SWITCHING ON THE LIGHTS: DO HIGHER INCOME TAXES PUSH ECONOMIC ACTIVITY INTO THE SHADE?

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This paper examines the effect of corporate income tax (CIT) rates on shadow economic activity. The paper revives the electricity consumption approach to measuring such activity with a new functional form, a larger sample of countries, a longer time span of 25 years, and the use of instrumental variables. We find that a 1 percentage point increase in the CIT rate increases the size of the shadow economy by 2.3 percent, which implies a tax elasticity of shadow economic activity of 0.78 at the mean CIT rate. This result suggests that efforts to reduce budget deficits with corporate tax rate increases may be offset by an increase in shadow economic activity.

Keywords: shadow economy, tax evasion, corporate income tax, electricity approach

JEL Codes: D73, H2, O1

I. INTRODUCTION

The period between 1980 and 2005 witnessed a considerable change in income tax systems throughout the world. Many countries opted for notably lower rates, flatter tax schedules, and simpler filing systems. Using data from 1981 and 2005 for 189 countries, Figure 1 shows a decline in the top statutory corporate income tax (CIT) rate from 44.6 to 30.5 percent and an even larger decline in the top statutory personal income tax (PIT) rate from 62 to 36 percent. Other noticeable changes include a reduction in the average number of tax brackets from 11 in 1981 to 4 in 2005 and a 20 percent drop in complexity over the same time period. Furthermore, flat personal income tax rates

1 Figure 1 is constructed with data from the World Tax Indicators (WTI v.1) described in Sabirianova Peter, Buttrick, and Duncan (2010). The WTI covers 189 countries for the years 1981–2005.

2 Complexity is measured by an index that takes into account several characteristics of the tax schedule, including the number of brackets, deductions, credits etc. A more detailed description is given in the online appendix and in Sabirianova Peter, Buttrick, and Duncan (2010).
Notes: PIT is the personal income tax, and $y$ denotes the level of gross annual income equivalent to a country’s per capita GDP. Tax rates are weighted by GDP in constant US dollars. PIT complexity is a time-varying index that summarizes several observable dimensions of the PIT schedule, including the complexity of allowances and tax credits, the use of multiple tax schedules, non-standard tax formulas, local taxes, national surtaxes, and the number of PIT brackets (Sabirianova Peter, Buttrick, and Duncan, 2010). The index ranges from 0 to 10, with 10 indicating the highest level of complexity.
are becoming increasingly popular. Even when a flat tax was not introduced, many countries chose to flatten their PIT schedules by reducing the upper rates. More recently, a number of mostly developed countries have begun to increase top rates in an effort to combat rising budget deficits and income inequality. Still, taxpayers on average face flatter schedules with significantly lower tax rates and simpler tax structures than they did in the early 1980s.

One of the primary reasons for reducing tax rates in the higher brackets and making tax systems simpler is to bring more potential tax payers into the official economy from the shadow economy. This justification seems intuitive and reasonable, can be rationalized by theory, and sounds convincing in political rhetoric. Yet, there is little support for this justification in the empirical literature. While it is widely accepted that higher tax rates lead to higher levels of tax evasion (Alm, 2012), the evidence on the relationship between tax rates and shadow economic activity is weaker. Existing estimates of the effect of taxes on the shadow economy vary from being positive and statistically significant (Schneider, 1986; Schneider and Enste, 2000; Torgler and Schneider, 2007; Schneider, Buehn, and, Montenegro, 2012) to being statistically indistinguishable from zero or even strongly negative (Loyaza, 1996; Johnson, Kaufmann and Zoido-Lobaton, 1998; Friedman et al., 2000; Dreher and Schneider, 2010; Torgler and Schneider, 2007).

A common explanation for the observed weak relationship between tax rates and the shadow economy is that institutions, rather than taxes, are the main drivers of the level of activity in the shadow economy. However, it has yet to be established if this statistically weak result for tax rates is driven by empirical limitations (e.g., small sample size, endogeneity of tax rates, measurement error, etc.) or a more fundamental intrinsic relationship between tax rates and the shadow economy. In either case, there seems to be a contradiction between the justification espoused by policy makers that lowering tax rates will bring potential tax payers back to the official economy, thus reducing the size of the shadow economy, and the lack of conclusive empirical evidence to support

3 By 2005, more than 8 percent of countries had one flat PIT rate, as compared to less than 1 percent in the early 1980s. The total number of countries with a flat rate PIT as of December 2012 was 38; the majority of these countries are in Eastern Europe.

4 The foundation for the flattening of tax rates is believed to have been set by slowing economic growth, inflation, the increased pace of globalization, economic liberalization, growing international trade, the rise of supply side economics, and a general shift towards smaller governments that characterized the 1980s and early 1990s (Bird and Zolt, 2005; Auerbach and Slemrod, 1997).

5 Although theoretical evidence on the relationship between tax rates and tax evasion is mixed, empirical results largely support the conclusion that the relationship is positive.

6 For example, many policy makers praise the flat tax and believe in its power to reduce the shadow economy. Macedonia’s Prime Minister, Nikola Gruevski, says “this [flat-tax] reform will decrease tax evasion and encourage people to meet their obligations to the state” (Basham and Mitchell, 2008, p. 121). Giorgios Alogoskoufis, Finance Minister of Greece, believes “a flat tax rate, by discouraging evasion and corruption and also boosting incentives for high earners, would help narrow the deficit” (“Greece Joins the Flat Rate Tax Bandwagon,” The Telegraph, August 15, 2005, http://www.telegraph.co.uk/finance/2920635/Greece-joins-the-flat-rate-tax-bandwagon.html). Prime Minister of Bulgaria Sergei Stanishev states that “the introduction of the flat tax is expected to generate more money for the country and bring undeclared incomes ‘to light’” (“The Low-Flat Option,” Oxford Business Group, August 29, 2007, http://www.oxfordbusinessgroup.com/economic_updates/low-flat-option).
this contention. The purpose of this paper is to re-examine the link between tax policy and the shadow economy. We are particularly interested in identifying the effect, if any, of tax rates on the size of the shadow economy. Because the focus of the paper is on the effect of tax rates, other determinants of shadow economic activity such as quality of institutions are discussed only briefly.

Although this is not a new question, we make several important contributions to the literature with the aid of a unique dataset and careful attention to issues of identification. First, we use a new comprehensive panel tax dataset from the World Tax Indicators, which covers 189 countries from 1981 to 2005. These data are combined with data on macroeconomic indicators, energy prices, weather conditions, and energy consumption statistics to produce a dataset that covers more countries and years than any other study in the existing literature. Together, our data collection efforts produced a dataset that represents approximately 94 percent of the world population and 98.5 percent of the world output for the entire period.

Second, we offer a new estimation framework by reviving the traditional electricity consumption approach to measuring the shadow economy. In particular, we show that under certain assumptions, a correctly specified function for the log of electricity per unit of output can produce a consistent estimate of the effect of the tax burden on the shadow economy. This contribution is particularly important given that the shadow economy is, by definition, immeasurable. Therefore, we view this paper as complementary to studies using alternative measures of the shadow economy. Since there is no single true observable measure of the shadow economy, results from various techniques are needed in order to provide a good understanding of what drives the shadow economy.

Because of our emphasis on the causal relationship between tax policy and the shadow economy, we pay careful attention to identification issues that some of the previous literature failed to address. For example, policy makers responding to a growing shadow economy may choose to increase tax revenues by (1) increasing the tax rate on the smaller base, or (2) expanding the tax base, by either reducing rates or simplifying the tax system. In either case, tax rates are endogenous thus leading to biased estimates in a simple ordinary least squares (OLS) framework. Similarly, cross-sectional studies that fail to control for unobserved time-invariant covariates that are correlated with tax policy will produce biased results. We address these issues by controlling for country fixed effects and using tax rates in neighboring countries as instrumental variables (IV) for national tax variables.

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7 Shadow economic activity in our context refers to all economic activity that requires energy consumption, but which are unrecorded in official GDP measures. Although shadow economic activity facilitates tax evasion, shadow economic activity is not the same as tax evasion. A more detailed discussion of these concepts is provided in Section II.

8 At the very least, mixed results across techniques is an indication that further research is required to understand this “invisible” phenomenon. It is important to note that our approach only allows us to identify the effect of tax rates on shadow economic activity. It does not address concerns related to quantifying the size or evolution of the shadow economy. It is for this reason that we focus exclusively on identifying the impact of tax rates on shadow economic activity.
The IV estimates with country fixed effects consistently show a strong positive effect of the top statutory corporate tax rate on the size of the shadow economy. We find that a 1 percentage point increase in the top statutory corporate income tax rate increases the size of the shadow economy by 2.3 percent, which implies a tax elasticity of shadow economic activity of 0.782 at the mean CIT rate. Extending the analysis to account for alternative definitions of the IVs as well as controls for region-specific shocks produces elasticities that range from 0.578 to 1.258, which suggest that tax rates play a more important role in determining shadow economic activity than suggested by the previous literature.

These results are relevant to current fiscal policy debates. Many countries facing persistent fiscal deficits are tempted (or advised) to increase tax rates in an effort to generate the revenues required to close budget deficits. Our results suggest that taxpayers shift economic activity to the informal sector as income tax rates increase. This behavioral response reduces the tax base and thus offsets some of the revenue gains from the higher tax rates. It is also possible that the shift in economic activity to the informal economy places additional costs on taxpayers, which may lead to an increase in the deadweight loss of the tax system. For example, taxpayers may have to pay bribes, choose obscure business locations, or remain inefficiently small in order to operate successfully in the shadow economy. While bribes represent pure transfers that do not affect economic efficiency, the latter two responses involve real resource costs that may increase the deadweight loss of the tax system (Chetty, 2009). The relative importance of transfers versus real resource costs of operating in the shadow economy is an empirical question that we do not pursue here.

The rest of the paper is organized as follows. Section II derives an empirical model of the shadow economy based on electricity or energy consumption, Section III describes identification issues, and Section IV introduces the data, variables, and sources. Section V describes our results and Section VI concludes.

II. EMPIRICAL MODEL OF THE SHADOW ECONOMY

The term shadow economy generally refers to economic activities that are not measured as part of GDP. Some of these activities such as home production are deliberately excluded from GDP, while others are excluded because they are hidden from the government by unregistered firms seeking to avoid (1) payment of taxes or social security contributions, (2) having to meet labor market standards, or (3) complying with certain administrative procedures (Lacko, 2000; Schneider, 2005; Slemrod and Weber, 2012). This paper focuses on all economic activities that contribute to a country’s consumption of energy, but are not measured in the country’s national income accounts. Because most of the economic activities that are excluded from the national income accounts generally facilitate tax evasion, there is significant overlap between shadow economic activity and tax evasion. Nonetheless, tax evasion and shadow economic activity are not the same; in particular, it is possible to evade taxes on income earned in the formal economy. It is also possible, though unlikely, for an individual to pay income taxes on income earned in the informal economy.
A. Measuring the Shadow Economy

Because the shadow economy is immeasurable, identification of its determinants often relies on traces of true income such as the electricity consumption method (ECM), traces of noncompliance such as currency in circulation, or the multiple-indicators, multiple-causes (MIMIC) method, which combines traces of true income, traces of noncompliance, and GDP (Slemrod and Weber, 2012). Although each of these methods has been used extensively, identifying the size of the shadow economy and its determinants remains problematic because each of the methods has serious flaws. For example, estimates of the shadow economy using the MIMIC and currency methods likely suffer from omitted variable bias and are based on strong exclusion assumptions that make identification of casual relationships difficult.

Although the ECM method has been criticized for these and other reasons,\(^9\) we argue that the general problems with the ECM measure do not necessarily create biased coefficients on tax variables if appropriate covariates are used in a fixed effects model of the shadow economy.\(^10\) Again, our objective is to provide an internally valid technique that complements other efforts to determine the effect of taxes on this elusive component of the economy. The following model is constructed to achieve this goal.

B. Model Specification

The relative size of the shadow economy can be linked to electricity/energy consumption through the following identity

\[
\ln \left( \frac{E}{Y} \right) = \ln \left( \frac{T}{Y} \right) + \ln \left( \frac{E}{T} \right),
\]

where total output \(T\) is the sum of output in the official economy \(Y\) and output in the shadow economy \(S\) \((T = Y + S)\) and \(E\) denotes either electricity consumption or total primary energy consumption, which includes the consumption of petroleum, natural gas, and coal, in addition to electric power. By including additional sources of energy, we can allow for the potential substitution effect among energy sources due to relative price changes.

The first term on the right hand side of (1) captures the log deviations of recorded GDP \((Y)\) from total output \((T)\), and hence it approximates the relative size of the shadow economy.\(^11\) We can model this term as a function of observable economic and institu-

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\(^9\) See the discussion in the online appendix, available at https://sites.google.com/site/denvild/publications.

\(^{10}\) The electricity consumption method is based on the presumption that electricity consumption is the single best indicator of total economic activity. As a product, electricity is homogeneous and measured in consistent physical units, it has relatively low substitutability with other goods and services, and it is difficult to hide at an aggregate level. Assuming unitary elasticity of electricity consumption with respect to total output, the difference between the growth rate of electricity consumption and the growth rate of recorded output (official GDP) can be attributed to the growth rate in the shadow economy (Kaufmann and Kaliberda, 1996).

\(^{11}\) Note that if \(S/Y\) is sufficiently small, the first term of (1) becomes the ratio of output in the shadow economy relative to recorded GDP.
ional determinants of the shadow economy \( X \) (e.g., tax burden, government size, law and order, macroeconomic volatility, etc.) and an unobserved error term \( \nu \)

\[
(2) \quad \ln \left( \frac{T}{Y} \right) = X\beta + \nu, \quad \text{with } E(\nu) = 0, \quad Cov(X, \nu) = 0.12
\]

We relax the assumption of constant elasticity that is generally made in the electricity consumption method and model the second term of (1) as a linear function of the vector \( Z \), which includes variables that affect the log ratio of energy consumption and total output\(^13\)

\[
(3) \quad \ln \left( \frac{E}{T} \right) = Z\gamma + \epsilon, \quad \text{with } E(\epsilon) = 0, \quad Cov(Z, \epsilon) = 0.
\]

The \( Z \) vector includes observable factors that alter energy/electricity consumption without a corresponding change in total output, such as energy-saving technological progress, changes in output mix and relative prices, and weather fluctuations. For instance, the share of renewable sources in total energy consumption might be a good proxy for efficient energy use. Services and agriculture tend to be less energy-intensive than manufacturing, and hence changes in output mix might be another relevant \( Z \) factor. Lagged GDP per capita is another proxy for technological progress and overall total factor productivity. Higher energy prices relative to the prices for other goods and services generally lead to a higher degree of energy conservation in both consumption and production. Unfortunately, it is not possible to control for energy efficiency at a more disaggregated level — industry-year within a given country, for example — in this study. Finally, Eilat and Zinnes (2002) and Hanousek and Palda (2006) find that a colder climate is positively associated with higher electricity consumption per unit of output.

By substituting (2) and (3) into (1), our model becomes

\[
(4) \quad \ln \left( \frac{E}{Y} \right) = X\beta + Z\gamma + (\nu + \epsilon),
\]

or

\[
(5) \quad \ln \left( \frac{E}{Y} \right)_{it} = \beta X_{it} + \gamma Z_{it} + \xi_{it} + \alpha_{it} + u_{it},
\]

where \( \alpha_{it} \) are country fixed effects, \( \xi_{it} \) are time effects, and \( u_{it} \) is a white noise error term. The empirical model in (5) has several important advantages over the cross-sectional

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12 The zero covariance assumption will be relaxed and addressed in Section IV below.

13 The assumption of constant elasticity could be imposed by assuming a relatively flexible functional form for energy consumption such as \( E = A T^{\mu} \), where \( \mu \) is the output elasticity of energy consumption. Note that if \( \mu \rightarrow 1 \) (the standard assumption of the shadow economy estimates), then \( \ln(E/T) \rightarrow \ln A \), which is constant, and hence the \( \ln(E/Y) \) function simplifies to the shadow economy function. A more general formulation for the second term in equation (1) is \( \ln(E/T) = (1/\mu) \ln A + \ln E - (1/\mu) \ln T \), which can be substituted into (1) to derive a functional form that allows us to estimate \( \beta \) and \( \mu \). The disadvantage of using this formulation is that \( \mu \) is neither country-specific nor time-variant. We therefore use the less restrictive, but more data demanding approach in (3).
regression of the standard ECM measure of the shadow economy on the $X$ variables. For example, the model does not require assumptions on the initial values of the shadow economy for which the Kaufman-Kaliberda method has been criticized. There is no need to assume unitary or any other constant value for the output elasticity of energy consumption. The inclusion of the $Z$ vector reduces omitted variable bias in estimating the $\beta$'s. Finally, the model is simple and can be estimated in one step, thus avoiding two-step estimation biases caused by the correlation between $X$ and $Z$. However, we must overcome other identification issues, which we discuss below.

### III. IDENTIFICATION ISSUES

Identifying the effects of the $X$ variables on the shadow economy requires several assumptions. These include omitted variable bias if the $Z$ vector is omitted, the fact that our measure of tax rate must be in $X$ and not in $Z$, and endogeneity of tax rate. This section of the paper discusses each of these issues.

#### A. Correlation Between $X$ and $Z$

The first empirical issue is that $X$ and $Z$ are likely to be correlated, which means that omitting $Z$ from the analysis will lead to biased estimates. For example, changes in energy/electricity prices might be associated with price liberalization and thus be correlated with other deregulation policies and institutional changes. The energy/electricity prices are also likely to fluctuate during periods of macroeconomic instability when informal economies tend to rise. A country’s efforts on renewable energy development could be driven by stronger government institutions. Also, trade and other services tend to grow following economic liberalization reforms. Perhaps the only variable that could be omitted without serious consequences, if country fixed effects are included, is cold weather.\(^{14}\) Thus, to obtain unbiased and consistent estimates of $\beta$, the $Z$ vector has to be included in the shadow economy function (5).

Even if the $Z$ vector includes all observables that are correlated with $X$, the $\beta$'s will be biased if we fail to control for time invariant unobserved factors that are themselves correlated with tax rates. For example, country characteristics such as geographic location, size, natural resource endowment, ethnic fractionalization, time-invariant social norms, and legal and colonial origins may affect a country’s shadow economic activities and tax policy. It is also possible that the shadow economy and its determinants in $X$ are affected by worldwide shocks. Therefore, obtaining unbiased estimates requires that we control for time-invariant unobserved country heterogeneity and shocks with country and year fixed effects, respectively.

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\(^{14}\) Without country fixed effects, climatic conditions should not be omitted from the shadow economy function since they may affect the overall productivity (Sachs, 2001) and participation in informal activities, especially in agriculture.
B. Tax Rate in X But Not in Z

The second and equally important issue for identification is the fact that the X and Z vectors likely overlap. For example, the output mix is an important determinant of the shadow economy, as it is easier to avoid taxes in agriculture and services than in manufacturing (Torgler and Schneider, 2007). For such factors, it is difficult to separate the energy efficiency effect from the shadow economy effect. More generally, for the \( \beta \)'s to be interpreted as the effect of X on the shadow economy, the corresponding X variable should not belong to the Z vector, i.e., it should not alter the technological relationship between energy consumption and total output. Therefore, since we are particularly interested in the effect of taxes on the size of the shadow economy, identification requires the assumption that taxes are not in the Z vector.

We argue that this assumption seems reasonable on the basis of tax incidence assumptions and recent empirical evidence. The economic incidence of the corporate income tax is controversial, with evidence that it falls on labor and capital to varying degrees — from predominantly on labor (Randolph, 2006; Harberger, 2008) to predominantly on capital (Gravelle and Smetters, 2006). In either case, corporate income taxes could potentially affect energy use depending on the degree of substitutability or complementarity between energy use and capital inputs. However, a recent survey of 34 studies and 317 estimates concludes that the cross-price elasticities between energy and capital inputs tend to be close to zero (Koetse, de Groot, and Florax, 2008), implying that an increase in CIT rates is unlikely to alter the relationship between energy use and total output. Consequently, one can interpret the coefficients on CIT rates in (5) as the shadow economy effects.

C. Endogeneity of Tax Rates

The final identification issue is endogeneity of tax rates, which may arise due to reverse causality or omitted variable bias. First, policy makers can respond to changes in the size of the shadow economy in two ways: increase tax rates on the formal sector to meet a specified revenue target, or reduce tax rates in the hope of decreasing incentives to operate in the shadow economy. While the latter response implies a downward bias, the former implies our estimates might be too large, so the direction of the bias is unclear. Using statutory tax rates on the right hand side of the equation helps to alleviate this problem. In contrast to revenue-derived effective tax rates, which are simultaneously determined with the size of the shadow economy and hence adjust instantly, statutory rates tend to be sluggish due to political delays and the time lags needed to introduce new rates. Nevertheless, this is only a partial solution.

Second, despite our best efforts, it is possible that we fail to control for every time-varying variable that affects the size of the shadow economy and/or energy consumption. To the extent that these variables are correlated with tax policy, our estimated coefficient

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15 See Auerbach (2006) and Gravelle (2013) for reviews of the literature.
will suffer from omitted variable bias. We address the issue of endogeneity by using an instrumental variables estimation technique.

1. Definition of Instruments

Our instrumental variable (IV) approach exploits the spatial correlation in tax rates among neighboring countries in order to obtain consistent estimates (Lee and Gordon, 2005; Ferede and Dahlby, 2012). There are several channels through which this spatial correlation might arise. First, tax rates will be correlated if countries actively compete for the various tax bases; this is especially true for high skilled labor (Kleven, Landais, and Saez, 2010; Egger and Radulescu, 2009) and capital (Devereux, Lockwood, and Redoano, 2008). Second, the adoption of successful policies previously implemented by neighboring countries can lead to spatial correlation, an effect that has been termed policy diffusion (Whalley, 1990). Finally, spatial correlation in tax rates can arise as a result of yardstick competition if voters are able to pressure policy makers to adopt policies similar to those of neighboring countries in an effort to win re-election (Besley and Case, 1995).

As a starting point, we define our IVs as the mean of the corresponding tax rates of bordering countries based on geographic contiguity. For country-islands, the tax rate of the five closest neighbors is used. The contiguity indicator is taken from the CEPII Country Distance Data, and each contiguous neighbor is given equal weight. The IV estimates are performed using XTIVREG2 Stata module (Schaffer, 2010) and standard errors are clustered on region.

2. Validity of Instruments: Orthogonality

A good instrumental variable is one that it is uncorrelated with the error term in (5); i.e., \( E(u_i \bar{\tau}_n) = 0 \), where \( \bar{\tau}_n \) is the mean tax rate of country \( i \)'s neighbors. In other words, our identification assumption is that tax rates from bordering countries are uncorrelated with the unobservable within-country component of the shadow economy. This assumption is unlikely to be satisfied if there are region specific time-invariant factors that are correlated with both the shadow economy and our IVs. For example, the wholesale adoption of flat rate PIT structures in Eastern Europe is likely influenced by time invariant characteristics that exist at the regional level and similar arguments can be made for other regions. This problem can be addressed by including region fixed effects.

Note, however, that this is the same as controlling for country fixed effects since none of the countries in our sample changes region over the sample period. We also include several variables on country characteristics and year fixed effects that should minimize any bias caused by global shocks that affect both tax rates and shadow economic activity.

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Our IV strategy is also unlikely to satisfy the orthogonality condition if region-specific shocks drive both tax rates and shadow economic activity. We describe our efforts to address this concern along with the relevance of our IVs in Section V.3.

IV. VARIABLES AND SOURCES

Unlike many conventional economic functions (e.g., earnings, production, economic growth, etc.), the shadow economy function is not very well defined. Nevertheless, the four factors that the theoretical and empirical literature consistently include in the shadow economy function are the official tax burden, the degree of administrative controls of the economy (or regulations broadly defined), the extent of macroeconomic volatility, and some measure of overall socio-economic development. As a starting point, the $X$ vector in our base specification of (5) includes variables that represent each of the above factors, maximize the sample size subject to specification constraints, and are publicly available for easy replication.

The tax burden is approximated by the top statutory CIT rate. The top rate is of particular interest since entrepreneurs deciding to divert resources to the underground economy are likely to face the maximum tax rate. These statutory rates are strictly preferable to effective rates or to any other measure derived from actual tax revenues since low tax collections (and hence effective rates) are a direct outcome of the shadow economy, making the effective tax rates endogenous.\footnote{For the same reason, some of the widely used indices of tax burden should also be avoided in the shadow economy function. For example, the Heritage Foundation Index of Fiscal Freedom is calculated as a weighted average of the top marginal income tax rates (personal and corporate) and the tax revenue as a portion of GDP. The tax revenue component is clearly endogenous as it is directly affected by the size of the shadow economy.}

These tax data are taken from the World Tax Indicators (Sabirianova Peter, Buttrick, and Duncan, 2010), who document all of the data sources and describe consistency checks and data reconciliation efforts. The WTI tax dataset contains 3,587 top CIT rates from 1981 to 2005, averaging 145 countries per year.

Policy makers may influence the shadow economy not only via taxes but also through other forms of government regulations and administrative controls. Licenses, permits, subsidies to selected businesses, price and wage controls, inspections, and other forms of government interventions increase the costs of operating officially, and hence create greater incentives for escaping to the underground economy. The degree of government regulations is difficult to quantify, and it is often approximated by the size of the government measured via general government final consumption expenditures as percent of GDP.\footnote{In addition to government expenditures, we also used the share of public administration employment in total employment. While the results were qualitatively similar, the sample size was significantly smaller for this variable.}

It is also believed that the shadow economy thrives under macroeconomic instability. In particular, depreciation of the national currency and high inflation induce an escape to
foreign currency, stimulate non-taxable barter transactions, devalue previously accumulated tax debt and incurred penalties, and provide an easy escape from tax authorities. Both measures of macroeconomic volatility (the rate of currency depreciation and the inflation rate) exist for most of the countries from 1980 to 2005. They are primarily drawn from the IMF International Finance Statistics and supplemented by other data sources (see the online appendix for sources and calculations formula).

Based on our earlier discussion, the \( Z \) vector in (5) includes the share of renewable energy resources in total net electricity consumption, the share of industry in GDP, the share of services in GDP, lagged log per capita GDP in purchasing power parity (PPP)-adjusted international dollars, cold weather, and changes in energy prices. The first four variables are straightforward, available for most of the countries (140+ from 1980 to 2005), and obtained directly from the sources identified in online appendix B. Cold weather is approximated by the mean daily temperature in January or June depending on the hemisphere. The daily temperature data come from the global surface database published by the U.S. National Climatic Data Center. Missing values are replaced by the observed temperature in a country’s closest neighbor. Energy price changes are calculated on the basis of the consumer price indices for electricity, gas, and other fuels downloaded from the International Labor Organization Laborstat Database.

To construct dependent variables, we use primary energy consumption and net electricity consumption. Both measures are obtained from the U.S. Department of Energy International Energy Annual that publishes original data from individual country sources. Net electricity consumption is calculated as net electricity generation by hydroelectric, nuclear, and other electric power sources, plus electricity imports minus exports, and minus electricity distribution losses. Net energy generation excludes the energy used by the generating units. The consumption of primary energy includes net electricity consumption as well as the consumption of petroleum, natural gas, and coal. Finally, the denominator of the dependent variable is the log of recorded GDP in national currency at constant 1990 market prices. The GDP series is taken primarily from the United Nations Common Database, and supplemented by individual country sources in a few missing cases. GDP is estimated using the old 1968 System of National Accounts (SNA) methodology to avoid potential bias due to the inclusion of a portion of the shadow economy in the 1993 SNA methodology.

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19 The \( X \) and \( Z \) vector may overlap as some of the variables in the \( Z \) vector (e.g., GDP per capita, output mix, and energy prices) can have an independent effect of the size of the shadow economy.
20 These data are available at http://www.ncdc.noaa.gov/data-access.
21 These data are available at http://laborsta.ilo.org/. Note that energy price indices are missing for almost 30 percent of the sample. Instead of deleting missing observations and creating a sample selection problem, all estimates include a dummy variable for missing energy price indices.
23 We experimented with other units of measurement of GDP, such as constant U.S. dollars and PPP-adjusted international dollars. The estimates are virtually unchanged if controls for currency depreciation and inflation are added.
24 These data are available at http://unstats.un.org/unsd/default.htm.
The final estimation sample, after deleting all missing values, thus consists of 3156 country-year observations, or an average of 126 countries per year from 1981 to 2005. Additional descriptions of all variables and data sources are provided in the online appendix and in the summary statistics for the estimation sample shown in Table 1.

V. ESTIMATION STRATEGIES AND RESULTS

Having specified all variables, we now estimate (5). Because data on cold weather begins in 1987, it limits the time span for OLS estimates. However, the model with country fixed effects is not sensitive to the inclusion of the weather variable. We exclude this variable and use the longer period from 1981 to 2005 in the analysis.25

A. Baseline Estimates: Fixed Effects versus OLS

Table 2 presents OLS and FE estimates of the shadow economy function specified in (5). The coefficient on tax rates in the simple OLS (mis)specification is negative, which is in line with previous cross-sectional studies. On the other hand, the estimated coefficient on the top statutory corporate income tax rate is positive and statistically significant for both total energy and electricity consumption when we account for country fixed effects.26

The FE estimates in Table 2 show that the institutional structure and performance of the economy play important roles in determining the prevalence of shadow economic activity. For example, we find a predictable negative effect of the lagged log of per capita GDP and an expected positive effect of government size, inflation, and energy prices on the log of energy and electricity consumption per recorded output.27 The estimated coefficient on currency depreciation is also positive and large in magnitude (compared to inflation), but it has large standard errors in some specifications. The effect of output mix is not statistically significant, which is not surprising; although services may require less energy per unit of output, they provide more opportunities for informal activities, and hence the resulting net effect may be small. The share of renewable energy sources has the anticipated negative sign as it reduces energy consumption per unit of output.

25 We estimate the shadow economy function with and without the weather variable for the 1987–2005 period. The Hausman test suggests the OLS estimates are highly sensitive to omitting the weather variable, while the FE estimates are not affected by excluding this variable. These results are available upon request.

26 We also find some suggestive evidence that the effect of tax rate on shadow economic activity varies across countries at different stages of development. Similar to Schneider, Buehn, and Montenegro (2012), we find that the effect appears to be weaker in developing countries. However, the lack of suitable instruments for a model with multiple interaction terms prevents us from pursuing this line of investigation further. Results are available upon request.

27 Whereas higher energy prices are likely to reduce the demand for energy, they also reflect macroeconomic volatility (simple correlation with inflation is 0.7305) as well as the possibility of rent extractions in energy-producing countries, which tend to spread the shadow economy.
### Table 1
Summary Statistics of Key Variables by Period

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</thead>
<tbody>
<tr>
<td></td>
<td>(0.565)</td>
<td>(0.621)</td>
<td>(0.887)</td>
<td>(0.945)</td>
<td>(0.896)</td>
<td>(0.831)</td>
</tr>
<tr>
<td>Log (Electricity/GDP)</td>
<td>–1.100</td>
<td>–0.985</td>
<td>–0.733</td>
<td>–0.735</td>
<td>–0.738</td>
<td>–0.830</td>
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<tr>
<td></td>
<td>(0.591)</td>
<td>(0.596)</td>
<td>(0.864)</td>
<td>(0.956)</td>
<td>(0.961)</td>
<td>(0.853)</td>
</tr>
<tr>
<td>Top PIT rate (%)</td>
<td>51.887</td>
<td>43.634</td>
<td>35.893</td>
<td>33.295</td>
<td>30.994</td>
<td>37.757</td>
</tr>
<tr>
<td>Top CIT rate (%)</td>
<td>41.431</td>
<td>39.530</td>
<td>34.318</td>
<td>32.059</td>
<td>29.100</td>
<td>34.401</td>
</tr>
<tr>
<td>Log (GDP per capita)</td>
<td>8.165</td>
<td>8.404</td>
<td>8.494</td>
<td>8.551</td>
<td>8.715</td>
<td>8.498</td>
</tr>
<tr>
<td></td>
<td>(1.038)</td>
<td>(1.035)</td>
<td>(1.053)</td>
<td>(1.130)</td>
<td>(1.156)</td>
<td>(1.106)</td>
</tr>
<tr>
<td>Currency depreciation (%)</td>
<td>0.128</td>
<td>0.076</td>
<td>0.131</td>
<td>0.095</td>
<td>0.010</td>
<td>0.083</td>
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<tr>
<td></td>
<td>(0.196)</td>
<td>(0.217)</td>
<td>(0.247)</td>
<td>(0.153)</td>
<td>(0.138)</td>
<td>(0.195)</td>
</tr>
<tr>
<td>Inflation (%)</td>
<td>0.257</td>
<td>0.324</td>
<td>0.924</td>
<td>0.177</td>
<td>0.086</td>
<td>0.343</td>
</tr>
<tr>
<td></td>
<td>(0.837)</td>
<td>(1.201)</td>
<td>(2.454)</td>
<td>(0.739)</td>
<td>(0.258)</td>
<td>(1.343)</td>
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<td>Energy prices change (%)</td>
<td>0.160</td>
<td>0.137</td>
<td>0.375</td>
<td>0.117</td>
<td>0.051</td>
<td>0.163</td>
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<tr>
<td></td>
<td>(0.582)</td>
<td>(0.823)</td>
<td>(1.511)</td>
<td>(0.491)</td>
<td>(0.134)</td>
<td>(0.837)</td>
</tr>
<tr>
<td>Variable</td>
<td>0.302</td>
<td>0.299</td>
<td>0.303</td>
<td>0.305</td>
<td>0.391</td>
<td>0.324</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>Energy prices missing (dummy)</td>
<td>(0.460)</td>
<td>(0.458)</td>
<td>(0.460)</td>
<td>(0.461)</td>
<td>(0.488)</td>
<td>(0.468)</td>
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<tr>
<td>Service (% GDP)</td>
<td>51.281</td>
<td>52.743</td>
<td>52.950</td>
<td>54.398</td>
<td>54.690</td>
<td>53.442</td>
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<tr>
<td>Industry (% GDP)</td>
<td>33.153</td>
<td>32.296</td>
<td>31.617</td>
<td>30.273</td>
<td>31.092</td>
<td>31.505</td>
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<tr>
<td>Renewable energy (%)</td>
<td>1.433</td>
<td>1.391</td>
<td>1.335</td>
<td>1.419</td>
<td>1.864</td>
<td>1.508</td>
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<tr>
<td></td>
<td>(5.007)</td>
<td>(3.923)</td>
<td>(3.918)</td>
<td>(3.910)</td>
<td>(4.720)</td>
<td>(4.302)</td>
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<tr>
<td>N</td>
<td>470</td>
<td>511</td>
<td>644</td>
<td>758</td>
<td>773</td>
<td>3,156</td>
</tr>
</tbody>
</table>

Notes: Standard deviations are in parentheses, and N counts country-year observations with non-missing values on all variables (N=3156), except for energy prices (N=2133), the top PIT rate (N=3015), and cold weather (N=2521). The description of variables and sources is provided in the online appendix GDP per capita is measured in purchasing power parity (PPP) international dollars.
<table>
<thead>
<tr>
<th></th>
<th>Energy</th>
<th>Electricity</th>
</tr>
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<tr>
<td></td>
<td>OLS</td>
<td>FE</td>
</tr>
<tr>
<td>Top CIT rate</td>
<td>−0.025</td>
<td>0.003**</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.002)</td>
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<tr>
<td>Log (GDP per capita)_{t−1}</td>
<td>0.115</td>
<td>−0.257**</td>
</tr>
<tr>
<td></td>
<td>(0.700)</td>
<td>(0.129)</td>
</tr>
<tr>
<td>Government expenditures</td>
<td>0.148***</td>
<td>0.008*</td>
</tr>
<tr>
<td></td>
<td>(0.023)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>Currency depreciation</td>
<td>3.827***</td>
<td>0.038**</td>
</tr>
<tr>
<td></td>
<td>(1.143)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>Inflation</td>
<td>1.075***</td>
<td>0.010***</td>
</tr>
<tr>
<td></td>
<td>(0.296)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Energy prices change</td>
<td>−0.186</td>
<td>0.016***</td>
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<tr>
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<td>(0.290)</td>
<td>(0.006)</td>
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<td>Energy prices missing (dummy)</td>
<td>−0.160</td>
<td>−0.002</td>
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<td></td>
<td>(0.256)</td>
<td>(0.027)</td>
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<tr>
<td>Service (% GDP)</td>
<td>0.015</td>
<td>−0.001</td>
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<tr>
<td></td>
<td>(0.032)</td>
<td>(0.004)</td>
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<tr>
<td>Industry (% GDP)</td>
<td>0.039</td>
<td>0.001</td>
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<tr>
<td></td>
<td>(0.028)</td>
<td>(0.005)</td>
</tr>
<tr>
<td>Renewable energy</td>
<td>−0.026</td>
<td>−0.002***</td>
</tr>
<tr>
<td></td>
<td>(0.073)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Constant</td>
<td>−10.355**</td>
<td>−3.377***</td>
</tr>
<tr>
<td></td>
<td>(5.032)</td>
<td>(0.686)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.248</td>
<td>0.105</td>
</tr>
<tr>
<td>N</td>
<td>3,156</td>
<td>3,156</td>
</tr>
</tbody>
</table>

Notes: Standard errors, clustered on region, are in parentheses. Asterisks denote significance at the 1% (***) , 5% (**), and 10% (*) levels. All models include year fixed effects (FE), and the FE specifications include country fixed effects. CIT is the top statutory corporate income tax rate. Within R-squares are reported in the fixed effects specifications.
B. Difference-in-Differences Approach

The estimates presented above are likely biased due to reverse causality and possible omitted variable bias (see Section III.C). In order to get a sense of the severity of endogeneity problems, we implement a difference-in-differences (DID) technique using the following procedure. First, we identify the largest tax rate increase and decreases of at least 5 percentage points for each country, and generate two dummy variables that indicate tax increase and decrease, respectively. We then define pre-reform and post-reform periods for both dummy variables, each of which is limited to 10 years. Next, we regress our shadow economy measure on each tax reform indicator using the specification

\[
\ln \left( \frac{E}{Y} \right)_i = \alpha_1 R + \alpha_2 f(T) + \alpha_3 R^* f(T) + \beta X + \gamma Z_i + \xi + \alpha + u_i,
\]

where \(R\) is a dummy variable indicating post-reform years. The model is estimated for tax increases and tax decreases separately, \(T\) is a time variable that takes values \(-10\) to \(10\) and is equal to 0 in the year of the reform, and \(f(T)\) is a quadratic of the time variable. All other variables are as defined in Sections II and II.A. The predicted values on \(f(T)\) from these regressions are presented in Figure 2; we predict the trends before and after the reform separately. This analysis is done for the top statutory CIT and our two shadow economy measures, but we only present results for the total energy consumption-to-GDP ratio here. Furthermore, we do not report the estimated coefficients given space limitations.

Estimating (6) is advantageous for two reasons: it provides an initial look at the data to determine whether tax rates do in fact affect shadow economic activity, and it provides a clear look at the severity of endogeneity of tax rates. The results presented in Panel A of Figure 2 show a steady increase in shadow economic activity in the years leading up to tax rate increases, which confirms our suspicion that tax rate is endogenous. However, the results in Panel B suggest that this endogeneity is less severe for tax decreases; shadow economic activity increases in the years leading up to tax decreases, but the slope is much flatter. We also find that shadow economic activity increases after tax increases and tax decreases, which suggests that tax rates do not affect shadow economic activity.

Although this approach provides useful insights about the nature of the relationship between tax rates and shadow economic activity, we are careful not to assign a causal interpretation to the tax rate estimates for three reasons. First, this approach only evaluates one tax reform in each country. Since many of the countries in the sample changed their tax rates multiple times in the sample period, we argue that an alternative

\[28\] We would like to thank an anonymous referee for suggesting this approach.

\[29\] These are available from the authors upon request.

\[30\] The fact that shadow economic activity is increasing before tax increases as well as tax decreases means that we are not able to sign the bias caused by reverse causality.
approach that exploits all of the variation in the tax rates is more appropriate. Second, multiple tax rate changes for a given country also implies that the period before any tax reform is the period after a prior tax reform. As a result, there is no clean pre-reform or post-reform period with which to truly identify the effect of any given tax rate change. Third, this approach does not address the endogeneity of tax rates, which is a problem as demonstrated in Figure 2.\textsuperscript{31}

C. Instrumental Variable Results

This section describes our instrumental variables results, which uses the mean tax rate of neighboring countries as an IV to address the endogeneity of tax rate. We pro-

\textsuperscript{31} The DID type approach compares countries that have a tax reform in a given year with countries that do not have a reform in that year, thus implicitly assuming that countries with a tax reform are comparable to countries without a tax reform.
ceed by discussing the relevance of the IVs, the second stage results, and robustness checks that address regional shocks. The magnitude and implications of our estimates is discussed in Section 5.4.

1. Relevance of IVs

The first stage results reported in Models 1 and 4 of Panel A of Table 3 show clearly that the IV is relevant, as the estimated coefficient on the IV is large and statistically different from zero. We also find that the first stage F-statistic is larger than the benchmark of 10 (Staiger and Stock, 1997). Additional evidence in support of our identification strategy and the relevance of the IV is presented in Figures 3 and 4. First, Figure 3 reports the regional trend in the top CIT rate and the IV, and clearly shows that the two trends track each other closely. Second, Figure 4 compares the trend in our measure of shadow economic activity with the trend in the IV for each region. The results show that our measure of shadow economic activity tracks the trend in the IV very well in four of out five regions; the Americas is the stand out region, where the trends appear to move in opposite directions after the mid-1990s. Combined, these two figures provide a graphical representation of the two-stage least squares (2SLS) estimates by region and demonstrate that our identification strategy is valid.

2. Second stage result

Our second stage IV results are presented in Models 1 and 4 of Panel B of Table 3, for energy and electricity consumption, respectively. The IV estimates are positive and larger than the fixed effect estimates. Additionally, the estimate for energy consumption is statistically different from zero at the 5 percent level while that on electricity is marginally significant with a p-value of 0.12. Focusing on Model 1, we find that a one percentage point increase in the top CIT rate is associated with a 2.3 percent increase in the size of the shadow economy as measured by the energy/GDP ratio, ceteris paribus. This implies that the CIT rate elasticity of shadow economic activity is 0.782 — a 1 percent increase in the top CIT rate increases shadow economic activity by 0.782 percent.

---

32 The spike in the trend of the shadow economic measure for Asia and Europe is due to the addition of the former USSR countries after 1991. These additions affect the level of shadow economic activity but not the trend as can be seen by comparing Figure 4 with Figure A1 in the online appendix, where Figure A1 excludes the former USSR countries. We also estimate our baseline IV-fixed effect model with a dummy for post 1991 interacted with the tax rate and find that the relationship between the tax rate and shadow economic activity did not change in any meaningful way after 1991; estimates of the interaction term are economically close to zero and statistically indistinguishable from zero (results available upon request from the authors).

33 We would like to thank an anonymous referee for suggesting this method as a way of illustrating our IV strategy.

34 Recall that we estimate a log-linear model, which implies that the estimated coefficient is multiplied by 100 to obtain the marginal effect on the dependent variable measured in levels. To obtain the elasticity at the mean CIT rate, we multiply the estimated coefficient by the mean CIT rate for the full sample reported in Table 1.
### Table 3: Shadow Economy Function 1981–2005: Instrumental Variables, FE

<table>
<thead>
<tr>
<th></th>
<th>Log (Energy Consumption/GDP)</th>
<th>Log (Electricity Consumption/GDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
</tr>
<tr>
<td>Tax rate (IV)</td>
<td>0.194**</td>
<td>0.321***</td>
</tr>
<tr>
<td></td>
<td>0.055</td>
<td>0.037</td>
</tr>
<tr>
<td>F-statistic</td>
<td>12.461</td>
<td>75.934</td>
</tr>
<tr>
<td>F: P-value</td>
<td>0.024</td>
<td>0.001</td>
</tr>
</tbody>
</table>

#### Panel A: First Stage Results

#### Panel B: Second Stage Results

|                           | Model 1                      | Model 2                           | Model 3                           | Model 4                      | Model 5                           | Model 6                           |
| Top CIT rate              | 0.023**                      | 0.034***                         | 0.032***                         | 0.024                        | 0.033***                         | 0.030***                         |
|                           | (0.011)                      | (0.007)                          | (0.008)                          | (0.016)                      | (0.007)                          | (0.003)                          |
| N                         | 3,154                        | 3,154                            | 3,154                            | 3,154                        | 3,154                            | 3,154                            |

Notes: Standard errors, clustered on region, are in parentheses. Asterisks denote significance at the 1% (**), 5% (**), and 10% (*) levels. The models are estimated with country fixed effects, year dummies, and all of the covariates shown in Table 2. CIT is the top statutory corporate income tax rate. The IV is the mean of the corresponding tax rate of a country’s neighbors. The definition of neighbors used to create the IVs is contiguous neighbors in Models 1 and 4, weighted distance to 10 closest neighbors in models 2 and 5, and neighbor of neighbor in models 3 and 6.
Figure 3
Regional Trends in IV and CIT Rate

Note: Region specific trends in the IV (broken lines) defined as the weighted CIT rate of contiguous neighbors, and the regional trend in CIT rates (solid lines) are reported. Regions are as defined by the United Nations (https://unstats.un.org/unsd/methods/m49/m49regin.htm).
Figure 4
Regional Trend in IV and ln(Energy/GDP)

Notes: The regional trend in the IV (broken lines on left y-axis) and the log of Energy/GDP ratio (solid lines on right y-axis) are reported. The IV is defined as the mean CIT rate of a country’s contiguous neighbors. Regions are as defined by the United Nations. The spike in the Energy/GDP ratio for Asia and Europe is due to the addition of transition countries around 1991. These additions shift up the level of the ratio, but do not affect the trend (this is illustrated in Figure A1 in the online appendix). We show in an IV model with year and country fixed effects that controlling for this addition of “new” countries does not affect the results.
3. Regional Shocks

A potential concern with our IV strategy is that the tax rates of contiguous neighbors are possibly jointly determined as a result of regional shocks to shadow economic activity. We address this in several ways. First, all specifications include macro-economic indicators that should partially control for economic shocks. Second, we use two alternative definitions of neighbors to create our IVs. For the first alternative IV, we define neighbors as the 10 closest countries instead of the contiguous neighbors. The IV is then defined as the weighted average of the neighbors’ top CIT rate, where the weight is the inverse of the distance between capital cities. This approach gives greater weight to closer neighbors that are potentially more influential on domestic tax policies. The second alternative IV is defined using the mean CIT rate of the neighbors of a country’s contiguous neighbors. Allowing the IVs to be based on neighbors from different points in space should also help to break the correlation between the IVs and the error term.

These results are presented in Models 2 and 5 of Table 3 for distance-weighted neighbors and in Models 3 and 6 of Table 3 for the neighbor-of-neighbor IVs, respectively. In both cases we find that the top statutory CIT rate has a positive and statistically significant effect on the shadow economic activity. We are also able to confirm that the IVs are relevant, which we take as an indication that our estimates are not being driven by weak instrument bias.

Finally, we re-estimate (5) with region-specific time variables and report the results in Table 4. Since we are concerned that an exogenous regional shock might cause all countries in a region to simultaneously change their tax rates, the inclusion of region-specific time variables should break the link between the IV and the error term in our model. We implement this approach by estimating the baseline model with three types of region-specific time variables: region-year fixed effects, region-period fixed effects, and region-specific time trends.

We find that controlling for regional shocks does not affect the magnitude of the estimated coefficients on the top CIT rate. Furthermore, the estimates are statistically different from zero when IVs are based on distance to 10 closest neighbors. The estimated coefficients remain large when we use neighbor-of-neighbor as the basis for our IVs, but they are imprecisely estimated. We also find that controlling for regional shocks does not affect the relevance of the IVs except for IVs defined using contiguous neighbors. This suggests that the impact of regional shocks is likely stronger among bordering countries, and it increases our confidence in the distance-weighted and neighbor-of-neighbor IV results.

D. Discussion

Assuming that the energy-to-GDP ratio — conditional on the rich set of covariates included in our models — reflects variation in shadow economic activity, the estimates discussed here point to an economically meaningful causal relationship between tax

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35 We are cognizant of the fact that distant neighbors can be just as, if not more, influential than close neighbors. Still, we believe this robustness check is important since distance plays a non-trivial role in the empirical literature on tax mimicry.
<table>
<thead>
<tr>
<th>Table 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact of Region-specific Time Variables</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Period</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel A: Contiguous Neighbor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIT Rate</td>
<td>0.025</td>
<td>0.022*</td>
</tr>
<tr>
<td>F-Statistic</td>
<td>1.428</td>
<td>2.468</td>
</tr>
<tr>
<td>F: P-value</td>
<td>0.298</td>
<td>0.191</td>
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</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Period</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel B: Distance Weighted</td>
<td></td>
<td></td>
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<tr>
<td>CIT Rate</td>
<td>0.037***</td>
<td>0.030***</td>
</tr>
<tr>
<td>F-Statistic</td>
<td>21.747</td>
<td>98.400</td>
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<td>F: P-value</td>
<td>0.010</td>
<td>0.001</td>
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<th>Year</th>
<th>Period</th>
<th>Trend</th>
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</thead>
<tbody>
<tr>
<td>Panel C: Neighbor of Neighbor</td>
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<tr>
<td>CIT Rate</td>
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<td>0.028</td>
</tr>
<tr>
<td>F-Statistic</td>
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<td>15.371</td>
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<td>F: P-value</td>
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<td>0.017</td>
</tr>
<tr>
<td>N</td>
<td>3,154</td>
<td>3,154</td>
</tr>
</tbody>
</table>

Notes: Standard errors, clustered on region, are in parentheses. Asterisks denote significance at the 1% (***)**, 5% (**), and 10% (*) levels. The estimated effect of tax rates and the first stage F-statistics and corresponding P-values are shown. The specifications include all covariates reported in Table 2 of the text, including country fixed effects. The type of region-specific time variable is indicated in column titles: region year fixed effect, region period fixed effect, and region time trend. CIT is the top statutory corporate income tax rate. The IV is defined as the mean of the corresponding tax rate of contiguous neighbors, 10 closest neighbors (weighted by inverse of distance), and neighbor of neighbors, in panels A, B, and C, respectively.
rates and shadow economic activity. The estimated tax elasticity of the shadow economy, calculated at the mean CIT rate using results from the energy specifications, ranges from 0.578 to 1.258 depending on the definition of neighbor used to create the IV, and the type of regional time variables that are included to control for regional shocks. Restricting attention to distance-weighted results in the Energy/GDP specifications that account for regional time effects (Panel B of Table 4) narrows the range to 0.714 to 1.258. These results suggest that efforts to reduce corporate income tax rates as a means of stimulating economic activity are likely to yield fruitful results via reduced shadow economic activity. They also imply that the revenue effect of tax rate increases aimed at solving budget deficits are likely to be dampened by an increase in shadow economic activity.

Although these estimates are not directly comparable with other estimates in the shadow economy literature due to differences in the measurement of tax rates as well as in estimation strategy, there is evidence that our estimates are not unreasonably large. For example, Alm and Embaye (2013), using the currency method and defining tax rate as total tax revenue as a share of GDP, find elasticities of 0.72 for Non-OECD countries and 0.30 for OECD countries.

Previous studies based on the ECM method tend to find that tax rates have no effect on shadow economic activity. For example, Johnson, Kauffman, and Schleifer (1997) find that corporate tax rates have no effect on shadow economic activity in transition countries (similar to our OLS results), while a one unit increase in “tax fairness” (measured on a 0 to 10 scale, where 10 is the most fair) reduces the size of the shadow economy by 11 percentage points. Lacko (2000) finds a correlation coefficient of –0.56 between tax fairness and share of hidden economy in GDP for transition countries. Both of these estimates point to fairly large effects even though they measure tax burden differently than we do.

The results are also consistent with evidence from the literature on corporate taxable income elasticity. Results from this literature suggest that higher tax rates lead to lower taxable corporate income with estimated elasticities of 0.2 for the United States (Gruber and Rauh, 2007), 0.14–0.18 for the United Kingdom (Devereux, Liu, and Loretz, 2012) and 0.5 for Germany (Dwenger and Steiner, 2012). Additionally, there is evidence of much larger elasticities among corporations with greater income shifting opportunities (Dwenger and Steiner, 2012). Therefore, the results from this literature are consistent with firms under-reporting their economic activity in response to higher corporate income tax rates, which implies greater shadow economic activity as measured in the current study.

However, the corporate taxable income elasticity also reflects real responses such as decreased investments and income shifting responses such as changes in organizational form that are not captured by our framework. Additionally, our work captures responses of sole-proprietorships and other unincorporated forms of businesses that are generally excluded from the corporate taxable income elasticity literature. Therefore, the correspondence between the corporate taxable income elasticity and shadow economic activity is not one-to-one.

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36 We are not aware of any study of the corporate taxable income elasticity in developing countries.
VI. CONCLUSIONS

Income tax systems throughout the world have undergone a remarkable transformation from complex, graduated tax schedules to simpler, flatter tax schedules characterized by fewer tax brackets, lower rates, and simpler filing procedures. Many governments are introducing these changes with the expectation that simpler, flatter tax systems will discourage tax evasion and bring in more tax revenues. But are these expectations warranted? Will simply lowering tax rates and making tax systems simpler discourage unofficial economic activity? These are the questions this study attempts to address using an improved econometric methodology.

Previous cross-country studies provided ambiguous, mostly insignificant estimates of the tax effect due to small sample sizes, unaccounted endogeneity of tax rates, measurement errors, cross-sectional data, and other empirical limitations. This empirical study overcomes the limitations of previous literature by using better quality data, a larger sample, a longer time span of 25 years, a panel framework, instrumental variables, and by including previously omitted variables.

Unlike previous studies, our analysis provides strong evidence of a positive relationship between corporate income tax rates and the size of the shadow economy using the ECM approach. Consequently, the global transition to simpler, flatter income tax systems appears to have reduced the size of the shadow economy. The fact that a higher tax rate is associated with a larger share of the shadow economy does not imply that it is socially optimal to have a flatter tax system. There are implications of these tax changes for income inequality and economic justice that need to be addressed before such a conclusion can be drawn. The question is whether an increase in the tax base is sufficient to compensate for lower tax rates and thus generate higher tax revenues that could be subsequently redistributed.

While we cannot speak to the equity and revenue effects of recent shifts toward higher tax rates aimed at reducing fiscal deficits, our results suggest that these policies may lead to greater shadow economic activity. To the extent that this shift in economic activity requires real resource expenditures, the higher tax rates are likely to expand the deadweight loss of the tax system.

ACKNOWLEDGMENTS

We are thankful to Steve Buttrick and Jessica van Parys for their help with data collection for this project. We are also thankful Yuriy Gorodnichenko, two anonymous reviewers, and seminar participants at Georgia State University, Shadow2013, and the 2013 IIPF Congress for useful comments.

DISCLOSURES

We acknowledge research support from the National Council for Eurasian and East European Research.
REFERENCES


