Spatial Consequences of Corruption: Entry and Location Decisions of Firms

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November 2, 2023

Abstract

1 Introduction

When the federal government has limited capacity to monitor and hold lower levels of government accountable for corruption, in equilibrium, corruption would be heterogeneous and more severe in some regions. If corruption is an additional cost for the majority of firms using or providing goods/services to the government, the distribution of corruption creates spatial misallocation with potential aggregate consequences. In this paper we ask three questions. First, does corruption affects the spatial allocation of economic activity? Second, does it has dynamic implications on local and aggregate growth? Third, the reduced growth comes from less entry or lower investment of incumbents or both? In other words, does corruption secures market power to locally connected firms and refrain others from entry? We think the Brazilian case is an ideal setting to answer these questions. It provides us with a natural experiment marked by an exogenous reduction in corruption at the municipality level. Moreover, in Brazil, as described in Colonelli et al. (2022), there is substantial inter municipality trade with firms providing goods and services in other municipalities. We use this natural experiment and a General Equilibrium framework to assess the aggregate effect of the policy and decompose it between reallocation and aggregate entry.

There is a large literature on the implications of corruption at the firm level. The government has the ownership or regulates the access to different goods and services which are important in the production process of private firms (Shleifer and Vishny, 1994). Leff (1964) and Kaufmann and Wei (1999) advanced the idea that corruption is the expression of private agreements with the government to reduce burdensome constraints and regulations in the provision of those government services. This view, therefore, implies that market efficiency can benefit from corruption practices. Moreover, firms have incentives to actively connect with politicians to relax regulations (Dinc, 2005; Goldman et al. 2013; Sequeira, 2016; Arayavechkit et al. 2017; Bai et al., 2020) and earn preferential access to inputs (Khwaja and Mian, 2005; Fang et al. 2018; Schoenherr, 2019). As connections are costly, however, a few firms would be able to get them and earn the benefits (Fisman, 2001; Cingano and Pinotti, 2013). The latter raises concerns about the dynamic consequences of corruption practices. Akcigit et al. (2020) integrates this idea in a Schumpeterian model of growth where there is a trade off between relaxing constraints in the present but reducing entry and productivity growth in the future.

Contrary to the view of corruption as a potential benefit for efficiency, a strand of the literature supports how, for the majority of firms, paying bribes to corrupt bureaucrats represents an additional constraint inducing misallocation and reducing growth (Olken and Barron, 2009; Djankov and Sequeira, 2014). Empirically, Colonelli and Prem (2021) provide suggestive evidence that firms closely related to government officials lose the most once the connections are exposed. However, the majority of firms benefit from exposing corrupt politicians. In Brazil, municipalities audited experience an increase in entry and better firm dynamics.

We build a General Equilibrium model that allow us to interpret more broadly the aggregate effects of the policy from the empirical estimates obtained using Diff-in-Diff. Our model is static but features two decisions of firms, entry and location choice. We allow homogeneous firms to move across locations based on profits and amenity shocks. Corruption is a tax which is heterogeneous across locations. The levels of corruption will affect the number of firms and wages in each location. Before the location choice, firms compute the expected value of entry and decide whether to enter or not. We obtained closed form solutions for the aggregate entry of firms and the distribution of these firms across locations. In the model, corruption affects the aggregate economy by reducing aggregate entry and local demand. Therefore, we analytically observe the two margins that may be affected by corruption: overall entry and the distribution/reallocation of economic activity in the space. Finally, we show how the DD estimate of the policy effect (as in Colonnelli et al., 2021) captures precisely the reallocation margin, but it misses, by design, the effect on overall entry. Importantly, we show how different combinations of the model parameters are exactly consistent with the DD estimate of Colonnelli et al. (2021), but, at the same time, imply different responses of the overall economy to a change in local corruption levels.

Our research nurtures from previous findings in the political economy literature. Government bureaucrats own goods/services which are important to firms. Naturally, firms have incentives to connect with politicians to relax regulations (Dinc, 2005; Goldman et al. 2013; Sequeira, 2016; Arayavechkit et al. 2017; Bai et al., 2020) and earn preferential access to inputs (Khwaja and Mian, 2005; Fang et al. 2018; Schoenherr, 2019), and earn economic benefits (Fisman, 2001; Cingano and Pinotti, 2013). Contrary to this view, when goods/services are scarce or bureaucrats are able to use redtape, for the majority of firms paying bribes represents an additional constraint inducing misallocation and reducing growth (Olken and Barron, 2009; Djankov and Sequeira, 2014). Akcigit et al. (2020) integrates this idea in a Schumpeterian model of growth where there is a trade off between relaxing constraints in the present and reducing entry and productivity growth in the future. Empirically, Colonelli and Prem (2021) shows suggestive evidence consistent corruption being beneficial for some closely connected firms but detrimental for the broad majority.

A series of influential papers in the political economy literature used the random audits program in Brazil as a laboratory to study how accountability (in the form of information about politicians' malfeasance) influences reelection probabilities (Ferraz and Finan, 2008), incentives and behavior of public agents (Ferraz and Finan, 2011; Lichand et al., 2016), and public good provision (Ferraz et al., 2012; Lichand et al., 2016). This literature informs our theory and empirical analysis. Importantly, Avis et al. (2018) causally established how the accountability provided by audits reduced corruption. Using municipalities randomly audited twice, they found that being audited in the past reduced corruption in 8pc in subsequent audits and increased by 20pc the likelihood of prosecution conditional on corruption[1]. This is crucial for our analysis as it provides robust and causal evidence on how the audits represented a shock in the level of municipal corruption.

Related to our work, Colonnelli and Prem (2021) assessed the effects of the random audits on local economic activity. They found that municipalities audited had 1pc more establishments and firms per year[2], 6pc higher sales, 2.4pc and 3.2pc more credit and deposits than other municipalities never audited. Results are driven by a mix of selection, awareness and disciplining effects operating through a change in politicians' behavior. In a second paper, Colonnelli at all (2022) focus not on the municipalities audited, but on the

[1]Lichand et al. (2016) also found that the announcement of the program itself had significant effects on the corruption level: the awareness that audits were possible already induced a change in behavior of politicians.

[2]The effect was concentrated in those sectors closely related to government procurement (1.4pc). Incumbent firms, those who were in operation at least two quarters before the audit, grew the most (1.4pc in government dependent sectors). Interestingly, there is a negative coefficient on the audit dummy which means that a share of firms in non GD-Procurement sectors shrink in size following the audit. One interpretation of these results is that, at the firm-level, the anti-corruption program generates a reallocation of economic activity towards government-dependent firms that is partly due a shift away from other sectors of the economy.

firms exposed by the audit program, i.e., on those explicitly linked, by the audit reports, to irregularities in the administration of municipal funds. Interestingly, the majority of such firms were not located in the audited municipalities. Results show that firms exposed, on the one hand, became less likely in subsequent periods to receive a procurement from local governments - but on the other, experienced increases in employment level, capital investment and sales (which were 4.8pc, 2pc, and 13pc, respectively, larger than the increase in the control group), and in the number of loans contracted.[3]

Our first contribution is to extend the analysis of Colonelli and Prem (2021) and Colonelli et al. (2022) by assessing the spatial nature of how firms grow. One open question from Colonelli et al. (2022) is whether the growth of exposed firms is happening on audited municipalities or in control municipalities. Second, we want to understand whether exposed or non-exposed firms drive the growth experienced in treated municipalities. This question is important because it allows us to understand whether the results in Colonelli and Prem (2021) are driven by firms that did not contract with the government or by those contracting with the government. Those results can help us understand the role that the government plays in the economy, by securing market power or by creating misallocation in firm dynamics or in the spatial allocation of economic activity.

The increase in economic activity at an audited location (as found by Colonnelli and Prem, 2021) can either represent a reallocation of resources away from other municipalities towards the treated one, or represent a faster increase in entry and production. Similarly, when locations have production/demand connections, as detailed in Colonnelli et al. (2022), the aggregate effects of the policy are bigger than the observed DD estimate. Our second contribution is to evaluate the overall and aggregate effects of the policy on welfare and growth using a spatial GE model of firms that features local and aggregate growth, entry and reallocation of economic activity.

Finally, our research relates to the literature on the role of government in the spatial allocation of the economic activity. Government policies like taxes (Caliendo and Parro, 2019; Fajgelbaum et al. 2019) can create spatial misallocation of firms and workers with important implications on regional inequality and welfare.

2 Facts and Empirical Observations

We start the exercise assessing the effect of the audit on those municipalities treated following the empirical strategy of Colonelli et al. (2021). We use data from the non-identified RAIS which provides information on the universe of establishments in Brazil. The main covariate is the indicator variable of whether the municipalities was audited

[3] According to the authors, such findings support the hypothesis that exposed firms changed their business strategy, starting to invest more and to contract more loans, in adaptation to a new context in which they cannot rely as much on public procurement - and must compete for private demand.

or not. From Avis et al. (2018) we interpret the effects of the audit program as an exogenous reduction in corruption prompted by local politicians changing their behavior as a consequence of better supervision from the Central Government.

We obtain the overall effect of the policy between 2003 and 2010 on the total number of establishments (Y_{mt}) from the following equation:

$$Y_{mt} = \beta_1 Audit_{mt} + \alpha_m + \alpha_t + \epsilon_{mt}$$

Second, we assess the evolution of the effect over time. For a municipality audited in 2003, as we have data up to 2010, $T = 7$.

$$Y_{mt} = \sum_{j=0}^{T} \beta_j dAudit_{mt}^{j} + \alpha_m + \alpha_t + \epsilon_{mt}$$

We present the results for all establishments and disaggregated by size in table 1.

Outcome	**Total Number of Establishments**			
Size	**All**	**Small Size**	**Medium Size**	**Big Size**
Audit	0.00994***	0.00938***	0.0190***	-0.00153
	(0.00288)	(0.00298)	(0.00525)	(0.00379)
Mean in Control	694.2	654.7	32.2	7.2
	(1647.6)	(1533.7)	(98.3)	(22.5)
Observations	70,933	70,933	70,933	70,933
R-squared	0.635	0.619	0.301	0.214
N. Munic.	5,457	5,457	5,457	5,457

Table 1: Overall Effect of the Audit

The audits had a significant effect on firms' entry at the local level. In particular, in those municipalities audited, we observe 1% more productive establishments. This could be a result of (i) new firms entering or (ii) spatial reallocation of existing ones. The effect on medium size firms hints that spatial reallocation might also be at play.

1. Do firms from other municipalities open new establishments in treated municipalities?

2. Do connected/corrupt firms move to other locations or shrink everywhere?

3. Is the growth of exposed firms happening on audited municipalities or in control municipalities?

4. Is the growth in treated municipalities driven by exposed or by non exposed firms?

The results for the second specification are in figure 1. The effect of the policy is small for big establishments. Medium and small firms drive the observed overall effects obtained from the first model specification. Moreover, the effects for medium size firms are increasing over time.

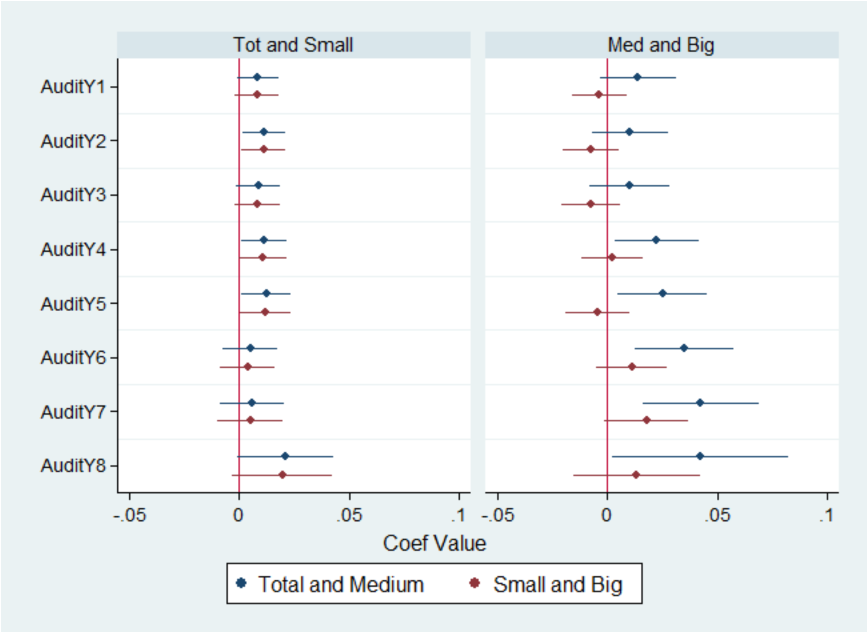


Figure 1: Effect of the Audit over Time

3 Theoretical Model

There are N locations. Local production is obtained by combining the inputs supplied by firms from all locations. Workers are fixed in the space $\{L_i\}_{i=1}^N$ but firms can decide where to operate. There are two stages in the model. First, a mass of potential entrants decide whether to enter or not evaluating the expected value of entry and the entry fixed cost. Second, they draw a random vector of amenities from each location and decide the location where to produce. Firms are homogeneous, but are monopolist in the variety they produce. The fundamentals of each location are heterogeneous and determine prospective profits. Locations with better local productivity and policies will attract more firms.

First, we derive the distribution of firms across the space, conditioned on entry. Second, we study the entry decision and obtain an expression for aggregate entry as a function of fundamentals and the policy.

3.1 Production Stage

3.1.1 Final output in Each Region

There is a representative final good producer in each location $k \in \{1, \ldots, N\}$ that hires inputs from all firms under the following objective function:

$$Y_k = \left[\sum_{i=1}^{N} \int_{\omega \in \Omega_i} q_{k,i}(\omega)^{\frac{\sigma-1}{\sigma}} d(w) \right]^{\frac{\sigma}{\sigma-1}}$$

where Ω_i is the set of varieties being produced at location i - which is endogenously determined by the measure of firms operating there.

The final good producer at location k demand for each variety $\omega \in \Omega_i$ produced in location i can be written as:

$$q_{k,i}(\omega) = P_{k,i}^{-\sigma}(\omega) X_k P_k^{\sigma-1}$$

where $P_{k,i}(\omega)$ is the price charged by the firm producing variety $\omega \in \Omega_i$ when selling it in k, P_k is the ideal price index in location k - given by $P_k = \left[\sum_i \int_{\omega \in \Omega_i} P_{k,i}(\omega)^{1-\sigma} d(w) \right]^{\frac{1}{1-\sigma}}$ - and X_k is the total expenditure from consumers in k.

3.1.2 Intermediate Firms

All firms operating at location j have the same productivity, but each of them is the monopolist supplier of a differentiated variety $\omega \in \Omega_j$ with the production function:

$$q_j(\omega) = A_j l_j(\omega)$$

where $A_j = G_j^{\eta} \bar{A}_j$. We think of G_j as a policy variable that affects the production of the firms and is related to the level of corruption in location j. When corruption is high, G_j is low. We leave the assessment of the mechanism for future versions of the paper. Importantly, η measures the elasticity of local productivity to the police parameter, capturing the intensity with which changes in corruption may affect the local economy. Finally, $\bar{A}_j$ is policy invariant and reflects fundamental characteristics of the location that make firms more productive.

Each firm in j produces and supplies to every other location i by maximizing total profits:

$$\max_{\{P_{i,j}(\omega)\}_{i=1}^{N}} \quad \sum_{i=1}^{N} \left(P_{i,j}(\omega) q_{i,j}(\omega) - \frac{w_j \tau_{ij}}{A_j} q_{i,j}(\omega) \right)$$

where $\{\tau_{ij}\}_i$ are the trade iceberg costs and w_j is the local wage level. The optimal supply of firm ω located in j to each location i takes the form:

$$q_{i,j}(\omega) = \left[\frac{\sigma}{\sigma - 1} \frac{w_j \tau_{ij}}{A_j} \right]^{-\sigma} X_i P_i^{\sigma-1}$$

Total profits of a firm who decides to locate at j is:

$$\pi_j(\omega) = \frac{1}{\sigma} \left(\frac{\sigma}{\sigma - 1} \right)^{1-\sigma} \left(\frac{w_j}{A_j} \right)^{1-\sigma} \sum_i \tau_{ji}^{1-\sigma} X_i P_i^{\sigma-1}$$

Given that population is fixed in the space, we can solve for the wage level in each location:

$$w_j = \left(\frac{\sigma - 1}{\sigma} \right) (A_j)^{\frac{\sigma-1}{\sigma}} \left(\frac{N_j}{L_j} \right)^{1/\sigma} D_j$$

where $D_j = \left[\sum_i \frac{X_i P_i^{\sigma-1}}{\tau_{ji}^{\sigma}} \right]^{\frac{1}{\sigma}}$ and N_j is the number of firms that will be located in equilibrium there. After we substitute for wages, we can express profits in terms of fundamentals and the number of firms in location j:

$$\pi_j(\omega) = \frac{1}{\sigma} \left(\frac{A_j L_j}{N_j} \right)^{\frac{\sigma-1}{\sigma}} \hat{D}_j$$

where $\hat{D}_j = D_j^{1-\sigma} \sum_i \tau_{ji}^{1-\sigma} X_i P_i^{\sigma-1}$. Next, we assess the location decisions of firms.

3.2 Location Decision

Entrepreneurs choose where to locate based on profits and also on idiosyncratic amenity shocks, $\{\epsilon_j\}_{j=1}^{N}$, affecting their preferences for each of the regions. Each entrepreneur independently draws ϵ_j, for every j, from a Fréchet distribution with shape parameter δ, and chose the location i that solves:

$$Max_i \quad \{\pi_i \epsilon_i\}_{i=1}^{N}$$

Under standard calculations we obtain the share and total number of firms who decides to operate in each location j.

$$\Pi_j = \frac{\pi_j^\delta}{\sum_i \pi_i^\delta} \quad \forall j$$

$$N_j = \frac{\pi_j^\delta}{\sum_i \pi_i^\delta} N_T \quad \forall j \tag{1}$$

where N_T is the total number of firms who decided to operate in the economy. Here, (1) is a system of N equations and N unknowns. This system of equations is easy to solve computationally. Moreover, we can get a very simple expression when we consider the case where trade iceberg costs are all equal to 1 ($\tau_{ij} = 1$ for all i and j).

$$N_j = \frac{\left(\frac{1}{\sigma}\left(\frac{A_j L_j}{N_j}\right)^{\frac{\sigma-1}{\sigma}} \hat{D}_j\right)^\delta}{\sum_i \left(\frac{1}{\sigma}\left(\frac{A_i L_i}{N_i}\right)^{\frac{\sigma-1}{\sigma}} \hat{D}_i\right)^\delta} N_T$$

This expression still depends on endogenous objects like $\hat{D}_i, D_i$. Under the case with no trade costs, it is easy to show that the price level P_i will be the same in every region i (we normalize it to 1), and $\hat{D}_i = D_i = D$. Moreover, notice that:

$$D^\sigma \equiv \left(\sum_i X_i\right)$$

where X_i, the total expenditure in each region i equals total income earned by local firms and workers $X_i = w_i L_i + N_i \pi_i$. This means that D can be considered a measure of aggregate GDP in this multi-region economy. Moreover, using the equations we already derived for profits and wages to substitute for X_i, we can express D as:

$$D = \left(\sum_i N_i^{\frac{1}{\sigma}} \left(A_i L_i\right)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{1}{\sigma-1}}$$

After solving for D, we get a very simple solution for the number of firms in each location as a function of fundamentals and the total number of firms N_T in two steps.

First, we take the ratio of the share of firms in two locations k and j.

$$N_k = \frac{\left(\frac{1}{\sigma}\left(\frac{A_k L_k}{N_k}\right)^{\frac{\sigma-1}{\sigma}}\right)^{\delta}}{\left(\frac{1}{\sigma}\left(\frac{A_j L_j}{N_j}\right)^{\frac{\sigma-1}{\sigma}}\right)^{\delta}} N_j$$

Second, we sum across the k locations and solve for N_j:

$$N_j = \frac{(A_j L_j)^{\theta_1}}{\sum_k (A_k L_k)^{\theta_1}} N_T$$

where $\theta_1 = \frac{\delta\frac{\sigma-1}{\sigma}}{1+\delta\frac{\sigma-1}{\sigma}}$. To fully solve the model, we need to obtain the total number of firms N_T. We do this in the next subsection.

3.3 Entry Decision

To determine the total number of firms in the economy N_T, we assume that entrepreneurs have to pay a cost to enter[4]. Entry will only occur only if the ex ante expected welfare is higher or equal than the entry cost. Under standard calculations, we have that the ex ante expected benefit of any firm equals:

$$\Omega_{entry} = E\left[Max_i \left\{\pi_i \epsilon_i\right\}_{i=1}^{N}\right] = \gamma\left[\sum_i \pi_i^{\delta}\right]^{\frac{1}{\delta}} = \gamma\left[\sum_i \left(\frac{1}{\sigma}\right)^{\delta}\left(\frac{A_i L_i}{N_i(N_T)}\right)^{\frac{(\sigma-1)\delta}{\sigma}} D^{\delta}\right]^{\frac{1}{\delta}}$$

where γ is a constant, and we wrote $N_i(N_T)$ to emphasise that the total number of firms in location j depends on the total number of firms in the economy, N_T.

Assume the fixed costs of entering the market are given by $F\left(\frac{N_T}{\bar{N}}\right)^{\alpha}$ with $\alpha > 0$ and $\bar{N}$ a constant. Notice that α represents a congestion externality - the extent to which ideas are getting harder to find. If we want this cost to be constant and doesn't depend on the number of firms entering, we can set $\alpha = 0$. As the number of firms in each location depends on the total number of firms that have entered, we can pin down the total number of firms in the economy. First, let's define $\hat{F} = \left(\frac{\sigma}{\gamma}F\right)^{\delta}$ and use free entry to write:

[4]The entry cost here can be thought as being in util units of risk neutral entrepreneurs, as in Caliendo et al. (2019).

$$\sum_i \left(\frac{A_i L_i}{N_i(N_T)}\right)^{\frac{(\sigma-1)\delta}{\sigma}} D^{\delta} = \hat{F}\left(\frac{N_T}{\bar{N}}\right)^{\alpha\delta}$$

Note that D depends on N_T, so we need to substitute for the value of D and for the number of firms in each location $N_i(N_T)$. After some calculations we get the final solution for N_T:

$$N_T = \left(\frac{1}{\hat{F}}\right)^{\theta_2} \bar{N}^{\theta_3} \left(\sum_i (A_i L_i)^{\theta_1}\right)^{\theta_4} \left(\sum_i (A_i L_i)^{\theta_5}\right)^{\theta_6}$$

We have derived an economic model to assess policy questions that have implications on the reallocation of economic activity and aggregate entry. The strength of each depends on the following elasticities which in turn depend on structural parameters:

$$\theta_1 = \frac{\delta\frac{\sigma-1}{\sigma}}{1+\delta\frac{\sigma-1}{\sigma}} \qquad \theta_2 = \frac{1}{\delta}\frac{\sigma-1}{(\sigma-2)+\alpha(\sigma-1)}$$

$$\theta_3 = \alpha\delta\theta_2 \qquad \theta_4 = \theta_2\left(1+\delta\frac{\sigma-2}{\sigma-1}\right)$$

$$\theta_5 = \frac{\sigma-1}{\sigma}\left[1+\frac{\delta}{\sigma+\delta(\sigma-1)}\right] \qquad \theta_6 = \frac{1}{(\sigma-2)+\alpha(\sigma-1)}$$

4 The Empirical Results Through the Model Lens

Remember the solution for the number of firms in each location:

$$N_j = \frac{(A_j L_j)^{\theta_1}}{\sum_k (A_k L_k)^{\theta_1}} N_T$$

Consider the DD estimates assessing the change in the number of establishments in audited municipalities, as we discussed in Section 2, and as estimated by Colonnelli and Prem (2021). In an economy represented by our model, we can solve in closed form for such estimate. Let the treated (audited) municipalities be denoted by j and the control ones by i. Also, assume that the audit happens between period t and $t-1$. The log difference in the number of firm between the two locations in two points in time is:

$$Ln\left(N_{j,t}\right) - L\left(N_{i,t}\right) = \theta_1\left[Ln\left(A_{j,t}L_{j,t}\right) - Ln\left(A_{i,t}L_{i,t}\right)\right]$$
$$Ln\left(N_{j,t-1}\right) - L\left(N_{i,t-1}\right) = \theta_1\left[Ln\left(A_{j,t-1}L_{j,t-1}\right) - Ln\left(A_{i,t-1}L_{i,t-1}\right)\right]$$

Avis at al. (2019) showed that the audit reduce the level of corruption at the treated municipality, but assumes there are no further changes in fundamentals as a consequence of the policy. The resulting estimate becomes:

$$\begin{aligned} DD &= \left(Ln\left(N_{j,t}\right) - L\left(N_{i,t}\right)\right) - \left(Ln\left(N_{j,t-1}\right) - L\left(N_{i,t-1}\right)\right) \\ &= \theta_1\left[Ln\left(A_{j,t}\right) - Ln\left(A_{j,t-1}\right)\right] \\ &= \theta_1\eta\left[Ln\left(G_j\right) - Ln\left(G_{j,t-1}\right)\right] \end{aligned}$$

The DD parameter obtained in section 2 and Colonnelli and Prem (2021) is equal to $\theta_1\eta$:

$$\theta_1\eta = \frac{\delta^{\frac{\sigma-1}{\sigma}}}{1+\delta^{\frac{\sigma-1}{\sigma}}}\eta = 1\% \tag{2}$$

It is important to notice that such estimate misses the effect on *overall* entry[5] which we calculate as follows:

$$\frac{\partial LnN_T}{\partial LnG_j} = \eta\left[\theta_1\theta_4\Pi_j^1 + \theta_5\theta_6\Pi_j^2\right] \tag{3}$$

[5]The effect on overall entry is also closely related to the effect on aggregate GDP. To see why, let us solve for GDP and compare it to the expression we already derived for N_T. Remember that D depended on the sum of income in all regions. It is straightforward to see that D^σ measures aggregate GDP in our multi-region economy:

$$D^\sigma = \sum_i X_i = \sum_i w_iL_i + \pi_iN_i$$

We can show, therefore, that aggregate GDP (similarly to N_T) equals:

$$D^\sigma = \left(\frac{1}{\hat{F}}\right)^{\frac{\theta_2}{\sigma-1}} \bar{N}^{\frac{\theta_3}{\sigma-1}} \left(\sum_k (A_kL_k)^{\theta_1}\right)^{\frac{\theta_4-1}{\sigma-1}} \left(\sum_k (A_kL_k)^{\theta_5}\right)^{\frac{\theta_6+\sigma}{\sigma-1}}$$

where:

$$
\Pi_j^1 = \frac{\left(A_j L_j\right)^{\theta_1}}{\sum_k \left(A_k L_k\right)^{\theta_1}}
$$

$$
\Pi_j^2 = \frac{\left(A_j L_j\right)^{\theta_5}}{\sum_k \left(A_k L_k\right)^{\theta_5}}
$$

This shows the importance of our general equilibrium approach to understand how important is corruption in the aggregate for economic growth, and productivity. The aggregate effects presented by (3) are not fully captured by the DD estimate (2).

Finally, let us see how a corruption reduction in municipality i affects the number of firms in municipality j. The following elasticity answers this question:

$$
\begin{aligned}
\frac{\partial LnN_i}{\partial LnG_j} &= -\,\eta\theta_1\Pi_j^1 + \frac{\partial LnN_T}{\partial LnG_j} \\
&= -\,\eta\theta_1\Pi_j^1 + \eta\left[\theta_1\theta_4\Pi_j^1 + \theta_5\theta_6\Pi_j^2\right]
\end{aligned}
$$

The first term captures the reallocation effect, the fact that region j can attract more firms because of better fundamentals. However, the improvement in region j, through trade, allows other regions to expand as well. The second term captures this trade effect.

4.1 How does aggregate income depends on the corruption program

We saw how our model predicts that the DD estimate, although informative of important parameters in our economy, cannot alone identify how important is corruption in the aggregate for economic growth and productivity. This point is now further investigated.

If we externally calibrate σ, the elasticity of substitution between varieties, the DD estimate pins down a relationship between the spatial elasticity δ and the elasticity to the public good quality, η. Figure 2 shows different combinations of δ and η which are consistent with a DD estimate of 1% (see 2) - given a calibration of $\sigma = 2.5$. Notice how multiple values are possible. The parameter η can range from 1.6% to 2.6% depending on how mobile economic activity is throughout the space.

The set of η and δ combinations consistent with the observed DD estimate provide different values for the overall entry elasticity (3). This is the information that we abstract when using the DD in a spatial setting. We run a simple numerical exercise to quantify the importance of the entry elasticity. The details of the calibration are in Table 2. We set the parameters δ and η such that the simulated economy is consistent with the DD estimate of 1pp found in section 2 and Colonnelli and Prem (2021). The fundamentals of each location are drawn from uniform distributions.

Figure 2: Combinations of η and δ consistent with the DD estimate

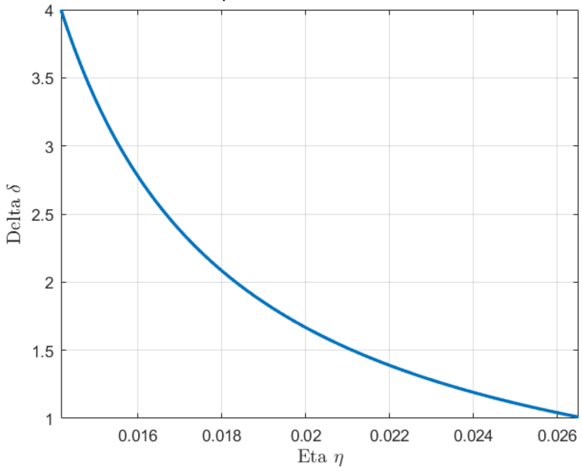


Table 2: Calibrated Parameters

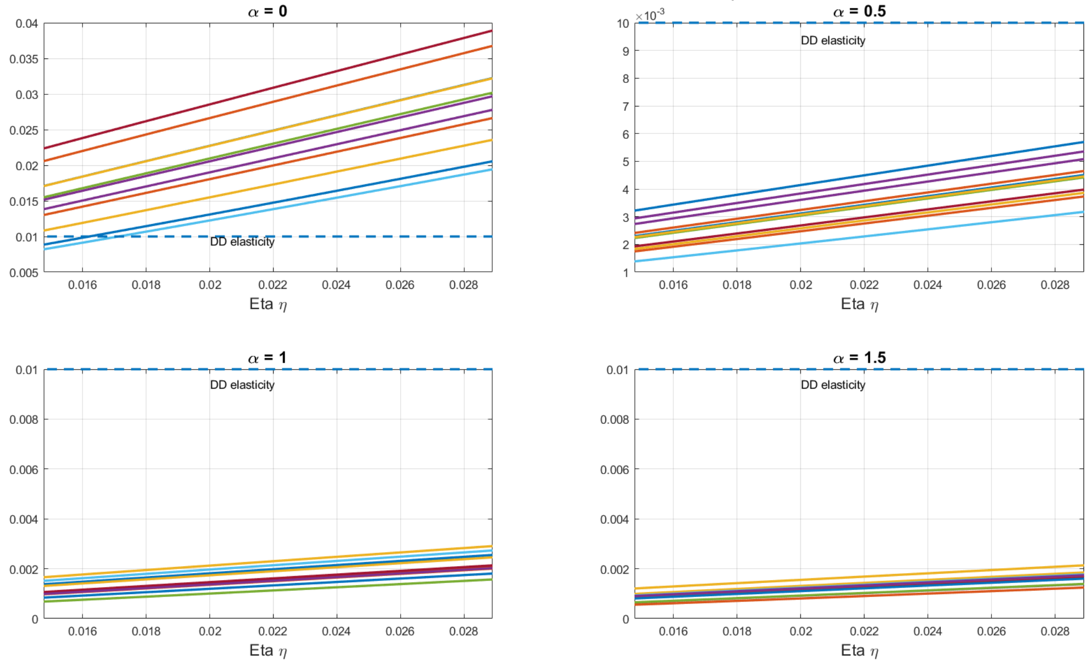
σ	$\{2, 2.5, 3.5\}$
(δ, η)	consistent with DD = 1%
N	11
α	$\{0, 0.5, 1, 1.5\}$
$\bar{A}_i$	Drawn from $U(1, 2)$
G_i	Drawn from $U(1, 2)$
L_i	Drawn from $U(1, 2)$

Each plot in figure 3 represents the effect on aggregate entry, N_T, as a result of a 1pp change in the public good in location j, G_j. Keeping σ constant, we increase η (and hence decrease δ, as shown in Figure 2) across the horizontal axis. Different lines represent different municipalities j where we are considering the change in G_j. Finally, each individual plot considers a different value for the congestion forces in entry, α. When α is high, the cost of entry increases rapidly with the number of firms in the market, the aggregate entry elasticity is low and there is no major difference on whether the audit was on a region with high fundamentals or with low fundamentals. Second, when α is close to zero and the region audited has high fundamentals, aggregate entry could be higher than the DD estimate. It means that when the number of firms in a location increases by 1pp the aggregate number of firms in the economy will increase by more than 1pp.

The aggregate entry elasticity can assume a range of different values while being consistent with the DD estimate and is highly sensitive to the value of σ and the value of η. Comparing the different plots, we can see how the entry elasticity, as expected, decreases as we make entry more difficult (increase in α), as the importance of the public goods η decreases, and the degree of substitution between varieties across location increases σ.

Moreover, for the same parameter values, locations with bigger population yield a higher aggregate elasticity (higher lines in each plot represent such municipalities), as

Figure 3: Overall entry elasticity $\frac{\partial Ln(N_T)}{\partial Ln(G_j)}$ with $\sigma = 2$



changes in these locations productivity will impact more workers and provide a higher share of varieties of the local output in each location. In Figures 4 and 5 we repeat the experiments described above but for other values of the parameter σ. For lower values (like in $\sigma = 2$), with low entry costs (low α), notice how the aggregate elasticity becomes higher than the DD estimate. Here, the substantial entry of firms in control municipalities causes the DD to underestimate the overall effects of the police.

Figure 4: Overall entry elasticity $\frac{\partial Ln(N_T)}{\partial Ln(G_j)}$ with $\sigma = 2.5$

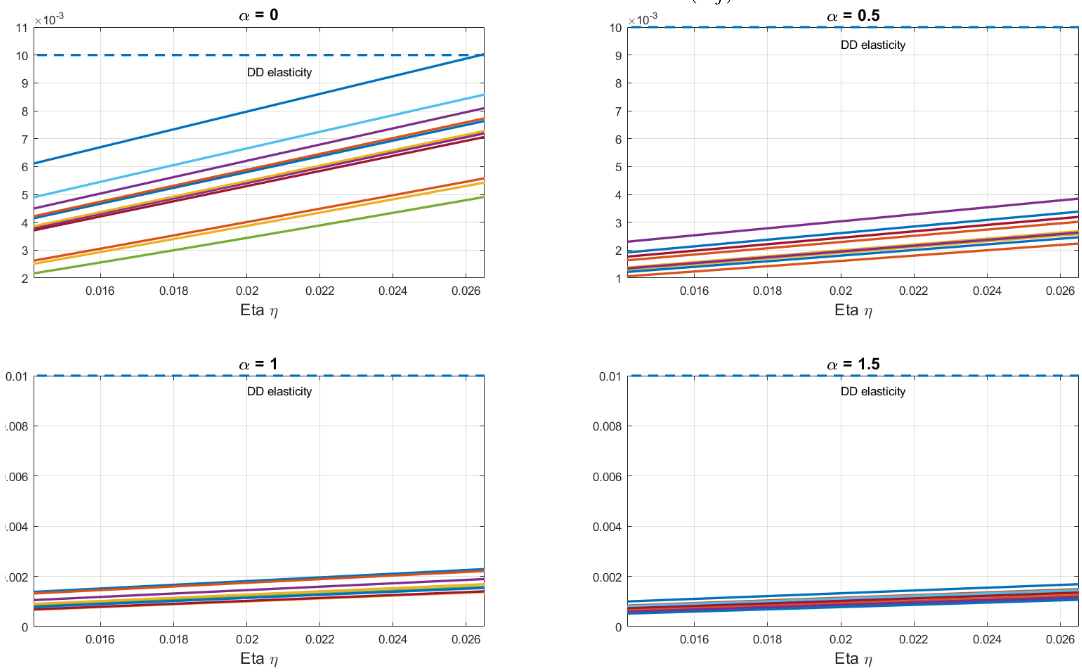


Figure 5: Overall entry elasticity $\frac{\partial Ln(N_T)}{\partial Ln(G_j)}$ with $\sigma = 3.5$