# Firm Dynamics and Economic Development with Corruption and Financial Frictions*

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**Abstract**

We build a firm dynamics model with corruption to study its impact on firm entry and exit, capital accumulation, and innovation. The effect of corruption depends on the degree of financial frictions and the stage of economic development. In the model, corruption serves as an endogenous entry barrier that reduces firm churning and protects the incumbent firms, allowing them to accumulate capital more quickly and grow out of financial constraints. Corruption can therefore have a positive effect when economic growth relies mainly on capital accumulation. However, as the economy develops, corruption can lead to increasing productivity losses when capital becomes abundant and technological progress is the main driver of growth. In addition, more corruption at the early stage could lead to a highly skewed distribution of firms later on, making it easier for asset-rich incumbent firms to bribe the government officials and prevent successful innovators from entering the market. We test the predictions of our theory using the Chinese firm-level data from 1998 to 2007. Our theory also has implications for the optimal anti-corruption policy over the development process.

**Keywords:** Corruption, financial frictions, firm dynamics, technology adoption and innovation, distance to frontier
**JEL Code:** O11, O33, O43

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# 1 Introduction

It is widely believed that corruption hinders economic growth and judicial reforms that target corruption activities would improve the growth potentials of developing countries.[1] However, as shown in Figure 1, although there exists a strong negative correlation between corruption and income across countries (Panel A), the correlation is much weaker for the poorest countries (Panel B). We postulate that this is because corruption may help growth in certain cases if it mitigates the effects of other frictions. The goal of our paper is to understand the role of corruption over the development process. To this aim, we incorporate corruption in a firm dynamics model with financial frictions and study the aggregate effect of corruption through impacting firm dynamics.

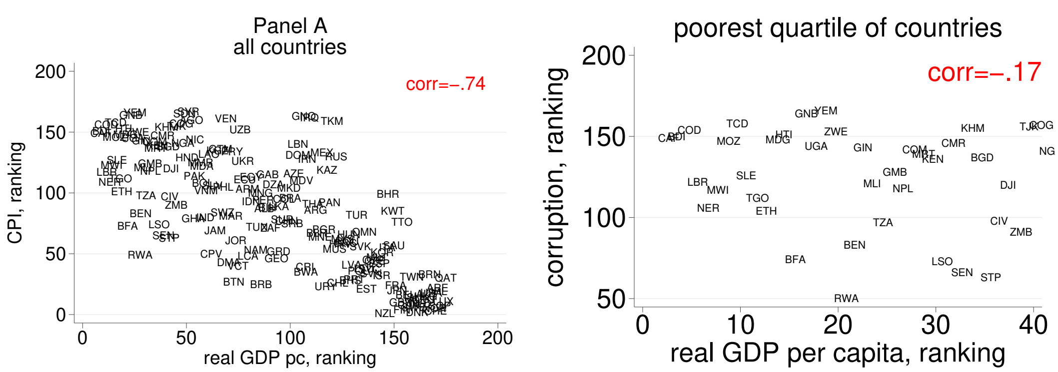


Figure 1: **Corruption and economic development**

**Source**: PWT (2017), corruption perception index (2017)
**Note**: The two figures plot the correlation between the rankings of real GDP per capita (x axis) and the corruption perception index (right axis) across countries. Panel A includes all countries in the sample and panel B only includes the poorest quartile of countries.

Our theory is motivated by two pieces of evidence on firm dynamics. First, using the Orbis firm-level database for 40 countries at different levels of economic development, we show that firms in less developed countries exhibit more volatile growth in sales, asset, employment, and labor productivity. Second, we construct a corruption index across Chinese provinces using the number of corruption cases

[1] Recently, the International Monetary Fund updated their framework in order to have an enhanced engagement with countries on corruption issues (see IMF, 2018*a* and IMF, 2018*b*).

brought up in the judicial system during the recent anti-corruption campaign. By exploring the regional variations in the level of corruption, we find that firms in provinces with a higher incidences of bribery cases tend to have a higher growth rate in capital, labor and output, but a lower growth rate in labor productivity.

Motivated by these two facts, we build a model of firm dynamics with financial friction, in which corruption is a bidding competition between incumbents and potential entrants to obtain an operating permit. Corruption serves as an endogenous entry barrier that protects incumbents at the expense of potential productivity gain from entry. In poor countries with higher growth volatility and less developed financial markets, the aggregate effects of corruption could be positive because it leads to faster wealth accumulation by keeping incumbents in the market longer.

In the model, there exists a continuum of goods markets, each of which is occupied by an incumbent entrepreneur. In each period, the incumbents are randomly matched with potential entrants, and depending on whether the market is corruptible, they engage in a Bertrand-style price competition (without corruption) or a bidding competition to bribe a corruptible government official for an operating permit (with corruption). Banks incur a monitoring cost that declines with size of collateral, hence the financing cost of entrepreneurs can be reduced through the accumulation of wealth.

In the markets without corruption, the entrepreneur with a lower unit cost of production wins the Bertrand competition and monopolizes the market. The unit cost of production decreases with both the idiosyncratic productivity shock and the financing cost (hence wealth). The shocks to entrepreneurs' idiosyncratic productivity lead to frequent entry and exit, making it difficult for entrepreneurs to stay in the market for a long period of time and accumulate enough wealth to alleviate financial frictions.

In the markets with corruption, instead of Bertrand competition, there is a corruptible government official handing out an operating permit. The incumbent and entrant engage in a bidding competition of bribery, in which the size of the bribery depends on the entrepreneurs' willingness and the ability to pay. If entrepreneurs are unable to pledge their gain from winning the permit, wealthier entrepreneurs win the competition because they can pay more bribe out of pocket. In this case, corruption serves as an endogenous entry barrier that protects incumbents who are on average wealthier, which allows them to accumulate wealth faster, but leads to relatively lower aggregate productivity.

The predictions of our model are confirmed in the data. We exploit the cross-province variation in China and show that higher incidences of bribery is associated with lower firm growth volatility, and the correlation is stronger for sectors that are more dependent on external financing. In a quantitative version of the model, we show that the steady-state output of an economy with corruption is 3.8 percent higher than that of an economy without corruption. The higher output in the economy with corruption can be attributed to a higher capital labor ratio, although its aggregate productivity is lower. We also find that the output gain from corruption is lower with less severe financial frictions and highly persistent idiosyncratic productivity shocks.

In addition, our model also has an implication for the dynamic effects of corruption and the optimal anti-corruption policy over the development process. In the extension of the benchmark model, firms have two options to improve their productivity: imitate from the world technological frontier or innovate. When the economy is far away from the technological frontier, imitation is preferred over innovation, and since entrepreneurs are ex-ante and ex-post identical in their ability to imitate, selection of productive entrepreneurs through entry is less important at this stage. It is therefore optimal to have a relatively higher level corruption to protect the incumbents, especially when the financial markets are underdeveloped. On the other hand, when the economy approaches the technological frontier and innovation is the preferred strategy of productivity progress, it becomes very important to allow successful innovators to enter the markets. Therefore it is optimal to adopt a higher level of anti-corruption effort. [2] However, corruption at the early stage of development could have long-lasting effects on the economy when the it enters the innovation stage, because corruption at the imitation stage generates a more unequal wealth distribution between incumbents and entrants and makes it easy for the incumbents to block the entry of more productive entrepreneurs.

[2] This is consistent with the findings in Acemoglu, Aghion and Zilibotti (2006) that the effect of entry barriers depends on the distance to the technology frontier.

## 1.1 Related Literature

This paper contributes to several strands of literature. First, we aim at providing a macroeconomic framework to understand the aggregate effects of corruption. In particular, we focus on how corruption affects firm dynamics patterns during the development process. Akcigit, Baslandze and Lotti (2018) provide rich evidence for how political connections affect firms' employment growth, productivity and innovation based on a novel data set of Italian firms and politicians. They illustrate the mechanisms with a firm dynamics model where corruption helps alleviate bureaucratic burden, but leads to a dynamic inefficiency because it reduces entry. Our model focuses instead on the interaction between corruption and financial constraints and we show that the trade off between the static and dynamic effects depends on the level of development. We test the model's predictions using Chinese firms and regional variation in corruption that was uncovered during a recent anti-corruption campaign.

Second, our paper is related to a broader literature on the effect of corruption on growth. Corruption could have a positive effects on economic growth if it helps "grease the wheel" in the face of bureaucratic hurdles. This view is supported by firm-level evidence regarding firm entry in Dreher and Gassebner (2013), while other studies have found that corruption largely has a negative effect at the macro level (Meon and Sekkat, 2005). Our paper provides a theory that carefully models the role of corruption for firms' growth. In particular, we emphasize how corruption can serve as an endogenous entry barrier that reduces firm churning and allowing firms to grow faster at early stages of development.

Third, our paper contributes to the growing literature of firm dynamics of developing countries. In Asturias et al. (2017), the authors argue that firm entry/exit is important for the productivity growth in fast-growing economies. In our paper, we find that corruption, which serves as an endogenous entry barrier, lowers the degree of firm churning and implies lower productivity growth. However our paper emphasizes the other aspect of firm churning, that is, it slows down the investment rate and wealth accumulation when firms are faced with financial frictions. Chiu, Meh and Wright (2017) propose a model where financial frictions affect innovation in an endogenous growth framework. Mukoyama and Popov (2014) study the political economy of entry barriers and show that there are multiple equilibria where some can have high entry barriers. Bridgman, Livshits and MacGee (2007) consider a case where workers lobby or corrupt the government to prevent the adoption of new technologies. Our framework also predicts that entry barriers can be too large, but in our case they arise endogenously. Since they depend on the wealth distribution, initially high levels corruption can lead to persistent entry barriers, because it protects incumbents who use their wealth for corruption at later stages of development when entry barriers should be reduced.

Fourth, we relate to a large literature on financial frictions and development (see for example (Rajan and Zingales, 1998). Corruption and financial friction are the two important frictions faced by firms in developing countries, yet, our paper is one of the few papers that study the two types of frictions jointly in order to understand their interaction. Ahlin and Pang (2008) also emphasize this interaction but is based on a more stylized model, while we allow for firm heterogeneity and dynamics.

Finally, our paper is related to a strand of literature that emphasize the importance of self-financing in helping the entrepreneurs to grow out of financial frictions (such as Midrigan and Xu, 2014). We build on the distance to frontier literature as in Acemoglu, Aghion and Zilibotti (2006) who highlight the role of entry barriers and financial constraints as two frictions that interact and vary over the development process. They show that the optimal development strategy is to encourage investment when the economy is far away from the technological frontier, and then switch to a strategy that encourages innovation and the entry of innovative firms. Zilibotti (2017) provides cross-country evidence that the effects of administrative entry barriers as well as corruption worsen when countries approach the technology frontier. Our contribution is to provide a firm dynamics model that allows us to study the role of these frictions in the presence of firm heterogeneity and we provide a micro foundation for how entry barriers arise endogenously as a consequence of corruption. Itskhoki and Moll (2014) find that in the presence of financial frictions, the optimal policy would be to subsidize investment at the cost of labor. Our theoretical framework shares this implication but we focus on the role of corruption.

# 2 Empirical motivation

In this section, we present the empirical motivation for our model. In section 2.1, we show cross-country evidence that firm growth in poor countries is more volatile than in rich countries. In section 2.3, we exploit the variation of corruption across provinces in China to study its impacts on firm growth.

## 2.1 Volatility of firm growth across countries

In this section, we document the cross-country differences in the volatility of firm growth using the Orbis data set.

### 2.1.1 Data

To document cross-country difference in the volatility of firm growth, we use the Orbis data set (2011-2016) which contains (among others) financial information of the private and public firms across countries. The empirical evidence in this section is based on the firm-level operating revenue (in US dollars), total assets and the number of workers. We deflate the operating revenue using CPI from the IMF World Economic Outlook (WEO) Database. We follow the procedures in Gopinath et al. (2017) (when applicable) to clean the data and keep only those countries with more than 10'000 observations.[3] This procedure generate a data set consisting of the following 40 countries: Australia, Austria, Belgium, Bulgaria, Bosnia and Herzegovina, China, Czech Republic, Germany, Spain, Estonia, Finland, France, Great Britain, Greece, Croatia, Hungary, Ireland, Italy, Japan, Kazakhstan, South Korea, Lithuania, Latvia, Moldova, Republic of North Macedonia, Netherlands, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Sweden, and Ukraine.

Following Ramey and Ramey (1995), we compute the annual growth rate, expressed as log difference, in operating revenue, total assets, number of workers and labor productivity. We then construct two measures for the growth volatility at the firm level. The first one is the standard deviation in growth rate for each firm within each 3-digit SIC industry and the second one is the standard deviation in annual

[3] For the details of the procedure, see section A in the Online Appendix of Gopinath et al. (2017).

growth rate for each firm over the 5-year window. We compute the average of these measures across industries and firm and we label them as the cross-sectional and over-time volatility in firm growth, respectively. More formally,

$$Vol^c = avg_{s,t}(SD_{s,t}(\Delta y_{i,s,t}))$$

where $Vol^c$ is the cross-sectional volatility, $\Delta y_{i,s,t}$ is the growth rates for firm $i$ in sector $s$ and year $t$ and $SD_{s,t}(\Delta y_{i,s,t})$ is the standard deviation of all firms $i$ in sector $s$ and year $t$. And,

$$Vol^o = avg_i(SD_i(\Delta y_{i,t}))$$

where $Vol^o$ is the over-time volatility, $\Delta y_{i,t}$ is the growth rates for firm $i$ in year $t$ and $SD_i(\Delta y_{i,t})$ is the standard deviation of firms $i$ over time.

## 2.2 Results

Figure 2 shows that there exists a strong and negative correlation between the volatility of firm growth ($Vol^o$) and the income level across countries. In other words, firm growth is more volatile in developing countries than developed countries. The pattern holds for both the employment (Panel A), operating revenue (Panel B), total assets (Panel C) and labor productivity (Panel D).[4]

Figure 3 displays distributions of annual growth rate in operating revenue (demeaned by firm-level average growth rate) for China, France and Ukraine—three countries with different levels of firm growth volatility. The dispersion in distribution is the highest for Ukraine firms and lowest for France firms. In addition, Figure 3 shows the distribution of annual operating revenue growth rate exhibits deviation from the normal distribution in all three countries. French firms have the highest kurtosis (10.06) while Ukraine firms have the lowest kurtosis (4.28). In other words, comparing to French firms, firms in Ukraine are more likely to draw extreme shocks. The distributions of the three countries are also rather symmetric with a small right skewness.

In the benchmark model, we treat the difference in the volatility of firm growth as exogenous, which reflects certain fundamental differences across countries. For

[4]The strong negative correlation also holds with the cross-sectional growth volatility ($Vol^c$).

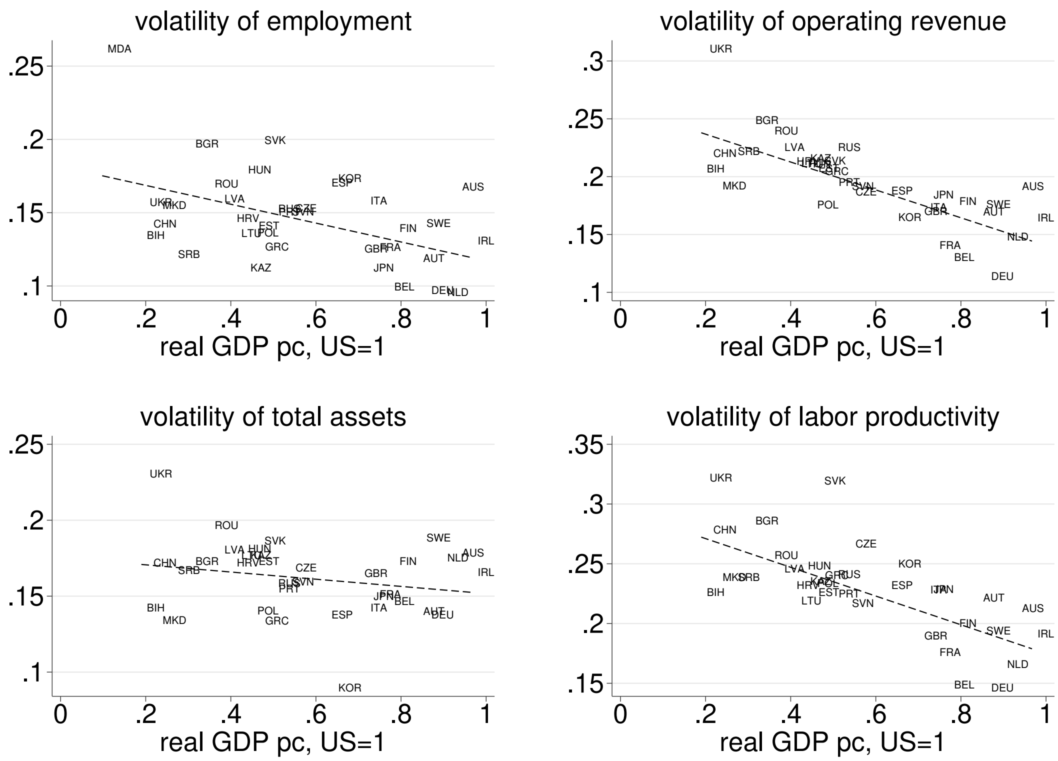


Figure 2: **Volatility of firm growth and income across countries**

**Source**: PWT, IMF WEO database (2011-2016), Orbis (2011-2016)
**Note**: The two figures plot the correlation between the over-time growth volatility $Vol^c$ of employment (Panel A), operating revenue (Panel B), total assets (Panel C) and labor productivity (Panel D) and the income level of the countries. The operating revenue are deflated using CPI from the IMF WEO database.

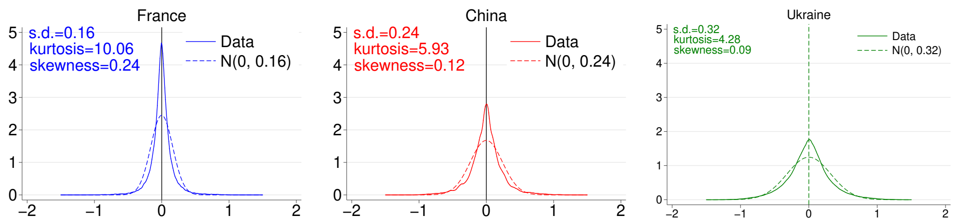


Figure 3: **Distributions of growth rate in operating revenue**

example, the higher volatility in less developed countries could be a result of a less persistent productivity process at the firm-level. As shown in Midrigan and Xu (2014), a more persistent productivity process could help firms overcome financial frictions through saving. The facts documented in this section suggest that a reduction in the growth volatility could benefit firms in less developed countries, especially the countries with a low level of financial development. With the lack of financial development, corruption could reduce firm churning and increase capital accumulation.

## 2.3 Corruption and firm-level outcomes in China

In this section, we use the corruption data and Chinese firms and examine the correlation between the regional corruption levels and firm-level outcomes.

### 2.3.1 Data

To motivate our model of how corruption affects economic outcomes at the firm level, we make use of two data sets. The first one is the Annual Survey of Chinese Industrial Firms for the period of 1998 to 2007. It contains the universe of Chinese industrial firms with an annual revenue above 5 million CNY. We get firms' balance sheet information and other firm-level characteristics from this data set. The descriptive statistics of this data set can be found in section 7.3.

The second data set measures the corruption activities at the province-level. To to this, we construct a data set of the number of corruption cases using published court judgements on the website of China Judgements Online.[5] We consider two

[5]The website is hosted by the Supreme People's Court of China (SPC) in an effort to make the

types of corruption cases. One is called "bribery" (*shouhui*), meaning government officials receiving bribery in exchange for favors. The other is called "graft" (*tanwu*), meaning the misuse of public funds.

In Figure A1, we plot the number of published judgements on these two types of corruption activities online. As shown in the figure, there is a clear trend break in the number of corruption cases around the year 2012, possibly reflecting the fact that the anti-corruption campaign that started after 2012 when President Xi Jinping took office, has dramatically increased the number of corruption cases. [6]

In Figure 4, we plot the number of corruption cases per million people for 31 provinces in mainland China. In Panel A, we plot all the bribery cases and in Panel B the graft cases. There is a sizable heterogeneity in the intensity of corruption across provinces. Interestingly, similar to the findings in Li (2017), we notice the southern provinces are more prone to bribery whereas the central provinces suffer more from graft.

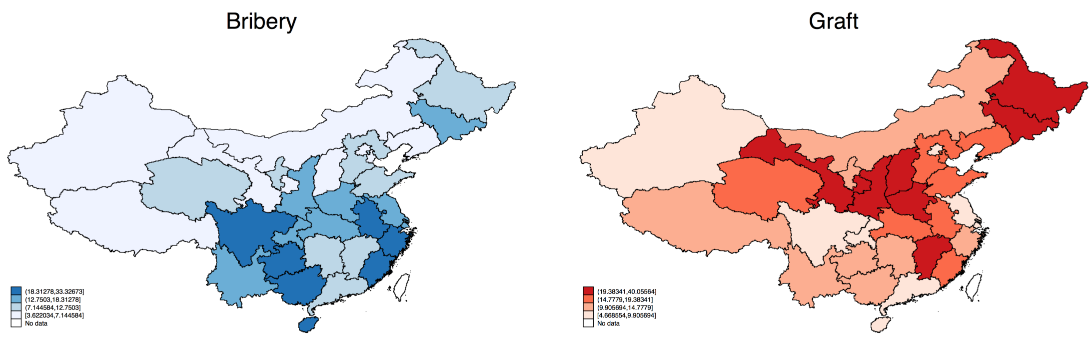


Figure 4: **Corruption level by type across provinces in Mainland China**

**Source**: China Judgements Online (2014-2018), Chinese Statistical Yearbooks (2014-2018)
**Note**: The two figures plot the number of bribery (top panel) and graft (bottom panel) cases per million people in each province. The darker color means that the number of cases per million people is larger. The correlation between bribery and graft per million people across provinces is -0.125. No data is available for Taiwan.

The anti-corruption campaign is a centralized effort by the CCP to examine and curb corruption at the local level. The CCP central committee set up an anti-corruption committee to coordinate the effort, and in many cases, sent special task forces to

judicial system more transparent.

[6]Another reason, other than the anti-corruption campaign is perhaps that there are less court judgements from earlier years published on the website. Although the goal of the website, according to the SPC, is to publish all court ruling. It is reasonable to assume that the judgement of the recent past is already digitized and thus easy to publish on the website.

the provinces and cities to help the local police force investigate and prosecute the corruption cases. As a result, we believe that the number of corruption cases prosecuted in court (rather than the number that were convicted) is a good proxy for the intensity of corruption of that region, and is less affected by their institutional qualities.

#### 2.3.2 Corruption and firm growth

In this section we explore the relationship between corruption and firm growth. We consider the balanced panel of the manufacturing firms from 1998 to 2007 and compute the annualized growth rate over this period of 10 years in firm sales, number of workers, total assets, and labor productivity. We run a regression of the following form,

$$Gr_i = \alpha + \gamma_s + X_i + \Gamma_p + \beta Corruption_p + \epsilon_i, \tag{1}$$

where the dependent variable $Gr_i$ is the annualized growth rate of firm $i$. On the right-hand-side, we control for 1) sector fixed effects $\gamma_s$, 2) a set of firm-level controls $X_i$, such as initial firm size, initial growth rate, and firm-level financial conditions, 3) province-level controls $\Gamma_p$ including initial level of GDP per capital and initial growth rate in GDP per capita. The coefficient $\beta$ in front of the province-level corruption measure $Corruption_p$ is the objective of interest. If $\beta$ is positive (negative) and significant, it means that high-level corruption is associated with higher (lower) growth at the firm level.

Table 5 shows that higher incidence of bribery is correlated with a significantly higher growth in employment and total assets (column 2 and 3). This result holds when we control for the level of graft and firm-level financial conditions such as share of long-term debt and the leverage ratio. As shown in column 7 and 8, a unit increase in the number of bribery cases per million people would lead to a 0.108 percent per annual higher growth rate in employment and total assets and a 0.128 percent higher annualized growth rate in total asset. As shown in column 1 and column 5, higher corruption is also associated with faster growth in sales, although the estimates are not significant at 10 percent level. More interestingly, higher level of corruption seems to associate with a lower growth rate in labor productivity (see column 4 and 8). In short, this set of regression results seem to suggest that, after controlling for a variety of province- and firm-level characteristics, higher incidence of bribery is positively correlated with a faster accumulation in capital and labor, but it is negatively associated with the productivity growth. The results motivate our benchmark model in section 3.

# 3 Baseline model

In this section we discuss our baseline model of firm dynamics with corruption and financial frictions.

## 3.1 Goods and production technology

There is one final good, which is used for investment and consumption. A representative final good producer produces the final good by aggregating over a measure 1 of intermediate goods $i \in [0, 1]$ with a CES technology, such that,

$$Y = (\int_0^1 y_i^{\frac{\rho-1}{\rho}} di)^{\frac{\rho}{\rho-1}}.$$

which yields a standard inverse demand function

$$p_i = Y^{\frac{1}{\rho}} y_i^{-\frac{1}{\rho}}. \tag{2}$$

Each intermediate good $i$ can be produced by one monopolistic entrepreneur with a constant returns to scale production technology,

$$y_i = z\varepsilon k^{\alpha} l^{1-\alpha},$$

where $z$ is the technology associated with the production of good $i$ and $\varepsilon$ is the idiosyncratic productivity of the entrepreneur. In the benchmark model, we assume that $z$ is fixed and is available to any entrepreneur that operates in this market. The idiosyncratic productivity $\varepsilon$ follows an exogenous stochastic process, and it is the main driver of entry and exit in the benchmark model.

### 3.2 Entrepreneurs and workers

The economy is populated by a measure 1 of incumbent entrepreneurs (one for each intermediate good market), a measure 1 of potential entrants, and a measure $N$ of workers. In each period, the incumbents and entrants are randomly matched with each other to engage in a Bertrand competition (without corruption) or bribe the government official to obtain an operating permit (with corruption), depending on whether the market is corruptible. The winner becomes monopolies the market and the loser joins the pool of potential entrants in the next period.

The entrepreneurs can save in the form of personal wealth $a$ whereas the workers are "hand-to-mouth." The entrepreneurs maximize over an expected utility, such that

$$U = \mathbb{E}_{t=0} \sum_{t} \beta^t u(c_t),$$

in which the expectation is taken over a stream of consumption and exogenous idiosyncratic productivity shock.

**Timing** At the beginning of each period, the incumbents carry over from the previous period the technology $z$ and their wealth $a^c$ while the entrants carry over only their wealth $a^e$. After their idiosyncratic productivity shocks $e^c$ and $e^e$ are realized, they are randomly matched with each other to form a pair $(z, a^c, e^c, a^e, e^e)$. In the case without corruption, they engage in a price competition of the Bertrand fashion, while in the case with corruption, they engage in a bidding competition to obtain the operating permit issued by a corruptible government official. Production occurs and the entrepreneurs consume and save. The winner enters the next period as the incumbent of the market and the loser joins the pool of potential entrants. The timing of the entrepreneurs is summarized in Figure 5.

### 3.3 Financial frictions

The banking sector is perfectly competitive and earns zero profit. Similar to Buera, Kaboski and Shin (2011), we model the borrowing and lending as a capital rental market. Following Cavalcanti et al. (2019), banks incur a monitoring cost $\phi(k, a)$

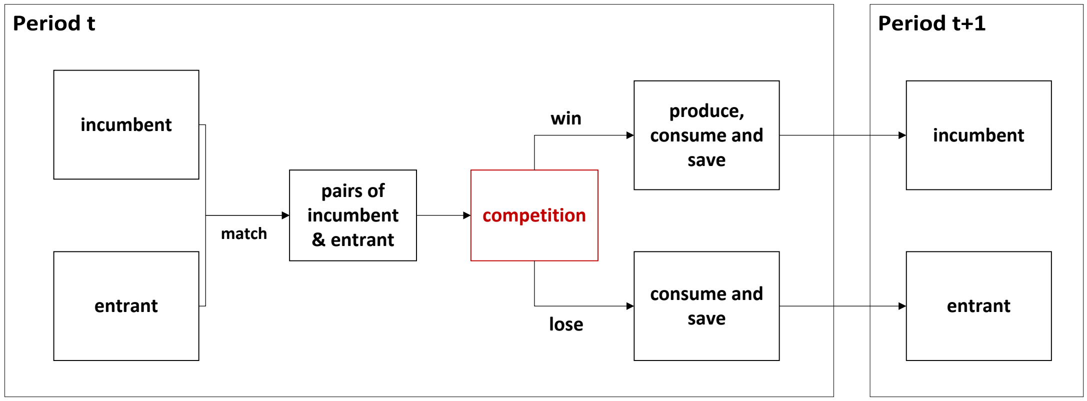


Figure 5: **Timing for the entrepreneurs**

when they rent capital $k$ to an entrepreneur with wealth $a$ as collateral, such that

$$\phi(k,a) = \phi_0 k + \phi_1 \frac{k}{a},$$

in which $\phi_0 \geq 0$ and $\phi_1 \geq 0$. The monitoring cost per unit of capital is therefore $\frac{\phi(k,a)}{k} = \phi_0 + \phi_1 \frac{1}{a}$. Since the banking sector makes zero profit, the effective interest rate for an entrepreneur with wealth $a$ is $\hat{r}(a) = r + \phi_0 + \phi_1 \frac{1}{a}$, which decreases with $a$.

## 3.4 Competition

In each period a share $s \in [0, 1]$ of the markets is corruptible. Let $x$ be the i.i.d. shock indicating whether the market is corruptible, therefore the state variables of a pair of incumbent and entrant is $(z, a^c, \varepsilon^c, a^e, \varepsilon^e, x)$. In the markets without corruption, the entrepreneurs engage in a Bertrand-style price competition (section 3.4.1), and in the corruptible markets, they engage in a bidding competition of bribery to obtain an operating permit issued by the government official (section 3.4.2).

### 3.4.1 Without corruption (Bertrand competition)

In the markets without corruption, the entrepreneur with the lowest unit cost wins the Bertrand competition.

The optimal choices of capital and labor of the entrepreneurs require that $\frac{wl}{1-\alpha} = \frac{(\hat{r}(a)+\delta)k}{\alpha}$, which implies that the unit cost of an entrepreneur with wealth $a$, idiosyncratic productivity $\varepsilon$ and technology $z$ is

$$\frac{1}{z\varepsilon}(\frac{\hat{r}(a)+\delta}{\alpha})^{\alpha}(\frac{w}{1-\alpha})^{1-\alpha}.$$

The unit cost decrease with productivity $\varepsilon$ and increases with financing cost $\hat{r}(a)$.

The outcome of the Bertrand competition is

$$\mathbf{I}(z,a^c,\varepsilon^c,a^e,\varepsilon^e,0)=\begin{cases}1 & if\ \frac{\hat{r}(a^e)+\delta}{(\varepsilon^e)^{1/\alpha}}>\frac{\hat{r}(a^c)+\delta}{(\varepsilon^c)^{1/\alpha}}\\ 0 & o.w.\end{cases}, \tag{3}$$

where $\mathbf{I}(z,a^c,\varepsilon^c,a^e,\varepsilon^e,0)\in\{0,1\}$ is an indicator function of entrepreneur turnover (successful entry) when the market is non-corrupt ($x=0$).

**Pricing** The winner of competition monopolizes the whole market and is faced with a competitive fringe, who can produce the same product with a unit cost that is a fraction $\chi$ ($\frac{\rho}{\rho-1}>\chi>1$) of her unit cost. This fringe thus limits the price to

$$p(z,a,\varepsilon)=\chi\frac{1}{z\varepsilon}(\frac{\hat{r}(a)+\delta}{\alpha})^{\alpha}(\frac{w}{1-\alpha})^{1-\alpha}. \tag{4}$$

Using the inverse demand function 2, total profit from production can be written as

$$\pi(z,a,\varepsilon)=\frac{\chi-1}{\chi^{\rho}}[\frac{1}{z\varepsilon}(\frac{\hat{r}(a)+\delta}{\alpha})^{\alpha}(\frac{w}{1-\alpha})^{1-\alpha}]^{1-\rho}Y, \tag{5}$$

where $Y$ is the aggregate output of final good.[7]

The assumption of the competitive fringe is used to simplify the pricing decision of the entrepreneurs in the monopolistic competition setting. In this way, the price depends only on the unit cost of production and the parameter $\chi$ and it does not depend on the aggregate demand (see Acemoglu, Aghion and Zilibotti, 2006 and Akcigit, Alp and Peters, 2016).[8]

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[7]The profit function is convex-concave in $a$ when $a$ is very small.

[8]Similar to Acemoglu, Aghion and Zilibotti (2006), the parameter $\chi$ also governs the monopolistic rent of the entrepreneurs. Unlike Acemoglu, Aghion and Zilibotti (2006), we simply treat $\chi$ as a fixed parameter and do not interpret it as a measure that captures the competitiveness of the market and entry barriers.

#### 3.4.2 With corruption

In a market with corruption, there exists a corruptible government official issuing an operating permits. The government official lives for one period, which eliminates the possibility of a long-term contract between entrepreneurs and the government official.

The incumbent and the entrant engage in a bidding competition to bribe the government official. We make two simplifying assumptions. First, bribery needs to be paid out of pocket and only a share $m \in (0,1)$ of the entrepreneurs' wealth can be used for bribery, and second, $m$ is small enough that entrepreneurs are better off paying the bribe. As a result, the wealthier entrepreneur would win the bidding competition and the winning bids reflect the losers' ability to bribe, such that

$$\mathbf{I}(z, a^c, \varepsilon^c, a^e, \varepsilon^e, 1) = \begin{cases} 1 & if \quad a^e > a^c \\ 0 & o.w. \end{cases}, \tag{6}$$

and

$$b(z, a^c, \varepsilon^c, a^e, \varepsilon^e, 1) = \begin{cases} m \cdot a^c & if \quad a^e > a^c \\ m \cdot a^e & o.w. \end{cases}, \tag{7}$$

where $\mathbf{I}(z, a^c, \varepsilon^c, a^e, \varepsilon^e, 1) \in \{0, 1\}$ is an indicator function of turnover (successful entry) when the market is corruptible and $b(z, a^c, \varepsilon^c, a^e, \varepsilon^e, 1)$ is the winning bribery bid.

**Discussion** Our model of corruption merits some discussions here. According to the definition of corruption in Jain (2008), corruption is an act in which the power of public office is used for personal gains in a manner that contravenes with the rule of the game. In our model, the personal gain is the bribe and corruption changes the game of competition from Bertrand competition to a bidding competition to obtain an operating permit.

According to the classification in Aidt (2003), the type of corruption in our model falls into the category of "efficient corruption." Corruption corrects existing market or government failures, which, in our model is the financial friction. It is important to note that corruption in our model does not result in the first-best allocation because there is restriction in the type of contract entrepreneurs and corruptible government officials can sign. In particular, the model setting fails to select the entrepreneur who can generate the highest revenue.

In our model, by assumption, the government officials issue only one permit for each market. However, it can be shown that, under the assumption that bribes have to be paid out of pocket, government officials are better off issuing one permit rather than multiple permits per market. This is because Bertrand competition is the default rule of game, therefore even there are multiple permit holders in a market, only the one with lowest unit cost would be active and is willing to pay for the permit. Since the potential winner of the Bertrand competition is not always the richest entrepreneur, i.e. does not necessarily have the highest capacity to bribe, the government officials might be worse off if they issue multiple permits.

# 4 Recursive competitive equilibrium

In this section, we analyze the problems of the entrepreneurs and workers and define the recursive competitive equilibrium.

The problem of the workers is static. In each period, the workers consume their labor income, such that

$$c^w = w. \tag{8}$$

Let $V^c(z, a^c, \varepsilon^c)$ and $V^e(a^e, \varepsilon^e)$ be the pre-matching (beginning-of-the-period) value functions of the incumbents and entrants. They are simply the expectation of the after-matching value functions over all potential matches, such that

$$V^c(z, a^c, \varepsilon^c) = \int W^c(z, a^c, \varepsilon^c, a^e, \varepsilon^e, x) d\Psi(a^e, \varepsilon^e) d\Pi(x) \tag{9}$$

$$V^e(a^e, \varepsilon^e) = \int W^e(z, a^c, \varepsilon^c, a^e, \varepsilon^e, x) d\Phi(z, a^c, \varepsilon^c) d\Pi(x), \tag{10}$$

where $W^c(z, a^c, \varepsilon^c, a^e, \varepsilon^e, x)$ and $W^e(z, a^c, \varepsilon^c, a^e, \varepsilon^e, x)$ are the value functions of the incumbents and the entrants after matching, $\Pi(x)$ is CDF of the distribution of the corruption status $x$ of the market, and $\Phi(z, a^c, \varepsilon^c)$ and $\Psi(a^e, \varepsilon^e)$ are the CDFs of the distribution of the incumbents and the entrants, respectively.

The after-matching value function for the incumbents are

$$W^c(z, a^c, \varepsilon^c, a^e, \varepsilon^e, x) = \begin{cases} \max_{c,a'} u(c) + \beta \mathbb{E}_{\varepsilon'|\varepsilon^c} V^c(z, a', \varepsilon') \\ st.\ c + a' = \pi(z, a^c, \varepsilon^c) + (1+r)a^c \\ -b(z, a^c, \varepsilon^c, a^e, \varepsilon^e, x), a' \geq 0 \\ if\ \mathbf{I}(z, a^c, \varepsilon^c, a^e, \varepsilon^e, x) = 0 \\ \\ \max_{c,a'} u(c) + \beta \mathbb{E}_{\varepsilon'|\varepsilon^c} V^e(a', \varepsilon') \\ st.\ c + a' = (1+r)a^c, a' \geq 0 \\ if\ \mathbf{I}(z, a^c, \varepsilon^c, a^e, \varepsilon^e, x) = 1 \end{cases}. \quad (11)$$

If entry is unsuccessful, i.e. $\mathbf{I}(z, a^c, \varepsilon^c, a^e, \varepsilon^e, x) = 0$, the incumbent stays as an incumbent and the expected value function of the next period is $\mathbb{E}_{\varepsilon'|\varepsilon^c} V^c(z, a', \varepsilon')$. Otherwise the incumbent becomes an entrant in the next period and the expected value function is $\mathbb{E}_{\varepsilon'|\varepsilon^c} V^e(a', \varepsilon')$. When the market is corruptible ($x = 1$), the winner of the bribery competition pays a bribe of size $b(z, a^c, \varepsilon^c, a^e, \varepsilon^e, 1)$. By assumption, in a non-corrupt market ($x = 0$), $b(z, a^c, \varepsilon^c, a^e, \varepsilon^e, 0) = 0$.

Similarly, the after-matching value function for the entrants can be written

$$W^e(z, a^c, \varepsilon^c, a^e, \varepsilon^e, x) = \begin{cases} \max_{c,a'} u(c) + \beta \mathbb{E}_{\varepsilon'|\varepsilon^e} V^c(z, a', \varepsilon') \\ st.\ c + a' = \pi(z, a^e, \varepsilon^e) + (1+r)a^e \\ -b(z, a^c, \varepsilon^c, a^e, \varepsilon^e, x), a' \geq 0 \\ if\ \mathbf{I}(z, a^c, \varepsilon^c, a^e, \varepsilon^e, x) = 1 \\ \\ \max_{c,a'} u(c) + \beta \mathbb{E}_{\varepsilon'|\varepsilon^e} V^e(a', \varepsilon') \\ st.\ c + a' = (1+r)a^e, a' \geq 0 \\ if\ \mathbf{I}(z, a^c, \varepsilon^c, a^e, \varepsilon^e, x) = 0 \end{cases}. \quad (12)$$

Now we are ready to define the recursive competitive equilibrium.

**Definition 1** *The recursive competitive equilibrium consists of interest rate $r$, wage rate $w$; aggregate output $Y$; before-matching value functions $V^c(a^c, z^c, \varepsilon^c)$, $V^e(a^e, \varepsilon^e)$; after-matching value functions $W^c(z, a^c, \varepsilon^c, a^e, \varepsilon^e, x)$, $W^e(z, a^c, \varepsilon^c, a^e, \varepsilon^e, x)$; policy functions of* *optimal pricing* $p(z,a,\varepsilon)$*, profit function* $\pi(z,a,\varepsilon)$*, indicator of entry* $\mathbf{I}(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)$*, bribery bid* $b(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)$*, consumption* $c^c(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)$*,* $c^e(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)$*,* $c^w$*, capital and labor inputs* $k^c(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)$*,* $k^e(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)$*,* $l^c(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)$*,* $l^e(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)$*, and saving* $a^{c'}(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)$*,* $a^{e'}(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)$*; stationary distribution of the entrepreneurs* $\Phi(z,a^c,\varepsilon^c)$ *and* $\Psi(a^e,\varepsilon^e)$*, such that,*

1. Given the prices, the policy function solves the workers' problem 8.

2. Given the prices and the aggregate output, the value functions and policy functions solve the entrepreneurs' problems 9, 10, 11, and 12.

3. Capital market clears

$$\begin{aligned}
&\int [\mathbf{I}(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)\ k^e(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)d\Phi(z,a^c,\varepsilon^c)d\Psi(a^e,\varepsilon^e)d\Pi(x)\\
&+\int (1-\mathbf{I}(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x))k^c(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)d\Phi(z,a^c,\varepsilon^c)d\Psi(a^e,\varepsilon^e)d\Pi(x)\\
&=\int (a^e+a^c)]d\Phi(z,a^c,\varepsilon^c)d\Psi(a^e,\varepsilon^e)d\Pi(x).
\end{aligned}$$

4. Labor market clears

$$\begin{aligned}
&\int [\mathbf{I}(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)\ l^e(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)d\Phi(z,a^c,\varepsilon^c)d\Psi(a^e,\varepsilon^e)d\Pi(x)\\
&+\int (1-\mathbf{I}(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x))l^c(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)d\Phi(z,a^c,\varepsilon^c)d\Psi(a^e,\varepsilon^e)d\Pi(x)=N.
\end{aligned}$$

5. The distributions are stationary

$$\begin{aligned}
&\phi(z,a^{c'},\varepsilon^{c'})=\\
&\int \mathbf{I}(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)\mathbb{I}_{a^{e'}(a^c,z^c,\varepsilon^c,a^e,\varepsilon^e)=a^{c'}}\pi_{\varepsilon^{c'}|\varepsilon^e}d\Phi(z,a^c,\varepsilon^c)d\Psi(a^e,\varepsilon^e)d\Pi(x)+\\
&\int [1-\mathbf{I}(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)]\mathbb{I}_{a^{c'}(a^c,z^c,\varepsilon^c,a^e,\varepsilon^e)=a^{c'}}\pi_{\varepsilon^{c'}|\varepsilon^c}d\Phi(z,a^c,\varepsilon^c)d\Psi(a^e,\varepsilon^e)d\Pi(x),\\
&\psi(a^{e'},\varepsilon^{e'})=\\
&\int \mathbf{I}(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)\mathbb{I}_{a^{c'}(a^c,z^c,\varepsilon^c,a^e,\varepsilon^e)=a^{e'}}\pi_{\varepsilon^{e'}|\varepsilon^c}d\Phi(z,a^c,\varepsilon^c)d\Psi(a^e,\varepsilon^e)d\Pi(x)+\\
&\int [1-\mathbf{I}(z,a^c,\varepsilon^c,a^e,\varepsilon^e,x)]\mathbb{I}_{a^{e'}(a^c,z^c,\varepsilon^c,a^e,\varepsilon^e)=a^{e'}}\pi_{\varepsilon^{e'}|\varepsilon^e}d\Phi(z,a^c,\varepsilon^c)d\Psi(a^e,\varepsilon^e)d\Pi(x).
\end{aligned}$$

To compute the stationary equilibrium of the model, we guess prices and the distributions of the entrepreneurs, and update them until the markets are clear and the distributions are consistent with the true ones.

# 5 Quantitative analysis

In this section, we perform a quantitative excise to show the effects of corruption on firm dynamics and the aggregate economy.

One period in the model corresponds to one year in the data. The discounting factor $\beta$ is set to 0.9 match the 4% risk-free rate.The utility function is in a CRRA form and the relative risk aversion is $\sigma = 2$. The capital share in the production function is $\alpha = 1/3$. The elasticity of substitution is $\rho = 4$ (Basu and Fernald, 1997) but the pricing is limited by $\chi = 5/4$. The capital depreciation rate is $\delta = 0.06$. We set $N = 18$ because the share of entrepreneurs in the data is around 10% and there is a measure of 2 entrepreneurs in the model. We assume that the idiosyncratic productivity process $\varepsilon^c$ and $\varepsilon^e$ follows an AR(1) process, such that $log\varepsilon_t = \rho^\varepsilon log\varepsilon_{t-1} + e_t,\ e_t \sim \mathcal{N}(0, \sigma^{\varepsilon 2})$. Following Gourio (2008), we set the persistence in the productivity process $\rho^\varepsilon = 0.75$, which is the lower bound of the estimates of persistence for the U.S. Compustat firms and $\sigma^\varepsilon = 0.403$. We set $\phi_1 = 0.015$ according to the estimates of Brazilian firms in Cavalcanti et al. (2019) and $\phi_0 = 0.036$ because the interest rate spread is 0.076 in the Chinese Annual Industrial Survey and the risk-free interest rate is 0.04 (see Figure A2 in the Appendix). We set $m = 0.01$ and under this parametrization, the assumption that entrepreneurs are better off paying the bribe is satisfied. The parameters are summarized in Table 1.

## 5.1 The effects of corruption

We consider an economy without corruption ($s = 0$) and one in which all markets are corruptible ($s = 1$). In the economy without corruption, the entrepreneurs compete on both wealth $a$ and idiosyncratic productivity $\varepsilon$, while in the economy with corruption, the entrepreneurs compete on wealth $a$ only. As a result, the economy without corruption has a high firm turnover and therefore higher productivity due

Table 1: **Parameters**

| Parameter | | Value | Target/Source |
|---|---|---|---|
| $\beta$ | discounting factor | 0.9 | 4% risk-free interest rate |
| $\sigma$ | relative risk aversion | 2 | — |
| $m$ | share of wealth for bribery | 0.01 | — |
| $\alpha$ | capital share in the production function | $1/3$ | capital share of $1/3$ |
| $\rho$ | elasticity of substitution between intermediate inputs | 4 | Basu and Fernald (1997) |
| $\rho^{\varepsilon}$ | persistence of idiosyncratic shock | 0.75 | Gourio (2008) |
| $\sigma^{\varepsilon}$ | variance of idiosyncratic shock | 0.403 | Gourio (2008) |
| $N$ | measure of workers | 18 | 10% share of entrepreneur |
| $\delta$ | capital depreciation rate | 0.06 | annual 6% depreciation rate |
| $\phi_0$ | parameter of the monitoring cost | 0.036 | China Annual Industrial Survey |
| $\phi_1$ | parameter of the monitoring cost | 0.015 | Cavalcanti et. al. (2019) |

Table 2: **Trade offs between Bertrand competition and bribery**

| **Bertrand competition** | **Bribery** |
|---|---|
| compete on $a$ and $\varepsilon$ | compete on $a$ only |
| more entry and exit | less entry and exit |
| high productivity due to firm entry | lower productivity |
| slower accumulation of wealth | faster accumulation of wealth |
| no loss from bribery | loss from bribery |

to the entry of highly productive entrepreneurs, but has a slower accumulation of wealth. Table 2 highlights the key differences between the two economies and the trade-off of corruption, which is lower productivity versus faster accumulation of entrepreneur wealth. In the presence of financial frictions, the effects of the later tends to dominate because it helps entrepreneurs grow out of financial frictions.

Table 3: **Steady state comparison of two economies**

| | w/o corruption | w/ corruption |
|---|---|---|
| firm turnover (exit rate) | 17% | 4% |
| output | 1 | 1.038 |
| capital stock | 1 | 1.054 |
| aggregate productivity | 1 | 0.985 |
| share of incumbent wealth in total wealth | 75% | 93% |

Table 3 summarizes the comparison between the outcome without corruption ($s = 0$) and with corruption ($s = 1$). The existence of corruption reduces the firm turnover rate from 17 percent to 4 percent, leading to an aggregate productivity loss of 1.5 percent. However, because the capital stock is 5.4 percent higher, the economy with corruption experiences an output gain of 3.8 percent. In addition, the incumbents' share of total wealth is 75% in the economy without corruption which in the model with corruption it is 93%, which means corruption generates higher inequality between incumbents and entrants.

## 5.2 Determinants of the effects of corruption

The result in Table 3 is obtained under a high degree of financial friction (calibrated to match Brazilian and Chinese firms) and a low persistence in the idiosyncratic productivity process. In this section, we study how the effects of corruption depends on financial friction and the persistence of the shock.

Table 4: **Differences between the two economies (percent)**

| | Benchmark | Higher persistence | | Lower fina. fric. |
|---|---|---|---|---|
| | | $\rho^{\varepsilon} = 0.89$ | $\rho^{\varepsilon} = 0.95$ | $\phi_0 = 0.03$ |
| Output | 3.75 | 1.34 | -3.83 | 3.00 |
| Capital stock | 5.36 | 2.96 | -3.90 | 5.66 |
| Productivity | -1.52 | -1.58 | 0.01 | -2.52 |

Table 4 shows that, in the benchmark model where $\rho^{\varepsilon} = 0.75$, the existence of corruption leads to a 3.75 percent gain in total output. The output gain decreases to 1.34 percent when the persistence of the idiosyncratic productivity $\varepsilon$ increases to $\rho^{\varepsilon} = 0.89$. When the persistence increases to $\rho^{\varepsilon} = 0.95$, corruption results in an output loss of 3.83 percent. This shows that the positive effects of corruption is more likely to dominate when the idiosyncratic productivity is less persistent. Our result also shows that the output gain from corruption is lower (3 percent) when the financial friction becomes less severe ($\phi_0 = 0.03$).

In Figure 6, we plot the aggregate output with different shares of corruptible markets $s$. As shown in Panel A with a relatively low persistence $\rho^{\varepsilon} = 0.75$, the aggregate output increases with the share of corruptible markets. On the other hand, as shown in Panel B with higher persistence $\rho^{\varepsilon} = 0.95$, the aggregate outcome in fact decreases with the share of corruptible markets.

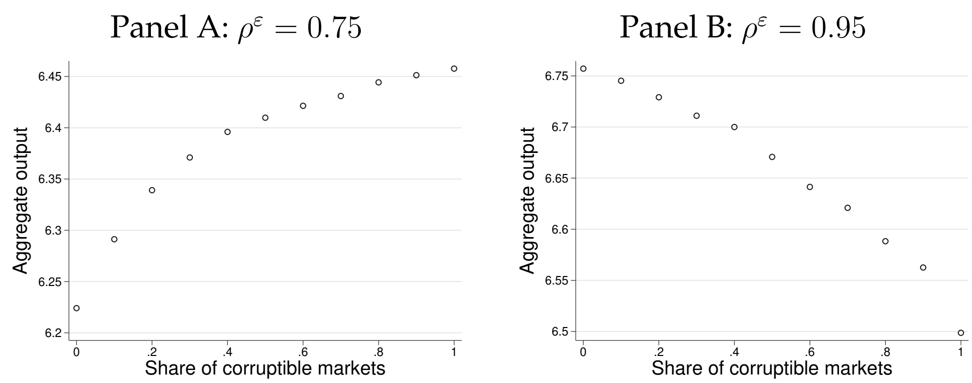


Figure 6: **Aggregate output and the share of corruptible markets**

# 6 Model with innovation

In the baseline model, the productivity is exogenous. We interpret the setting as a costless adoption of the world frontier technology. However, it is reasonable to assume that there is a lag in the adoption process. In other words, the economy will not be able to catch up to the frontier only through technological adoption. Therefore, to reach the world technological frontier, the economy would eventually needs to switch from adoption to costly innovation. To simplify the analysis we shut down the volatility in the idiosyncratic productivity shock by assuming $\varepsilon = 1$.

We first describe the timing with endogenous innovation (section 6.1). We then discuss the output gain from innovation (section 6.2), the cost of innovation and some simplifying assumptions (section 6.3). Lastly, we analyze entrepreneurs' decision of innovation (section 6.4).

## 6.1 Timing with innovation

The timing is similar to Figure 5 with one additional step. After matching, the incumbent $(a^c, z)$ and the potential entrant $a^e)$ decide separately whether they want to innovate and the size of the innovation. After the realization of the innovation outcome, the entrants and incumbents compete with each other in a Bertrand-style price competition (without corruption) or bribe the government official to obtain the operating permit (with corruption).

## 6.2 Output gain from innovation

Following the discussions in section 3.4.1, the unit profit of production, which is price minus the unit cost, can be written as $(\chi - 1)\frac{1}{z_i\varepsilon}(\frac{\hat{r}(a)+\delta}{\alpha})^{\alpha}(\frac{w}{1-\alpha})^{1-\alpha}$. We can use the inverse demand function to write the the total profit from production as

$$\frac{\chi - 1}{\chi^{\rho}}[\frac{1}{z_i\varepsilon}(\frac{\hat{r}(a)+\delta}{\alpha})^{\alpha}(\frac{w}{1-\alpha})^{1-\alpha}]^{1-\rho}Y,$$

Let $z_i'$ be the productivity after adoption/innovation. The total profit gain from innovation is

$$\underbrace{\frac{\chi - 1}{\chi^{\rho}}[\frac{1}{\varepsilon}(\frac{\hat{r}(a)+\delta}{\alpha})^{\alpha}(\frac{w}{1-\alpha})^{1-\alpha}]^{1-\rho}Y}_{A}\underbrace{(\frac{1}{z_i'^{1-\rho}} - \frac{1}{z_i^{1-\rho}})}_{\Delta_{z_i}},$$

where $\Delta_{z_i} = \frac{1}{z_i'^{1-\rho}} - \frac{1}{z_i^{1-\rho}}$ measures the productivity gain and $A\Delta_{z_i}$ is the total profit gain.

## 6.3 Cost from innovation

Suppose there exists a world technological frontier $\bar{z}_{i,t}$ that evolves at a constant rate $\gamma$: $\bar{z}_{i,t+1} = \gamma\bar{z}_{i,t}$. To simplify our analysis, we assume for now that $\gamma = 1$, such that the world technological frontier is constant for all industries. The domestic technological frontier is $z_{i,t}$, which is the productivity of the incumbent entrepreneur of market $i$. We can then normalize the domestic productivity by the world technological frontier, such that,

$$\tilde{z}_{i,t} = \frac{z_{i,t}}{\bar{z}_{i,t}}.$$

The normalization is useful to define the cost functions below.

We assume the cost of innovation $c(\tilde{z}_i, \Delta_{z_i})$ is of the following form,

$$c(\tilde{z}_i, \Delta_{z_i}) = \nu(\tilde{z}_i)\Delta_{z_i}^{\lambda}$$

where $\lambda > 1$, i.e., the cost function is convex in the size of productivity gain $\Delta_{z_i}$. Furthermore, the cost depends on the distance to frontier: this captures the idea that the cost of adoption is higher when $i$ is closer to the world technological frontier. We therefore assume that $\nu(\tilde{z}_i) > 0$ and that it strictly increases with $\tilde{z}_i$.

If entrepreneurs decide innovate, then they need to choose the size of innovation $\Delta_{z_i}$ (and simultaneously the cost of innovation). The optimization problem reads,

$$\max\ pA\Delta_{z_i} - \nu(\tilde{z}_i)\Delta_{z_i}^{\lambda},$$

where $p \in (0, 1]$ is the probability of successful innovation. The first order conditions with respect to $\Delta_{z_i}$ can be written as,

$$pA = \lambda\nu(\tilde{z}_i)\Delta_{z_i}^{\lambda}, \qquad \Delta_{z_i} = (\frac{pA}{\lambda\nu(\tilde{z}_i)})^{\frac{1}{\lambda-1}}.$$

Notice that since $\nu(\tilde{z}_i)$ increases with $\tilde{z}_i$, the optimal size $\Delta_{z_i}$ decreases with $\tilde{z}_i$. One interesting thing to note is that the optimal size of productivity progress $\Delta_{z_i}$ increases with $A$. We recall that $A = \frac{\chi-1}{\chi^{\rho}}[\frac{1}{\varepsilon}(\frac{\hat{r}(a)+\delta}{\alpha})^{\alpha}(\frac{w}{1-\alpha})^{1-\alpha}]^{1-\rho}Y$, which is higher when the cost of financing is lower. Intuitively, this says that the potential gain from productivity progress is larger when the financing cost is lower. Therefore, a lower financing cost will not only increase the profit, but also leads to a faster pace of innovation.

To ensure the tractability of the problem, we make the following assumptions about the cost function:

**Assumption 1** *The function $\nu(\cdot)$ is positive and strictly increasing.*

This assumptions says that the cost of innovation increases when the economy approaches the world technological frontier.

**Assumption 2** $\nu(0) < \infty$ *and* $\lim_{\tilde{z}=1} \nu(\tilde{z}) = \infty$.

This assumption says that when the economy is far away from the frontier, the cost is not infinite. It also ensures that the optimal size of productivity progress $\Delta_z$ never surpasses the world technological frontier.

**Assumption 3** *There exists $z^* \in (0, 1)$, such that $z^*$ is the limit of technological adoption.*

This assumption says that adoption is not possible beyond the point of $z^*$. The idea of this assumption is that the adoption is easier when the economy is far away from the frontier, but the economy can not reach the frontier with technological adoption only. As a result, economic development has two stages: the adoption stage $[0, z^*]$ and the innovation stage $[z^*, 1]$.

We also assume, similar to Acemoglu, Aghion and Zilibotti (2006), that at the end of each period, the productivity progress from innovation diffuses to the entire economy, even across markets. This means that the technologies of all markets are the same and they are equal to the average technology in the economy.

## 6.4 Innovation decisions

**Innovation without corruption** Unlike adoption, innovation is risky. It is likely that some lucky entrants successfully innovates and surpass the productivity of the incumbent. If the productivity gain from successful innovation, $\Delta_z$, is large enough to compensate the high interest rate associated with lower wealth, the successful innovator enters the market and push out the incumbent. The speed of convergence to the world technological frontier depends not only on the success probability $p$, but also on the degree of financial frictions in the economy.

**Innovation with corruption** Assume that for each market $i$, there is a corruptible government official handing out an operating permit. To simplify the analysis, we assume that the bribery has to be paid out of pocket.

In order to discuss the innovation stage, we go backwards and first consider the bribery decision conditional on the innovation outcome and then we consider the innovation strategy. The entrants will choose to innovate only if they are able to win the bidding competition. If the wealth inequality between the incumbent and the potential entrants are large enough, in equilibrium, only the incumbent innovates, because the potential entrants know that they will not have enough wealth to bribe the government official. Therefore, even if they successfully innovate, they will not earn any profit from the innovation. As a result, only the incumbents innovate and the aggregate innovation activities in the economy is too low. The economy will still converge to the technological frontier, but at a much slower rate compared with the economy without corruption.

Another aspect to note is that if we allow entrepreneurs to borrow against their future income, this could mitigate the negative effect of corruption in the innovation stage. The effectiveness of the mitigation depends on the wealth inequality between the incumbent and the entrants; and it also depends on the size of the innovation steps and how long the innovator can keep the productivity advantage.

Consider the case where 1) the incumbent is much wealthier than the potential entrants, 2) the productivity gain from innovation is relatively small, and 3) the productivity gain from innovation diffuses to the entire economy within one period. Then, the expected future income from a successful innovation will not be able to cover the wealth difference between the incumbent and the potential entrants. As a result, even if the future income can be pledged as a part of the bribery bid, the successful innovator still cannot enter the market. In other words, financial development could help mitigate the negative effects of corruption at this stage. But its effect depends on 1) wealth inequality and 2) intellectual property protection.

**Dynamics effect of corruption on innovation** In the model, corruption at the early stage of development could have a long-lasting impact on innovation activities later on though its impact on the wealth distribution of entrepreneurs. Corruption activities at the adoption stage would reduce churning of the entrepreneurs. But because corruption protects the incumbent, When the economy approaches the frontier, the difference in wealth of the incumbent and the entrants will be higher in the economy with a lot of corruption.

### 6.5 Anti-corruption policy and testable implications

We can model anti-corruption policy is a technology of the planner to detect corruption. If the corruption activity in market $i$ is detected by the planner, a fraction $\tau$ of the entrepreneur's wealth is seized by the planner and redistributed to all agents in the economy in a lump-sum fashion. After the detection, the corrupted entrepreneur is excluded from the market for this period and there are no corruption activities in market $i$ for this period. The entrepreneurs are faced with a decision whether or not to bribe. The expected profit is $(1-q)\pi(z, a, \varepsilon)+q(0-\tau a)$, where $q$ is the probability of getting caught, $\pi(z, a, \varepsilon)$ is the production profit (0 in case of detection) and $\tau a$ is the punishment when detected. If the expected profit is too low, then the entrepreneurs will not engage in bribery activities.

According to our previous analysis, the effect of the anti-corruption campaign depends on the degree of financial frictions and the relative importance of selection for productivity. Our theory also predicts that if a corrupted firm is detected by the anti-corruption campaign, firms that produce complementary goods will suffer and firms that produce substitutes will benefit from it only if they have the financial capacity to expand. One could test these predictions with data on which firms are corrupt. The non-corrupt firms in the same sector could be treated as substitute-goods producers, and the firms in the upstream/downstream sectors as complement-goods producers.

The optimal anti-corruption policy shares some similarities with the development policies described in Acemoglu, Aghion and Zilibotti (2006). When the economy is closer to the frontier, the planner should increase $q$ to remove inefficient incumbents from the market and allow the potential entrants to enter if they successfully innovate. However, it is interesting to note that the optimal $q$ might not be 1 even at the frontier, because financial frictions give an advantage in production to the wealthy incumbent.

# 7 Empirical evidence

In this section we provide empirical evidence of the model's predictions. In section 7.1, we describe the data set. In section 7.2, we describe the variables used in the empirical exercise and in section 7.3 we provide the summary statistics of the data. From section 7.4 to 7.7, we provide further evidence based of the theory of our model.

## 7.1 Overview of the data set

The empirical evidences are based on three data sets. The first one is the Annual Survey of Chinese Industrial Firms for the period of 1998 to 2007. It contains the universe of Chinese industrial firms with an annual revenue above 5 million CNY. We obtain firms' balance sheet information and other characteristics from this data set. The second one is the Chinese patent data, which is matched with the Annual Survey of Chinese Industrial Firms and allows us to measure the innovation activities at the firm level. The third data set is a province-level index of corruption intensity constructed by ourselves using the published courts judgements. More specifically, we count the number of corruption cases that were prosecuted in the judicial system in each province during the period 2014-2018 and normalize the number of corruption cases by the population or the GDP level of each province to construct an index of corruption at the province level.

## 7.2 Variables

Our baseline regression uses a balanced panel of firms over the period of ten years. We dropped observations with missing variables. We drop all firms with negative assets and firms with a positive debt-level but with 0 interest payment. We then winsorize all variables at the top and bottom 1 percentile. We drop all firms that are 100 percent owned by foreigners, including Hong Kong and Taiwan sole ownership firms.

**Growth volatility** Since the industrial survey is left-truncated, it is not the ideal data set to study the entry and exit of firms. We therefore focus on the growth volatility of a balanced sample of firms. To do this, we follow Kalemli-Ozcan, Sorensen and Volosovych (2014) and compute, using a balanced-panel of the firms during the period 1998-2007, the standard deviation (SD) and the coefficient of variation (CV) of annual growth rate of firm sales, number of workers employed, total assets and labor productivity, such that,

$$SD^x = \sqrt{\frac{\sum_{t=1999}^{2007} \mid x_t - \bar{x} \mid^2}{9}},$$

$$CV^x = \frac{\sqrt{\frac{\sum_{t=1999}^{2007} |x_t - \bar{x}|^2}{9}}}{\bar{x}},$$

where $x_t$ is the annual growth rate of variable $x \in \{sales,\ total\ assets,\ workers, labor\ productivity\}$ from year $t-1$ to $t$. One thing to note is that the standard deviation SD is not scale-free: it doubles when the annual growth rate $x_t$ doubles. There are different ways to control for the scale effects. The first one is to use $SD^x$ on the dependent variable and control for the average growth rate $\bar{x}$. The second way is to construct the variable $CV^x$, which is essentially $SD^x$ divided by the average growth rate, in order to account for the scale effect.

**Firm-level financial frictions** We construct three variables to measure firm-level financial frictions. The first one is the average interest rate, which is the total interest payment divided by total debt. The second one is the leverage ratio, which is the total debt divided by net worth. The third one is the share of long-term debt in total debt, since it is shown in the literature that the short-maturity of debt is a key measure of financial frictions in developing countries.

**Corruption index at the province level** We follow Li (2017) to construct a measure of corruption at the province-level using the published courts judgements from the website China Judgements Online. Published judgements on this websites are categorized by the summary of the case. We consider "graft and bribery" cases under the criminal lawsuits as corruption cases and treat these two different types of cases separately. Graft means an intentional misuse of public funds (stealing) and bribery means making payment to officials to influence their decisions. For the bribery cases, since there are two sides of the bribery (the briber and the official), we include cases from the side of the government officials to avoid double-counting. In the analysis below, we normalize the number of corruption cases by the population size in each province.[9]

**Sector-level measurement of dependence on external financing** Later on in our analysis, we also construct, following Rajan and Zingales (1998), a sector-specific indicator of dependence on external financing. We compute a firm-level measure of dependence on external financing as

$$\frac{investment - internal funds}{internal funds},$$

where internal funds is calculated as the operating revenue net of changes in net current assets and inventory. We then take the median value of all firms in each sector as the sector-level indicator.

[9]The results are similar when we normalize the indexes by GDP instead of population.

**Innovation** By merging the industrial survey with the Chinese invention patent data, we can construct, at the firm level, a dummy variable indicating whether this firm has been granted, or applied for, a patent from the Chinese patent office.[10] We use this dummy variable to measure whether a firm is an innovator. Alternatively, we also use the number of patents applied/granted normalized by the number of workers in the firm to measure the level of innovation at the firm-level.

**Other controls** In the regressions, we control for the sector-level fixed effects and firm types (whether they are state-owned, collectively-owned, or private).[11] We also control for the provincial GDP per capita of the initial year (1998). The idea of controlling for the initial income level is to control for the difference in the speed of convergence across different provinces. If the distance to the frontier affects the growth volatility of the province, the initial income level of the province should be able to control for that.

## 7.3 Descriptive statistics

Following common practices in the literature, we winsorize the variables of interests by top and bottom 1 percent of the distribution to remove outliers. We drop provinces with less than 100 firms. In the end, this leaves us with 31 provinces and 30 2-digit sectors. In Table 6, we present the summary statistics of the firm-level variables in the balanced panel from 1998 to 2007. In Table 7, we present the summary statistics of the mean, standard deviation, and coefficient of variance of the variables of interests.

Figure A1 plots the number of corruption cases, which shows that the number of bribery and graft cases has been increasing since the beginning of the 2000s. But it appears that the increase might have be the result of an overall increasing number of published judgements online and there is no clear trend in the share of bribery and graft cases in total judgements.

In Figure 4, we plot the corruption intensity index (number of cases normalized

[10]There are three types of patents: invention, utility, and design. We only consider the invention patents because they are the most consistent type of patents internationally.

[11]Following Hsieh and Song (2015), we adjust for the share of the state-owned enterprise by the state's share in capital of the firm.

by population) of all provinces in mainland China. In Panel A we plot the number of bribery cases and in Panel B the number of graft cases. Similar to the findings in Li (2017), we observe that the southern provinces are more prone to bribery, whereas the central provinces suffer more from graft. Since in our model, we consider only bribery as the form of corruption, in our empirical exercise, we focus on studying the effects of bribery cases, controlling for the number of graft cases.

In Table 8, we list the measure of dependence on external financing (DEF) at the 2-digit sector level. A higher number indicates a heavier reliance on external financing, which is equivalent to higher financial frictions. As shown in this table, the industry that is most reliant on external financing is electric machinery and equipment manufacturing (industry 39), while the industry that is least reliant on external financing is paper products (industry 22).

## 7.4 Corruption and growth volatility

Our data set is a cross-section of firms in the balanced panel. For each firm, we compute the 10-year standard deviation of the variables. Our dependent variable of the baseline specification is the firm-level growth volatility measured by the standard deviation of annual growth rate. We include several firm-level controls and province-level controls. We also control for the mean growth rate of these three variables to account for mechanical scale effects from growth on standard deviation.

More specifically, our regression equation reads,

$$VolGr_i = \alpha + \gamma_s + X_i + \Gamma_p + MeanGr_i + \beta Corruption_p + \epsilon_i, \quad (13)$$

where $VolGr_i$ is a measure of standard deviation in the annual growth rate in sales, employment, total assets and labor productivity during the period 1998-2007. The specification is analogous to the one in section 2. Comparing this to specification 1, this specification has one additional control $MeanGr_i$ to account for the mechanical scale effect of the growth rate on the standard deviation of the variables. The coefficient of interest is $\beta$. Based on our theory, we expect $\beta$ to be negative, meaning that more corrupted provinces should see less growth volatility.

In Table 9, we present the regression results for growth volatility. One unit increase in the number of bribery cases is associated with reductions in the standard deviation of sales growth by 0.218 (column 1), the standard deviation of employment growth by 0.205 (column 2), and the standard deviation of total asset growth by 0.248 (column 3). The results are robust to controlling for the number of graft case per million people (columns 4 to 6). A higher level of graft cases is associated with a higher growth volatility, although the effects are not statistically significant. Furthermore, the results are essentially unchanged when we control for firm-level financial conditions in column 7 to 9.

### 7.5 Corruption and financial frictions

Our theory also predicts that the role of corruption is more prominent when financial frictions are stronger. To test this prediction, we explore the sector-level variation in the dependence on external financing (DEF), to test whether the correlations between bribery and firm outcomes are stronger for firms in sectors with a higher dependence on external financing. We test the prediction for both the mean growth and growth volatility at the firm level. The specification are based on equations 1 and 13, while also controlling for an interaction term between an indicator of dependence on external financing at the sector-level.

In Table 10, we report the results for the relationship between corruption, financial constraints, and firm growth. As shown in columns 1 to 3, the interaction between bribery and a dummy variable indicating whether the sector has a DEF level higher than the median of all sector is positive for all three firm-level outcomes and it is significant for sales (column 1) and size of employment (column 2). This result suggests that firms in sectors that are more reliant on external financing have higher growth rates in provinces with a higher bribery level. The estimate on the corruption level itself is still significantly positive for the case of employment and assets (column 2 and 3), and it becomes negative but insignificant if the outcome variable is sales (column 1). In column 4 to 6, we run a similar regression but also control for the level of graft, and the coefficients of interest are essentially unchanged. In addition, in column 7 to 9, we control for an interaction term between the sector-level DEF and province-level number of graft case per million people. The results are still robust with these additional control. Interestingly, the interaction term between graft and DEF is negative for all three cases, and it is significant when the dependent variable is employment.

Table 11 reports the results on firms' growth volatility. Consistent with our theory, column 1 to 3 show that the interaction term between bribery and DEF is negative for all three outcome variables and is significant in the case of sales and employment. The results are robust when we control for the level of graft (column 4 to 6) and an interaction between graft and DEF (column 7 to 9).

## 7.6 Corruption and distance to frontier

Our theory predicts that the potential positive growth effects of corruption is the strongest when the economy is far away from the world technological frontier. In this section, we test this theory by exploring the cross-industry differences in productivity. For each industry, we assign the labor productivity of the 90th percentile of the firm as the industry-level measure. We test how the effect of corruption changes with the initial labor productivity level. More formally, we consider the specification 1 and control for an interaction term between the initial labor productivity and the corruption index at the province level.

The results are presented in Table 12. As shown in the table, after controlling for the interaction term, a higher incidence of bribery cases continues to be associated with a significantly higher growth rate in sales, employment and total assets (column 1-3). These results remain even after controlling for the incidence of graft cases (column 4-6) and firm-level financial conditions (column 7-9). At the same time, the interaction term between initial labor productivity of the industry and the incidence of bribery is consistently negative and significant. This means that the positive growth effect of corruption is less significant when the initial technology level–measured by the initial labor productivity–is higher.

## 7.7 Corruption and innovation

Similar to our previous specifications, we can test the role of corruption in determining firm-level innovation activities. To this end, we run a regression analogous to specification 13, in which the dependent variable is the number of total patents granted to the firms, or a dummy variable indicating whether the firms are granted a patent. We control for initial conditions at the firm- or province-level, such as initial firm size or the initial GDP per capita, and the growth rate of the GDP per capita at the province-level. Interestingly, the results in Table 13 show that higher incidence of bribery cases is associated with a significantly higher probability that the firm is granted a patent during the period 1998-2007. The estimated coefficient is 0.0016 (column 1) and the results are robust when we control for the number of graft cases (column 2) and firm's financing conditions (column 3). In column 4-6, we run the same regression but control for whether the firm was granted a patent during the first two years (1998-1999), and the dependent variable is a dummy variable of whether the firm is granted a patent during the subsequent years (2000-2007). The results show that the correlation between the bribery incidences and the probability of a patent granted remains significantly positive.[12]

The results presented in Table 13 seem to be at odds with our early result that higher incidence of bribery is associated with a slower growth in labor productivity (column 4 and 8 in Table 5). One possible explanation of the two different results could be that the decision of innovation activities are constrained by firms' financing conditions, such as cash flow and their access to external financing. In Table 14, we investigate which firm-level initial characteristics can explain the application or granting of patents. As shown in column 1 and 3, the initial operating profit and asset size are positively correlated with the probability of a grant application or being granted a patent. The correlations are significant at 1% level. However, the estimated coefficient of the initial labor productivity is insignificant and negative. This result says that the initial financial condition, rather than productivity, can explain the subsequent innovation behavior. We show in Table 5 that correlation is significantly and positively correlated with firms' total assets. It is thus reasonable to expect that these firms would engage in more innovative activities, since they have access to more financial resources. Furthermore, it is interesting to note that according to theory, the most productive firms choose to innovate, whereas less productive firms imitate from the frontier. Our result suggests that, in the presence of financial frictions, access to financing, rather than productivity, determines the choice of innovation. Corruption can distort the innovation decisions in the dynamic setting by giving less productive firms an advantage in financing and innovating.

[12]The results are similar when using patents applied instead of granted in the regressions.

# 8 Conclusion

We propose a novel firm dynamics model to study the role of corruption for growth. Incumbent firms and potential entrants can make bids to bribe government officials and obtain a permit to operate. Bribes are paid out of pocket and wealthier incumbents are likely to outbid entrants, creating an entry barrier. Firms are subject to financial constraints, which they can outgrow more rapidly if they are more profitable. This implies that corruption can potentially increase growth: it acts as an entry barrier that protects incumbents, reduces firm churning, and allow incumbents to accumulate wealth more rapidly to outgrow the financial constraint. However, the entry barrier keeps out entrants with potentially higher productivity. This cost is more likely to outweigh the benefit of corruption (alleviating the financial constraint) when the economy is more developed, because firms have outgrown the financial constraint. Furthermore, as the economy approaches the technology frontier, innovation becomes a more important source of growth than capital accumulation. While corruption can be beneficial at early stages of development, it also skews the wealth distribution and the wealthier incumbents are more likely to be able to protect themselves against entrants even at later stages of development.

We use Chinese firm-level data and variation in corruption across provinces in order to show that higher corruption is associated with higher growth in employment and capital, but lower productivity growth. This relationship is stronger for industries that are more financially constrained, which is in line with our theory.

## Table 5: Corruption and growth

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| corruption (bribery) | 0.00346 | 0.0954*** | 0.122** | -0.108** | 0.0397 | 0.101*** | 0.125*** | -0.0700 |
| | (0.0476) | (0.0309) | (0.0438) | (0.0504) | (0.0453) | (0.0295) | (0.0353) | (0.0481) |
| corruption (graft) | | | | | 0.151 | 0.0378 | 0.0757 | 0.0860 |
| | | | | | (0.0895) | (0.0368) | (0.0508) | (0.0839) |
| log of initial workers | -3.616*** | -6.816*** | -4.276*** | 6.478*** | -2.581*** | -6.688*** | -2.964*** | 6.437*** |
| | (0.976) | (0.681) | (1.138) | (1.369) | (0.916) | (0.664) | (0.969) | (1.191) |
| log of initial GDP p.c. | -3.760*** | -0.992** | -1.337** | -2.619*** | -2.400*** | -0.715 | -0.538 | -1.963** |
| | (0.826) | (0.378) | (0.643) | (0.865) | (0.796) | (0.514) | (0.616) | (0.813) |
| inital GDP p.c. growth | 10.62** | 3.180 | 7.923*** | 6.046 | 7.210** | 2.502 | 5.460** | 4.241 |
| | (4.291) | (2.324) | (2.723) | (5.430) | (3.044) | (2.252) | (2.257) | (4.182) |
| initial sales growth | | | | | 0.0703*** | | | |
| | | | | | (0.00507) | | | |
| initial worker growth | | | | | | 0.000214* | | |
| | | | | | | (0.000107) | | |
| initial assets growth | | | | | | | 0.131*** | |
| | | | | | | | (0.0106) | |
| inital labor productivity growth | | | | | | | | 0.0351*** |
| | | | | | | | | (0.00352) |
| Dependent variable | sales gr | employment gr | assets gr | lab. prod. gr | sales gr | employment gr | assets gr | lab. prod. gr |
| Sector FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Firm type FE | Y | Y | Y | Y | Y | Y | Y | Y |
| N | 22821 | 22861 | 22848 | 22815 | 22698 | 22861 | 22757 | 22704 |
| AR2 | 0.0857 | 0.220 | 0.123 | 0.118 | 0.167 | 0.221 | 0.253 | 0.150 |

Note: This table presents the estimated effects of corruption on mean growth while controling for firms' inital growth rate. All regressions control for sectorl-level fixed effects. Standard errors are clustered at the sector and province level.

Table 6: Summary Statistics; balanced panel 1998-2007

| Variable | Mean | Std. Dev. | Min. | Max. | N |
|---|---|---|---|---|---|
| employment | 429.81 | 714.58 | 12 | 4904 | 243890 |
| output | 113187.35 | 276478.1 | 1340 | 2068579 | 243890 |
| sales | 110701.2 | 272407.91 | 1200 | 2040922 | 243890 |
| total assets | 169807.21 | 1228500.66 | 0 | 128000000 | 243890 |
| labor productivity | 339.18 | 560.61 | 9.96 | 4105.19 | 243890 |
| share of long term debt | 0.11 | 0.18 | 0 | 0.81 | 243080 |
| leverage ratio | 2.57 | 6.56 | -21.16 | 42.09 | 243208 |
| operating profit | 5017.90 | 18567.97 | -22007 | 137130 | 243890 |
| current assets | 63108.36 | 158710.38 | 716 | 1178387 | 243890 |
| current debt | 58570.86 | 148163.95 | 0 | 1096728 | 243890 |
| inventory | 19228.87 | 47865.45 | 0 | 352636 | 243890 |
| investment | 3705.19 | 16596.16 | 0 | 132439 | 243890 |
| number of invention patent filed | 0.99 | 4.05 | 0 | 31 | 243890 |
| number of invention patent granted | 0.55 | 2.34 | 0 | 18 | 243890 |
| year | 2002.5 | 2.87 | 1998 | 2007 | 243890 |

Table 7: Summary Statistics; computed from the balanced panel 1998-2007

| **Variable** | **Mean** | **Std. Dev.** | **Min.** | **Max.** | **N** |
|---|---|---|---|---|---|
| mean growth rate of workers (percent) | 11.6 | 25.63 | -35.14 | 211.55 | 24389 |
| s.d. in growth rate of workers | 46.49 | 64.16 | 0 | 351.06 | 24389 |
| c.v. in growth rate of workers | 0.32 | 0.23 | 0 | 2.78 | 24389 |
| mean growth rate of output (percent) | 18.03 | 16.74 | -72.68 | 117.33 | 24383 |
| s.d. in growth rate of output | 39.65 | 24.69 | 0 | 156.41 | 24375 |
| c.v. in growth rate of output | 0.5 | 0.27 | 0 | 2.82 | 24389 |
| mean growth rate of sales (percent) | 18.7 | 17.29 | -73.57 | 121.75 | 24387 |
| s.d. in growth rate of sales | 40.79 | 26.37 | 0 | 180.5 | 24380 |
| c.v. in growth rate of sales | 0.5 | 0.28 | 0 | 2.78 | 24389 |
| mean growth rate of labor productivity (percent) | 20.52 | 18.64 | -92 | 154.15 | 24383 |
| s.d. in growth rate of labor productivity | 51.87 | 35.72 | 0 | 282.65 | 24375 |
| c.v. in growth rate of labor productivity | 0.62 | 0.48 | 0 | 3.08 | 24389 |
| mean growth rate of total assets (percent) | 12.37 | 13.86 | -21.95 | 98.90 | 24389 |
| s.d. in growth rate of total assets | 28.55 | 20.08 | 0.15 | 119.24 | 24389 |
| c.v. in growth rate of total asset | 0.38 | 0.26 | 0 | 2.66 | 24389 |

Table 8: Dependence on external financing

| industry | description | DEF |
|---|---|---|
| 13 | Manufacturing of agricultural and non-staple foodstuff | .16 |
| 14 | Foodstuff manufacturing industry | .67 |
| 15 | Beverage manufacturing industry | .24 |
| 16 | Tobacco industry | -.25 |
| 17 | Textile industry | .09 |
| 18 | Manufacturing industry of textile costumes, shoes, and caps | .04 |
| 19 | Manufacturing industry of leather, fur, feather (cloth with soft nap) and their products | -.45 |
| 20 | Wood processing and manufacturing industry of wood, bamboo, rattan, palm, and straw-made articles | .32 |
| 21 | Cabinetmaking industry | .23 |
| 22 | Papermaking and paper product industry | -.85 |
| 23 | Printing industry and reproduction of record media | .58 |
| 24 | Manufacturing industry for culture, education and sports goods | -.04 |
| 25 | Petroleum processing, coking and nuclear fuel manufacture | .39 |
| 26 | Chemical feedstock and chemical manufacturing industry | .16 |
| 27 | Medicine manufacturing industry | -.31 |
| 28 | Chemical fiber manufacturing industry | .35 |
| 29 | Rubber production industry | .26 |
| 30 | Plastic industry | .28 |
| 31 | Non-metallic minerals product industry | .63 |
| 32 | Ferrous metal smelting and extrusion | .08 |
| 33 | Non-ferrous smelting and extrusion | .89 |
| 34 | Metalwork industry | .24 |
| 35 | General-purpose equipment manufacturing industry | .35 |
| 36 | Specialized facility manufacturing industry | .54 |
| 37 | Transport and communication facilities manufacturing industry | .61 |
| 39 | Electric machinery and equipment manufacturing industry | .95 |
| 40 | Manufacturing industry of communication equipment, computers and other electronic equipment | .54 |
| 41 | Manufacturing industry of instruments and meters, and machinery for culture and office | .52 |
| 42 | Artwork and other manufacturing industries | .8 |
| 43 | Processing of discarded resources, and waste and scrap recovery | -.27 |

## Table 9: Corruption and growth volatility

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| corruption (bribery) | -0.218** | -0.205* | -0.248*** | -0.213*** | -0.198 | -0.241*** | -0.215*** | -0.198 | -0.243*** |
| | (0.0880) | (0.122) | (0.0431) | (0.0822) | (0.121) | (0.0469) | (0.0821) | (0.120) | (0.0468) |
| corruption (graft) | | | | 0.0337 | 0.0446 | 0.0450 | 0.0341 | 0.0472 | 0.0443 |
| | | | | (0.0999) | (0.105) | (0.0694) | (0.0985) | (0.105) | (0.0687) |
| log of initial workers | -0.230 | 2.244 | -1.461 | -0.188 | 2.285 | -1.405 | -0.149 | 2.264 | -1.363 |
| | (1.769) | (3.063) | (0.914) | (1.731) | (3.021) | (0.937) | (1.706) | (3.013) | (0.936) |
| log of initial workers squared | -0.124 | 0.0568 | 0.0238 | -0.128 | 0.0527 | 0.0186 | -0.128 | 0.0578 | 0.0168 |
| | (0.144) | (0.266) | (0.0797) | (0.141) | (0.262) | (0.0819) | (0.138) | (0.261) | (0.0824) |
| log of initial GDP p.c. | 0.519 | 1.777* | -1.823*** | 0.758 | 2.096 | -1.501** | 0.647 | 2.048 | -1.573*** |
| | (1.010) | (0.958) | (0.665) | (1.150) | (1.435) | (0.602) | (1.180) | (1.477) | (0.603) |
| inital GDP p.c. growth | -12.34*** | -8.750 | -5.103 | -12.93*** | -9.534 | -5.889 | -12.73*** | -9.420 | -5.771 |
| | (4.649) | (6.580) | (4.911) | (3.438) | (6.182) | (4.660) | (3.393) | (6.100) | (4.652) |
| share of long-term debt | | | | | | | -2.654 | -1.799 | -1.355** |
| | | | | | | | (1.855) | (2.010) | (0.681) |
| leverage ratio | | | | | | | -0.0246 | 0.0612 | -0.0493 |
| | | | | | | | (0.0614) | (0.0612) | (0.0326) |
| Dependent variable | s.d. sales gr | s.d. wkr gr | s.d. assets gr | s.d. sales gr | s.d. wkr gr | s.d. assets gr | s.d. sales gr | s.d. wkr gr | s.d. assets gr |
| Sector FE | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Firm type FE | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| N | 22852 | 22861 | 22861 | 22852 | 22861 | 22861 | 22850 | 22859 | 22859 |
| AR2 | 0.398 | 0.799 | 0.502 | 0.398 | 0.799 | 0.502 | 0.398 | 0.799 | 0.502 |

Note: Standard errors are clustered at the sector and the province level. All regressions control for sectorl-level fixed effects and the mean of annual growth rate.

Table 10: Corruption, financial friction, and firm growth

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| corruption (bribery) | -0.0269 | 0.0799*** | 0.0965** | -0.00607 | 0.0847*** | 0.106** | -0.00557 | 0.0878*** | 0.109** |
| | (0.0438) | (0.0264) | (0.0426) | (0.0364) | (0.0243) | (0.0414) | (0.0365) | (0.0242) | (0.0416) |
| corruption (graft) | | | | 0.150 | 0.0348 | 0.0715 | 0.154 | 0.0608 | 0.0904 |
| | | | | (0.0921) | (0.0365) | (0.0523) | (0.102) | (0.0365) | (0.0582) |
| bribery X DEF above median | 0.0707*** | 0.0485** | 0.0301 | 0.0743*** | 0.0493** | 0.0317 | 0.0735*** | 0.0443** | 0.0281 |
| | (0.0242) | (0.0185) | (0.0194) | (0.0250) | (0.0183) | (0.0199) | (0.0246) | (0.0170) | (0.0201) |
| graft X DEF above median | | | | | | | -0.00724 | -0.0448* | -0.0326 |
| | | | | | | | (0.0294) | (0.0232) | (0.0233) |
| DEF above median | 0.274 | -0.623 | 0.00746 | 0.226 | -0.633 | -0.0139 | 0.334 | 0.0339 | 0.471 |
| | (0.468) | (0.398) | (0.401) | (0.474) | (0.400) | (0.409) | (0.643) | (0.523) | (0.596) |
| log of initial workers | -3.629*** | -6.641*** | -3.411*** | -3.444*** | -6.597*** | -3.323*** | -3.442*** | -6.584*** | -3.314*** |
| | (0.990) | (0.608) | (0.980) | (0.971) | (0.590) | (0.994) | (0.974) | (0.593) | (0.994) |
| log of initial workers squared | 0.245*** | 0.403*** | 0.247*** | 0.229*** | 0.399*** | 0.239*** | 0.228*** | 0.398*** | 0.238*** |
| | (0.0808) | (0.0519) | (0.0787) | (0.0790) | (0.0502) | (0.0795) | (0.0792) | (0.0504) | (0.0794) |
| log of initial GDP p.c. | -3.473*** | -0.810* | -0.940 | -2.382*** | -0.557 | -0.420 | -2.380*** | -0.544 | -0.410 |
| | (0.856) | (0.411) | (0.593) | (0.829) | (0.537) | (0.625) | (0.829) | (0.536) | (0.621) |
| inital GDP p.c. growth | 9.943** | 3.073 | 6.708** | 7.285** | 2.457 | 5.446** | 7.271** | 2.365 | 5.380** |
| | (4.574) | (2.408) | (2.947) | (3.194) | (2.305) | (2.379) | (3.187) | (2.337) | (2.368) |
| Dependent variable | sales gr | wkr gr | assets gr | sales gr | wkr gr | assets gr | sales gr | wkr gr | assets gr |
| Sector FE | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Firm type FE | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| N | 22698 | 22861 | 22757 | 22698 | 22861 | 22757 | 22698 | 22861 | 22757 |
| AR2 | 0.148 | 0.213 | 0.243 | 0.151 | 0.214 | 0.244 | 0.151 | 0.214 | 0.245 |

Note: Standard errors are clustered at the province level. All regressions control for sectorl-level fixed effects and the inital growth rate of the dependent variables.

## Table 11: Corruption, financial friction, and firm growth volatility

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| corruption (bribery) | -0.119 | -0.113 | -0.211*** | -0.114 | -0.104 | -0.203*** | -0.112 | -0.108 | -0.204*** |
| | (0.0803) | (0.116) | (0.0591) | (0.0777) | (0.116) | (0.0634) | (0.0778) | (0.116) | (0.0644) |
| corruption (graft) | | | | 0.0384 | 0.0636 | 0.0562 | 0.0504 | 0.0263 | 0.0474 |
| | | | | (0.104) | (0.112) | (0.0814) | (0.117) | (0.116) | (0.0841) |
| bribery X DEF above median | -0.140** | -0.180*** | -0.0445 | -0.139** | -0.178*** | -0.0432 | -0.142** | -0.171*** | -0.0415 |
| | (0.0613) | (0.0460) | (0.0355) | (0.0605) | (0.0454) | (0.0346) | (0.0599) | (0.0433) | (0.0346) |
| graft X DEF above median | | | | | | | -0.0206 | 0.0641 | 0.0152 |
| | | | | | | | (0.0571) | (0.0540) | (0.0471) |
| DEF above median | 0.540 | 1.815* | -0.953 | 0.528 | 1.797* | -0.971 | 0.836 | 0.843 | -1.197 |
| | (1.089) | (1.001) | (0.685) | (1.082) | (0.998) | (0.675) | (1.131) | (1.246) | (0.842) |
| log of initial workers | 0.265 | 2.521 | -1.074 | 0.308 | 2.571 | -1.012 | 0.313 | 2.559 | -1.016 |
| | (1.853) | (3.024) | (0.968) | (1.810) | (2.983) | (0.981) | (1.808) | (2.982) | (0.984) |
| log of initial workers squared | -0.151 | 0.0226 | -0.00726 | -0.155 | 0.0176 | -0.0130 | -0.155 | 0.0185 | -0.0127 |
| | (0.150) | (0.258) | (0.0797) | (0.146) | (0.253) | (0.0816) | (0.146) | (0.253) | (0.0817) |
| log of initial GDP p.c. | 0.665 | 1.454 | -1.989** | 0.941 | 1.915 | -1.582** | 0.947 | 1.895 | -1.586** |
| | (1.052) | (1.096) | (0.807) | (1.191) | (1.580) | (0.667) | (1.190) | (1.582) | (0.669) |
| inital GDP p.c. growth | -12.77** | -8.751 | -5.221 | -13.45*** | -9.876 | -6.209 | -13.49*** | -9.745 | -6.178 |
| | (4.969) | (6.685) | (5.559) | (3.783) | (6.222) | (5.200) | (3.746) | (6.285) | (5.182) |
| mean sales growth | 0.938*** | | | 0.938*** | | | 0.938*** | | |
| | (0.0412) | | | (0.0417) | | | (0.0417) | | |
| mean worker growth | | 2.252*** | | | 2.251*** | | | 2.252*** | |
| | | (0.0591) | | | (0.0583) | | | (0.0584) | |
| mean total assset growth | | | 0.978*** | | | 0.977*** | | | 0.977*** |
| | | | (0.0410) | | | (0.0411) | | | (0.0412) |
| Dependent variable | s.d. sales gr | s.d. wkr gr | s.d. assets gr | s.d. sales gr | s.d. wkr gr | s.d. assets | s.d. sales gr | s.d. wkr gr | s.d. assets gr |
| Sector FE | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Firm type FE | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| N | 22852 | 22861 | 22861 | 22852 | 22861 | 22861 | 22852 | 22861 | 22861 |
| AR2 | 0.389 | 0.798 | 0.491 | 0.389 | 0.798 | 0.491 | 0.389 | 0.798 | 0.491 |

Note: Standard errors are clustered at the province level. All regressions control for sectorl-level fixed effects.

Table 12: Corruption and distance to frontier

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| corruption (bribery) | 0.591** | 0.547*** | 0.455*** | 0.569** | 0.542*** | 0.444*** | 0.572** | 0.542*** | 0.443*** |
| | (0.240) | (0.126) | (0.127) | (0.235) | (0.125) | (0.130) | (0.233) | (0.127) | (0.128) |
| log initial lab. pro. X bribery | -0.0882** | -0.0694*** | -0.0524*** | -0.0814** | -0.0678*** | -0.0490** | -0.0815** | -0.0678*** | -0.0490** |
| | (0.0329) | (0.0171) | (0.0184) | (0.0317) | (0.0169) | (0.0185) | (0.0314) | (0.0172) | (0.0182) |
| corruption (graft) | | | | 0.149 | 0.0363 | 0.0745 | 0.150 | 0.0351 | 0.0765 |
| | | | | (0.0900) | (0.0368) | (0.0510) | (0.0892) | (0.0363) | (0.0500) |
| log of initial workers | -2.782*** | -6.737*** | -3.065*** | -2.580*** | -6.688*** | -2.965*** | -2.623*** | -6.676*** | -2.976*** |
| | (0.943) | (0.688) | (0.959) | (0.910) | (0.670) | (0.972) | (0.899) | (0.655) | (0.968) |
| log of initial workers squared | 0.167** | 0.403*** | 0.213** | 0.149** | 0.398*** | 0.204** | 0.151** | 0.395*** | 0.209** |
| | (0.0749) | (0.0572) | (0.0767) | (0.0717) | (0.0554) | (0.0773) | (0.0704) | (0.0535) | (0.0766) |
| log of initial GDP p.c. | -3.490*** | -0.990** | -1.084* | -2.418*** | -0.730 | -0.548 | -2.351*** | -0.699 | -0.624 |
| | (0.825) | (0.375) | (0.589) | (0.795) | (0.512) | (0.614) | (0.806) | (0.522) | (0.609) |
| inital GDP p.c. growth | 9.834** | 3.140 | 6.767** | 7.209** | 2.502 | 5.461** | 7.097** | 2.441 | 5.612** |
| | (4.392) | (2.312) | (2.827) | (3.051) | (2.242) | (2.252) | (3.035) | (2.217) | (2.231) |
| initial sales growth rate | 0.0705*** | | | 0.0703*** | | | 0.0702*** | | |
| | (0.00513) | | | (0.00506) | | | (0.00504) | | |
| initial worker growth rate | | 0.000211* | | | 0.000212* | | | 0.000211* | |
| | | (0.000107) | | | (0.000108) | | | (0.000109) | |
| initial assets growth rate | | | 0.131*** | | | 0.131*** | | | 0.131*** |
| | | | (0.0106) | | | (0.0105) | | | (0.0105) |
| initial lab. pro. growth rate | | | | | | | | | |
| share of long-term debt | | | | | | | 1.287 | 1.024 | -2.252*** |
| | | | | | | | (0.983) | (0.650) | (0.669) |
| leverage ratio | | | | | | | 0.0450 | -0.0253 | 0.0339 |
| | | | | | | | (0.0304) | (0.0254) | (0.0239) |
| Dependent variable | sales gr | wkr gr | assets gr | sales gr | wkr gr | assets gr | sales gr | wkr gr | assets gr |
| Sector FE | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Firm type FE | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| N | 22698 | 22861 | 22757 | 22698 | 22861 | 22757 | 22696 | 22859 | 22755 |
| AR2 | 0.164 | 0.221 | 0.252 | 0.167 | 0.222 | 0.254 | 0.167 | 0.222 | 0.254 |

Note: Standard errors are clustered at the province level. All regressions control for sector times province fixed effects and firm type fixed effects.

Table 13: Corruption and patents granted

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| corruption (bribery) | 0.00160*** | 0.00125*** | 0.00127*** | 0.00169*** | 0.00136*** | 0.00138*** |
| | (0.000459) | (0.000371) | (0.000380) | (0.000422) | (0.000338) | (0.000345) |
| corruption (graft) | | -0.00231*** | -0.00241*** | | -0.00214*** | -0.00224*** |
| | | (0.000499) | (0.000536) | | (0.000488) | (0.000533) |
| log of initial workers | -0.165*** | -0.168*** | -0.167*** | -0.143*** | -0.146*** | -0.144*** |
| | (0.0193) | (0.0188) | (0.0190) | (0.0182) | (0.0177) | (0.0178) |
| log of initial workers squared | 0.0201*** | 0.0204*** | 0.0201*** | 0.0177*** | 0.0180*** | 0.0177*** |
| | (0.00171) | (0.00167) | (0.00169) | (0.00165) | (0.00160) | (0.00162) |
| log of initial GDP p.c. | 0.0481*** | 0.0313*** | 0.0337*** | 0.0464*** | 0.0309*** | 0.0332*** |
| | (0.00826) | (0.00937) | (0.00951) | (0.00762) | (0.00836) | (0.00854) |
| inital GDP p.c. growth | -0.0690 | -0.0281 | -0.0330 | -0.0641 | -0.0262 | -0.0300 |
| | (0.0404) | (0.0332) | (0.0337) | (0.0402) | (0.0316) | (0.0317) |
| dummy patents 98-99 | | | | 0.507*** | 0.506*** | 0.509*** |
| | | | | (0.0324) | (0.0326) | (0.0340) |
| share of long-term debt | | | 0.0718** | | | 0.0701** |
| | | | (0.0276) | | | (0.0273) |
| leverage ratio | | | -0.00249*** | | | -0.00233** |
| | | | (0.000873) | | | (0.000891) |
| Dependent variable | dummy granted 98-07 | dummy granted 98-07 | dummy granted 98-07 | dummy granted 00-07 | dummy granted 00-07 | dummy granted 00-07 |
| Firm type FE | Y | Y | Y | Y | Y | Y |
| Sector FE | Y | Y | Y | Y | Y | Y |
| N | 22861 | 22861 | 22859 | 22861 | 22861 | 22859 |
| AR2 | 0.0882 | 0.0894 | 0.0909 | 0.105 | 0.106 | 0.108 |

Note: The dependent variables are a dummy variable of patents granted during the period of 1998-2007 (column 1-3) or a dummy variable of patents granted during the period of 2000-2007 (column 4-6). Standard errors are clustered at the province level. All regressions control for sectoral fixed effects and firm-type fixed effects.

Table 14: Determinants of innovation activities

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| log initial worker | 0.00420 | 0.00278 | 0.00596 | 0.00459 |
| | (0.00435) | (0.00428) | (0.00486) | (0.00477) |
| log initial labor productivity | -0.00285 | -0.00344 | -0.00169 | -0.00267 |
| | (0.00285) | (0.00280) | (0.00321) | (0.00314) |
| log initial assets | 0.0571*** | 0.0532*** | 0.0675*** | 0.0630*** |
| | (0.00347) | (0.00342) | (0.00384) | (0.00379) |
| log initial oper profit | 0.0165*** | 0.0163*** | 0.0181*** | 0.0175*** |
| | (0.00169) | (0.00168) | (0.00189) | (0.00187) |
| dummy patent granted 98-99 | | 0.437*** | | |
| | | (0.0369) | | |
| dummy patent filed 98-99 | | | | 0.365*** |
| | | | | (0.0286) |
| Dependent variable | dummy granted | dummy granted 00-07 | dummy filed | dummy filed 00-07 |
| SectorXProvince FE | Y | Y | Y | Y |
| Firm type FE | Y | Y | Y | Y |
| N | 17546 | 17546 | 17546 | 17546 |
| AR2 | 0.179 | 0.189 | 0.200 | 0.210 |

Note: Standard errors are clustered at the province level. All regressions control for sector times province fixed effects and firm type fixed effects.

# Appendix

## A Additional figures and tables

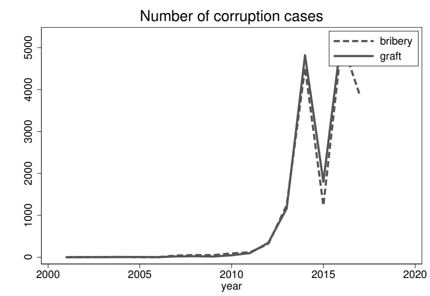


Figure A1: **Number of corruption cases**

**Source**: China Judgements Online (2014-2018)

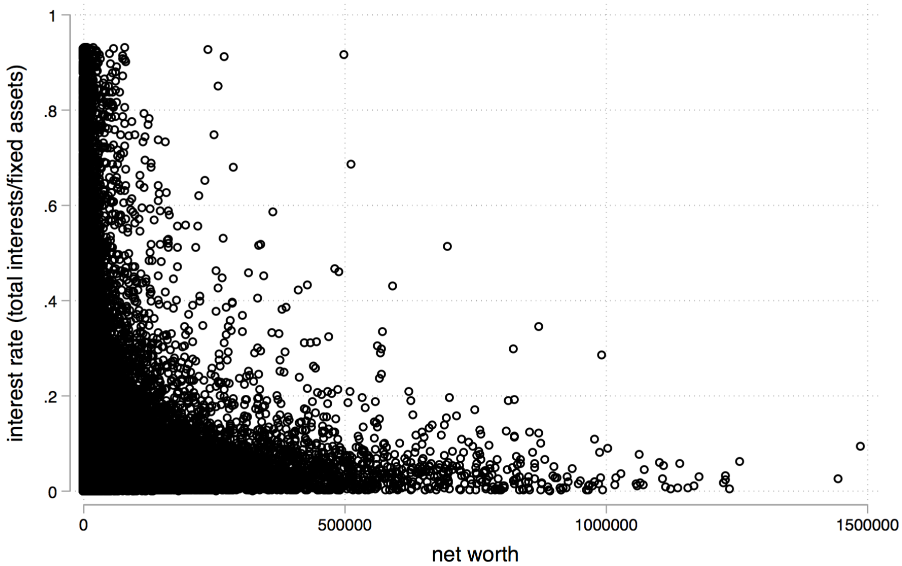


Figure A2: **Interest rate and net worth**

**Source**: Chinese annual industrial survey (1998-2005)
**Regression:** $r_{i,t} = \beta_0(0.076^{***}) + \beta_1 \frac{1}{a_{i,t}} + \gamma_i + \epsilon_{i,t}$

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