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Environmental Regulation, Pollution and the Informal Economy

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Abstract

The regulation of environmental pollution is challenging. Particularly, the presence of institutional weaknesses like informal economy may not allow effective regulation. In this context, this paper addresses three related questions: (a) How stringent environmental regulation affects pollution? (b) What is the link between stringency of environmental regulation and the size of the informal economy? (c) How informal economy affects formal sector pollution? We use a data set of more than 100 countries from 2007 to 2010, a multivariate framework that controls for the influence of important factors and an index of perceived stringency of environmental regulation. The main findings of the paper, in line with theoretical reasoning, are that (i) stringent environmental regulation reduces pollution and (ii) stringent environmental regulation increases the size of the informal economy. This evidence suggests that informal economy helps avoid environmental regulation by being outside the regulatory sphere. An additional support to this finding is provided by the robust negative correlation between the size of the informal economy and the formal sector pollution. Our findings are based on interactive and non-linear effects that are tested and verified. In this regard, the paper raises new issues about possible mechanisms to reduce pollution in the presence of the informal economy.

Informal Economy; environmental regulation; carbon emissions; pollution; interaction terms.

JEL Classification: O17, Q53, Q58

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1. Introduction

Researchers and policymakers are taking increasing interest in the effectiveness of measures to control pollution. Yet, a workable set of policy prescriptions that ensures low per capita carbon emissions remain elusive. Environmental regulation, consequently, has become an important policy issue at national and international levels (see Percival et al, 2009 and Blackman, 2010 for literature reviews). As with business regulation, the effectiveness of environmental regulation also depends crucially on the existing institutional framework. The size of the informal sector[3], an indicator of the institutional weakness, might significantly affect policy outcomes aimed at reducing pollution. In this respect, this research focuses on the link between pollution, environmental regulation and the size of the informal economy.

The presence of informal economy constrains regulation and undermines environmental performance by being outside the regulatory sphere. Consequently, even when recorded pollution is decreasing with strict environmental regulation (SER), actual carbon emissions may increase if firms, wholly or partially, shift to informal sector to avoid pollution controls. In other words, environmental regulation can affect pollution nominally without having a real effect in the same direction or, in the worst case, can have a real effect in the opposite direction. Ultimately, we have to consider how the environmental regulation is affecting informal sector, and how the latter relates to pollution. If complying with environmental regulation is decreasing the efficiency of the firms, then the size of the informal sector will be increasing in the stringency of environmental regulation (Baksi and Bose, 2010).

This important link between environmental regulation and pollution on the one hand, and environmental regulation and informal sector on the other, has not been given sufficient attention in the existing literature. In one of the few studies, Blackman and Bannister (1998a) claim that in various developing countries the informal sector, "...is a major source of pollution" and that "...environmental management in this sector is exceptionally challenging." In line with this, Blackman and Bannister (1998b) argue that it is virtually impossible to regulate the informal sector with conventional tools as the absence of proper institutional framework does not permit the evaluation of costs (e.g. increased unemployment for informal workers) and benefit (e.g. increased government revenue) associated with regulation and, at the same time, does not influence agents to internalize environmental externalities. (For an attempt to estimate the benefits of controlling informal

[3] Informal economy is generally defined as a set of economic activities that takes place outside the framework of bureaucratic public and private sector establishments (see Hart, 2008). Additionally, there are other definitions, which share the common feature in defining the informal economy that, as opposed to formal economy its activities are not, (or at best partially) regulated or observed by the government (e.g. Schneider et al, 2010; Elgin and Oztunali, 2012a).
[3]

sector emissions see Blackman et al. 2006). The complexity of the relationship between environmental regulation and informal sector has been noted theoretically (e.g. Baksi and Bose, 2010 and Chattopadhyay et al, 2010). More recently, Elgin and Oztunali (2012b) empirically examine the relationship between informal economy size and various pollution indicators, and find an inverted-U relationship between these two variables. Accordingly, small and large sizes of the informal economy are associated with little environmental pollution and medium levels of the size of the shadow economy are associated with higher levels of environmental pollution. As we will explain in greater detail below, the mechanism behind this nonlinearity will also be one of the keystones of our hypothesis. However, the current paper is unique in the literature in analyzing the effect of informality on the relationship between regulation and pollution.

Extending the existing literature, this paper empirically investigates the influence of stringent environmental regulation on pollution while explicitly considering the presence of informal economy. Using a pooled data set of more than 100 countries over 2007 to 2010, this paper shows that SER decreases measured pollution. However, the effect of environmental regulation on aggregate carbon emissions is ambiguous because the informal sector increases as environmental regulation becomes more stringent. Nonetheless, in our analysis we try to see the linkages between various factors by incorporating interaction effects.

The rest of the paper is organized as follows: In the next section we lay out the theoretical framework to support our hypothesis as well as the economic mechanism behind it. Following this, in section three we develop the empirical framework and describe our data. Section 4 presents results of the econometric analysis and checks the robustness of our findings, as well as the assumptions underlying the reasoning. Finally, we provide discussion and concluding remarks.

2. Theoretical Framework

Public regulation is an important policy tool influencing economic agents to internalize externalities sabotaging social welfare. However, more stringent regulation increases the cost of businesses in the formal sector.[4] Therefore, it is important to identify the factors that determine the degree of effectiveness of regulation in achieving its intended objectives. (For example, see Johnson et al. 1998 or Friedman et al. 2000 for the case of the effect of taxation on business activity and Tosun and Knill, 2009 for environmental regulations).

[4] Important factors that increase costs of businesses in the formal sector include (a) specification of the pollution caps on facilities covered by regulatory program, (b) imposition of specific technology requirement, (c) levying of performance standards related to carbon emissions.

The effect of SER on recorded pollution, after controlling for the influence of informal sector, is likely to be negative but its effect on actual level of pollution is not obviously clear under the presence of informality. It is because of the "deregulation effect" that is exercised by the informal sector. This effect, originating from the definition of the informal sector, does not comply with most, if not all, of the government regulations, including environmental regulations and restrictions as well. Therefore, through the deregulation effect a larger informal sector is expected to be associated with a worse environmental performance or larger amount of environmental pollution. (Blackman and Banister, 1998a; 1998b; Chaudhuri 2005; Baksi and Bose, 2010; Elgin and Oztunali, 2012b). Therefore, a more SER might be pro-pollution through informality. That is, the effect of stringent regulation on pollution taken as a function of informality is positive and increasing in stringency. Surely, in order for this line of argument to be true, one should also be able to show that the effect of stringent regulation on informality is positive and increasing in stringency, as well. The above reasoning provides us with two testable hypotheses:

Hypothesis 1: More SER reduces carbon emissions.

Hypothesis 2: SER increases the size of the informal sector.

However, the possibility that the relationship between pollution and informality is not necessarily a linear one, opens up the prospects of a third testable hypothesis:

Hypothesis 3: The association between the informal sector size and pollution is nonlinear and interacts with stringency of environmental regulations.

Considering that the informal economy mainly operates on a small scale with a highly (if not fully) labor intensive and less capital intensive production technology, (see Haan, 1989; Thomas, 1992; Lall, 1989; De Soto, 1989; Ihrig and Moe, 2004; Elgin and Oztunali, 2012b for this argument), the low level of capital intensity and the small scale of production might make the informal sector less prone to environmental pollution (Antweiler et al, 2001). This is what Elgin and Oztunali, 2012b call the "scale effect" of informality on pollution. Therefore, in order to fully understand how informality changes the effect of SER on pollution, one should also take the potential nonlinear relationship between informality and pollution into account through the deregulation and scale effects. Figure 1 exhibits the relationship between informal sector and carbon emissions in our sample. It is clear that the relationship is anything but linear with a tendency to become negative over a reasonable range of informal sector.

Building upon these theoretical considerations, the next section will test these hypotheses in the data.

Empirical Analysis

This section develops the empirical model to test the theoretical insights detailed out in the previous section. We develop an integrated empirical framework based on structural variables to gather evidence from an analysis of more than 100 countries. The first subsection explains the empirical methodology. The second and third subsections deal with the explanation of data and empirical results, respectively.

Data and Variables

Table 1 provides the descriptive statistics of the variables used in our empirical analysis.[5] The main dependent variable, an indicator for environmental pollution, is the per capita emission of carbon dioxide (CO2).[6] It is a widely used measure of environmental pollution and permits an easy comparison of our findings with the previous studies. Our main variable of interest, the stringency of environmental regulation, is a sub-component of the Travel and Tourism Competitiveness Index (TTCI) developed by World Economic Forum.[7] It measures, on the basis of an executive opinion survey, stringency of regulation on a graduated scale from 1 to 7 with higher values indicating more stringent regulation.

Table 1 is about here

The data on the size of the informal economy is taken from Elgin and Oztunali, 2012a who provide a comprehensive cross section time series data for 161 countries from 1950 to 2010. In comparison with others, their measure of the size of the informal sector is less prone to measurement errors because their methodology utilizes a structural model rather than estimating it by proxy variables and indicators.

Following previous studies, notably Elgin and Oztunali, 2012a and Biswas et al, 2012, we control for the influences of GDP per capita, urbanization, capital formation, and the rule of law. We control for the extent of urbanization because it is one of the main determinants of

[5] Our original data set comprises of 137 countries over the period from 2007 to 2010. However, due to unbalanced panels the number of countries used in the analysis varies and leaves us with a number from 118 to 122 at most.

[6] According to the World Bank, "carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring", http://data.worldbank.org/indicator/EN.ATM.CO2E.KT/countries?display=default, (accessed 7 August 2012). Therefore, carbon emissions in the underground sector would not be captured in the official emissions estimates.

[7] The TTCI measures factors and policies that determine the performance of travel and tourism sector across countries. The TTCI is composed of 13 sub-indices, which include policy rules and regulations, environmental regulation, safety and security, health and hygiene, prioritization of travel and tourism, air transport infrastructure, ground transport infrastructure, tourism infrastructure, ICT infrastructure, price competitiveness in the travel and tourism industry, human resources, national tourism perception, natural and cultural resources. The detailed index is published annually from 2007 in the World Economic Forum's Travel and Tourism Competitiveness Reports.

pollution: A greater absolute number of people, keeping other things unchanged, will increase the consumption of fossil fuels (see a recent paper by Martinez-Zarzoso and Maruotti, 2011 among many others). Similarly, the magnitude of the capital formation increases environmental pollution and should be controlled. To this end, we use annual measure of gross fixed capital formation as a percentage of GDP.

Moreover, to avoid any misspecification due to correlation of our variables of interest with the institutional quality, we also control for the influence of the rule of law. A more effective rule of law is likely to check the pollution leakages due to non-compliance or corruption. Finally, to take into account the influence of living standard of a country and its level of economic development we also control for GDP per capita and its square.

Results

Table 2 reports the results of the following pooled OLS regression of log per capita carbon emissions on the index of stringent environmental regulation (SER)[8]:

$$E = \beta_0 + \beta_1 SER + \sum^{n}_{k=2} \beta_k X_k + \varepsilon \qquad (3.1)$$

Where E is for environmental pollution, *SER* measures the stringency of environmental regulations.[9] And X_k includes other relevant factors whose influence we have controlled.

Table 2 about here

The Wald chi-square test, reported towards the bottom of Table 2, indicates that all the models are highly significant. Moreover, as the endogeneity test shows, SER, our main variable of interest, can be considered statistically exogenous in our analysis. The basic specification is shown in Column (1.1) that controls for the effects of per capita GDP, annual rate of growth and the rule of law. As the results show, per capita income and the rate of economic growth are positively associated with per capita carbon emissions. In terms of elasticity, a one percent increase in per capita national income will increase carbon emissions by 1.5 percent by our estimates in Column 2.1. But for long term growth rate, the

[8] We use pooled least squares technique with robust standard errors to capture both within panel and between panel variations in our data. This is necessary for a number of reasons: first, it allows us to exploit the largest number of observations. Secondly, besides lacking in sufficient within variation, the cross-section panels are unbalanced. It renders the use of fixed effects inappropriate. Nonetheless we control for the time fixed effects to incorporate technological and economic shocks over sample period. Finally, one may argue that in the face of stiff environmental regulations firms, instead of going informal, may shift their operations overseas. Even if this is the case, it will be captured by our pooled regression because it considers variation in informal sector and environmental regulation in the whole sample and not in individual countries.

[9] The time and cross sectional subscripts are not mentioned in equation (3.1) because we are pooling observations.

ceteris paribus elasticity is only 0.05. Apparently, this difference in the coefficients of per capita national income and the growth rate of national income is surprising. However, one must note that in view of the heavy interdependence of per capita income and long term growth rate it is not very plausible to assume that one increases holding other constant.

The elasticity of pollution with respect to the rule of law is significant and negative. However, its economic magnitude is small: a one percent increase in the value of the rule of law index decreases emissions by 0.05 percent. It is understandable given the more direct influence by the environmental regulation. The small but significant elasticity of the rule of law nonetheless indicates that good quality institutions will improve the environmental outcome.

Coming to environmental regulation, SER has negative effect on carbon emissions in line with our prediction. Its coefficient is significant beyond one percent in all the models reported in Table 2. In terms of elasticity, our estimates indicate that a one percent increase in SER from its lowest level will decrease carbon emissions by 0.42 percent. This elasticity is not constant, however. It increases in stringency and reaches the value of 1.28 when SER assumes its maximum value in our sample. Importantly, in our sample the countries that have below average carbon emissions with highest stringency of environmental regulation are all middle-income countries (with the only exception being Malawi). The important question is how these countries managed to have higher per capita incomes (their average per capita income in $PPP terms is around 10800) and higher growth rates (their average annual growth rate is 5.5 percent) with below average carbon emissions? A possible explanation is the discrepancy between recorded and unrecorded carbon emissions that allows businesses to sidetrack environmental regulation without being caught. In other words, the evidence in Table 2 hinted at a link between SER and informality.

In Column (2.2) we include corruption in our basic specification. Like informal economy, bureaucratic corruption can also allow pollution to go undetected. Our model supports this reasoning, as corruption and pollution are negatively correlated. This is in line with the evidence of Dreher and Schneider (2010) that corruption and informal economy are complements. In our sample, however, the effect of corruption and informal sector, though in the same direction, is not quantitatively same: the percentage effect of informal (Column 2.5) is greater than percentage effect of corruption. This difference remains intact even if we consider both corruption and informal in the same model. Thus, by Columns (2.2) and Columns (2.5) a one percent increase in corruption decreases pollution by 0.11 percent while a similar increase in the size of informal sector decreases emissions by 0.37 percent.

The effect of capital formation on emissions is significant and positive. Specifically, a one percent increase in gross fixed capital formation, at average value, increases carbon

emissions by 0.64 percent by the estimates of Column (2.4). The effect of urban population on pollution is, somewhat surprisingly, insignificant.

A crucial link in our reasoning is what happened to informal sector as environmental regulation becomes more stringent. In Table 3 we report results over this link. In Column (3.1) we report the effect of SER on the informal sector. As La Porta and Shleifer (2008) note, the decision to going informal depends on the dynamic benefits and costs of staying informal. Therefore, we control for the dependence of SER on the previous size of the informal sector. In addition we also control for the important determinants of the informal sector, namely, rule of law, political stability, and corruption. As shown by the Wald Chi-square test reported towards the bottom of Column (3.1), the model is highly significant. There is no issue of endogeneity. Our results are in line with our earlier arguments and results presented in Table 2. Thus, greater enforcement of the rule of law decreases informal sector, and so the increase in per capita income. As in Table 2, corruption is positively correlated with the informal supporting the complementarity hypothesis.

Table 3 about here

Importantly, the marginal effect, reported in the lower panel, indicates a significant positive effect of strict environmental regulation on informal sector size.[10] This effect increases as the perceptions about the strictness of the regulation increases. Thus, at the maximum level of stringency in our sample, our estimates tell that a one percent increase in stringency of environmental regulation will increase the informal sector size by 1.59 percent. Even at average value of SER the elasticity is approximately unity.

Although our estimates are not suffering from an endogeneity problem there remains the issue of simultaneity. To circumscribe this issue we estimate the following system of equations using 3SLS method:

$$E = \beta_0 + \beta_1 SER + \beta_2 RL + \sum_{i=3}^{6} \beta_i X_i + \varepsilon \qquad (3.2a)$$

$$Infor = \gamma_0 + \gamma_1 SER + \gamma_2 RL + \sum_{j=3}^{5} \gamma_j Z_j \qquad (3.2b)$$

It allows two of our key variables to be determined simultaneously by SER. Where *RL* is for the rule of law; X_i is a vector of regressors comprising of per capita income, gross fixed capital formation and the annual rate of economic growth. While in Z_j we include political stability and corruption. The results of the system are reported in Columns (3.2) and (3.3) of Table 3. From the bottom panel of the Table we can see that both equations are

[10] In precise terms this marginal effect equals the first derivative of informal with respect to SER. One may refer to Brambor et al. (2006) for the interpretation of interaction terms.

highly significant. The Breusch-Pagan test that there is no simultaneity between equations is convincingly rejected. The marginal effect of SER on both the dependent variables is estimated at three different levels of stringency and reported in the lower half of the table. It indicates a significant negative effect of SER on pollution while significant positive effect on the informal sector. Importantly both these effects are increasing (in absolute magnitude) with increase in SER.

Robustness Checks

Until now, we have shown the negative effects of SER on pollution and positive correlation of SER with the informal. In particular, our results show that more stringent environmental regulations are associated with a larger informal sector size. However, what happened to actual pollution is difficult to determine because of the complex relationship between informal sector and pollution. As argued previously, it is possible that informal sector reduces actual or recorded pollution due to two interrelated causes. For instance, if informal sector is less pollutant than formal sector, the net outcome may be a reduction in the real pollution. Secondly, if firms shift their pollutants to the informal sector, the recorded carbon emissions may reduce due to this shifting of pollutants towards unrecorded informal sector. But former effect is unlikely to hold over the long term because, if the informal sector is harboring pollutants due to stringent environmental regulation, then it will eventually become more polluting. Therefore it is important to see how informal sector influences pollution when taken as a function of SER and capital formation.

Table 4 is about here

In Table 4 we present the results specifically considering the following interactions:

$$\partial E/\partial Infor = \beta_3 + \beta_4 SER + \beta_6 K \quad (4.1)$$

$$\partial E/\partial Infor = \beta_3 + \beta_4 SER + \beta_6 K + \beta_{11} K*SER \quad (4.2)$$

$$\partial E/\partial Infor = \beta_3 + \beta_4 SER + \beta_6 K + \beta_{10} HIE \quad (4.3)$$

$$\partial E/\partial Infor = \beta_3 + \beta_4 SER + \beta_6 K + 2\beta_{12} Infor \quad (4.4)$$

All the equations from (4.1) to (4.4) evaluate the relationship between pollution and informal sector as a function of SER and capital formation as explained above. However, equations (4.2), (4.3) and (4.4) consider additional effects as well. In (4.2) for example, we take the interaction between SER and *K* into account; in (4.3) we include the interaction term to delineate the difference in the nature of informal sector behavior in high income and

developing countries; in equation (4.4) we take the dependence of $\partial E/\partial Infor$ on the previous size of informal sector into account.

As shown in the bottom panel of Table 4, we find significant negative effect of informal sector in the case of interaction (4.1), that is, when the influence of informal sector is modelled depending on SER and capital formation. The negative effect of informal sector is reinforced in Column (4.2) by the addition of joint effect of *K* and SER in the relation (4.2) above. Notably, all of our marginal effects in Table 4 indicate inverted U-shaped influence of informal sector on carbon emissions.

Understandably, there is no additional effect associated with high-income economies as shown in the results in Column (4.3). However, the relation (4.4) shows significant negative link between informal sector and pollution at 1 percent level of significance.

Our results clearly indicate a robust link between SER and pollution, and also, between SER and informal sector. However, the effect of informal sector on pollution as a function of capital formation and stringent regulation is nonlinear. Importantly, the marginal effects of all the models exhibit a similar pattern: they first increase and then decrease, in absolute magnitude. This pattern implies two things: first it is in line with the inverted U-shaped Kuznets curve. Secondly, it implies that maximum discrepancy between recorded and unrecorded carbon emissions is likely to exist for countries with average levels of informal sector. Noticeably, the informal sector reduces recorded carbon emissions the most at the mean levels.

Discussion and concluding remarks

In this paper we attempt to gather empirical evidence on the effectiveness of the environmental regulation. In doing so we explicitly consider, in line with theoretical insights, the role of the informal sector. Our findings suggest that "deregulation effect" due to informal sector may not allow the true evaluation of the success of the environmental regulations.

The findings of the paper shows that SER decreases measured carbon emissions. In order to see what happened with the real carbon emissions, we investigate the link between SER and the informal sector and also the link between the informal sector and measured carbon emissions. We find, in line with our hypothesis, that SER increases informal sector; while the size of the informal sector reduces pollution. Apparently puzzling, these three findings support the theoretical predictions that stringent environmental regulation may decrease "formal" pollution but increases "informal" pollution.

The evidence presented here contributes to the literature by addressing two important themes: First, an open question is how to regulate the carbon emissions. A general tendency of environmental authorities is to implement regulations in the formal economy. However, our analysis indicates that the objective of cleaner environment is unlikely to be realized by focusing on stringency or on formal sector alone. It requires an understanding of the possible constraints like the presence of an informal sector. Second, another important question in this regard is how to deal with the informal sector. An effort to curb informal sector may not be desirable for political and economic reasons as in many countries informal sector harbors many small businesses and is providing employment to many households. We leave the empirical exploration of these issues as an avenue for future research.

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Appendix A

Figures and Tables

Fig. 1 The effect of informal sector on carbon emissions

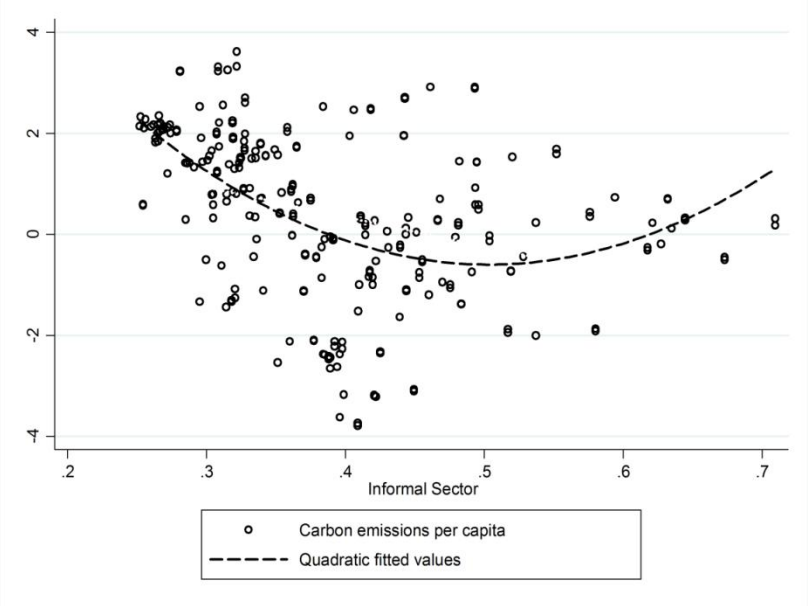

Table 1. Descriptive Statistics

Variable	Obs.	Mean	Sd.	Min.	Max.
CO2(log)	399	0.93	1.58	-3.79	4.07
SER	515	4.04	1.07	1.90	6.70
Enforcement	515	3.83	1.03	1.80	6.40
Informal	524	0.32	0.13	0.08	0.71
GDP per capita (log)	512	9.12	1.22	5.92	11.39
Urban population (log)	540	3.99	0.48	2.31	4.61
K-formation	498	23.91	6.97	0.53	52.51
Rule of law	544	0.10	0.98	-1.84	2.01
Political stability	544	-0.02	0.89	-2.70	1.52
Corruption	544	0.10	1.01	-1.44	2.51

Table 2. Effect of stringent environmental regulation on pollution

Dependent Variable CO2 emissions per capita; Pooled-LS estimates.

	(2.1)	(2.2)	(2.3)	(2.4)	(2.5)
SER	-0.192***	-0.138***	-0.192***	-0.134***	-0.212***
	(0.052)	(0.047)	(0.052)	(0.050)	(0.050)
GDP per capita	1.496***	1.516***	1.509***	1.426***	1.474***
(log)	(0.040)	(0.039)	(0.063)	(0.040)	(0.041)
Growth	0.016**	0.014*	0.016**	0.007	0.014*
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Rule of law	-0.259***	-0.266**	-0.261***	-0.242***	-0.329***
	(0.068)	(0.106)	(0.070)	(0.063)	(0.068)
Corruption		-0.590***			
		(0.090)			
Urban			-0.038		
Population (log)			(0.122)		
K-formation (%				0.026***	
of GDP)				(0.005)	
Informal					-1.193***
					(0.297)
Time effects	Yes	Yes	Yes	Yes	Yes
Obs.	352	352	352	331	349
R-squared	0.875	0.886	0.875	0.870	0.880
No. of countries	124	124	124	119	123
Wald Chi-sq p-value	0.000	0.000	0.000	0.000	0.000
Endogeneity test p-value[a]	0.655	0.225	0.650	0.332	0.940

*Robust standard errors in parenthesis. Constant is included but not reported; ***p<0.01, **p<0.05, *p<0.1; a. It tests the null hypothesis that SER regulation can be treated as exogenous.*

Table 3. Effect of stringent regulation on informal sector

	(3.1)	(3.2)	(3.3)
	Pooled LS	3SLS Estimation	
	Informal	Pollution	Informal
SER	-0.066***	-0.165***	0.031**
	(0.003)	(0.052)	(0.015)
SER*Lagged Informal	0.251***		
	(0.005)		
Rule of law	-0.029***	-0.203***	-0.090***
	(0.006)	(0.067)	(0.019)
Political Stability	-0.004		0.002
	(0.003)		(0.009)
Corruption	0.038***		0.009
	(0.005)		(0.018)
GDP per capita (log)	-0.004**	1.404***	
	(0.002)	(0.042)	
K-formation (% GDP)		0.022***	
		(0.005)	
Growth		0.002	
		(0.006)	
MARGINAL EFFECTS[a]			
Stringent reg. (at min.)	0.411***	-0.362***	0.282***
Stringent reg. (at mean)	0.948***	-0.673***	0.301***
Stringent reg. (at max.)	1.590***	-1.104***	0.313***
Time effects	Yes	No	No
Obs.	367	328	328
R-square	0.952	0.800	0.472
Wald Chi-sq p-value	0.000	0.000	0.000
Endogeneity test (p-value)[b]	0.668	n.a	n.a
Breusch-Pagan test of independence (p-value)		9.04 (0.00)	

*Robust standard errors in parenthesis. Constant is included but not reported; ***p<0.01, **p<0.05, *p<0.1; Standard errors for marginal effects are computed using delta method. It tests the null hypothesis that SER regulation can be treated as exogenous*

Table 4. Effect of Informal sector on pollution

Dependent Variable CO2 emissions per capita; Pooled-LS estimates.				
	(4.1)	(4.2)	(4.3)	(4.4)
SER	-0.652***	-0.524**	-0.419*	-0.747***
	(0.183)	(0.206)	(0.241)	(0.173)
Enforcement	-0.216	-0.142	-0.155	-0.239
	(0.164)	(0.177)	(0.174)	(0.160)
SER*Enforcement	0.036	0.017	0.021	0.041
	(0.032)	(0.035)	(0.034)	(0.031)
Informal	-3.640**	-5.796***	-2.249	-6.094***
	(1.564)	(2.216)	(1.901)	(2.350)
SER*Informal	1.230***	2.014***	0.718	1.434***
	(0.320)	(0.593)	(0.499)	(0.345)
K-formation % of GDP	0.039***	0.047***	0.037***	0.035***
	(0.010)	(0.011)	(0.010)	(0.010)
K-formation*Informal	-0.065**	0.054	-0.060**	-0.052*
	(0.029)	(0.099)	(0.030)	(0.029)
GDP per capita log	1.317***	1.316***	1.350***	1.316***
	(0.039)	(0.039)	(0.044)	(0.038)
Growth	0.003	0.005	0.004	
	(0.006)	(0.006)	(0.006)	
High income dummy			-0.560*	
			(0.318)	
High income*Informal			1.369	
			(1.064)	
K-formation*Informal*SER		-0.040		
		(0.028)		
Informal squared				1.862
				(1.339)
MARGINAL EFFECTS[a]				
Informal (at min.)	-3.282**	-5.171**	-2.085	-5.097***
Informal (at mean)	-3.546**	-5.632***	-1.625	-5.831***
Informal (at max.)	-2.814**	-4.357**	-0.811	-3.793***
Time effects	Yes	Yes	Yes	Yes
Obs.	328	328	328	328
R-square	0.875	0.876	0.877	0.877
Wald Chi-sq (p-value)	0.000	0.000	0.000	0.000

*Robust standard errors in parenthesis. Constant is included but not reported; ***p<0.01, **p<0.05, *p<0.1; a. Standard errors for marginal effects are computed using delta method.*

Appendix B. Definitions and sources of variables

Stringent environmental regulation. A survey based measure of stringency of environmental regulation. The question asked is "How would you assess the stringency of your country's environmental regulation"? The response categories range from 1 "very lax" to 7 "most stringent". Source The Travel and Tourism Competitiveness Report, World Economic Forum, years 2007 to 2010, **www.weforum.org**

Carbon dioxide emissions. Annual per capita emission of carbon dioxide in metric tons. Source United Nations Statistical Database.

Informal. It refers to the size of informal sector as estimated by Elgin and Oztunali (2012a). The estimates use structural general equilibrium modeling approach.

GDP per capita. GDP per capita in purchasing power parity dollars. Source IMF.

Urban population. It refers to the urban population as percentage of total population. Source United Nations Statistical Database.

K-formation. It refers to gross fixed capital formation and measured as percentage of expenditure on gross domestic product. Source United Nations Statistical Database.

Rule of law. It measures perceptions of the extent to which agents have confidence in and abide by the rules of society and, in particular, the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. Source World Governance Indicators, World Bank.

Growth. Annual percentage change in GDP. Source United Nations Statistical Database.

Political stability. It measures perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically motivated violence and terrorism. Source World Governance Indicators, World Bank.

Control of corruption. It captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. Source World Governance Indicators, World Bank.

Countries in the sample (122)

Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Barbados, Belgium, Benin, Bolivia, Bosnia-Herzegovina, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Chad, Chile, China, Columbia, Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Ethiopia, Finland, France, Gambia, Georgia, Germany, Ghana, Greece, Guatemala, Guyana, Honduras, Hong Kong, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea, Kuwait, Kyrgyz Republic, Latvia, Libya, Lithuania, Luxembourg, Macedonia, Madagascar, Malawi, Malaysia, Mali, Malta, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Nigeria, Norway, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russia, Saudi Arabia, Senegal, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Suriname, Sweden, Switzerland, Syria, Tajikistan, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Turkey, UAE, US, Ukraine, Uruguay, Vietnam, Zambia.