm's ease of relocating to another jurisdiction. In this section, we will set up the problem and state the key propositions. Details of the mathematical derivations and proofs can be found in the Appendix.

We assume that there are there are two provinces, denoted 1 and 2.[4] The model has two periods. At the beginning of period 1, each province is endowed with a unit mass of incumbent firms. In period 1, the government in each province p sets a bribe rate b_p, which is the percent of a firm's revenues that it must pay in bribes.[5] In period 2, firms in each province choose whether to stay in the province or relocate to the other province. The cost of moving depends on the firm's property rights over its land. Since firms cannot take their land with them, if a firm is able to transfers the property rights to its land to someone else and recoup the value of its land if it moves, mobility will be higher. In period 3, firms then choose their factors of production, produce, and the government collects bribes.

We begin by specifying the firm's problem, then the problem for local governments, and lastly characterize the equilibrium. Suppose all firms have the same two-factor Cobb-Douglas production function with diminishing returns to scale. We assume diminishing returns to scale in order to pin down firm size and generate profits in equilibrium. Capital and labor are perfectly elastically supplied at the same wage rate w and interest rate r in both provinces. Denote the bribe rate set in period 1 in province p as b_p. We focus on the problem for firms in province 1 (naturally the analysis is symmetric for firms in province 2). A typical firm in province 1 solves

$$\max_{K \geq 0, L \geq 0} (1 - b_1) A K^\alpha L^\beta - wL - rK \tag{1}$$

where A is the total factor productivity of the firm; alternatively, we can think of A as the price of the products in the firm's industry.

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[4]The same results apply in a context where we have a large number of jurisdictions, and firms everywhere face some fixed outside option.

[5]We focus on bribe as a percent of revenues, since this is the variable we observe in our empirical exercise. All of the results shown here go through if we instead use bribe as a proportion of the firm's capital stock K. See the Appendix for details.

This maximization problem yields the following familiar results:

$$\frac{L^*}{K^*} = \frac{r}{w}\frac{\beta}{\alpha} \tag{2}$$

$$K^* = \left(\frac{r}{(1-b_1)A\alpha}\left(\frac{r}{w}\frac{\beta}{\alpha}\right)^{-\beta}\right)^{\frac{1}{\alpha+\beta-1}} \tag{3}$$

$$\pi^* = (1-b_1)AK^{*\alpha}L^{*\beta} - wL^* - rK^* \tag{4}$$

In addition to affecting the firm's decision of whether to move as described below, the bribe rate also affects the firm's optimal choice of capital and its profits: the higher the rate of bribe extraction b_1, the smaller the firm's capital stock and profits will be.

The firm will choose to stay in province 1 if and only profits in province 1 are greater than profits in province 2 less moving costs, i.e. if $\pi^*_{f1} \geq \pi^*_{f2} - m$, where m is the firm's moving cost. To proceed, we need to impose some structure on the moving cost m. Intuitively, we think that the moving cost is increasing in the firm's capital stock (since the capital stock would need to be moved or sold and repurchased with transaction costs), and that some firms have higher moving costs than others. We parameterize the moving costs for a firm i as

$$m_i = \theta K^{*\eta}\epsilon_i$$

K^* is the equilibrium level of capital stock from Equation (3), and η captures the degree to which moving costs are increasing in the size of the firm.[6] Conditional on the capital stock, moving costs vary across firms in two ways. First, the θ term captures the part of firm's moving costs that is observable to the government, with higher θ corresponding to higher moving costs. In our empirical analysis, we focus on a firm's property rights status as a proxy for the observable component of a firm's moving costs. Second, moving costs include a stochastic error term ϵ that captures the variation in moving costs among firms. Crucially, while θ will be observable to the government in determining bribe rates, the idiosyncratic part of the moving costs ϵ is unobserved.

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[6]Note that K^* refers to the equilibrium level of capital that is chosen in province 1. The idea is that if you move, you must move your existing capital stock to province 2, and then readjust. Alternatively, one could specify the amount of capital to be moved as the amount that would be chosen in either province if there were no bribes; the results would be unaffected.

Put together, a firm in province p chooses to stay if and only if

$$
\begin{aligned}
\pi_1^* &\geq \pi_2^* - \theta K^{*\eta}\epsilon, \quad \text{or} \\
\epsilon &\geq \frac{\pi_1^* - \pi_2^*}{\theta K^{*\eta}}
\end{aligned}
\tag{5}
$$

To simplify the algebra, we further assume that ϵ is uniformly distributed over $[0, 1]$.[7] The equilibrium number of firms for a given θ in province 1 is therefore simply $1 - \frac{\pi_2^* - \pi_1^*}{\theta K^{*\eta}}$.[8] Since the problem is symmetric for both provinces, this expression will be greater than 1 if $b_1 < b_2$ (so firms are moving into province 1 from province 2) and less than 1 if $b_1 > b_2$ (so firms are moving out of province 1 to province 2).

The two governments in period 1 set bribe rates, taking firms' response and the other province's bribe rate as given. To solve this, we consider the government in province 1. This government takes b_2 as given and solves,

$$
\max_{b_1 \geq 0} b_1 A K^{*\alpha} L^{*\beta} \left(1 - \frac{\pi_2^* - \pi_1^*}{\theta K^{*\eta}}\right)
\tag{6}
$$

Assuming a symmetric equilibrium, the first-order condition can be simplified to:

$$
K^* + b_1^*(\alpha + \beta)\frac{dK^*}{db_1} + \frac{b_1^*}{\theta}K^{*1-\eta}\frac{d\pi_1^*}{db_1} = 0
\tag{7}
$$

Applying some algebra generates:

$$
\left(\frac{1}{\theta}A\left(\frac{r\beta}{w\alpha}\right)^\beta K^{*\alpha+\beta-\eta} - (\alpha + \beta)\frac{1}{\alpha + \beta - 1}\frac{1}{1 - b^*}\right)b^* = 1
\tag{8}
$$

Note that we have suppressed the province subscript since $b_1^* = b_2^*$ in equilibrium.

Several aspects of the equilibrium condition in Equation (8) are worth noting. First, as θ goes to $+\infty$, or firms are completely immobile, the expression simplifies such that $b^* = 1 - \alpha - \beta$. This implies that the greater the diminishing returns to scale, the higher

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[7]This assumption simplifies the algebra but is not essential; in the Appendix, we show that all of the key results go through for arbitrary distributional forms of the error term.

[8]Even though we have in mind a world of many firms with heterogenous θ, we are solving the model for a particular θ. (This would correspond to firms with the same property right status in our empirical section.) After we obtain the equilibrium bribe rate, which is a function of θ, we will examine how bribes and the effect of firm growth on bribes vary with θ. It is important to bear in mind that by doing so, we are assuming there is no interaction, either through factor markets or products market, among different types of firms. This is a non-trivial simplifying assumption, but it makes the problem tractable.

the bribe rate. Intuitively, if output is highly concave in capital, even when the bribe rate is reduced, firms will not expand their capital stock too much due to diminishing returns. Thus, the elasticity of capital with respect to the bribe rate is low. The same applies to labor. Therefore, when the government increases the bribe rate, it can extract more revenue from firms without discouraging production. Hence, the optimal bribe rate is higher.

The second observation is that as θ decreases, so that moving costs decrease, inter-regional competition increases and the equilibrium bribe rate decreases (see the Appendix for the proof). Thus far, the model captures the idea that increasing competition between political jurisdictions can drive down corruption, as in Shleifer and Vishny (1993) and Burgess, Hansen, Olken, Potapov, and Sieber (2012).

Next, we examine how the equilibrium bribe rate responds to increases in the profitability of firms, i.e. increases in A. Taking the derivative with respect to $\log A$ on both sides of Equation (8) and re-arranging terms, we get,

$$\frac{db^*}{d \log A} = \frac{A b^* \left(1 - \dfrac{\alpha + \beta - \eta}{\alpha + \beta - 1}\right)}{\dfrac{\theta}{(1-b)^2} \dfrac{\alpha + \beta}{\alpha + \beta - 1} \left(\dfrac{w\alpha}{r\beta}\right)^\beta K^{*\eta - \alpha - \beta} - A \left(1 + \dfrac{b^*}{1 - b^*} \dfrac{\alpha + \beta - \eta}{\alpha + \beta - 1}\right)} \tag{9}$$

This generates our first result:

Proposition 1. $\dfrac{db^*}{d \log A} < 0$ *if* $0 \leq \eta < 1$; $= 0$ *if* $\eta = 1$; *and* > 0 *if* $\eta > 1$.

The critical factor that determines the sign of $db^*/d \log A$ is η, which characterizes the concavity of the moving cost with respect to the capital stock. The intuition is that with a positive shock to A, for a given size, firms enjoy higher revenues and hence care more about the bribes they will pay and less about the moving cost. This tends to drive down the equilibrium bribe rate due to inter-regional competition. However, at the same time, the cost of moving rises as firms expand in size to take advantage of the higher productivity. This instead tends to drive up the equilibrium bribe rate. With the Cobb-Douglas production function, the two effects exactly cancel at $\eta = 1$. If $\eta < 1$, or a firm's moving costs scale up less than linearly with its capital stock, then the first effect (inter-regional competition effect) dominates the second effect (moving cost effect), and the equilibrium bribe rate falls. In practice, since moving entails at least some element of fixed costs, it seems plausible that $\eta < 1$, which implies $db^*/d \log A < 0$. We will test this prediction in the empirical section below.

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Proposition 1 specifies conditions when the *rate* of bribe extraction falls as A increases; the rate b is the size of the distortion to production. It is also worth noting that another (potentially testable) prediction is that the *total amount of bribes* extracted from the firm will increase when A increases. To see this note that the firm's moving decision is a tradeoff between its total moving costs and its total bribes. Since when A increases, the firm's moving costs increase, the government can retain the same firms even with a higher total bribe extraction.

Next, we examine how the effect of a productivity shock on bribes varies across firms with different θ. As discussed above, we focus on the firm's property right status as the empirical analogue of θ, where higher θ corresponds to less transferable property rights and a higher difficulty of moving. From Equation (8) and (9), we can derive the elasticity of bribes with respect to productivity:

$$-\frac{d\log b^*}{d\log A} = -\frac{1 - \dfrac{\alpha + \beta - \eta}{\alpha + \beta - 1}}{\dfrac{\alpha + \beta}{\alpha + \beta - 1 + b^*}\dfrac{b^*}{1 - b^*} - \left(1 + \dfrac{b^*}{1 - b^*}\dfrac{\alpha + \beta - \eta}{\alpha + \beta - 1}\right)} \tag{10}$$

We can then show the following result:

Proposition 2. *If $0 \leq \eta < 1$, the elasticity $-\dfrac{d \log b^*}{d \log A}$ is monotonically decreasing in θ, that is, $\dfrac{d^2 \log b^*}{d \log A d\theta} > 0$.*

Intuitively, Proposition 1 implies that bribes fall when there is an increase in A, because more profitable firms are more willing to pay moving costs and escape from high bribe rates, so the elasticity increases. Proposition 2 states that the bribe rate falls more after such a shock for firms with better property rights, as the fraction of firms who are on the margin of moving is larger, so a given change in bribes will induce a larger number of them to leave.[9] We will test these predictions in the empirical part of this paper below.

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[9]Note that while Proposition 2 is stated in terms of elasticity or percentage change in the bribe rate (i.e. the change in $\log b$), in the Appendix, we state and prove a similar result for the bribe rate b. In particular, we show that the relationship between $\dfrac{db^*}{dA}$ and θ is U-shaped and increasing as $\theta \to \infty$, and $\dfrac{d^2 b^*}{dAd\theta} > 0$ for a reasonable range of θ as assessed by the ratio of moving cost to revenue.

3 Setting and data

3.1 Background on Vietnam

Vietnam provides a unique opportunity to test the implications of our model. At its 6th Party Congress in 1986, the country initiated the *Doi Moi* (Renovation) economic reforms, which eliminated the role of central planning in the economy and opened the country's borders to international capital and trade flows (Fforde and De Vylder, 1996; Riedel and Turley, 1999). Since that time, the country has achieved an average annual growth rate of 7.3%, ranking it among the very fastest growing countries in the world over the period.

Three post-*Doi Moi* events are critical for understanding the role these drivers play in Vietnam's economic development and the context of our research design. The Enterprise Law in 2000 created the formal legal basis for the private, corporate sector in Vietnam and eased registration into all non-restricted activities. One year after the Enterprise Law, Vietnam finalized the long-standing negotiations with the United States over their bilateral trade agreement (US-VN BTA), which granted Vietnam Most-Favored Nation (MFN) status in accessing US markets. Third, in 2007, Vietnam joined the World Trade Organization. Combined, these reforms led the period we study to be one of dramatic expansion in private activity in Vietnam: today, there are well over 350,000 private companies in Vietnam, operating in a range of sectors from food processing and light manufacturing to sophisticated financial services. The degree of economic growth over this period varied substantially across provinces, as shown in Figure 4.[10]

Despite this growth, there is still substantial corruption in Vietnam. For example, most international perceptions-based indices put Vietnam around the 30th percentile of corruption (where lower is more corrupt). Similarly, Transparency International's Global Corruption Barometer reports that 44% of Vietnamese report paying a bribe in 2011 (Transparency International, 2011).

Existing research has noted that corruption in Vietnam takes three main forms: grease or speed money to fulfill basic tasks or services; the illegal privatization of state property; and the selling of state power (Vasavakul, 2008). While all are undoubtedly important, the first is the most directly observable. About grease money, Vasavakul (2008) writes that,

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[10]Figure 4 uses provinces' reports of their GDP, which, when aggregated, give a higher national GDP and growth rate than the official national statistics, which are likely more accurate. Thus, while the figure demonstrates the heterogeneity in growth across provinces, the levels shown are likely inaccurately high.

"A number of studies on informal payments [by individuals] show informal bribery totals from 100,000 to 2.1 million VND (roughly 5 to 100 USD) [per individual per year]. The key recipients are the traffic police, land cadres, custom officers, and tax authorities." These same offices were highlighted as the most corrupt in an internal study prepared by the Party's Internal Affairs Committee (Central Committee of Internal Affairs 2005). Gueorguiev and (2011) document that the same types of bribes are common for firms, finding that 23% of business paid bribes to expedite business registration, 35% paid bribes when competing for government procurement contracts, and 70% paid bribes during customs procedures.

An important institutional feature of Vietnam is that corruption is largely subnational. Due to a series of laws in the early 1990s, most business-government interactions were decentralized to the provincial level. These include business registration, environmental and safety inspections, labor oversight, local government procurement, and land allocation. In practice, provincial departments of line ministries are "dual subordinate," meaning they report both to the provincial executive (the People's Committee Chairman (PCOM)), as well as the relevant national line ministry. In practice, however, appointments of department directors and budget allocations are set by the PCOM, closely aligning department interests with those of the province. Moreover, proximity matters. The PCOM interacts with department directors regularly, while the line ministries are hundreds of kilometers away in Hanoi. As a result, many studies have documented that the provincial government, more than the central government, is the relevant level of government when thinking about the institutional climate facing firms, including the degree of bribe extraction (Meyer and Nguyen, 2005; Cung, Tuan, Van, and Dapice, 2004; Tran, Grafton, and Kompas, 2009; Malesky, 2008).

As with all measures of governance in Vietnam, there is a high degree of subnational variation in firms' responses about corruption in the data we use. Figure 5 shows the distribution across provinces of the average response by firms for two corruption questions from the PCI survey in 2010, the last year of our sample period. In the worst-scoring province, 77% of private firms reported that firms in their line of business were subject to bribe requests. In the best-scoring province, a substantially smaller 15% claimed such activities were common. Similarly high inter-provincial variation is observed for the share of revenue paid in bribes by firms - the core dependent variable in our analysis. In 2010, 16% of firms in the most corrupt province said bribe payments were greater than 10% of their annual revenue, compared to 0% in the lowest province. It is exactly this spatial variation, along with temporal and cross-industry variation, that we seek to explain in our empirical

analysis.

3.2 Description of data

To examine the effect of growth on corruption, we use two firm-level data sets from Vietnam, the Vietnam PCI Survey (Malesky, 2011), and the annual enterprise survey collected by the General Statistics Office of Vietnam, henceforth referred to as the PCI and GSO data, respectively. For each data set, we have five years of repeated cross-sectional firm-level data from 2006 to 2010.[11]

The PCI survey is a comprehensive governance survey of formal sector firms across Vietnam's 63 provinces.[12] The survey team randomly sampled from a list of at least partly private companies registered with each province's tax authority. Stratification was based on firm size, age, and broad sector (agriculture, services, construction and industry) in order to accurately reflect the population of firms in each province. The PCI survey contains basic firm-level information, including the firm's ISIC 2 digit industry code, location (province), year of establishment, total assets, and total employment.

What makes the PCI survey well-suited for our study is that it has a module on corruption and red tape faced by the firm. The most relevant question that matches our theoretical predictions is the amount of unofficial payments to public officials the firm makes, expressed as a percentage of its revenue, which maps almost precisely to b in our model. To the best of our knowledge, this dataset is the only frequently repeated cross-section of firms' corruption experiences that is representative at the sub-national level in the developing world.

In addition to corruption activities, the PCI also has various measures of property rights status that we can use as proxies for the firm's mobility, such as whether the firm owns the land that it occupies and whether firm has a Land Use Rights Certificate (LURC). We will discuss these variables in detail when we discuss the results.

Table 1 presents summary statistics for the firms in the PCI data. Note that we merge the PCI firms with aggregate information from the GSO survey at the industry-province-year level. For industry, we use the ISIC alphabetical category. Thus, the PCI firms in our

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[11]The PCI survey is conducted in the early part of each calendar year (March-June). Information about firm's business and operations refer to the previous calendar year. For variables regarding bribe payment, it is reasonable to think that firms are also reporting based on past year's experiences. We therefore lag the PCI survey by one year before merging with the GSO data. The 2006 to 2010 timeframe thus corresponds to the surveys conducted in early 2007 through early 2011 waves of the PCI survey.

[12]In 2008, Ha Tay province was merged into Ha Noi, reducing the number of provinces covered from 64 to 63.

sample are those with valid industry data and whose province-industry-year is represented in the GSO data. Our final analysis dataset contains 13,160 firms that meet this sample inclusion criterion.

As discussed above, the key dependent variable is constructed from the PCI question that asks the firm its unofficial payments as a percentage of total revenue, which corresponds to b in our model. The question is categorical, with the following possible responses: $0, < 1\%$, $1 - 2\%, 2 - 5\%, 5 - 10\%, 10 - 20\%, 20 - 30\%, > 30\%$. We transform this into a scalar variable by assigning each response the middle of the corresponding bin, using 0.5% for the $< 1\%$ category and 35% for the $> 30\%$ category. The mean of this variable is 3.8%. While this may seem small, recall that this is a percent of revenues, not profits. If firms averaged 10% net profit margins, for example, this would be the same magnitude as a 38% profit tax. (In the empirical section below, we also consider an alternative specification using ordered probit models that allows the model to determine appropriate breakpoints; results are similar).

Our empirical strategy uses aggregate shocks to a firm's industry size as predictor of the firm's size. Since the PCI is a sample, not a census, to measure the total employment in an industry in each year, we use the annual GSO census of firms in Vietnam to construct industry-level size. The GSO data includes all formal sector firms in Vietnam, both private and state-owned. We restrict our sample to private firms in order to match with the PCI, and then merge the aggregate industry-province-year GSO measures to the PCI firms, at the industry-province-year level. We use the ISIC alphabetical industry codes in both datasets for our analysis. In the final merged dataset, we have 18 distinct industry categories (see Appendix Table 1 for a description of the industries).

4   Empirical strategy

In the model laid out above, we considered the effect of a shock to A, total factor productivity, on bribes, or more specifically, bribes as a percentage of the firm's revenues. The predictions are that an increase in A should decrease the bribe rate ($Bribes$), and that this pattern should be less true when moving costs ($MovingCost$) are higher. With data on firms indexed by i in province p, industry j and time t, one could in principle translate Propositions 1 and 2 to

the data as follows.

$$Bribes_{ipjt} = \alpha + \beta A_{ipjt} + \epsilon_{ipjt} \tag{11}$$

$$Bribes_{ipjt} = \alpha + \beta A_{ipjt} + \gamma A_{ipjt} \times MovingCost_{ipjt} + \delta MovingCost_{ipjt} + \epsilon_{ipjt} \tag{12}$$

The model's predictions are that β in Equation (11) is negative, so that on average growth reduces bribes, and that γ in Equation (12) is positive, so that the reduction in bribes as A increases is smaller for firms with higher moving costs.

There are two issues with estimating Equations (11) and (12) directly. The first is a data problem: we do not directly observe TFP in the data, so, empirically, we use a firm's total employment ($Employ$) as a proxy.[13] Under the assumption that factor prices are constant, changes in employment reflect changes in A, so to the extent we can find a measure of employment that is exogenous with respect to the bribe rate b, we can replace A with $Employ$ and test the same predictions.

Of course, as is clear from Equation (1) in the model, a second issue is that employment levels are potentially endogenous to the bribe level b. Thus, we use an instrumental variable strategy to estimate Equations (11) and (12). The instrumental variable we use is employment in the firm's industry in provinces other than its own, controlling for common national year fixed effects and province-by-industry fixed effects. The IV strategy is predicated on industry-specific employment (or TFP) shocks in an industry being similar across provinces (i.e., on there being a strong first stage). The approach is similar to a Bartik shift-share instrument in that we are assuming that the size of an industry is different across provinces, but changes in the industry size within a province can be predicted by aggregate growth of the industry in other provinces. (See, for example, Bartik (1991), Blanchard and Katz (1992), and Bound and Holzer (2000)). The identification assumption is that industry-specific bribe-setting is determined independently by each province. In particular, we are ruling out a large-scale national crackdown on corruption specific to an industry, which would violate this assumption (note that a national crackdown across all industries would be absorbed by year effects and would not be a problem for our identification strategy). The assumption matches the institutional context of corruption in Vietnam as discussed above.

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[13]The reason we cannot calculate TFP directly is that we do not have measures of revenue, capital stock, and wages in our data.

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Our first stage specification is as follows:

$$\log Employ_{pjt} = \alpha + \beta \log Employ_{p^-jt} + \nu_{pj} + \mu_t + \epsilon_{pjt}. \tag{13}$$

The outcome variable, $\log Employ_{pjt}$, is log total employment for industry j in year t in province p. $\log Employ_{p^-jt}$ is log total employment for firms in industry j and year t in all provinces other than p. We control for province-industry and year fixed effects, so the specification is capturing differential changes in employment across industries over time, netting out common national time trends.

To examine the effect of exogenous productivity shocks on bribes, we estimate the reduced form equation:

$$Bribes_{ipjt} = \alpha + \beta \log Employ_{p^-jt} + \nu_{pj} + \mu_t + \epsilon_{ipjt} \tag{14}$$

The dependent variable is the amount that firm i paid in bribes as a percentage of its revenue in year t. We control for province-industry and year fixed effects, as in the first stage. The regressor of interest varies at the industry-province-year level but to correct for possibly correlated errors across time and industry, we cluster standard errors at the province level. We also estimate the IV regression, instrumenting for $\log Employ_{pjt}$ with $\log Employ_{p^-jt}$.

To explore heterogenous effects with respect to the firm's cost of relocating to another province, we add interaction terms to Equation (14):

$$\begin{aligned} Bribes_{ipjt} \;=\; & \alpha + \beta \log Employ_{p^-jt} + \delta MovingCost_{ipjt} \\ & + \gamma \log Employ_{p^-jt} \times MovingCost_{ipjt} + \nu_{pj} + \mu_t + \epsilon_{ipjt}. \end{aligned} \tag{15}$$

The prediction from the model is $\gamma > 0$, or that the negative effect of firm productivity (proxied by size) on bribes as a percent of revenue is smaller in magnitude when firms are more mobile. We test these hypotheses and present the results in the next section.

5 Results

In this section, we present evidence that a positive shock to aggregate productivity decreases unofficial payments by firms, and the decrease is bigger for firms that are more mobile, specifically those that have better property rights. These results are consistent with the model's predictions.

5.1 First stage results

We estimate the first stage regression as specified by Equation (13). To do so, we use the GSO data and compute total employment at the pjt and p^-jt level. Each observation in the regression is a pjt (province-industry-year) combination.

As discussed above, the GSO data is a census of all firms in Vietnam in a given year. We can either run the first stage for all firms, or we can restrict our sample to only private firms. Since the PCI data only contains private firms, the most appropriate aggregate measures of firm productivity to predict outcomes in the PCI are based on only using private firms, so we make this sample restriction.

We report the first stage results from estimating Equation (13) in Table 2. We classify firms into their alphabetical ISIC code (18 industries in total).[14] We report standard errors clustered at the province level throughout.

Table 2 shows that the first stage coefficient is positive and significant at the 1 percent level. The coefficient on $\log Employ_{p^-jt}$ is 0.724. This means that for a 10 percent increase in total employment in other provinces for industry j in year t, there is an 7.24 percent increase in one's own province. Theoretically, if the aggregate shock propagates to all regions equally, we should observe a coefficient of 1; the coefficient of 0.724 suggests that much but not all of the variation in productivity in Vietnam is aggregate to an industry.

Ideally, we would have constructed our instrument using the same data set that has our outcome (bribe) data. However, as discussed above, the PCI data, which has information on bribes and firm mobility, is a sample, and does not include all firms. As such, while the PCI is suitable for examining how a typical firm changes, we cannot use it for accurately calculating aggregate shocks. For example, an increase in prices for goods sold by industry j (which is equivalent to an increase in A in the model) might lead to entry of firms, so even though A increased, average firm size might decrease. For this reason, we use the GSO data, which is a census, to construct our instrument. However, before proceeding, it is important to make sure that the PCI firms are a reasonably representative sample of all firms in the GSO data, and that the industry codes we merge on are comparable across the datasets. If not, then the reduced form results from regressing bribes as measured in the PCI data on the GSO-based instrumental variable could be spurious, or null results could reflect poorly matched data.

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[14]We have an equally strong first stage using the finer two-digit ISIC codes, but the broader alphabetical codes are more robust to differences in classification across the GSO and PCI datasets.

To cross-validate the two datasets and ensure that we are matching them appropriately, we compare mean and median firm employment among private firms for each pjt group. One issue with the PCI data is that employment is coded as a categorical variable: 10 to 50, 50 to 100, etc. To assign cardinal values to these bins, we compute the empirical mean and median employment for all firms in GSO for each of these PCI bins, and use these values to create the cardinal employment measure for the PCI firms. We then run the following regression, with province-industry and year fixed effects:

$$\log Employ_{pjt}^{PCI} = \alpha + \beta \log Employ_{pjt}^{GSO} + \nu_{pj} + \mu_t + \epsilon_{pjt} \tag{16}$$

If the PCI firms are a perfect random sample of GSO firms, stratified by province, industry and year, we should have $\beta = 1$. We report the estimates in Appendix Table 2. We can see that the changes in mean employment in PCI and mean employment in GSO are positively correlated: β is about 0.7 and significant at 5% level. Similarly, the median employment in PCI and median employment in GSO are positively correlated and the coefficient is highly significant. These results confirm that, while the match between the two datasets is not perfect, they are indeed very comparable, even looking just over time at changes within a given province-industry cell.

5.2   Effect of employment growth on bribes

Our outcome variable, which measures the degree of corruption firms face, is the unofficial payments as a percentage of revenue. As discussed above, it is a categorical variable, which we linearize by using the middle of each category. We estimate two versions of Equation (14), one using the linearized variable and one using an ordered probit specification that allows the regression to determine the precise cardinalization of each of the various categories.

The results from estimating Equation (14) are shown in Table 3. Columns 1 and 2 report the reduced form results, using a linear model and an ordered probit model respectively, and Column 3 reports the IV estimate. All specifications control for province-industry and year fixed effects, and standard errors are clustered at the province level.

The reduced form results in Column 1 show that the coefficient for $\log Employ_{p-jt}$ is -1.72, and significant at the 5 percent level. Growth in firm employment leads to a drop in the rate of bribe extraction from firms. Column 2 reports the results from an ordered probit specification. The coefficient is again negative and significant at the 5 percent level. The

ordered probit results suggest that the negative relationship shown in column 1 is not merely driven by the OLS functional form. Column 3 shows the IV coefficient, which suggests that a 10 percent increase in a firm's employment level leads to a 0.23 percentage point decline in the bribe rate.

To interpret magnitudes, note that column 3 implies that a doubling of total employment in the industry is associated with a 1.6 percentage point reduction in informal payments, or about 42% of the mean level. Translated into an elasticity, this suggests an elasticity of the informal payment rate (i.e. the share of revenues devoted to informal payments) with respect to predicted firm size of about -0.6. Note that since this elasticity is substantially less than 1 in absolute value, it implies that while the share of firm revenues paid in bribes (i.e. b in the model) declines as A increases, total unofficial payments, which are b multiplied by revenues, increase. While of course b is the key parameter that determines aggregate distortions due to corruption (see Equation (3)), it is worth noting that given this elasticity, the amount of corruption in absolute dollar terms actually increases even though the rate does not, consistent with the model's predictions.

5.3 Heterogeneous effects based on firms' moving costs

While the evidence presented thus far is consistent with the model, the specific inter-jurisdictional competition idea outlined in our model is not the only explanation for why an increase in employment reduces bribes. For example, it is possible that bureaucrats simply have diminishing marginal utility of income relative to the risk of being caught and going to jail, so that as it becomes easier to extract revenues, they reduce rates. However, a key prediction of our model, as opposed to potential alternative explanations, is that the effect of an increase in A on the bribe rate b should be greater in magnitude when firms are more mobile.

To examine this prediction, we examine heterogeneity in the effect of shocks to A based on measures that seem plausibly correlated with firm mobility. In particular, we examine heterogeneity across firms with differing property rights over the land they operate on.

In Vietnam, firms can have three types of tenure over the land on which they operate: renting, owning the land with official land use rights, and owning the land without official land use rights.[15] Specifically, for firms that have purchased their land, they may or may not

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[15]Note that while we use the term "own," the more precise term would be "purchased" since in Vietnam, firms can purchase land, but in a technical sense, the state still owns all of the land.

have a land use rights certificate (LURC). Conditional on having purchased land, having an LURC makes it easier for the firm to move, because the firm can sell or trade its certificate if it decides to relocate to another province. However, if a firm purchased the land it occupies but does not have a land use rights certificate, it is difficult for the firm to move for two reasons. First, it is costly and difficult to obtain land in a new province for business operations. More importantly, however, firms without LURCs will have difficulty obtaining the true commercial value of their land when they try to sell. Land without LURCs is known to be less valuable, as it can easily be expropriated by local authorities (Kim, 2004; Do and Iyer, 2003). Consequently, they will find it more difficult to relocate. It is not ex ante obvious whether firms that rent face higher or lower relocation costs than those that own. For example, renters cannot recoup the value of any improvements they made to the property and may be locked into hard-to-renegotiate long-term leases, but they do not face transaction costs from having to sell property. What is clear though is that conditional on owning, transaction costs are lower for those with an LURC. We therefore examine heterogeneity across these different levels of moving costs: firms that rent land versus purchased land, and conditional on having purchased land, firms that have LURCs versus those that do not.

We estimate a model that interacts $Employ_{p-jt}$ with these measures of property rights. In general, since we have a repeated cross-section of firms, not a panel, there is a potential endogeneity problem if we use θ at the firm level (e.g., firms could adjust their θ in response to a shock in A). For the LURC variable, we know the year the firm acquired the certificate, so we can also use lagged values of LURC ownership to address this concern.[16] In addition to interacting these measures of movings costs with $Employ_{p-jt}$, we also show the results controlling for the interaction of $Employ_{p-jt}$ with average firm size in the industry to isolate the effects of land ownership status from other general industry characteristics, in case land ownership and LURC status are correlated with firm size.

The first two columns of Table 4 examine heterogeneity based on whether the firm owns its land as opposed to renting it. The coefficient on the interaction term is negative, though not statistically significant. As mentioned above, it is not theoretically obvious whether firms that rent or own have more mobility.

Columns 3 and 4 of Table 4 compare firms that own land and have an LURC against the omitted category of all other firms, either those that are renting or holding a long-term

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[16]Unfortunately, we do not know the year the firm purchased its land, so we cannot do the analogous exercise for land ownership. In Appendix Table 3 , we show the results of using contemporaneous LURC.

lease. The coefficient on the interaction with log employment is negative and significant at the 1 percent level, suggesting indeed that those who own land and have LURCs have the largest reduction in bribe rates as predicted employment increases. This is consistent with the predictions of Proposition 2.

Columns 5 and 6 include both sets of interactions. Here, since we have also included the interaction with firm owning land and employment, the coefficient on the interaction of *Firm owns land and has LURC×log(Employ)* is now the additional impact of owning an LURC conditional on owning land, i.e. comparing firms that own land and have a LURC with those that own land and do not have an LURC. The coefficient continues to be negative. Across all 6 columns, it is important to note that the coefficient on the interactions are not sensitive to whether we control for firm size interacted with log employment, suggesting that the land ownership and LURC variables are really picking up something about the land characteristics rather than industries with larger or smaller firms.

To interpret the magnitudes, recall that the overall average reduced form coefficient of increasing employment on reduced corruption (from Table 3) is -1.7. The results in column 3 suggest that the impact is about 17 (=0.29/1.7) percent larger in magnitude for firms with a LURC than those without it.

In sum, the estimates suggest that, first, positive economic shocks reduce corruption, and, second, that corruption falls faster in response to positive economic shocks when firms are more elastic in their location choices.[17]

6   Conclusion

This paper establishes two empirical facts. The first is that economic growth (as measured by higher employment for a firm or industry) reduces the proportion of firms' revenues extracted as bribes. The second is that the reduction in corruption caused by economic growth is larger in magnitude for firms that can more easily relocate due to stronger property rights over their land.

These two facts map to the two main contributions of the paper. The first is a simple

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[17]We have also estimated ordered probit reduced form specifications for the three categories of firms: firms that rent the land they operate on, firms that own their land but do not have an LURC, and firms that own their land and have an LURC. Results are presented in Appendix Table 4. The coefficient estimates are consistent with the findings for the linear model in that the most negative impact of economic shocks on the bribe rate is observed for firms that own their land and have an LURC. We run separate ordered probit models on the subsamples because the interacted model is computationally infeasible.

but important empirical contribution: we provide causal evidence on the effect of economic growth on the amount of corruption in an economy. Despite much interest in the relationship between corruption and development, there exists very little credible evidence of a causal relationship. The challenge is finding a way to separate causation from just correlation. We provide rigorous evidence by using subnational variation and an often-used identification strategy based on aggregate-level (national) shocks outside of a subnational region as a source of plausibly exogenous variation in the region.

What makes this Bartik-style identification strategy both possible and plausible is the setting: Vietnam. We make use of a unique data set that collects data from firms on their bribe payments to government officials and is available for several years, samples firms from several industries, and is representative at the province level. In addition, the institutional context of Vietnam makes our key identifying assumption plausible. A limitation of this general class of aggregate-shock empirical strategies is that there could be reverse causality bias if there are aggregate shocks to the outcome (bribes), which in turn affect the independent variable (economic activity). Corruption likely does affect economic activity, but what addresses this concern in our context is that nationwide shocks to corruption are unlikely. There is a large body of research in political science showing that corruption is decentralized in Vietnam, and provincial governments independently determine the level of bribes extracted from firms in their jurisdiction.

Our second contribution is to lay out a mechanism through which economic growth reduces corruption. We model provincial governments' decisions about bribe extraction. Competition among provinces to retain or attract firms is the mechanism that keeps corruption in check. Not surprisingly, then, if firms are more able to relocate, a government will be more cautious about extracting bribes from it. Less obvious is how a change in economic activity affects corruption. There are offsetting forces. As a firm grows, a given increase in the bribe rate would translate into a larger increase in bribe revenues extracted from the firm. On the other hand, the larger a firm is, the more it would benefit from moving to a different region with a lower bribe rate. We show that under the plausible assumption that a firm's moving costs scale up less than one-for-one with its size, economic growth leads to a decline in the rate of bribe extraction. We also derive the prediction that this effect of economic growth on bribe extraction is larger in magnitude for firms with lower moving costs. Our second empirical fact described above—that the effect of growth on corruption is larger for firms with transferable rights to their land—is consistent with this prediction, suggesting that the

mechanism of inter-provincial competition is indeed important in determining the degree of corruption in an economy.

Our results have several implications for understanding the determinants of corruption in developing countries. The finding that growth reduces corruption suggests that corruption might decline naturally as a country grows even without explicit anti-corruption efforts. Meanwhile, the mechanism of inter-jurisdictional competition offers ways that a national government might expedite the decline in corruption. Most directly tied to our empirical findings, strengthening property rights so that firms can more easily recoup the value of their land if they move would strengthen the competition among jurisdictions and hence the corruption-reducing effect of growth. More generally, reducing any barriers to firm mobility, for example related to business registration, would amplify the negative effect of growth on corruption. The results also highlight a complex interplay between growth and institutions. The fact that economic growth is most successful in reducing corruption when coupled with strong property rights implies a complementarity between policies to strengthen institutions and to promote growth, and a mechanism through which strengthening institutions can be self-reinforcing.

Finally, it is important to note that while we have implemented the idea of economic growth and firm mobility as forces for reducing corruption within a single country, similar ideas could work across countries as well. For example, multinationals face a choice of which countries to locate in or to source their products from. As they grow, it becomes more worthwhile to pay a cost to move to a country with lower corruption, and as long as that cost is concave in firm size, this will lead to countries to reduce bribe rates in an attempt to prevent too many firms from switching. This effect will be larger in industries with low switching costs across countries, like textiles, than in industries with high switching costs, such as mining. We leave exploration of these issues for future work.

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Figure 1: Cross-Country Relationship Between GDP and Corruption

## Panel A. Transparency International Corruption Index (2005)
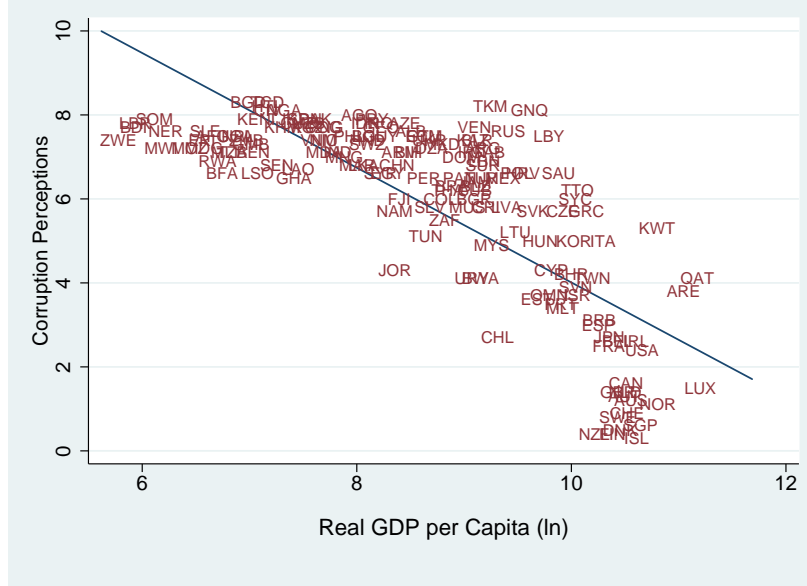
## Panel B. World Bank Control of Corruption (2005)
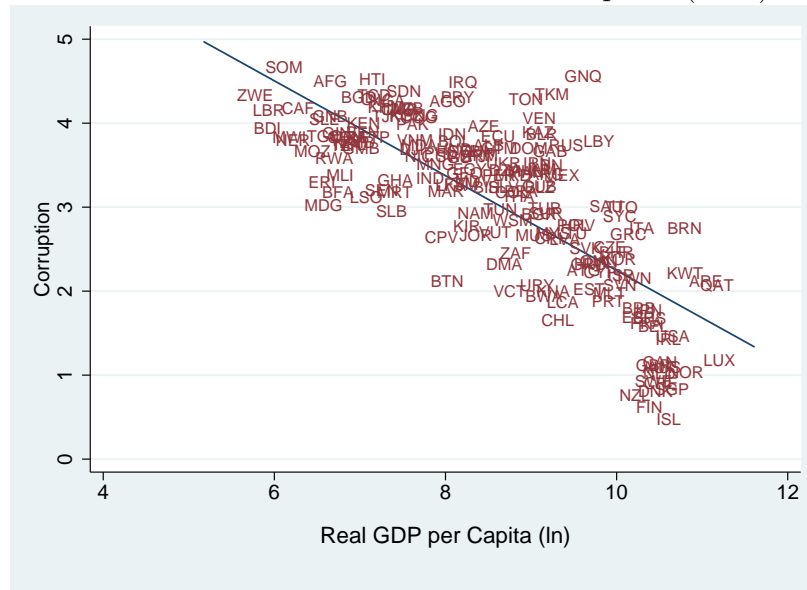
In Panel A, the Corruption Perception Index (CPI) defines corruption as the abuse of public office for private gain. The CPI Score measures perceptions of the degree of corruption as seen by business people, risk analysts and the general public and ranges between 10 (highly corrupt) and 0 (highly clean). In Panel B, Control of Corruption measures perceptions of corruption, conventionally defined as the exercise of public power for private gain. It ranges between 5 (highly corrupt) and 0 (highly clean). In both panels, the x-axis is the log of PPP Converted GDP Per Capita (Chain Series), at 2005 constant prices.

Figure 2: Relationship Between GDP and Corruption Using Survey Data from Firms
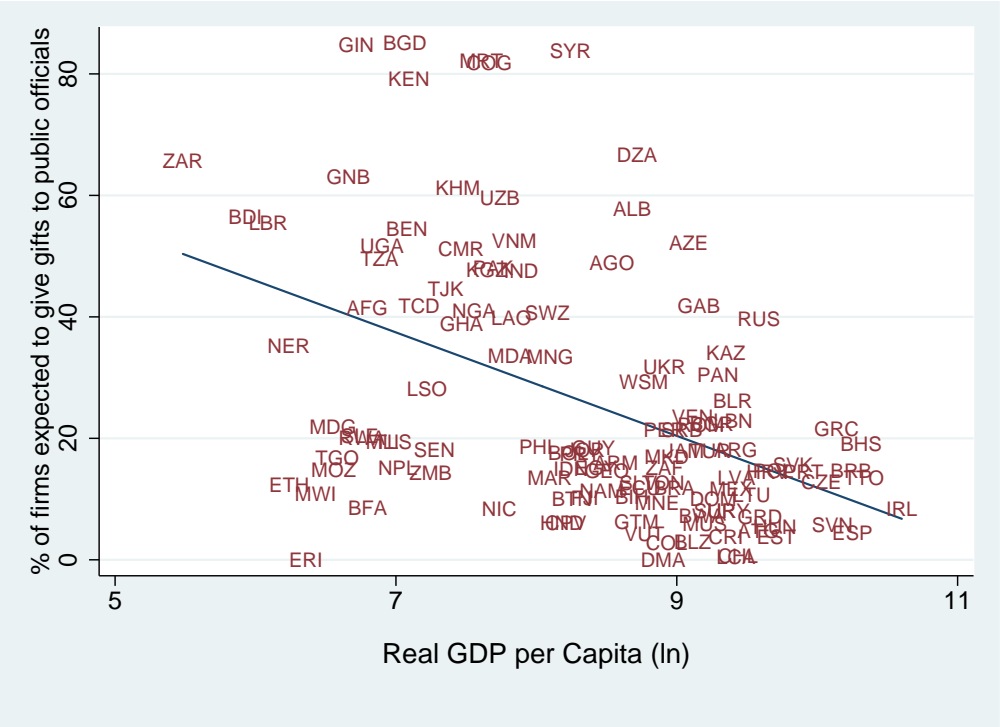
This figure plots the percentage of firms who expect to give gifts to public officials to get things done for 122 countries in the World Bank Enterprise Survey. For each country, we use the year that the country is most recently surveyed. The x-axis is the log of PPP-adjusted GDP per capita (Chain Series), at 2005 constant prices.

Figure 3: Time Trend in Bribes and GDP in Vietnam
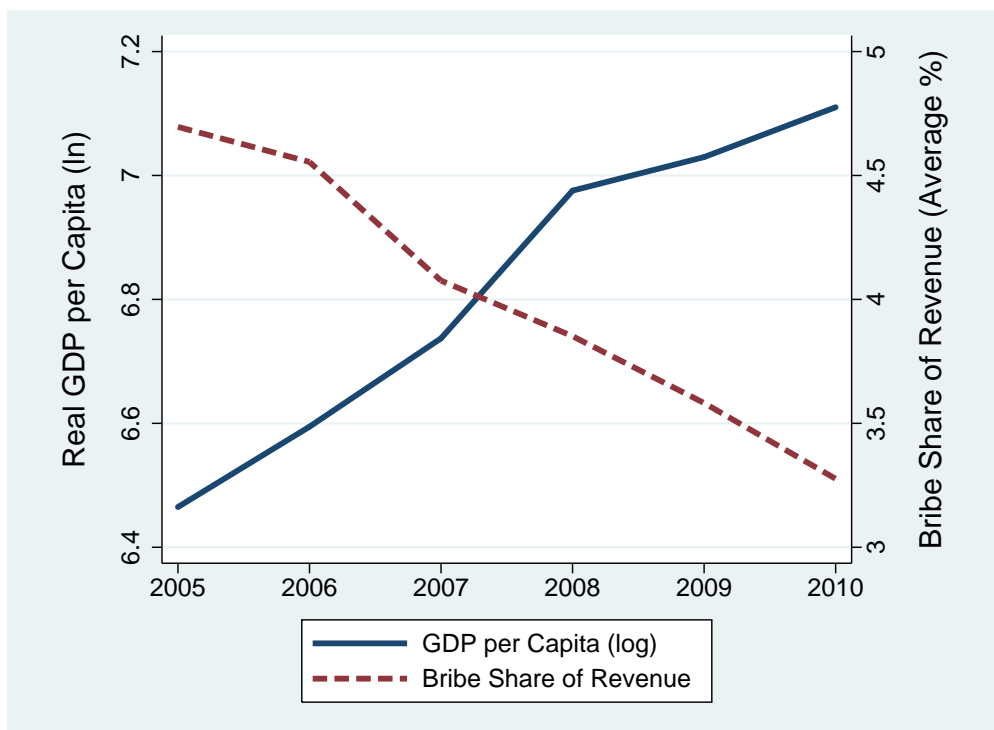
This figure plots real GDP per capita and the average amount of bribe as a share of revenue paid by firms in Vietnam from 2005 to 2010. The bribe share variable is averaged across all firms surveyed in the PCI for the corresponding year.

Figure 4: Average Annual GDP Growth by Province in Vietnam (2006-2010)
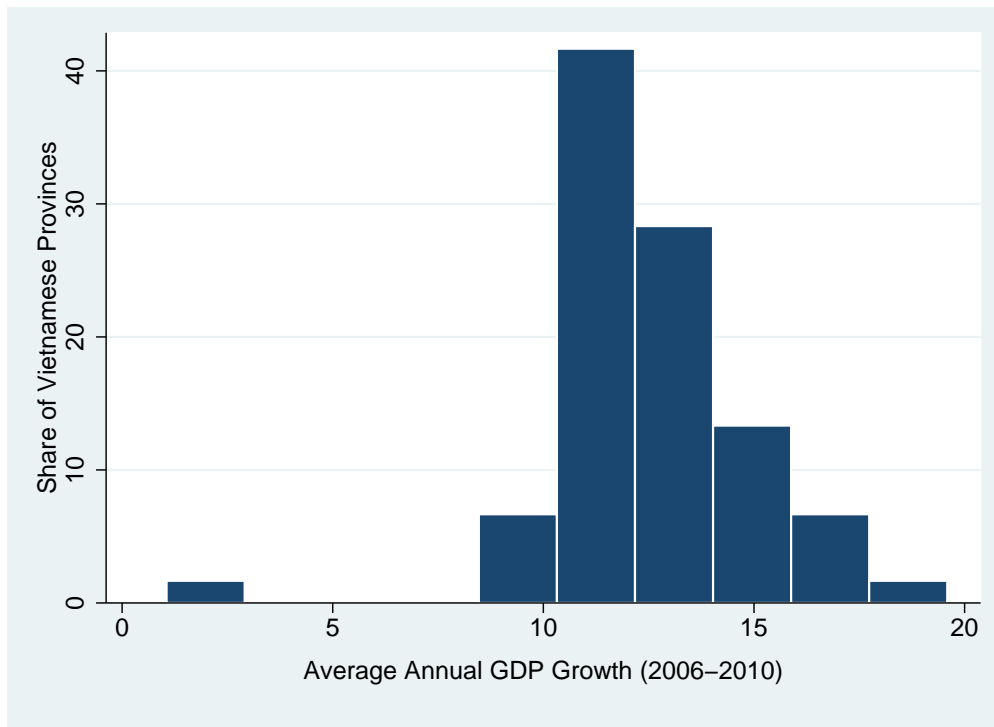
This figure plots the distribution of average annual GDP growth across provinces in Vietnam from 2006 to 2010. We have excluded provinces that reported implausibly high growth rate over this period (over 20%) as these numbers are very much likely overstated.

Figure 5: Variation in Corruption across Provinces in Vietnam
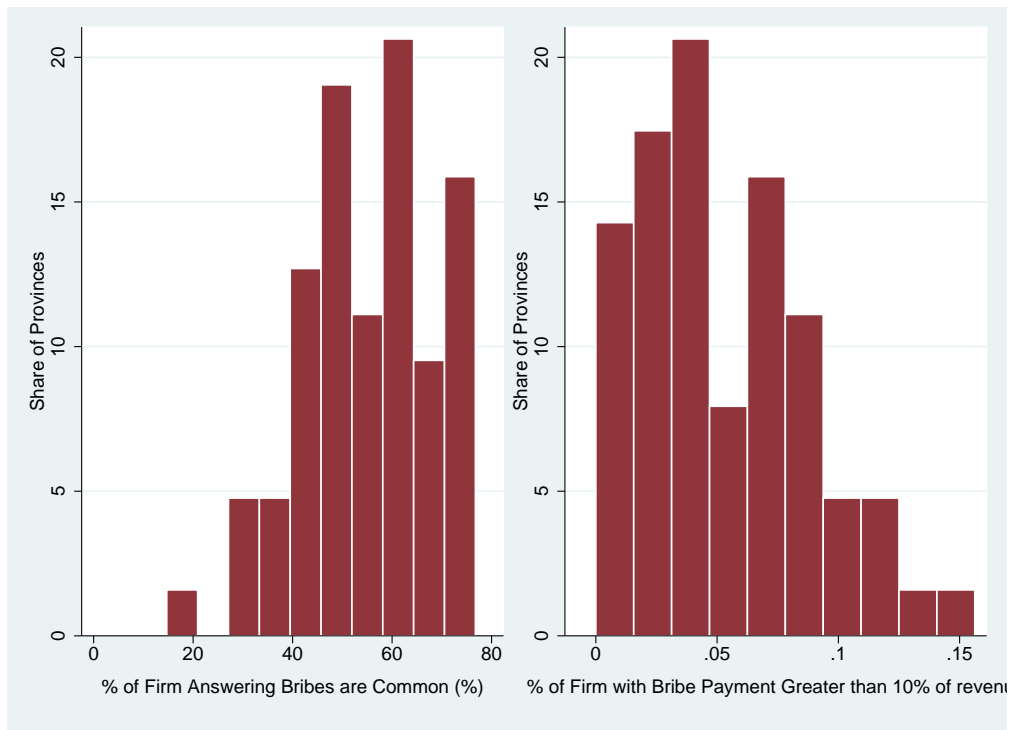
This figure plots the distribution of corruption across provinces in Vietnam, using data from the 2010 PCI survey. The bribe variables are averages across all firms surveyed within a province. The variable in the left panel is a dummy that equals 1 if the firm responds "strongly agree" or "agree" to the following statement: "It's common for firms like mine to pay informal charges." The variable in the right panel is a dummy that equals 1 if the firm paid more than 10% of revenues as bribes to public officials.

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Table 1: Summary Statistics of Firms

	Observations	Mean	Std Dev
Bribes as percentage of revenue (%)	13,160	3.800	5.671
Years since establishment	12,846	5.505	6.317
Employment	12,011	102.474	305.382
Land ownership (dummy)	13,160	0.726	0.446
Land use right certificate (dummy)	13,160	0.575	0.494
Land ownership without land use right certificate (dummy)	13,160	0.139	0.346

Note: Each observation is a firm, and we pool the sample of firms over all years from 2006 to 2010. The PCI firms in our sample are those with valid industry and bribe payment data and whose province-industry-year is represented in the GSO data. The summary statistics reported in this table are for the 13,160 firms that meet this sample inclusion criterion. Note that the PCI employment variable is categorical and we recode each category with the corresponding empirical cell mean from the GSO data.

Table 2: First Stage Results

	Dep. var.: Log total employment (own-province-industry-year level)
Log total employment	0.724***
(industry-year level, excluding own province)	(0.107)
Observations	3,873
R-squared	0.958
Province–industry and year fixed effects	✓

Note: Each observation is a province-industry-year. The dependent variable is log total employment in the province-industry-year. The independent variable is log total employment of the same industry-year in all provinces other than own. Both variables are calculated using the GSO Enterprise Survey data. Industry refers to an ISIC alphabetical industry code. The regression controls for province-industry and year fixed effects. Standard errors are clustered at the province level. *** implies significance at 0.01 level, ** 0.5, * 0.1.

Table 3: Effect of Economic Performance on Bribes

Dependent variable: Firm's bribe payment as percentage of revenue

	(1) RF: OLS	(2) RF: Ordered Probit	(3) IV
Log total employment	-1.723**	-0.275**	
(at industry-year level, excluding own province)	(0.76)	(0.131)	
Log total employment			-2.302**
(own-province-industry-year level)			(1.00)
Province–industry and year fixed effects	✓	✓	✓
Observations	13,160	13,160	13,160

Note: The dependent variable is the firm's bribe payment as percentage of revenue. This is coded as a categorical variable in the data: 0%, 0.5%, 1.5%, 7.5%, 15%, 25%, 35%. Industries refer to ISIC alphabetical industry codes. All regressions control for province-industry and year fixed effects. Standard errors are clustered at the province level. *** implies significance at 0.01 level, ** 0.5, * 0.1.

Table 4: Heterogeneous Effects Based on Firms' Property Rights

Dependent variable: Firm's bribe payment as percentage of revenue

	(1)	(2)	(3)	(4)	(5)	(6)
Log total employment	-1.626**	6.328	-1.583*	7.485	-1.598**	7.33
(at industry-year level, excluding own province)	(0.751)	(4.635)	(0.798)	(5.236)	(0.785)	(5.277)
Firm owns its land	2.751*	2.709*			2.518	2.475
	(1.564)	(1.55)			(2.024)	(2.004)
Firm owns its land X log(Employ)	-0.186	-0.183			-0.139	-0.136
	(0.116)	(0.115)			(0.152)	(0.151)
Firm owns land and has LURC			3.891***	3.817***	2.393	2.345
			(1.426)	(1.419)	(1.574)	(1.582)
Firm owns land and has LURC X log(Employ)			-0.291***	-0.286***	-0.206*	-0.203*
			(0.104)	(0.103)	(0.115)	(0.116)
Observations	13,160	13,160	11,486	11,486	11,486	11,486
Control for average firm size X log(Employ)	NO	YES	NO	YES	NO	YES
Province–industry and year fixed effects	✓	✓	✓	✓	✓	✓

Note: The dependent variable is the firm's bribe payment as percentage of revenue. This is coded as a categorical variable in the data: 0%, 0.5%, 1.5%, 7.5%, 15%, 25%, 35%. The interaction term is the product of log total employment of the same industry-year group in all provinces other than own and firm-level property rights. Industries refer to ISIC alphabetical industry codes. All regressions control for province-industry and year fixed effects. Standard errors are clustered at the province level. *** implies significance at 0.01 level, ** 0.5, * 0.1.

Appendix Table 1: Industry Codes and Descriptions

ISIC Rev 4 Code	Description
A	Agriculture, forestry and fishing
B	Mining and quarrying
C	Manufacturing
D	Electricity, gas, steam and air conditioning supply
E	Water supply; sewerage, waste management and remediation activities
F	Construction
G	Wholesale and retail trade; repair of motor vehicles and motorcycles
H	Transportation and storage
I	Accommodation and food service activities
J	Information and communication
K	Financial and insurance activities
L	Real estate activities
M	Professional, scientific and technical activities
N	Administrative and support service activities
P	Education
Q	Human health and social work activities
R	Arts, entertainment and recreation
S	Other service activities

The alphabetical industry codes and descriptions are based on International Standard Industrial Classification (ISIC) of All Economic Activities, Rev.4. The list includes the 18 industries that appear in our analysis sample.

Appendix Table 2: Cross-Validation of PCI and GSO Data

	(1) Mean Employment in PCI data	(2) Median Employment in PCI data
Corresponding variable	0.691**	0.463**
in GSO data	(0.301)	(0.174)
Observations	4,607	4,607
R-squared	0.607	0.598
Province–industry and year fixed effects	✓	✓

Note: Each observation is a province-industry-year. The dependent variable is the mean or median firm-level employment for each province-industry-year group in the PCI data. The independent variable is the corresponding variable computed using the GSO data. For both datasets, we keep only private firms. Since the firm employment variable in PCI is categorical, we compute the empirical mean and median for each category from the GSO data and apply these to the PCI data. All specifications control for province by industry and year fixed effect. Industries refer to ISIC 2-digit industry code. Robust standard errors are clustered at the province level and reported. *** implies significance at 0.01 level, ** 0.5, * 0.1.

Appendix Table 3: Heterogeneous Effects Based on Firms' Property Rights (Contemporaneous Measure of LURC)

Dependent variable: Firm's bribe payment as percentage of revenue

	(1)	(2)	(3)	(4)	(5)	(6)
Log total employment	-1.626**	6.328	-1.534**	7.509	-1.570**	7.404
(at industry-year level, excluding own province)	(0.751)	(4.635)	(0.762)	(5.212)	(0.76)	(5.27)
Firm owns its land	2.751*	2.709*			2.235	2.204
	(1.564)	(1.55)			(2.169)	(2.167)
Firm owns its land X log(Employ)	-0.186	-0.183			-0.114	-0.111
	(0.116)	(0.115)			(0.164)	(0.163)
Firm owns land and has LURC			3.939**	3.858**	2.448	2.39
			(1.792)	(1.784)	(2.193)	(2.217)
Firm owns land and has LURC X log(Employ)			-0.290**	-0.284**	-0.213	-0.209
			(0.132)	(0.131)	(0.162)	(0.164)
Observations	13,160	13,160	11,486	11,486	11,486	11,486
Control for average firm size X log(Employ)	NO	YES	NO	YES	NO	YES
Province–industry and year fixed effects	✓	✓	✓	✓	✓	✓

Note: The dependent variable is the firm's bribe payment as percentage of revenue. This is coded as a categorical variable in the data: 0%, 0.5%, 1.5%, 7.5%, 15%, 25%, 35%. The interaction term is the product of log total employment of the same industry-year group in all provinces other than own and firm-level property rights. Industries refer to ISIC alphabetical industry codes. Standard errors are clustered at the province level. *** implies significance at 0.01 level, ** 0.5, * 0.1.

Appendix Table 4: Heterogeneous Effects Based on Firms' Property Rights (Ordered Probit)

Dependent variable: Firm's bribe payment as percentage of revenue

	(1) Firms that rent their land	(2) Firms that own land without LURC	(3) Firms that own land with LURC
Log total employment	-0.018	0.638	-0.396
(at industry-year level, excluding own province)	(0.247)	(0.461)	(0.257)
Observations	3,610	1,760	5,183
Province–industry and year fixed effects	✓	✓	✓

Note: This table reports the reduced form results using the ordered probit model for firms in three categories: (1) firms that rent their land; (2) firms that own land without an LURC; (3) firms that own land with an LURC. All regressions control for province-industry and year fixed effects. Standard errors are clustered at the province level. *** implies significance at 0.01 level, ** 0.5, * 0.1.

Appendix: Mathematical Details of the Model

Part I: Bribe as Revenue Tax

Consider a firm in region 1. Given tax rates b_1 and b_2, the firm chooses capital and labor to maximize profit. Then the firm compares profits in region 1 and region 2, and decides whether to stay or relocate. Firm solves:

$$\max_{K \geq 0, L \geq 0} (1-b)AK^\alpha L^\beta - wL - rK \tag{1}$$

We get,

$$\frac{L^*}{K^*} = \frac{r}{w}\frac{\beta}{\alpha} \tag{2}$$

$$K^* = \left(\frac{r}{(1-b)A\alpha} \left(\frac{r}{w}\frac{\beta}{\alpha} \right)^{-\beta} \right)^{\frac{1}{\alpha+\beta-1}} := \psi^{\frac{1}{\alpha+\beta-1}} \tag{3}$$

$$\pi^* = (1-b)AK^{*\alpha}L^{*\beta} - wL^* - rK^* \tag{4}$$

Similarly to above, firm chooses to stay in own iff $\epsilon \geq \dfrac{\pi_2^* - \pi_1^*}{\theta K^{*\eta}}$.

Assumption 1. *Firms have Cobb-Douglas production function with diminishing return to scale in capital and labor.*

Assumption 2. *Capital and labor are perfectly elastically supplied at exogenous wage rate w and interest r.*

Assumption 3. *ϵ is uniformly distributed on $[0,1]$.*

Given the firm's decision as a function of bribe, government in region 1 solves (the problem is symmetric for region 2):

$$\max_{b_1 \geq 0} b_1 AK^{*\alpha}L^{*\beta} \left(1 - \frac{\pi_2^* - \pi_1^*}{\theta K^{*\eta}} \right) \tag{5}$$

FOC (assuming symmetric equilibrium):

$$K^* + b_1^*(\alpha + \beta)\frac{dK^*}{db_1} + \frac{b_1^*}{\theta}K^{*1-\eta}\frac{d\pi_1^*}{db_1} = 0 \tag{6}$$

After some algebra, we get:

$$\left(\frac{1}{\theta}A\left(\frac{r\beta}{w\alpha} \right)^\beta K^{*\alpha+\beta-\eta} - (\alpha+\beta)\frac{1}{\alpha+\beta-1}\frac{1}{1-b^*} \right) b^* = 1 \tag{7}$$

As θ goes to $+\infty$, we have $\dfrac{\alpha+\beta}{1-\alpha-\beta}\dfrac{b^*}{1-b^*} = 1, \Rightarrow b^* = 1-\alpha-\beta$

Next we calculate $\dfrac{db^*}{dA}$ by taking derivative of the FOC:

$$\frac{db^*}{dA} = \frac{b^*\left(1 - \dfrac{\alpha + \beta - \eta}{\alpha + \beta - 1}\right)}{\dfrac{\theta}{(1 - b^*)^2}\dfrac{\alpha + \beta}{\alpha + \beta - 1}\left(\dfrac{w\alpha}{r\beta}\right)^{\beta}K^{*\eta - \alpha - \beta} - A\left(1 + \dfrac{b^*}{1 - b^*}\dfrac{\alpha + \beta - \eta}{\alpha + \beta - 1}\right)} \tag{8}$$

Claim 1. $1 + \dfrac{b^*}{1 - b^*}\dfrac{\alpha + \beta - \eta}{\alpha + \beta - 1} > 0.$

Proof. From Equation (7), we get $1 + \dfrac{b^*}{1 - b^*}\dfrac{\alpha + \beta}{\alpha + \beta - 1} > 0.$ ∎

Proposition 1. $\dfrac{db^*}{dA} < 0$ *if* $0 \leq \eta < 1$; $= 0$ *if* $\eta = 1$; > 0 *if* $\eta > 1$.

Proof. : Using $1 + \dfrac{b^*}{1 - b^*}\dfrac{\alpha + \beta - \eta}{\alpha + \beta - 1} > 0$ and Equation (8). ∎

Next, we examine the cross partial with respect to θ. Note that $b^* \to 1 - \alpha - \beta$ as $\theta \to +\infty$ and $b^* \to 0$ as $\theta \to 0^+$. From Equation (8), easy to show that $\dfrac{db^*}{dA} \to 0^-$ as $\theta \to +\infty$ and $\theta \to 0^+$. We hypothesize that the graph of $\dfrac{db^*}{dA}$ against θ is U-shaped.

We solve the model using Matlab and plot $\dfrac{db^*}{dA}$ against θ for different parameter values. Simulations from Matlab show that $\dfrac{d^2 b^*}{dAd\theta} > 0$ for large values of θ where the ratio of moving cost to revenue is above 1:10. Next, we prove analytically that the elasticity of equilibrium tax rate with respect to A is monotonically decreasing in θ.

Claim 2. : $\dfrac{db^*}{d\theta} > 0.$

Proof. : Recall Equation (7),

$$\left(\frac{1}{\theta}A\left(\frac{r\beta}{w\alpha}\right)^{\beta}K^{*\alpha + \beta - \eta} - (\alpha + \beta)\frac{1}{\alpha + \beta - 1}\frac{1}{1 - b^*}\right)b^* = 1 \tag{9}$$

Take derivative with respect to θ and re-arrange, we get:

$$\frac{db^*}{d\theta}\left(\frac{A(r\beta/w\alpha)^{\beta}}{\theta}\left(1 + \frac{\alpha + \beta - \eta}{\alpha + \beta - 1}\frac{b^*}{1 - b^*}\right) + \frac{\alpha + \beta}{1 - \alpha - \beta}\frac{K^{*\eta - \alpha - \beta}}{(1 - b^*)^2}\right) = \frac{b^* A(r\beta/w\alpha)^{\beta}}{\theta^2} \tag{10}$$

Using Claim 2, it is easy to see that $\dfrac{db^*}{d\theta} > 0.$ ∎

Proposition 2. *The elasticity* $-\dfrac{db^*}{dA}\dfrac{A}{b^*}$ *is monotonically decreasing in* θ *when* $0 \leq \eta < 1$.

Proof. : From Equation (8)

$$-\frac{db^*}{dA}\frac{A}{b^*} = \frac{1 - \dfrac{\alpha+\beta-\eta}{1-\alpha-\beta}}{\dfrac{\theta}{A(1-b^*)^2}\dfrac{\alpha+\beta}{1-\alpha-\beta}\left(\dfrac{w\alpha}{r\beta}\right)^\beta K^{*\eta-\alpha-\beta} + \left(1 + \dfrac{b^*}{1-b^*}\dfrac{\alpha+\beta-\eta}{\alpha+\beta-1}\right)} \tag{11}$$

Recall Equation (7),

$$\left(\frac{1}{\theta}A\left(\frac{r\beta}{w\alpha}\right)^\beta K^{*\alpha+\beta-\eta} - (\alpha+\beta)\frac{1}{\alpha+\beta-1}\frac{1}{1-b^*}\right)b^* = 1 \tag{12}$$

Substitute for $\theta K^{*\eta-\alpha-\beta}$ and rearrange, we can re-write the denominator as:

$$\frac{b^*}{1-b^*}\left(\frac{\alpha+\beta}{1-\alpha-\beta-b^*} - \frac{\alpha+\beta-\eta}{1-\alpha-\beta}\right) + 1 \tag{13}$$

Easy to see that the denominator increases in magnitude as b^* increases. Since we have shown that b^* increases in θ, this implies that as θ increases, $-\dfrac{db^*}{dA}\dfrac{A}{b^*}$ decreases. ∎

Finally, we show that our results can generalized to arbitrary distribution of ϵ. For general CDF $F()$ of ϵ, the government's problem is:

$$\max_{b_1\geq 0} b_1 A K^{*\alpha}L^{*\beta}\left(1 - F\left(\frac{\pi_2^*-\pi_1^*}{\theta K^{*\eta}}\right)\right) \tag{14}$$

Assuming symmetric equilibrium, the FOC can be simplified to:

$$K^* + b_1^*(\alpha+\beta)\frac{dK^*}{db} + \frac{b_1^*}{\theta}K^{*1-\eta}\frac{f(0)}{1-F(0)}\frac{d\pi_1^*}{db} = 0 \tag{15}$$

This is exactly the same as the FOC for uniform distributed ϵ except the term $\dfrac{f(0)}{1-F(0)}$. However, we can just interpret that term as multiplying θ. All the above claims and propositions hold true.

Part II: Bribe as Capital Tax

Firm solves (abbreviating region subscript since firm's problem is identical)

$$\max_{K\geq 0, L\geq 0} AK^\alpha L^\beta - wL - (r+b)K \tag{16}$$

$$\text{FOC:}\quad A\alpha K^{*\alpha-1}L^\beta = r+b \tag{17}$$
$$A\beta K^{*\alpha}L^{*\beta-1} = w \tag{18}$$

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Solve for optimal capital and labor,

$$\frac{L^*}{K^*} = \frac{r+b}{w}\frac{\beta}{\alpha} \tag{19}$$

$$K^* = \left(\frac{r+b}{\alpha A}\left(\frac{r+b}{w}\frac{\beta}{\alpha}\right)^{-\beta}\right)^{\frac{1}{\alpha+\beta-1}} := \psi^{\frac{1}{\alpha+\beta-1}}$$

Firm's profit in region 1 is

$$\pi_1^* = AK^{*\alpha}L^{*\beta} - wL^* - (r+b_1)K^* \tag{20}$$

Firm chooses to stay in region 1 iff:

$$\pi_1^* \geq \pi_2^* - \theta K^{*\eta}\epsilon \tag{21}$$

$$\epsilon \geq \frac{\pi_2^* - \pi_1^*}{\theta K^{*\eta}} \tag{22}$$

Total moving cost is $\theta K^{*\eta}\epsilon$, where θ captures the industry's mobility factor- higher θ means less mobility, and ϵ is a stochastic error term. [18]

The fraction of firms that stay in region 1 is $1 - \frac{\pi_2^* - \pi_1^*}{\theta K^{*\eta}}$.

Government in region 1 solves:

$$\max_{b_1 \geq 0} b_1 K^* \left(1 - \frac{\pi_2^* - \pi_1^*}{\theta K^{*\eta}}\right) \tag{26}$$

$$\max_{b_1 \geq 0} b_1 K^* - b_1 \frac{\pi_2^* - \pi_1^*}{\theta} K^{*1-\eta} \tag{27}$$

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[18]Suppose we don't impose any distributional form assumption on ϵ, we show that our results from assuming uniform distribution can be generalized. The argument is essentially the same as that for revenue bribe.

Government in region 1 solves

$$\max_{b_1 \geq 0} b_1 K^* \left(1 - F\left(\frac{\pi_2^* - \pi_1^*}{\theta K^{*\eta}}\right)\right) \tag{23}$$

FOC and assuming symmetric equilibrium, we get:

$$\left(\frac{1}{\theta}K^{*1-\eta}\frac{f(0)}{1-F(0)} - \frac{1-\beta}{\alpha+\beta-1}\frac{1}{r+b_1^*}\right)b_1^* = 1 \tag{24}$$

And, we have

$$\frac{db_1^*}{dA} = \frac{b_1^*(1-\eta)K^{*-\eta}\dfrac{dK^*}{dA}}{\dfrac{r}{r+b_1^*}\dfrac{1-F(0)}{f(0)}\dfrac{\theta}{K^*}\dfrac{dK^*}{db} - K^{*1-\eta}} \tag{25}$$

Note that the results are exactly the same as assuming uniform except that θ is multiplied by a constant term $\frac{1-F(0)}{f(0)}$.

FOC:

$$b_1^* \frac{dK^*}{db_1} + K^* - \frac{\pi_2^* - \pi_1^*}{\theta} K^{*1-\eta} - b_1^* \left((1-\eta) K^{*-\eta} \frac{dK^*}{db_1} \left(\frac{\pi_2^* - \pi_1^*}{\theta} \right) - \frac{1}{\theta} K^{*1-\eta} \frac{d\pi_1^*}{db_1} \right) = 0 \quad (28)$$

Assuming symmetric equilibrium $\pi_1^* = \pi_2^*$, we get

$$b_1^* \frac{dK^*}{db_1} + K^* + \frac{b_1^*}{\theta} K^{*1-\eta} \frac{d\pi_1^*}{db_1} = 0 \quad (29)$$

Apply some algebra, we get,

$$\left(\frac{1}{\theta} K^{*1-\eta} - \frac{1-\beta}{\alpha+\beta-1} \frac{1}{r+b_1^*} \right) b_1^* = 1 \quad (30)$$

As θ goes to $+\infty$, $b_1^* = \max\{1, \frac{r(1-\alpha-\beta)}{\alpha}\}$.

Next, we calculate $\frac{db^*}{dA}$ by taking derivative of the FOC (abbreviate the region subscript):

$$\left(\frac{1}{\theta} K^{*1-\eta} - \frac{1}{K^*} \frac{dK^*}{db} \right) \frac{db^*}{dA} + b^* \left(\frac{1}{\theta}(1-\eta) K^{*-\eta} \frac{dK^*}{dA} + \frac{1-\beta}{\alpha+\beta-1} \frac{1}{(r+b^*)^2} \frac{db^*}{dA} \right) = 0 \quad (31)$$

After some algebra, we get

$$\frac{db^*}{dA} = \frac{ -\dfrac{b^*}{A} \dfrac{1-\eta}{\alpha+\beta-1} K^{*1-\eta} }{ \dfrac{r\theta}{(r+b^*)^2} \dfrac{1-\beta}{\alpha+\beta-1} - K^{*1-\eta} - b\dfrac{1-\beta}{r+b^*} \dfrac{1-\eta}{\alpha+\beta-1} K^{*1-\eta} } := \frac{u}{v} \quad (32)$$

Observe that $u > 0$. Thus $\frac{db^*}{dA} < 0$ iff the denominator< 0.

Proposition 3. $\frac{db^*}{dA} < 0$ if $0 \le \eta < 1$; $=0$ if $\eta = 1$; $¿0$ if $\eta > 1$.

Proof.

$$v = \frac{r\theta}{(r+b^*)^2} \frac{1-\beta}{\alpha+\beta-1} - K^{*1-\eta} \left(1 + \frac{b^*(1-\beta)}{r+b^*} \frac{1-\eta}{\alpha+\beta-1} \right) \quad (33)$$

Recall that,

$$\left(\frac{1}{\theta} K^{*1-\eta} - \frac{1-\beta}{\alpha+\beta-1} \frac{1}{r+b^*} \right) b^* = 1 \quad (34)$$

$$\Rightarrow K^{*1-\eta} = \theta \left(\frac{1}{b^*} + \frac{1-\beta}{\alpha+\beta-1} \frac{1}{r+b^*} \right) > 0 \quad (35)$$

This immediately implies $1 + \dfrac{b^*(1-\beta)}{r+b^*} \dfrac{1-\eta}{\alpha+\beta-1} > 0$. Therefore, $v < 0$ for $\eta > 0$. Easy to

see that $u > 0$ if $0 \le \eta < 1$ and $u < 0$ if $\eta > 1$. Hence $\dfrac{db^*}{dA} < 0$ for $0 \le \eta < 1$; $\dfrac{db^*}{dA} > 0$ for

$\eta > 1$.   ∎

Next, we would like to examine the cross partial $\dfrac{d^2 b^*}{d\theta dA}$. We solve the model using Matlab and plot $\dfrac{db^*}{dA}$ against θ for different parameter values. As θ goes to $+\infty$, $\dfrac{db^*}{dA}$ goes to 0 from below. As θ goes to 0, $\dfrac{db^*}{dA}$ goes to 0 from below. We hypothesize that the graph of $\dfrac{db^*}{dA}$ against θ is U-shaped. Simulations from Matlab show that $\dfrac{d^2 b^*}{dAd\theta} > 0$ for large values of θ where the ratio of moving cost to revenue is above $1/10$. Next, we prove analytically that the elasticity of equilibrium tax rate with respect to A is monotonically decreasing in θ.

Claim 3. $: \dfrac{db^*}{d\theta} > 0.$

Proof. : Recall we have,

$$\left(\frac{1}{\theta} K^{*1-\eta} - \frac{1-\beta}{\alpha+\beta-1} \frac{1}{r+b^*} \right) b^* = 1 \tag{36}$$

Take derivative with respect to θ and re-arrange, we get:

$$\frac{db^*}{d\theta} = \frac{b^*}{\theta^2} K^{*1-\eta} \left(\frac{1}{b^*} + \frac{b^*(1-\beta)}{\alpha+\beta-1} \frac{1}{r+b^*} \left((1-\eta) \left(\frac{1}{b^*} + \frac{1-\beta}{\alpha+\beta-1} \frac{1}{r+b^*} \right) + \frac{1}{r+b^*} \right) \right)^{-1} \tag{37}$$

From above, we have $1 + \dfrac{b^*(1-\beta)}{r+b^*} \dfrac{1-\eta}{\alpha+\beta-1} > 0 \Rightarrow \dfrac{db^*}{d\theta} > 0.$ ∎

Proposition 4. *The elasticity* $-\dfrac{db^*}{dA} \dfrac{A}{b}$ *is monotonically decreasing in* θ.

Proof.

$$-\frac{db^*}{dA} \frac{A}{b^*} = \frac{\dfrac{1-\eta}{\alpha+\beta-1}}{\dfrac{r\theta}{(r+b^*)^2} \dfrac{1-\beta}{\alpha+\beta-1} K^{*\eta-1} - b^* \dfrac{1-\beta}{r+b^*} \dfrac{1-\eta}{\alpha+\beta-1} - 1} \tag{38}$$

Recall we have,

$$\left(\frac{1}{\theta} K^{*1-\eta} - \frac{1-\beta}{\alpha+\beta-1} \frac{1}{r+b^*} \right) b^* = 1 \tag{39}$$

Substitute for $\dfrac{1}{\theta} K^{*1-\eta}$ and rearrange, we can re-write the denominator as:

$$\frac{1-\beta}{\alpha+\beta-1} \frac{b^*}{r+b^*} \left(\frac{r}{r + \dfrac{\alpha}{\alpha+\beta-1} b^*} - (1-\eta) \right) - 1 \tag{40}$$

Easy to see that the denominator increases in magnitude as θ increases (recall that we have shown b increases with θ).Therefore, $-\dfrac{db^*}{dA} \dfrac{A}{b^*}$ decreases in θ.   ∎