Predation, protection, and productivity: a firm-level perspective

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

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Abstract

This paper studies the consequences of predation when firms deploy guard labor as a means of protecting themselves. We build a simple model and combine it with data for 144 countries from the World Bank enterprise surveys which ask about firm-level experiences with predation and spending on protection. We use the model to estimate the output loss caused by the misallocation of labor across firms and from production to protection. The loss due to protection effort is substantial and patterns of state protection at the micro level can have a profound impact on aggregate output losses. Various extensions are discussed.

1 Introduction

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

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between cross-country differences in summary measures of private and state predation and income differences.[1] These capture a wide variety of effects and are therefore difficult to link back to specific underlying mechanisms and distortions in resource allocation that result.

This paper takes a bottom-up picture to the misallocation of labour due to weak law and order taking a firm level perspective. We emphasize the importance of heterogeneous predation threats in different firms and how these distort labor allocation between firms. In addition to output losses from predation, we also estimate the cost of predation in terms of the labor used for the protection of output. These distortions are highly relevant even in developed countries. Protective service labor grew by about 2.4 percentage points of total hours worked in Europe between 1993 and 2010, for example. 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. The model developed here provides a way to think about the welfare loss imposed by allocating labor to improving security ends when it could have been used productively. A key insight is that the threat of predation can lead to a welfare loss even if there is no actual predation.

We make use of direct measures of distortion measures from the World Bank Enterprise surveys.[2] These can be used to create a quantitative assessment of the output loss due to factor misallocation directly. To do this we propose a theoretical framework where firms allocate labor to productive activity or predation. It provides a link between a firm-specific predation threat and a firm's response in terms of a lower level of total factor productivity which is greater among firms where predation is a bigger problem. The advantage of having firm level data on both dimensions, predation and protection, is that we do not need to make any assumptions regarding the details of the endogenous relationship between these two factors. The model and data can be used to generate an expression for the aggregate output loss which depends on the joint distribution of predation, protection and firm level productivity.

In line with the recent literature on resource misallocation (Restuccia and Rogerson,

[1] See, for example, Hall and Jones (1999), Acemoglu, Johnson and Robinson (2001) and Djankov et al (2002).

[2] These surveys are used to look at international productivity differences in Bartelsman et al (2013).

2008, and Hseih and Klenow, 2009), the framework also allows us to consider what would happen to output if predation were lower. For this purpose, we take a low predation country, South Korea, as the main benchmark. In this counter-factual, labor gets re-allocated from protection to production and from firms that are least affected by crime to those who are most affected by crime. Firm heterogeneity is important; the aggregate output loss is particularly large when productive firms are vulnerable to crime. Moreover, labor misallocated to protection due to the threat of predation generates an output loss even if predatory activities are a pure transfer.[3]

The paper offers an empirical estimate of how predation losses, compared to a benchmark, vary across countries, illustrating the importance of firm-level heterogeneity. For some countries, these losses are around 10 percent of output. Moreover, we estimate that around two thirds of these losses come from reallocating labor to protection rather than using it productively.

One finding which comes from looking at firm-level heterogeneity is that, on the whole, larger firms appear to be more susceptible to predation. That said, countries vary in the extent to which this is true. We develop a specific parametric version of the model which allows us to run a thought experiment in which we consider how much output different countries would gain or lose from adopting a Chinese pattern of protection by firm size. We estimate that output in Mexico, for example, would increase by about 3.5 percent if this happened. Moreover, we show that low private costs of crime do not seem to be primarily achieved through substituting private protection for public protection. Instead, we find a strong and robust negative correlation between the overall loss and measures of the effectiveness of the criminal justice system.

We extend the model to allow for sectoral heterogeneity in the production technology using data based on US labor shares. This reveals an interesting pattern of sectoral differences in output losses. The model can be used to look at 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 more predation.

[3]This idea goes back to Tullock (1967, 1971) who discusses theft as an example.

The analysis is also extended to consider the impact of predation on investment decisions by firms. We find that it has a negative effect on investment while protection enhances investment. This allows us to speculate on a wider range of effects which could further create an output cost from weak law and order. We also model the reaction of managerial effort to predation which can affect firm-level productivity and find that the output loss estimates increase substantially from around 2.6 percent on average in a country to 5.2 percent.

The symptoms of lawlessness and disorder that we study here are specific. However, they provide a different way of engaging in debates about the value of state effectiveness by building a "bottom up" picture based on micro-foundations and micro-data. The World Bank enterprise surveys are the only firm-level data that we are aware of which have a wide coverage of countries, including those in the developing world and have not previously been used to look at these issues. But it is also important to acknowledge that a bottom-up exercise also has its limitations; a firm-level perspective is not able to engage in wider debates about a whole range of macro-factors which influence productivity across countries and could be equally, if not more important. Thus, what we are offering is only one piece of a bigger picture based on a direct measure of an important distortion. However, there is also value in specificity because we can isolate a specific channel rather than trying to look at state effectiveness at large where the specific role of any given channel is hard to discern.[4] Hence, we view the top-down and bottom-up approaches as ultimately complementary lines of work in trying to engage in debates in why poorly functioning states can have adverse economic consequences.

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 a benchmark case 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,

[4]Section H in the on-line appendix follows Bartelsman et al (2013) to show how the covariance between different productivity measures and firm size is affected by predation. The fact that we can measure distortions directly means that we can also assess the extent of productivity rank reversals as discussed by Hopenhayn (2014).

we look at how adding measures of public protection affects things and calibrate a constant elasticity model for the protection technology to look at patterns of protection across firms and countries. Section eight presents some additional analysis on firm investment, sector-specific technologies, allowing for a labor reallocation effect across sectors and endogenous managerial effort. Section nine concludes.

2 Related Literature

There is a growing literature on the quantitative implications of resource misallocation beginning with Restuccia and Rogerson (2008) and Hseih and Klenow (2009).[5] This has lead to a debate about what it would take for distortions in factor and product markets to have large effects – see, for example, Hopenhayn (2014). This paper has two novel features compared to existing contributions First, we consider the consequences of private actions to limit distortions. Second, we have a direct measure of a particular distortion since the data provides reports of losses by firms as well as the share of sales spent on protection.

There is a large related literature which calculates the cost of crime.[6] 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.[7] Other approaches include individual valuations of counterfactuals, 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 welfare gains from crime reductions. And property prices are used to assess the cost of crime in London by Gibbons (2004). Compared to this literature, the approach in this paper has more of a focus on macro-economic implications and equilibrium effects of crime distortions. Similar to us, Soares (2009) also develops a simple model with both public and private security spending to

[5] 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).

[6] For an overview see Soares (2009).

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

organize existing measurement exercises. However, we focus on firm behavior and are able to link the model directly to observables in enterprise survey data.

The role of private spending in driving up the welfare costs is an old theme in the crime literature starting with Tullock (1967) and Becker (1968).[8] Benson and Mast (2001), for example, discuss how spending on protection can be quantified in assessing the costs of crime. Besley, Fetzer and Mueller (2015) exploit shipping prices in the spot market for bulk shipping to calculate the welfare cost of Somali piracy. The latter show that costs incurred by the shipping industry were greatly in excess of the revenues that pirates extracted through ransoms which is, in part, due to spending on armed security guards.

This paper follows in the footsteps of contributions which have emphasized labor misallocation through employing guard labor. Jayadev and Bowles (2006) look at aggregate evidence,[9] while Field (2007) uses Peruvian data to show that families with weak property rights remain at home to guard their property. The main contribution of this paper is to widen the scope of these ideas to a range of country experiences using micro-data to gain an insight in the macro-economic picture.

Finally, the paper is also related to the large literature, reviewed in Besley and Ghatak (2009), on the economic consequences of imperfect property rights protection. This literature has looked at both macro- and micro- evidence; however, there is little work joining the two together as we do here. Taking a macro-economic perspective, Acemoglu et al (2001) and Hall and Jones (1999) argue that large differences in income per capita can be explained by differences in institutions which affect expropriation risk. The micro-economic literature instead has explored the implications of property rights insecurity on productivity and investment.[10]

[8] 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)

[9] They find much higher numbers for guard labor than in our data. However, their definition includes police and prison guards, supervisors in firms, the unemployed and military personal.

[10] See, for example, Besley (1995) and Goldstein and Udry (2008).

3 Data

Our data comes from the World Bank enterprise surveys which are plant-level surveys of a representative sample of an economy's formal private sector – agriculture, small informal firms and pure government-owned businesses are excluded. They cover a range of topics measuring the business climate 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 155,000 companies in 144 economies.[11] The data is made available both at the plant level and at different levels of aggregation. Further details on the data and the collection methods can be found in Appendix A.

We focus on answers to two specific survey 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 155,000 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 weighted averages using the survey weights provided by the World Bank. These numbers reveal that the average expenditure by a firm was 1.7 percent of sales for security (protection) and the loss in sales was around 0.8 percent due to theft, robbery, vandalism (predation).[12] The share of firms that report paying for security is at 62 percent and is more than double the 20 percent reporting a loss. This makes intuitive sense. Not every firm that 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

[11] We discuss our modifications to the raw data in appendix A.

[12] In appendix Figure A1 we show that, on average, spending on protection is relatively constant across firm size whereas predation losses increases slightly with firm size.

firm size in our sample is about 120 workers which varies between 1 worker and just under 66,000. Table 1 also reports the sample size by country where the average is over 2400 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 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 return to these issues in section 6 and discuss value added measures in Appendix C.

More generally, there is a trade-off involved in using the World Bank enterprise surveys. They are not as carefully collected as some country's manufacturing surveys. However, they cover a wide range of sectors and unusually give information about some specific distortions such as what we are examining here. The fact that they cover a wide range of countries also widens the experience that we study. We are also comfortable in the belief that employment which we use in our main calculations is reasonably well measured.

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, θ_i, indexed by

$i = 1, .., N$ where π_i denotes the proportion of firms type i in the population of all firms.[13] 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 type of plant 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 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. Our formulation of the protection technology allows for firm-level heterogeneity. 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 θ_i. We will rely on the data to tell us about this.

The arbitrary function $p^i(e_i, g)$ allows for several interesting features in the data. For example, our model could easily incorporate the possibility of spillovers between firms, e.g. where

$$p^i(e_i, g) = p^i(e_i, g, \bar{e}_i)$$

and $\bar{e}_i$ is a vector of protection effort by other relevant firms in the same location or sector. Our model also allows both e_i and $p^i(e_i, g)$ to be endogenous to factors which we cannot measure. In fact, it can be shown that, even controlling for location, sector and year of the survey, firms with high e_i are also firms which have low values of $p^i(e_i, g)$. Under the assumption that θ_i does not change without predation this is not a concern for our identification strategy as we measure both e_i and $p^i(e_i, g)$ directly. In section (6) we discuss

[13] We use π_i to capture the survey weights in the empirical implementation.

the effect on our results if this assumption is violated.

The fraction $1 - p^i(e_i, g)$ 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 τ to see how much this parameter matters to the conclusions that we reach.[14]

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

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

The production function is a standard constant elasticity formulation with $\alpha < 1$ being the labor share. Hence, this is basically, a "span-of-control" model in the spirit of Lucas (1977). Here, we assume a common production technology, i.e. α 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 α 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 (1) 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 where the consequences of the distortion is felt 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

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

[14] 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.

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:

$$p^i(e_i, g)\,\alpha\theta_i\,[l_i - e_i]^{\alpha-1} = w \tag{2}$$

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

$$\frac{p^i_e(e_i, g)}{p^i(e_i, g)} = \frac{\alpha}{l_i - e_i}. \tag{3}$$

Our analysis of the cost of predation will use this model to construct a counter-factual with lower predation. Without predation we would have $p^i(e_i, g) = 1$ and $e_i = 0$ for all i.

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 otherwise. We are therefore studying the marginal effect of our measured distortions assuming that any others remain in place, i.e. these are contained in θ_i. We regard this a conservative approach which prevents us from attributing other factors of firm productivity to predation. Some alternatives are discussed in section 8.

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 allocation effects of the labor market equilibrium and use this 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

$$\begin{aligned}\sigma_i &= \frac{we_i}{p^i(e_i, g)\,\theta_i\,[l_i - e_i]^{\alpha}} \\ &= \alpha\frac{e_i/l_i}{1 - e_i/l_i}\end{aligned} \tag{4}$$

after using (2). 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 the labor misallocation directly to the share of sales variable from the data after we plug in an assumed value for α. We choose $\alpha = 0.66$ as our core case below, i.e. a two thirds labor share. In the extensions we

relax this assumption.

Predation Losses 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 μ_i and $p^i(e_i, g) = 1/[1 + \mu_i]$. Note, however, that given our assumptions on τ the welfare loss due to predation is given by $\tau + (1 - \tau)/1 + \mu_i$ which implies that if $\tau = 1$ there is no welfare loss from predation itself since all predation is a transfer.

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:

$$l_i = \left(\frac{\hat{\theta}_i \alpha}{w}\right)^{\frac{1}{1-\alpha}} \tag{5}$$

where

$$\hat{\theta}_i = \theta_i \frac{1}{(1 + \mu_i)} \left(\frac{\alpha + \sigma_i}{\alpha}\right)^{1-\alpha} \tag{6}$$

can be thought of as "adjusted" firm-level productivity as a function of our two observables $\{\mu_i, \sigma_i\}$.[15] Equation (5) states that firms hire more laborers if they are intrinsically more productive (higher θ_i), experience smaller predation losses (lower μ_i) and allocate more labor to protection spending (higher σ_i).

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:

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

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

[15] Note that with $\mu_i = \sigma_i = 0$ we have $\hat{\theta}_i = \theta_i$.

sector as a whole.[16] The share of total employment in firm i can then be written as:

$$\frac{l_i}{L} = \left(\frac{\hat{\theta}_i}{\hat{\Theta}}\right)^{\frac{1}{1-\alpha}}. \tag{7}$$

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 firm productivity if the predation threat were removed, θ_i which we will refer to as "undistorted" productivity. We can estimate θ_i/Θ 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

$$\frac{\theta_i}{\Theta} = \frac{(1+\mu_i)(l_i)^{1-\alpha}\left(\frac{\alpha}{\alpha+\sigma_i}\right)^{1-\alpha}}{\left(\sum_j \pi_j \left((1+\mu_j)(l_j)^{1-\alpha}\left(\frac{\alpha}{\alpha+\sigma_j}\right)^{1-\alpha}\right)^{\frac{1}{1-\alpha}}\right)^{1-\alpha}} \tag{8}$$

using the fact that in the undistorted allocation, $\sum \pi_j l_j = L$. Equation (8) 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, θ_i/Θ, 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, θ_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

[16] In practice we use firm shares as sample weights π_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.

to 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 θ_i and that we are capturing only the marginal effect of the distortion due to predation with a view to measuring how important it is in affecting the level of output.

Aggregate Output Costs of Predation We now use equation (1) to write total output in the firm sector. If we rely on the data to rewrite $p^i(e_i, g) = 1/[1+\mu_i]$ and $l_i - e_i = l_i \frac{\alpha}{\alpha+\sigma_i}$ we get

$$\begin{aligned} \hat{Y} &= \sum_i \pi_i \theta_i \left[\left[\tau + \frac{(1-\tau)}{1+\mu_i}\right]\right] (l_i)^\alpha \left(\frac{\alpha}{\alpha+\sigma_i}\right)^\alpha \\ &= L^\alpha \Theta \sum_i \pi_i \frac{\theta_i}{\Theta} \left[\tau + \frac{(1-\tau)}{1+\mu_i}\right] \left(\frac{\hat{\theta}_i}{\hat{\Theta}}\right)^{\frac{\alpha}{1-\alpha}} \left(\frac{\alpha}{\alpha+\sigma_i}\right)^\alpha \end{aligned} \tag{9}$$

after substituting in l_i from equation (7). This gives aggregate output with predation as a function of $\{\theta_i, \sigma_i, \tau, \mu_i\}$.

In order to calculate the output loss due to crime, however, we need a benchmark to compare this output to. For now, to generate a simple benchmark, we assume some constant and low values of $\mu_i = \mu_B$ and $\sigma_i = \sigma_B$ across all firms where B stands for "benchmark".[17] In principal any benchmark can be used including $\mu_R = \sigma_R = 0$. It is straightforward to show from equation (9) that the level of output in this benchmark case is:

$$Y^* = \varphi(\tau_B, \sigma_B) \times L^\alpha \Theta \sum_i \pi_i \left(\frac{\theta_i}{\Theta}\right)^{\frac{1}{1-\alpha}} \tag{10}$$

where $\varphi(\tau_B, \sigma_B) = \left[\tau + \frac{(1-\tau)}{1+\mu_B}\right] \left(\frac{\alpha}{\alpha+\sigma_B}\right)^\alpha < 1$. Note, that equation (10) displays the output of the economy without crime when $\mu_B = \sigma_B = 0$ so that $\varphi(\tau_B, \sigma_B) = 1$. Using (10) together with (9), yields the following expression for the proportional output loss from predation and protection:

$$\Delta = \frac{Y^* - \hat{Y}}{Y^*} = 1 - \frac{\sum_i \pi_i \frac{\theta_i}{\Theta} \left[\tau + \frac{(1-\tau)}{1+\mu_i}\right] \left(\frac{\hat{\theta}_i}{\hat{\Theta}}\right)^{\frac{\alpha}{1-\alpha}} \left(\frac{\alpha}{\alpha+\sigma_i}\right)^\alpha}{\varphi(\tau_B, \sigma_B) \sum_i \pi_i \left(\frac{\theta_i}{\Theta}\right)^{\frac{1}{1-\alpha}}} \tag{11}$$

[17] In section 7 we provide a more sophisticated way to calculate this benchmark in a model with parameterised predation and protection functions.

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

First observe that if $\mu_i = \mu_B$ and $\sigma_i = \sigma_B$ for all i then $\frac{\hat{\theta}_i}{\hat{\Theta}} = \frac{\theta_i}{\Theta}$ for all i and hence $\Delta = 0$.[18]

Second, note that a convenient feature of (11) is that, with the exception of τ and α, it is stated entirely in terms of variables which are either observable or can be estimated from the firm-level data using (8). We are therefore able to calculate Δ for each country in our data set.

Third, equation (11) illustrates the importance of the heterogeneous pattern of predation μ_i, protection σ_i, and productivity θ_i, in determining aggregate output losses. The output loss from predation depends on how the threat of predation is correlated with firms' undistorted productivity levels. Thus if large firms are more susceptible to predation, this can lead to higher losses in three ways – directly higher μ_i or indirectly through them spending more on protection, i.e. higher σ_i. These distortions will also affect allocation of labor across firms indirectly through changes in $\hat{\Theta}$. Without predation, labor will be reallocated towards firms that are heavily affected as $\hat{\theta}_i/\hat{\Theta}$ increases to θ_i/Θ.

Fourth, equation (11) makes clear why τ matters. If more of the predation is in the form of output transfers (τ 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 τ has no impact on the output loss in (11); the loss is given entirely by σ_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 how assumptions regarding τ affect the calculation of the output loss due to predation.

Fifth, the output loss measure is increasing in the φ_B. Hence the output loss will be smaller if we use a less demanding benchmark than zero crime. Moreover, for values of $\varphi_B < 1$, it is possible that some countries have an output gain, i.e. they have less crime than the benchmark example. This will be avoided if we take the case of a low crime country to compare all of the other countries to.

[18] This is because $\frac{\hat{\theta}_i}{\hat{\Theta}} = \frac{\theta_i \frac{1}{(1+\mu_B)} \left(\frac{\alpha+\sigma_B}{\alpha}\right)^{1-\alpha}}{\left(\sum \pi_i \left(\theta_i \frac{1}{(1+\mu_B)} \left(\frac{\alpha+\sigma_B}{\alpha}\right)^{1-\alpha}\right)^{\frac{1}{1-\alpha}}\right)^{1-\alpha}} = \frac{\theta_i}{\Theta}$

6 Results

Our estimates of the output loss is based on the sample of firms in the World Bank enterprise surveys.[19] We look at variation across both countries and firms. Hence we write θ_{ic} for firm type i in country c with corresponding weights π_{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 τ or α to be country specific. However, we will maintain common values for these parameters in what follows.

It is important in interpreting the results that follow to realize that θ_{ic} does not have to be a purely technological parameter but could reflect a range of other pre-existing distortions in the economy. We are considering what would happen if we removed the specific distortion that we are interested in while holding all others in place. The data we have on σ_i and μ_i together with our model allow us to do this. However, this is quite separate from whether, if one actually removed the distortion that we are considering, there would be changes in θ_i due to spillovers to other sources of inefficiency. A case in point would be a generalized improvement in the legal system which could have a range of effects.

Throughout this section, we will take as our benchmark, the least distorted country in the data based on the parameter $\varphi(\tau_B, \sigma_B)$ which is South Korea for which the value is 0.9975. Hence, by construction, South Korea has an output loss of zero in the homogeneous firm case.

Benchmark: Identical Firms Even though our main interest is in exploiting firm-level heterogeneity, a useful benchmark is 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 (11) now boils down to a very simple form:

$$\Delta_c = 1 - \frac{1}{\varphi(\tau_B, \sigma_B)} \left[\tau + \frac{(1-\tau)}{(1+\bar{\mu}_c)}\right] \left(\frac{\alpha}{\alpha + \bar{\sigma}_c}\right)^{\alpha} \tag{12}$$

[19] 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.

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.[20]

Given direct measures of $\bar{\mu}_c$ and $\bar{\sigma}_c$, we can estimate the loss in (12) without any assumptions about the technology $p^i(e_i, g)$ and without the typical identification issues. In our data, $\bar{p}_c = 1/(1+\bar{\mu}_c)$ varies between 94.6 percent and 100 percent. Table 2 depicts averages of $\bar{e}_c/\bar{l}_c$ and Δ_c. The parameter α 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 3 percent as we vary α.[21] The next rows present estimates of the output loss for the benchmark case where $\tau = 0$ and for the three values of α. The estimated average output loss is about 2.4 percent regardless of the choice of α. We will for now focus on the case $\alpha = 0.66$ until we look at sectoral variation in α as an extension below. Table 2 also gives the average loss for $\tau = 1$ which is 1.6 percent. Thus, about two thirds of the output loss from predation in the enterprise sector is estimated to be from expenditure on protection.

Figure 2, panel A shows the distribution of the output loss measure for $\tau = 0$ across countries to give a sense of the heterogeneity of the loss. Most countries lose about 2 percent of their output due to crime.[22] Around one 5th of countries lose more than 4 percent. In Figure 2, panel B we plot the output loss when $\tau = 1$. This illustrates just how important the output loss coming from protection spending is. As in panel A, there is considerable heterogeneity across countries and around one 5th of countries lose more than 2.5 percent just due to spending.

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 firms rather than the private actions that firms take to prevent it happening.

[20] Note that the share of workers employed in protection is given through $\frac{\alpha}{\alpha+\bar{\sigma}_c} = 1 - \bar{e}_c/\bar{l}_c$.

[21] 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.

[22] A country by country list is provided in appendix table A4.

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, $\frac{\theta_i}{\Theta}$, 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 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 calculated as in equation (12) for every decile of firm size. 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. In Mexico there will be a strong drive of labor away from larger firms. 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:

$$\Delta_c = 1 - \frac{\sum_i \pi_{ic} \frac{\theta_{ic}}{\Theta_c} \left[\tau + \frac{(1-\tau)}{1+\mu_{ic}}\right] \left(\frac{\hat{\theta}_{ic}}{\hat{\Theta}_c}\right)^{\frac{\alpha}{1-\alpha}} \left(\frac{\alpha}{\alpha+\sigma_{ic}}\right)^{\alpha}}{\varphi\left(\tau_B, \sigma_B\right) \sum_i \pi_{ic} \left(\frac{\theta_{ic}}{\Theta_c}\right)^{\frac{1}{1-\alpha}}} \tag{13}$$

where we exploit firm level variation in productivity, losses and security expenditures in the enterprise survey data.[23] Again, given direct measures of μ_{ic} and σ_{ic}, we can estimate the loss in (13) without any assumptions about the technology or exogeneity of $p^i\left(e_i, g\right)$. Note also that we have made no assumption regarding whether e_i is provided by the firm internally or whether e_i is provided by another firm. Both are consistent with the data we have. We discuss organized crime in the Appendix B.

Equation (13) also allows us to return to the key identifying assumption underlying our

[23] We validate this approach by looking at the correlation between the most comparable measure of crime at the country level, homocides, 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.

output loss estimates. We assume that a change in predation does not change the relative productivity θ_{ic}/Θ_c of firms. This assumption is violated if, for example, managerial effort or investment is hindered by predation so that productivity of firms would increase without predation. In section 8 we discuss these possibilities further. We show that in this scenario the most affected firms are the ones who would benefit most from the absence of predation. The change from $\hat{\theta}_{ic}/\hat{\Theta}_c$ to θ_{ic}/Θ_c would then be even larger and our estimates provide a lower bound to the true output loss.

Figure 4 compares the estimate from equation (13) to the estimates that come out the model with identical firms, i.e. equation (12). Observations on the red line would mean that the output loss estimate is identical with and without firm heterogeneity. Around 55 percent of the observations lie above this line and the loss increases on average by about 0.3 percentage points. In other words, allowing for heterogeneity tends to increase the size of the estimated loss modestly. There are a few countries like Sierra Leone or Afghanistan where the increased output loss with heterogeneity is particularly pronounced. This 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 will see in the following section that these are also countries that suffer particularly from weak protection of large firms.

We have run several robustness checks regarding both output loss estimates shown in Figure 4. As a first check we changed the benchmark from South Korea to China which has a value of $\varphi(\tau_B, \sigma_B) = 0.9926$ and find that changes are minimal.[24] We also ran checks by excluding firms with very large weights π_{ic}, dropping outliers in terms of firm size and restricting the analysis to countries with many observations. The findings are fairly robust to all of these changes.[25] 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.[26] First, if we focus on large,

[24] See Figure A2. Note, that some countries, including South Korea, now have a negative loss from predation with respect to the benchmark.

[25] However, most of the extreme losses we find in Figure 4 are in countries with small samples (except Cambodia). This is illustrated in Figure A3 where we restrict the sample to countries with more than 500 observations.

[26] For calculations and discussion see Appendix C and Figures A4 to A7.

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. This is because the productivity weights given to different firms, θ_{ic}/Θ_c, fluctuate dramatically in small samples if we use the sales and cost data. The values of a very few firms then determine the total output loss estimate.

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. 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 (13) and $(\theta_{ic}/\Theta_c)^{\frac{\alpha}{1-\alpha}}$ in the denominator. The output loss is always smaller without labor reallocation. However, this decrease is fairly small; around 0.2 percent of output on average.[27] 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 considerably larger.

7 Public and Private Protection

Our estimates so far have kept government policy in the background. However, a central role of government is to determine the level of spending and the effectiveness of state institutions in maintaining law and order by limiting predation. Accordingly, developed countries spend around 0.8 percent of their GDP on policing, prosecution, courts and prisons.[28] 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 having an effective criminal justice system.

[27] Figure A8 tries to gauge the importance of the labor reallocation effect by plotting the output loss in (13) 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 because $\left(\hat{\theta}_{ic}/\hat{\Theta}_c\right)^{\frac{\alpha}{1-\alpha}} = (l_{ic}/L_c)^{\alpha}$.

[28] Estimate based on Farrell and Clark (2004). The lions share of this, around 60 percent, is spent on policing. We use Eurostat data below which shows that countries in the European Union spend somewhat more, between 1.1 and 2.3 percent of their GDP in 2015.

In this section we therefore first explore the trade-off between private and public spending in the data. For this, we explore data from Eurostat on spending by European states, UNODC data on employment in the police, courts and prisons and an institutional measure of the effectiveness of the criminal justice system. We first explore this data to show that public spending does not, in general, substitute for private spending and vice versa so that the country ranking we found in the previous section is maintained. The data is consistent with the idea that differences in judicial institutions which do not generate large budgetary requirements are at least partially responsible for this. We then use an expansion of the model to simulate what would happen if countries adopted the policy environment of other countries. In particular, we analyze what would happen if the Chinese protection patterns would be adopted elsewhere.

7.1 Public Protection and the Policy Environment

As a first proxy for the policy environment, we use the World Justice project index which is intended to measure the effectiveness of the criminal justice system on a scale between 0 and 1. The index summarizes a range of factors which capture the effectiveness and impartiality of the criminal investigation system, the criminal adjudication system and the correctional system. We relate this index to our output loss measures in Figure 5 for the case where $\tau = 0$, i.e. assuming that all predation is destructive. There is a strong correlation between our two output loss measures (with and without heterogeneity among firms) and this measure.[29] If we were to interpret this correlation as causal (which is obviously problematic), it says that the adoption of a system of criminal justice in Venezuela with the effectiveness of Chile would boost Venezualan output by around 2 percent. Similarly, adopting a legal system with the effectiveness of Sweden, Chile would gain more than 3 percent.[30]

To look at the quantitative importance of public protection, we will consider how our

[29] This relationship is robust to controlling for GDP per capita, political institutions and continent fixed effects. This is not suprising given that many poor autocracies have relatively low crime rates. We also find that our estimate of $p^i(e_{ic}, g_c)$ is positively correlated with the firm reporting that the court system in the country is effective, fair and free of corruption. This holds controlling for country/year fixed effects and firm productivity.

[30] We would, of course, expect other gains from improving the effectiveness of criminal justice beyond those highlighted here.

measure of output loss changes if when employment devoted to establishing law and order is E. This implies that the workforce available for private production/protection is reduced to $L - E$. This can be incorporated into our output loss formula for country c which becomes:

$$\Delta_c^{overall} = 1 - \left[\frac{1 - (E/L)_c}{1 - (E/L)_B}\right]^{\alpha} [1 - \Delta_c] \tag{14}$$

where Δ_c is defined as in equation (13) and $(E/L)_B$ is the share of public employment in the country which is chosen to be the low employment benchmark.[31] Thus, there is an additional factor affecting output the loss due to the fact that productive labor is diminished by state provision. One striking feature in all data related to spending is that public spending does not rise as quickly as Δ_c falls with higher institutional scores.[32] Many countries, such as South Korea, even tend to have relatively low public employment in security-related occupations. Hence, adding in the losses from public sector does not materially change the overall pattern across countries even though the output loss numbers do increase.

To see this, we begin by taking the 13 European countries in our dataset where we have good quality spending data on different types of public order from Eurostat sources. Applying the results above we calculate public employment from the spending data as $(E/L)_c = \sigma_c / [\sigma_c + \alpha]$ where σ_c is the share of GDP spent by the government. To facilitate comparison with the earlier results, we continue to use South Korea as the benchmark for measuring Δ_c. However, for public spending on establishing law and order, we use Sweden (which has the lowest level of public spending) as our benchmark country since Eurostat does not have South Korean data. The relationship between the total loss in equation (14) and the criminal justice measure is shown in Panel A of Figure 6. The negative relationship between the two suggests that more lawful countries have a lower overall loss.

[31] To see this, note that

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

and

$$Y^* = [1 - (E/L)_B]^{\alpha} \varphi(\tau_B, \sigma_B) L^{\alpha} \Theta \sum_i \pi_i \left(\frac{\theta_i}{\Theta}\right)^{\frac{1}{1-\alpha}}.$$

[32] In appendix Figure A9 we show that only employment by judges and magistrates is clearly positively correlated with the institutional measure.

Hence, it does not appear that a low level of predation is achieved through substituting private protection for public protection. Instead, it suggests that it is a common set of background cultural and/or institutional country-level features which enter the function $p^i(e_i, g)$ and are shaping the threat of predation to which both government and firms are responding when deciding how much security to invest in.

While there are no comparable data on public order spending across a large set of countries, UNODC does provide data on employment in the police force, courts and prison staff for the years 2003-2014. We use the total of these three numbers for each country and then calculate the value relative to total employment to generate a measure of $(E/L)_c$.[33] Since there are data for South Korea, we now use South Korea as the benchmark for both public and private security, and predation levels. Using these data in equation (14), we obtain a similar pattern to Panel A. This confirms that countries with 'better' legal/justice systems tend to have lower overall losses from crime even if public spending is taken into account.[34]

7.2 A Calibrated Policy Environment

To explore the policy environment further, it is useful to work with a "constant elasticity" functional form where:

$$p^i(e, g) = \begin{cases} \varepsilon^i(g) \times e_i^{\gamma^i(g)} & \text{for } \varepsilon^i(g) \times e_i^{\gamma^i(g)} \leq 1 \\ 1 & \text{otherwise.} \end{cases} \tag{15}$$

The parameter $\varepsilon^i(g)$ can be thought of as the baseline level of protection *perceived* by a firm which rationalizes its protection behavior and its reported loss. The parameter $\gamma^i(g)$ is the protection effort elasticity which consistent with the firms level of protection spending. Both can depend on the policy environment, g, as well as other country-specific factors. This functional form has the convenient property that a constant fraction of any

[33] We take employment data from the Penn World Tables version 8.0. Our measure of $(E/L)_c$ lies between 0.004 for the Phillipines and 0.026 for Bosnia.

[34] As Figure A9 shows, the picture across different catergories of employment differs somewhat. It is, perhaps, interesting to note that there is a significant positive relationship between the employment in courts and the institutional measure.

firm's labor force is used for protection purposes, i.e.

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

Using (15) gives a specific interpretation of the heterogeneity in firms' decisions in terms of these technology parameters.[35]

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:

$$\varepsilon^i(g) = \frac{[l_i \gamma^i(g)]^{-\gamma_i(g)}}{(1+\mu_i)}. \tag{16}$$

Firm size, l_i, is increasing in θ_i in equation (16) 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.[36]

For this exercise we will take China rather than South Korea as our benchmark country. This is because the sample size in China is large enough to be able to disaggregate the key parameters by productivity decile which turns out to be instructive and would not be feasible given the sample size for South Korea. China is also a somewhat less ambitious benchmark for a low and middle income countries. [37]

Figure 6 returns to the China/Mexico comparison first shown in Figure 3 but now

[35] We suppose that $\alpha + \gamma^i(g) < 1$. Note that

$$l_i = \left[\alpha + \gamma^i(g)\right] \left(\frac{\left(\varepsilon^i(g)\,\theta_i \left(\gamma^i(g)\right)^{\gamma^i(g)} (\alpha)^{\alpha}\right)}{w} \right)^{\frac{1}{1-\alpha-\gamma^i(g)}}$$

so that variation in labor hired is increasing in $\varepsilon^i(g)$ and θ_i.

[36] This will depend in part on the covariance of θ_i and $\gamma^i(g)$. Appendix Figure A10 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 with firm size. In Appendix D, we explore correlates of perceived protection. We find that firms that expect more protection (higher $\varepsilon^i(g)$) report crime less as an obstacle. We also find that firms located in the capital city perceive that they are better protected from predation and that state owned and foreign firms seem better able to defend against predation.

[37] Although China does have relatively low losses from predation and protection, Figure A2 in the Appendix shows that there are countries in our data which have higher output than they would with Chinese levels of predation and protection.

plots the distribution of protection by productivity decile. They illustrate two archetypal patterns in the data. Some countries seem to offer reasonably equal levels of protection across firms, regardless of firm size whereas in others it tails 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.

This observation about the difference between China and Mexico inspires us to ask what would happen if the protection and predation environment in China applied in other countries.[38] The pattern across firm sizes motivates an approach which applies the China benchmark by firm size. Protection by firm size is a more reasonable benchmark than assuming constant parameters across the board and will, in particular, highlight the potential value in protecting larger, more productive firms. To do this we proceed as follows. First, we divide all firms in each country into fifty equal-size groups based on their relative productivity, $\frac{\theta_{ic}}{\Theta_c}$. We then draw values of $\{\varepsilon^i(g), \gamma^i(g)\}$ at random from the observed distribution in each productivity group in China. Third, we give these values to firms in the same productivity group in other countries in our data. We then compute the gains/losses in output that this would yield. Since some countries have quite small sample sizes we need to make sure we repeat this procedure and use the mean. We do so five hundred times and calculate the mean and the standard deviation of the gains/losses in output as a form of "bootstrapping".[39] This also gives us a standard deviation of the gains/losses.

Table 3 shows the change in output that we estimate in countries from this thought experiment.[40] To be included, the gain or loss needs to be statistically significant, i.e. it needs to be more than 1.65 times its standard deviation above or below zero. European and Asian countries are largely absent from the table since we do not find significant gains from having a Chinese-style protection environment. This contrasts with many African and Latin American countries which mostly show positive and significant gains. Columns (1) and (4) of Table 3 focus on the output gain if $\tau = 0$. In some cases the output gains

[38] While we use values from China, the pattern is similar in other East Asian countries such as South Korea, Thailand and Vietnam.

[39] Details of the procedure are in Appendix D.

[40] We exclude small territories with a population of less than one million as well as countries with less than 100 observations in the enterprise surveys.

from the policy experiment are substantial. For example, we estimate that Sierra Leone could increase output in the enterprise sector by almost 7.8 percent by adopting a Chinese pattern of protection and Mexico might increase output in the enterprise sector by 3.5 percent. Of course, this says nothing about how practically to achieve this nor the cost of doing so. But it does give a sense of how much willingness to pay there might be for bringing about changes which protect larger firms better.

In columns (2) and (5) we assume that $\tau = 1$. In this case, all changes are due to labor re-allocation towards or away from protection. The gains remain substantial in most countries. This column shows that the losses are very significantly linked to protection; the average change in output reported on the bottom of each column suggests that over 70 percent of all changes in output can be attributed to protection spending. This shows how important it is to consider the protection margin in considering the output effects of lawlessness.

Column (3) reports the difference between columns (1) and (2), i.e. the change in output that is only due to differences in predation losses. There is a significant amount of heterogeneity in the gains here with many countries gaining very little. Cambodia, for example, would gain 3.12 percent of output entirely due to a reallocation from unproductive to productive labor. In fact, countries with moderate gains in column (6) would benefit most from a reduction in protection efforts. The average gain in this group is 1.12 percentage points and 1.05 would come from changes in protection spending. This finding is in line with Figure 2 which showed that most countries with low output losses face relatively minor predation losses. This is, perhaps, due to the fact that for intermediate values of public security provision the private response manages to prevent significant losses from predation.[41] The countries that would gain most from an adoption of Chinese parameter values tend to gain through both channels.

Importantly, the gains in Table 3 are fairly large when compared to the gains calculated without firm heterogeneity.[42] This underlines why looking at this for heterogeneous firms is important and is coming from the fact that we assumed that firms at different parts of

[41] There is indeed a U-shape relationship between the share due to predation and our criminal justice measure.

[42] See Figure A2 for comparisson. The simulation has the additional benefit of providing an estimate of the standard deviation of the loss. Some countries, like Vanuatu, with large losses are missing in Table 3 due to their high standard deviation.

the productivity distribution would be protected as in China. This helps heavily affected firms particularly. If these are productive firms then output benefits particularly from the adoption.

8 Further Analysis

Adding the Cost of Predation in Transit The more recent section of the World Bank enterprise survey asks two additional questions on predation to measure the losses incurred due to predation in transit.[43] These questions are i) *"In fiscal year [insert last complete fiscal year] what percentage of the value of the products exported directly was lost while in transit because of theft?"* and ii) *"In fiscal year [insert last complete fiscal year], what percentage of the value of products this establishment shipped to supply domestic markets was lost while in transit because of theft?"*. These represent additional losses which should be taken into account.

Call these two losses $\mu_i^{transit}$ and μ_i^{export}. We combine this data with the share of sales in firm i which goes to domestic markets d_i to calculate the following measure of the loss due to predation:

$$p^i(e_i, g) = 1/\left[1 + \mu_i + d_i\mu_i^{transit} + (1 - d_i)\mu_i^{export}\right].$$

Incorporating this into the analysis results in an output loss for the case of homogeneous and heterogeneous firms in Figure 8. Some countries, Sierra Leone and the Republic of Congo for example, experience a dramatic increase in the estimated output loss if we allow firms to be heterogeneous. The changes under the assumption of homogeneous firms tend to be small. This makes sense given that large firms are more likely to sell their products outside of local markets and hence are more subject to predation in transit.

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

[43] We are grateful to Hannes Malberg for drawing these survey questions to our attention.

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 ω. This could be thought of as a Lewis-style dual economy model where ω for the whole economy is the wage set in agriculture. But labor reallocation could be from the public sector or the informal sector. We show in the Appendix G that if we assume that ω is fixed, i.e. there is no general equilibrium response in the sector that is supplying labor to the formal enterprise sector, then we can approximate 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 (11). Thus, allowing for the aggregate labor force in the enterprise sector to respond to 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 ω 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 α is assumed 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 ω is fixed in this exercise. If ω 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.[44] Moreover, as this would be a shift from profits to wages, it would also be

[44] Also, according to findings in Gould et al (2002) and Machin and Meghir (2004) criminals will leave the predatory sector. This will free up additional labor. For example, the prison populations in Rwanda and Russia are around 1 percent of the employed population.

likely to create pro-worker redistributive effects.

This discussion underlines the idea that we have been quite conservative in our core estimates of the output loss from predation.

Reallocation Between Sectors We have assumed up until now that α is the same for all firms. We now relax this assumption by assuming a sector-specific technology, i.e. α_s for sector s. For sectoral labor intensity, we use the US economy as a benchmark. Specifically, we use payroll shares from Elsby et al (2013).[45] 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.[46]

In the case in which labor does not move then, following (11), the output loss from predation in sector s is given by:

$$1-\frac{\hat{\Omega}_s}{\Omega_s}=1-\frac{\sum_i \pi_{is}\frac{\theta_{is}}{\Theta_s}\left[\tau+\frac{(1-\tau)}{1+\mu_{is}}\right]\left(\frac{\hat{\theta}_{is}}{\hat{\Theta}_s}\right)^{\frac{\alpha_s}{1-\alpha_s}}\left(\frac{\alpha_s}{\alpha_s+\sigma_{is}}\right)^{\alpha_s}}{\sum_i \pi_{i\alpha_s}\left(\frac{\theta_{is}}{\Theta_s}\right)^{\frac{1}{1-\alpha_s}}}. \tag{17}$$

where we have used a benchmark of $\varphi(\tau_B,\sigma_B)=1$ and instead use Table 4 to compare the loss in each sector for the quartiles of countries that are most (panel A) and least affected (panel B) by predation. We first report raw data averages of μ_{is} and σ_{is} by sector. In the third column of Table 4 we report our estimates of (17) by sector which now takes into account firm heterogeneity. Panel A shows that the least affected countries lose around 0.7 per cent of output due to predation with little variation across sectors. The most affected countries in panel B show a little more variation across sectors with the construction sector losing over 6.6 percent on average, i.e. almost 6 percentage points

[45] A similar argument is made in Hseih 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 Elsby et al (2013).

[46] We exclude sector/country/years with less than 10 firms in this and the following section.

more than the least affected countries.

Allowing α_s to vary has 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, ω.[47] Table 4, Panel A reports the employment loss from predation for the least affected countries which lies between 0.9 percent in the primary sector and 2.4 percent in construction. In the most affected countries in panel B we estimate a 12.3 percent gain in manufacturing employment and a whopping 25.4 percent gain in construction employment from eliminating predation. This means a loss of employment when compared to the east affected countries by more than 20 percentage points. Here, relaxing the assumption of a common technology has an important bearing on the findings with labor intensive sectors being much more affected in their total employment.[48] The greater output loss in construction is an immediate consequence of this being a more labor intensive sector where labor distortions matter more.

To provide further insight into effects of predation/protection on sector size, we conduct an exercise along the lines of section 7 at the sector level. We do this by attributing values of $\{\varepsilon^i(g), \gamma^i(g)\}$ from the Chinese construction sector to firms in the construction sector in other countries. Since the sample of firms at the sector level is smaller, the standard errors are inevitably somewhat larger. Nonetheless, we will get a feel for how much a sector might expand with lower levels of predation. As above, we focus on countries where the output change is statistically significant; the results are presented in Table 5. This draws attention in particular to a number of African economies where there are considerable gains. For example, we estimate that output in the construction sector in Togo, Senegal, Zambia and Botswana would expand by more than 10 percent if Chinese levels of protection were available to firms in the construction sector.

[47] 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 ω. Using this observation and taking logs in a sector-specific version of equation (3) in Appendix G, we can estimate the proportionate difference in the size of the labor force in sector s with and without predation from:

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

[48] As we mentioned above, use of a Lewis-style model of labor allocation where there is an unlimited supply of laborers tends to make these effects labor allocation an upper bound. If ω were to increase due to the elimination of predation in the enterprise sector, then these effects would tend to be smaller.

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 straightforward 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 η,[49] i.e.

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

This extension of the model allows us to think about how productivity affects investment in the constant elasticity model with parameters $\{\varepsilon^i(g), \gamma^i(g)\}$. Appendix F shows that the optimal capital stock is increasing in $\varepsilon^i(g)$ and $\gamma^i(g)$ if $p^i(e_i, g) < 1$.[50]

Our data allow us to look at this empirically by looking at investment by firms.[51] Specifically, we look at whether a firm reports purchasing any fixed asset and/or expenditure in fixed assets over the previous year. The results are reported in Table 6 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 1.8 percent. An increase in the elasticity of protection effort increases the likelihood of an investment by 3.5 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

[49] It would be straightforward to have a standard monopolistic competition model with a constant markup instead.

[50] This assumption implies decreasing returns in $\{l_i, k_i\}$ overall. To see this observe that in this case, we can write:

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

[51] To map formally from the capital stock to investment, it would be straightforward to introduce adjustment costs along with shocks to θ_i.

this margin are consistent with the theory and fairly large. A standard deviation increase in protection implies an increase of investment by almost 12 percent. An increase of the protection elasticity by one standard deviation implies an increase in investment by more than 18 percent. Thus, as we would expect, predation and protection are also related to investment decisions. This pattern of investment effects largely corroborates our findings on firm perceptions reported in the Appendix D.

Selection and Incentive Effects on Productivity While investment is important, it is only one dimension of a wider set of margins on which predation can affect firm performance. Returning to the base line model with only labor, note that firm profits as a function of θ_i with optimal labor allocation decisions $\{l_i^*(g,w), e_i^*(g,w)\}$ are:

$$S^i(g,w,\theta_i) = \theta_i p^i\left(e_i^*(g,w), g\right)\left(l_i^*(g,w) - e_i^*(g,w)\right)^{\alpha} - w l_i^*(g,w).$$

There are possible selection and incentive effects which can affect θ_i and which respond to the threat of predation. The selection effect comes from making endogenous which firms are active. Suppose that there is a fixed cost F of being active then the critical efficiency level above which a firm is active, given by $\tilde{\theta}_i(g,w)$, is defined by:

$$S^i\left(g,w,\tilde{\theta}_i(g,w)\right) = F.$$

If $p_g^i > 0$, then a marginal increase in g reduces $\tilde{\theta}_i(g,w)$.[52] Hence less efficient firms can afford to be active in the market all else equal when there is a lower threat of predation. Note, however, the distribution of predation and productivity matters for the selection effect. If predation is concentrated among high productivity firms, then they may close down. In that case average productivity in the economy as a whole could be higher when g is increased. This has implications for the countries identified above, such as Mexico.

There is also the possibility of an incentive effect which applies to efforts by firms to

[52] This follows from noting that:

$$S_g^i(g,w,\theta_i) = \theta_i p_g^i\left(e_i^*(g,w), g\right)\left(l_i^*(g,w) - e_i^*(g,w)\right)^{\alpha} > 0$$

and

$$S_\theta^i(g,w,\theta_i) = p^i\left(e_i^*(g,w), g\right)\left(l_i^*(g,w) - e_i^*(g,w)\right)^{\alpha} > 0.$$

increase their productivity. This could be due to variety of decisions that firms make. Here, we will focus on managerial decision-making as a source of productivity differences.[53] To model this simply suppose that $\theta_i(I_i)$ where I_i is firm-level managerial effort measured in units of labor input. The first order condition for managerial effort is:

$$\frac{\partial \theta_i(I_i^*(g))}{\partial I_i}\left[p^i(e_i^*(g,w),g)(l_i^*(g,w)-e_i^*(g,w))^{\alpha}\right]=w$$

where we have used the envelope condition for $\{l_i^*(g,w), e_i^*(g,w)\}$. We show in the appendix that, with a constant elasticity functional form for the value of managerial effort given by $\theta_i = \frac{\theta_i}{1-\kappa}(I_i)^{1-\kappa}$, then the relative productivity of a firm with and without predation, in terms of the observable μ_i is[54]

$$\left(\frac{1}{1+\mu_i}\right)^{\frac{1-\kappa}{\alpha-\kappa}}<1$$

if $\alpha > \kappa$ which is the empirically plausible case since we expect $\alpha \simeq 2/3$ and $\kappa \simeq 0.2$.[55] To illustrate the productivity consequences of predation via this channel, note that if $\alpha = 0.66$ and $\kappa = 0.2$, a firm that loses 2% of its output due to predation experiences a 4% fall in productivity due to lower managerial effort.

We can use this simple model to see what happens to the aggregate loss with heterogenous firms when $\alpha = 0.66$ and $\kappa = 0.2$. In this thought experiment we maintain the benchmark crime loss from South Korea. On average the loss increases from about 2.6 percent to 5.2 percent. Three things about this are worth noting. First, regardless our assumptions on τ the predation loss μ_i will lower output as managerial effort does not internalize the gain to predators. Second, the effect will shift the magnitude of the loss due to predation compared to that due to spending on security; the share of the loss due to predation increases from around 30% to 50%. Third, the effect differs depending on both the level of predation and its distribution across firms. The estimated output loss in Cambodia, for example, barely changes from 4.2 percent under the model in equation (13) to a loss of 4.7 percent in the modified model. However, the estimate for Mexico increases

[53] Bloom and VanReenen (2007) suggests that this is empirically important.

[54] The adjusted to productivity depends only on μ_i. We show in Appendix I that this is due to security spending being chosen optimally by the firm.

[55] Prendergast (2015) estimates the effect of managerial effort in the U.S. to be lower than 0.25.

from 4.3 percent to 7.6 percent in the modified model which reflects the fact that large firms are more exposed to predation. The loss in Afghanistan is now estimated to be a striking 23 percent.

Although specific to one channel, the analysis in this section illustrates why our estimates of the put loss from predation are likely to be a lower bound on true losses. It also illustrates the value of an approach which builds up to the macro-picture from specific distortions which can be studied in micro-economic terms.

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. Given the size and growth of the private security sector in developed countries this point is of considerable importance here as well.

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 reduced. We estimate that employment in the sector with the highest labor intensity, construction, might expand by more than 20 percent if predation could be lowered in high predation countries.

We have also use a specific parametrization of the protection technology to look at

patterns of predation across and within countries. 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 analysis developed here is deliberately simple in order to home in on the new issues. We have focused on one distortion and have not considered a wider range of policy failures which could also be important including taxes, corruption or regulations. These are all part of the θ_i term in the model. We have also abstracted from a range of frictions in firm level decisions such as adjustment costs and capital constraints. To the degree that they are positively correlated with the vulnerability to crime, for example due to a general absence of the state, we would expect our estimates to be a lower bound on the cost of crime.

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 Hseih 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, our data allows us to sidestep the discussion of positive and negative spillovers between firms who choose their levels of protection.[56] However, for policy this is an important issue. Third, 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. Fourth, more could be done to capture a wider range of channels through which predation affects productivity

[56] 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.

through selection and incentives. A full treatment of this would require modeling firm dynamics but would also provide a link to the growth literature.

This paper has shown that in study the consequences of predation in any context, the distortionary effect of private protection needs to be taken into consideration. And understanding this requires modeling specific micro-economic consequences of predation. Only then can the full range of consequences of state ineffectiveness be appreciated.

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Table 1: Summary Statistics on the Firm Level

	Obs.	Mean	SD	Min	Max
share of total annual sales paid for security	155,915	0.017	0.048	0	0.99
loss due to theft, robbery, vandalism or arson as a share of total annual sale	155,915	0.008	0.040	0	0.99
firm size (number of workers)	155,915	119.9	678.2	1	65994
firm reports paying for security	155,915	0.62	0.49	0	1
firm reports a loss due to predation	155,915	0.20	0.40	0	1
number of firms interviewed in country/year	155,915	2411	2125	59	9183
firm reports crime as worst obstacle	108,665	0.04	0.19	0	1

Notes: Table shows summary statistics for our main variables. The response to "share of total annual sales paid for security" is our measure of spending on security. The response to "loss due to theft, robbery, vandalism or arson as a share of total annual sale" is our main measure of predation.

Table 2: Simple Output Loss Calculations

Estimate	α	Mean Share	SD
share of workers employed in protection	0.9	0.0180	0.0416
	0.66	0.0237	0.0524
	0.5	0.0299	0.0637
output loss (τ=0)	0.9	0.0248	0.0526
	0.66	0.0245	0.0515
	0.5	0.0242	0.0505
output loss (τ=1)	0.66	0.0160	0.0366

Notes: The table shows estimates from our benchmark model with identical firms. The parameter α is the standard parameter on labor from the production function. The parameter τ captures the extent to which predation is a transfer to the criminal, under τ=1 all predation losses for the firm are gains for the criminal. The only loss from crime is then generated by security spending.

Table 3: Policy Experiment - Adoption of Chinese Protection Parameters

country	(1) estimated change in output	(2) estimated change in output (protection)	(3) estimated change in output (predation)	country	(4) estimated change in output	(5) estimated change in output (protection)	(6) estimated change in output (predation)
Lesotho	12.32%	4.71%	7.61%	North Sudan	1.85%	2.17%	-0.32%
C. African Republic	11.33%	6.78%	4.55%	Mauritius	1.81%	1.39%	0.42%
Sierra Leone	7.75%	6.28%	1.47%	Namibia	1.78%	1.38%	0.40%
Malawi	6.79%	4.58%	2.21%	Philippines	1.78%	1.47%	0.31%
Swaziland	5.66%	4.28%	1.39%	Botswana	1.76%	0.55%	1.21%
Afghanistan	4.56%	2.31%	2.24%	El Salvador	1.73%	1.34%	0.39%
Zambia	4.48%	2.74%	1.74%	Malaysia	1.62%	1.64%	-0.02%
Angola	4.45%	4.42%	0.03%	Russian Federation	1.62%	1.35%	0.26%
Honduras	4.39%	2.90%	1.48%	Azerbaijan	1.60%	2.16%	-0.56%
Cameroon	4.02%	2.71%	1.30%	Tanzania	1.54%	1.40%	0.15%
Gambia, The	4.00%	3.28%	0.72%	Moldova	1.37%	1.59%	-0.22%
Burkina Faso	3.96%	4.46%	-0.50%	Ukraine	1.37%	1.33%	0.04%
Congo, Dem. Rep.	3.72%	3.32%	0.40%	Brazil	1.26%	1.06%	0.19%
Liberia	3.66%	2.26%	1.39%	Kazakhstan	1.22%	1.23%	-0.01%
Mexico	3.52%	1.13%	2.38%	Togo	1.22%	1.21%	0.01%
Timor-Leste	3.39%	2.96%	0.44%	Solomon	1.21%	1.54%	-0.33%
Cambodia	3.39%	3.12%	0.27%	Macedonia, FYR	1.21%	1.06%	0.15%
Congo, Rep.	3.23%	2.65%	0.58%	Mongolia	1.19%	1.13%	0.06%
Cote d'Ivoire	3.11%	1.97%	1.14%	Senegal	1.13%	1.04%	0.09%
Chad	2.96%	1.75%	1.21%	Ghana	1.06%	1.26%	-0.19%
South Sudan	2.87%	1.81%	1.06%	Mali	1.05%	1.37%	-0.32%
Kosovo	2.82%	3.22%	-0.40%	Zimbabwe	1.03%	1.03%	0.00%
Ecuador	2.50%	1.73%	0.77%	Sri Lanka	1.03%	0.87%	0.15%
Venezuela	2.30%	2.16%	0.14%	Serbia	1.00%	0.47%	0.53%
Mozambique	2.24%	1.44%	0.80%	Madagascar	0.98%	0.95%	0.03%
Kenya	2.23%	1.55%	0.68%	Romania	0.95%	0.97%	-0.02%
Dominican Republic	2.18%	1.96%	0.22%	Guyana	0.90%	0.92%	-0.02%
Nigeria	2.17%	2.27%	-0.10%	Panama	0.85%	0.78%	0.07%
Guatemala	2.10%	1.40%	0.69%	Turkey	0.78%	1.05%	-0.27%
Uganda	2.00%	2.02%	-0.02%	South Africa	0.76%	0.37%	0.39%
Rwanda	1.98%	2.29%	-0.31%	Estonia	0.75%	0.66%	0.09%
Guinea	1.98%	1.95%	0.03%	Bolivia	0.71%	0.44%	0.27%
Paraguay	1.92%	1.84%	0.08%	Pakistan	0.69%	1.07%	-0.37%
Nicaragua	1.91%	1.62%	0.29%	Argentina	0.61%	0.25%	0.36%
Kyrgyzstan	1.86%	1.79%	0.08%	Slovenia	-0.53%	-0.19%	-0.34%
Tajikistan	1.86%	2.29%	-0.43%	Jordan	-0.61%	-0.32%	-0.29%
Average in column:	3.77%	2.78%	0.99%		1.12%	1.05%	0.06%

Notes: Change in output is calculated by replacing the gamma and protection elasticity in each firm by a random draw from the Chinese parameter values for firms of similar relative productivity (50 categories). We do this repeatedly (500 iterations) and report the mean of those countries whose mean change in output is larger in absolute terms than 1.65 the standard deviations of the change in output. "Change in output (protection") uses the assumption tau=1 to estimate the loss just from the distortions caused by protection. "Change in output (predation)" is the difference between the first two columns and captures the otuptut change that derives from just predation. We drop countries and territories with less than 1 million inhabitants and less than 100 interviewed firms.

Table 4: 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	1.11%	0.23%	0.62%	0.91%
Manufacturing	0.72%	0.26%	0.73%	1.63%
Services	0.63%	0.33%	0.78%	1.85%
Construction	0.75%	0.37%	0.67%	2.44%

Panel B: countries most affected by crime

sector	losses due to predation	spending on security	average output loss	average employment loss
Primary	5.24%	2.56%	6.10%	9.37%
Manufacturing	3.37%	1.94%	5.33%	12.32%
Services	3.44%	1.86%	5.88%	14.40%
Construction	3.83%	2.36%	6.61%	25.36%

Notes: "Losses due to predation" and "spending on security" are relative to sales. Other numbers are relative to output and employment in that sector repectively. "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. Note, that we assume a benchmark loss of 0 in the calculations here.

Table 5: Policy Experiment - Adoption of Chinese Protection Parameters in Construction

country	estimated change in output in the construction sector	country	estimated change in output in the construction sector
Senegal	30.8%	Kazakhstan	2.2%
Zambia	21.0%	Czech Republic	2.1%
Togo	20.0%	Azerbaijan	2.1%
Botswana	10.2%	Albania	2.0%
Malawi	10.1%	Germany	2.0%
Nicaragua	9.8%	Argentina	1.9%
Philippines	7.8%	Russia	1.9%
Mauritius	7.3%	Mali	1.8%
South Sudan	7.0%	Moldova	1.8%
Cambodia	7.0%	Paraguay	1.6%
Congo, Dem. Rep.	6.5%	Estonia	1.5%
Madagascar	6.1%	Macedonia, FYR	1.4%
Nigeria	5.8%	Timor-Leste	1.4%
El Salvador	5.7%	Belarus	1.3%
Burkina Faso	5.6%	Armenia	1.3%
Kyrgyzstan	5.6%	Mongolia	1.3%
Egypt	5.3%	Vietnam	1.2%
Namibia	4.5%	India	1.2%
Brazil	4.2%	Romania	1.2%
Tunisia	4.1%	Lithuania	1.2%
Cameroon	3.4%	Bulgaria	1.1%
Colombia	3.4%	Poland	0.9%
Kosovo	3.3%	Spain	-1.1%
Bolivia	3.2%	Israel	-1.5%
Ukraine	2.9%	Lebanon	-1.6%
Ecuador	2.8%	Sweden	-1.9%
Tajikistan	2.7%	Afghanistan	-2.2%
Bosnia and Herzegovina	2.5%	Mexico	-4.0%
Average in column:	7.63%		0.96%

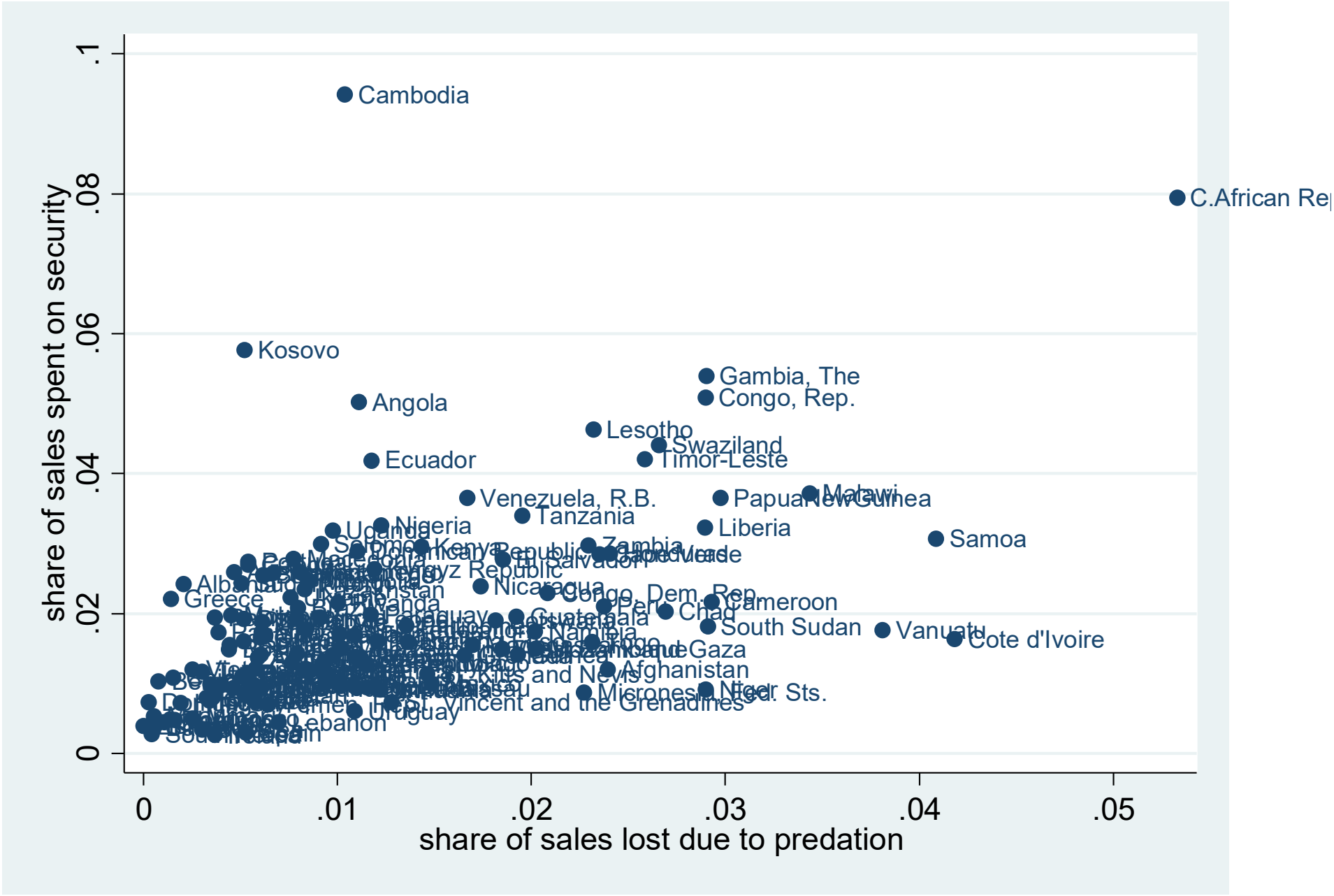
Note: Change in output is calculated by replacing the gamma and protection elasticity in each firm by a random draw from the Chinese parameter values for firms in the construction sector. We do this repeatedly (500 iterations) and report the mean for those countries whose mean change in output is larger in absolute terms than 1.65 the standard deviations of the change in output. We drop countries and territories with less than 1 million inhabitants and less than 20 interviewed firms in construction.

Table 6: Crime and Firm Growth

VARIABLES	(1) firm purchased asset	(2) firm purchased fixed asset	(3) ln(fixed asset expenditure)
perceived protection	0.0178***	0.00784**	0.119***
	(0.00399)	(0.00389)	(0.0322)
protection effort elasticity	0.0351***	0.00691*	0.180***
	(0.00416)	(0.00389)	(0.0297)
firm productivity decile dummies	yes	yes	yes
country/year fixed effects	yes	yes	yes
sector fixed effect	yes	yes	yes
Observations	135,283	76,718	59,174
R-squared	0.244	0.405	0.753

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

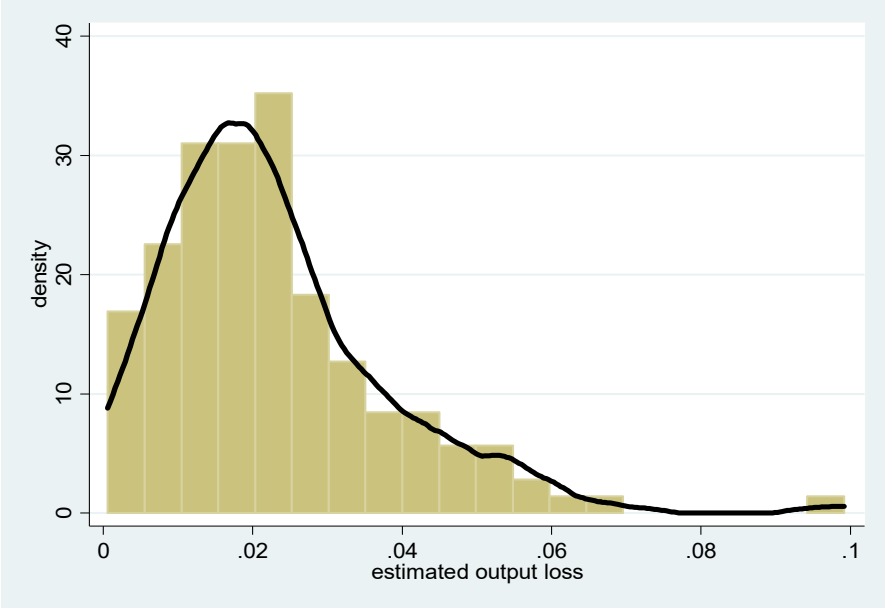
Figure 1: Country Averages of Predation Loss and Security Spending



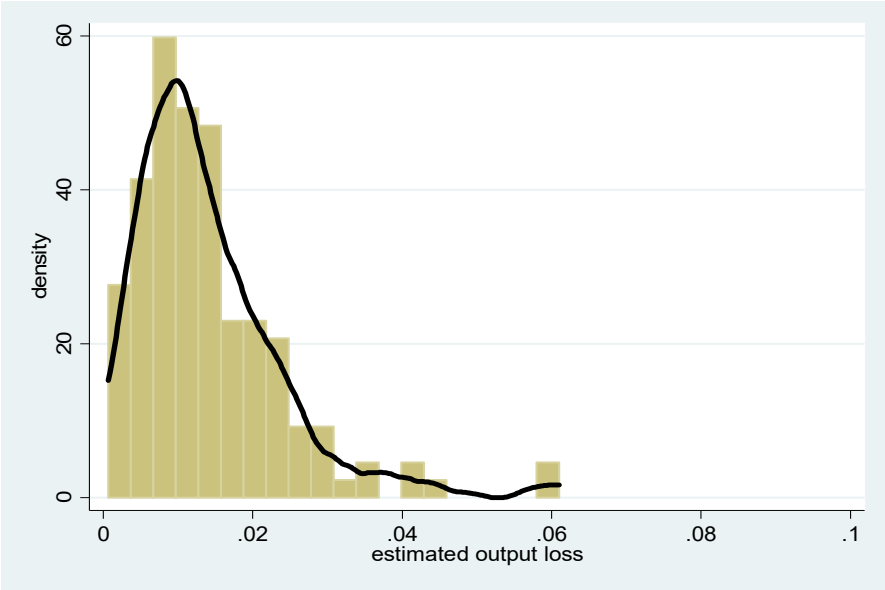
Notes: Figure shows simple mean values for the responses to two survery questions. We first calculate the weighted mean for every country/year using the survey weights. This is close to what the World Bank reports. The Figure displays the mean value for each country across years.

Figure 2: Histogram of Estimated Output Loss

Panel A: Estimated Output Loss

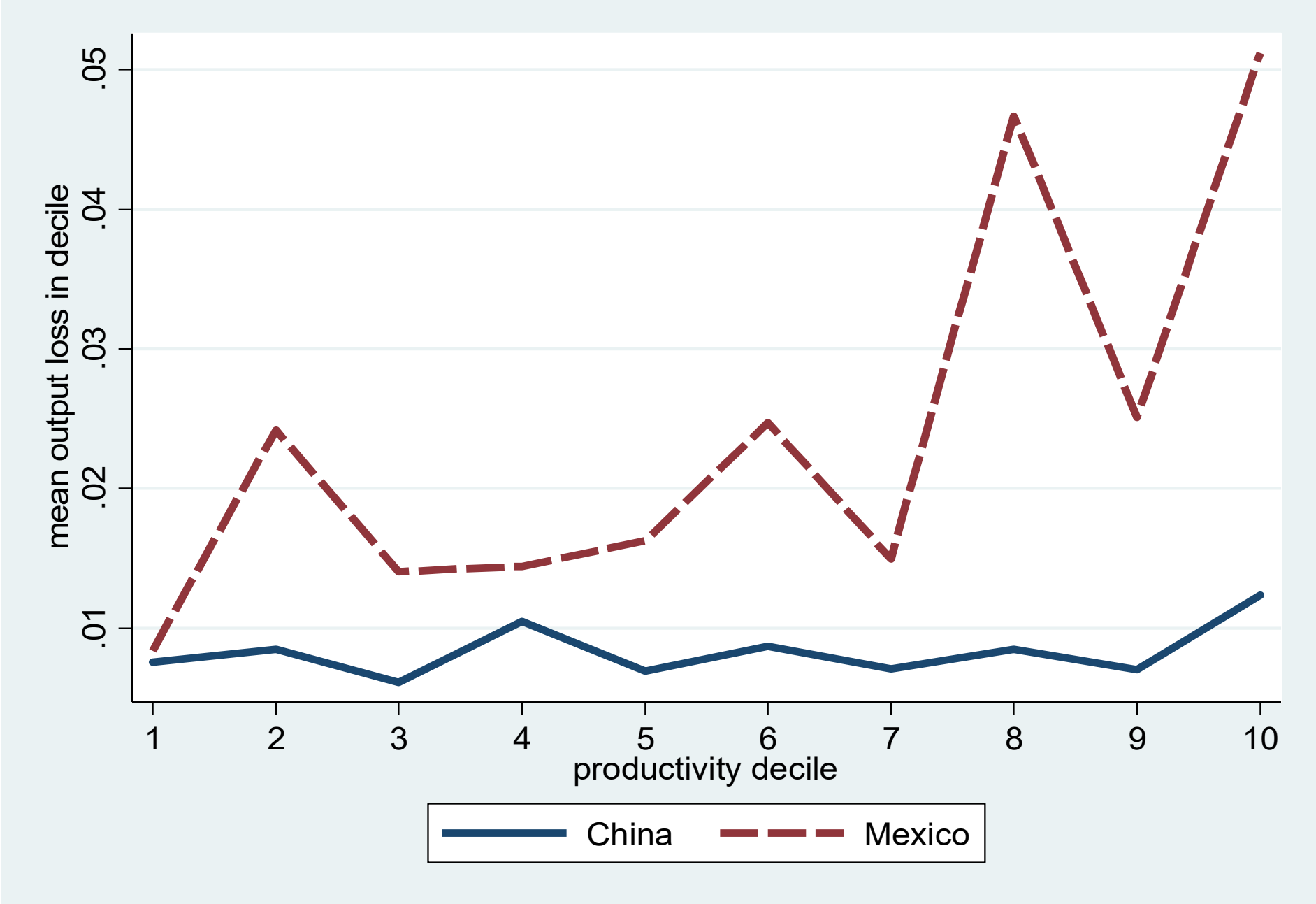


Panel B: Estimated Output Loss Without Predation



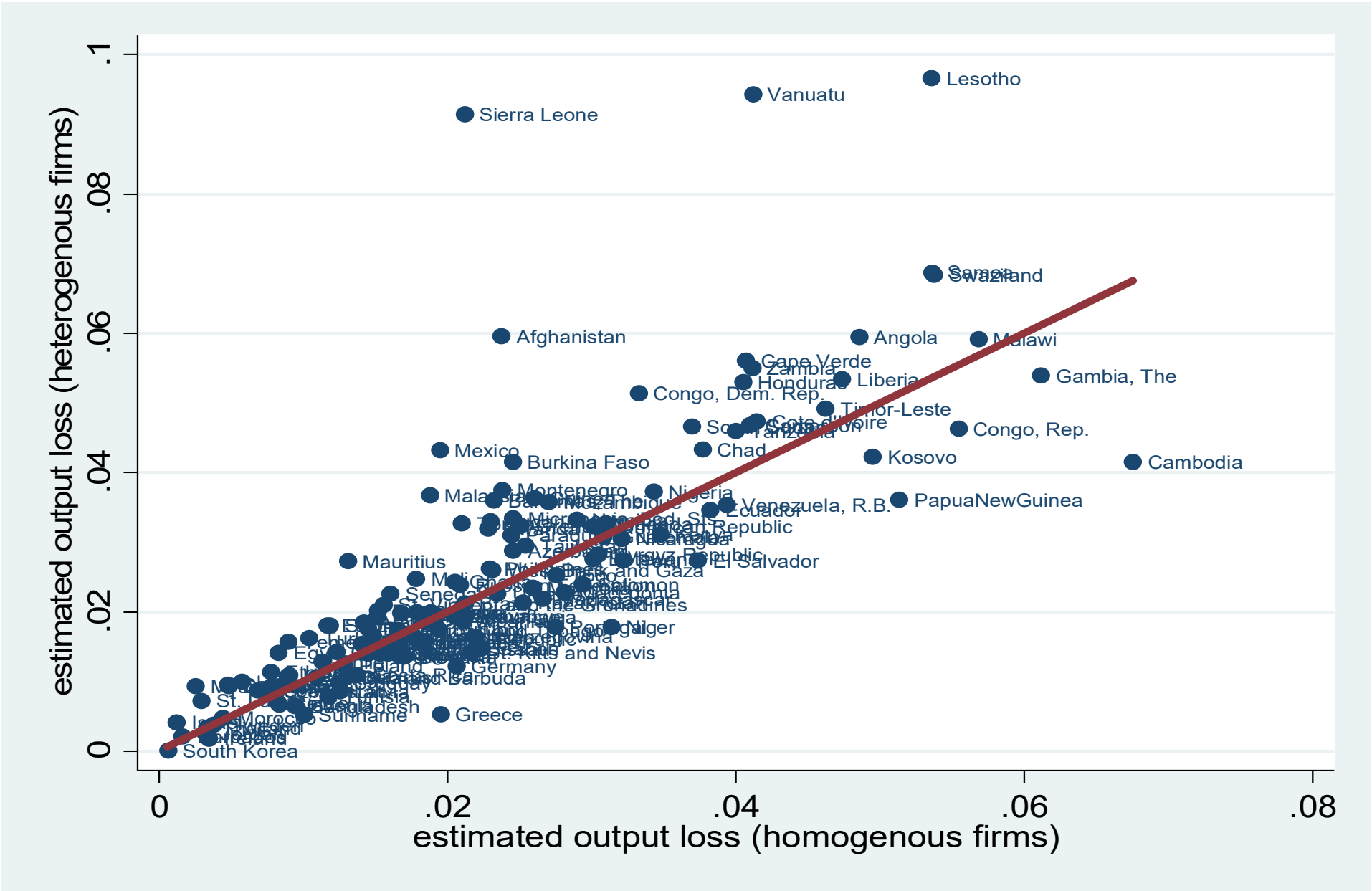
Notes: Figure contrasts two ways of calculating the output, Δc, from equation (12) . The output loss in Panel A is calculated under the assumption that all predation constitutes a loss (τ=0). The loss due to spending in Panel B is calculated by assuming that all predation is an efficient transfer (τ=1).

Figure 3: Estimated Loss by Firm Productivity Deciles



Notes: Figure shows the output loss, Δc, from equation (12) calculated by productivity decile, i.e. each point represents one tenth of the firms in the respective sample ordered by our estimate of θ/Θ. Note that in both cases we maintain South Korea as a benchmark crime loss.

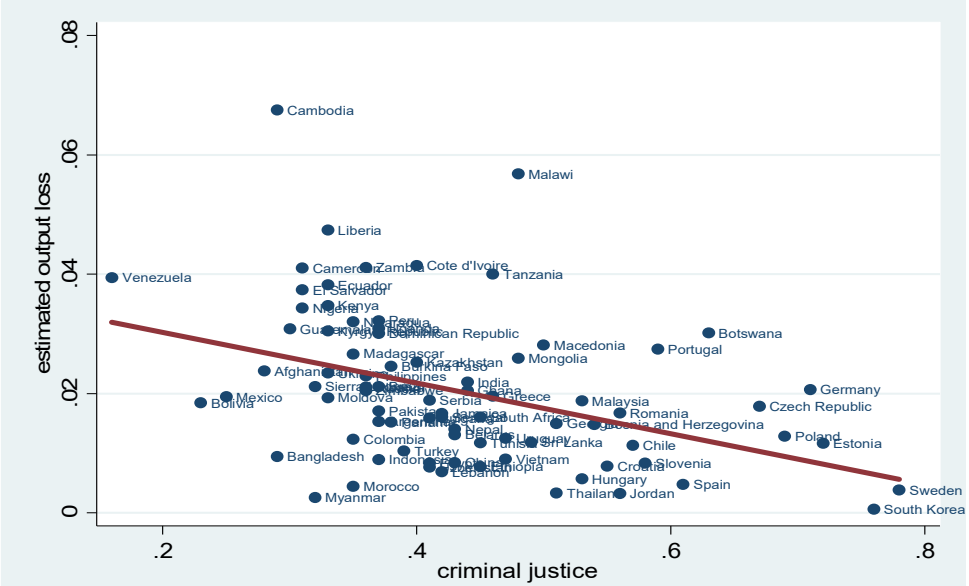
Figure 4: Introducing Productivity Weights



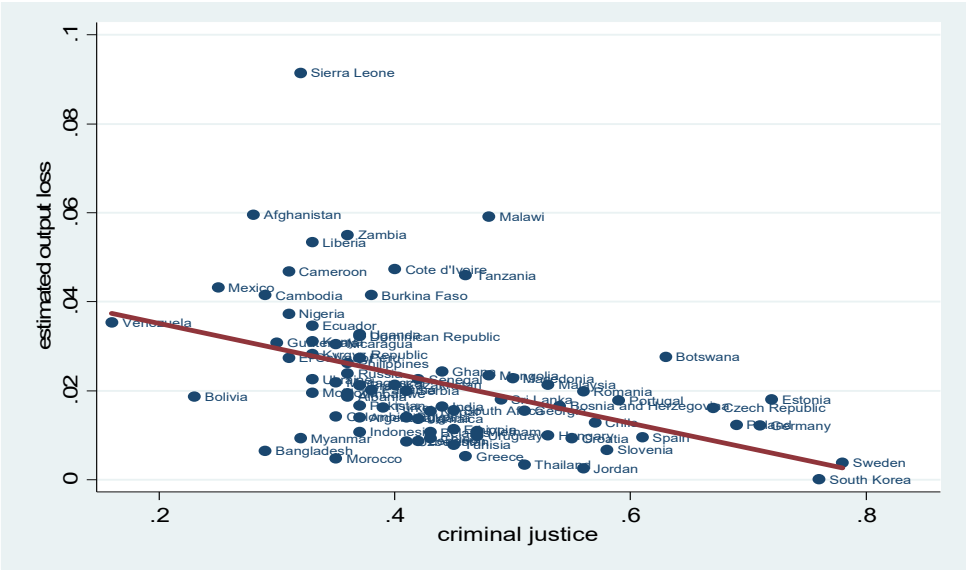
Notes: Figure contrasts the output loss, Δc, from equation (12) on the x-axis with the output loss, Δc, from equation (13). In each case we first calculate the output loss for each country/year and then take the mean value for the respective country. The red line represents the points at which the two losses are the same. The Central African Republic dropped as an outlier.

Figure 5: Estimated Output Loss and State Action

Panel A: Output Loss Estimated Assuming Homogenous Firms



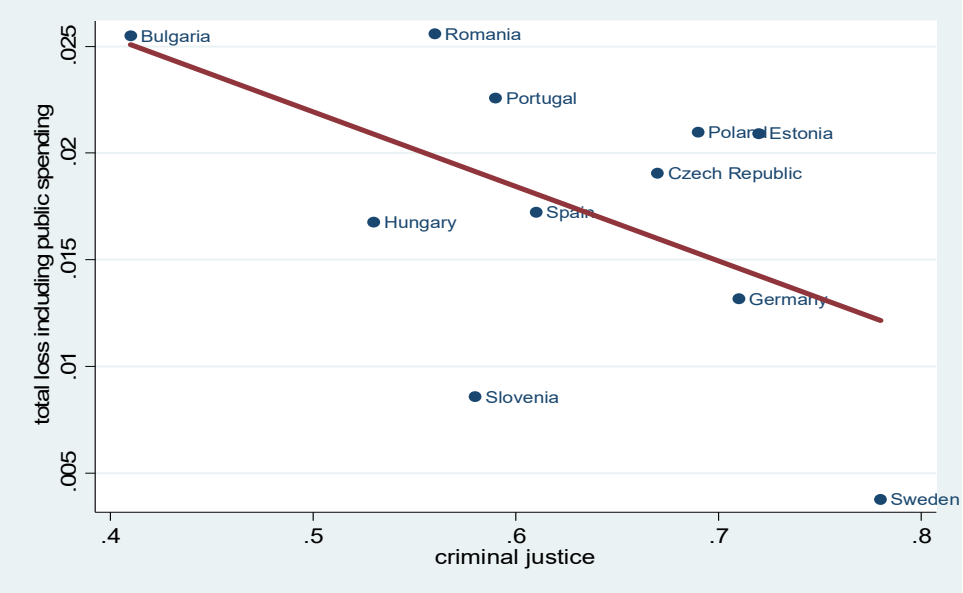
Panel B: Output Loss Estimated Assuming Heterogenous Firms



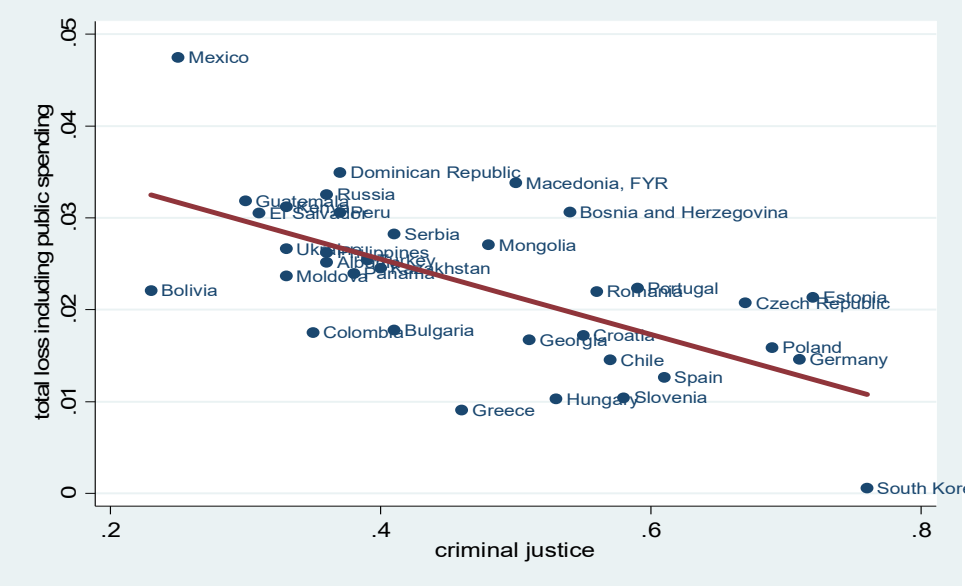
Notes: Panel A shows the output loss, Δc, from equation (12) and Panel B shows the output loss, Δc, from equation (13). This is contrasted with the World Justice project index which measures the effectiveness of the criminal justice system on a scale between 0 and 1.

Figure 6: Estimated Output Loss and State Action

Panel A: Total Output Loss Using EU Public Spending Data

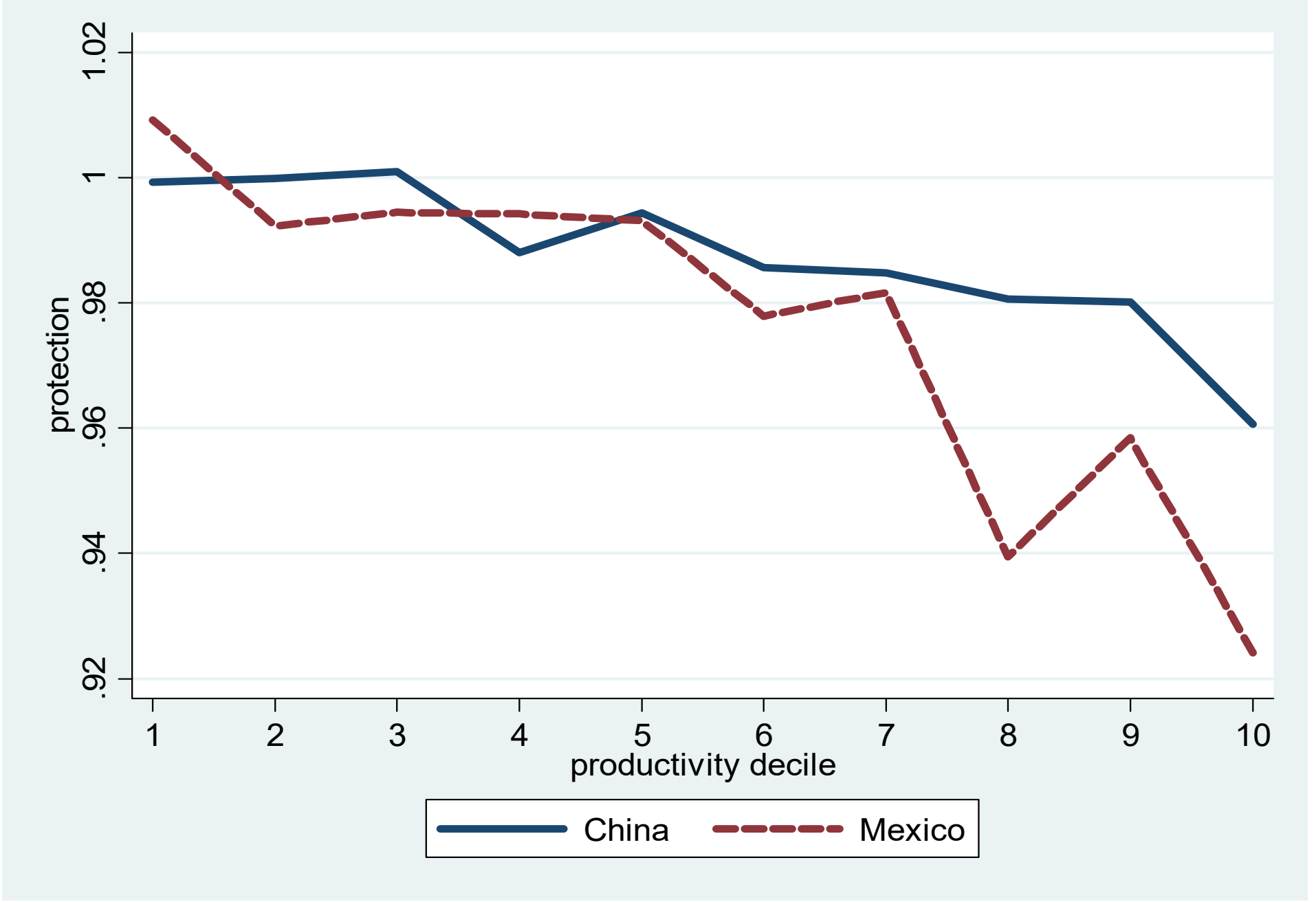


Panel B: Total Output Loss Using UNODC Employment Data



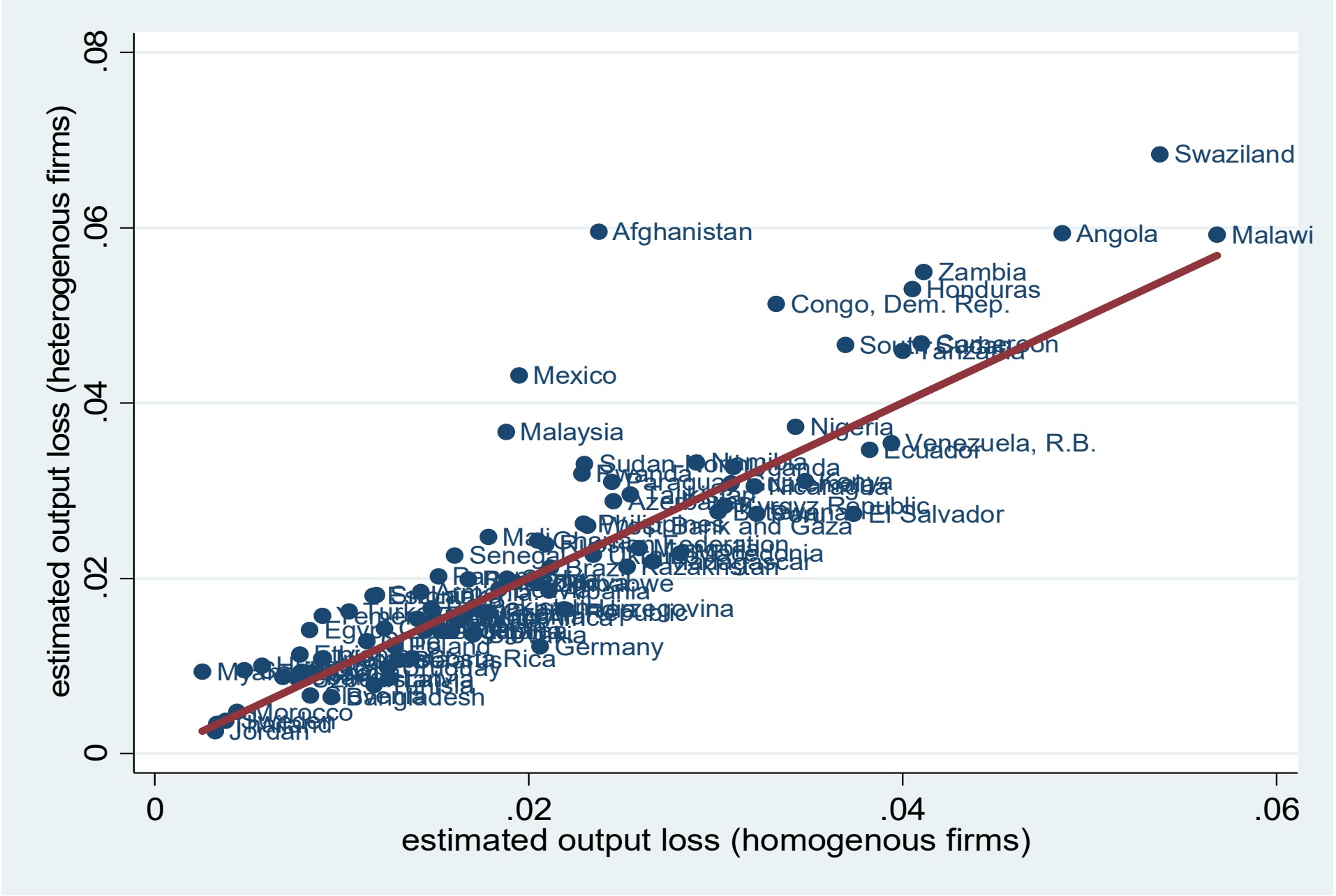
Notes: Panels A and B show the output loss from equation (14) as discussed in the text. This is contrasted with the World Justice project index which measures the effectiveness of the criminal justice system on a scale between 0 and 1.

Figure 7: Protection Estimates by Firm Productivity Deciles



Notes: The Figure displays the average value of ϵ from equation (15) by productivity decile, i.e. each point represents one tenth of the firms in the respective sample ordered by our estimate of θ/Θ.

Figure 8: Adding Predation During Transport



Notes: Figure contrasts the output loss from equation (12) on the x-axis with the output loss from equation (13). The only difference to Figure 4 is that we add predation losses due to theft in transit or export. For details see section 8 in the main text. South Korea is the mimum crime benchmark but has no data on losses during transport. The red line represents the points at which the two losses are the same.