Envelope Wages, Hidden Production and Labor Productivity*

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Abstract

We evaluate the relative importance of aggregate labor productivity versus income taxes and social contributions for tax compliance in an economy with a large degree of informality. Empirical evidence points out that tax evasion in Europe happens through partially concealing wages and profits in formally registered enterprises. To this end, we build a model in which employer-employee pairs of heterogeneous productive capacities make joint decisions on the degree of tax evasion. The quantitative model is used to analyze the case of Bulgaria which has the largest informal economy in Europe and underwent a number of important tax reforms over the period 2000-2014, including the introduction of a flat income tax in 2008. The estimation strategy relies on matching the empirical series for the size of the informal economy, average wages and observed labor productivity for 2000-2014. Our counterfactual experiments show that the most important factor for the changing size of the informal economy is labor productivity, which accounts for around 75% of the change. The variation in corporate income tax accounts for the rest. We find that the 2008 flat tax reform did not play any visible role in coping with informality.

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1 Introduction

Informal economic activity is a pervasive phenomenon worldwide.[1] Moreover, informal production is present not only in developing countries but also in emerging and developed economies. Informality is well-spread in Eastern and Southern Europe and reaches its highest in Bulgaria where the informal production amounts to a third of officially reported GDP in the late 2000s, as shown in Figure 1a.[2]

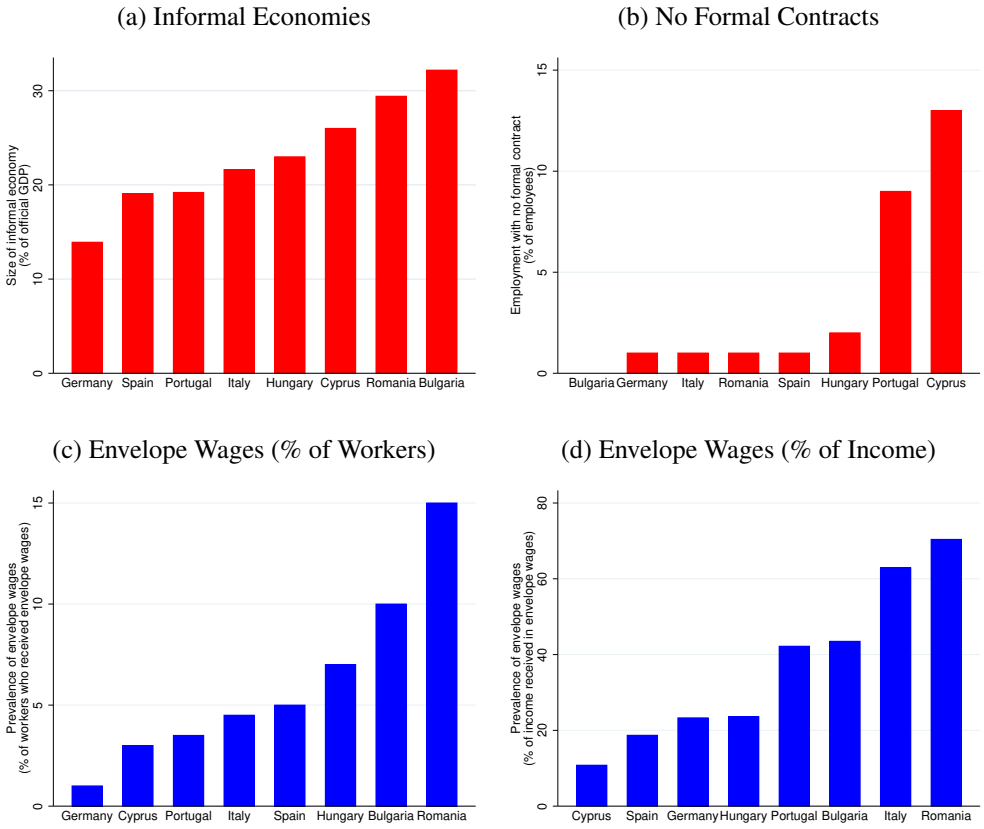
According to the 2013 World Bank Enterprise Survey almost all firms in Europe, and in particular in Bulgaria, are officially registered (see Appendix A.1 for further details). These firms conceal part of their economic activity to avoid paying taxes and social contributions. However, the number of their employees is not underreported. The 2013 Eurobarometer survey on undeclared work confirms this statement. Figure 1b presents the share of employees with no formal contracts. The average share across Europe is 2%, however, in Bulgaria it is 0%. Informal production, in this context, amounts to misreporting wages and profits to the tax authorities. Williams (2008), among others, emphasizes the pervasive practice of firms reporting lower official wages and compensating their employees with informal payments, known as *envelope wages*.

The share of workers with envelope wages is almost at its peak in Bulgaria at 10% according to the Eurobarometer surveys in 2007-2013 (Figure 1c). Only Romania has a higher share of 15%. The followers in the European ranking are Hungary, Italy and Spain with about 5-7%. Note that the average share of workers with envelope wages for the European Union is 4% in 2007-2013. Finally, the reported fraction of income received in envelope wages in Bulgaria of 43% is also at the high end of the distribution (Figure 1d). In the Eurobarometer surveys, workers self-report whether they receive informal payments or not. These results are likely to underestimate the occurrence of envelope wage practices since respondents are usually not comfortable to confess to tax evasion. Therefore, the numbers in Figures 1c and 1d can be viewed as a lower bound (see Appendix A.1 for further details on envelope wages).

[1] We follow the definition of informal economic activity of the OECD: *"all legal production activities that are deliberately concealed from public authorities for the following kind of reasons: to avoid payment of income, value added or other taxes; to avoid payment of social security contributions; to avoid having to meet certain legal standards such as minimum wages, maximum hours, safety or health standards, etc."* Therefore, criminal activities and unpaid work are *not* considered as part of the informal economy.

[2] This fact is confirmed by both the estimates of Schneider and Enste (2013) which we utilize in the paper and by a recent report on the size of the shadow economy across the globe by the Association of Chartered Certified Accountants (ACCA 2017).

Figure 1: Economic Informality in Europe, 2007-2013



Notes: The size of the informal economy is taken from Schneider and Enste (2013). The share of employees with no formal contracts is derived from the 2013 Eurobarometer survey (Special Eurobarometer 402). The share of workers with envelope wages and the share of income received in envelope wages are derived from 2007-2013 Eurobarometer surveys (Special Eurobarometer 284 and 402). A detailed description of the data used in all figures and tables is presented in Appendices A.1 and A.2.

The Bulgarian economy underwent a number of significant changes in the last 15 years (2000-2014). The informal economy size shrank from 37% of official GDP to 31%. At the same time the observed aggregate labor productivity (GDP per employee) rose by around 45%. Furthermore, several major tax reforms were implemented in this time period which reduced the average tax burden levied on both workers and firms. The corporate income tax rate went from 32.5% in 2000 to 10% in 2008. The progressivity of the personal income tax was gradually reduced in the 2000-2007 period and finally eliminated in 2008 when personal income taxes became proportional with a 10% rate (see Section 2 for further details). An important motivation behind these tax reforms was the inherent idea that lower and less progressive taxes would reduce the amount of informality and tax evasion. These stylized facts suggest that the Bulgarian economy in the last two decades can be viewed as a natural laboratory to study the determinants of the informal economic activity

and tax evasion practices related to it.

Our main goal in the paper is to determine the driving forces behind the observed changes in the informal economy using Bulgaria as a case study. We start from the premise that envelope wage practices are the predominant source of informal production there. We explore what is the role of reducing taxes and whether different taxes have a differential effect on the informal economy. The mechanism at work is clear: when taxes are lower, tax evasion becomes less attractive. At the same time, we control for various other factors that may influence the degree of tax evasion such as institutional efficiency in tax collection and the aggregate productivity level in the economy. When aggregate productivity rises, there is more income to be hidden. However, tax evasion will rise only if the marginal benefit of hiding increases. In such case, rising income levels imply higher marginal tax rates and stronger incentives for evasion. On the other hand, a rise in productivity may mechanically decrease the level of informality measured as the share of official GDP. Suppose that the nominal amount of tax evasion increases little to none. However, the GDP level increases due to the higher productivity. Then, the share of informal activity out of GDP is to decrease.

Ultimately, disentangling the forces behind the observed decline in the size of the informal economy in Bulgaria for the period 2000-2014 is a quantitative question. Up to this end, we build a model suited for studying tax evasion in Bulgaria. In particular, we carefully model the prevalent practice of envelope wages/profits used for generating informal output and evading taxes. The model economy is populated by a large number of islands with different productivity levels. Each island is occupied by one-period lived employer and a worker who collaborate on the production of a homogeneous good. Production depends on both an aggregate productivity shock which changes over time and an island-specific productivity level. The government in the economy cannot observe the island-specific productivity on each island. This creates possibilities of tax evasion by the productive pair. When underreporting production, the employer pays the worker an official salary which should be at least as high as the prevailing minimum wage. The rest of the worker's remuneration is an unofficial undeclared salary which we dub the *envelope wage*. The rest of the undeclared output is appropriated by the employer as an *envelope profit*.

The level of underreported production in the model is pinned down by comparing the benefits of tax evasion in terms of forgone tax and social contributions payments to its costs. Hiding output reduces the overall production capacity of the pair. This reflects the adjustments of the production process due to tax evasion. For instance, double accounting practices can be costly in terms of time or concealed production may take place at night.

The quantitative implementation of the model takes as inputs the detailed tax and social contribution schemes in Bulgaria for the 2000-2014 period. The parameters of the model are estimated via a *minimum distance* technique. In doing so, we match the evolution of the size of the informal economy in Bulgaria for the time period of 2000-2014. Additional time series data targets utilized in the estimation are the observed aggregate labor productivity and average wages. Utilizing them, the model recovers the evolution of true productivity and workers remuneration over time. To the best of our knowledge, this is the first quantitative economic model that captures the *prevailing* tax evasion practices in Europe.

The performed quantitative experiments point out that the rise of productivity over the period is the main driver behind the declining informality. If we fix taxes to their 2000 level but let productivity rise as predicted by the baseline model, then this counterfactual economy generates more than 74% of the decline in informality observed in the baseline version.[3] Tax policy is important too but plays a secondary role. Feeding observed tax and social contributions changes over the period into the model while fixing productivity to its 2000 level accounts for around 30% of the change in informality observed in the baseline economy. Among the taxes considered in the model, the most important determinant for the changing patterns of tax evasion is the corporate income tax. Social contributions and personal income taxes have no effect on the evolution of the informal economy size. Personal income tax and social contributions do not play a significant quantitative role in our model because they are levied on the official wages which turn out to be only a small fraction of production output. Therefore, falling tax rates on the workers' income are quantitatively much less relevant than the falling tax rates on the employers' profits.

In a subsequent exercise, we take the model economy in 2014 and ask what are the optimal tax schedules for personal and corporate income. The Ramsey-type problem amounts to maximizing produced output and, therefore, minimizing tax evasion, which is the only factor that reduces production. At the same time, the collected tax revenue is fixed to the observed levels in the baseline model. Optimal taxation requires a mild reduction in the corporate tax and a significant rise of the personal income tax. Also, optimal personal income taxes are proportional as observed in the data for 2014. The exercise delivers one more important insight: the benefits of setting optimal taxes instead of the observed ones in terms of productive efficiency are very small.

[3] We empirically check whether the model's mechanism which links negatively labor productivity and informality is valid across countries. We find strong evidence that this is so. Results of the empirical analysis are reported in Appendix A.4.

What are the policy implications of these findings? Reducing personal income tax levels and/or progressivity would not have a slashing effect on tax evasion. Instead, our quantitative results point out that reforming the corporate tax code can lead to lower levels of tax evasion. More importantly, our findings emphasize that further improvements in labor productivity may be the main driver for eradicating tax evasion. This calls for active policies aimed at product/labor market liberalization, entry barriers removal and further investments in research and development.

The rest of the document is structured as follows. In the next Subsection 1.1, we review the current literature and its relation to our work. Section 2 presents stylized facts about informality, labor productivity and the specifics of the tax and social contributions system in Bulgaria. In section 3 we present the economic environment. Section 4 discusses the estimation strategy and model fit. Section 5 contains the results of the counterfactual exercises. Section 6 discusses optimal taxation. We provide conclusions in the last section.

1.1 Related Literature

The practice of envelope wages in Europe have been studied empirically by Williams (2008), Williams and Padmore (2013) and Williams (2014) among others using data from the Eurobarameter surveys. In an innovative empirical exercise Pelek and Uysal (2016) estimate the extent of envelope wages in the case of Turkey combining data collected on a firm and household level. Tonin (2011) is the first to take into account the interaction between workers and employers in the process of tax evasion within an economic framework. Unlike us, he explores the role of minimum wage legislation for tax evasion in the case of Hungary.

A small but growing macroeconomic literature deals with the aggregate consequences of tax evasion. Chen (2003) incorporates tax evasion in an endogenous growth model, whereas Maffezzoli (2011) studies the distributional implications of income tax evasion in a heterogeneous agents framework with uninsurable income risk. In a more recent work, Di Nola et al. (2018) introduce tax evasion into a dynamic model with entrepreneurs and incomplete markets and examine the aggregate consequences of tax evasion on macroeconomic outcomes and inequality. In contrast to these papers, we abstract from the dynamic consequences of tax evasion but focus on the employer-worker joint decision to go informal. In addition, we incorporate in our macroeconomic model a detailed representation of different taxes which allows us to assess the relative importance of each

of them for tax evasion.[4]

A number of macroeconomic papers apply two-sector models of formal and informal production to emerging economies. Antunes and Cavalcanti (2007) use a general equilibrium model of occupational choice and informality to emphasize the role of regulation costs and financial contracts enforcement for cross-country differences in informality. In a similar spirit, Kuehn (2014) outlines the role of taxes and government quality for the level and dispersion of informal activity in OECD countries. Orsi et al. (2014) studies the determinants of the size of the informal economy for the case of Italy. Pappa et al. (2015) show that tax evasion and corruption matter for the size of fiscal multipliers. Joubert (2015) explores the link between informality and the design of a pension system within a structural model, while Albrecht et al. (2009) and Meghir et al. (2015) study the interaction between informality and labor market dynamics. Koreshkova (2006) evaluates the role of inflation as an implicit tax on the informal economy. Note that the two-sector setup used in these papers implies that informality never takes place in formally registered firms. Therefore, this approach is not entirely suited to study the observed envelope wage practices in Europe.

On the empirical side, Lemieux et al. (1994) estimate the effects of different axes on informal labor supply using a randomized survey from Canada. In the spirit of Pissarides and Weber (1989) who measure underreporting by using income and consumption data from household surveys, Gorodnichenko et al. (2009) study the effects of the 2001 flat tax reforms in Russia on tax evasion and economic activity. The reform reduced the average taxes of the rich while leaving the tax burden for the poor unchanged. The results point out that less progressive income taxes led to a sizable decrease in tax evasion coming from the affected affluent households. In contrast, the flattening of the income tax does not have a dramatic effect on informality in our estimated model. This is so, because envelope wage practices occur in relatively poor households who are unaffected by the flat tax reform.

Our approach has two main advantages over an empirically-driven analysis based on a quasi-experimental setup. First, we can recover the parameters of the model using only time series variations in aggregate productivity, tax rates and informal economy size. This is a huge advantage when detailed micro-data are not available. Second, the model allows us to separate the relative strengths of several driving forces behind informality and tax evasion. This can be done in the

[4]The theoretical literature on tax evasion starts with Allingham and Sandmo (1972) who present a stylized model of tax evasion by a risk-averse agent who faces the probability of getting caught and penalized by the tax authorities. For a detailed summary of the existing literature, see Slemrod and Yitzhaki (2002).

quantitative framework by explicitly shutting down one or several of these driving forces at a time. Therefore, we have a say on how important are changes in taxation versus changes in productivity in shaping the informal economic activities. Moreover, we can distinguish the role of changing different taxes in coping with tax evasion practices.

2 Facts and Institutional Design

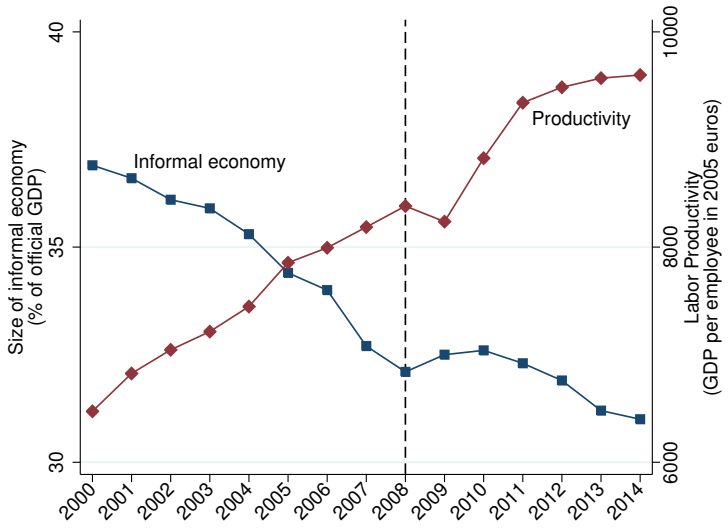
The Bulgarian economy was in transition from planning to market in the 1990s. Therefore, here we focus on the subsequent period. We start our analysis in 2000, just three years after the introduction of the currency board in Bulgaria which stabilized the macroeconomic environment. In what follows, we summarize the evolution of the Bulgarian informal economy and its potential determinants in the period 2000-2014.

2.1 Informal Economy, Labor Productivity and Institutional Efficiency

The size of the informal economy in Bulgaria decreased by around 7 percentage points (from 37% of the official GDP to 31%) in the period 2000-2014. Figure 2 presents this decline along with the corresponding 45% rise in labor productivity (computed as GDP per employee) in this period. The dotted line in 2008 marks both the start of the Great Recession, which arrived a year later in Bulgaria, and the introduction of the flat tax personal income schedule. In the period 2008-2010 informality slightly increased, while observed productivity decreased (due to the Great Recession). As already mentioned, one of the main goals of this paper is to disentangle the role of economic development and productivity growth from the effects of tax reforms for the level of tax evasion and informal production.

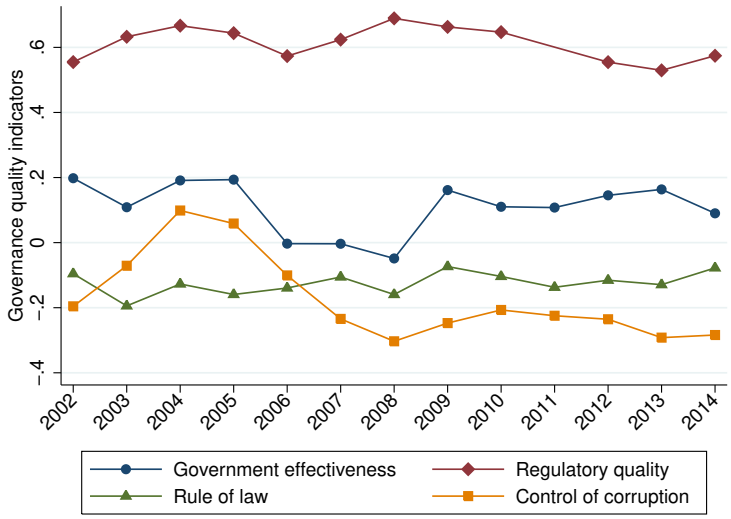
Figure 3 depicts four indicators of the institutional efficiency and the quality of governance in Bulgaria in the last 15 years reported by the World Bank. The indicators for government effectiveness, regulatory quality, rule of law, and control of corruption range from -2.5 (weak governance) to 2.5 (strong governance). All four measures of institutional efficiency do not change significantly over the analyzed period. Therefore, institutions are unlikely to have a major role in accounting for the observed decline of informality.

Figure 2: Size of Informal Economy and Labor Productivity



Notes: The size of the informal economy is taken from Schneider and Enste (2013) and Schneider (2015). The average labor productivity is taken from the International Labor Organization Key Indicators of the Labour Market (ILO-KILM) 16a database.

Figure 3: Governance Quality



Notes: The governance quality indicators are taken from the World Bank Worldwide Governance Indicators (WB-WGI) database. We include the data from 2002 on because of lack of availability for the previous years. See Appendix A.1 for additional details about these indicators.

2.2 Taxes and Social Contributions

Another factor that may have contributed to the decline in the informal economic activity, and therefore tax evasion in Bulgaria, is the changing tax system. Here we summarize the changes in

personal and corporate income tax code and the social contribution levels over the years.[5]

The personal income tax schedule underwent a number of major reforms in the last 15 years. Figure 4a depicts the average tax rate as a function of income. This tax schedule applies to the earnings of workers in the economy. Several observations are in order. First, the top marginal tax rate has decreased dramatically in the first part of the time period, from 40% in 2000 to 24% in 2007. This led to a decrease of the average rate for high earners. Second, in 2008 a flat tax of 10% was introduced without any deductible amount.[6]

To further clarify the changes in the income tax schedule we estimate the parameters of a simple tax function, which we use in the economic model outlined later. Similar tax function is used in the theoretical analysis of Ferriere 2015. The particular functional form is given by $T_W(\tilde{w}) = (1-\tau)\tilde{w} - \alpha$, where $\tilde{w}$ is taxable personal income and $T_W(\tilde{w})$ is the overall tax paid. The two parameters of the function summarize the marginal tax rate $(1-\tau)$ and the level of tax progressivity (α).[7] The estimated $1-\tau$ and α for each year in the time period are displayed in Figure 4b (see Appendix A.3 for details). The progressivity does not change much before 2008 and disappears after 2008 due to the flat tax reform. The marginal tax rate has a decreasing trend over time but the magnitude of the change is fairly small before 2008. With the introduction of the flat tax in 2008, the marginal tax rate is equalized to the average tax rate of 10%.

The rate of the proportional corporate income tax was at an all-time high in 2000 at 32.5%. Several governments in a row implemented tax cuts by reducing this rate down to 15%. Finally, in 2008 the corporate income tax was further slashed down to 10% (see Figure 4c). This came along with the corresponding reduction in the personal income tax to a flat rate of the same magnitude.

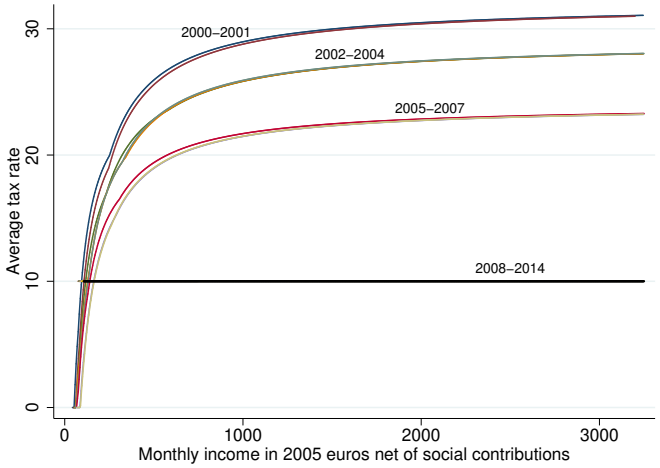
[5] An important dimension of the tax system which is left out here is the value-added tax of 20%. This rate did not change in the period under consideration. Therefore, this indirect method of taxation is unlikely to play a role when it comes to *changes* in informality and tax evasion.

[6] We use popular commercial accounting software to derive tax rates at a very fine grid of income which goes up to 100 times the average wage in each year for the period 2000-2014. For more details, see Appendix A.2.

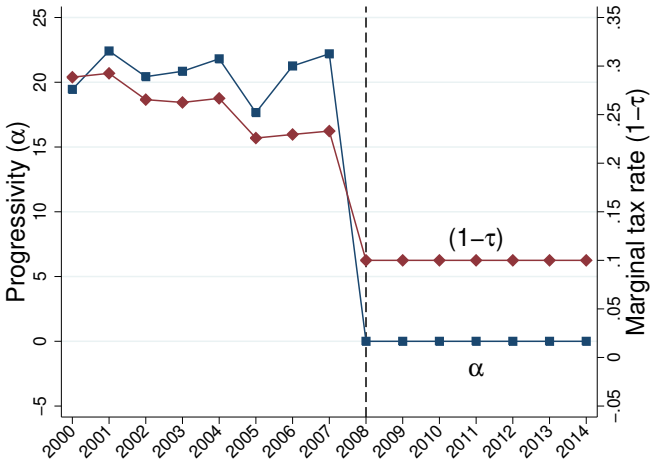
[7] The average tax rate is given by $(1-\tau) - \alpha/\tilde{w}$. Therefore, the parameter α determines the curvature of the average tax function.

Figure 4: Personal Income and Corporate Taxes

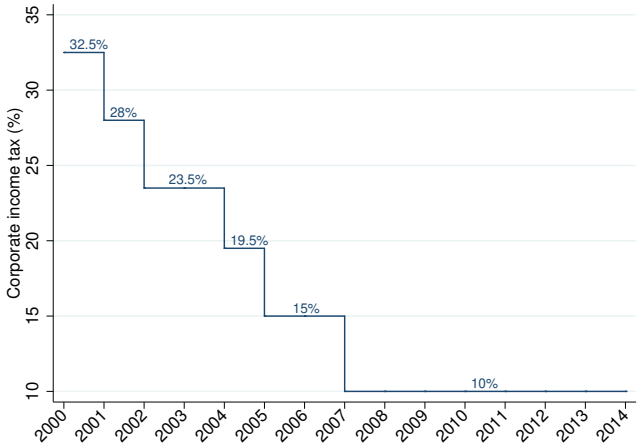
(a) Average Personal Income Tax Rates



(b) Estimated Tax Functions for Personal Income



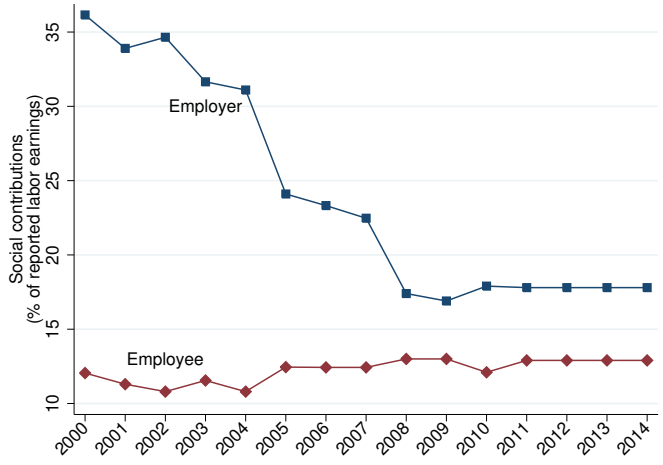
(c) Corporate Income Taxes



Notes: Tax rates for Bulgaria in 2000-2014 are derived using accounting tax calculators; see Appendix A.2. For details on the estimation of the tax functions for personal income and the interpretation of the parameters, see Appendix A.3.

The last item to be discussed about the Bulgarian tax system is the social contributions paid by employers and employees. These contributions consist of payments for unemployment, disability, maternity, pensions and health insurance of the employees. However, they are levied on both the employer and the employee. The time evolution of social contribution rates of employers and employees is depicted in Figure 5. The employee's rate varies slightly during the years, but its general level is always around 12-13%. The employer's contribution, however, fell sharply from more than 35% in 2000 to less than 20% after 2008.

Figure 5: Social Contribution Rates Paid by Employers and Employees



Notes: Social contribution rates for Bulgaria in 2000-2014 are derived using accounting tax calculators; see Appendix A.2.

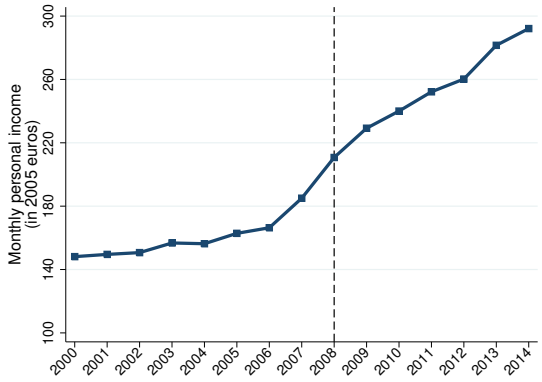
2.3 Wages and Unemployment

Figure 6a depicts the time series for average monthly wage income for the period 2000-2014. The evolution of unemployment is shown in Figure 6b. While observed wages rose monotonically throughout the period and more than doubled, unemployment first went down until 2008, and rose again as a consequence of the global financial crisis.

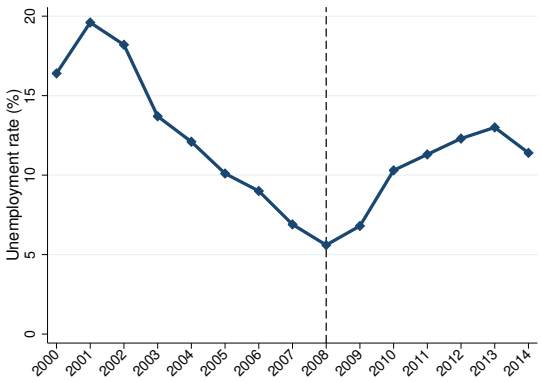
Observed wages in Bulgaria for the period 2000-2014 are important data targets for the estimated model presented in the next section. At the same time the evolution of the unemployment rate will be used an input series in the model.

Figure 6: Wages and Unemployment

(a) Average Wages



(b) Unemployment Rate



Notes: Average monthly wages and the unemployment rate are taken from the National Statistical Institute; see Appendix A.2.

3 The Model

In this section we develop an equilibrium model of informal production that incorporates the main ingredients needed to describe tax evasion practices in Bulgaria. Then, the model is estimated on observed time-series data and used for quantitative work and counterfactual experiments.

3.1 Economic Environment

Time is discrete and each period the economy is populated by a unit measure of infinitely-lived producers with different productivity levels $\lambda \sim F(\lambda)$. Each period, a unit measure of homogeneous one-period lived workers enters the economy. Workers randomly match with employers forming potentially productive pairs. The matching process implies that only a fraction $(1-u)$ of all workers are matched, while the remaining fraction u become unemployed. These unemployed workers receive unemployment benefit b.

The production technology depends on the inherent productivity of the employer, which is given by λ, and an aggregate productivity shock z, which hits the economy each period. In addition, matched workers can either supply a unit of labor in production or be inactive in which case production is not undertaken. The outside option of inactivity for the worker is b, and for the employer it is zero. The fact that the employer cannot call another worker if the current one refuses to cooperate, gives rise to a production surplus which can be shared between the two parties through bargaining.

The production when undertaken is given by the following production function,

$$y = z\lambda.$$

The match-specific productivity λ is distributed according to a distribution $F(\lambda)$ with support $[\underline{\lambda}, \infty)$.[8] We normalize the mean of distribution F to unity. Thus, if all islands are active in production, the average island productivity in the economy is unity and the aggregate production equals z. Employers and workers are risk-neutral and their payoffs are given by the *net* remuneration from production, i.e., a wage for the worker and a profit for the employer net of personal/corporate income taxes and social contributions. The social contributions related to a job position are paid by both the employer and the worker via proportional payroll taxes. In particular, if the job position is associated with an earnings level of w, then the employer needs to contribute $s_E w$, while the worker pays $s_W w$. Labor income net of payroll tax, $(1 - s_W)w$, is subject to the personal income tax schedule $T_W((1 - s_W)w) = (1 - \tau)[(1 - s_W)w] - \alpha$, which is increasing in the tax base $(1 - s_W)w$, and allows for an arbitrary degree of progressivity through the parameter τ. When $\tau = 0$, the system implies full redistribution, because disposable income is not related to gross income. Taxation with $\tau = 1$ corresponds to lump-sum transfers. The parameter τ determines the marginal tax rate, while both parameters determine how average taxes change with income. Business income e net of social contributions $s_E w$ paid by the employer is taxed at a proportional rate t_E. Note that the payroll taxes $s_E w$ covered by the employer are deductible from business income e.

Each matched production unit makes decisions on wages, profits and tax evasion. We assume that the production surplus is split according to a Kalai-Smorodinsky bargaining procedure. This bargaining procedure allows us to formulate concisely the decision-making problems for both the case of tax and no-tax evasion. Moreover, with this formulation we can derive closed-form solutions for the net payoffs of the worker and the employer.[9]

It is instructive to first describe the case in which the productive pairs are not allowed to evade

[8] We assume that the lower bound of productivity is sufficient to make the outside option of unemployment unattractive, i.e. $z\underline{\lambda} \geq b$.

[9] This solution to the bargaining problem is introduced in Kalai and Smorodinsky (1975). The Nash solution (Nash 1950) imposes the assumption of independence of irrelevant alternatives. This assumption implies that effective bargaining power depends on alternatives (tax evasion levels), which are not chosen. Instead, the Kalai-Smorodinsky solution works with the assumption of monotonicity. This assumption states that if one of the players achieves better payoffs for any given payoff level of his opponent, then the said player has a higher payoff in the agreed solution.

any taxes. In this case, they bargain over the net payments they would receive from production, taking into account taxes and social contributions levied by the government. Now think of the process of tax evasion. First, let us clarify that the tax authorities can observe the aggregate productivity level z in the economy but do not have any information on the match-specific productivity levels λ. Therefore, they do not observe the overall productivity level on the matched pair. This creates possibilities of tax evasion conducted *jointly* by the employer and the employee by underreporting their production. In doing so, the productive unit needs to mimic the decision-making process in the case of no tax evasion.

Hiding production is costly. If the productive unit coordinates on reporting $\hat{y}$ production instead of y, they incur an output loss of $\kappa \exp(\theta(y - \hat{y}))$. The cost function is increasing and convex in misreported production capacity $y - \hat{y}$. Naturally, no cost is incurred if no output is hidden. Then, the hidden income to be distributed between the employer and the worker is given by $h = y - \hat{y} - \kappa \exp(\theta(y - \hat{y}))$. The forgone output due to tax evasion, $\kappa \exp(\theta(y - \hat{y}))$, reflects the resources spent on concealing the informal economic activities from the fiscal authorities.[10]

The decision on tax evasion is made by the employer and employee who maximize the total surplus due to tax evasion by comparing the benefits of tax evasion in terms of forgone tax payments and its costs. In doing so, they take into account the prevailing tax structure in the economy. The amount of hidden income that each employee receives, h_W, is dubbed the *envelope wage*. The remaining hidden amount, $h_E = h - h_W$, goes to the employer as an *envelope profit*. Therefore, the outlined environment captures the prevailing practices of tax evasion in Eastern and Southern Europe.

In the rest of this section we state the decision problems in the cases of no evasion and tax evasion.

3.2 The Case of No Evasion

The aggregate productivity in the economy is given by z, which is a common knowledge.[11] Suppose that the match-specific productivity is λ, and therefore productive capacity is $y = z\lambda$. Therefore, the reported production for tax purposes is $\hat{y} = y$. The outside options for the worker and the

[10] Hiding output from the government can be costly due to a number of reasons. First, production may need to take place at night and/or double accounting practices may be costly in terms of time. Second, tax evasion practices may require bribing government officials.

[11] The aggregate productivity z is treated as a known parameter in the decision-making process that follows.

employer are set to the unemployment benefits b and to zero, respectively. The bargaining solution to the problem is given by

$$(e, w) \in \arg\max_{e,w} \left[(1 - t_E)(e - s_E w)\right] \tag{1}$$

subject to

$$e + w = y \tag{2}$$

$$(1 - \gamma)\left[(1 - t_E)(e - s_E w)\right] = \gamma\left[\tau(1 - s_W)w + \alpha - b\right] \tag{3}$$

where the bargaining power of the employer is given by $\gamma \in (0, 1)$. The surplus of the employer is given by the amount of earned business income e net of payroll taxes and corporate income taxes, $(1 - t_E)(e - s_E w)$. The worker's surplus relative to the outside option b equals the earnings w net of payroll and personal income taxes, $\tau(1 - s_W)w - \alpha - b$. The solution to problem (1) amounts to choosing wage w and profit e so that the surplus of the employer is maximized subject to the resource constraint (2) and keeping the net payoff of the worker fixed according to the monotonicity constraint (3).

The solution of the above problem can be summarized by the wage and profit functions,

$$e^*(y) = \frac{\left[\gamma\tau(1 - s_w) + (1 - \gamma)(1 - t_E)s_E\right] y + \gamma(\alpha - b)}{\gamma\tau(1 - s_w) + (1 - \gamma)(1 - t_E)(1 + s_E)} \tag{4}$$

and

$$w^*(y) = \frac{(1 - \gamma)(1 - t_E)y - \gamma(\alpha - b)}{\gamma\tau(1 - s_w) + (1 - \gamma)(1 - t_E)(1 + s_E)}. \tag{5}$$

In essence, functions (4) and (5) map the level of production to the gross income of the employer and the worker. We make two crucial assumptions. First, we assume that the lower bound of productivity is sufficient to make the outside option of unemployment unattractive, i.e. $z\underline{\lambda} > b$. Therefore, unemployment in involuntary. Second, we assume that wages in the no tax evasion case are always positive, and therefore, described by (5). This implies that $z\underline{\lambda} > \frac{\gamma(\alpha-b)}{(1-\gamma)(1-t_E)}$, i.e. the parameter α that regulates the lump-sum transfer in tax function $T_W(\cdot)$ is not too large relative to the outside option b. Then, the after-tax income levels for workers and employers in the case of no tax evasion are given by

$$c_E^*(y) = (1 - t_E)(e^*(y) - s_E w^*(y)) \tag{6}$$

and

$$c_W^*(y) = \tau(1 - s_W)w^*(y) + \alpha. \tag{7}$$

What are the effects of the different tax parameters on the splitting decisions for profits and wages? The following proposition addresses this.

Proposition 1. *The decision rules* $e^*(y)$ *and* $w^*(y)$ *have the following properties with respect to tax parameters:*

(i) $\frac{\partial e^*}{\partial(1-\tau)} < 0$ and $\frac{\partial w^*}{\partial(1-\tau)} > 0$ (if $\alpha \approx b$),
(ii) $\frac{\partial e^*}{\partial \alpha} > 0$ and $\frac{\partial w^*}{\partial \alpha} < 0$
(iii) $\frac{\partial e^*}{\partial s_E} > 0$ (if $\alpha \approx b$) and $\frac{\partial w^*}{\partial s_E} < 0$,
(iv) $\frac{\partial e^*}{\partial s_W} < 0$ (if $\alpha \approx b$) and $\frac{\partial w^*}{\partial s_W} > 0$
(v) $\frac{\partial e^*}{\partial t_E} > 0$ and $\frac{\partial w^*}{\partial t_E} < 0$.

These comparative statics exercises show that whenever personal income tax progressivity is on the rise, $(1-\tau)\uparrow$, pre-tax profits go up and earnings go down. This follows from the fact that with personal income tax schedule, the after-tax income of the worker is given by $\tau[(1 - s_W)w] + \alpha$. Therefore, upward changes in $(1 - \tau)$ lead to a reduction of the marginal utility of wage w to the worker. Naturally, the decision rules e^* and w^*reflect that. The effect of and increase in α is similar. The other important tax rate for the determination of the income split is the rate of social contributions paid by employers and workers, s_E and s_W. Whenever s_E increases, the payoff of the employer goes up to compensate him for the increased tax burden. If s_W, worker's compensation goes up. Finally, increasing the tax on business income leads to compensating higher gross profits for the employer.

3.3 The Case of Tax Evasion

Now suppose that a matched pair with productive capacity $y = z\lambda$ can hide the level of production, thus evading taxation. The employer and the worker need to decide on the reported level of island-specific productivity $\hat{\lambda}$ which implies that reported production is $\hat{y} = z\hat{\lambda}$. When doing so, they need to obey the publicly observed splitting rule stemming from problem (1), that is equations (4) and (5). In particular, the reported output can be expressed as $\hat{y} = e^*(\hat{y}) + w^*(\hat{y})$, where $e^*(\hat{y})$ and $w^*(\hat{y})$ are reported gross income levels. Taxes are paid on these reported levels. Therefore, the corresponding net income levels will be given by $c_E^*(\hat{y})$ and $c_W^*(\hat{y})$.

As explained previously, the technology of tax evasion is associated with the cost $\kappa \exp(\theta(y - \hat{y}))$ in terms of production, where $y - \hat{y}$ is the underreported production capacity. The bargaining outside options are given by the net income levels when no evasion is agreed upon, $c_E^*(y)$ and $c_W^*(y)$. Then, the surplus of the employer is now given by the hidden amount net of the loss in official net profit, $h_E - [c_E^*(y) - c_E^*(\hat{y})]$. At the same time, the surplus of the worker is $h_W - [c_W^*(y) - c_W^*(\hat{y})]$. Then, the reported output $\hat{y}$, and the hidden amounts h_E and h_W should solve

$$(\hat{y}, h_E, h_W) \in \arg \max_{\hat{y}, h_E, h_W} \{h_E - [c_E^*(y) - c_E^*(\hat{y})]\} \tag{8}$$

subject to

$$h_E + h_W = (y - \hat{y}) - \kappa \exp(\theta(y - \hat{y})) \tag{9}$$

and

$$(1 - \gamma) [h_E - [c_E^*(y) - c_E^*(\hat{y})]] = \gamma [h_W - [c_W^*(y) - c_W^*(\hat{y})]] . \tag{10}$$

The problem is similar to (1). The objective is to maximize the surplus of the employer taking into account the resource constraint (9), which states that the total hidden amount should be equal to the concealed output $y - \hat{y}$ net of hiding costs $\kappa \exp(\theta(y - \hat{y}))$. In addition, the monotonicity constraint (10) holds too.

From equations (4)-(7), it is evident that the losses in official net income due to tax evasion, $c_E^*(y) - c_E^*(\hat{y})$ and , $c_W^*(y) - c_W^*(\hat{y})$ are linear functions of the hidden capacity $y - \hat{y}$. Therefore, we can reformulate problem (8) by using constraints (9)-(10) into the objective function and solve for $y - \hat{y}$:

$$(y - \hat{y}) \in \arg \max_{y - \hat{y}} \{(1 - \beta)(y - \hat{y}) - \kappa \exp(\theta(y - \hat{y}))\} ,$$

where

$$\beta = \frac{(1 - t_E)\tau(1 - s_W)}{\gamma\tau(1 - s_w) + (1 - \gamma)(1 - t_E)(1 + s_E)}$$

is a constant expression of the tax parameters. It can be shown that for non-negative tax rates $0 \leq \beta \leq 1$. Additionally, the restriction $\beta \leq 1 - \theta k$ implies that hiding production is feasible, i.e. the benefits of misreporting are (weakly) larger relative to the costs. Then, the interpretation of the problem is straightforward. Misreporting productive capacity should maximize the joint benefits of tax evasion $(1 - \beta)(y - \hat{y})$ net of the costs of tax evasion in terms of output, $\kappa \exp(\theta(y - \hat{y}))$.[12]

[12] We rule out the corner solution $y - \hat{y} = y$ by imposing the restriction $z\underline{\lambda} \geq \frac{1}{\theta} \log \left(\frac{1-\beta}{\theta\kappa} \right)$.

The solution to the problem is given by

$$\hat{y}^*(y) = y - \frac{1}{\theta}\log\left(\frac{1-\beta}{\theta\kappa}\right).$$

Note that the hidden fraction of productive capacity decreases in y,

$$\frac{y - \hat{y}^*(y)}{y} = \frac{1}{\theta y}\log\left(\frac{1-\beta}{\theta\kappa}\right).$$

We can use the constraints to problem (8) and solve for the envelope profits and wages,

$$h_E^* = \frac{\gamma}{\theta}\left[\log\left(\frac{1-\beta}{\theta\kappa}\right) - (1-\beta)\right],$$

$$h_W^* = \frac{1-\gamma}{\theta}\left[\log\left(\frac{1-\beta}{\theta\kappa}\right) - (1-\beta)\right].$$

Note that hidden income $h^* = h_E^* + h_W^*$ is split in proportion to the bargaining power parameters. For the case of the interior solution, h is also constant with respect to productivity y but is inversely related to the cost parameter κ.

A rise in any tax rate leads to a potential increase in the marginal gain from evading one more unit of production. In such a case hidden income h increases. This is summarized in the following proposition:

Proposition 2. *The decision rule for hidden income $h^*(y)$ has the following properties with respect to tax parameters,*

(i) $\frac{\partial h^*}{\partial(1-\tau)} > 0$
(ii) $\frac{\partial h^*}{\partial\alpha} = 0$,
(iii) $\frac{\partial h^*}{\partial s_E} > 0$,
(iv) $\frac{\partial h^*}{\partial s_W} > 0$,
(v) $\frac{\partial h^*}{\partial t_E} > 0$.

A rise in the progressivity of personal income taxes, $(1-\tau)\uparrow$, produces more tax evasion. Changes in the parameter (α) do not lead to changes in hidden income. The reason is that the parameter α does not interact with taxable income in the tax function formulation. The other items in the proposition simply show the relationship between social contributions and business income taxes and hidden income.

3.4 Aggregate Statistics

Here we report some important aggregate outcomes for the economy under investigation. These aggregates will be analyzed in detail in the next section where we describe the quantitative implementation of the model.

The total production capacity in the economy is given by the level of the aggregate productivity shock z because $E(\lambda) = 1$. We need to subtract from this because the amount of inactive units which is given by the unemployment rate u. That is, total production capacity in any given period is

$$Y = (1-u)z. \tag{11}$$

At the same time the reported production (official GDP) is

$$\hat{Y} = (1-u)\frac{z\theta - \log((1-\beta)/\theta\kappa)}{\theta}. \tag{12}$$

The aggregate reported production is strictly positive due to the parameter restrictions we impose ($z\underline{\lambda} \geq \frac{1}{\theta}\log\left(\frac{1-\beta}{\theta\kappa}\right)$). The observed labor productivity in the economy is $[z\theta - \log((1-\beta)/\theta\kappa)]/\theta$. The amount of hidden production after incurring the productive cost of tax is given by

$$H = (1-u)\left(h_E^* + h_W^*\right) = (1-u)\frac{\log\left(\frac{1-\beta}{\theta\kappa}\right) - (1-\beta)}{\theta}. \tag{13}$$

The aggregate efficiency loss due to tax evasion is given by the costs of hiding in terms of forgone output,

$$L{=}(1-u)\left(\frac{1-\beta}{\theta}\right). \tag{14}$$

Note that given the aggregate hidden amount and the aggregate efficiency loss, we can compute the reported production in the economy, i.e. the official GDP also as $\hat{Y} = Y - H - L$.[13]

We are interested in the size of the informal economy relative to reported production, which can be readily calculated as

$$\frac{H}{\hat{Y}} = \frac{\log\left(\frac{1-\beta}{\theta\kappa}\right) - (1-\beta)}{z\theta - \log((1-\beta)/\theta\kappa)}.$$

The observed average wages of workers and profits of employers are given by

$$W = w^*\left([z\theta - \log((1-\beta)/\theta\kappa)]/\theta\right),$$

[13] Bulgarian tax authorities do not yet include an estimate of the undeclared production in the calculation of GDP.

and

$$E = e^* \left([z\theta - \log((1-\beta)/\theta\kappa)] / \theta \right).$$

The tax revenue raised by the government is given by

$$T = (1-u) \left[t_E \left(E - s_E W \right) + (1-\tau)(1-s_W)W - \alpha \right]. \tag{15}$$

Note that expression (15) describes a generalized Laffer curve for this economy. At the same time, the collected social contributions are

$$S = (s_E + s_W)W(1-u).$$

We assume that the social contributions are partially used to pay out unemployment benefits. Therefore, the level of unemployment benefits will be given by

$$b = \frac{\chi S}{u}, \tag{16}$$

where χ is the fraction of social contributions paid for unemployment insurance.

It is important to characterize what happens to the aggregate size of the informal economy when labor productivity rises. Suppose, for instance, that parameter θ is a function of aggregate productivity z. Ultimately, what happens to informality in the course of development depends on the properties of the function $\theta(z)$. If this parameter is constant or decreases slower than z assymptotically, then the informal economy will shrink as development takes place. If, however, this cost shrinks at the pace of rise of labor productivity, then informal sector will tend to reach a lower bound. The asymptotic size of the informal economy will depend on the properties of the function $\theta(z)$.

Proposition 3. *(i) If* $\lim_{z\to\infty} \theta(z)z = \Delta$*, where* Δ *is a non-negative finite constant, then the size of the informal economy will converge asymptotically to a positive constant in the course of development:*

$$\lim_{z\to\infty} \frac{H}{\hat{Y}} = \frac{\log\left(\frac{1-\beta}{\theta\kappa}\right) - (1-\beta)}{\Delta - \log((1-\beta)/\theta\kappa)}.$$

This can be viewed as a lower bound of informal activity.

(ii) If, however, $\lim_{z\to\infty} \theta(z)z = \infty$*, that is,* $\theta(z)$ *does not decrease as fast as* z *asymptotically,*

then informality is going to disappear in the limiting case,

$$\lim_{z \to \infty} \frac{H}{\hat{Y}} = 0.$$

4 Bringing the Model to the Data

The model period is set to one year and the simulation is performed for the time period 2000-2014. We use the schedules for taxes, social contributions and unemployment rates over the time period as exogenous inputs to the model.[14] Then, we use the environment to generate *time paths* for the overall size of the informal economy, the observed average monthly wages and the observed labor productivity (measured as output per worker). As argued later in the text, these moments are useful targets for estimating the model parameters. We match the model outcomes to the corresponding data moments using a minimum distance estimation strategy. Finally, we employ our quantitative environment to gauge the determinants of the informal economy and its changes over time through a series of counterfactual experiments.

4.1 Estimation

We consider the two parameters related to the cost of hiding, κ and θ, the bargaining parameter γ (more precisely, the employer's bargaining power), and the sequence of unobserved labor productivity level, $\{z_t\}_{t=2000}^{2014}$ for the time period 2000-2014. We estimate these 18 parameters by matching 45 data moments (see Appendix A.1 for details). The data targets that we consider are:

1. *The size of the informal economy (2000-2014)* [15 targets]
2. *Observed average monthly wages (2000-2014)* [15 targets]
3. *Observed labor productivity measured as output per worker (2000-2014)* [15 targets]

A discussion of the parameter identification strategy is in order. It is well understood that changes to any of the parameters considered in estimation affect the model outcomes for all of the above moments. However, some moments are more responsive to certain parameters. Heuristically, a moment target is informative about an unknown parameter if that target is sensitive to changes in the parameter value.

[14] The description of the tax data calculations is presented in Appendix A.2. The estimation results for the tax function for personal income are in Appendix A.3.

In order to pin down the values of the parameters related to the cost of hiding (κ and θ), we match the 2000-2014 time series of the size of the informal economy. The mean of the size of the informal economy across time is informative about the level of the cost of evasion, captured by the parameter κ. A higher value of κ shifts down the size of the informal economy in all years. The curvature of the cost function (θ) affects the changes in the size of the informal economy. Therefore, θ is recovered by matching the decreasing pattern of tax evasion over time.

The level of observed wages for 2000-2014 is used to identify the bargaining parameter γ. Workers remuneration consists of observed wages and unobserved envelope wages. By matching the overall size of the informal economy, we essentially determine the sum of hidden income for workers and employers. Then, the bargaining parameter γ determines the split of this hidden income between workers and employers. It also determines the levels of observed wages and profits.

Finally, our last aim is to target the evolution of the observed labor productivity between 2000 and 2014. This set of moments is informative about the true production capacity of the economy, before the resource cost of tax evasion and the hidden income are taken into account. This is interesting because we use the model to estimate a moment (true labor productivity) that cannot be observed in the data.

The parameters to be estimated are summarized in the following vector,

$$\Theta = \{\kappa, \theta, \gamma, \{z_t\}_{t=2000}^{2014}\}.$$

Let d represent the vector of 45 data targets. The vector $\hat{m}(\Theta)$ contains the analogous model moments which are a function of the parameter vector Θ. We define the difference between the data targets and the corresponding model moments as

$$g_i(\Theta) = d_i - \hat{m}_i(\Theta),$$

for $i = 1, \ldots, 45$.

The minimum distance procedure chooses the optimal parameters in order to bring the model as close as possible to the data. More precisely, it picks Θ to minimize the weighted sum of squared deviations between the data and the model,

$$\hat{\Theta} = \min_{\Theta} g(\Theta)' \, \mathcal{W} \, g(\Theta)$$

where W is a positive semidefinite matrix. The estimator $\hat{\Theta}$ is consistent for any positive semidefinite weighting matrix (Lee and Ingram 1991). We chose to weight the difference between data and model moments by the inverse of the observed data moment.[15]

4.2 Estimation Results

The parameter estimates are summarized in Table 1. The estimated parameters related to the cost of evasion, κ and θ, do not have an immediate economic interpretation. The estimated cost function implies very small penalty for small hidden amounts. However, it implies much higher levels of penalty for realistic levels of evasion and it is highly convex. It is interesting to focus on the estimate for the employer's bargaining power, γ. Our bargaining model obtains a good match to the data of observed wages whenever γ takes values close to 1. Such a value implies that the employer is able to get most of the income generated by production. This result suggests that taxes affecting the employer's profits are going to play a major role in determining the decision to hide income.[16] Taxes levied on the income of workers, on the contrary, would not matter so much for tax evasion because wages are only a small fraction of total production. The differences between the estimated (true) and observed labor productivity levels will be discussed in the next subsection.

Table 1: Parameter Estimates

Parameter	Description	Value	Std. Error	95% Confidence Interval
κ	Cost of evasion, level	0.002211	0.001105	$[4.4216 \times 10^{-5}, 0.004377]$
θ	Cost of evasion, curvature	0.00401	0.00042	[0.00318, 0.00484]
γ	Employer barg. power	0.98517	0.00005	[0.98507, 0.98527]
$\{z(t)\}_{t=2000}^{2014}$	Output per worker	See Figures 7, 9	See Figure 7	See Figure 7

Notes: The table shows point estimates and 95% confidence interval for the model structural parameters. Standard errors are computed following Lee and Ingram (1991). We leave out the 15 estimates $z(t)$ related to the true labor productivity to save space but show them in Figures 7 and 9.

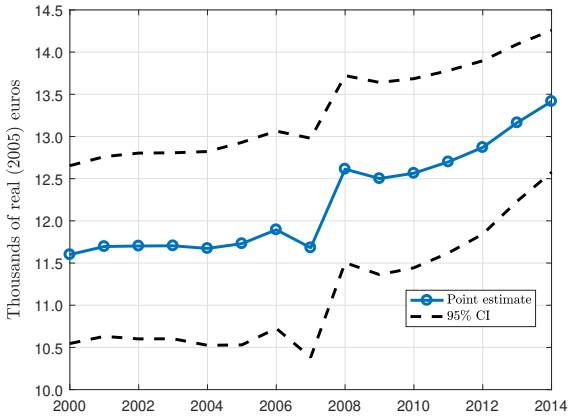
Table 1 also reports standard errors of the estimation for the main parameters κ, θ and γ. The standard errors of the parameter estimates are computed using the methodology proposed by Lee and Ingram (1991). All parameters are tightly estimated. In particular, the 95% confidence interval for the bargaining parameter γ is very small. The estimated series for output per worker series,

[15] Specifically, the diagonal elements of W are set to $1/d_i^2$ for $i = 1, \ldots, 45$ and the off-diagonal elements are set to zero. In this way, we are effectively minimizing the percentage error instead of the absolute error.

[16] There is empirical evidence of the weak role of labor in Bulgaria. First, the labor share in Bulgaria is rather low compared to Western European economies - 0.49 in the period 2000-2010 (Raleva 2014). Second, Tomev et al. 2008 directly point out that Bulgarian real wages are the lowest in the European Union mainly because of lack of collective bargaining mechanisms which ensure that economic growth is reflected in living standards. Third, in a comparative analysis for Eastern Europe, Crowley 2004 claims that labor is a weak economic and political actor mainly due to institutional and ideological legacies of the communist period.

$\{z(t)\}_{t=2000}^{2014}$, along with the corresponding confidence intervals implied by the standard errors are plotted in Figure 7.

Figure 7: Estimated Output per Worker $z(t)$, 2000-2014



It is useful to confirm the intuition about the identification strategy that we have previously outlined. Table 2 summarizes the responses of important model moments to small changes of 1% in the parameter values. Essentially, we estimate the numerical elasticities of wages $\hat{W}$, level of the informal economy $H/\hat{Y}$, changes to informal economy $\Delta H/\hat{Y}$, and labor productivity $\hat{Y}$, all averaged over the period 2000-2014 with respect to the parameters. The numbers in Table 2 tell us what is the percentage change response of the moments to the small perturbation of the parameters.[17]

The average level of observed wages $\hat{W}$ is most informative for estimating γ. Indeed, the first element on the top left corner of the table shows that the elasticity of $\hat{W}$ with respect to γ is quite high. This reinforces our confidence about the very high value of γ. The relationship between moments and parameters is strong also for the two cost parameters κ and θ. Most of the identification comes from the level and the evolution of the informal economy size $H/\hat{Y}$, as can be seen by the corresponding diagonal elements of Table 2. For instance, a 1% increase in κ leads to a 2.4% decrease in the average level of the informal economy. The average wages do not change much due to changes to these two parameters. Finally, the parameters on true labor productivity z produce sizable change in the model-generated observed labor productivity $\hat{Y}$.

[17]We target the full time path of the moments in the estimation procedure. Here for simplicity we present the responses of the time-averaged moments.

Table 2: Identification of Model Parameters

		Structural parameters			
Moments	**Description**	γ	κ	θ	z
$\hat{W}$	Average (2000-2014)	2.716	0.393	0.615	0.455
$H/\hat{Y}$	Average (2000-2014)	1.554	-2.407	-1.186	-1.016
$\Delta H/\hat{Y}$	Change (2000-2014)	0.568	0.996	-1.852	-1.276
$\hat{Y}$	Average (2000-2014)	1.038	1.766	1.558	4.370

Notes: The table shows the sensitivity of selected functions of model moments with respected to the model parameters. Specifically, the k^{th} row and j^{th} column of the table report the numerical elasticity $\frac{\Delta k/k}{\Delta j/j}$ where Δk is the absolute change in moment $k = \{\hat{W}, H/\hat{Y}, \Delta H/\hat{Y}, \hat{Y}\}$ induced by a Δj variation in parameter j. Note furthermore that $\Delta j/j = 0.01$ for each $j = \{\gamma, \kappa, \theta, z\}$. Finally, to compute the elasticity of moments with respect to z we averaged over $z(t)$ for $t = 2000, \ldots, 2014$.

4.3 Model Fit

The model does a very good job in matching the declining trend of the size of the informal economy over time in Bulgaria; see Figure 8a. It slightly overemphasizes the importance of the shadow economy at the middle of the sample and slightly underpredicts it for the last five years, but these differences between the model and the data are fairly small. Figures 8b and 8c present the the model fit in terms of average observed wages and observed labor productivity over time. Here again the model performs well in terms of matching the trends in the data.

To better assess the model goodness of fit, we compute the time-average of the data targets presented in Figure 8 and compare them with their model counterparts. Table 3 shows these comparisons. The model has no problem matching the time averages.

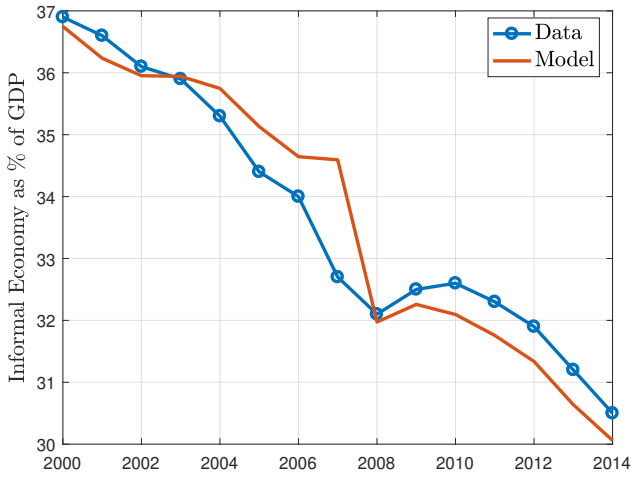
Table 3: Model Fit - Time-Averaged Moments

Averages (2000-2014)	**Data**	**Model**
Informal Economy (% of GDP)	33.667	33.674
Observed Wages (2005 euros)	202.782	198.074
Observed Labor Productivity (2005 euros)	8165.252	8086.518

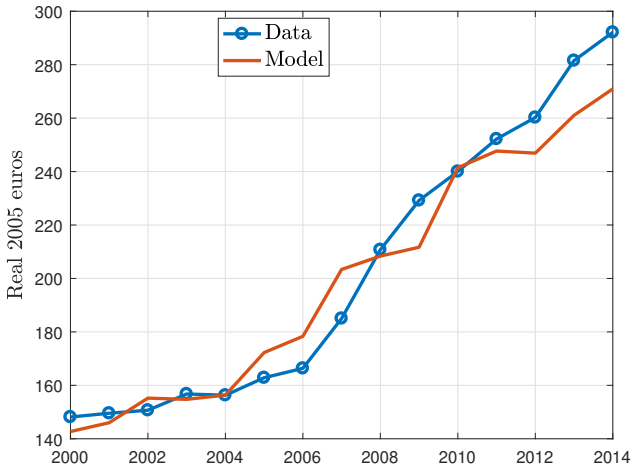
We conclude the discussion of the model fit by presenting an interesting insight generated by the model which is not observed in the data. The estimated model allows us to retrieve the unobserved aggregate labor productivity across time. We compare the unobserved versus the observed labor productivity in Figure 9. Both series increase over time (with the exception of the 2007-2008 period). The true production capacity averages around 12,000 euros whereas the observed one averages around 8,800 euros. Therefore, tax evasion implies that observed labor productivity is roughly 25% lower than its true value.

Figure 8: Model Fit - Time Trends

(a) Size of Informal Economy



(b) Observed Wages



(c) Observed Labor Productivity

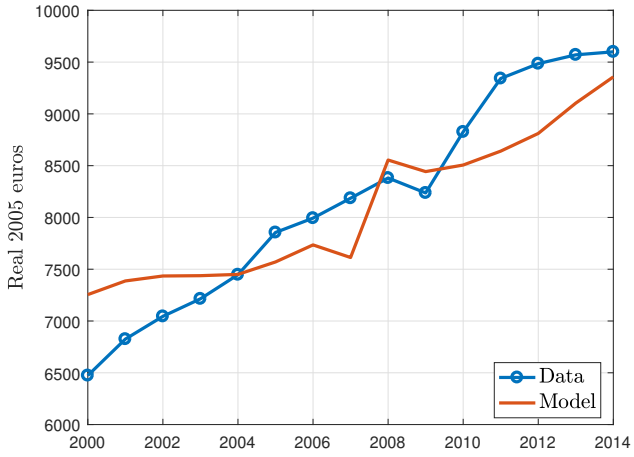
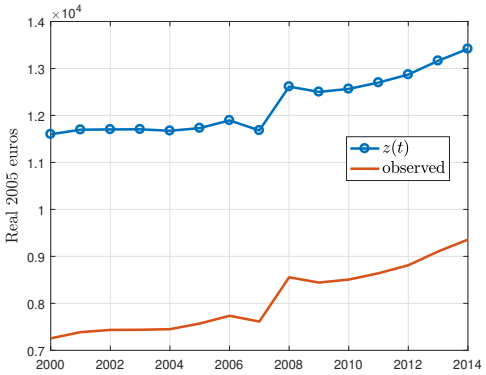


Figure 9: Observed versus Unobserved Aggregate Productivity



5 Counterfactual Experiments: Productivity versus Taxes

Now we can use the estimated model economy for counterfactual analysis. We perform a set of quantitative experiments in order to quantify the relative effects of taxes and labor productivity on the size of the informal economy.

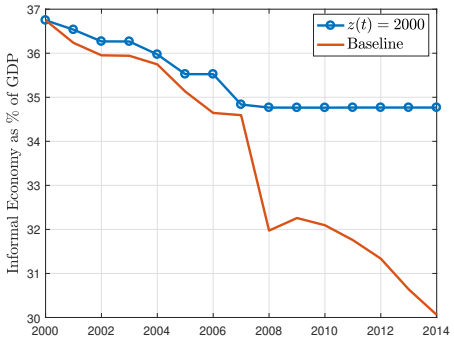
Shutting down Productivity Growth. In the first exercise, we keep labor productivity constant at its 2000 value over the whole time period 2000-2014. However, we feed in the model the correct tax schedules and their changes over time. Figure 10a plots the evolution of the informal economy in the baseline model and in this new counterfactual world. Therefore, we can assess how taxes alone (solid circle line) matter for the observed decrease in informality (solid line). The distance between the two lines is due to the productivity growth over the period. Several things are worth mentioning. First, in the baseline scenario informality drops by around 7 percentage points (from around 37% to 30% of GDP), whereas it decreases by only 2 percentage points when only taxes are at play. Hence, changes in taxation can account for less than a third of the change in the size of the informal economy. Second, almost all of the decline in informality induced by taxes takes place in the first half of the time period, between 2000 and 2007. This is not surprising, since the major tax reforms regarding employers were implemented before 2008, as we documented in Section 2. The fact that taxes do not have a sizable impact on informality after 2008 points out that the role of the 2008 personal income flat tax reform as a coping device against evasion is rather small.

Shutting down Tax Reforms. In the second counterfactual exercise, we keep all taxes at their 2000 levels. Essentially, we let productivity growth be the only driving force behind changes in informality. Tax reforms would not play any role because they are omitted (see Figure 10b). The

rise of labor productivity over the period can account alone for a sizable fraction of the decline in informality. The informal size now declines from 36.7% to 31.8% of GDP - a decrease of almost five percentage points. We summarize the results in terms of informal economy size from the two counterfactual experiments in Table 4.

Figure 10: Productivity versus Taxes

(a) Shutting down Productivity Growth



(b) Shutting down Tax Reforms

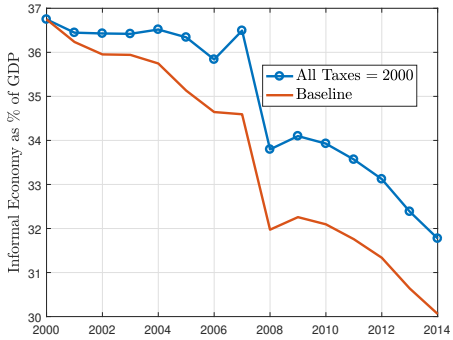


Table 4: Productivity versus Taxes - A Decomposition

	Informal Economy (% of GDP)		
	2000	**2014**	**Change**
Model	36.75	30.06	**-6.69**
Shutting down Productivity	36.75	34.77	-1.98
Shutting down Tax Reforms	36.75	31.77	-4.97

Notes: The table summarizes the results of the performed counterfactual experiments for the informal economy size. The second row reports the scenario in which productivity is fixed at the 2000 level and taxes are the only driving force to account for changes in informality. Similarly, the third row shows the scenario in which taxes are fixed at the 2000 level and productivity is the only driving force.

Digging Deeper - The Role of Different Tax Reforms. So far we have documented that tax reforms alone account for slightly less than a third of the decline in informality in the model (roughly 2 percentage points out of the total decline of 6.7 percentage points). How do changes in

each of the three tax schedules in the model contribute to this result? We now turn our attention to decomposing the overall role of taxes into individual effects of the personal income tax, the corporate business tax, or the social security contributions.

To quantify the effect of personal income taxes more precisely, we solve the model by feeding in only the changes of the personal income tax code, while keeping all other taxes and productivity fixed at their 2000 levels. Figure 11a compares this counterfactual to the scenario in which all taxes change with a fixed productivity as in Figure 10a. It is clear that changes in personal income taxes do not play any relevant role for the decline of the size of the informal economy. Neither the flat tax reform in 2008, nor the previous reductions in the effective marginal tax rates have a sizable impact on tax evasion. All in all, personal income taxes account for only 0.21 percentage point decline in informal economy size (from 36.75% to 36.54%).

We perform a similar exercise with respect to the corporate income tax. Again keep productivity constant at its 2000 levels but allow only this tax to change over time. Figure 11b presents the comparison to the economy in which all taxes are allowed to vary but productivity is fixed to the level in 2000. The results show that changing corporate income taxes account for almost all of the effect of taxes on informality (from 36.75% to 34.9%).

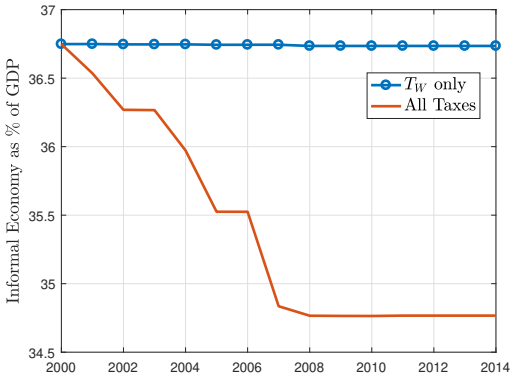
Due to the high bargaining power of employers in the model, most of the value added from production accrues as profits. Therefore, taxes on profits are the most relevant factor influencing the marginal incentive to hide production.[18] What about social contributions? Since wages are only a small fraction of total income from production, social contributions levied either on the employer or on the worker do not change significantly the incentives to report income. The relevant experiment is depicted on Figure 11c.

To sum up, the experiments point out that the most important driver for the decline of the informal economy in Bulgaria is the rise in labor productivity. It alone accounts for around three quarters of the observed decline in our baseline economy. Taxes play a secondary but not negligible role. Most of the effect of taxes comes from changes to the corporate income tax.

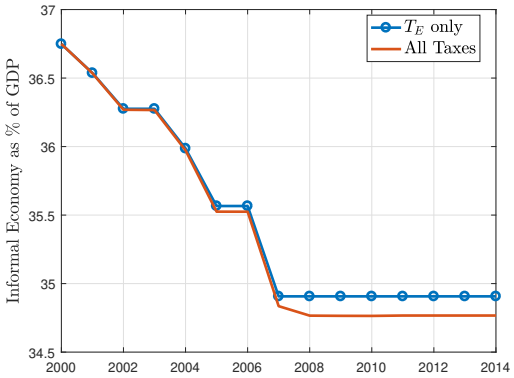
[18]This result hinges crucially on the estimated high value of the parameter γ which summarizes the bargaining power of employers. We perform sensitivity analysis with respect to this parameter and find that in economies where workers have a higher bargaining power, this result can be quantitatively less relevant. See details on that in the next subsection.

Figure 11: Digging Deeper - The Role of Different Tax Reforms

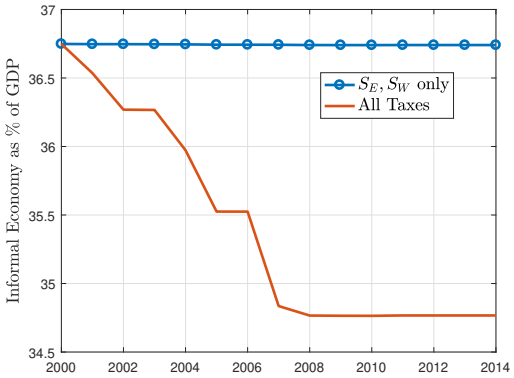
(a) Personal Income Tax



(b) Corporate Income Tax



(c) Social Contributions

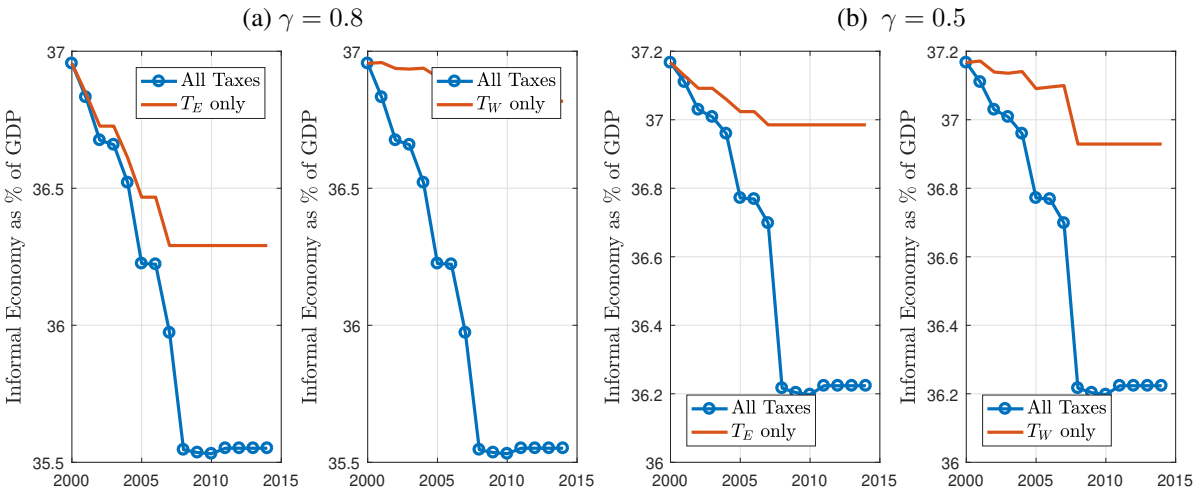


5.1 Sensitivity Analysis

As mentioned before, in the baseline economy ($\gamma = 0.985$) changes in taxes account for a decline of informality of 1.98 percentage points. Personal income taxes account for a negligible part of the decline as shown on Figure 11a. This is related to the high value of the parameter γ.

We perform similar decomposition exercises when the bargaining power of the employers takes lower values. When $\gamma = 0.8$, changes in personal income taxes become more important and account for 15% of the overall decline of informality attributed to taxes. Corporate taxes still account for slightly less than 50% of the overall decline due to taxes (see Figure 12a). Finally, when $\gamma = 0.5$, the contribution of the personal income taxes becomes quantitatively similar to the contribution of the corporate business taxes (see Figure 12b).

Figure 12: Power to the Workers - Sensitivity Analysis



6 Optimal Taxation

What are the optimal taxes in this economy? What we have in mind is a benevolent government which maximizes average welfare by choosing tax schedules for personal and business income subject to collecting at least as much revenue as in the baseline model economy. In this exercise, we allow employers and employees to adjust their behavior with respect to hiding production in response to the imposed tax levels. The optimal taxation exercise is performed for the year of 2014. We use the estimated true productivity for this year along with information on social contributions

and the unemployment rate. In addition, we impose that tax revenue should be at least as much as in the 2014 baseline economy. Corporate taxes are proportional, while the considered personal income tax schedules are restricted to the functional form $T_W(\tilde{w}) = (1-\tau)\tilde{w} - \alpha$ used throughout the paper. Essentially, the government makes a decision on the corporate income tax rate, t_E, the progressivity of personal income taxes, α, and the marginal personal income tax, $1-\tau$.[19]

People in our economy are risk-neutral and all output is consumed. Therefore, the welfare criterion boils down to the level of total production. The government solves a Ramsey-like problem of the following type,

$$\max_{\{\alpha,\tau,t_E\}} \hat{Y} + H \equiv Y - L \tag{17}$$

subject to identities (11)-(14) which define the objective function and equation (16) describing the social security budget constraint. [20] Finally, the government budget constraint should also be satisfied,

$$\left[t_E\left(E - s_E W\right) + \left(1-\tau\right)\left(1-s_W\right)W - \alpha\right] \geq \overline{T}, \tag{18}$$

where E and W denote respectively aggregate profits and aggregate wages in the economy. In words, the total level of production in the economy is maximized with respect to the tax parameters $\{\alpha, \tau, t_E\}$. The constraint (18) states that the tax revenue collected across all productive islands amounts at least to the taxes raised in the baseline economy, $\overline{T}$. Note that when optimizing over the tax parameters, the government faces the optimal reaction of workers and employers to taxes encoded into the functions E and W for aggregate profits and wages from Section 3.4.

The results of the optimization exercise are summarized in Table 5. To minimize the loss of production due to evasion the government should shift the tax burden from corporate income to labor income. In particular, it should cut the corporate tax rate from 10% to 9%, while at the same time it should increase the average tax rate on workers from 10% to around 35%. The informal economy size, and thus, tax evasion is responsive to changes to the corporate tax but does not react to changes in the personal income taxes. This is so because the bargaining power is shifted almost entirely to the employers. As a consequence, minimizing productive efficiency due to evasion calls for a lower corporate tax. Then, personal income tax is set to a high level in order to generate the necessary tax revenue.

[19] Note that in the baseline economy in 2014, personal income taxes are proportional with a rate of 10%. Therefore the implied tax function parameters are given by $\alpha = 0$ and $\tau = 0.9$.

[20] When choosing the optimal tax rates for individuals and corporations, the government takes into account the constraint that expenditures on unemployment benefits must equal revenues from payroll taxes.

Table 5: Optimal Taxation

	Baseline	Optimal
Personal Income Taxes		
Level tax rate, α	0.000	0.000
Tax Progressivity, τ	0.900	0.650
Corporate Taxes		
Proportional Rate, t_E	0.100	0.090
Objective Function Value	12930.40	12997.24

Notes: The table compares the tax rates emerging in the 2014 economy to the optimal tax rates. The corporate tax rate is proportional whereas the personal income tax is described by the function $T_W(\tilde{w}) = (1-\tau)\tilde{w} - \alpha$, where $\tilde{w}$ denotes the taxable income. α measures the progressivity of the tax code, and τ captures the marginal tax rate, which is equal to $1-\tau$.

The optimal tax progressivity is summarized in the parameter $\alpha = 0$, which dictates a flat tax regime with no deductible, in which the marginal and the average tax rate coincide. Therefore, we can conclude that redistribution through taxing personal income does not play any major role in shaping the optimal tax code. The personal income schedule essentially consists of a proportional rate of 35%. Note that our model does not feature a labor supply decision. If introduced, this additional feature may produce lower optimal personal income tax rate.

It is worth mentioning that the productive gains of implementing the optimal tax system are small (in order of 0.5%) relative to the case of the baseline economy, as shown on last row of Table 5. This implies that the optimal taxation economy does not differ significantly from the baseline economy in terms of aggregate statistics.

7 Conclusions

In this paper we evaluated the relative importance of labor productivity *versus* income taxes and social security contributions for tax compliance in an economy with a large degree of informality. The results from our quantitative exercise point out that informality in Bulgaria is largely irresponsive to changes in the personal income tax, whereas a non-negligible role is played by the corporate income tax. The main driver of the decline of informality is the rise in labor productivity, which accounts for three quarters of the decline in informality during the period under investigation.

Such findings call into question one of the main benefits argued in favor of a personal income flat tax reform. Hall and Rabushka (1995) claim that a sizable cut of top marginal tax rates would lead to higher tax revenues due to an increase in tax compliance. We find that this might not be the

case.

We envision two useful ways of extending the simple framework introduced in this paper. First, in the current analysis we abstract from life-cycle savings and pension benefits. This additional feature would make tax evasion less attractive because avoiding social contributions would reduce pension entitlements. We think, however, that this is not a quantitatively relevant margin for the economy under investigation. Bulgarian pension benefits are quite limited and the retirement age is very close to life expectancy.[21] Second, the introduction of decreasing returns to scale technology in the model would generate a meaningful notion of firm size, and hence, would allow us to explore the relationship between tax evasion, firm size and firm-level productivity. This additional structure would require the availability of very detailed matched employer-employee data. We leave these extensions to future research.

[21] The average pension benefit is around 40% of the net average wage in the 2000s (Adascalitei 2015). Moreover, the effective retirement age of men in Bulgaria is 64 years, while male life expectancy at birth was 68 years in 1960 and is around 71 years in 2016 (World Development Indicators).

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A Appendix

A.1 Data

Here we provide more details regarding data that we use for the stylized facts about Bulgarian economy in Sections 1 and 2. We also supply more information regarding the data targets that we use to estimate the model parameters (informal economy size, labor productivity, average wages and Gini coefficient of labor income).

Informal Economy Size. Several papers by Friedrich Schneider and others provide data on the size of the informal economy across European countries and over time (see Table A.1).
Figure 1a in the main text presents cross-country data on the size of the informal economy in 2013 from Hassan and Schneider (2016). Figure 8a plots the time series of informal economy size for Bulgaria and it is based on the papers reported in Table A.1. We use this time series in the quantitative analysis (see Section 4) as targets for estimating the model parameters related to the cost of hiding income.

There are several methodologies to measure the size and extent of informal economy.[22] In this paper we use the estimates of Friedrich Schneider based on the econometric technique MIMIC (multiple inputs multiple causes estimation).

Table A.1: Size of Informal Economy - Data Sources

Time Period	Source	Link
1999-2007	Schneider et al. (2010)	here
2003-2013	Schneider (2013)	here
2003-2015	Schneider (2015)	here

Envelope Wages. One of the very few data sources on the envelope wages practice in Europe is the Eurobarometer survey (*Undeclared work in the European Union*). Such a Europe-wide survey was conducted for the first time in 2007 (Special Eurobarometer 284), and repeated in 2013 (Special Eurobarometer 402). It was ordered by the European Commission and it collected data on undeclared work for all 27 member states (at the time) of the European Union. A link to the survey results can be found here. The results point out that envelope wages are a widespread phenomenon that characterize employer-employee relationships in developed countries: enterprises are formally

[22] See Enste and Schneider (2000) for a comprehensive review of the methodologies that have been used in the literature of measuring informality.

registered but may pay to their employees informal compensation in cash. The share of envelope wage earners varies from 3% in Germany and in the UK to 14% in Bulgaria. The Eurobarometer survey and its main findings are discussed in detail by Williams (2008) and Williams (2014).

Share of Formally Registered Firms. Data on the share of formally registered firms are taken from the 2013 World Bank Enterprise Survey that can be found here. The survey aims at measuring the degree of informality among firms. It is based on a panel of more than 125,000 firms in 139 countries. The results from the survey are condensed in four indicators, namely:

1. Share of firms competing against unregistered or informal firms (Bulgaria: 59,2%)
2. Share of firms formally registered when they started operations in the country (Bulgaria: 96.9%)
3. Number of years firms operated without formal registration (Bulgaria: 0.2)
4. Share of firms identifying practices in the informal economy as a major constraint (Bulgaria: 32.9%)

The 2013 World Bank Enterprise Survey also reports that the top business obstacle is competition from informal firms. The share of firms competing against informal firms is 60% among smallest firms (5-19 employees) but it drops to 40% among largest firms (with more than 100 employees. This finding can be reviewed here.

Governance Quality. Figure 3 shows the evolution of four governance quality indices for Bulgaria in the 2002-2014 period. These indices are constructed by the Worldwide Governance Indicators (WGI) project administered by the World Bank.[23] The WGI reports governance indicators for over 200 countries in the period 2000–2015. Governance is defined in the following way: *"Governance consists of the traditions and institutions by which authority in a country is exercised. This includes the process by which governments are selected, monitored and replaced; the capacity of the government to effectively formulate and implement sound policies; and the respect of citizens and the state for the institutions that govern economic and social interactions among them."*
Four governance indices are available for Bulgaria:

1. Government Effectiveness: Reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of

[23]The link to the project can be found here.

policy formulation and implementation, and the credibility of the government's commitment to such policies.

2. Regulatory Quality: Reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.

3. Rule of Law: Reflects 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.

4. Control of Corruption: Reflects 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.

These governance indicators are in units of a standard normal distribution (with a mean of zero and a standard deviation of one) and run from approximately -2.5 to 2.5, with higher values corresponding to better governance.

Gini on Labor Income. The Gini coefficient of labor income is taken from Eurostat (see link here). It is used as a data target in the estimation of the model (see Table 3) in order to identify the variance of the island-specific productivity shocks.

Labor Productivity, Average Wages and Unemployment. Figure 2 shows the evolution of labor productivity in Bulgaria between 2000 and 2014. Labor productivity is computed as GDP per employee and is reported in real 2005 euros. The data source is the ILO-KILM database. Data on monthly average wages and unemployment are displayed in Figure 6. The data source is the National Statistical Institute.

A.2 Taxes and Social Contributions in Bulgaria

Here we summarize the basic features of the tax and social security system in Bulgaria in the period 2000-2014. Workers pay a personal income tax on their earnings. Corporations pay corporate income tax on declared profits. Both the employer and the employee make contributions towards different insurance pools, and the employee receives a payout in case one of those contingencies occurs. We use popular commercial accounting software to derive tax rates for any income level

up to around 100 times the average wage.[24] The resulting dataset is used in the estimation of the tax functions described in Appendix A.3. We discuss each of the taxes and contributions in more detail below.

Personal Income Taxation. The Personal Income Tax is levied on an individual's earnings. The evolution of the income tax code can be divided into two periods: *(i)* progressive income tax system (2000-2007), and *(ii)* proportional tax system (flat tax) from 2008 onwards.[25] The levels and the progressivity of the personal income tax schedule are depicted in Figures 4a and 4b.

Corporate Income Taxation. Corporations pay corporate income tax on their reported profits. The proportional rate of this tax has been decreasing from 32.5% in 2000 to 10% in 2008 and onwards. The evolution of the corporate income tax rates is depicted in Figure 4c.

Employee Social Contributions. According to the social security legislation in Bulgaria, each employee makes contributions towards *unemployment*, *general (disease and maternity)*, *old-age pension* ("first pillar" of the pension system, which is state-managed), *supplementary compulsory pension insurance* ("second pillar", also state-managed; the "third pillar" consists of voluntary contributions to a private pension fund), and *health insurance*. These contributions are proportional to the salary of the worker. Generally, they vary across years, but these changes are not significant as shown in Figure A.1a. The sum of these contributions equals the Total Contribution Payment of the worker, which is deducted from the gross salary. If the gross salary exceeds the legislated ceiling income for contribution purpose for the year, the contribution payments are calculated based on that ceiling amount. The ceiling amounts vary across years. In the early 2000s, the ceiling is around 4 times the average salary, while in the later years it goes down to around 3 times the average salary. It is evident that the majority of these payments are related to pensions, followed by payments for health insurance.

Employer Social Contributions. Similarly, in order to abide by the social security legislation in Bulgaria, each employer has to make contributions on the worker's account for *unemployment*, *general (disease and maternity)*, *old-age pension*, *supplementary compulsory pension insurance*, *health insurance*, *employment accidents and occupational diseases*, and *insolvency of employer*. These contributions are also proportional to the salary of the worker. They are bound by the same ceiling in terms of worker's salary as the employee contributions. The composition of the social

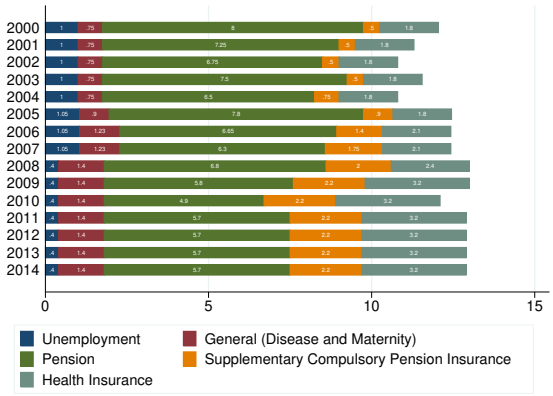
[24] The tax calculators we use can be found here.

[25] In both cases the tax is applied after employee social contributions are deducted from the gross salary.

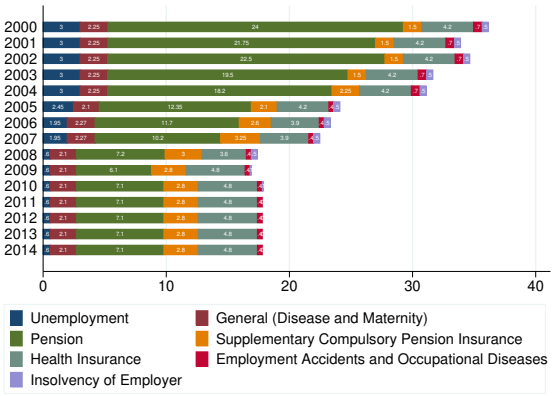
contribution rate of employers is presented in Figure A.1b.

Figure A.1: Composition of Social Contributions

(a) Employee



(b) Employer



A.3 Estimating Tax Functions of Personal Income

In order to understand the evolution of personal income taxes in Bulgaria in the 2000-2014 period, we fit a parametric tax function on the Bulgarian tax data. The parametric tax function is specified as follows,

$$T_W(\tilde{w}) = (1-\tau)\tilde{w} - \alpha, \tag{1}$$

where $T_W(\tilde{w})$ are taxes paid by a worker with taxable personal income $\tilde{w}$. This tax function has been recently used by Ferriere (2015) among others and is notable for its simplicity. The parameter τ governs the marginal tax rate. When $\tau = 0$, the marginal tax rate is 100% and the system is fully redistributive. On the other hand, if $\tau = 1$, then workers face a lump-sum tax $1 - \alpha$. Intermediate values of the parameter τ give rise to a progressive tax system. The parameter α reflects the initial deduction in the personal income tax code. The following linear relation can be estimated via ordinary least squares,

$$T_{Wit} = \beta_0 + \beta_1 \tilde{w}_{it} + \epsilon_{it}, \tag{2}$$

where $\tilde{w}_{it}$ is taxable personal income of worker i in year t, T_{Wit} are taxes paid and ϵ is the error term.[26] We can recover the tax function parameters by setting $\hat{\alpha} = -\hat{\beta}_0$ and $\hat{\tau} = 1 - \hat{\beta}_1$, where $\hat{\beta}_0$ and $\hat{\beta}_1$ are the estimated parameters. We estimate equation (A.4) above for each year in the

[26]Taxable personal income is defined as gross labor earnings net of social contributions levied on the worker.

period 2000-2014 and report the results in Figure 4b. We also estimate a pooled version of (2) on two subsamples (before 2008 and after 2008) and report the results in Table A.2. This simple tax function fits the relationship between disposable income and taxable income remarkably well - the resulting R^2 is larger than 0.94. Note that after 2007 the Bulgarian tax system becomes a flat tax regime without initial deduction. The estimated parameters reported in the second column of Table A.2 indeed show $\tau = 0.9$ and $\alpha = 0$, which imply a constant average tax rate of 10%.

Table A.2: Tax Functions - Estimates

	2000-2007	2008-2014
α	18.874***	-0.000***
	(0.664)	(0.000)
τ	0.754***	0.900***
	(0.002)	(0.000)
R^2	0.948	1.000

Notes: Estimation results for Linear tax function on real 2005 income. Standard errors (in parentheses) are below the estimates. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. In the 2008-2014 period the tax function achieves perfect fit by construction due to the proportional tax.

A.4 Validating the Mechanism

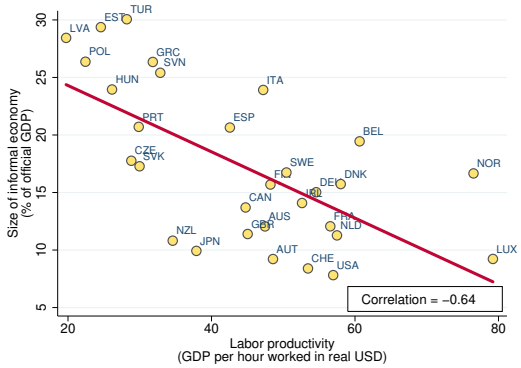
We evaluate the results of our quantitative analysis in the light of additional empirical evidence. To be more precise, we test some of the implications of our quantitative analysis using data on informality, taxes and labor productivity across countries. If the economic mechanism described in the previous section is relevant and can be generalized across time and levels of aggregation, one should observe the following:

Countries with higher labor productivity have a lower level of tax evasion/informality ceteris paribus. In addition, countries which experience stronger productivity growth also have a sharper decrease in informal production.

Validation across Countries. The analysis performed here relies on a panel dataset consisting of 30 countries for the time period 1999-2013. The measured variables of interest are the size of the informal economy and the prevailing labor productivity measured by output per hour worked.[27] Figure A.2 depicts the empirical relation between labor productivity and informality with no additional controls across the countries in our sample. The correlation between the two variables is

[27] We use output per hour worked instead of output per worker because of better data availability.

Figure A.2: Informality and Labor Productivity across Countries, 1999-2013 Averages



Notes: The size of the informal economy is taken from Schneider and Enste (2013). Labor productivity is measured by GDP per hour worked in 2010 USD and comes from the ILO-KILM 16a database.

Table A.3: Informality and Labor Productivity across Countries and Over Time, 1999-2013

	Dependent variable: *Informality*			
	(1)	(2)	(3)	(4)
Output per hour worked	-0.719***	-0.703***	-0.670***	-0.224***
	(0.124)	(0.127)	(0.119)	(0.0627)
Country fixed effects	No	No	Yes	Yes
Time fixed effects	No	Yes	No	Yes
Number of observations	442	442	442	442
Number of countries	30	30	30	30
R^2	0.416	0.427	0.364	0.676

Notes: Robust standard errors in parentheses. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Informality is measured as the log of the hidden production as a share of GDP (in %). Labor productivity is measured as GDP per hour worked in 2010 USD.

strongly negative (-0.64), which provides a first confirmation of the role of productivity we have documented in the model.

Furthermore, the mechanism is confirmed in a set of estimated regression specifications in Table A.3. The correlation between the two variables of interest is significantly negative even when we control for time effects. Moreover, specifications (3)-(4) add country fixed effects which allows us to focus on the association between labor productivity and informality within countries over time. The magnitude of the correlation is smaller but still highly significant and negative.

In a next step we also include as explanatory variables, the average tax rates on labor and capital for 15 countries in the period 1999-2007. This empirical exercise identifies the relation between productivity and informality after controlling for differences in taxes and their evolution over time in the same spirit as in the quantitative analysis in the previous section. Table A.4 shows

Table A.4: Informality and Labor Productivity across Countries and Over Time, 1999-2013

	Dependent variable: *Informality*					
	(1)	(2)	(3)	(4)	(5)	(6)
Output per hour worked	-0.786**	-1.014***	-1.007***	-1.207***	-0.727***	-1.378***
	(0.279)	(0.121)	(0.233)	(0.116)	(0.241)	(0.126)
Labor tax rate			1.591	-1.416***	1.523*	-1.248*
			(0.957)	(0.388)	(0.841)	(0.599)
Capital tax rate			0.164	-0.631***	0.304	-0.661***
			(0.675)	(0.151)	(0.602)	(0.180)
Government quality					-1.757***	0.064
					(0.545)	(0.0753)
Country fixed effects	No	Yes	No	Yes	No	Yes
Number of observations	131	131	126	126	102	102
Number of countries	15	15	15	15	15	15
R^2	0.236	0.545	0.379	0.700	0.598	0.723

Notes: Robust standard errors in parentheses. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Informality is measured as the log of hidden production as a share of GDP (in %). Labor productivity is measured as GDP per hours worked in 2010 USD. Tax rates are taken from Trabandt and Uhlig (2011). The index of government quality comes from the WB-WGI database.

the results (specifications (1)-(4)). The impact of the productivity on informality and evasion is still negative and significant. Moreover, in all specifications the magnitude of the estimated coefficient is larger than before (when we did not control for taxes).[28] Interestingly, the elasticity of the size of informal economy with respect to labor productivity in our quantitative model is of smaller magnitude. Recall that observed labor productivity in Bulgaria increased around 48% over the period 2000-2014. At the same time the reduction in informality in the model when only productivity is present is 4.97 percentage points which is a reduction of around 13.5% (see Table 4). This implies an elasticity of informal economy size with respect to productivity of around 0.28. The fact that the cross-country empirical analysis also implies a large role of productivity for the decrease in informality is reassuring.

In a final set of exercises, we also control for the quality of governance too (Table A.4, specifications (5)-(6)). Results do not change dramatically relative to the previous specifications. Note that the signs of the estimated coefficients become negative and significant when we control for country fixed effects in specifications (4) and (6). This might be an indication that within countries and over time taxes are set high whenever informality is on its way down.

[28]The sample size here is much smaller because of the additional explanatory variables are not available for all countries/years.