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Corruption, Regulatory Burden and Firm Productivity

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Abstract

Using firm-level data from more than 39,000 firms in 111 economies, this paper tests the hypothesis that corruption impedes productivity more at higher levels of regulation. The analysis finds that there is a significant negative relationship between corruption and firm productivity when regulation is high and an insignificant relationship when it is low. These findings are robust to different controls and specifications.

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1. Introduction

Corruption hinders firm productivity by diverting resources away from their best uses. It does so, among other channels, by increasing the premium on rent seeking, creating secrecy and uncertainty and undermining public resources. Corruption also promotes excessive regulation, further empowering bureaucrats to extort rents and amplifying corruption's negative effects on productivity (e.g. Shleifer and Vishny 1993; Banerjee 1997; Aidt 2016). Adverse effects of corruption on talent, investment, innovation, entrepreneurship, growth and public resources are well documented in the literature (e.g. De Soto 1989; Murphy et al. 1991, 1993; Mauro 1995; 1998; Tanzi and Davoodi 1997; Wei 2000; Djankov et al. 2002; Gamberoni et al. 2016; d'Agostino et al. 2016; Cieslik and Goczek 2018).

Empirical studies such as Meon and Sekkat (2005) and De Rosa et al. (2010) show that corruption is more damaging for economic performance at higher levels of regulation or lower levels of governance quality. Some studies also find that corruption eases the burden of excessive regulation and thereby improves economic performance (e.g. Leff 1964; Lui 1985; Dreher and Gassebner 2013). However, as pointed out in several studies, such as Campos et al. (2010), there is no widespread evidence for the latter. One reason is that corruption may speed the bureaucratic process in the short run, but in the long run, it will lead to more regulation and cause more damage in the economy.

Building on the above literature, in this paper, we use firm-level survey data on 39,732 firms in 111 countries collected by the World Bank's Enterprise Surveys between 2009 and 2017 to test the hypothesis that corruption impedes firm productivity more at higher levels of regulation. Corruption is measured with three indicators: bribe rate (measured as the percentage of bribes in firms' sales), bribery incidence (percentage of firms from which bribe is requested by public

officials at least once) and bribery depth (percentage of public transactions for which a gift or informal payment was requested). Regulation is measured with two indicators: percent of management time spent on complying with regulatory processes and number of visits made to the tax office to meet with tax officials. Productivity refers to labor productivity computed as sales of firms per worker.

We estimate the model using sample weighted OLS (Ordinary Least Squares) regression analysis. To mitigate the endogeneity problem, we control for country, industry, sector, region and year fixed effects, and extensive numbers of productivity determinants cited in the literature. To further mitigate the endogeneity between productivity and corruption and regulation, we use the averages of the latter two over all other firms in the cell, where cell is defined as the group of firms in the same size category, industry and city within a country.

We find that the negative relationship between corruption and productivity is amplified at high levels of regulation. In fact, at low levels of regulation, the relationship between corruption and productivity is insignificant. To fix ideas, we find that a 1 percent increase in bribes that firms pay to get things done, expressed as the share of annual sales, is significantly associated with about a 0.9 percent decrease in productivity of firms at the 75th percentile value of regulation (high regulation). In contrast, at the 25th percentile value of regulation (low regulation), the corresponding change is very small and statistically insignificant, though it is still negative.

This paper is the first using global firm-level data to investigate the interlinkages between corruption, regulation and productivity and it is among the handful of firm-level studies on the subject. To the best of our knowledge, De Rosa et al. (2010) is the only other study using international firm-level data to analyze the corruption-regulation-productivity nexus. However, their data cover only 28 countries in Central and Eastern Europe and the Commonwealth of

Independent States in 2009. They find that corruption decreases productivity more at higher levels of regulation. Other differences of our study from De Rosa et al. (2010) are that we include larger numbers of controls, remove outliers using a command developed for sample weighted data, and provide numerous sensitivity analyses.

The rest of the paper is organized as follows. The next section provides a brief analysis of the theoretical and empirical literature followed by Section 3 explaining the data and methodology. Section 4 provides a brief overview of the descriptive statistics. Section 5 presents the empirical results, and Section 6 concludes the paper.

2. Literature review

2.1 *Theoretical literature*

Economic theory suggests several channels through which corruption impacts growth and productivity in the private sector. For example, Murphy et al. (1991) and Shleifer and Vishny (1993) show that corruption retards productivity by shifting talent, investment and technology away from their most productive uses, as it raises the returns to rent-seeking activities vis-à-vis productive activities. Uncertainty associated with bribes, arising from the random demands of bureaucrats for bribe on the same projects, either causes firms to adopt easily reversible suboptimal production methods, the so called "fly-by-night" production technology, or completely shut down their operations (Shleifer and Vishny 1993; Choi and Thum 1998).

Demand for secrecy associated with corruption opens other channels through which corruption retards economic outcomes (Shleifer and Vishny 1993). In this case, government's decision on rewarding projects is based more on the potential that those projects offer for secrecy than the social value of the projects, distorting resource allocation. Demand for secrecy also prevents efficient and innovative firms from entering markets through red tape, if they pose the

threat of exposing corruption. Corruption also retards growth and development by decreasing government revenue and the quality of public services (Tanzi and Davoodi 1997).

Unlike corruption, theories of regulation are less clear about the effect of regulation on economic performance and productivity. The public interest theory of Pigou (1938), the oldest and the most influential theory of regulation throughout the last century, postulates that regulation is necessary to correct market failures caused by monopoly and externality. However, according to Shleifer (2005), this theory fails to recognize that competition and private litigation can address many of these market failures.

The contract theory of Coase (1960) and the capture theory of Stigler (1971) challenge the public interest theory further by asserting that regulators are incompetent, corrupt and captured by vested interest groups, therefore, they are highly unlikely to have any incentive to correct for market failures. Coase (1960) proposes to address market failures through independent courts enforcing contracts based on laws. However, the weakness of this model is that it relies heavily on courts being impartial, informed and incorruptible, while evidence shows that courts can also be inefficient, politically motivated, slow, and corrupt (Djankov et al. 2003a; Shleifer 2005).

As an alternative to these traditional models of regulation, Djankov et al. (2003b) and Shleifer (2005) offer the enforcement theory of regulation. This model is based on the recognition that optimum institutional design requires choosing among the alternative theories (mentioned above) based on analysis of the trade-off between the social costs and benefits of those alternatives in different institutional environments. They point out that market discipline is the best option to the extent that it can address the failure, but it may not always be sufficient, in which case other theories will be called upon. They present firm entry as an example to be left to market discipline and safety standards and security issuance to be regulated by government.

Recent theories of corruption and regulation often recognize the feedback between them (e.g. Banarjee 1997; Guriev 2004). For example, Banerjee (1997) predicts that red tape is used by bureaucrats for two reasons: (i) to screen in the users with high willingness to pay bribe, in which case it will be placed on those users who have a low probability of obtaining the service or good; and (ii) to screen out the users with low ability to pay bribe, in this case the users with high ability to pay and high probability to obtain the service will be the subject of the red tape. That public rule is prone to public abuse and the scope of this abuse increases as the public rules increase is well recognized by many studies, such as Shleifer (2005). This premise is the basis of our hypothesis: corruption becomes more entrenched and therefore, more detrimental to productivity at higher levels of regulation. Consequently, all the negative effects of corruption cited above are expected to be more pronounced at higher level of regulation.

For example, uncertainty arising from the demands of different bureaucrats for bribes on the same projects forces firms to adopt easily reversible and potentially sub-optimal production methods. Arguably, the stated uncertainty can only increase as regulation becomes more widespread, intricate and excessive. For example, heavier regulation through an increase in the number of procedures required to obtain an import license gives greater leeway for bureaucrats to exercise their power for extraction of rents, exacerbating uncertainty. Similarly, as regulation becomes more excessive, it offers greater benefits to those who are able to bribe their way through.

2.2 *Empirical literature*

Empirical analyses of corruption and economic performance generally rely on macro-level data. For example, Mauro (1995) analyzes the association of corruption with investment and growth and he finds that corruption reduces both. Wei (2000) provides evidence that both tax on foreign direct investment (FDI) and the corruption level in the host country decrease inward FDI.

Meon and Sekkat (2005) and Lambsdorff (2004) find evidence that the negative impact of corruption on economic growth and productivity, respectively, becomes worse as the quality of governance deteriorates. Similarly, Loayza et al. (2004) provide evidence that heavier regulation goes hand in hand with worse governance in adversely affecting economic growth and macroeconomic volatility. Salinas-Jimenez and Salinas-Jimenez (2007) show that corruption reduces both the level and growth rate of total factor productivity and the main channel of this effect is the reduction in technological change.

Among the micro-level studies, Fisman and Svensson (2007) is one of the early studies employing firm-level data from Ugandan Industrial Enterprise Surveys covering 243 firms in 1998. They investigate the impact of corruption and taxation on growth, instrumenting bribe and taxation with their industry-location averages to address a potential endogeneity problem. After excluding outliers, they find that a 1 percent increase in the bribe rate is associated with about a 7 percent decrease in growth. They do not find any significant relationship between taxation and growth. Another micro-level study, carried out by Aghion et al. (2016), employing data from the U.S. Census Bureau for 1983-2007, finds that higher corruption decreases the positive effect of taxation on growth, innovation, and entry.

Diwan et al. (2015) employ data from 469 firms connected to the Mubarak regime in the Arab Republic of Egypt during 1996-2006 to analyze whether they received favorable regulatory treatment and had a negative impact on productivity. They find that those firms were more likely to benefit from trade protection, energy subsidies, access to land and regulatory enforcement and there was a slowdown in the employment growth and productivity in the industries after their entry into them, as that skewed the distribution of employment towards less productive and smaller firms. De Rosa et al. (2010) use firm-level data from the EBRD/World Bank Business

Environment and Enterprise Performance Survey (BEEPS) collected in 2009 from 28 countries in Central and Eastern Europe and the Commonwealth of Independent States to examine the impact of regulation and corruption on productivity. They find that an increase in the incidence of bribes from zero to one decreases productivity by 0.045 percent, while an increase in time spent on tax administration does not have a significant impact. They also show that corruption reduces productivity more when it is more prevalent and the legal framework is weaker.

3. Data and methodology

In this section, we discuss the data and the estimation methodology used in the empirical analysis. The analysis is based on the surveys from 39,732 firms conducted by the World Bank's Enterprise Surveys in 111 economies during 2009-2017. A common sampling methodology – stratified random sampling – was followed in all the surveys along with a common questionnaire.[1] The sample for each country was stratified by industry, firm-size, and location. Sampling weights, which take into account the industry-size-location strata, are provided in the survey and used in all the analyses, including regressions, descriptive statistics and graphs, to ensure that the sample is representative of the non-agricultural private sector of the economy.

We start our analysis with data from 40,613 firms in 111 economies that have observations on the main variables used in the analysis. After excluding the countries with three and fewer cells and treating the sample for outliers using a program developed for data with sampling weights, the sample size drops to 39,732 firms in 111 economies. The sample size reduces slightly to 39,650 with the inclusion of the variable proxying for the investment of firms, which is a dummy variable showing whether firms bought assets in the previous year.[2]

[1] Details of the sampling methodology and surveys are available at www.enterprisesurveys.org.
[2] ES data also have an indicator on the capital-labor ratio. However, since this indicator has too many missing observations, reducing the sample size from 39,000 to 12,000, we opted for the above-mentioned indicator.

Inclusion of the share of the labor force with a high school degree (which proxies skilled labor share) and raw materials in the analysis decreases the sample size to 28,979 and 17,132 respectively, due to missing data. Since there are no other proxies for skilled labor and raw materials, we reported the results with these variables for a robustness check. The definitions of the variables, list of countries, and the summary statistics and correlation coefficients of all variables used in the regressions are reported in Tables A.1 and A.2, while the distribution of the main variables of interest are presented in Figure 1 in the appendix.

We estimate the model using OLS regression analysis that accounts for sampling weights (using the *svy* command in STATA) and country, industry, sector and region dummies to address potential endogeneity issues.[3] The identification of our results comes from differences across firms within a region, country, sector and industries, a strategy that is less prone to endogeneity problems than one based on cross-country and cross-industry regressions. To further mitigate the endogeneity concerns, we proxy the level of corruption and regulation faced by a firm by the average level of corruption and regulation experienced by all other firms in the same size-industry-city cell (details below).

To see how the relationship between corruption and productivity of firms varies depending on the level of regulation, we take two approaches. First, we use the interaction term between corruption and regulation in our regressions. Second, we estimate the corruption-productivity relationship separately for the sample of firms that face a high level of regulation and those that face a low level of regulation (split sample approach). Despite the attempts, due caution is necessary in interpreting our results based on cross-section data. That is, while the results are

[3] Year trend is also included in the analysis to control for global shocks that took place in different years during 2009-2017, when data were collected for 111 countries covered by the analysis.

suggestive of a possible causal effect of corruption and regulation on the productivity of private firms, they are not necessarily causal.

3.1 Description of variables

Our dependent variable, productivity, refers to labor productivity defined as the log of total annual sales of the firm (in 2009 USD) during the last fiscal year divided by the total number of permanent full-time workers employed by the firm at the end of the last fiscal year (*Productivity*). The mean and median values of *Productivity* are 9.79 and 9.83, respectively, while its minimum and maximum values are 2.63 and 16.87, respectively. This indicates that the log of productivity is normally distributed and varies substantially across firms (Table A.2).

Our main explanatory variables include measures of corruption and business regulations faced by the private firms and the interaction term between the two. Regarding corruption, the ES asked firms the amount of bribes firms like "themselves" pay as a percentage of their sales to public officials to "get things done". Note that the bribe amount is for other firms and not the firm in question. This is because firms may not feel comfortable reporting their own bribe payments. However, it is expected that the responses of firms to the question most likely reflect their own experience with bribery.

Using the reported bribery rate (henceforth, bribes) in the regression directly is problematic. Bribes paid by a firm is likely to be endogenous to various firm characteristics such as its size, location, industry, et cetera. In fact, a feedback effect from productivity to bribes cannot be ruled out. For instance, the opportunity cost of waiting to obtain a license is likely to be greater for the more productive firms. Hence, these firms may be targeted by government officials for higher bribes.

One approach suggested in the literature to mitigate the endogeneity issue mentioned above is to proxy the firm-level bribes with the average value of the variable taken over all other firms in the industry-size-city cell (e.g. Fisman and Svensson 2007; De Rosa et al. 2010; Dollar et al. 2006). The assumption here is that a firm's experience with corruption is likely to be correlated with the experience of other similar firms in the cell. Thus, it would be a good proxy for corruption faced by a firm. At the same time, there is little reason to expect the firm's own productivity level and other characteristics to have any causal impact on the level of corruption faced by the other firms in the cell, giving validity to the proposed strategy.

Thus, we define our main corruption variable as the average value of bribes paid to get things done as reported by the firms and expressed as percentage of firm's annual sales, where the average (of bribes to sales ratio) is taken over all other firms, excluding the firm in question, in the industry-size-city cell (*Corruption*). In our sample, there are 7 industries, three firm-sizes (small, medium and large) and 418 cities.

For regulation, we use the ES indicator on the share of the senior management's time spent on dealing with business regulations. Similar to corruption, we use the average value of the variable over all other firms in the industry-size-city cell (*Regulation*). Note that our regulation measure is a *de facto* measure rather than a *de jure* measure (rules on the books) typically used in the literature. We believe that this is an important distinction as what is likely to exacerbate the adverse effects of corruption is not just the regulations on the books, but the leeway that bureaucrats and politicians have in their interpretations and implementation. Our regulation measure has been used in other studies such as Duvanova (2014).

The interaction term, our key explanatory variable, is given by the product of *Corruption* and *Regulation*. It captures how the relationship between productivity and corruption depends on the level of regulation faced by the firms.

For robustness, we employ alternative measures of regulation and corruption. For regulation, we use the average number of visits or required meetings with tax officials averaged over all other firms in the cell (*Regulation 1*). For corruption we use bribery depth (percent of public transactions where a gift or informal payment was requested) and bribery incidence (percent of firms experiencing at least one bribe payment request), both averaged over all other firms in the cell (*Corruption 1* and *Corruption 2*, respectively). Details of the public transactions for which bribe payments were expected or requested are provided in table A.1.

3.2 *Other control variables*

As discussed above, reverse causality from firm productivity to the average value of corruption and regulation faced by all other firms in the cell is highly unlikely, although it cannot be ruled out completely. A relatively bigger concern with our regression results is the omitted variable bias, even though part of the bias is addressed by using the cell-averages instead of firms' own values. To further mitigate this issue, we control for a wide range of variables as well as their interaction terms with corruption and regulation. The choice of control variables is based on the existing literature on the covariates of productivity, corruption and regulation, explained in detail below.

First, we include in the regressions the log of GDP per capita as well as the dummy variables of countries where the firm is located (country fixed effects). Controlling for GDP per capita and country fixed effects ensures that our main results (for corruption and regulation and interaction between them) are not spuriously driven by macro-level variables such as the overall institutional and regulatory environment of countries. To provide an example, richer countries are

known to have lower levels of corruption and regulation, but they also have better physical and financial infrastructure which could have direct impacts on productivity. Thus, in the absence of country fixed effects, our corruption and regulation variables could easily spuriously pick up the effects of physical and financial infrastructure on productivity.

Second, productivity differences can also arise across industries and sectors. If industries or sectors that have high productivity also happen to be with low or high corruption and/or low or high regulation, then our main results could suffer from omitted variable bias problem. To guard against this possibility, we control for industry and sector fixed effects. Our data have 9 one-digit industries and 3 sectors, including manufacturing, retail and services. We also include region dummies and year trend in the analysis to control for region specific characteristics that may affect productivity and potential effects of global shocks that took place in the years when the data were collected.

The next set of controls includes size, age, export status and foreign ownership. There is a fair amount of literature on the importance of these variables for the productivity of firms. Among other factors, the positive relationship between firm-size and productivity is often attributed to greater allocative efficiency for the relatively larger firms (Tybout 2000; Bartelsman et al. 2013). Firm-size is also considered an important proxy measure for several firm attributes such as access to finance, access to raw materials and product markets, tendency to innovate, exporting activity, firm-efficiency, and growth (e.g. Acs and Audretsch 1988; Cohen and Klepper 1996; Pagano and Schivardi 2003; Söderbom and Teal 2004). For firm-size, we use (log of) number of full-time permanent workers at the firm at the end of the last fiscal year (*Firm size*).

Substantial work has also been done linking productivity and age of the firm. Age related effects among surviving firms may be due to a number of reasons, including scale economies

gained from expansion over time, vintage effect due to younger firms employing new and improved technology or equipment, selection effects which weed out inefficient firms implying higher productivity for the surviving older firms, and of course passive learning or learning by doing (see for example, Jovanovic 1982; Zimmerman 1982; Bahk and Gort 1993; Jensen et al. 2001; and Thompson 2005, 2010).

Productivity differences between exporting and non-exporting and foreign and domestic firms have long been at the center of research. There is robust evidence that exporting activity is positively correlated with productivity, although it is not certain if exporting causes firms to become more productive or productive firms self-select themselves into exporting activity (Bernard and Jensen 1999; Melitz 2003; Wagner 2007). Similarly, firms with foreign ownership enjoy numerous benefits such as better access to modern technology, greater access to international markets, etc. These benefits in turn translate into improved productivity. If the levels of corruption and regulation faced by firms vary systematically with exports or foreign ownership, it could result in an omitted variable bias problem with our results. For exporting activity, we use a dummy variable that indicates whether the firm exports or not (*Exporter*).[4] For foreign investments, we use the proportion of the firm that is owned by foreign individuals and companies (*Foreign*).

The subsequent set of controls includes measures for firms' access to finance and the characteristics of managers. Access to finance is frequently cited as one of the biggest obstacles faced by firms in developing countries (Levine and Zervos, 1998; Beck et al., 2000; Benhabib and Spiegel 2000; Midrigan and Xu 2014; Heil, 2017). We use three measures of access to finance. A dummy variable indicating if the firm has overdraft facility (*Overdraft*), and two dummy variables indicating if access to finance is a major or severe obstacle to firm's operations (*Fully Constrained*)

[4] We use a 5% cut-off level for the proportion of output sold in international markets for a firm to be classified as an exporter. We experimented with other cut-off levels but this did not change our main results qualitatively.

or moderate obstacle (*Partially Constrained*) as opposed to slightly constrained or not constrained at all.

A number of studies have analyzed gaps in productivity stemming from the manager's gender and quality. Firms owned/managed by women tend to have lower productivity than those owned/managed by men (Coleman 2000; Du Rietz and Henrekson 2000; Sabarwal Terrell 2008). This is likely to be due to differences in the size of the firms managed by women, difficulty that women face relative to men in obtaining finance, and social attitudes that tend to discourage women's economic participation. We control for this with a dummy variable indicating if the top manager of the firm is female or not (*Female manager*). Differences in the quality of management, for reasons other than the gender of the top manager, have been found to impact firm productivity (see for example, Bloom and Van Reenen 2007; Syverson 2011; Pfeifer 2015). Differences in education and experience of the top manager could be the possible factors driving differences in management quality. We control for this using a proxy measure which equals (log of) the number of years of experience the top manager of the firm has working in the industry (*Manager's experience*).

The higher the innovative activities of firms and training provided to employees the higher will be the expected productivity according to the endogenous and human capital-based growth theories (Lucas 1988; Romer 1990). To account for these effects, we included dummy variables on whether the firm has an internationally recognized quality certification (*Certification*) and whether it provides formal training for its permanent, full time employees (*Training*) as well as the share of employees who completed high school (*Skills*).

Institutional quality and secure business environment are essential for day to day activities of firms. Therefore, we also include indicators on the quality of courts (*Courts*) and crime (*Crime*).

Quality of courts is measured as a dummy variable averaged over all other firms in the industry-size-region cell. The variable is equal to 1 if the firm reports the functioning of courts as a major, severe, or very severe obstacle for its current operations and 0 if it reports it as a minor or no obstacle. Crime dummy takes on 1 if the firm experienced losses due to theft, robbery, vandalism or arson in current fiscal year and 0 otherwise.

Factors of production are incorporated in the model last, as their sample size is smaller than the other indicators. We proxy physical investment using a dummy variable for whether firms bought assets in the previous year (*Assets*). Skill of the labor force is measured through the share of the firm's permanent full-time workers who completed high school (*Skills*) and the raw materials are measured as the ratio of materials in 2009 USD to permanent full-time employees.

3.3 *Interaction terms as controls*

The control variables discussed above are all level variables and filter out several possible ways in which the estimated relationship between corruption, regulation and productivity could be biased. However, our focus is not on the level of corruption and regulation but their interaction term. The level controls do not control for the fact that the differential impact of corruption on productivity depending on the level of regulation could be spuriously picking up the differential impact of corruption for example depending on firm-size under the assumption that firm-size and regulation are correlated.

To provide an example, De Rosa et al. (2010) report evidence that the negative impact of corruption on firm productivity is much higher for non-EU countries than for the recent EU-member countries in their sample. The authors conclude that since the levels of institutional quality are generally higher in EU countries, it is likely that the effects of corrupt behavior on firm performance vary depending on broader country characteristics. Clearly, there are numbers of

potential candidates for the broader country characteristics other than regulation. In order to remove any lingering concerns about the possibility of spurious correlation mentioned in the previous paragraph, we interact all controls discussed above, including industry, country, region, year fixed effects, with both the corruption and regulation variables. The resulting interaction terms are then added as additional controls.

3.4 *Non-monotonic effects of corruption and regulation*

One issue that remains is that corruption and regulation are not completely independent of one another. That is, corruption creates incentive for more regulation and more regulation leads to higher corruption. This suggests the possibility that the impact of our interaction term between corruption and regulation might pick up the non-monotonic effect of corruption/regulation on productivity. For instance, using cross-country data and various indicators of corruption, Mendez and Sepulveda (2006) find evidence of a non-monotonic relationship between corruption and economic growth with the relationship being negative only at sufficiently high levels of corruption incidence. To rule out the possibility, we also control for the square of corruption and regulation variable**s.**

4. Descriptive statistics

This section provides a brief overview of the descriptive statistics of the main variables and their patterns across countries, regions and income groups. (see Section 3 and Table A.1. for descriptions of the variables.) All the main variables of interest, i.e. productivity, corruption, regulation and the interaction term between the latter two, are in natural logarithms. To mitigate a potential endogeneity between firm's productivity, corruption and regulation, we use averages of corruption and regulation over all other firms, excluding the firm in question, in the same industry-

size-city cell. For instance, in Nepal's data there are 18 cells, indicating 18 different groups of firms of same size in the same industry and city. In our baseline model, there are 2,617 cells covering 39,732 firms in 111 countries. Each cell includes at least 5 firms and the mean and median numbers of cells per country are 25 and 18 respectively.

The mean values of productivity, corruption and regulation are 9.79, 0.12, and 0.09, respectively. Standard deviation of productivity is among the highest, 1.66; while the standard deviation of corruption and regulation are among the lowest, 0.15 and 0.08, respectively, compared to other indicators of the model (Table A.1 and Figure 1). Our model does not have multicollinearity as the highest correlation coefficient between the explanatory variables is 0.35 (excluding the correlations between regulation and corruption and their interactive terms and squares).

An overarching finding of the simple statistical analyses of the main variables of interest is that association of productivity with corruption and the interactive term between corruption and regulation is consistently negative across countries, regions and different income groups (Figures 2 to 4). That is, countries, regions and income groups with lower corruption and the interactive term between corruption and regulation also tend to have higher productivity. Furthermore, productivity increases with the income levels of countries, while corruption and the interaction term between corruption and regulation decreases. There is no such clear pattern for regulation.

5. Regression analysis of corruption, regulation and productivity

Our estimation is based on the following standard linear Ordinary Least Square (OLS) model that incorporates country, industry, sector and region fixed effects and time trend:

$$y_{ijs} = \alpha_0 + \alpha_1 Corruption_{cjs} + \alpha_2 Regulation_{cjs} +$$

$$\alpha_3 Corruption_{cjs} * Regulation_{cjs} + \alpha_4 X_{ijs} + \alpha_5 D_j + \alpha_6 D_{s1} + \alpha_7 D_{s2} + \alpha_8 D_r + e_{ijs} \quad (1)$$

where *y* is labor productivity (henceforth, productivity), *X* is control variables; *i, j, s, c* denote firm, country, industry and cell, respectively; D_j, D_{s1}, D_{s2}, D_r denote country, industry, sector and region dummies (fixed effects), respectively. We also include year trend in the model to control for the potential impact of global shocks in different years on productivity, given that data across 111 countries were collected throughout 2009-2017.

The results of the baseline model without any interaction terms are reported in Table 1. As observed, irrespective of the set of controls in place, there is a significant negative correlation between productivity and corruption. Specifically, a 1 percent increase in corruption is associated with around a 0.32 percent decrease in productivity (Table 1).

For the remaining variables, there is no statistically significant relationship between regulation and productivity, once the control variables are included (Table 1). Firm-size has a significant positive relationship with productivity, but this relationship becomes insignificant once we control for training provided to employees and the innovative capacity of the firm (*Certificate*). Thus, one possibility is that the impact of firm-size on productivity travels mainly through its impact on innovation and skills acquired through training. As expected, productivity is significantly higher for exporting firms; firms with higher share of foreign ownership; better access to finance; higher innovative capacity; and higher training opportunities for their employees. As Table 1 shows, these findings hold irrespective of the set of controls in place. In all regressions, we also included per capita income, prevalence of crime, perception of firms on the impartiality of courts, manager's experience, and gender. We have not reported the results for these variables

for brevity and the fact that all but income per capita (which always had a positive sign) was insignificant in most regressions.

5.1. Baseline regression with interaction terms

Next, we explore how the relationship between corruption and productivity depends on the level of regulation in different specifications of the model. To this end, we include three sets of new variables in the baseline model reported in Table 1: (i) interaction term between corruption and regulation, main variable of interest; (ii) squares of corruption and regulation to factor in any non-linearity in terms of how these variables correlate with productivity; and (iii) interaction terms of corruption and regulation with all explanatory variables in the model to account for the fact that the impact of corruption and regulation on productivity may depend on factors such as firm-size, exporting status, foreign ownership, etc.

Table 2 reports the full regression results and the estimates of the magnitude of the relationship between corruption and productivity at the 25th, 50th and 75th percentile values of regulation. As observed from columns 1 through 8, the coefficient of the interaction term between corruption and regulation continues to be negative, economically large and statistically significant at the 1 or 5 percent level for all the specifications shown. That is, irrespective of the set of controls in place, including square terms of corruption and regulation and all the other interaction terms mentioned above, the coefficient value of the interaction term is always negative, large and statistically significant. The square of corruption enters in the regressions with a negative and significant coefficient while the square of regulation is insignificant in all regressions.

We also computed the total magnitude of the relationship between corruption and productivity evaluated at different percentile values of regulation. As observed from the bottom

Table 1. Baseline regression of productivity (log) without interaction terms

	(1)	(2)	(3)	(4)	(5)	(6)
Corruption	-0.322*	-0.300*	-0.326**	-0.322**	-0.315*	-0.323**
	(0.168)	(0.168)	(0.168)	(0.167)	(0.167)	(0.168)
Regulation		0.695**	0.381	0.324	0.314	0.298
		(0.307)	(0.310)	(0.306)	(0.303)	(0.305)
Firm size (log)			0.109***	0.063***	0.029	0.027
			(0.017)	(0.017)	(0.018)	(0.018)
Firm age			0.120***	0.117***	0.098***	0.098***
			(0.025)	(0.024)	(0.027)	(0.027)
Exports (dummy)			0.254***	0.228***	0.186***	0.186***
			(0.058)	(0.057)	(0.058)	(0.058)
Foreign ownership (share)			0.523***	0.527***	0.497***	0.496***
			(0.072)	(0.071)	(0.071)	(0.071)
Overdraft (dummy)				0.384***	0.366***	0.365***
				(0.042)	(0.042)	(0.042)
Fully constrained (dummy)				-0.353***	-0.343***	-0.343***
				(0.055)	(0.056)	(0.056)
Partially constrained (dummy)				-0.186***	-0.175***	-0.175***
				(0.044)	(0.043)	(0.043)
Training (dummy)					0.206***	0.205***
					(0.041)	(0.041)
Certification (dummy)					0.245***	0.244***
					(0.058)	(0.058)
Fixed effects[a]	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	39,732	39,732	39,732	39,732	39,732	39,732
Number of countries	111	111	111	111	111	111
R2	0.307	0.307	0.326	0.343	0.349	0.349

Note: Standard errors in brackets. Significance is denoted by *** (1%), ** (5%), * (10%). Fixed effects included are: country, industry, sector, region and year. Following variables are also included in the regressions above but are not reported in the table for brevity: GDP per capita; manager's experience; manager's gender; whether firms reported courts being fair; and whether firms experienced crime.

rows of Table 2, at the 25th percentile of regulation, the relationship between corruption and productivity is insignificant. However, as we move to the 50th and 75th percentile values of regulation, the relationship becomes negative and significant in most of the specifications. In particular, a 1 percent increase in corruption is associated with a 0.86 percent to 0.94 percent decrease in productivity at the 75th percentile of regulation. Only in the regressions with the square of corruption and regulation the total magnitude of the relationship is insignificant. However, since the interaction term is still negative, large and statistically significant in these regressions, it means that the total impact of corruption in these regressions would be significant at much higher values of regulation than its 75th percentile value we used here.

Results of the regressions incorporating the indicators on investment, skills and raw materials are reported in Table 3. These indicators are included in the model last, as they have smaller samples due to missing data. As expected, both assets dummy, proxying investment, and skills variable, measured as the share of labor with high school degree, have a positive and significant coefficient until the raw materials indicator enters in the analysis with a positive and significant coefficient. This might be because neither assets dummy nor labor share with high school degree are complete measures of physical and human capital.

Returning to our main variables of interest, as seen from Table 3, after we control for investment, skills and raw materials, the coefficients of the interaction term between corruption and regulation became much larger than those reported in Table 2. Furthermore, the total value of the corruption-productivity relationship evaluated at the 75th percentile of regulation is now significant in all regressions, including those with square of corruption and regulation (Table 3). Specifically, as seen in column 6 of Table 3, which reports the findings of the regression that includes all relevant variables, a 1 percent increase in corruption is associated with a 0.93 percent

reduction in productivity at the 75th percentile of regulation. The corresponding reduction in productivity at the 25th percentile value of regulation is only 0.046 percent and insignificant at the 10 percent level or less. This provides support for the hypothesis that corruption is more damaging for productivity at higher levels of regulation (Shleifer and Vishny 1993; Djankov et al. 2002, Banerjee 1997 and Aidt 2016).

5.2. Robustness analyses

To assess whether the results of our main model are sensitive to different specifications and alternative indicators, we conduct two additional analyses. First, instead of using the interactive term between corruption and regulation, we conduct the analysis separately for two samples with low and high levels of regulation (split sample regressions). Second, we run the interactive model using alternative measures of corruption and regulation.

In the split sample regressions, we run the regression model specified in Table 3, after excluding interaction terms, separately for the *"low regulation*" and "*high regulation*" samples, which include the values of regulation below and above the median values of regulation, respectively. As seen from Table A.5, the estimated coefficient value of corruption is negative, economically large and statistically significant for the sample of firms facing high regulation (columns 3 and 4). For the sample facing low levels of regulation, the coefficient of corruption is insignificant (columns 1 and 2). These results support our findings in Table 3, implying that corruption is negatively associated with productivity at higher levels of regulation.

Table 2. Baseline regressions of productivity (log) with interactive terms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Corruption (log)	0.103	0.145	0.092	0.100	0.120	1.378***	-3.461*	-1.757
	(0.240)	(0.237)	(0.238)	(0.238)	(0.238)	(0.441)	(1.934)	(2.091)
Regulation (log)	1.051***	0.795**	0.689**	0.702**	0.690**	0.511	6.641	6.963*
	(0.340)	(0.344)	(0.340)	(0.340)	(0.340)	(0.802)	(4.072)	(4.094)
Corruption*Regulation (log)	-4.822**	-5.640***	-4.966**	-5.109**	-5.293**	-6.747***	-5.398**	-6.736***
	(2.178)	(2.172)	(2.155)	(2.154)	(2.149)	(2.222)	(2.255)	(2.295)
Firm size (log)		0.110***	0.064***	0.063***	0.028	0.029	0.037	0.034
		(0.017)	(0.017)	(0.017)	(0.018)	(0.018)	(0.029)	(0.029)
Firm age		0.120***	0.117***	0.100***	0.097***	0.095***	0.142***	0.143***
		(0.025)	(0.024)	(0.027)	(0.027)	(0.027)	(0.041)	(0.041)
Exports (D)		0.251***	0.226***	0.226***	0.184***	0.184***	0.248***	0.252***
		(0.058)	(0.057)	(0.057)	(0.058)	(0.058)	(0.093)	(0.093)
Foreign ownership (share)		0.530***	0.534***	0.534***	0.503***	0.505***	0.538***	0.525***
		(0.071)	(0.071)	(0.071)	(0.071)	(0.071)	(0.130)	(0.129)
Overdraft (dummy)			0.383***	0.382***	0.365***	0.364***	0.133**	0.139**
			(0.042)	(0.042)	(0.042)	(0.042)	(0.061)	(0.061)
Fully constrained (D)			-0.349***	-0.351***	-0.339***	-0.338***	-0.186**	-0.186**
			(0.055)	(0.055)	(0.055)	(0.055)	(0.081)	(0.080)
Partially constrained (D)			-0.185***	-0.186***	-0.173***	-0.172***	-0.119*	-0.121*
			(0.044)	(0.044)	(0.043)	(0.043)	(0.068)	(0.068)
Training (D)					0.205***	0.204***	0.222***	0.218***
					(0.041)	(0.041)	(0.068)	(0.068)
Certification (D)					0.248***	0.251***	0.308***	0.311***
					(0.058)	(0.058)	(0.091)	(0.091)
Corruption-squared						-2.502***		-2.217***
						(0.744)		(0.826)
Regulation-squared						0.676		0.336
						(2.271)		(2.275)
Fixed effects[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Interactive terms[b]	No	No	No	No	No	No	Yes	Yes
Number of observations	39,732	39,732	39,732	39,732	39,732	39,732	39,732	39,732
Number of countries	111	111	111	111	111	111	111	111
R2	0.308	0.327	0.344	0.344	0.349	0.350	0.356	0.357
Estimated coefficient value of corruption at 25th, 50th and 75th percentile value of regulation								
25th	-0.09	-0.08	-0.106	-0.103	-0.092	0.5079	-0.043	0.4475
	0.188	(0.186)	(0.186)	(0.187)	(0.187)	(0.253)	(0.196)	(0.262)
50th	-0.331**	-0.362**	-0.354**	-0.359**	-0.356**	0.1205	-0.138	0.2442
	0.170	(0.170)	(0.169)	(0.169)	(0.169)	(0.216)	(0.163)	(0.215)
75th	-0.862***	-0.982***	-0.901***	-0.921***	-0.938***	-0.521	-0.939**	-0.626
	0.314	(0.315)	(0.310)	(0.309)	(0.310)	(0.333)	(0.425)	(0.445)

Note: Standard errors in brackets. Significance is denoted by *** (1%), ** (5%), * (10%). a: Fixed effects included are: country, industry, sector, region and year; b: Both regulation and corruption are interacted with all explanatory variables in the analysis. Following variables are also included in the regression but are not reported in the table: GDP per capita, manager's experience, manager's gender, whether firms reported courts being fair; whether firms experienced crime.

Table 3. Interaction regressions of productivity (log)

	(1)	(2)	(3)	(4)	(5)	(6)
Corruption (log)	0.107	0.238	-0.121	1.239**	-6.455***	-5.542**
	(0.240)	(0.307)	(0.321)	(0.609)	(2.215)	(2.201)
Regulation (log)	0.653*	1.805***	0.391	0.015	-2.432	-1.315
	(0.340)	(0.524)	(0.399)	(1.120)	(3.489)	(3.394)
Corruption*Regulation (log)	-5.139**	-14.676***	-8.594**	-10.547**	-8.893**	-9.980**
	(2.151)	(3.407)	(3.909)	(4.238)	(4.123)	(4.548)
Firm size (log)	0.024	-0.011	0.033	0.033	0.062	0.059
	(0.018)	(0.029)	(0.023)	(0.023)	(0.041)	(0.042)
Firm age	0.099***	0.166***	0.076**	0.073**	0.014	0.019
	(0.027)	(0.040)	(0.031)	(0.031)	(0.053)	(0.052)
Exports (D)	0.183***	0.221***	0.074	0.069	0.244***	0.229***
	(0.058)	(0.083)	(0.052)	(0.051)	(0.090)	(0.089)
Foreign ownership (share)	0.503***	0.587***	0.206**	0.208**	0.419***	0.421***
	(0.071)	(0.107)	(0.095)	(0.094)	(0.149)	(0.150)
Overdraft (dummy)	0.361***	0.389***	0.190***	0.191***	-0.013	-0.010
	(0.042)	(0.065)	(0.057)	(0.056)	(0.086)	(0.086)
Fully constrained (D)	-0.335***	-0.269***	-0.029	-0.029	-0.109	-0.121
	(0.055)	(0.075)	(0.071)	(0.071)	(0.089)	(0.090)
Partially constrained (D)	-0.170***	-0.179***	0.006	0.000	-0.043	-0.058
	(0.044)	(0.061)	(0.048)	(0.048)	(0.077)	(0.079)
Training (D)	0.194***	0.137**	-0.086	-0.083	0.073	0.064
	(0.042)	(0.057)	(0.057)	(0.057)	(0.091)	(0.091)
Certification (D)	0.240***	0.316***	0.273***	0.271***	0.118	0.122
	(0.058)	(0.096)	(0.058)	(0.059)	(0.095)	(0.096)
Bought assets (D)	0.099***	0.117**	0.058	0.057	-0.014	-0.010
	(0.037)	(0.053)	(0.046)	(0.046)	(0.077)	(0.076)
Skills (share of labor)		0.516***	0.114	0.112	0.135	0.109
		(0.083)	(0.071)	(0.070)	(0.103)	(0.105)
Raw material per worker (USD)			0.559***	0.559***	0.469***	0.471***
			(0.023)	(0.023)	(0.033)	(0.033)
Corruption-squared				-2.527**		-2.285**
				(1.040)		(1.062)
Regulation-squared				1.468		5.934*
				(3.345)		(3.264)
Fixed effects[a]	Yes	Yes	Yes	Yes	Yes	Yes
Interactive terms[b]	No	No	No	No	Yes	Yes
Number of observations	39,650	28,979	17,132	17,132	17,132	17,132
Number of countries	111	111	111	111	111	111
R2	0.350	0.345	0.687	0.689	0.706	0.707
Estimated coefficient of corruption at different percentiles of regulation						
25th	-0.098	-0.349	-0.378	0.1136	-0.453*	-0.046
	(0.189)	(0.244)	(0.261)	(0.293)	(0.248)	(0.281)
50th	-0.355**	-1.082***	-0.636***	-0.101	-0.713***	-0.221
	(0.169)	(0.260)	(0.246)	(0.284)	(0.212)	(0.258)
75th	-0.869***	-2.697***	-1.495***	-1.055**	-1.406***	-0.933**
	(0.291)	(0.539)	(0.483)	(0.503)	(0.475)	(0.453)

Note: Standard errors in brackets. Significance is denoted by *** (1%), ** (5%), * (10%). a/Fixed effects included are: country, industry, sector, region and year. b/Both regulation and corruption are interacted with all explanatory variables in the analysis. Following variables are also included in the regression but are not reported in the table: GDP per capita, manager's experience, manager's gender, whether firms reported courts being fair; whether firms experienced crime.

To see whether the results reported in Table 3 are sensitive to different measures of corruption and regulation, we also estimated the model using the averages of bribery depth (*Corruption* 1), bribery incidence (*Corruption* 2) and number of visits or required meetings with tax officials (*Regulation 1*) over all other firms in the industry-size-city cell. As shown in Table A.6 in the appendix, the coefficient of the interaction term between corruption and regulation is still negative and significant, indicating that the results are robust to different measures of corruption and regulation in the ES data.

6. Conclusion

Using nationally representative survey data from 39,732 private firms in 111 economies in six different regions of the world, we estimated the relationship between firm productivity and corruption, and how this relationship varies with the level of business regulation. We find robust evidence that on average there is a negative relationship between corruption and productivity, and this negative relationship becomes stronger at higher levels of regulation. In fact, at low levels of regulation (for example, at the 25th percentile of regulation), there is no significant relationship between corruption and productivity. These findings are consistent with the findings of many prominent studies, such as Shleifer and Vishny (1993), Djankov et al. (2002), Banerjee (1997) and Aidt (2016), pointing out that corruption and excessive regulation reinforce each other and together they are more detrimental to economic performance.

As discussed in the paper, even though we incorporate a wide range of control variables and fixed effects and use cell averages of corruption and regulation, we still cannot entirely rule out the endogeneity problem. As panel data and instrumental variables become available, future studies can address this issue more accurately.

In addition, there are number of ways in which the negative impact of corruption on productivity is exacerbated by high levels of regulation. Data limitations did not allow us to test through which mechanisms this relationship manifests itself. Furthermore, here we use a broad measure of regulation. The de facto assumption here is that all regulations are similar in how they affect productivity directly and in tandem with corruption. However, regulations are heterogeneous with different effects on productivity and varying degrees vulnerability to rent-seeking activities. Future work can tackle these issues and help shed more light on the interlinkages between corruption, regulation and productivity.

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Appendix

Table A.1. Definitions of variables

Variable Name	Description
Cell	Group of firms with same size located in the same country, city and industry.
Productivity	Labor productivity computed as the log of the ratio of sales during the last fiscal year (in USD) to the number of permanent full-time workers employed by the firm at the end of the last fiscal year.
Corruption	Log of the average value of a "bribe dummy" taken over all other firms, excluding the firm in question, in the industry-size-city cell. Bribe dummy is equal to 1 if percentage share of bribe in annual sale is 1 % and above, 0 otherwise. To measure bribe, Enterprise Surveys (ES) team asked the managers of firms how much firms like themselves pay as a percentage of their annual sales to government officials to "get things done."
Regulation	Log of the average value of the percentage of the firms' management's time spent on dealing with government regulations over all other firms in the industry-size-city cell.
Corruption*Regulation	Interaction term between Corruption and Regulation variables (in logs).
GDP per capita	Log of GDP per capita, PPP (constant 2011 International USD) from WDI.
Assets	Dummy variable equal to 1 if firm has bought assets in the previous year, 0 otherwise.
Certification	Dummy variable equal to 1 if firm has an internationally recognized quality certification, 0 otherwise.
Courts	Average value of a dummy variable over all other firms in the industry-size-city cell. Dummy variable is equal to 1 if the firm reports the functioning of courts as a major, severe, or very severe obstacle for its current operations and 0 if it reports it as a minor obstacle or no obstacle at all.
Crime	Dummy variable equal to 1 if the firm experienced losses as a result of theft, robbery, vandalism or arson in current fiscal year and 0 otherwise.
Direct exports	Dummy variable equal to 1 if direct exports as share of annual sales is equal to or above 1%; 0 otherwise.
Firm size	Log of number of permanent full-time workers employed at the firm at the end of the fiscal year three years ago. Without loss of generality, mean-adjusted values of the variable are used.
Female manager	Dummy variable equal to 1 if the top manager of the firm is a female and 0 otherwise.
Firm's age	Log of firm's age.
Foreign ownership	Proportion of firm owned by private foreign individuals, companies or organizations.
Fully constrained	Dummy variable equal to 1 if firm is fully financially constrained, 0 otherwise.
Partially constrained	Dummy variable equal to 1 if firm is partially financially constrained, 0 otherwise.
Manager's experience	Log of top manager's experience in years.
Overdraft	Dummy variable equal to 1 if the firm currently has overdraft facility and 0 otherwise.
Raw material	Log of per labor raw materials used (in 2009 USD).
Skills	Proportion of permanent full-time workers of the firm who have completed high school.
Training	Dummy variable equal to 1 if the firm provides formal training for its permanent, full time employees, 0 otherwise.
Regulation 1	Log of the average number of visits or required meetings with tax officials where the average is taken over all other firms, excluding the firm in question, in the same size-industry-city cell.
Corruption 1	Log of the average percentage of six public transactions for which a gift or informal payment was requested (bribery depth), where the average is computed over all other firms, excluding the firm in question, in the same size-industry-city. These six public transactions include: obtaining electricity connection, obtaining water connection, obtaining construction permit, obtaining import license, obtaining operating license, and inspections or meetings with tax officials. Following the ES methodology, a refusal to answer a question on whether bribes were requested or expected for a given transaction is considered as an affirmative answer.
Corruption 2	Log of the average percentage of firms experiencing at least one bribe payment or request in one or more of the six public transactions mentioned above (bribery incidence), where the average is computed over all other firms in the same size-industry-city cell.

Table A.2. Region, country, sample size and year of data used in the analysis

Code	Year	N	Code	Year	N	Code	Year	N	Code	Year	N
Sub Saharan Africa			TZA	2013	193	XKX	2013	68	MEX	2010	1050
AGO	2010	113	TGO	2016	109	KGZ	2013	121	NIC	2016	230
BEN	2016	92	UGA	2013	187	MDA	2013	200	PAN	2010	136
BWA	2010	190	ZMB	2013	493	MNE	2013	57	PRY	2017	212
BFA	2009	52	ZWE	2016	431	ROU	2013	304	PER	2017	611
BDI	2014	111	**East Asia & Pacific**			RUS	2012	1901	KNA	2010	90
CMR	2016	144	KHM	2016	125	SRB	2013	212	LCA	2010	121
CAF	2011	92	CHN	2012	1880	TJK	2013	114	VCT	2010	105
TCD	2009	35	IDN	2015	1003	UZB	2013	273	SUR	2010	148
CIV	2016	178	LAO	2016	238	**Latin America & Caribbean**			TTO	2010	271
COD	2013	304	MYS	2015	536				VEN	2010	87
ERI	2009	34	MNG	2013	187	ATG	2010	106	**Middle East & North Africa**		
ETH	2015	574	MMR	2016	442	ARG	2017	441			
GHA	2013	415	PNG	2015	37	BHS	2010	87	DJI	2013	114
GIN	2016	32	PHL	2015	627	BRB	2010	85	EGY	2016	1280
KEN	2013	480	SLB	2015	83	BLZ	2010	131	IRQ	2011	560
LSO	2016	77	THA	2016	593	BOL	2017	186	JOR	2013	323
LBR	2017	93	TLS	2015	41	BRA	2009	658	LBN	2013	328
MWI	2014	228	VNM	2015	472	CHL	2010	803	MAR	2013	210
MLI	2016	63	**Europe & Central Asia**			COL	2010	777	TUN	2013	381
MRT	2014	48	ALB	2013	112	CRI	2010	338	PSE	2013	262
NAM	2014	190	ARM	2013	176	DMA	2010	125	YEM	2013	221
NER	2017	59	AZE	2013	148	DOM	2016	159	**South Asia**		
NGA	2014	203	BLR	2013	160	ECU	2017	281	AFG	2014	36
RWA	2011	140	BIH	2013	218	SLV	2016	474	BGD	2013	1220
SEN	2014	275	BGR	2013	165	GRD	2010	101	BTN	2015	172
SLE	2017	46	MKD	2013	281	GTM	2010	365	IND	2014	7286
SSD	2014	309	GEO	2013	141	GUY	2010	116	NPL	2013	421
SDN	2014	181	HUN	2013	101	HND	2016	182	PAK	2013	373
SWZ	2016	66	KAZ	2013	301	JAM	2010	161	LKA	2011	354

Table A.3. Descriptive statistics

	Mean	P50	Min	Max	SD	Size
Productivity (log)	9.79	9.83	2.63	16.87	1.66	39732
Corruption (log)	0.12	0.05	0	0.69	0.15	39732
Regulation (log)	0.09	0.07	0	0.52	0.08	39732
Corruption*Regulation	0.01	0.00	0	0.09	0.02	39732
Firm size (log)	2.58	2.40	0	7.82	1.10	39732
Firm's age (log)	2.56	2.56	0	5.42	0.72	39732
Exports (dummy)	0.05	0	0	1	0.18	39732
Foreign ownership (share)	0.08	0	0	1	0.25	39732
Overdraft (dummy)	0.41	0	0	1	0.49	39732
Fully constrained (dummy)	0.15	0	0	1	0.36	39732
Partially constrained (dummy)	0.18	0	0	1	0.39	39732
Training (dummy)	0.32	0	0	1	0.47	39732
Certification (dummy)	0.13	0	0	1	0.34	39732
Assets (dummy)	0.39	0	0	1	0.49	39650
Skills (labor share)	0.60	0.7	0	1	0.38	28979
Raw material per labor (log)	7.82	8.01	-0.91	15.36	1.97	17132
Regulation 1	0.88	0.85	0	2.97	0.48	39732
Corruption 1	2.22	2.49	0	4.62	1.43	39139
Corruption 2	2.00	2.14	0	4.62	1.36	39139

Source: Enterprise Surveys, World Bank Group.

Table A.4. Correlation coefficients

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Productivity	1	1.00														
Corruption	2	-0.09	1.00													
Regulation	3	0.09	-0.07	1.00												
Corruption*Regulation	4	-0.06	0.71	0.35	1.00											
Firm size	5	0.29	-0.01	0.07	0.02	1.00										
Firm's age	6	0.18	-0.03	0.07	-0.01	0.30	1.00									
Exports	7	0.15	0.10	-0.05	0.07	0.33	0.04	1.00								
Foreign ownership	8	0.16	0.06	0.01	0.03	0.29	0.01	0.23	1.00							
Overdraft	9	0.28	-0.11	0.10	-0.04	0.29	0.11	0.12	0.08	1.00						
Fully constrained	10	-0.20	0.03	-0.07	0.02	-0.17	-0.08	-0.08	-0.02	-0.22	1.00					
Partially constrained	11	-0.05	-0.03	-0.08	-0.06	-0.06	0.02	-0.01	-0.05	0.00	-0.23	1.00				
Training	12	0.18	-0.05	0.13	-0.01	0.27	0.07	0.10	0.10	0.18	-0.13	-0.08	1.00			
Certification	13	0.25	-0.01	0.05	0.05	0.32	0.09	0.18	0.11	0.15	-0.12	-0.07	0.23	1.00		
Assets	14	0.15	-0.01	0.11	0.08	0.18	0.01	0.06	0.07	0.09	-0.14	-0.07	0.21	0.11	1.00	
Skills	15	0.22	0.05	0.08	0.03	0.13	0.12	0.02	0.02	0.10	-0.11	-0.02	0.13	0.16	0.06	1.00
Raw material	16	0.77	-0.17	0.05	-0.14	0.25	0.15	0.13	0.13	0.25	-0.20	-0.05	0.18	0.19	0.15	0.22

Table A.5. Split sample regressions of productivity (log)

	Low Regulation		High Regulation	
	(1)	(2)	(3)	(4)
Corruption (log)	-0.287	0.188	-0.541*	-0.936***
	(0.237)	(0.312)	(0.298)	(0.252)
Firm size (log)	0.022	0.073	-0.025	0.068***
	(0.030)	(0.045)	(0.029)	(0.027)
Firm age	0.137***	-0.014	0.117***	0.029
	(0.043)	(0.070)	(0.043)	(0.040)
Exports (D)	0.315***	0.164*	0.124	0.025
	(0.091)	(0.085)	(0.080)	(0.056)
Foreign ownership (share)	0.625***	0.093	0.450***	0.141
	(0.126)	(0.199)	(0.096)	(0.118)
Overdraft (dummy)	0.315***	0.220***	0.427***	0.144**
	(0.062)	(0.081)	(0.064)	(0.067)
Fully constrained (D)	-0.169**	-0.053	-0.459***	-0.026
	(0.076)	(0.119)	(0.085)	(0.081)
Partially constrained (D)	-0.148**	-0.167*	-0.194***	0.088*
	(0.070)	(0.086)	(0.062)	(0.053)
Training (D)	0.093	-0.203**	0.312***	-0.008
	(0.073)	(0.101)	(0.056)	(0.057)
Certification (D)	0.269***	0.196**	0.290***	0.287***
	(0.094)	(0.088)	(0.088)	(0.069)
Bought assets (D)		-0.098		0.080
		(0.083)		(0.057)
Skills (share of labor)		0.022		0.201**
		(0.134)		(0.085)
Raw material per worker (USD)		0.545***		0.578***
		(0.028)		(0.026)
Fixed effects[a]	Yes	Yes	Yes	Yes
Number of observations	19,792	8,719	19,872	8,735
Number of countries	102	50	106	66
R2	0.385	0.729	0.367	0.719

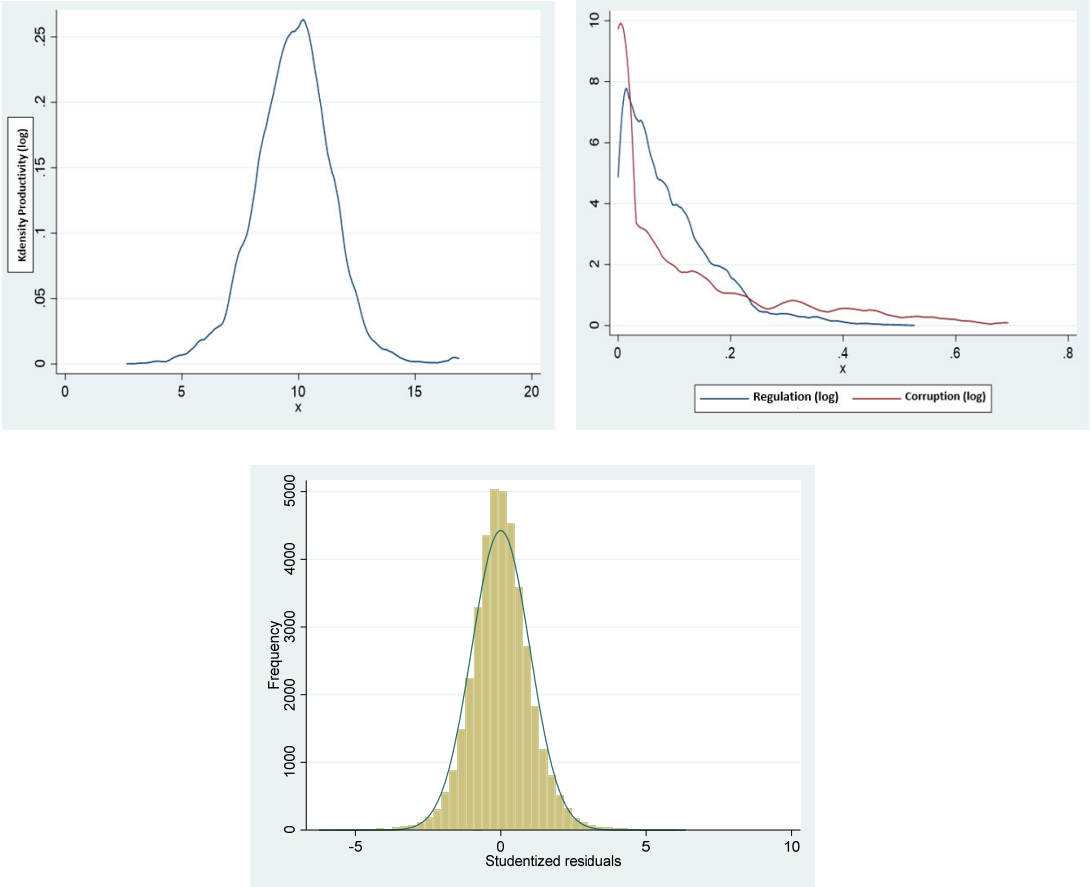
Standard errors in brackets. Significance is denoted by *** (1%), ** (5%), * (10%). Following variables are also included in the regression but are not reported in the table: GDP per capita, manager's experience, manager's gender, whether firms reported courts being fair; whether firms experienced crime. a/Fixed effects included are: country, industry, sector, region and year.

Table A.6. Interaction regressions of productivity using different indicators of corruption and regulation

	Corruption1 and Regulation 1				Corruption 2 and Regulation 1			
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Corruption (log)	0.061***	-0.137	-0.343	-0.224	0.051**	-0.045	-0.548	-0.330
	(0.023)	(0.378)	(0.323)	(0.320)	(0.024)	(0.397)	(0.337)	(0.335)
Regulation (log)	0.057	0.313	1.361	1.382	0.040	0.185	1.459	1.493
	(0.071)	(1.477)	(1.376)	(1.382)	(0.069)	(1.469)	(1.378)	(1.385)
Corruption*Regulation	-0.071***	-0.077***	-0.078**	-0.079**	-0.068**	-0.071**	-0.065*	-0.068*
	(0.026)	(0.029)	(0.037)	(0.036)	(0.027)	(0.031)	(0.038)	(0.037)
Firm size (logs)	0.020	0.085*	0.035	0.034	0.020	0.074*	0.035	0.032
	(0.019)	(0.045)	(0.041)	(0.042)	(0.019)	(0.044)	(0.041)	(0.042)
Firm age (Logs)	0.104***	0.026	-0.029	-0.030	0.105***	0.034	-0.036	-0.039
	(0.028)	(0.066)	(0.061)	(0.061)	(0.028)	(0.064)	(0.060)	(0.060)
Exports	0.148***	0.146	0.064	0.061	0.148***	0.135	0.065	0.063
	(0.057)	(0.134)	(0.124)	(0.124)	(0.057)	(0.132)	(0.122)	(0.122)
Foreign ownership (%)	0.490***	0.284	-0.080	-0.083	0.491***	0.275	-0.125	-0.137
	(0.081)	(0.182)	(0.173)	(0.172)	(0.081)	(0.178)	(0.172)	(0.171)
Overdraft (dummy)	0.364***	0.208**	0.205**	0.209**	0.364***	0.225**	0.191**	0.200**
	(0.042)	(0.097)	(0.099)	(0.099)	(0.042)	(0.096)	(0.096)	(0.097)
FFC (dummy)	-0.374***	-0.329**	-0.339***	-0.337***	-0.374***	-0.334**	-0.345***	-0.339***
	(0.056)	(0.136)	(0.128)	(0.128)	(0.056)	(0.133)	(0.127)	(0.126)
PFC (dummy)	-0.184***	-0.302***	-0.106	-0.103	-0.185***	-0.321***	-0.117	-0.113
	(0.044)	(0.103)	(0.094)	(0.094)	(0.044)	(0.102)	(0.092)	(0.092)
Training (dummy)	0.219***	0.299***	0.367***	0.365***	0.219***	0.326***	0.369***	0.366***
	(0.040)	(0.096)	(0.121)	(0.121)	(0.040)	(0.095)	(0.118)	(0.118)
Certification (dummy)	0.274***	0.213	0.498***	0.494***	0.274***	0.188	0.492***	0.487***
	(0.056)	(0.130)	(0.168)	(0.169)	(0.056)	(0.128)	(0.163)	(0.163)
Bought Assets (D)			0.018	0.019			0.028	0.031
			(0.085)	(0.085)			(0.083)	(0.083)
Skills (share)			0.326**	0.327**			0.320**	0.322**
			(0.130)	(0.130)			(0.128)	(0.127)
Raw material pw (log)			0.501***	0.502***			0.500***	0.502***
			(0.035)	(0.035)			(0.035)	(0.035)
Corruption-squared				-0.012				-0.025*
				(0.013)				(0.013)
Regulation-squared				0.016				0.019
				(0.075)				(0.075)
Interactions	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Number of observations	40,451	40,451	17,190	17,190	40,450	40,450	17,190	17,190
R2	0.353	0.356	0.718	0.718	0.353	0.356	0.718	0.718

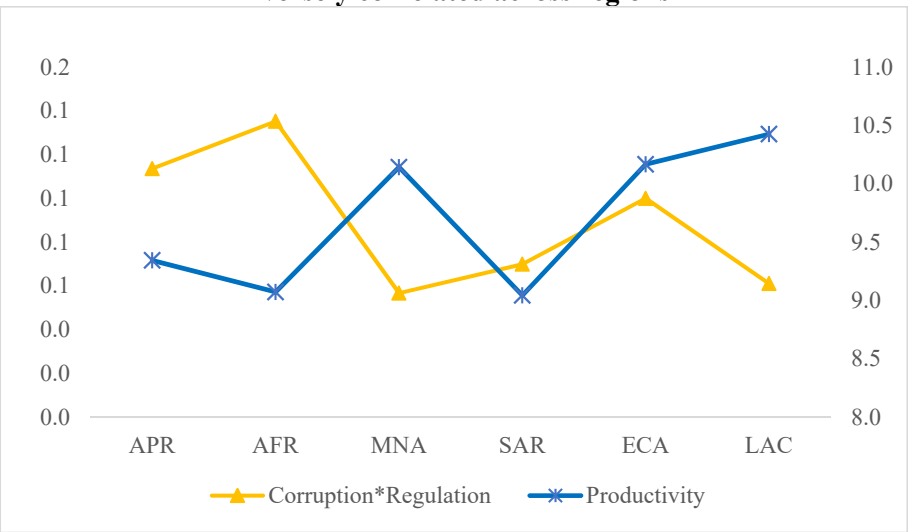
Note: Standard errors in brackets. Significance is denoted by *** (1%), ** (5%), * (10%). a/Fixed effects included are: country, industry, sector, region and year. b/Both regulation and corruption are interacted with all explanatory variables in the analysis. Following variables are also included in the regression but are not reported in the table: GDP per capita, manager's experience, manager's gender, whether firms reported courts being fair; whether firms experienced crime.

Figure 1. Distribution of productivity, corruption, regulation and regression residuals



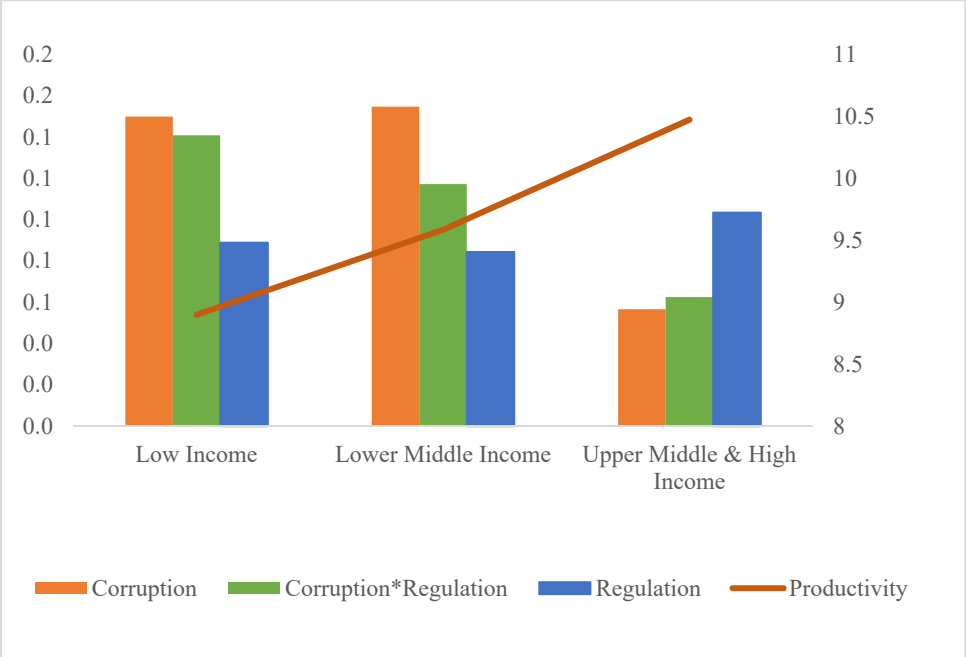
Enterprise Surveys, World Bank Group.

Figure 2. Corruption and regulation interaction and productivity are inversely correlated across regions



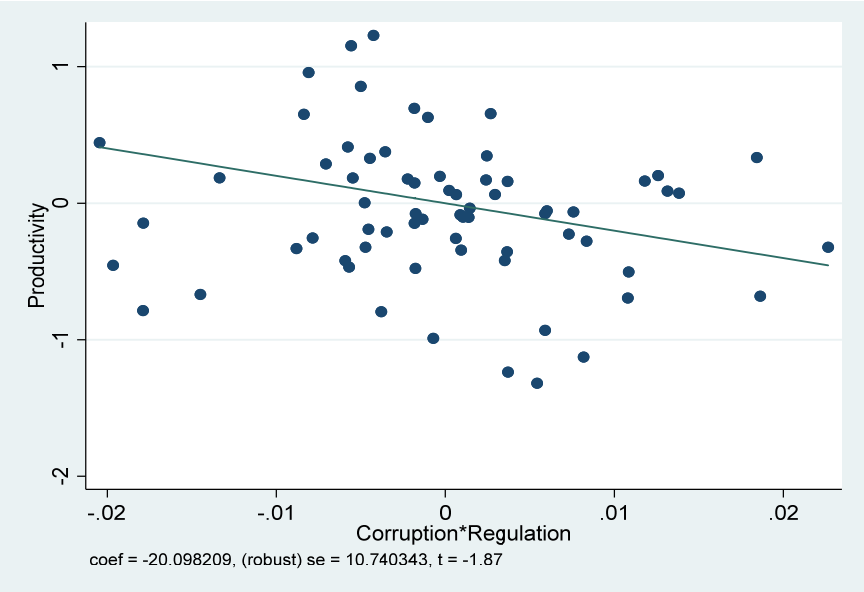
Source: Enterprise Surveys, World Bank Group.

Figure 3. Productivity increases, while the interaction term between corruption and regulation decreases at higher income levels



Source: Enterprise Surveys, World Bank Group.

Figure 4. Cross country analysis also shows that negative relationship between corruption and productivity increases as regulation increases



Source: Enterprise Surveys, World Bank Group.
Note: All controls of the regression model are included in the estimation of the above relationship.