

# Predation, Protection and Productivity: A Firm-Level Perspective\*

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## Abstract

Firms which are vulnerable to predation due to vandalism and theft can hire labor as a means of protecting themselves. Here, we explore the implications of this for the loss of output due to predation. We use data for the 142 countries covered by the World Bank enterprise surveys which ask about firm-level experiences with predation and spending on protection. We build a model that allows us to interpret these two factors and show that there would be significant increases in output due to labor reallocation if predation were reduced. About two thirds of the output gains would be due to being able to shift labor from protection towards productive activities. The results provide a novel perspective on the resource misallocation which results from poor enforcement of law and order. Heterogeneity across firms matters with a number of countries protecting large firms less effectively than small firms.

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# 1 Introduction

When firms are subject to predation due to vandalism and theft, they have the option of hiring guard labor to protect themselves. Thus, even if criminal activity was purely a transfer to its perpetrators, the diversion of labor power to protection reduces output and leads to labor being allocated away from production. To the extent that firms face different predation threats in different sectors/regions of the economy, there will also be a distortion of labor allocation between firms. These distortions are relevant to some degree in all economies.<sup>1</sup> However, they are a particular issue in developing countries where law and order is poorly enforced by the state. Moreover, to the extent that the threat of predation is larger in more productive firms the welfare loss will be larger as it is more of a “tax” on larger firms.

Although a central function of the state is to maintain law and order, it is widely appreciated that a number of states, particularly in poor countries, fail to deliver. For example, World Justice Project (2014) highlights the deficiencies in formal and informal adherence to basic principles of justice enforced by law around the world. The economic consequences of this are now given a central role in explaining differences in the level of income per capita. Acemoglu and Robinson (2012) and Besley and Persson (2011) have emphasized this theme and the institutional underpinnings of efforts to build legal capacity to support markets. One of the main approaches for assessing this has to be to exploit the correlation between cross-country differences in summary measures of private and state predation and income differences.<sup>2</sup> These capture a wide variety of effects and are therefore difficult to link back to the underlying mechanisms and distortions in resource allocation that result.

This paper looks at aggregate effects of predation using firm-level data from the World Bank Enterprise surveys to provide a quantitative assessment of the size of the output loss due to labor misallocation. Although these surveys lack the sample size and detailed information available on manufacturing firms in some countries, they have direct questions

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<sup>1</sup>Protective service labor grew by about 2.4 percentage points of total hours worked in Europe between 1993 and 2010. This made it the fastest growing occupation studied by Goos et al (2014). According to the US bureau of labor statistics about 2.2 percent of all employed in 2014 worked in protective service occupations, 0.7 percent of all employed were security guards.

<sup>2</sup>See, for example, Hall and Jones (1999) and Acemoglu, Johnson and Robinson (2001).

on predation and protection at the firm level which permit us to look at a wide range of country experiences across the entire range of the formal economic activity.

The theoretical framework that we propose as a guide to the empirical work models how firms allocate labor to productive activity or predation. It provides a way of thinking about the firm-specific predation threat and the firm's response in terms of a lower level of total factor productivity which is greater among firms where predation is a bigger problem. It can also be used to generate an expression for the aggregate output loss which depends on the joint distributions of predation and firm level productivity. In line with the recent literature on resource misallocation (Restuccia and Rogerson, 2008, and Hsieh and Klenow, 2009), the theoretical framework also allows us to consider what would be a counter-factual "no predation" outcome with which to compare the actual allocation of labor. A key finding in this framework is that the labor misallocation caused by the threat of predation can generate a welfare loss even if it is a pure transfer.<sup>3</sup> We also extend the model to consider how the sectoral allocation of labor could change in response to the threat of predation.

The paper creates an empirical estimate of how predation losses vary across countries, illustrating the importance of firm-level heterogeneity. For some countries, these losses are around 10 per cent of output. Moreover, we estimate that around two thirds of these losses come from reallocating labor to protection rather than using it productively. This implies that welfare losses would fall by only one third if predation was regarded a transfer. On the whole, larger firms appear to be more susceptible to predation although countries do vary in the extent to which this is true. We illustrate this by contrasting the situation in China and Mexico. China has a fairly even distribution of protection by firm size whereas it is lower for large firms in Mexico. As a thought experiment we consider how much output different countries would gain or lose from adopting a Chinese pattern of perceived predation by firm size. We estimate that output in Mexico would increase by about 3 percent if this happened.

The analysis is extended to consider investment decisions by firms. We find that predation also has a negative effect on investment while protection seems to enhance it. We then allow for sectoral heterogeneity in the production technology using US labor shares. This

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<sup>3</sup>This idea goes back to Tullock (1967, 1971) who discusses theft as an example.

reveals an interesting pattern of sectoral differences in output losses which is, however, not very large on average. The model can be used to give an expression for sectoral labor reallocation if the threat of predation were eliminated. In countries with high predation, we estimate large increases in labor supplied to the formal enterprise sector of the economy, more than 20 percent in the case of the construction sector which is both labor intensive and relatively susceptible to predation.

The symptoms of disorder that we study here are specific. Unlike most of the literature of factor misallocation we do, however, have direct measures of the distortion. Our thought experiment always holds in place other things that could influence the level of efficiency in the economy. Thus, it constitutes only one piece of a bigger picture. That said, it is still striking that a distinctive pattern emerges in the data which suggests material output losses from this specific form of distortion.

The remainder of the paper is organized as follows. In the next section, we discuss related literature. Section three introduces the data and documents some basic facts. In section four, we lay out a model which we use to derive a measure of the output loss in the enterprise sector relative to undistorted output. Section five shows how this can be brought to the data and section six presents estimates of output losses by aggregating firm level data and illustrates how heterogeneous productivity matters for this. In section seven, we use a constant elasticity model for the protection technology and use this to calibrate its parameters as a means of looking at patterns of protection across firms and countries. Section eight presents some additional analysis, including firm investment, sector-specific technologies and allowing for a labor reallocation effect between the enterprise sector and other parts of the economy. We also compare our measure of output loss with what can be learned by looking at the covariance between firm size and productivity. Section eight concludes.

## 2 Related Literature

The focus distortions in firm level behavior and their consequences for productivity relates to recent emerging interest in firm-level behavior and aggregate effects of resource misallocation. These ideas have been developed most notably in Restuccia and Rogerson

(2008) and Hsieh and Klenow (2009).<sup>4</sup> The former look at generic policy distortions which destroy firm output while the primary focus of this approach has been on capital market distortions which are inferred from looking at measures of differences in the marginal revenue product of capital across firms. We add two things to this. First, we allow private actions by firms to limit the policy distortion that they experience by making a protection decision. This leads to labor misallocation which varies by firm. Second, we have actual measures of distortion measured from reported losses by firms and the share of sales spent on protection. However, we share with this literature the desire to gauge the aggregate implications of this for the economies concerned. We find that the costs of predation are significant and change markedly when an effort is made to adjust these from firm-level productivity differences.

The second literature that the paper speaks to is that on the welfare cost of imperfect property rights protection and the costs of predation.<sup>5</sup> There is now a large macro-economic literature such as Acemoglu et al (2001) and Hall and Jones (1999) which argues that large differences in income per capita are due to the risk of expropriation. Micro studies in developing countries have provided proof of fairly large effects on investment associated with these distortions.<sup>6</sup> Private protection through guard labor in this context has been studied by Field (2007) who shows that there is a significant misallocation of household labor due to the need of families with weak property rights having to remain in the home to guard their property. Jayadev and Bowles (2006) discuss the use of guard labor in a cross-section of countries.<sup>7</sup>

Our study is related to a large literature that calculates the cost of crime.<sup>8</sup> The standard accounting approach is to estimate this cost simply by adding the costs and losses due to crime. For example, Van Ours and Vollaard (2014) use estimates from an accounting approach to study the welfare gain from installing electronic engine immobilizers in the Netherlands.<sup>9</sup> Other approaches include individual valuations of counter-factuals,

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<sup>4</sup>For an overview of some of the wider issues involved in explaining cross-country income differences in terms of differences in factor endowments and technology, see Caselli (2005).

<sup>5</sup>This literature is reviewed in Besley and Ghatak (2009).

<sup>6</sup>See, for example, Besley (1995) and Goldstein and Udry (2008).

<sup>7</sup>They find much higher numbers than we do here. However, their definition of guard labor includes police and prison guards, supervisors in firms, the unemployed and military personal.

<sup>8</sup>See Soares (2009) for a review.

<sup>9</sup>Their benchmark measures of the cost comes from the UK Home Office. The methodology is based on Brand and Price (2000). This is an accounting exercise in which security expenditures, insurance costs

contingent-valuation, and changes in market prices to estimate the welfare costs. For example, Cook and MacDonald (2011) use both contingent-valuation surveys and jury awards to victims of violent crimes to calculate the social welfare gains from crime reductions. The estimates which emerge from both of these methods turn out to be quite similar which is somewhat surprising given that the ex-ante willingness to pay and ex-post damage are conceptually different. One reason is spending on protection which we analyze here.

An example of a paper which uses market prices to assess the cost of crime is Gibbons (2004) which estimates the costs of property crimes on property prices in London. Besley, Fetzer and Mueller (2015) exploit shipping prices in the spot market for bulk shipping to calculate the welfare cost of Somali piracy. Their key finding is that total costs in the shipping industry were a multiple of what pirates managed to extract through ransoms. One of the reasons is the spending on protection in the shipping industry like, for example, spending on armed security guards. Due to spending on protection successful predation decreased and welfare costs shifted from costs from predation to costs from protection. The early literature on the costs of predation such as Tullock (1967) observed that protection spending should be factored into the costs.<sup>10</sup>

The role of private spending in driving up the welfare costs is an old theme in the crime literature starting with Becker (1968). Benson and Mast (2001), for example, discuss how spending on protection can be quantified in assessing the costs of crime. Our focus here is on the costs to firms rather than individuals and hence how it affects output in the economy also how it is distributed across types of firms.

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and damages are added up to derive a per case cost.

<sup>10</sup>In line with the argument developed here, he notes that:

"The theft itself is a pure transfer, and has no welfare cost, but the existence of theft as a potential activity results in very substantial diversion of resources to fields where they essentially offset each other, and produce no positive product. The problem with income transfers is not that they directly inflict welfare losses, but that they lead people to employ resources in attempting to obtain or prevent such transfers. A successful bank robbery will inspire potential thieves to greater efforts, lead to the installation of improved protective equipment in other banks, and perhaps result in the hiring of additional policemen. These are its social costs, and they can be very sizable." (Tullock (1967), p. 231)

### 3 Data

Our data comes from the World Bank enterprise surveys. An enterprise survey is a plant-level survey of a representative sample of an economy's formal private sector – agriculture, small informal firms and pure government-owned businesses are excluded. The surveys cover a range of business environment topics including access to finance, corruption, infrastructure, crime, competition, and performance measures. Since 2002, the World Bank has collected this data from face-to-face interviews with top managers and business owners. This allows us to use data from over 140,000 companies in 142 economies.<sup>11</sup> The data is made available both at the plant level and at different levels of aggregation.

We focus on answers to two specific questions: (i) *"In fiscal year [insert last complete fiscal year], what percentage of this establishment's total annual sales was paid for security?"* and (ii) *"In fiscal year [insert last complete fiscal year], what were the estimated losses as a result of theft, robbery, vandalism or arson that occurred on this establishment's premises either as a percentage of total annual sale?"*. While not all questions are answered by every enterprise that is surveyed, we have more than 140,000 observations where we can calculate both pieces of data. In what follows, we will use the term predation to capture the various forms of loss that could be experienced by firms, i.e. "theft, robbery, vandalism or arson". Most of these acts are likely to have been perpetrated by criminals rather than the state itself.

Table 1 gives summary statistics for the plant level where we report simple averages using the survey weights provided by the World Bank. These numbers reveal that the average expenditure by a firm was 1.8 percent of sales for security and the loss in sales was around 1 percent due to predation.<sup>12</sup> The share of firms that report paying for security is at 60 percent and is more than double the 25 percent reporting a loss. This makes intuitive sense. Not everybody who spends on security is or has been victim of predation - this implies that losses due to predation are spread throughout the population through the investment in security. The average firm size in our sample is about 84 workers which varies between 1 worker and just under 66,000. Table 1 also reports the sample size by

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<sup>11</sup>We discuss our modifications to the raw data in appendix A.

<sup>12</sup>In appendix Figure A1 we show that, on average, losses and spending on protection are relatively constant (falling slightly) across firm size.

country where the average is nearly 1200 firms per country. Finally, we report the fraction of firms in our sample which report crime as most important obstacle to doing business. This is about 4.4 percent.

In Figure 1 we show a scatter plot of the country-level averages to the two core questions for different years. These numbers are close to what the World Bank reports at the country level. They illustrate the significant variation across countries. There is also a clear positive correlation between protection spending and damages. The latter suggests, in line with common sense, that high levels of predation are associated with high efforts at protection. There are two quite striking outliers in the data: Cambodia is an outlier in terms of spending on protection and the Central African Republic is an outlier in terms of predation.

For our analysis we use the number of workers, losses, spending on protection and our model to make statements on firm productivity. In other words, we do not rely on value-added calculations in the data. Data on sales and costs contain large errors so that dropping outliers becomes a crucial issue. Our model allows us to use some of the three most commonly reported parts of the data. This should minimize errors at the cost of additional assumptions regarding the production function and the absence of distortions in the labor market of the economy. We will return to these issues in sections 6 and discuss value added measures in appendix B.

## 4 Conceptual Framework

Consider the enterprise sector of the economy, as defined by the World Bank Enterprise surveys, which is populated by a finite set of firms with productivity levels,  $\theta_i$ , indexed by  $i = 1, \dots, N$  where  $\pi_i$  denotes the proportion of firms type  $i$  in the population of all firms.<sup>13</sup> We will think of the  $N$  firms in our data as representing a sample of firm types that we aggregate to get the effect of predation on the economy as a whole. Thus we think of firm  $i$  as a specific firm in our data.

The enterprise sector allocates a fixed amount of labor,  $L$ , with the wage rate  $w$  being determined endogenously. This benchmark case is in effect assuming that labor markets

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<sup>13</sup>We use  $\pi_i$  to capture the survey weights in the empirical implementation.

in different parts of the economy are segmented. However, we will consider below what happens if labor can migrate between the enterprise sector and other activities such as agriculture, the informal sector or government employment.

A firm of type  $i$  hires labor  $l_i$ , taking the wage as given, and can choose to allocate a part of this labor to security, denoted by  $e_i$ . There is a type-specific protection technology which determines the fraction of output that a firm of type  $i$  realizes which is denoted by  $p^i(e_i, g) \in [0, 1]$  where  $g$  denotes investment by the state in protection. We assume that  $p^i(\cdot, g)$  is increasing and concave. Thus having more protection reduces the amount of output that is lost. The other fraction of output is either transferred to criminals or destroyed by their activity. Let  $\tau \in [0, 1]$  be the fraction that is a transfer. We do not have a breakdown between vandalism and theft in the data. In the case of pure vandalism then we would expect  $\tau = 0$  i.e. no part of the lost output is transferred to criminals whereas with theft it is reasonable to suppose that  $\tau > 0$ . In this case output is transferred rather than destroyed. We will report our results for different values of  $\tau$  to see how much this parameter matters to the conclusions that we reach.<sup>14</sup>

Allowing the protection technology to be firm type-specific reflects the fact that firms face are differentially vulnerable to predation due to their specific location and mode of doing business. A special case that we make use of below is when the protection technology has a constant elasticity form:

$$p^i(e, g) = \begin{cases} \varepsilon^i(g) \times e_i^{\gamma^i(g)} & \text{for } \varepsilon^i(g) \times e_i^{\gamma^i(g)} \leq 1 \\ 1 & \text{otherwise.} \end{cases} \quad (1)$$

We can interpret  $\varepsilon^i(g)$  as the perceived level of protection as determined by public policy and  $\gamma^i(g)$  as the protection effort elasticity. We allow both of these parameters to be dependent on the government's protection policy,  $g$ . This functional form has the convenient property that a constant fraction of any firm's labor force is used for protection purposes. Below, we will consider how we can back out estimates of the parameters  $\{\varepsilon^i(g), \gamma^i(g)\}$  from firm-level behavior by imposing (1).

Our formulation of the protection technology allows for heterogeneity in firm-level het-

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<sup>14</sup>Another interpretation of setting  $\tau = 0$  is that we do not value the share of output that goes to criminals even when GDP is not lower.

erogeneity. This makes sense since we expect exposure to predation to be quite idiosyncratic, depending on the firm's location, its political connections, the nature of its production process/location of its client base. In particular, we make no a priori assumption about how the protection technology covaries with productivity  $\theta_i$ . We will rely on the data to tell us something about this.

The output of a type  $i$  firm net of predation losses is:

$$y_i = p^i(e_i, g) \theta_i [l_i - e_i]^\alpha. \quad (2)$$

The production function is a standard constant elasticity formulation with  $\alpha < 1$  being the labor share. Here, we assume a common production technology, i.e.  $\alpha$  is the same for all firms. This constitutes a somewhat extreme case with unlimited heterogeneity in the protection technology alongside a common production function (albeit with heterogeneous productivity levels). Below, we will relax this by allowing  $\alpha$  to be sector specific. We will also extend the approach to allow both labor and capital to be used in production. The value of the simple case that we begin with is that it allows us to home in on the novel aspect of the approach before including complications.

The function  $p^i(e_i, g)$  in (2) is formally similar to the kind of policy distortion studied in Restuccia and Rogerson (2008). However, we add a key difference of approach by allowing firms to mitigate this distortion by choice of  $e_i$ , i.e. choosing a level of protection. However, this just shifts the distortion since firms are not using all of the labor that they hire productively.

A firm of type  $i$  chooses  $\{e_i, l_i\}$  to maximize

$$p^i(e_i, g) \theta_i [l_i - e_i]^\alpha - w l_i.$$

There are two conditions which hold at an interior solution. First, there is the standard condition stating that the marginal product of labor is set equal to the wage:

$$p^i(e_i, g) \alpha \theta_i [l_i - e_i]^{\alpha-1} = w \quad (3)$$

The second is that the marginal product of labor employed in protection is equal to that of productive labor:

$$\frac{p_e^i(e_i, g)}{p^i(e_i, g)} = \frac{\alpha}{l_i - e_i}. \quad (4)$$

When the protection technology is as in (1), then (4) implies that

$$\frac{e_i}{l_i} = \frac{\gamma^i(g)}{\alpha + \gamma^i(g)}$$

which means that each firm hires a constant fraction of its labor force to protect output.

Our analysis of the cost of predation will use this model to construct a counter-factual without predation. In the general model we simply assume  $p^i(e_i, g) = 1$  and  $e_i = 0$  for all  $i$ , i.e. we construct a situation in which there is not even a threat of predation. In the constant elasticity model in equation (1) the equivalent assumptions are  $\gamma^i(g) = 0$  and  $\varepsilon^i(g) = 1$ .

Note that using the model and data on  $l_i$  implies that we calculate the output loss from predation as if labor use is not distorted. We regard this a conservative approach which prevents us from attributing other factors of firm productivity to predation. We are therefore studying the marginal effect of our measured distortions assuming that any others remain in place, i.e. these are contained in  $\theta_i$ .

## 5 Bringing the Model to the Data

We now use the model to derive an expression for aggregate output lost to predation in terms of measurable factors. We will then consider the general equilibrium implications of the model and use it to derive an expression for the aggregate output loss.

**Spending on Security** In the data, we observe the share of sales that are spent on protection by firm  $i$  in our data set. This can be related to the model by noting that this is given by

$$\begin{aligned} \sigma_i &= \frac{we_i}{p^i(e_i, g) [l_i - e_i]^\alpha} \\ &= \alpha \frac{e_i/l_i}{1 - e_i/l_i} \end{aligned} \tag{5}$$

after using (3). Another way to think about this is that the share of total labor hired that is used as protection is  $e_i/l_i = \sigma_i / [\sigma_i + \alpha]$ . This relates labor misallocation directly to the share of sales variable from the data after we plug in an assumed value for  $\alpha$ . We choose  $\alpha = 0.66$  as our core case below, i.e. a two thirds labor share. In the extensions we relax this assumption.

**Losses by Firms** The share of losses due to predation experienced by firm  $i$  can also be expressed in terms of the model as:

$$\text{value of sales lost by firm } i = \mu_i = \frac{1 - p^i(e_i, g)}{p^i(e_i, g)}.$$

The data give us a direct measure of  $\mu_i$  and  $p^i(e_i, g) = 1/[1 + \mu_i]$ .

**Labor Market Equilibrium** We assume that labor is allocated across firms to equalized marginal products and with the wage adjusting to achieve this. This assumption allows us to back out the relative productivities from firm size. Write firm  $i$ 's labor demand as:

$$l_i = \left( \frac{\hat{\theta}_i \alpha}{w} \right)^{\frac{1}{1-\alpha}}. \quad (6)$$

where

$$\hat{\theta}_i = \theta_i \frac{1}{(1 + \mu_i)} \left( \frac{\alpha + \sigma_i}{\alpha} \right)^{1-\alpha} \quad (7)$$

can be thought of as “adjusted” firm-level productivity as a function of our two observables  $\{\mu_i, \sigma_i\}$ .<sup>15</sup> Equation (6) states that firms that are intrinsically more productive (higher  $\theta_i$ ), experience smaller predation losses (lower  $\mu_i$ ) and allocate more labor to protection spending (higher  $\sigma_i$ ) hire more laborers.

To solve for the labor allocation across all firms, we sum the labor demands of all firms, using sample weights, and equate labor supply,  $L$ , with demand to yield:

$$\sum_i \pi_i l_i = \left( \frac{\alpha \hat{\Theta}}{w} \right)^{\frac{1}{1-\alpha}} = L.$$

where  $\hat{\Theta} = \left( \sum \pi_i \left( \hat{\theta}_i \right)^{\frac{1}{1-\alpha}} \right)^{1-\alpha}$  is an aggregate measure of productivity for the enterprise sector as a whole.<sup>16</sup> The share of total employment in firm  $i$  can then be written as:

$$\frac{l_i}{L} = \left( \frac{\hat{\theta}_i}{\hat{\Theta}} \right)^{\frac{1}{1-\alpha}}. \quad (8)$$

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<sup>15</sup>Note that with  $\mu_i = \sigma_i = 0$  we have  $\hat{\theta}_i = \theta_i$ .

<sup>16</sup>In practice we use firm shares as sample weights  $\pi_i$  so that  $\sum_i \pi_i l_i$  is the average firm size. As we do not consider firm entry and exit this does not change our results.

This share of total labor employed in firm  $i$  can be seen to depend exclusively on its relative “adjusted” productivity level.

In interpreting these equations, it is important to recall that  $e^i$  will be chosen optimally and hence determine  $\{\mu_i, \sigma_i\}$  in equilibrium as a function of the protection technology and the perceived threat of predation that a firm faces. Below, we will work with a specific technology where we can calibrate the parameters of the protection technology from the data explicitly. For the time being, we will state everything in terms of observables without restricting the form of the protection function  $p^i(e_i, g)$ .

**Firm Level Productivity** In order to estimate the output loss from predation and protection, we need a measure of the undistorted firm productivity,  $\theta_i$ . We can estimate  $\theta_i/\Theta$  where  $\Theta = \left(\sum \pi_i (\theta_i)^{\frac{1}{1-\alpha}}\right)^{1-\alpha}$ , i.e. the firm’s relative productivity from the distribution of firm size. To see this note that

$$\frac{\theta_i}{\Theta} = \frac{(1 + \mu_i) (l_i)^{1-\alpha} \left(\frac{\alpha}{\alpha + \sigma_i}\right)^{1-\alpha}}{\left(\sum_j \pi_j \left((1 + \mu_j) (l_j)^{1-\alpha} \left(\frac{\alpha}{\alpha + \sigma_j}\right)^{1-\alpha}\right)^{\frac{1}{1-\alpha}}\right)^{1-\alpha}} \quad (9)$$

using the fact that in the undistorted allocation,  $\sum \pi_j l_j = L$ . Equation (9) is useful in bringing the model to the data since it allows us to estimate the undistorted labor allocation and hence the output level in the absence of predation. We will use it to create productivity weights,  $\theta_i/\Theta$ , for each firm in the data based on its observed firm size, along with its reported loss from predation and spending on protection.

Although we refer to,  $\theta_i$  as the “undistorted level of firm productivity”, we are using this term in a very specific sense. The distortion which we observe in the data is specific to experience predation losses and spending on protection. It is quite likely that, even if these were removed, others would remain in place. We think of these other distortions remaining in  $\theta_i$  and that we are capturing only the marginal effect of the distortion due to distortion with a view to measuring how important it is in affecting the level of output.

**Aggregate Output Costs of Predation** To create a benchmark, consider aggregate output in the formal enterprise sector in the absence of predation and protection, i.e. when

$\mu_i = \sigma_i = 0$ . This is given in terms of the model parameters by:

$$Y^* = \sum_i \pi_i \theta_i (l_i)^\alpha = L^\alpha \Theta \sum_i \pi_i \left( \frac{\theta_i}{\Theta} \right)^{\frac{1}{1-\alpha}} \quad (10)$$

where we have used the fact that without predation  $\frac{l_i}{L} = \left( \frac{\theta_i}{\Theta} \right)^{\frac{1}{1-\alpha}}$ . By contrast, productive labor with predation is given by  $l_i - e_i = l_i \frac{\alpha}{\alpha + \sigma_i}$ . Total output with predation can therefore be written as

$$\begin{aligned} \hat{Y} &= \sum_i \pi_i \theta_i \left[ \tau + \frac{(1-\tau)}{1+\mu_i} \right] (l_i)^\alpha \left( \frac{\alpha}{\alpha + \sigma_i} \right)^\alpha \\ &= L^\alpha \Theta \sum_i \pi_i \frac{\theta_i}{\Theta} \left[ \tau + \frac{(1-\tau)}{1+\mu_i} \right] \left( \frac{\hat{\theta}_i}{\hat{\Theta}} \right)^{\frac{\alpha}{1-\alpha}} \left( \frac{\alpha}{\alpha + \sigma_i} \right)^\alpha \end{aligned} \quad (11)$$

after substituting in  $l_i$  from equation (8). This gives aggregate output with predation as a function of  $\{\theta_i, \sigma_i, \tau, \mu_i\}$ . Using this together with (10), yields the following expression for the proportional output loss from predation and protection:

$$\Delta = \frac{Y^* - \hat{Y}}{Y^*} = 1 - \frac{\sum_i \pi_i \frac{\theta_i}{\Theta} \left[ \tau + \frac{(1-\tau)}{1+\mu_i} \right] \left( \frac{\hat{\theta}_i}{\hat{\Theta}} \right)^{\frac{\alpha}{1-\alpha}} \left( \frac{\alpha}{\alpha + \sigma_i} \right)^\alpha}{\sum_i \pi_i \left( \frac{\theta_i}{\Theta} \right)^{\frac{1}{1-\alpha}}} \quad (12)$$

This is a key equation that we bring to the data. We make four key observations about it

First observe that if  $\mu_i = 0$  and  $\sigma_i = 0$  then  $\frac{\hat{\theta}_i}{\hat{\Theta}} = \frac{\theta_i}{\Theta}$  and hence  $\Delta = 0$ .

Second, note that a convenient feature of (12) is that, with the exception of  $\tau$ , it is stated entirely in terms of variables which are either observable or can be estimated from the firm-level data using (9). We are therefore able to estimate  $\Delta$  for each country in our data set.

Third, equation (12) illustrates the importance of the heterogeneous pattern of predation  $\mu_i$ , protection,  $\sigma_i$  and productivity  $\theta_i$ , in determining aggregate output losses. The output loss from predation depends on how the threat of predation and is correlated with firms' undistorted productivity levels. Thus if large firms are more susceptible to predation, this can lead to higher losses in two ways – directly higher  $\mu_i$  or indirectly through them spending more on predation, i.e. higher  $\sigma_i$ . This is reminiscent of the literature that has used the firm-size productivity covariance as measure of misallocation and we return to this below.

Fourth, (12) makes clear why  $\tau$  matters. If more of the predation is in the form of

output transfers ( $\tau$  close to one) then the output cost is lower. However, even with  $\tau = 1$  there is still an output loss since some labor may be allocated to protection. Another way to think of this is also to imagine that  $\mu_i = 0$ . Now the parameter  $\tau$  has no impact on the output loss (12); the loss is given entirely by  $\sigma_i$ . Thus even an economy which appeared to face no predation could in fact have a distorted level of output if the threat is latent and it employs workers to guard against it. Below, we will explore below how assumptions regarding  $\tau$  affect the calculation of the output loss due to predation.

## 6 Results

Our estimates of the output loss is based on the sample of firms in the sample frame of the World Bank enterprise surveys.<sup>17</sup> We look at variation across both countries and firms. Hence we write  $\theta_{ic}$  for firm type  $i$  in country  $c$  with corresponding weights  $\pi_{ic}$ . We allow  $g$  to vary across countries so that  $p_{ic} = p^i(e_{ic}, g_c)$  is the loss experienced by a firm type  $i$  in country  $c$  when it allocates labor  $e_{ic}$  to protection. We could also allow  $\tau$  or  $\alpha$  to be country specific. However, we will maintain common values for these parameters in what follows.

**Benchmark: Identical Firms** As a benchmark, consider the case where all firms within a country are the same with the same losses and spending on protection as well as the same level of productivity:  $\theta_{ic} = \Theta_c$  for all  $i$  in country  $c$ . Equation (12) now boils down to a very simple equation:

$$\Delta_c = 1 - \left[ \tau + \frac{(1 - \tau)}{(1 + \bar{\mu}_c)} \right] \left( \frac{\alpha}{\alpha + \bar{\sigma}_c} \right)^\alpha. \quad (13)$$

where  $\bar{\mu}_c$  and  $\bar{\sigma}_c$  are the country (weighted) averages for the share of sales lost to predation and the share of sales spent on protection. Note that the share of workers employed in protection is given through  $\frac{\alpha}{\alpha + \bar{\sigma}_c} = 1 - \bar{e}_c / \bar{l}_c$ .

In our data,  $\bar{p}_c = 1/(1 + \bar{\mu}_c)$  varies between 94.6 percent and 100 percent. Table 2 depicts

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<sup>17</sup> We are not therefore able to say anything about losses from predation and/or protection experienced by fully government-owned, agricultural or informal firms. Moreover, it is an open question whether such firms' experience with law and order is different from the firms on which we do have data and this is, in any case, likely to be heterogeneous by country and firm type.

averages of  $\bar{e}_c/\bar{l}_c$  and  $\Delta_c$ . The parameter  $\alpha$  enters in both estimates. To explore how much this affects the results, Table 2 gives some summary statistics for the country/year level averages assuming three different values,  $\alpha = 0.9$ ,  $\alpha = 0.66$  and  $\alpha = 0.5$ . The first three rows of Table 2 show that our estimate of the fraction of the work force employed in protection,  $\bar{e}_c/\bar{l}_c$ , varies from around 1.8 percent to 2.9 percent as we vary  $\alpha$ .<sup>18</sup> The next rows present estimates of the output loss for the benchmark case where  $\tau = 0$  and the three values of  $\alpha$ . The estimated average output loss is about 2.4 percent regardless of the choice of  $\alpha$ . In what follows we focus on the case  $\alpha = 0.66$  until we look at sectoral variation in  $\alpha$  as an extension below.

Table 2 also gives the loss for  $\tau = 1$  which is 1.6 percent on average. Thus, about two thirds of the output loss from predation in the enterprise sector is estimated to be from expenditure on protection. In Figure 2, we plot the output loss from equation (13) when  $\tau = 0$  and plot it against the share of the loss that comes from spending on protection, i.e. (13) when  $\tau = 1$  divided by (13) when  $\tau = 0$ . This gives a feel for the balance of the loss coming from protection and predation. Figure 2 shows that the total loss is negatively correlated with the share of the loss due to protection. This suggests that protection technologies could be more effective in some countries.

The loss from protection varies significantly across countries and is over 5 percent in several cases. Thus, even in an economy in which all predation is an “efficient” transfer from firms to criminals, the loss in output caused by predation can still be substantial. This is an interesting finding given that the main focus of the discussion about the cost of predation and the misallocation that it causes has been on the fact that it reduces the output retained by the firm rather than the private actions that firms take to prevent it happening.

**Heterogeneous Firms** We now explore the implications of firm level heterogeneity in productivity, predation and protection. As an intermediate step, Figure 3 plots the loss in different deciles of the firm productivity distribution,  $\frac{\theta_i}{\bar{\theta}}$ , in two countries: China and Mexico. We choose these two cases since both have decent-sized samples of firms. Moreover, the pattern found in these two cases appear somewhat representative of the

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<sup>18</sup>These are reasonable numbers given the employment share of protection in the US in 2014 was between 0.7 and 2.2 percent depending on which definition we use.

pattern of output losses in Asian and Latin American economies. Asian countries tend to show consistently lower output losses.

Figure 3 illustrates the variation in losses across the firm-size distribution. It shows that losses in Mexico tend to be proportionately greater in large firms compared to China. This suggests that there will be distortions across firms in the way that labor is allocated. We will return to some further implications of this in section 7 where we report the result of a thought experiment which increases protection for larger firms.

The main point to take away from Figure 3 is that there is considerable variation across countries regarding which part of the firm-size distribution is most affected by predation. A model with heterogeneous firms can take this into account in the calculation of aggregate losses. The estimated output loss in country  $c$  is given by:

$$\Delta_c = 1 - \frac{\sum_i \pi_{ic} \frac{\theta_{ic}}{\Theta_c} \left[ \tau + \frac{(1-\tau)}{1+\mu_{ic}} \right] \left( \frac{\hat{\theta}_{ic}}{\Theta_c} \right)^{\frac{\alpha}{1-\alpha}} \left( \frac{\alpha}{\alpha+\sigma_{ic}} \right)^\alpha}{\sum_i \pi_{ic} \left( \frac{\theta_{ic}}{\Theta_c} \right)^{\frac{1}{1-\alpha}}} \quad (14)$$

where we exploit firm level variation in productivity, losses and security expenditures in the enterprise survey data.<sup>19</sup>

Figure 4 compares the estimate from (14) to the estimates that comes out the model with identical firms, i.e. (13). Observations on the red line would mean that the output loss estimate is identical with and without firm heterogeneity. Most points are, however, above that line indicating that allowing for heterogeneity tends to increase the size of the estimated loss; the estimated output loss under the assumption of heterogeneous firms is close to 5 percent whereas it is just above 2 percent under the assumption of homogeneous firms. There a few countries where the increased output loss with heterogeneity is particularly pronounced and is due to large firms being particularly susceptible to predation in these countries. In line with Figure 3, Mexico is a notable member of this group of countries.

We have run several robustness checks regarding both output loss estimates shown in Figure 4. For example, we exclude firms with very large weights  $\pi_{ic}$ , drop outliers

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<sup>19</sup>We validate this approach by looking at the correlation between the most comparable measure of crime at the country level, homicides, in Table A1. We find a positive correlation between our loss measure and this measure both in pooled regressions and in panel regressions with country fixed effects.

in terms of firm size and restrict the analysis to countries with many observations. The findings are fairly robust to all of these changes.<sup>20</sup> Our model allows us to calculate the productivity weights from firm size alone and so we do not rely on data on sales and costs which are reported less often and contain larger errors. Two findings emerge if we calculate productivity weights from sales and costs data, i.e. if we use value added estimates.<sup>21</sup> First, if we focus on large, comparable samples and exclude outliers of the value added data the two ways to calculate weights yield very similar results. Second, moving away from large, comparable samples the output loss measures look less similar.

According to our model, some part of the estimated losses in Figure 4 are due to firms which are most affected by predation losses shedding labor and we would expect such firms to expand were predation to be eliminated. We now look at how important labor reallocation across firms is for our output loss estimates. This effect can be captured empirically in our framework by computing the difference between  $\left(\hat{\theta}_{ic}/\hat{\Theta}_c\right)^{\frac{\alpha}{1-\alpha}}$  in the numerator of (14) and  $(\theta_{ic}/\Theta_c)^{\frac{\alpha}{1-\alpha}}$  in the denominator.

Figure 5 tries to gauge the importance of the labor reallocation effect by plotting the output loss in (14) when we replace  $(\theta_{ic}/\Theta_c)^{\frac{1}{1-\alpha}}$  by  $(\theta_{ic}/\Theta_c)\left(\hat{\theta}_{ic}/\hat{\Theta}_c\right)^{\frac{\alpha}{1-\alpha}}$  in the denominator. This is like assuming that in the hypothetical no-predation scenario, labor allocation remains as it is in our data i.e., does not move across firms.<sup>22</sup> We then compare the resulting output loss to the one in equation (14). The output loss is always smaller without labor reallocation and the difference is around 0.2 percent of output on average so could be regarded as fairly small. Note however, that we are not allowing the total amount of labor supplied to the enterprise sector of the economy to vary and we are assuming that all firms use the same technology. We will see below that when we look at this from a sectoral perspective with sector-specific technologies and the possibility of inflows of labor from other parts of the economy, these labor reallocation effects can be much larger.

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<sup>20</sup>However, most of the extreme losses we find in Figure 4 are in countries with small samples (except Cambodia). This is illustrated in Figure A2 where we restrict the sample to countries with more than 500 observations.

<sup>21</sup>For calculations and discussion see Appendix B.

<sup>22</sup>To see this note that  $\left(\hat{\theta}_{ic}/\hat{\Theta}_c\right)^{\frac{\alpha}{1-\alpha}} = (l_{ic}/L_c)^\alpha$ .

## 7 Patterns of Protection

Our estimates so far have kept government policy firmly in the background. However, a central role of government is to determine the level of spending and the effectiveness of state institutions in maintaining social order by limiting predation. If this is the case, we would expect to find that our measures of output loss are correlated with proxies for the extent to which governments are actively fighting predation through employing police and having an effective criminal justice system.

We now look at two proxies for state action. Our first measure is an index created by the World Justice project which is intended to measure the effectiveness of the criminal justice system on a scale between 0 and 1. The index summarizes many sub-factors which capture, for example, effectiveness and impartiality of the criminal investigation system, the criminal adjudication system and the correctional system. Our second measure is the number of police force per employed which we construct from data on the police force from United Nations Office on Drugs and Crime (UNODC) and data on population and total employment from the Penn World Tables 8.0. Both measures serve as a crude measure of the likelihood that the state is effective in deterring predation. The second figure also provides an idea of the shares of public employment in defence against predation.<sup>23</sup>

Figure 6 relates our estimates of the output loss to these proxies for the policy environment for the case where  $\tau = 0$ , i.e. all predation is destructive. The left hand panels in both figures use data on the effectiveness of the criminal justice system. There is a strong correlation between our two output loss measures (with and without heterogeneity among firms) and this measure. If we interpret the relationship as causal (which is obviously problematic) the adoption of a system of criminal justice in Venezuela with the effectiveness of Chile would boost output in the former by around 2 percent. If it were to adopt a legal system with the effectiveness of Sweden, it would gain more than 3 percent. Of course, we would expect other gains from improving the effectiveness of criminal justice beyond those highlighted here. The right hand panels plot our measures of output loss against the size of the police force. This also displays a downward sloping pattern although the relationship is not statistically significant.

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<sup>23</sup>It is interesting to know that formal public policing is an order of magnitude smaller than the labor shares that we find at the firm level.

**Parametric Estimates and Firm-level heterogeneity** Another way to think about the underlying situation in a country is to focus on the constant elasticity model and to interpret variation in the two firm-level parameters  $\{\gamma^i(g), \varepsilon^i(g)\}$  which characterize the protection technology. Our data allow us to calculate the productivity of protection effort and the degree of protection that a firm enjoys. Since we think of  $g$  as reflecting country-specific factors we can use these estimates to think about policy differences across locations.<sup>24</sup>

To estimate  $\gamma^i(g)$  directly from the share of sales that is spent on protection in firm  $i$ , we use the observation that  $\gamma^i(g) = \sigma_i / [\sigma_i + \alpha]$ . The parameter  $\varepsilon^i(g)$  can be backed out from observables by observing that, when firms make their optimal decisions, then:

$$\varepsilon^i(g) = \frac{[l_i \gamma^i(g)]^{-\gamma_i(g)}}{(1 + \mu_i)}. \quad (15)$$

The best way to interpret  $\varepsilon^i(g)$  is as the *perceived* level of protection by a firm which is consistent with its protection behavior and its reported loss. Firm size  $l_i$  is increasing in  $\theta_i$  in equation (15) which implies that, in theory at least, more productive firms should be less well-protected (all else equal). However, it is still an open empirical question whether this is indeed the case in the data.<sup>25</sup>

Figure 7 plots our estimates of protection,  $\varepsilon^i(g)$ , against the percentile of firms in the firm-size distribution. This measure ranges from around 1.04 to 0.93 and, as we expected, we find a downward relationship overall with firm size. Thus our data suggest that the behavior of large firms is consistent with them perceiving a larger predatory threat on average than small firms. The 10th percentile to the 90th percentile implies a fall of  $\varepsilon^i(g)$  by 5 percentage points. To interpret this it is useful to keep in mind that if the firm cannot defend against predation,  $\gamma^i(g) = 0$ , then  $\varepsilon^i(g)$  is the share of output that the firm keeps. However, large firms seem to be compensated for this lack of perceived protection with high elasticities in private protection spending  $\gamma^i(g)$  so that lower perceived protection does not go hand in hand with predation losses.<sup>26</sup>

Table 3 reports some firm level regressions to explore correlates of perceived protection.

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<sup>24</sup>Of course, these need not be due to policy at all and could reflect cross-country technological differences and differences in culture etc.

<sup>25</sup>This will depend in part on the covariance of  $\theta_i$  and  $\gamma^i(g)$ .

<sup>26</sup>We discuss this further below.

In all regressions we include country/year fixed effects, sector fixed effects for four sectors and dummy variables representing the decile of the productivity distribution that the firm is in. In columns (1) and (2), we relate  $\{\varepsilon^i(g), \gamma^i(g)\}$  to some subjective questions on the perception of crime at the firm level. We find that firms that expect more protection (higher  $\varepsilon^i(g)$ ) reduce the extent to which they report crime as an obstacle on a 0-4 scale and are less likely to say that crime is the worst obstacle the firm faces. Interestingly,  $\gamma^i(g)$  is negatively correlated with reports that crime is an obstacle. Thus despite experiencing higher losses due to spending on defence, the fact that a firm is able to defend against crime appears to make it less inclined to state that predation is an obstacle to doing business.

In column (3) of Table 3 we find that firms located in the capital city perceive that they are better protected from predation. This makes a lot of sense given that many state institutions are most robust in the capital cities of the developed countries. In column (4), the dependent variable is the protection effort elasticity  $\gamma^i(g)$ . Here, we find that state owned and foreign firms seem better able to defend against predation. The elasticity of defending against predation is lower in the capital city. This points to the possibility of some substitutability between public and private protection.

Following on from what we showed in Figure 3, Figure 8 returns to the case of China and Mexico where we now plot the distribution of protection by productivity decile. They illustrate two archetypal patterns where some countries seem to offer reasonably equal levels of protection across firms, regardless of firm size whereas in others it appears to tail off markedly as firms get larger. The latter pattern is well illustrated by Mexico while the pattern in China shows little difference in protection across the firm size distribution. Drilling down this way into country-specific patterns shows the value of being able to look at these issues through a parametric interpretation of the firm-level data.

Our model also allows us to consider the following policy experiment – what would happen if we applied the pattern of protection and effort elasticities from China to other countries?<sup>27</sup> To do this we first compute the average level of  $\{\varepsilon^i(g), \gamma^i(g)\}$  in percentiles of relative productivity,  $\frac{\theta_{ic}}{\Theta_c}$ , in China. We then replace the mean values across percentiles of  $\frac{\theta_{ic}}{\Theta_c}$  in each country by the Chinese values and compute the gains/losses in output that this would yield. This, rather than zero predation, seems like a more reasonable benchmark

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<sup>27</sup>We use values China but the pattern is similar in other East Asian countries like South Korea, Thailand and Vietnam, .

and highlights the potential value in protecting larger, more productive firms. Table 4 shows the change in output that we estimate in all countries from this policy experiment. Some countries would lose output. Sweden, for example, would lose 1.4 percent of its output in the enterprise sector. However, for most developing countries the gains would be substantial. For example, we estimate that Sierra Leone could increase output in the enterprise sector by almost 7 percent by adopting a pattern of protection that we see in China and Mexico might increase output in the enterprise sector by 3 percent. This reinforces the point that failing to protect the most productive firms from predation does most damage to the economy.

## 8 Further Analysis

**Impact on Investment and Firm Growth** We have so far focused on a production structure with only labor and a single distortion due to predation/protection. However, it is easy to embed the approach in a more general setting while preserving the insights that we use in fitting the model to the data. Suppose, for example, that there is both labor and capital and we have a Lucas (1978) span of control model with a decreasing returns parameter  $\eta$ ,<sup>28</sup> i.e.

$$y_i = \theta_i p^i(e_i, g) \left[ (l_i - e_i)^\alpha k_i^{(1-\alpha)} \right]^\eta.$$

Let  $\{w, r\}$  be the factor prices for labor and capital respectively, then solving for the factor demands in this case yields:

$$l_i = \frac{\alpha\eta}{w} A \left( \theta_i \frac{1}{1 + \mu_i} \left( \frac{\sigma_i + \alpha}{\alpha} \right)^{1-\eta} \right)^{\frac{1}{1-\eta}}$$

and

$$k_i = \frac{(1 - \alpha)\eta}{r} A \left( \theta_i \frac{1}{1 + \mu_i} \right)^{\frac{1}{1-\eta}}$$

where  $A = \left[ \left( \frac{\alpha\eta}{w} \right)^\alpha \left( \frac{(1-\alpha)\eta}{r} \right)^{1-\alpha} \right]^{\frac{\eta}{1-\eta}}$  is an economy-wide constant. In this case, observe that we have two dimensions to the productivity distortion. For capital  $\hat{\theta}_i^k = \theta_i \frac{1}{1 + \mu_i}$  which

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<sup>28</sup>It would be straightforward to have a standard monopolistic competition model with a constant markup instead.

is decreasing in the share of output loss. For labor we have  $\hat{\theta}_i^l = \theta_i \frac{1}{1+\mu_i} \left(\frac{\sigma_i+\alpha}{\alpha}\right)^{1-\eta}$  which is directly analogous to (7) and is also increasing in  $\sigma_i$ .<sup>29</sup> Notice that the adjustment in productivity has a general firm-specific part and a labor-specific part due to the distortion in the labor market due to employing guard labor as security.

This extension of the model allows us to think about how productivity affects investment in the constant elasticity model with parameters  $\{\varepsilon^i(g), \gamma^i(g)\}$ . We assume that  $\gamma^i(g) + \eta < 1$  so that there is decreasing returns in  $\{l_i, k_i\}$  overall.<sup>30</sup> Appendix C shows that the optimal capital stock is increasing in  $\varepsilon^i(g)$  and  $\gamma^i(g)$  if  $p^i(e_i, g) < 1$ .

Our data allow us to look at this empirically by looking at investment.<sup>31</sup> Specifically, we look to see whether a firm reports purchasing any fixed asset and/or expenditure in fixed assets over the previous year. The results are reported in Table 5 and include country-year fixed effects, sector fixed effects and dummies for firm-size class. Columns (1) through (3) show that there is positive correlation between investment and our measure of firm-level protection as well as our measure of the productivity of protection. Column (1) uses data on a general question regarding the purchase of any fixed asset. A one standard deviation increase in the protection parameter increases investments by 1.6 percent. An increase in the elasticity of protection effort increases the likelihood of an investment by 3.4 percent.

Columns (2) and (3) use data on fixed asset purchases which is reported less frequently by firms. Column (2) finds patterns that are broadly consistent with the findings on the correlation with protection in column (1). Column (3) focuses on the intensive margin of firm investments as the log function leads to the exclusion of all zero investments. Effects on this margin are consistent with the theory and fairly large. A standard deviation increase in protection implies an increase of investment by 9.5 percent. An increase of the

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<sup>29</sup>Note that

$$\frac{l_i}{L} = \frac{\left[\theta_i \frac{1}{1+\mu_i} \left(\frac{\sigma_i+\alpha}{\alpha}\right)^{1-\eta}\right]^{\frac{1}{1-\eta}}}{\sum_j \left[\theta_j \frac{1}{1+\mu_j} \left(\frac{\sigma_j+\alpha}{\alpha}\right)^{1-\eta}\right]^{\frac{1}{1-\eta}}}.$$

Hence, as in the core model, adjusted firm-level productivity is reflected in labor shares.

<sup>30</sup>To see this observe that in this case, we can write:

$$y_i = \theta_i \varepsilon^i(g) [\gamma^i(g)]^{\gamma^i(g)} [1 - \gamma^i(g)]^{\alpha\eta} \left[(l_i)^{\gamma^i(g)+\alpha\eta} (k_i)^{(1-\alpha)\eta}\right]$$

<sup>31</sup>To map formally from the capital stock to investment, it would be straightforward to introduce adjustment costs along with shocks to  $\theta_i$ .

protection elasticity by one standard deviation implies an increase in investment by more than 16 percent. Thus, as we would expect, predation and protection are also related to investment decisions. This pattern of investment effects largely corroborates our earlier findings and is in line with our theory as well as the core findings in Table 3.

**The Size of the Enterprise Sector** The model implicitly assumes that the level of employment in the enterprise sector as covered by the World Bank enterprise surveys remains constant. This can be thought of as a segmented labor-markets assumption. The efficiency effects are therefore exclusively due to labor reallocation within the segment rather than between this segment of the private sector and other parts of the economy. We now discuss how a further margin can matter due to entry and exit of labor from working in the sector that is surveyed. Our approach to this is very simple, supposing that there is a fixed outside wage set in either public employment or agriculture which we denote by  $\omega$ . This could be thought of as a Lewis-style dual economy model where  $\omega$  for the whole economy is the wage set in agriculture. But labor reallocation could be from the public sector or the informal sector. We will show that if we assume that  $\omega$  is fixed, i.e. there is no general equilibrium response in the sector that is supplying labor to the formal enterprise sector, then a back-of-the-envelope calculation suggests that the output loss could be about double that which we estimated above. That said, we are only eliminating predation in this thought-experiment from the sector in our data rather than from the rest of the economy.

Let  $L^*$  be labor allocated to the enterprise sector without predation/protection and  $\hat{L}$  be the amount with predation/protection. Write output as:

$$Y^* = (L^*)^\alpha \Omega \text{ and } \hat{Y} = \hat{L}^\alpha \hat{\Omega}$$

where  $\Omega = \Theta \sum_i \pi_i \left(\frac{\theta_i}{\bar{\theta}}\right)^{\frac{1}{1-\alpha}}$  and  $\hat{\Omega} = \Theta \sum_i \pi_i \frac{\theta_i}{\bar{\theta}} \left[\tau + \frac{(1-\tau)}{1+\mu_i}\right] \left(\frac{\hat{\theta}_i}{\bar{\theta}}\right)^{\frac{\alpha}{1-\alpha}} \left(\frac{\alpha}{\alpha+\sigma_i}\right)^\alpha$  using (10) and (11). Now labor allocation to the enterprise sector will equate the marginal product of labor in the enterprise sector to the outside wage, i.e.

$$\omega = \alpha (L^*)^{\alpha-1} \Omega = \alpha \left(\hat{L}\right)^{\alpha-1} \hat{\Omega}.$$

From this we have an expression for the relative size of the labor force in the distorted and

undistorted cases given by:

$$\frac{\hat{L}}{L^*} = \left( \frac{\hat{\Omega}}{\Omega} \right)^{\frac{1}{1-\alpha}}. \quad (16)$$

Now let  $M$  be the total workforce and denoted aggregate productivity as  $Z \in \{\Omega, \hat{\Omega}\}$ . Then with  $\tau = 0$  we have that aggregate labor demand to the enterprise sector is:

$$L = \left( \frac{\alpha Z}{\omega} \right)^{\frac{1}{1-\alpha}} \quad (17)$$

and the level of national income is:

$$\begin{aligned} Y(Z) &= \omega M + L^\alpha Z - \omega L \\ &= \omega M + (1 - \alpha) Z^{\frac{1}{1-\alpha}} (\alpha/\omega)^{\frac{\alpha}{1-\alpha}} \end{aligned}$$

after using (17). Given the economy as specified here, this is the sum of labor earnings at the fixed wage,  $\omega$ , plus profit generated in the enterprise sector which we are implicitly assuming is the source of all profits. Our expression for the loss from predation/protection is now:

$$\begin{aligned} \Delta &= \frac{Y(\Omega) - Y(\hat{\Omega})}{Y(\Omega)} \\ &= \frac{\Omega^{\frac{1}{1-\alpha}} (1 - \alpha) \left(\frac{\alpha}{\omega}\right)^{\frac{\alpha}{1-\alpha}}}{(1 - \alpha) \Omega^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{\omega}\right)^{\frac{\alpha}{1-\alpha}} + \omega M} \left[ 1 - \left( \frac{\hat{\Omega}}{\Omega} \right)^{\frac{1}{1-\alpha}} \right]. \end{aligned}$$

To give a back-of-the-envelope measure of this and its effect on our core output loss measures, we can estimate  $\frac{\Omega^{\frac{1}{1-\alpha}} (1-\alpha) \left(\frac{\alpha}{\omega}\right)^{\frac{\alpha}{1-\alpha}}}{(1-\alpha) \Omega^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{\omega}\right)^{\frac{\alpha}{1-\alpha}} + \omega M}$  from the profit share in GDP.

Putting this together, then to a first-order approximation, we have the following expression for the aggregate output loss as:

$$\Delta \simeq \frac{\alpha}{1 - \alpha} \left[ 1 - \left( \frac{\hat{\Omega}}{\Omega} \right) \right].$$

In interpreting this, it is useful to observe that  $1 - \left( \frac{\hat{\Omega}}{\Omega} \right)$  is the measure of output loss from our original expression (12). Thus, allowing for the aggregate labor force in the enterprise sector to respond increases the size of the welfare loss by a factor which is approximately:  $\alpha / (1 - \alpha) \simeq 2$ , i.e. allowing for labor reallocation between sectors could be thought of

as roughly doubling the output loss that we estimated above. Of course, this is only approximate and given that  $\omega$  does not respond could be viewed as an upper bound on the output loss. Moreover, it throws into sharp relief the fact that we have maintained the assumption that  $\alpha$  is assumed for the purposes of our exercise to be the same across economies. While it would be straightforward to relax this for the purposes of calculation, it would affect how much labor reallocation across sectors to expect as predation changes as well as the returns to labor reallocation within the sector.

It is worth underlining that we have assumed that  $\omega$  is fixed in this exercise. If  $\omega$  did respond to increased productivity in the formal enterprise sector, then we would expect the output effect to be dampened. However, part of the benefit of reduced predation and protection would then be experienced by increases in wages in other sectors of the economy. Moreover, as this would be a shift from profits to wages, it would also be likely to create a progressive redistributive effects.<sup>32</sup>

Following this discussion, what does seem robust is the suggestion that we were quite conservative in our approach to estimating the output loss from predation in the core results above.

**Reallocation Between Sectors** We have assumed up until now that  $\alpha$  is the same for all firms. We now relax this assumption by assuming a sector-specific technology, i.e.  $\alpha_s$  for sector  $s$ . For sectoral labor intensity, we use the US economy as a benchmark. Specifically, we use payroll shares from Elsbey et al (2013).<sup>33</sup> Based on this, we use 32.2 percent as the labor share in the primary sector for which we use the natural resources and mining sector in the US. Construction in the US has a payroll share of 72.4 percent. For manufacturing we calculate an average US labor share of 55.1 percent from durable goods manufacturing and non-durable good manufacturing and for the services sector we calculate an average of 57.5 percent from across all services sectors weighted by their value added. Using this, we will estimate the sectoral output loss when labor allocation does not move as well as the labor reallocation effect from for every sector/country/year.<sup>34</sup>

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<sup>32</sup>Also, there is some evidence that higher wages and employment in the legal economy would induce a fall in crime. See, for example, Gould et al (2002) and Machin and Meghir (2004).

<sup>33</sup>A similar argument is made in Hsieh and Klenow (2009). Specifically, we use a weighted average of the payroll share from the year 2011 using the shares of value added as weights. All data is from Table 2 in Elsbey et al (2013).

<sup>34</sup>We exclude sector/country/years with less than 10 firms in this and the following section.

In the case in which labor does not move then, following (12), the output loss from predation in sector  $s$  is given by:

$$1 - \frac{\hat{\Omega}_s}{\Omega_s} = 1 - \frac{\sum_i \pi_{is} \frac{\theta_{is}}{\Theta_s} \left[ \tau + \frac{(1-\tau)}{1+\mu_{is}} \right] \left( \frac{\hat{\theta}_{is}}{\hat{\Theta}_s} \right)^{\frac{\alpha_s}{1-\alpha_s}} \left( \frac{\alpha_s}{\alpha_s + \sigma_{is}} \right)^{\alpha_s}}{\sum_i \pi_{i\alpha_s} \left( \frac{\theta_{is}}{\Theta_s} \right)^{\frac{1}{1-\alpha_s}}}. \quad (18)$$

Following the calculations in Table 2, allowing  $\alpha_s$  to vary across sectors does not affect our estimate of the output loss in equation (12) substantially.<sup>35</sup> Table 6 summarizes the results from looking at the loss in each sector for the quartiles of countries that are most and least affected by predation. We first report raw data averages of  $\mu_{is}$  and  $\sigma_{is}$  by sector. In the third column of Table 6 we report our estimates of (18) by sector which now takes into account firm heterogeneity. The least affected countries lose around 0.7 per cent of output due to predation with little variation across sectors. The most affected countries show a little more variation with the construction sector losing most (6.87 percent).

Allowing  $\alpha_s$  to vary does however have substantial consequences for the estimated employment effects using a model of the kind that we developed in the previous section where we assumed a fixed outside wage,  $\omega$ . Specifically, we allow the labor allocated to sector  $s$ , denoted by  $L_s$  to vary when predation is eliminated so that the marginal product of labor used in sector  $s$  is equal to  $\omega$ . Using this observation and taking logs in a sector-specific version of equation (16), we can estimate the proportionate difference in the size of the labor force in sector  $s$  with and without predation from:

$$\ln \frac{L_s^*}{\hat{L}_s} = \frac{1}{1 - \alpha_s} \ln \frac{\hat{\Omega}_s}{\Omega_s}. \quad (19)$$

It is immediate from (19) that  $\alpha_s$  affects labor reallocation with larger effects occurring in more labor-intensive sectors, i.e. where  $\alpha_s$  is higher.

Table 6 reports the employment loss from predation which lies between 0.9 percent in the primary sector and 2.4 percent in construction. The greater output loss in construction is an immediate consequence of this being a more labor intensive sector where labor

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<sup>35</sup>We plot the output loss at the country/sector level under the assumption of US labor shares (explained below) against the estimate with constant labor share in Figure A3. The estimated output loss is only slightly higher with the assumption of higher labor shares.

distortions matter more. While the output losses vary only by around a percentage point in the countries most affected by predation, the employment loss effects vary dramatically between sectors and can be quite large. We estimate that there would be a 12 percent gain in manufacturing and whopping 23.9 percent gain in construction employment from eliminating predation. Here, relaxing the assumption of a common technological has an important bearing on the findings with labor intensive sectors being much more affected in their total employment.

It is important to bear in mind that the approach taken here is in the spirit of a Lewis-style model of labor allocation where there is an unlimited supply of laborers who could in principle be brought into formal sector employment with increasing the wage  $\omega$ . To the extent that this is not the case, these effects would tend to be smaller. So what we have shown should probably be regarded as an upper bound.

**The Covariance between Firm-Size and Productivity** Since we have a direct measure of the distortions due to predation and protection, our approach can be used to look at labor misallocation in terms of the effect that it has on the covariance between firm size and productivity. This is a popular way of thinking about misallocation suggested by Bartelsman et al (2013). Based on our theoretical approach, the covariance between labor productivity and firm size can be written as:

$$cov\left(\log\frac{y_{is}}{l_{is}}, \log\frac{l_{is}}{L_s}\right) = cov\left(\log\frac{w}{\alpha_s + \sigma_{is}}, \log\frac{l_{is}}{L_s}\right), \quad (20)$$

which immediately reveals that, according to our model, this covariance reflects how  $\sigma_{is}$  and  $l_{is}$  move with one another.<sup>36</sup> If larger firms hire more labor for protection, we would expect the covariance in (20) to be lower, i.e. labor productivity would be a weaker predictor, all else equal, of the number of workers that a firm employs.

An alternative way to look at this is to use the covariance between firm productivity

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<sup>36</sup>Note that in (20), the wage rate,  $w$  and sector labor shares  $L_s$  are fixed at the country/year/sector level.

and firm size instead. In terms of our notation this covariance is

$$cov \left( \log \frac{\theta_{is}}{\Theta_s}, \log \frac{l_{is}}{L_s} \right) = cov \left( \log \frac{(1 + \mu_{is}) (l_{is})^{1-\alpha_s} \left( \frac{\alpha_s}{\alpha_s + \sigma_{is}} \right)^{1-\alpha_s}}{\Theta_s}, \log \frac{l_{is}}{L_s} \right) \quad (21)$$

where  $\Theta_s$  and  $L_s$  are fixed at the country/year/sector level. The covariance will depend mainly on the variance of firm size,  $l_{is}$ , within a sector. Firm level distortions have two opposing effects on our estimates of productivity through the term  $\frac{1}{(1+\mu_{is})} \left( \frac{\alpha_s + \sigma_{is}}{\alpha_s} \right)^{1-\alpha_s}$ . Predation losses,  $\mu_{is}$ , lower the optimal firm size while protection spending,  $\sigma_{is}$ , increases firm size by increasing the amount of labor that a firm hires. The change in the covariance induced by distortions induce by predation and protection will depend on whether such distortions are correlated with a firm's productivity.

We compute the covariances in (20) and (21) within each sector/country/year under the assumption that the labor share,  $\alpha_s$ , varies by sector.<sup>37</sup> Two patterns are worth noting. First, both the median and mean covariance in (20) are negative implying that larger firms tend to protect themselves more. Second, the covariance in (21) decreases in  $\alpha_s$  as the formula suggests. Moreover, the covariance between firm productivity and firm size is more than one standard deviation higher in manufacturing than in construction.

Table 7 shows, following the logic in Bartelsman et al (2013), that a lower covariance between firm size and productivity in a sector is indeed associated with a higher estimated loss of output due to predation. We would expect this if we regard predation as inducing a misallocation of labor across firms with heterogeneous productivity levels.<sup>38</sup> The pattern holds for the covariance in (20) shown in columns (1) and (2) and for the covariance in (21) as shown in columns (3) and (4). The findings are robust to controlling for country/year and sector fixed effects and constitute an economically meaningful relationship; an increase of 4 percentage points in the output loss in column (2) is associated with a decrease of the covariance between labor productivity and firm size by one standard deviation.

The mechanism at work here is worth elaborating further. The negative covariance in columns (1) and (2) is driven by the fact that protection spending is positively correlated

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<sup>37</sup>We drop sector/country/years with less than 10 firms.

<sup>38</sup>In interpreting this, we should emphasise that we are only looking at the marginal misallocation that is being attributed to the distortion in the labor market due to predation. Our benchmark measure of  $\frac{\theta_i}{\Theta}$  takes any other sources of misallocation and/or productivity loss as given.

with firm size. This is not surprising in our framework as it is protection which leads to a firm expanding its level of employment. Somewhat surprisingly, this negative relationship becomes more pronounced if we relate output losses to the covariance measure given by equation (21). Column (5) shows that this is due to the predation loss,  $\mu_{is}$ , decreasing with firm size, i.e. larger firms tend to lose a smaller share of their output to predation but hire more unproductive labor. Both of these factors reduce the size of the covariance (21).

Our findings here also highlight the importance of including endogenous firm protection effort in the analysis of the distortions caused by predation. Our finding that large firms are less protected in some countries, for example, is a direct consequence of having protection spending in the model – absent protection spending we would observe a level of the distortion due to predation for larger firms.

## 9 Concluding Comments

One important feature of many developing and emerging market economies is the extent to which firms face threats of predation due to weakness in law and order. We have emphasized the possibility that firms will respond to this threat by diverting labor from productive uses towards protecting themselves. While this reduces the expected loss from predation it also reduces labor available for productive purposes.

We have incorporated the possibility of predation and protection into a simple model to illustrate how it affects the allocation of labor across firms. The model was used to derive an expression for productivity which reflects the costs of predation. By writing this in terms of observables, we are able to use data from the World Bank enterprise surveys to estimate these losses based on answers to survey questions posed to firms about losses from robbery, theft, arson and vandalism as well as the amount that they spend on security.

Heterogeneity in predation threats and protection technologies mean that firms vary in the extent to which they experience an output loss. All else equal, firms that suffer less or have no viable protection technology hire more productive workers as a fraction of their total employment. This results in labor misallocation across firms even when the marginal product of labor is equalized across firms. We quantify this and show sizeable output losses which vary by country and firm-size. Around two thirds of these losses are due to protection rather than predation, emphasizing the importance of looking at this aspect of the issue.

By extending the model to allow for sector-specific labor intensities, we can estimate the extent of labor across sectors that we might expect if predation were eliminated. We estimate that employment in the sector with the highest labor intensity, construction, might expand by more than 20 percent if predation could be eliminated in high predation countries. We also show how the covariance between predation, protection and productivity determines the aggregate output loss.

To gain an insight into how policy might matter, we have also looked at patterns of predation across and within countries. We find that firms in the capital city are better protected while those which are state owned appear to be worse protected. There is also a tendency for protection to be worse in larger firms, although this pattern is heterogeneous by country. Our analysis suggests that East Asian countries protect their large firms better than most other developing countries. Adopting the pattern of protection found in China, for example, would provide significant output gains for countries most affected by predation. That said, it is clear that this finding is only suggestive with a more complete policy analysis having to consider the costs of different policy interventions.

The paper speaks to wider debates about the role of institutions in affecting productivity. It is now accepted that institutions affect the economy through their impact on law and order. We have provided a specific focus on this through looking at both predation and protection. This complements the recent literature which has looked at capital misallocation and its consequences for output.

While the analysis provides a range of insights, much remains to be done to provide a more complete picture of how predation affects labor allocation and productivity. First, we are holding other distortions in the economy as fixed when we look at the effect of improving protection. It is quite possible that distortions other than that focused on here are more quantitatively important in explaining low levels of productivity in some countries. Following Hsieh and Klenow (2009), capital market misallocation is a case in point. Moreover, it is possible that both capital and labor enters the protection technology. Second, we have not looked at entry and exit into crime and the impact of moving people from being criminals into productive workers. Third, we have not allowed for positive and negative spillovers between firms who choose their levels of protection and the interplay

between public and private protection.<sup>39</sup> We have been agnostic regarding the extent and nature of spillovers and the protection technology.<sup>40</sup> Fourth, we have not considered the role of public protection and how it interacts with protection decisions at the firm level. Our estimates suggest that the level of private protection might exceed the share of labor force allocated to public protection. The interaction between firms' decisions to protect and policy making requires investigation.

But in all of these lines of enquiry, private protection needs to be taken into account by future efforts that consider how weak law and order affects resource allocation. Otherwise an economically significant dimension of resource misallocation may be missed.

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<sup>39</sup>Ayres and Levitt (1998) discuss the importance of spillovers and provide empirical evidence for a positive spill over from investing in protection. Bandiera (2003) provides evidence for a negative spill-over in the context of Sicilian land protection. See also Draka and Machin (2015) for a discussion. Clotfelter (1977) provides an early discussion and empirical investigation of the interplay between private and public provision of protection.

<sup>40</sup>We could allow  $p^i$  to be a function of all the protection decisions,  $e_j$ , of other firms  $j$ . To look at public protection, we would need to delve into determinants of the level of public protection  $g$ . Of particular interest would be to think about the distribution of protection across firms of different kinds/locations.

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# Appendix

## A Data Description

**Enterprise Survey Data** We use data base on Enterprise Survey of the World Bank Group for the period 2002-2014 . For that we merge two standardize data sets, the Standardized data for 2002-2005 and the Standardized data 2006-2014. We describe the construction of the variables for each of the two periods.

For the 2002-2005 period, Security Costs as percentage of sales (SCAS) is computed as the sum of two variables, namely, Cost of providing security as percentage of sales and Cost of providing protection payments as percentage of sales. Loss due to theft, robbery, vandalism or arson as a percentage of sales (LDTV) is directly reported in the data set. For the 2005-2014 period, respondents indicate either the absolute amount, which one can use to compute as percentage of total sales, or directly the amount as percentage of total annual sales. SCAS and LDTV are the two type of answers combined. We disregard observed loss shares or security costs above 100% of total sales. By doing it, we lose 46 observations for LDTV and 104 observations for SCAS.

The number of employees is constructed as the sum of permanent employees and temporary employees adjusted by the average length of employment of temporary workers. Finally, capital is computed as the sum of the net book value of machinery and equipment and the net book value of land and buildings. In most of our analysis we only use observations with data on all three variables which gives us 142,315 observations of originally 183,451 observations.

For 2002-2005, Sector is constructed from the variable industry which specifies the sector of activity. We divide sector into four; primary sector which includes mining, manufacturing, services, and construction. For 2006-2014, data set includes information about the industry accordingly to the two-digit ISIC Rev 3.1. We use the ISIC digits 1-14 as primary sector including mining, digits 15-37 as manufacturing, the digits 40-44 and 46-99 as services, and 45 as construction. The web site for the surveys (<http://www.enterprisesurveys.org/Methodology>) describes the sample process as follows:

“The sampling methodology for Enterprise Surveys is stratified random sampling. In a simple random sample, all members of the population have the same probability of being selected and no weighting of the observations is necessary. In a stratified random sample, all population units are grouped within homogeneous groups and simple random samples are selected within

each group. This method allows computing estimates for each of the strata with a specified level of precision while population estimates can also be estimated by properly weighting individual observations. The sampling weights take care of the varying probabilities of selection across different strata. Under certain conditions, estimates' precision under stratified random sampling will be higher than under simple random sampling (lower standard errors may result from the estimation procedure). The strata for Enterprise Surveys are firm size, business sector, and geographic region within a country. Firm size levels are 5-19 (small), 20-99 (medium), and 100+ employees (large-sized firms). Since in most economies, the majority of firms are small and medium-sized, Enterprise Surveys oversample large firms since larger firms tend to be engines of job creation. Sector breakdown is usually manufacturing, retail, and other services. For larger economies, specific manufacturing sub-sectors are selected as additional strata on the basis of employment, value-added, and total number of establishments figures. Geographic regions within a country are selected based on which cities/regions collectively contain the majority of economic activity. Ideally the survey sample frame is derived from the universe of eligible firms obtained from the country's statistical office. Sometimes the master list of firms is obtained from other government agencies such as tax or business licensing authorities. In some cases, the list of firms is obtained from business associations or marketing databases. In a few cases, the sample frame is created via block enumeration, where the World Bank "manually" constructs a list of eligible firms after 1) partitioning a country's cities of major economic activity into clusters and blocks, 2) randomly selecting a subset of blocks which will then be enumerated. In surveys conducted since 2005-06, survey documentation which explains the source of the sample frame and any special circumstances encountered during survey fieldwork are included with the collected datasets."

The survey weights play an important role in our analysis. If weights are not given (this is the case for about 30,000 observations from the 2002-2005 data) we give a weight of  $w_t=1$  to the observation which is below the mean of 37.7. In all calculations we first aggregate by country/year and then calculate means across years of the same country to get to the country values.

**World Justice Project Data** The website of the World Justice Project describes the construction of the index as follows. *"An effective criminal justice system is a key aspect of the rule of law, as it constitutes the natural mechanism to redress grievances and bring action against individuals for offenses against society. An effective criminal justice system is capable of investigating and adjudicating criminal offences effectively, impartially, and without improper influence, while ensuring that the rights of suspects and victims are protected."*

The index consists of 97 variables combined to form the following seven sub-factors:

criminal investigation system is effective, criminal adjudication system is timely and effective, correctional system is effective in reducing criminal behavior, criminal justice system is impartial, criminal justice system is free of corruption, criminal justice system is free of improper government influence, due process of law and rights of the accused, effective investigations, timely and effective adjudication, effective correctional system, no discrimination, no corruption, no improper government influence, due process of law. We use the aggregate score from 2013.

**Penn World Table Data** We also use data on Penn World Tables 8.0 from 2002 onwards. Particularly we use data on employment and population from the data and merge by country/year to countries in our sample. For survey data in 2014 we use data from the previous year. Details about this data can be found in Appendix B of Inklaar and Timmer (2013).

## B Using Value Added as a Productivity Measure

In our baseline estimates, we calibrate productivity from firm size. We now assess how robust our measures of output loss are to using a value-added measure of productivity computed using information on sales and input cost data from the enterprise surveys. This has the advantage of giving a direct measure of productivity. However, it suffers the usual difficulty with residual-based measures of loading more measurement error into the productivity estimate. There are good reasons to think that number of employees is measured more accurately.

We begin by estimating measure of value-added for firm  $i$ ,  $VA_i$ , as the value of sales minus costs for raw materials and intermediate goods, electricity, generators and fuel. We then compute productivity and adjusted productivity as a function of  $\{l_i, \sigma_i, \mu_i\}$  as:

$$\theta_i = \frac{[1 + \mu_i] VA_i}{\left[\frac{\alpha}{\alpha + \sigma_i}\right]^\alpha l_i^\alpha} \text{ and } \hat{\theta}_i = \frac{VA_i}{l_i^\alpha}$$

As our measure of  $l_i$  we will total labor cost which should pick up both variation in the quantity and quality of labor input. However, our results are essentially the same if we use total employment to measure  $l_i$ .

We use these estimates of productivity and adjusted productivity to construct firm weights  $\theta_i/\Theta$  and  $\hat{\theta}_i/\hat{\Theta}$  to estimate output loss from equation (14). Reinforcing the point

about the importance of measurement error using this method, we do find that there are sometimes very large productivity differences across firms which contain orders of magnitude. We therefore work with calculations which mitigate the influence of outliers on the estimates. We propose the following procedure. First, we exclude firms with negative  $VA_i$  and focus on the sample of countries where there are more than 500 firms included in the survey. Second, we calculate the mean level of productivity using two different methods: (i) excluding outliers that have more than 50 times the mean productivity level, (ii) including all firms. We then calculate the output loss measure as before.

Figure A3 illustrates the measures of output loss using these two different methods. It shows how the treatment of outliers matter for estimating the output loss. Kenya, for example is estimated to have an output loss of almost 20 percent if we do not exclude outliers using the rule that we have specified but only a little over 4 percent if we do. Another example is Ukraine which is estimated to have an output loss below 1 percent when outliers are excluded but is closer to 5 percent if they are included. In Figure A4 we focus on manufacturing and show that this apparent randomness due to outliers is mitigated although it does not disappear completely.

Pulling this together, Figure A5 shows that, if we restrict the comparison to firms in the same sector and remove outliers according to our specified rule, then the estimates of output loss using value added are quite close to the estimates using the firm-size based approach if we drop the same set of firms from both estimates. This is true both whether we look at the overall loss or the way that output loss is ranked across countries; the mean is around two to three percent in both cases and the rank correlation is 0.85. However, we do find that moving away from large, comparable samples the output loss measures look less similar. For example, were we to add countries with more than 300 firms in manufacturing, then the rank correlation of the two measures would fall to 0.68.

## C The Optimal Capital Stock in the Constant Elasticity Model

In this Appendix, we discuss the dependence of the capital stock on the parameters  $\{\varepsilon^i(g), \gamma^i(g)\}$  in the constant elasticity model. We start from the following equation

for the optimal capital stock:

$$k_i = \frac{(1 - \alpha)\eta}{r} A (\theta_i p^i(e_i, g))^{\frac{1}{1-\eta}} \quad (22)$$

which implies that if  $p^i(e_i, g)$  increases capital stock will increase. Looking at comparative statics, we need to allow for  $e_i$  to be endogenous.

Note that in the constant elasticity model we have

$$p^i(e, g) = \begin{cases} \varepsilon^i(g) \times e_i^{\gamma^i(g)} & \text{for } \varepsilon^i(g) \times e_i^{\gamma^i(g)} \leq 1 \\ 1 & \text{otherwise.} \end{cases}.$$

We assume an interior solution for  $e_i$  which implies that if  $\varepsilon^i(g)$  increases then  $p^i(e_i, g)$  increases as long as  $e_i$  does not fall. Using the first order condition for the choice of  $e_i$ :

$$\frac{p_e^i(e_i, g)}{p_i(e_i, g)} = \frac{\eta\alpha}{l_i - e_i} = \frac{\gamma^i}{e_i}$$

which implies that  $e_i$  does not change with  $\varepsilon^i(g)$  for fixed  $l_i$  and that  $k_i$  is increasing in  $\varepsilon^i(g)$ .

The first order condition for firm's optimal labor supply is given by

$$\theta_i \frac{\alpha\eta}{w} p^i(e_i, g) \left[ (l_i - e_i)^\alpha k_i^{(1-\alpha)} \right]^\eta = l_i - e_i. \quad (23)$$

Substituting in (22) and using the constant elasticity formula for  $p^i(e_i, g)$ , substituting in  $l_i - e_i$  from (23) and collecting terms we obtain:

$$\gamma^i(g) = e_i^{\frac{1-\eta-\gamma^i(g)}{1-\eta}} C_i$$

where  $C_i$  is a constant at the firm level. This implies that  $e_i$  is increasing in  $\gamma^i$  as long as  $\gamma^i + \eta < 1$ . Since  $p_i(e_i, g)$  is an increasing function of  $e_i$ , we can conclude that the optimal capital stock  $k_i$  is increasing in  $\gamma^i(g)$ .

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Table 1: Summary Statistics on the Firm Level

	Obs.	Mean	SD	Min	Max
percentage of total annual sales paid for security	142135	0.018	0.051	0	0.991
loss due to theft, robbery, vandalism or arson as a percentage of total annual sale	142135	0.010	0.045	0	0.990
firm size (number of workers)	142135	83.676	408.201	1	65994
firm reports paying for security	142135	0.608	0.488	0	1
firm reports a loss	142135	0.252	0.434	0	1
number of firms interviewed in country	142135	1229.591	1163.574	59	9183
crime is worst obstacle	95082	0.044	0.205	0	1

Table 2: Simple Output Loss Calculations

Estimate	alpha	Mean Share	SD
share of workers employed in protection	alpha = 0.9	0.018	0.041
	alpha = 0.66	0.023	0.051
	alpha = 0.5	0.029	0.062
output loss (tau=0)	alpha = 0.9	0.024	0.051
	alpha = 0.66	0.024	0.050
	alpha = 0.5	0.024	0.049
output loss (tau=1)	alpha = 0.66	0.016	0.036

Table 3: Protection and Crime as an Obstacle

VARIABLES	(1) degree to which crime is an obstacle (0-4)	(2) crime is worst obstacle	(3) perceived protection	(4) protection effort elasticity
perceived protection	-0.136*** (0.0104)	-0.0132*** (0.00294)		
protection effort elasticity	-0.0335*** (0.0112)	-0.00715*** (0.00264)		
foreign owned firm			0.0135 (0.0132)	0.0267** (0.0112)
state owned firm			-0.0348 (0.0213)	0.0480*** (0.0159)
firm in capital			0.00578** (0.00245)	-0.00582** (0.00237)
firm productivity decile dummies	yes	yes	yes	yes
country/year fixed effects	yes	yes	yes	yes
sector fixed effect	yes	yes	yes	yes
Observations	139,032	95,070	110,901	110,901
R-squared	0.248	0.088	0.100	0.099

Robust standard errors in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . All estimates assume  $\alpha = 0.66$ . "perceived protection" is the estimate of the epsilon parameter. "protection effort elasticity" is the estimate of the gamma parameter. Both variables are weighted by their standard error.

Table 4: Policy Experiment - Adoption of Chinese Protection Parameters

country	estimated change in output	country	estimated change in output
Eritrea	-2.7%	Turkey	0.3%
Iraq	-2.3%	Serbia	0.3%
Guinea-Bissau	-2.0%	Germany	0.3%
Nepal	-1.6%	Zimbabwe	0.3%
Israel	-1.5%	Madagascar	0.4%
Sweden	-1.4%	Mongolia	0.4%
Slovenia	-1.3%	South Africa	0.4%
Benin	-1.3%	Macedonia, FYR	0.5%
Ireland	-1.3%	Malaysia	0.5%
Latvia	-1.2%	Swaziland	0.5%
Jordan	-1.2%	Sri Lanka	0.6%
Lebanon	-1.2%	Tanzania	0.6%
Myanmar	-1.2%	Kazakhstan	0.7%
Lithuania	-1.1%	El Salvador	0.7%
Uruguay	-1.1%	Senegal	0.7%
Tunisia	-1.1%	Moldova	0.7%
South Korea	-1.0%	Ukraine	0.8%
Jamaica	-0.9%	Brazil	0.8%
Morocco	-0.9%	Portugal	0.9%
Trinidad and Tobago	-0.8%	Azerbaijan	0.9%
Slovakia	-0.8%	Nigeria	0.9%
Burundi	-0.8%	North Sudan	1.0%
Greece	-0.8%	Nicaragua	1.0%
Yemen, Rep.	-0.7%	Namibia	1.0%
Uzbekistan	-0.7%	Rwanda	1.1%
Costa Rica	-0.7%	Dominican Republic	1.1%
Croatia	-0.6%	Guinea	1.1%
Colombia	-0.6%	Botswana	1.1%
Niger	-0.6%	Uganda	1.2%
Lao PDR	-0.5%	Tajikistan	1.2%
Bosnia and Herzegovina	-0.5%	Paraguay	1.2%
Bolivia	-0.5%	Russia	1.3%
Belarus	-0.5%	Kyrgyzstan	1.3%
Hungary	-0.4%	Mozambique	1.3%
Mauritania	-0.4%	Venezuela	1.4%
Bulgaria	-0.4%	Mauritius	1.4%
Spain	-0.3%	Guatemala	1.5%
Vietnam	-0.3%	Kenya	1.6%
Poland	-0.3%	South Sudan	1.8%
Gabon	-0.3%	Ecuador	1.8%
Indonesia	-0.2%	Philippines	1.9%
Bangladesh	-0.2%	Chad	1.9%
Thailand	-0.2%	Kosovo	2.0%
Togo	-0.1%	Cote d'Ivoire	2.1%
Mali	-0.1%	Timor-Leste	2.2%
Czech Republic	0.0%	Congo, Rep.	2.2%
Albania	0.0%	Liberia	2.4%
Ethiopia	0.0%	Cameroon	2.7%
Peru	0.0%	Mexico	2.9%
Armenia	0.1%	Congo, Dem. Rep.	2.9%
India	0.1%	Gambia, The	3.0%
Panama	0.1%	Angola	3.2%
Argentina	0.1%	Burkina Faso	3.3%
Georgia	0.1%	Honduras	3.5%
China	0.1%	Afghanistan	3.6%
Chile	0.1%	Zambia	3.8%
Estonia	0.1%	Cambodia	4.0%
Guyana	0.2%	Sierra Leone	6.6%
Pakistan	0.3%	Malawi	8.9%
Romania	0.3%	Central African Republic	10.4%
Ghana	0.3%	Lesotho	13.1%

Note: Change in output is calculated by replacing the mean gamma and protection elasticity estimate in each firm productivity percentile of each country with the means in the respective percentile in China. We drop countries and territories with less than 1 million inhabitants and less than 100 interviewed firms.

Table 5: Crime and Firm Growth

VARIABLES	(1) firm purchased asset	(2) firm purchased fixed asset	(3) ln(fixed asset expenditure)
perceived protection	0.0160*** (0.00403)	0.00633* (0.00378)	0.0950*** (0.0333)
protection effort elasticity	0.0344*** (0.00429)	0.00617 (0.00383)	0.163*** (0.0305)
firm productivity decile dummies	yes	yes	yes
country/year fixed effects	yes	yes	yes
sector fixed effect	yes	yes	yes
Observations	121,802	72,941	55,467
R-squared	0.244	0.397	0.751

Robust standard errors in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . All estimates assume  $\alpha = 0.66$ . "perceived protection" is the estimate of the epsilon parameter. "protection effort elasticity" is the estimate of the gamma parameter. Both variables are weighted by their standard error.

Table 6: Estimated Output Loss and Employment Loss by Sector

*Panel A: countries least affected by crime*

sector	losses due to predation	spending on security	average output loss	average employment loss
Primary	0.18%	0.71%	0.52%	0.76%
Manufacturing	0.20%	0.66%	0.67%	1.51%
Services	0.31%	0.64%	0.75%	1.77%
Construction	0.37%	0.73%	0.60%	2.18%

*Panel B: countries most affected by crime*

sector	losses due to predation	spending on security	average output loss	average employment loss
Primary	3.78%	4.06%	6.41%	9.96%
Manufacturing	2.04%	3.19%	5.11%	11.75%
Services	1.78%	3.30%	5.52%	13.46%
Construction	2.22%	4.52%	6.87%	26.45%

Note: "Losses due to predation" and "spending on security" are relative to sales. Other numbers are relative to output and employment in that sector respectively. "Countries least affected by crime" are countries in the quartile with the lowest estimated output loss. "Countries most affected by crime are countries" in the quartile with the highest estimated output loss. Calculations assume  $\alpha=0.322$  for the primary sector,  $\alpha=0.551$  for manufacturing,  $\alpha=0.575$  for services and  $\alpha=0.724$  for construction.

Table 7: Covariance Between Firm Size and Productivity

VARIABLES	(1) covariance (size, output per worker)	(2) covariance (size, output per worker)	(3) covariance (size, firm productivity)	(4) covariance (size, firm productivity)	(5) ln(firm size)
estimated output loss in sector	-0.204*** (0.0639)	-0.377*** (0.0580)	-1.905*** (0.573)	-2.269*** (0.737)	
loss due to theft, robbery, vandalism or arson as a percentage of total annual sale					-0.760*** (0.177)
percentage of total annual sales paid for security					0.447*** (0.161)
country/year/sector fixed effects	no	no	no	no	yes
country/year fixed effect	no	yes	no	yes	no
sector fixed effects	no	yes	no	yes	no
Observations	774	774	774	774	141,093
R-squared	0.117	0.614	0.016	0.665	0.232

Robust standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. "covariance (size, firm productivity)" is the covariance between log firm size and estimated log relative theta at the sector level. "covariance (size, output per worker)" is the covariance between log firm size and -log of spending on protection plus the sector labor share ( $\gamma + \alpha$ ).

Table A1: Estimated Output Loss and Homocide Rate

VARIABLES	(1) estimated output loss	(2) estimated output loss	(3) estimated output loss
homocide rate (per 100,000 population)	31.38** (14.93)	130.9** (53.74)	135.8*** (48.56)
country fixed effects	no	yes	yes
Observations	167	167	256
R-squared	0.057	0.103	0.079
Number of countryid		86	125

Robust standard errors in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

"estimated output loss" is under the assumption of heterogeneous firms.

Column (3) expands the data on the homocide rate 3 years in the future and past to gain more matches to the enterprise survey data.

Figure 1: Country Averages of Predation Loss and Security Spending

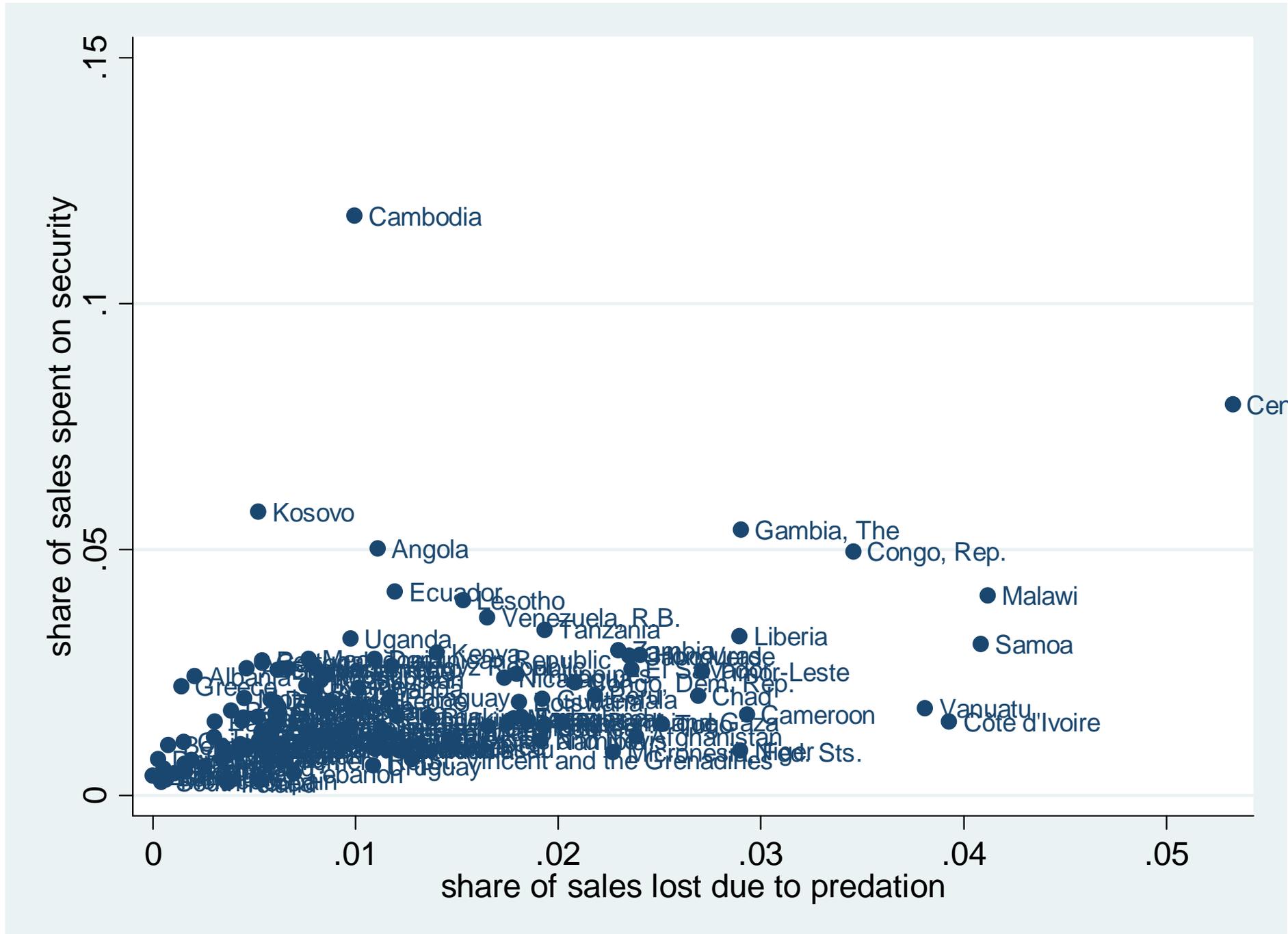


Figure 2: Estimated Output Loss and Share due to Spending on Security

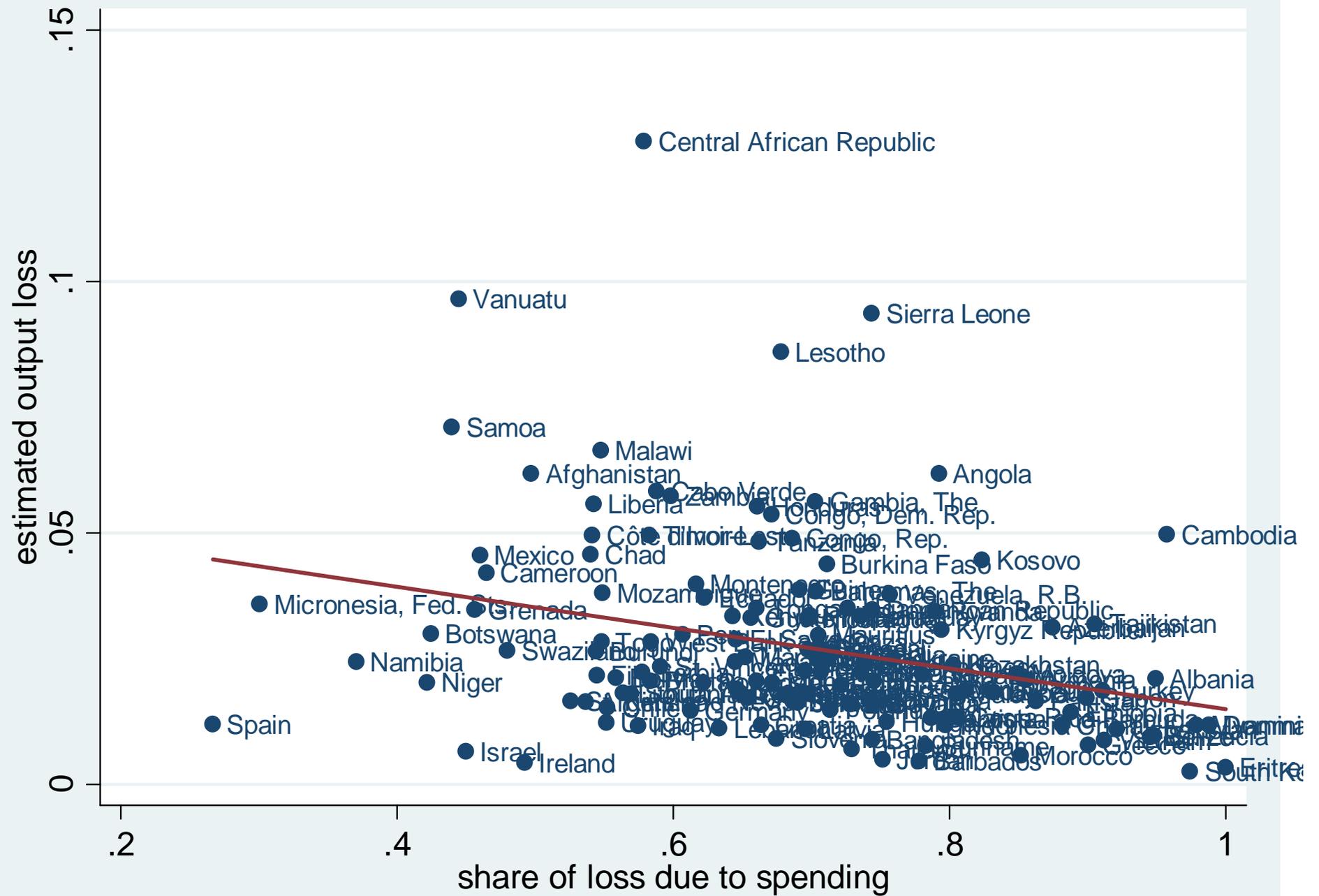


Figure 3: Estimated Loss by Firm Productivity Deciles

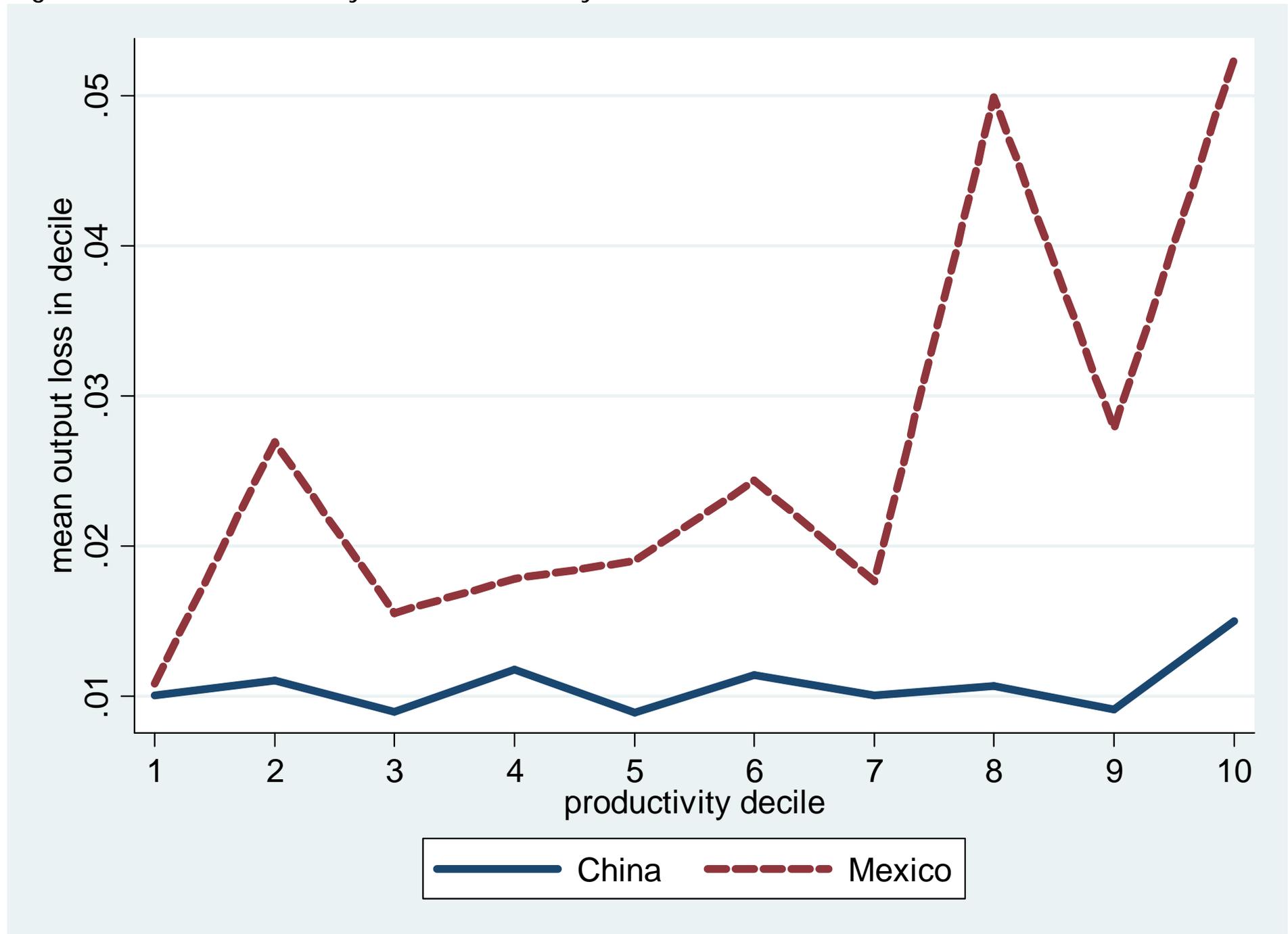


Figure 4: Introducing Productivity Weights

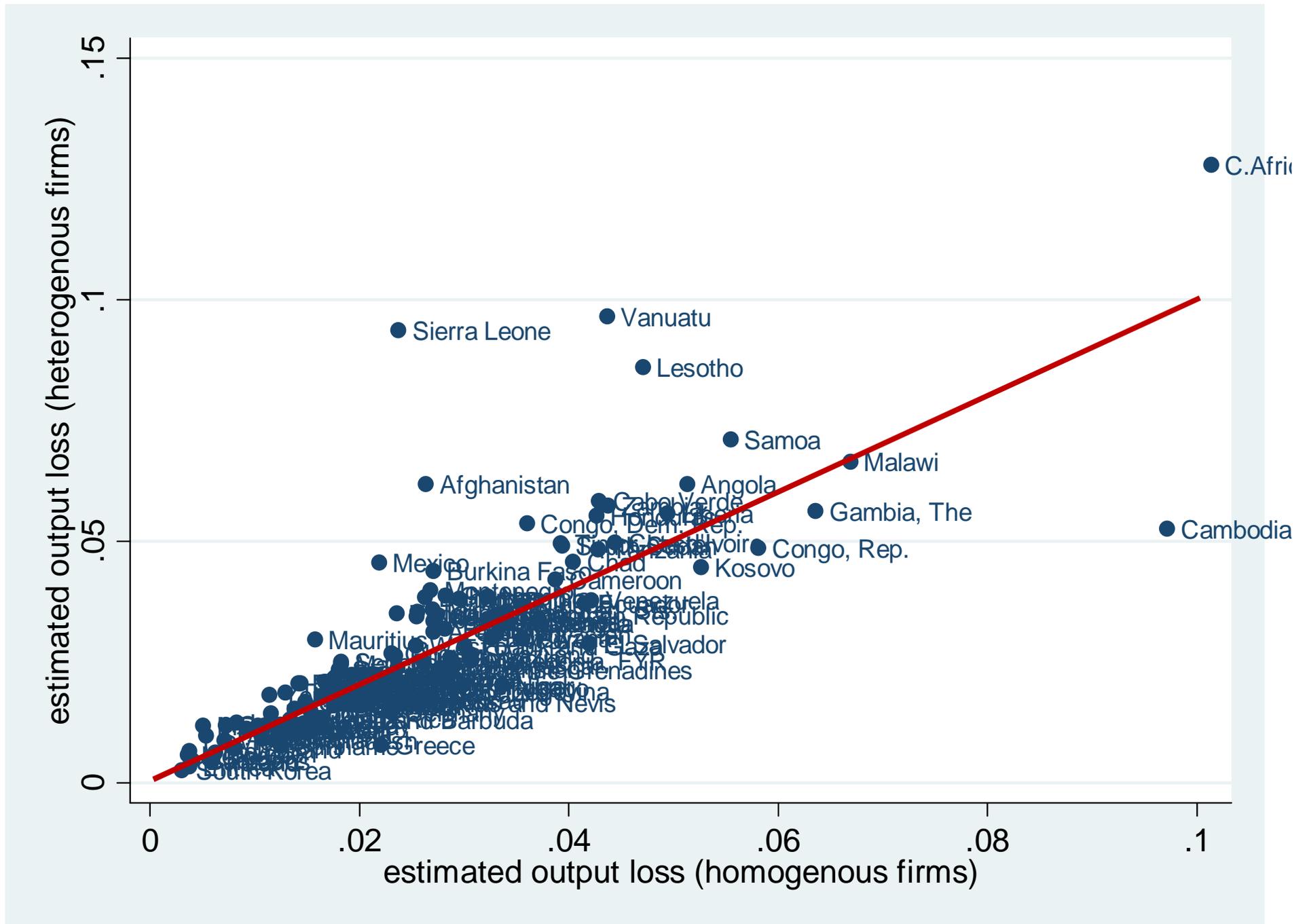
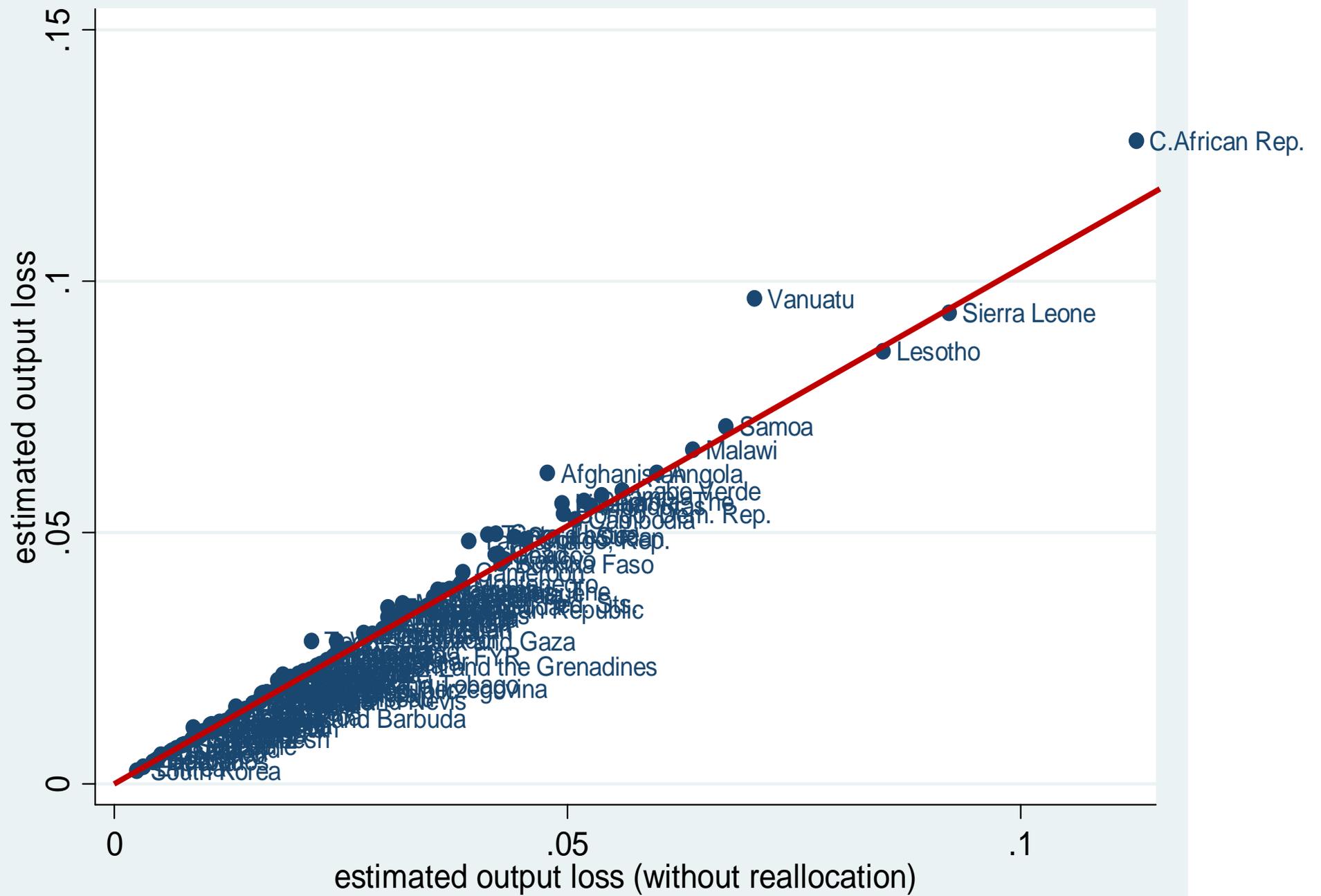
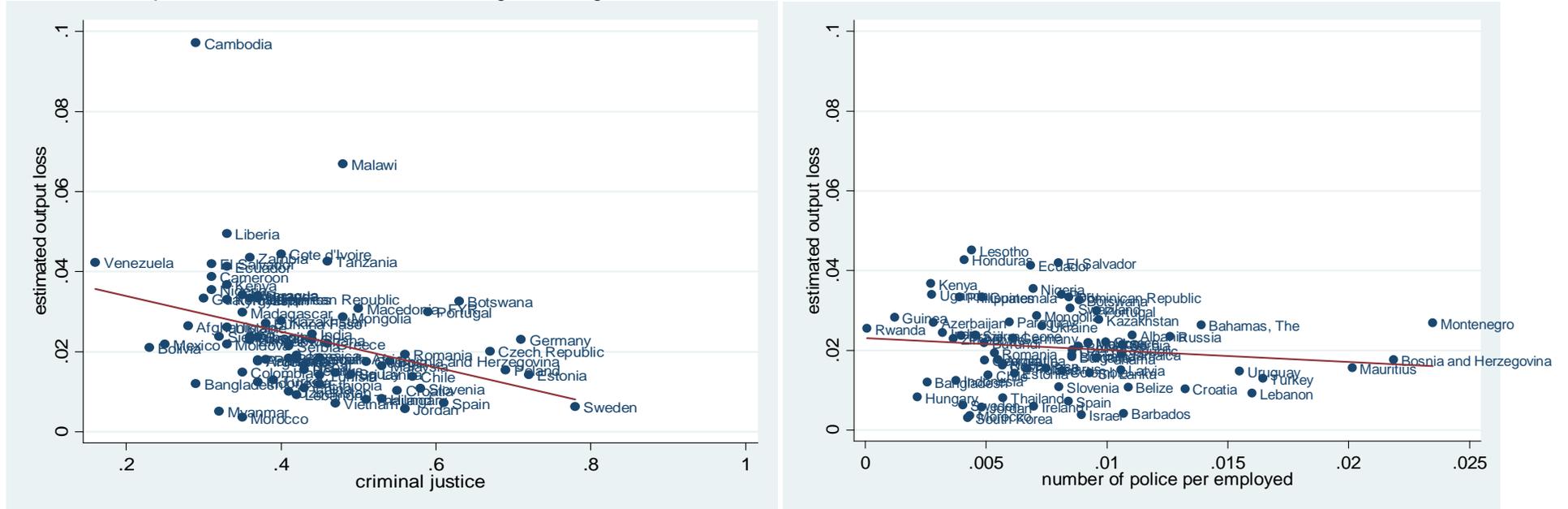


Figure 5: Re-Allocation Effect



# Figure 6: Estimated Output Loss and State Action

Panel A: Output Loss Estimated Assuming Homogenous Firms



Panel B: Output Loss Estimated Assuming Heterogenous Firms

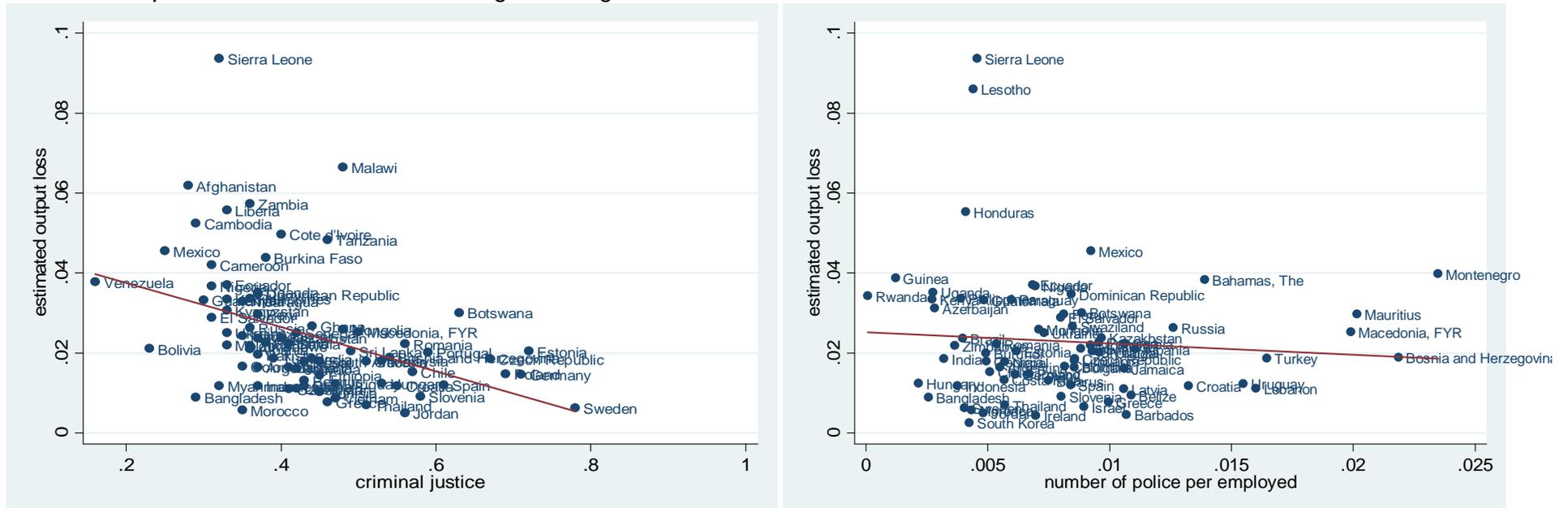


Figure 7: Protection Estimates by Firm Productivity

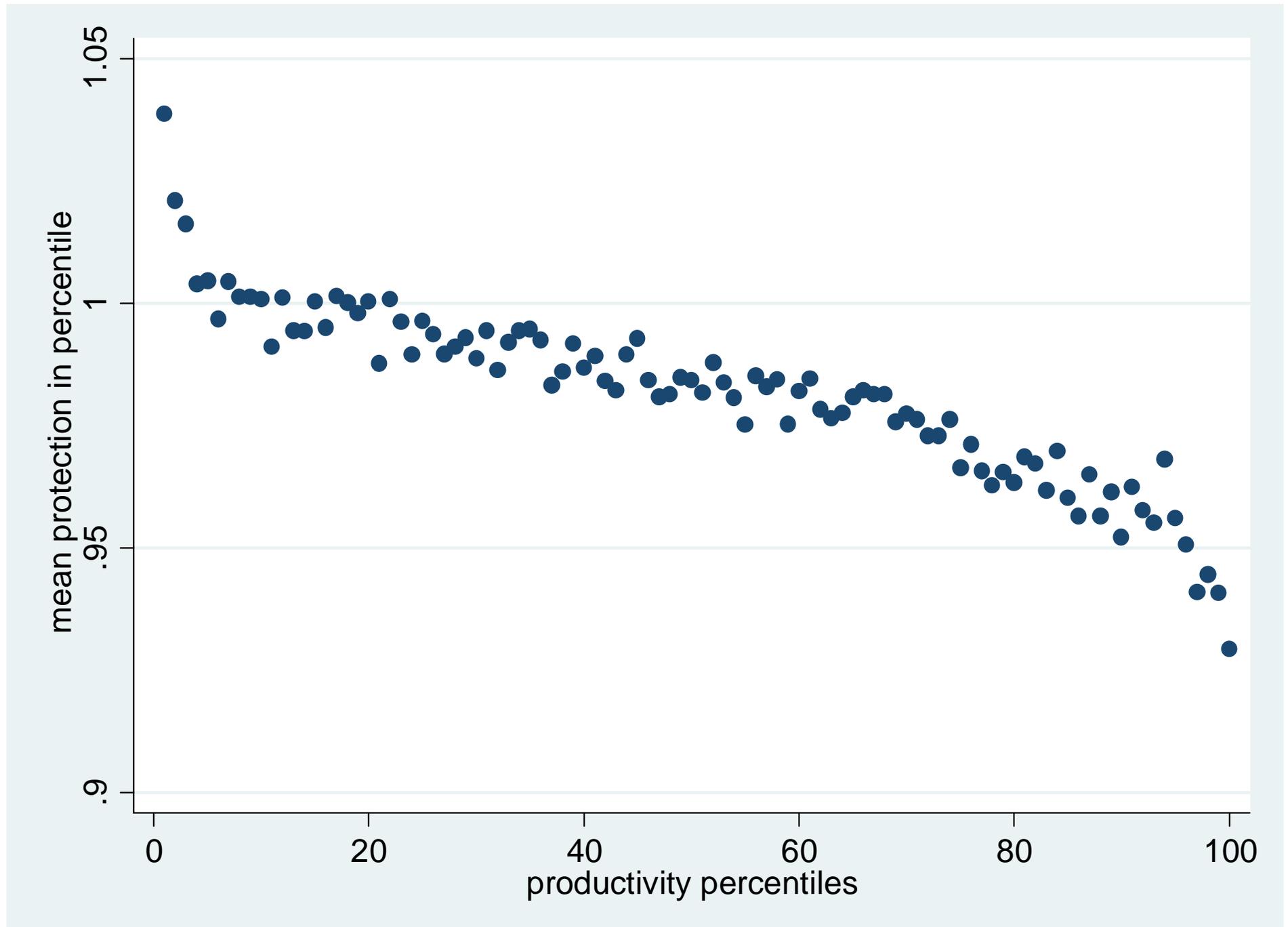


Figure 8: Protection Estimates by Firm Productivity Deciles

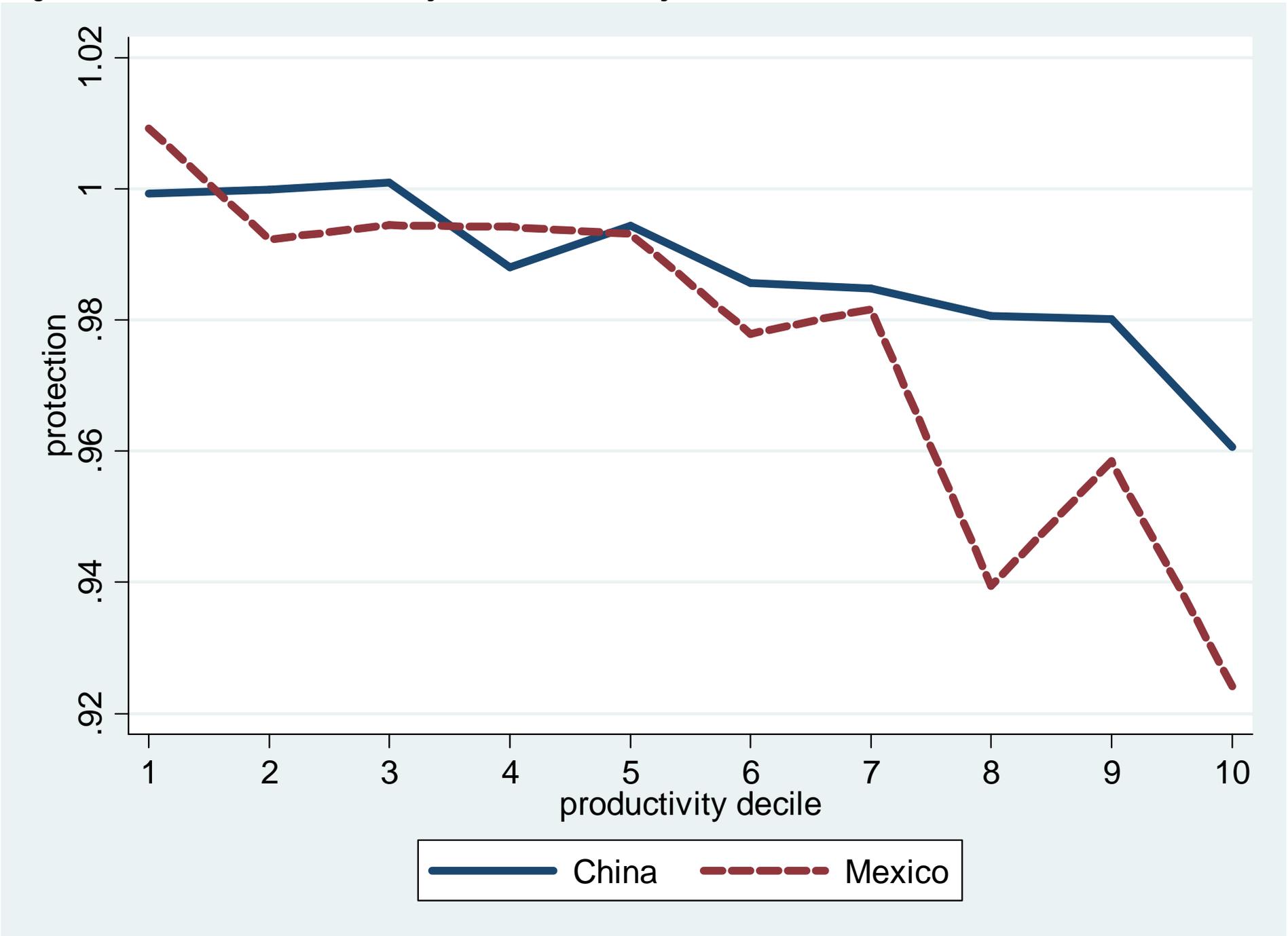


Figure A1: Predation Loss and Spending on Security Across Firm Size

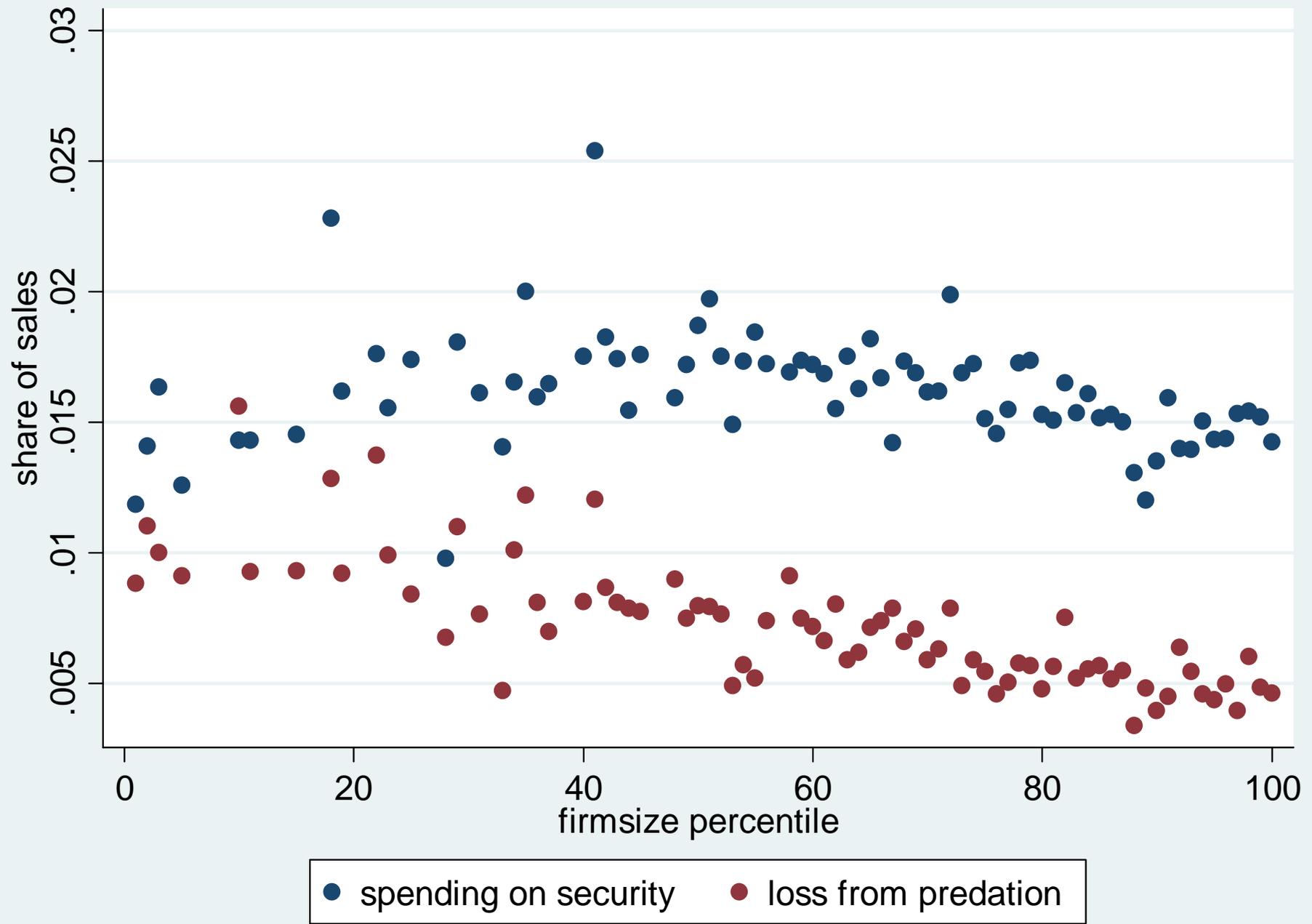




Figure A3: Non-Robustness to Dropping Outliers (all sectors)

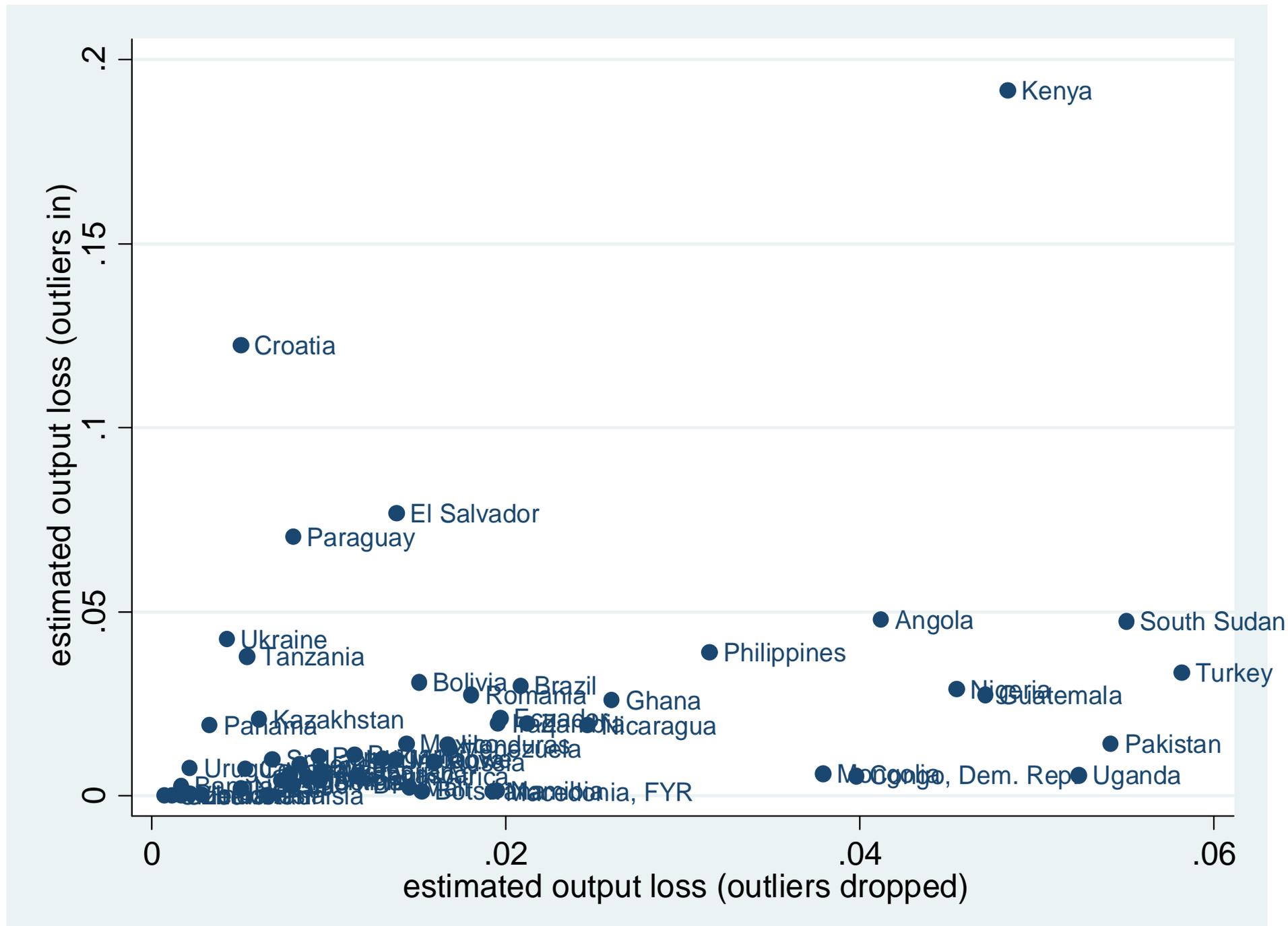


Figure A4: Non-Robustness to Dropping Outliers (manufacturing)

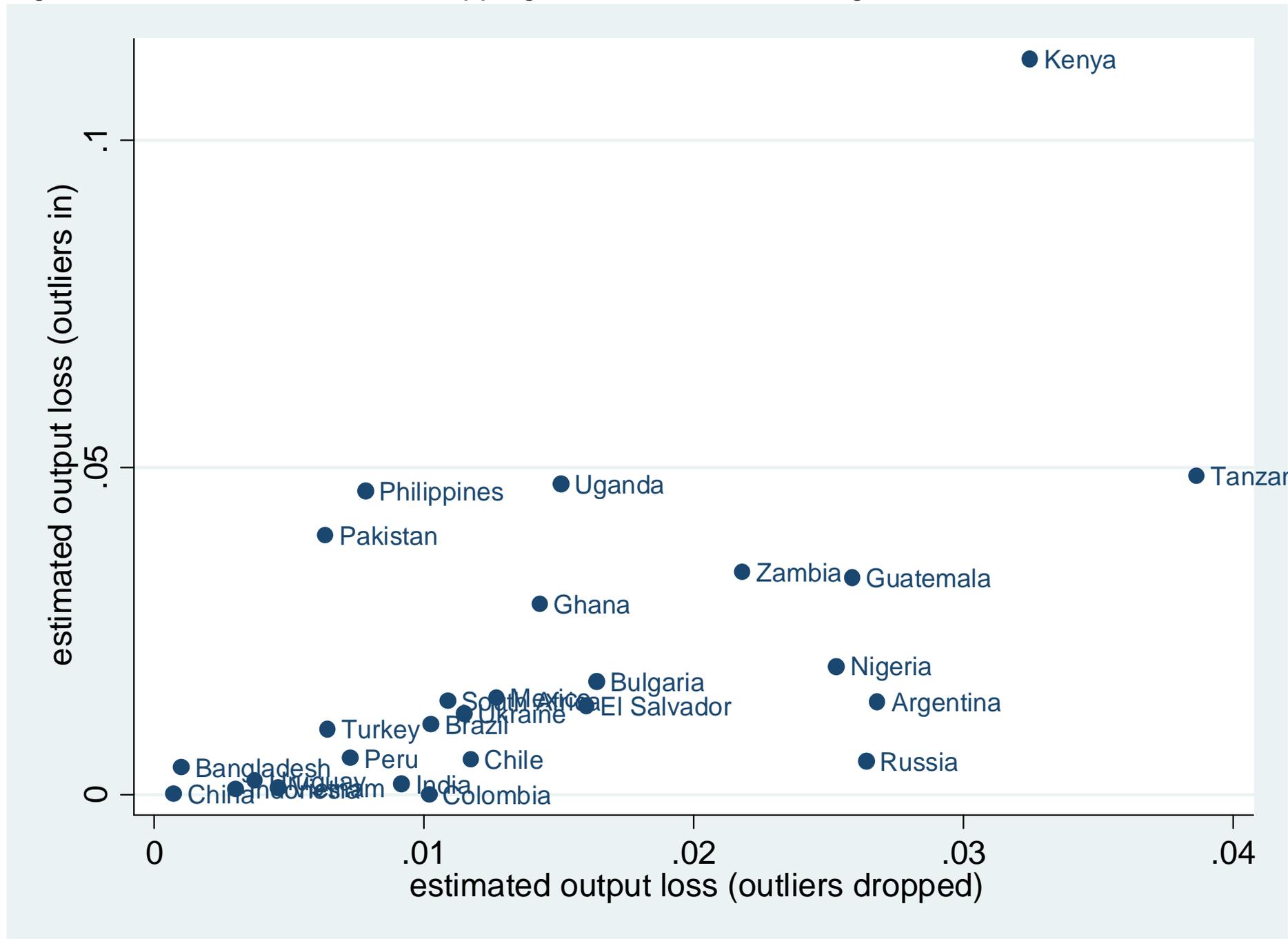


Figure A5: Comparison of Output Loss Estimates in Manufacturing

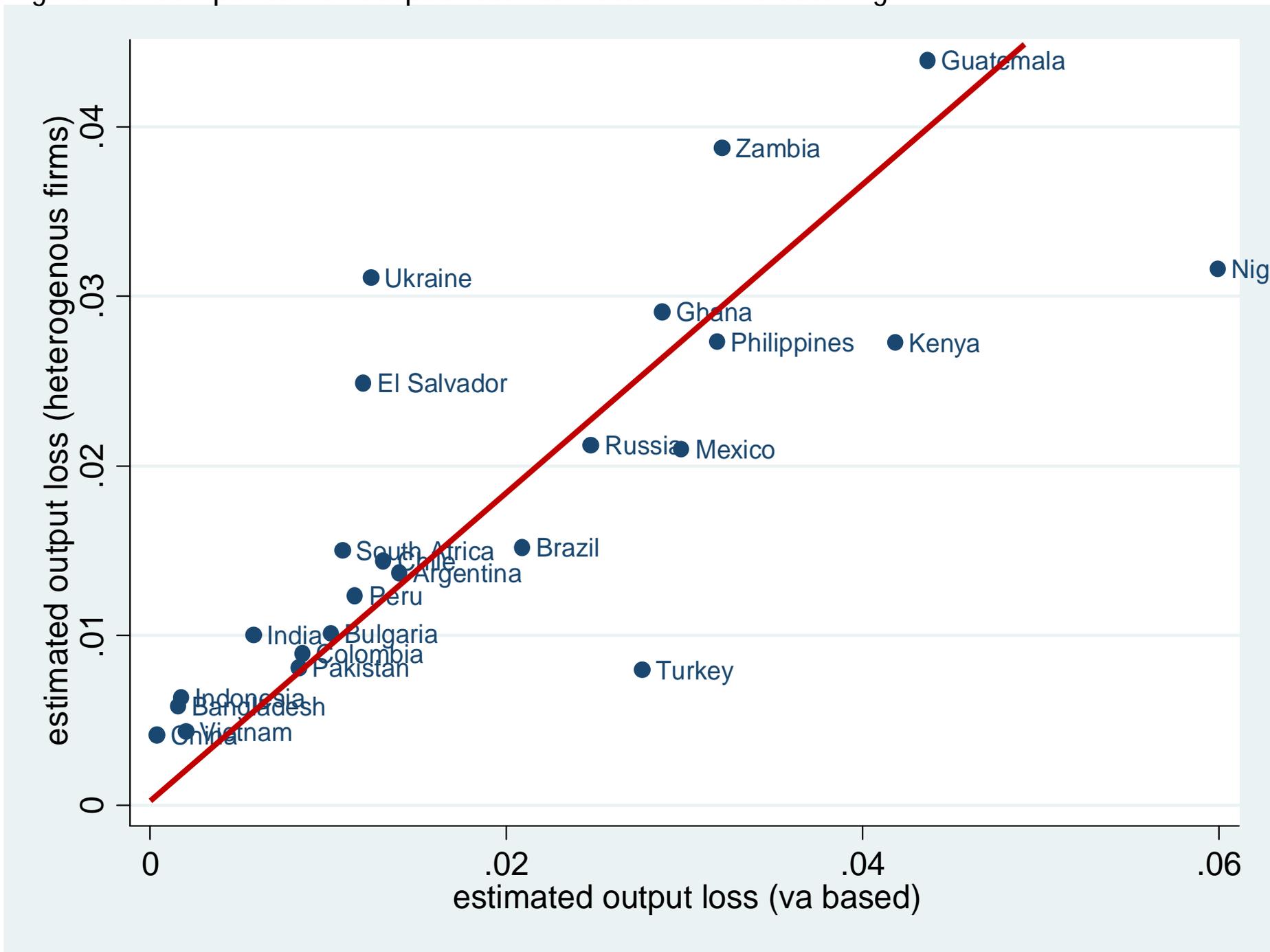


Figure A6: Output Loss by Sector

