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ABSTRACT

Striking a Balance: Optimal Tax Policy with Labor Market Duality*

This paper develops a dynamic general equilibrium model where employers may avoid making social security contributions by offering some workers "secondary contracts". When calibrated using aggregate tax revenue data, the model delivers estimates of secondary "off the books" employment that are consistent with survey evidence for the EU14 and United States. We investigate the fiscal and welfare effects of varying the avoidable and unavoidable shares of labor income tax while keeping the total wedge constant, and find that increasing the employer component raises hours worked, output, and welfare. Partial labor tax evasion makes tax revenues more elastic, but full tax compliance need not be a welfare enhancing policy mix.

JEL Classification: H2, H26, H3, E13, E26, J81

Keywords: Laffer Curve, tax evasion, labor market duality

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1 Introduction and motivation

Labor income taxes are generally levied in two parts, a tax on earnings paid by workers, and a proportional social security contribution made by employers. The contributions component can form a substantial part of an employer's costs of hiring labor. For instance, within the OECD, there are countries where social security contributions (SSC) amount to more than seventy percent of the total labor tax wedge, see Figure 1. Across countries, various forms of *de jure* arrangements permit employers of *de facto* salaried workers to avoid the burden of contributions. These arrangements lead to dual labor markets where some workers, under "primary contracts," are formally employed, while others are offered "secondary contracts" which result in atypical, non-standard, or (forced) self-employment. The effective scope of SSC reduction is very country-specific, as are the methods and rates of labor taxation. In many countries, the high share of employer SSC in the total labor tax wedge gives strong incentives to engage in tax avoidance. We develop an equilibrium model where the burden of the employer contribution component of labor income tax and the scope of its avoidance explains the level of labor market duality in the economy.

Tax avoidance and tax evasion are clearly different concepts: the latter, if detected, involves heavy fines and even incarceration. However, avoidance of social security contributions operates in legal ambiguity and if detected, is typically less penalized (see Buscaglia 2008, Girandi 2008, for the cases of US and Europe, respectively). For example, the "secondary contracts" prevalent in the *gig economy* may be challenged in labor courts, but absent health hazard or other public safety concerns, regulators have not been able to even commence litigation within the OECD.[1] Due to this legal ambiguity and the diversity in the legal norm of a standard employment contract across countries, obtaining consistent estimates of social security avoidance is difficult. A crude and imperfect proxy is the ratio of actual employer contributions from national accounts, to the theoretical tax liability, obtained as if the entire working population was employed using a standard employment contract (Baumann, Friehe and Jansen 2009). Using data from 2018, avoidance rates across the OECD range from just below 5% in Sweden to as much as 80% in Turkey. These avoidance rates exhibit high correlation with the share of SSC borne by employers, as shown in Figure 2. It is against this background that we propose to treat SSC as a potentially avoidable labor cost.

We develop a dynamic general equilibrium model following Trabandt and Uhlig (2011), extending their framework to include dual labor markets where employers can reduce wage costs by avoiding contributions. The labor market duality in our model arises from non-standard secondary employment contracts that exclude social security protection.[2] Our model design

[1] In some countries, legislation preemptively prevents gig economy platforms from operating at all, but there have not been any successful prosecutions of labor code violations or avoidance of taxes and social security contributions.

[2] This in line with broad empirical evidence on labor market duality, see for example a review of the situation across European countries in the volume edited by Salverda et al. (2014). There are many methods used to avoid

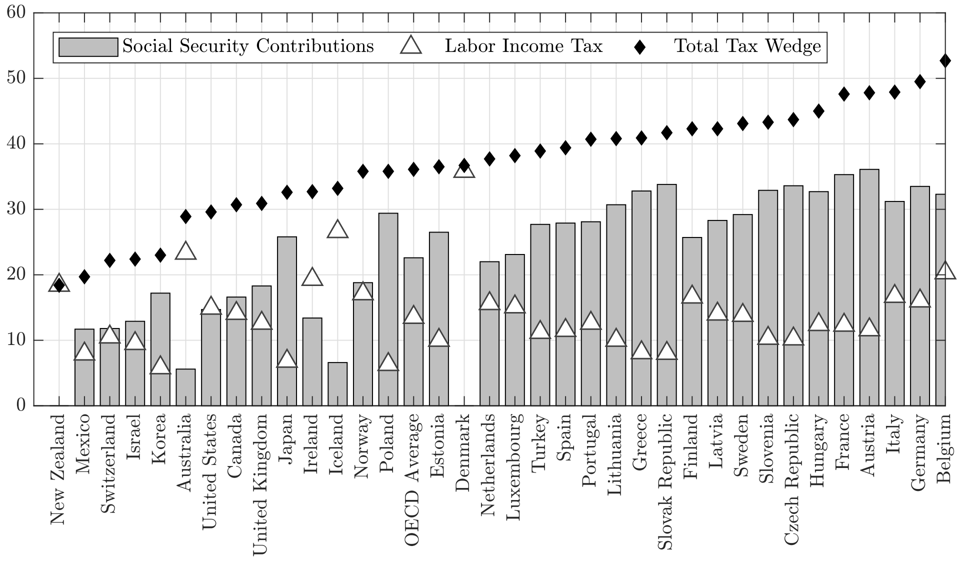
introduces a novel trade-off between direct labor income taxation and SSC: while contribution avoidance by employers reduces tax distortions and raises labor demand, the disutility of working in "secondary contracts" devoid of social protection reduces supply. We calibrate the model to match features of 14 EU economies and the United States, and deliver several novel results. We show that the extent of secondary "*off the books*" employment in an economy can be explained by the employer share of SSC in the total labor tax wedge. We also show that with SSC avoidance, Laffer curves are more elastic, achieving maxima at lower overall labor tax rates. We provide normative inference, using the model to study the welfare effects of changing the composition of avoidable and unavoidable labor taxes. We show that in most of the countries we consider, welfare could be raised without reducing total tax revenue by changing the mix of avoidable (SSC) and unavoidable labor income tax. Finally, we study changes in labor code enforcement and find that raising the penalty for social security avoidance has negligible effects on welfare and revenues.

Our paper builds on two strands of the literature: one on labor market duality arising from tax evasion, and the other on optimal taxation á la Laffer. On tax evasion and duality, we contribute to a small literature that focuses evasion of labor market regulations such as SSC. Madzharova (2011) shows how the deductibility of wages in light of a lowered corporate tax rate gives incentives to under-report wages and shift income from the social security tax base to the lower corporate tax base. Ulyssea (2018) separates a firm's decision to operate formally (the extensive margin) from its decision to hire workers "off the books" (the intensive margin), and shows that the intensive margin accounts for a large share of total informal employment. More recently, Cuff, Mongrain and Roberts (2020) consider firms who can evade labor regulations including payroll taxes by hiring workers informally while also engaging in profit tax evasion. Since wages are deductible input costs, a higher corporate tax makes informal workers less attractive, while high payroll taxes have the opposite effect. Optimal payroll taxes are consequently lower in the presence of both types of evasion. A stream of the literature on labor market duality focuses on obtaining reliable measures of undeclared work. Following Schneider and Enste (2000), a number of approaches have been developed to obtain internationally comparable estimates of the incidence of the undeclared work (e.g. Schneider 2011, Williams 2013).[3] Our work contributes to this literature by providing estimates of the share of informal or undeclared workers from aggregate data. Our calibration exercise shows

SSC, broadly categorized as legal (structuring employment contracts such that the workers are not classified as employed or making the workers take compensation as profit share rather than wages, see Bailey and Turner 2001), or illegal (undeclared work, with unreported, untaxed income, see e.g. Schneider 2011).

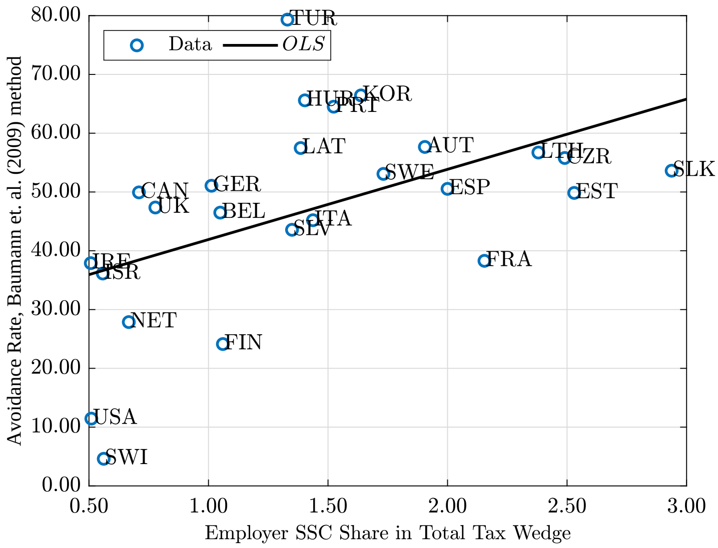
[3]Time-series data and natural experiments have been used to estimate the size of the informal sector in one or a selected group of countries. In addition to the usually large literature on the United States, these studies are common for Latin America (e.g. Rakowski 1994, Loayza 1996, Loayza et al. 2005, Alanon and Gomez-Antonio 2005, Castillo and Montoro 2010, Schneider and Hametner 2014), Italy (e.g. Castellucci and Bovi 1999, Dell'Anno 2003, Ardizzi et al. 2014, Di Caro and Nicotra 2015) and Germany (e.g. Merz and Wolff 1993, Pickhardt and Sardà Pons 2006). Schneider (2014) provides an extensive characterization of the literature in this field. See also Breusch (2005) for a critique on Schneider's method of estimating the shadow economy.

Figure 1: Labor taxes and social security contributions in the OECD



Data source: OECD (2019), tax rates for single earner households, no children at 100% of average earnings.

Figure 2: Avoidance of employers' social security contribution



Data source: Avoidance rate calculated following the method of Baumann et al. (2009) as one minus the ratio of theoretical liability to actual contributions. Theoretical liability is computed as employer social security contribution rate times Gross Labor costs from *Table 1.2. Income tax plus employee and employer social security contributions as % of labor costs* (OECD 2019). See also Table 5.6 in OECD (2004). Actual contributions are computed based on OECD national accounts revenue statistics. The labor costs are given in per worker terms, so to obtain comparable values of actual contributions we use the total employer SSC from Revenue Statistics 2018 (2200 Employers SSC, Total tax revenue in USD) divided by annual employment in 2018 (annual Labor Force Survey). Data source for taxes the same as in Figure 1. Pearson correlation, 0.43 (p-value: 0.034).

that the share of SSC taxes in the total tax wedge explains both the cross-country variation in secondary employment and the size of the informal economy.

A succession of recent papers have focused on the question of optimizing tax rates to maximize revenue (rather than optimal taxation á la Ramsey or Mirrlees). Trabandt and Uhlig (2011) obtained the inverse U-shaped Laffer curve in a friction-less dynamic general equilibrium model and showed that the EU14 economies and the US could increase revenue by raising labor or capital taxes. Similar approaches include models incorporating an explicit underground- or informal-economy with its own capital and labor inputs, hidden production, and Laffer curves peaking at lower labor income tax rates (Busato, Chiarini and Marchetti 2011, Busato and Chiarini 2013).[4] We innovate relative to this literature in two key ways. First, unlike Busato and Chiarini (2013), Orsi, Raggi and Turino (2014) or Solis-Garcia and Xie (2018), both primary and secondary labor use the same capital inputs in our economy, and output from secondary employment is part of measured GDP. Our model is consequently simpler, yet able to give plausible implied estimates of the extent of informal economic activities. Second, since secondary employment is driven by SSC avoidance in our model, we are able to link the cross-country variation in its size or prevalence to the burden of employers' SSC. While there are studies that make cross-country comparisons on the size of informal-economy or secondary employment, our approach enables us to systematically obtain values of difficult to calibrate parameters such as the elasticity of substitution between primary and secondary labor, and the probability of tax audits.[5]

There are two important policy implications of our study. First, we show that in most advanced economies, there is room for improving welfare and raising tax revenue by increasing the weight of employer SSC in the total labor tax wedge. These gains are achievable without changing the overall labor tax rate, and emanate from the reduction in effective taxation as a result of employers offering some workers secondary contracts. The lower effective taxation increases hours worked, despite the higher disutility of supplying labor without social security protection, and leads to higher output and more elastic Laffer curves. Second, we show that the transition from the *status quo* to the optimal structure of labor taxes is not likely to be fiscally costly. Some caveats apply. Our results are obtained in a dynamic general equilibrium model that does not account for the fact that in some countries part of the social security contributions may be considered an implicit subsidy for old-age consumption. Although this is clearly a limitation of our approach, empirical evidence favoring such a perception of social

[4]This literature is particularly rich for Italy, see e.g. Busato, Chiarini and Rey (2012), Orsi, Raggi and Turino (2014), Bernasconi, Levaggi and Menoncin (2015), Pappa, Sajedi and Vella (2015). Other extensions include models featuring worker heterogeneity (Gillman and Kejak 2014, Guner, Lopez-Daneri and Ventura 2016, Holter, Krueger and Stepanchuk 2019) and financial frictions (Feve, Matheron and Sahuc 2017). The model of Feve et al. (2017) features incomplete markets and heterogeneous, liquidity constrained agents and a horizontally S-shaped Laffer curve.

[5]This is in contrast to, for instance, Solis-Garcia and Xie (2018) who set the probability of default to zero in all cases and consequently need a sensitivity analysis to justify their choice.

security contributions is rather weak (Lusardi and Mitchell 2011, Chetty, Friedman, Olsen and Pistaferri 2011).

The remainder of the paper is structured as follows. The next section presents our theoretical model. In Section 3 we discuss how the model is solved and calibrated to replicate the steady-state features of the EU–14 and United States economies. We present results and our policy experiments in Section 4. Conclusions and policy implications are discussed in the final section.

2 Model

Following Trabandt and Uhlig (2011), we consider a standard neoclassical model of an economy that produces a single good used for both consumption and investment. The economy consists of many firms who combine capital and labor to produce the consumption good which is sold to identical households. Households own the economy's stock of capital which they rent to firms while also supplying labor services. There is a government that levies taxes on households' incomes and consumption to finance its expenditure on goods and lump-sum transfers. Taxes levied by the government include a proportional tax on labor income to be paid by households and a proportional social security contribution to be made by firms.

We innovate relative to Trabandt and Uhlig (2011) in three main ways. First, we assume the labor market is dual: there is a primary market, where firms make the required SSC for their workers and a secondary market, where they avoid making these contributions. Second, we assume that workers prefer to work in the primary market and hence any labor supplied in the secondary market induces a higher disutility of working captured by an additional parameter in our utility function compared to Trabandt and Uhlig (2011). Accordingly, as we describe in Subsection 2.1, the labor input enters the production function as a CES aggregate of primary and secondary hours worked. Third, since the avoidance of SSC contributions is risky and subject to detection by the government, firms face a non-negligible probability of detection and a penalty for avoiding social security contributions. Our representative firm therefore optimizes expected revenue, similar to Busato and Chiarini (2013) and Orsi et al. (2014). However, rather than hide output, firms in our economy under-report labor input which allows them to avoid the cost of SSC. We discuss the details of these modeling choices in the next section. These unique features of our economic environment mean households and firms optimization problems and budgets are different from standard models as they now accommodate non-taxed income, while the government revenue includes penalties imposed on firms found to be avoiding SSC.

2.1 Production and profit maximization

The economy has a representative, perfectly competitive enterprise sector. Firms combine capital (k) and labor (n) to produce output using the production function:

$$y = Ak^{\alpha}n^{1-\alpha}, \tag{1}$$

where A denotes exogenous technological progress. The production input n is a CES aggregator of labor where social security contributions are unavoidable (primary market, subscript P) and labor where social security contributions are avoidable (secondary, subscript S):

$$n = ((1-\omega)n_P^{\rho} + \omega n_S^{\rho})^{\frac{1}{\rho}}\,. \tag{2}$$

The elasticity of substitution σ, between labor from primary and secondary market, is defined by the parameter ρ through the relation $\sigma = \frac{1}{1-\rho}$,[6] and the extent of labor market duality from the production function is given by $\omega = \frac{n_S}{n}$.

Taxation of labor income Labor is taxed in two forms. Workers pay a tax τ^n on earnings while employers make the proportional social security contributions τ^s. This split replicates the features of many advanced economies where employers are required by law to make social security contributions. Without loss of generality, we assume that labor income tax cannot be avoided by workers.[7] In contrast, firms may avoid social security contributions by offering workers secondary – non-standard or atypical – contracts that do not provide the full social benefits of formal employment. This feature of the model replicates the institutional design in many advanced economies. Our motivation is that social security contributions by the employer are a direct cost and firms have an incentive to avoid this cost. If a firm avoids social security contributions, it employs a non-zero share of workers on secondary contracts.

Profit maximization with SSC avoidance Employers face an exogenous probability of being audited and penalized for avoiding SSC. With probability p, a firm is audited and has to pay the un-remitted contributions τ^s together with a proportional surcharge $s < 1$. Denote profits when a firm is detected for using unregistered labor by π^D and when not detected by π^{ND}. Denote the user cost of capital by d and the wage paid to workers by w_i, $i = \{P, S\}$.

[6] Note, that if the two types of labor are identical, as is perfectly feasible in our setup, they become perfect substitutes in the production function.

[7] See Busato, Chiarini and Rey (2012) for an example of such an approach. Typically, the fully informal sector uses no capital input. It makes the theoretical treatment suitable for some forms of "secondariness", but not others. It appears that in many advanced economies secondary contracts are associated with a relatively strong bargaining position of a regular, formal employer vis-a-vis some groups of workers in combination with relatively weak enforcement (Williams 2015). Hence, eliminating capital-labor "complementarity" may not be the most appropriate way to replicate features from the real world in a model.

Then the firm's expected profit π^e is given by:

$$\begin{aligned}\pi^e &= p\pi^D + (1-p)\pi^{ND} \\ &= y - dk - (1+\tau^s)w_P n_P - (1+p\bar{s}\tau^s)w_S n_S\end{aligned} \tag{3}$$

where $\bar{s}\tau^s w_S n_S$ is the penalty on avoided social security contributions which includes the amount owed $\tau^s w_S n_S$ and a surcharge $s w_S n_S$ so that $\bar{s} = 1 + s$.[8] For brevity, wages are considered in *quasi*-net terms: gross wage is the wage paid to the worker augmented by social security contributions and net wage is the wage paid to the worker less the labor income tax. The firm chooses $\{k, n_P, n_S\}$ to maximize profits.

2.2 Households

A representative household has preferences over consumption c and leisure time $l = 1 - n_P - n_S$. The household has utility function:

$$U(c, l(n_P, n_S)) = \frac{1}{1-\eta}\left(c^{1-\eta}\left[1 - \kappa(1-\eta)(n_P + \phi n_S)^{1+\frac{1}{\varphi}}\right]^{\eta} - 1\right). \tag{4}$$

The parameter ϕ captures the *additional* disutility from working in a secondary contract. This parameter captures in an abstract way the idea that working without employer social security contributions would reduce say future consumption in an OLG type model or that having a secondary market contract precludes the worker from some other non-monetary benefits of a primary market contract. The remaining parameters are standard: η is the inverse of intertemporal elasticity of substitution, φ is Frisch's elasticity of labor supply and κ is the weight of labor.[9]

The representative household does not have technology to engage in tax evasion or avoidance and faces the budget constraint:

$$\begin{aligned}(1+\tau^c)c + b + x \quad = \quad & (1-\tau^n)w_P n_P + (1-\tau^n)w_S n_S && \equiv \text{labor income} \\ & +\pi^e + (1-\tau^k)(d-\delta)k_{-1} + \delta k_{-1} && \equiv \text{capital income} \\ & +R^b b_{-1} + h + m && \equiv \text{interest, transfers and trade}\end{aligned} \tag{5}$$

[8]This approach to modeling detection and punishment is standard in the tax evasion literature, and is consistent with instances where violations of labor regulations resulted in settlement or compensation. For example, prior to its IPO, Uber Inc. had settled a class action suit for 100 million USD, stating as follows "[...] Uber has agreed to a historic settlement of the claims we have brought in California and Massachusetts for misclassifying its drivers as independent contractors." Already in 1990s, private lawsuits set precedents in the US, that independent contractors should be eligible for the 401k programs and employee stock purchase programs (the case of Vizcaino v Microsoft). This precedent is confronted with the opposite ruling in another district court (the case of Clark v. DuPont) without universal resolution until these days in either the US or European economies.

[9]The separability of consumption and labor in the utility function may affect the shape of the Laffer curve even on consumption taxes, for discussion see Hiraga and Nutahara (2016).

where τ^c is tax on consumption c, b is new public debt, and $x = k - (1-\delta)k_{-1}$ is investment in the capital stock k, which depreciates at rate δ. The parameter h denotes net social transfers to households and m is a trade balance (which may be zero). Solving the consumer problem for labor supply and combining with labor demand from the firm's problem yields:

$$\frac{1}{\phi} = \left(\frac{1-\omega}{\omega}\right)^{\rho} \frac{1 + p\bar{s}\tau^s}{1+\tau^s}, \tag{6}$$

which defines the labor market equilibrium in our model.

2.3 Government

The government levies taxes and borrows to finance its consumption, transfers to households and debt for which it pays the same interest as firms. Government expenditure equals its consumption g, transfers to households h, and servicing of outstanding debt plus interest Rb_{-1}. The government expenditure is financed using tax revenues T and new borrowing b. The government budget constraint is given by:

$$T + b = g + R^b b_{-1} + h + x, \qquad \text{where} \tag{7}$$

$$T = \tau^c c + \tau^k (d-\delta)k_{-1} + (\tau^n + \tau^s)n_P w_P + (\tau^n + p\bar{s}\tau^s)n_S w_S. \tag{8}$$

Tax revenue comes from levies on consumption expenditure, and on capital and labor income. Revenue deriving from labor consists of three sources: labor income tax, SSC (the un-avoided share) and penalties or surcharges arising from government audits of employer SSC. The government is not strategic in setting $p\bar{s}$, i.e. we do not assume any optimization on the side of the government.

2.4 Equilibrium

The competitive equilibrium is defined by the allocation $\{c, g, k, n_P, n_S\}$, the price system $\{R, w_P, w_S\}$ and government policy $\{\tau^n, \tau^s, \tau^k, p\bar{s}, \tau^c\}$ such that: (a) given the price system and government policy, the allocation solves both the household's and firm's problem, and (b) given the allocation and price system, the government policy satisfies (7) and (c) all markets clear.

We solve for hours worked. Substituting for tax revenues (8) into the households feasibility constraint (5) and using the government budget constraint (7) implies:

$$\overline{\left(\frac{c}{y}\right)} + (\psi - 1 + \delta)\overline{\left(\frac{k}{y}\right)} = 1 + (m-g)\frac{1}{\overline{\left(\frac{y}{n}\right)}}\frac{1}{n}. \tag{9}$$

In equation (9), ψ is the steady state growth rate of output, and the ratios of consumption-to-output $\overline{(c/y)}$, capital-to-output $\overline{(k/y)}$, and labor productivity $\overline{(y/n)}$ are defined by:

$$\overline{\left(\frac{c}{y}\right)} = \frac{1}{\chi}\left[\left(\eta\kappa n^{1+\frac{1}{\varphi}}\right)^{-1} - \frac{1}{\eta} + 1\right], \tag{10}$$

$$\text{where} \quad \chi = \frac{1+\tau^c}{1-\tau^n}\frac{(1-\omega)^{-\rho}(1-\omega(1-\phi))}{1-\alpha}\left(\frac{1+\varphi}{\varphi}\right) \text{ is a parameter cluseter,}$$

$$\overline{\left(\frac{k}{y}\right)} = \left[\frac{(R-1)}{\alpha(1-\tau^k)} + \frac{\delta}{\alpha}\right]^{-1} \quad \text{and} \quad \overline{\left(\frac{y}{n}\right)} = \left(A\left(\frac{k}{y}\right)^{\alpha}\right)^{\frac{1}{1-\alpha}}. \tag{11}$$

Replacing the consumption- and capital-to-output ratios, and labor productivity in (9) with equations (10) and (11), gives a non-linear equation in labor supply n which can be solved numerically. We give details of how we solve the model and compute welfare (in consumption equivalent terms) in Appendix B.

3 Calibration

Values of standard parameters used in the baseline calibration are summarized in Table 1. In all cases we use the steady state relationships to calibrate individual country parameters so as to match capital- and consumption-to-output ratios, and hours worked. Specifically, to exactly match the capital output ratio, we compute δ using the steady state capital investment relationship and α is calculated as rate of return in equation (11). These values are matched exactly in our model (as shown in Figures B.1a-B.1c). The estimates of TFP growth we use coincide with those made by the European Commission and with a recent account of US TFP growth prospects by Fernald and Jones (2014).

Table 1: Calibration of model parameters

Parameter	Description	Value	Source
α	Capital share in output	Country Specific	European Commission
β	Time preference	0.9615	European Commission
ψ	TFP growth[1]	1.017	European Commission
$\bar{R}$	Gross interest rate	1.04	Standard
δ	Depreciation rate	Country Specific	Trabandt and Uhlig (2011)
η	Inverse of IES	2	Standard
ω	Weight of secondary labor	Country Specific	See Appendix A.1.
ρ	Primary and secondary labor substitution.	Country Specific	See Appendix A.2
$p\bar{s}$	Expected penalty for SSC avoidance.	Country Specific	See Appendix A.2
φ	Frisch's elasticity	1	Standard
ϕ	Disutility of supplying secondary labor	Country Specific	See Appendix A.2
κ	Weight of labor	Country Specific	OECD, Trabandt and Uhlig (2011)
τ^c, τ^k	Consumption and capital tax rates	Country Specific	OECD, Mendoza et al. (1994)
τ^n, τ^s	Earnings and employer SSC tax rates	Country Specific	OECD, Mendoza et al. (1994)[3]
b	Public debt (in % of GDP)	Country-specific	OECD
g and s	Gov. cons. and social transfers (in % of GDP)	Country Specific	OECD
m and x	Trade balance and other (in % of GDP)	Country Specific	OECD

Notes: [1.] TFP growth rates are the long-run estimates provided by the European Commission.
[2.] OECD values are computed as averages over 1995-2007. [3.] See Appendix A.1.

In the utility function, the inter-temporal elasticity of substitution has been set to 2, consistent with values used in the literature (see e.g. Havránek 2015). Similarly, Frisch's elasticity is set to 1 (Chetty et al. 2012). We follow the approach of Mendoza, Razin and Tesar (1994) which uses government revenue statistics, described in Table A.1, to obtain effective tax rates which we report in Table A.2. Their approach takes all labor income levies into consideration when computing the effective labor income tax rate $\tau^l = (\tau^n + \tau^s)$. We however need to separate social security taxes contributed by the employer from other labor income related taxes. To obtain τ^n we subtract employer SSC from the numerator of the ratio τ^l, and compute τ^s as the ratio of employer SSC to the denominator of τ^l. We describe the details of our modified version of the Mendoza et al. (1994) method in Appendix A.1.

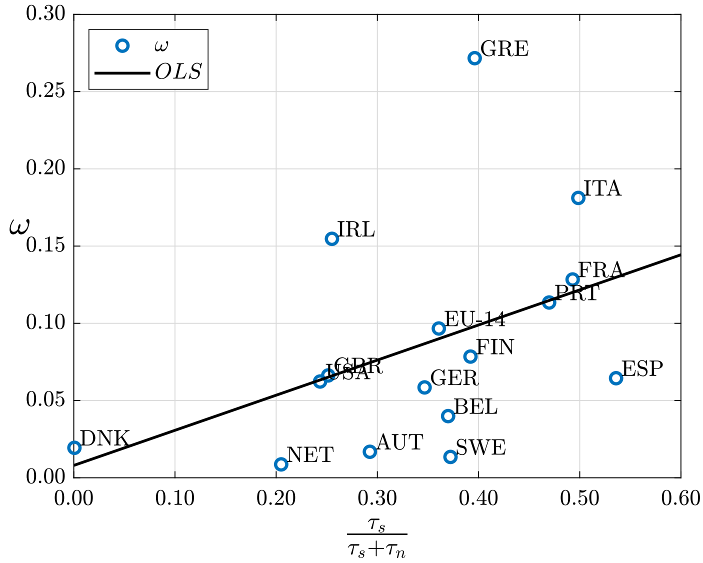
The parameters ω, ρ and $p\bar{s}$ as well as ϕ fit for every country are reported in Table A.3 in Appendix A.2. These parameters are obtained from a numerical solution to three non-linear equations (A.1)–(A.3), described in Appendix A.2. Across countries, our calibration results have $p\bar{s}$ varying from a low of 0.01 in Portugal to a high of 1.12 in France.[10] Most administrations do not disclose the effective identified non-compliance rates, neither is the detailed information about actual penalties available, hence the available studies either set these to zero (see e.g. Solis-Garcia and Xie 2018) or rely on legislation to calibrate p and $\bar{s}$. Busato et al. (2012) use earlier work by Joulfaian and Rider (1998) who derive penalties from the United States tax code to calibrate their tax evasion model of the Italian economy with $p = 0.03$ and a surcharge factor $\bar{s} = 2$ so that $p\bar{s} = 0.06$. In another paper, Busato et al. (2011) use the values $p = 0.05$ and $\bar{s} = 1.75$ for the United States, implying a value of $p\bar{s} = 0.0875$. For comparison, our calibration for the United States and Italy results into $p\bar{s}$ of 0.0543 and 0.0398 respectively. These values are very close to those of Busato et al. (2011) and Busato et al. (2012) even though we determine these numbers from aggregate tax revenue data.

While most of the values we obtain from the solver are within the expected range, the values of the expected penalty $p\bar{s}$ reported for France and the Netherlands are considerably higher. A search through a wide set of initial values does not yield any improved numerical results for these two countries. The range of parameters is intuitive. For instance, ω is the weight of secondary labor, therefore $0 \leq \omega < 1$. If primary and secondary labor are perfect substitutes then the elasticity of substitution $\sigma = \frac{1}{1-\rho} \to \infty$, so $\rho \to 1$. These conditions constrain $\phi > 1$ which in turn constrains $p\bar{s} \leq 1$. Given our interest in total hours worked – both by primary and secondary workers – we chose the weight of labor κ, by inverting the equilibrium relation (9), so as to exactly match aggregate hours worked, and α, δ to match consumption- and capital-to-output ratios (see Figures B.1a - B.1c). The implied labor and consumption tax revenues (all as a share of GDP) are also reasonably well matched (see Figures B.1e-B.1f).

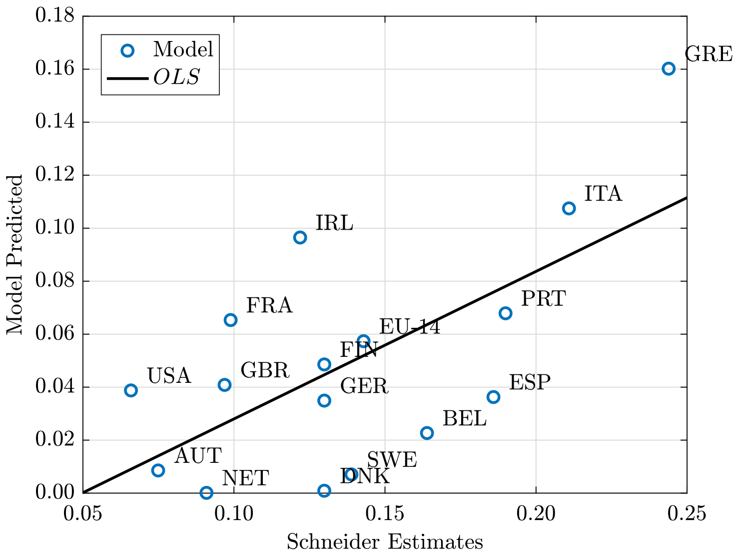
The model predictions are generally plausible and reasonably close to empirical estimates.

[10]The number $p\bar{s} = 0.01$ in Portugal could for example reflect a probability of being caught $p = 0.005$ accompanied by a surcharge $\bar{s} = 2$ when caught.

Figure 3: Model predictions versus empirical sources on prevalence of labor market duality



(a) Predicted ω vs tax structure



(b) Informal economy (Schneider 2014)

Notes: Pearson's r for 3a at 0.46 (p-value= 0.08) and for 3b at at 0.64 (p-value=0.01).

For instance, the Pearson correlation coefficient between our model implied size of the secondary employment (ω) and self-reported incidence of atypical employment based on the European Social Survey (ESS) data summarized by Flórez and Perales (2015) is 0.70 with a p-value of 0.03.[11] Moreover, the tax mix (from the data) and the calibrated values of ω display a plausible

[11]Rank correlation coefficients: Kendall's τ = 0.28 (p-value=0.15) Spearman's ρ = 0.32 (p-value=0.23). Similarly close match is held to cross-country dispersion in informal, atypical and irregular employment based on a smaller scale survey, the Eurobarometer, as reported by Williams (2015), Williams and Windebank (2015), detailed results available upon request.

relationship, both in terms of range and in cross-sectional dispersion, see Figure 3a. Using the model parameters, we also find the share of output produced using secondary workers in the economies analyzed.[12] We compare these to the estimates of Schneider (2014) on the size of the informal sector in an economy, see Figure 3b. Our model replicates the dispersion in the size of the informal economy with a Pearson's correlation coefficient of 0.64 (p-value 0.01). This is reassuring, as our model focuses only on the scope and scale for partial tax avoidance.[13] Given that the model performs reasonably well, we now move to addressing the main question of this study about the optimal mix between avoidable and unavoidable labor taxes.

4 Policy analyses

We report the results of our counterfactual experiments in two substantive parts. First, we show changes to the Laffer curve relative to a benchmark model of Trabandt and Uhlig (2011). We then utilize the model to produce several counter-factual scenarios. Keeping the overall labor taxes unchanged, we change the composition of avoidable and unavoidable taxes, showing how the proportions in this policy mix affect tax revenues and welfare. We also analyze the path of transition if a country altered the composition of labor taxes. The second set of counter-factual experiments concerns possible effects of strategic action by the government: varying the expected penalty associated with avoiding SSC.

4.1 How does the Laffer curve change with SSC avoidance?

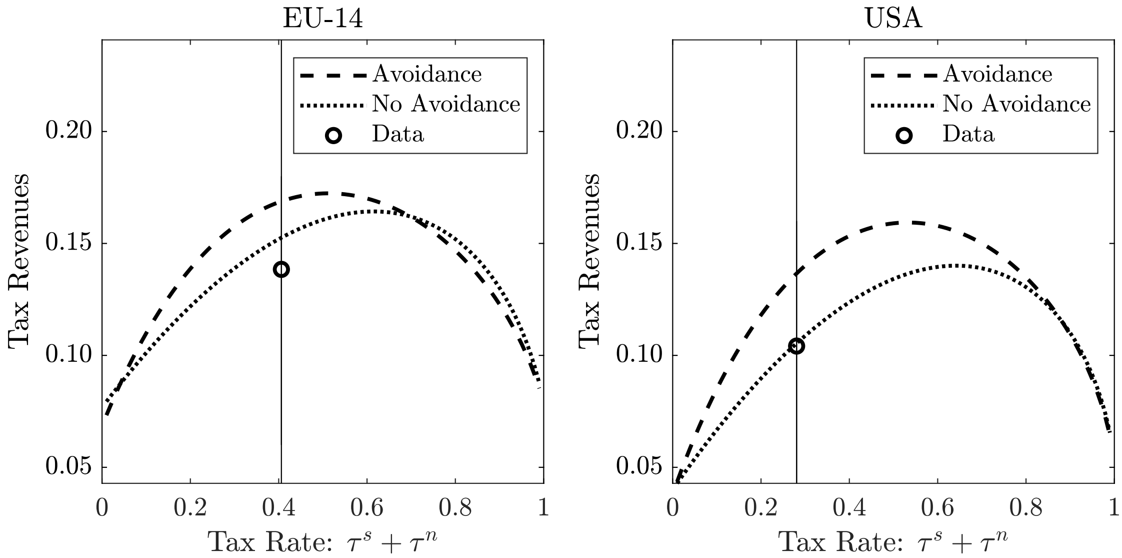
We report Laffer curves for aggregate revenue from the labor income tax wedge which includes the unavoidable labor income tax and the partially avoidable SSC. We keep the ratio of the avoidable employer SSC to the unavoidable labor income tax constant while increase their sum from zero to unity. The results for the EU-14 and the US are depicted in Figure 4 (respective results for each individual EU14 country are available upon request). For comparative purposes, we replicate the results of Trabandt and Uhlig (2011), i.e. with both taxes together, but without tax avoidance (all employed labor is fully taxed). This scenario is denoted as "no avoidance" while that of the full model with SSC avoidance is denoted as "avoidance" in Figure 4.

The shape of Laffer curves exhibit the basic novel insights from our study. The effects of SSC avoidance on labor tax revenues are indirect: all supplied labor remains taxed and avoidance reduces revenues from SSC. Given the model setup and these premises, one would expect the Laffer curve to be more responsive to the tax rate (i.e. more curved) and peak at lower combined labor taxation. We confirm this to be the case: current rates of labor tax are closer to the maximum revenues than in the case without tax avoidance, even though they

[12]The share of output due to secondary workers is computed as the share of secondary labor : $y_S = \frac{(1-\alpha)\omega^{1+\rho}}{1+p\bar{s}\tau^s}$.

[13]The rank correlations for results from Schneider (2014) and our model are positive and statistically significant: Kendall's $\tau = 0.3629$ (p-value=0.0577) and Spearman's $\rho = 0.4484$ (p value=0.0815).

Figure 4: The shape of Laffer curves



Notes: Tax revenue refer to overall tax revenue T. We compute the figures as if each of the respective tax values occurred in steady state. Parameters conditional on τ^s and τ^n fixed.

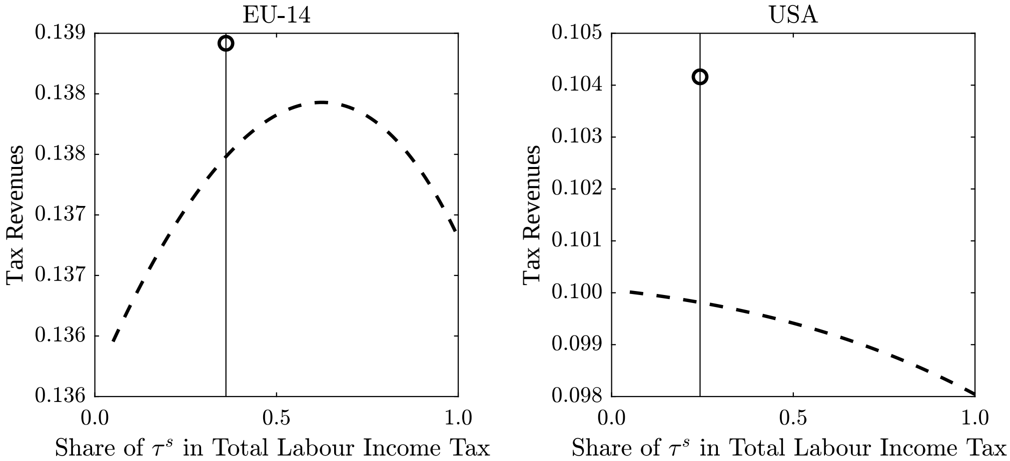
remain to the left of maximum revenues. Since labor taxes are flat in our setting, with no kinks due to tax progression or deductions, these results are likely to understate the possible effects of raising the labor income tax rates (see Section 4.4 for a further discussion). However, the results also suggest that in most EU countries and the US, labor taxes may be increased in in the presence of tax avoidance. This finding is important for two reasons. First, most European countries struggle with growing deficits in their pension systems and increasing contribution rates is one potential intervention available to policy makers. Second, in our model an increase in contributions is likely to reduce its coverage. While the SSC "tax rates" vary substantially among countries, the scope of irregular employment does to a much lesser extent as shown in Section 3. This suggests a small empirical extensive margin elasticity to changes in SSC.

The Laffer curves as depicted by Figure 4 are not fully informative about the optimal mix of avoidable (τ^s) and unavoidable (τ^n) tax. Basic intuition suggests that if employer contributions are avoidable, tax revenues should be maximized with all labor taxation occurring *via* levies on earnings. However, changing these proportions increases effective taxation of labor, thus generating general equilibrium effects: higher labor taxes affect the relative price of labor, changing the overall labor demand and supply. Given that the direct and indirect effects work in the opposite directions, quantifying the overall effect is an empirical question of appraising their respective strengths. We perform this evaluation in the next section.

4.2 How optimal is the mix of avoidable and unavoidable taxes?

We perform a set of counter-factual experiments where we gradually vary the share of the *avoidable* employer SSC (τ^s) in total taxation of labor from zero to unity. In all the simulations

Figure 5: Alternative policy mix: fiscal revenues



Notes: Tax revenues refers to overall tax revenue T. We compute the subsequent shares as if they were the steady state conditions. The vertical line and circle indicate the steady state share of τ^s in labor income taxes and the corresponding tax revenue.

we keep the total tax wedge $(\tau^s + \tau^n)$ unchanged. To perform these simulations, we effectively solve the model for each of the respective labor tax combinations while holding the remaining parameters constant. We treat as given the capital share (α) and elasticity of substitution between the two types of labor (ρ), but allow the contributions of each type of labor (ω) to adjust since its value varies with the composition labor tax.[14] We also fix the expected penalty for tax avoidance $(p\bar{s})$ to the values calibrated in Section 3. For the household parameters, the additional disutility of working without social security contribution (ϕ) is fixed at the steady state level.

Changing the share of τ^s in total labor taxation has a two effects. First, higher τ^s reduces the incentive to supply labor. Second, it has composition effects on labor demand; higher τ^s increases gains from avoiding formal employment. Since we keep a *constant rate* of total labor taxation, the overall price of hiring labor may be reduced if the lower price of labor uncovered by SSC leads to a lower overall price of labor (that is, if a quantitative adjustment in the composition of labor is larger than the increase in price of formal labor). Alternatively, if composition effects do not dominate price effects, the price of labor increases, leading to changes in the relative demand for capital. Consequently, there would be changes in the capital–to–labor ratio and general equilibrium effects. Figure 5 shows simulation results of these counter-factual scenarios for the EU-14 and US. For convenience, we mark on these figures the steady state share of τ^s (and the corresponding steady state tax revenue, as % of GDP from Section 4.1). The circle denotes total tax burden on labor. The vertical axis, as before, measures total tax revenues as a share in GDP.

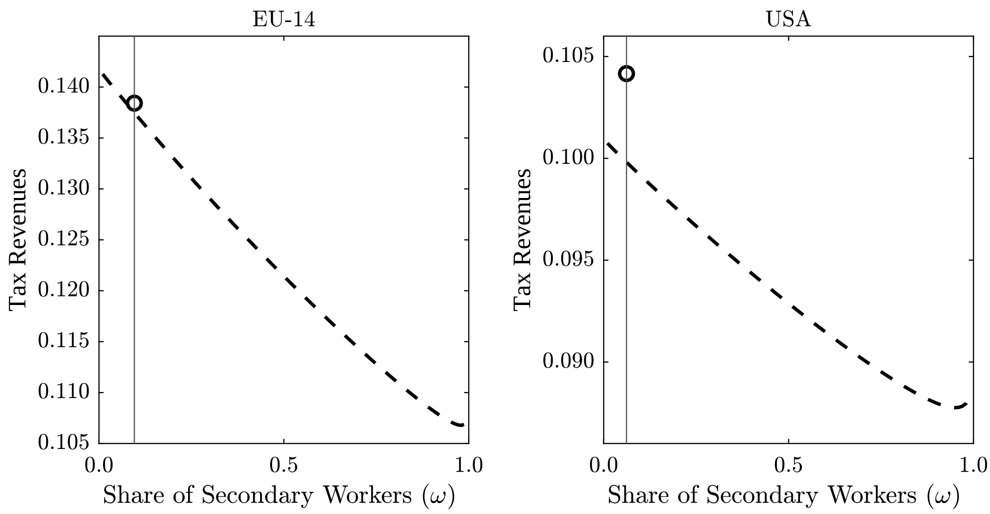
Somewhat surprisingly, tax revenues are a relatively linear function of the share of SSC in

[14]We perform out of steady state approximations for the value of ω using a polynomial approximation as described in Appendix A.2.

total labor tax. This finding is general and suggests that for most of the countries we considered, the trade off between higher rates and lower SSC coverage is strongly dominated by the downward quantitative adjustment in demand for fully covered labor. Static comparisons then imply that with lower SSC and higher unavoidable labor taxation, fiscal revenues could be increased in virtually all countries.[15] One possible interpretation of these findings is that the scope for SSC tax avoidance is too broad in the analyzed countries, suggesting insufficient enforcement. An alternative view would however focus on the changing nature of labor, suggesting that SSC avoidance may be in line with how contemporary labor markets function in some industries or occupations. Our model cannot discriminate between these two explanations, but keeping in mind that most individuals will be eligible for some form of old age benefits (pensions or social assistance), the second explanation is less well suited to actual policy challenges.

In the preceding analysis, we have used a polynomial approximation to compute ω while varying the share of τ^s (see Appendix A.2). This leads to a fairly limited variation of ω. However, tax revenues vary much more when we simply let ω move freely over a much wider set of values. Figure 6 shows the change in aggregate tax revenue as we vary ω from zero to one. These results assume that the tax rates and other parameters including the disutility of working are fixed at the steady state level as before. There is gradual fall in tax revenues as the share of ω increases. This fall is quite large for the EU-14, around 2 percentage points in aggregate tax revenue when the share of secondary workers increases to 50%.[16]

Figure 6: Alternative policy mix: fiscal revenues with changing ω



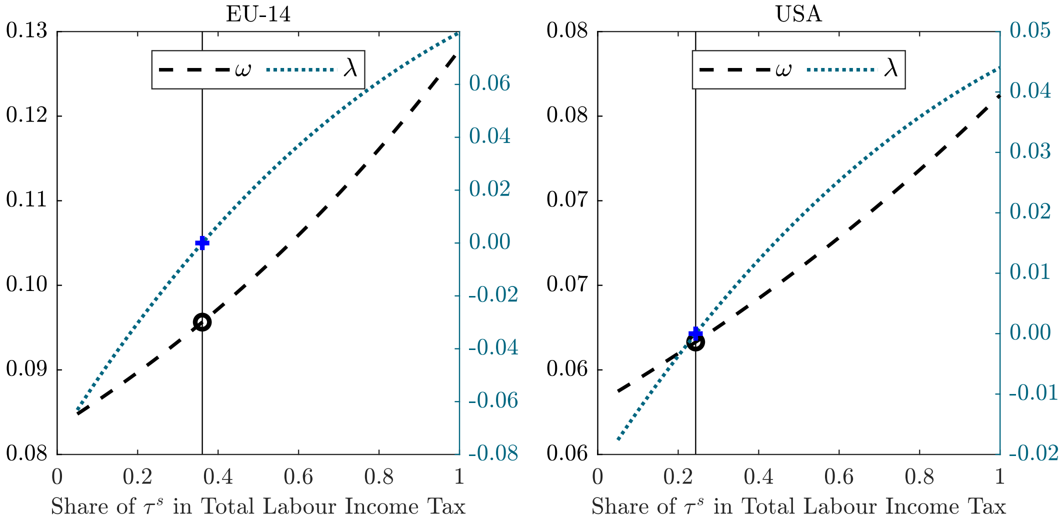
Notes: Tax revenues refers to overall tax revenue T. We compute the subsequent shares as if they were the steady state conditions. The vertical line and circle indicate the steady state value of ω.

While a given proportion of τ^s and τ^n may maximize tax revenues, it is not given that it

[15]Given the specific conditions of Denmark, our model poorly matches the outcomes in this country. However, in other countries with relatively lower share of SSC, such as the UK it performs relatively well.

[16]However, note that this is not an equilibrium outcome in our economy as we have not adjusted any of the parameters in equation (6), though equation (A.3) approximately holds for ω ranging from zero to unity given ρ.

Figure 7: Alternative policy mix: employment and welfare



Notes: ω (dashed line, left axis) is computed from the polynomial approximation described in Appendix A.2. λ (dotted line, right axis) is computed following equation (B.4) in the Appendix, where *baseline* is taken from the data and *reform* is the re-estimated counter-factual equilibrium for alternative proportion of avoidable tax in labor tax wedge. Negative values of λ signify that welfare is lower in the reform scenario than in the baseline scenario (consumers ought to be compensated to accept the change). The vertical line, circle ($\circ$), and plus($+$) indicate the steady-state values of τ^s, ω and λ respectively.

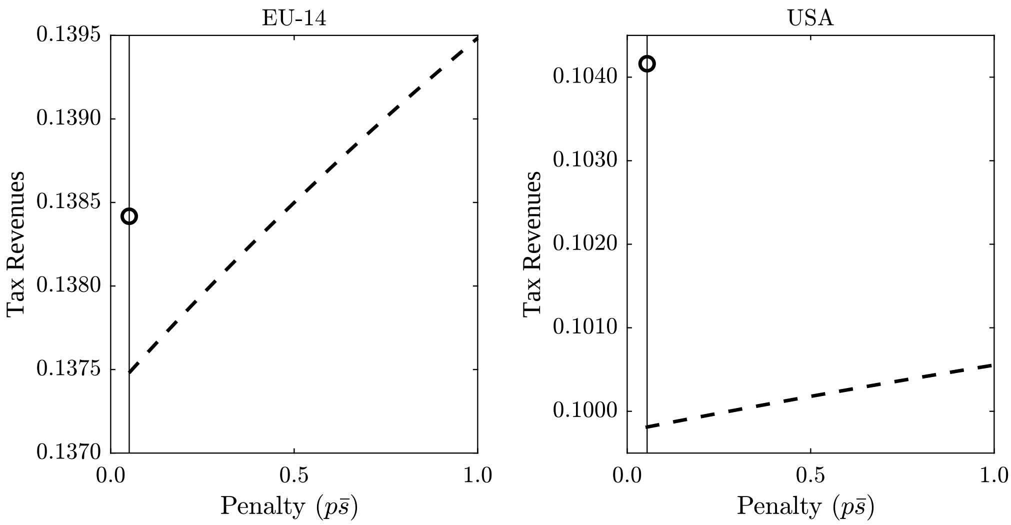
would also optimize welfare. An analytical solution to the Ramsey problem does not exist in our case and neither would it be feasible; by changing the proportions of τ^s and τ^n we only indirectly affect the actual effective tax rate. We therefore pursue an alternative approach: we operationalize welfare (λ) as the change in utility when the combination of τ^s and τ^n are varied to their counter-factual values, which provides estimates of the welfare effects of departing from the steady state. We plot it against share of secondary employment (ω) consistent with a given counter-factual steady state. These results are displayed for EU-14 and the US in Figure 7.

The value of ω is a convex function increasing in fraction of τ^s in the total labor income tax wedge. This feature seems to be general to the extent that it is replicated in all analyzed economies. However, the relationship between the SSC share and welfare changes is concave, with welfare gains increasing as the share increases from zero to unity. There are two mechanisms affecting the overall welfare when τ^s is raised: (a) higher consumption due to a rise in hours worked and after-tax-earnings as effective taxation falls, and (b) increased disutility from working *per se* and working in the uncovered sector in *particular*. If the calibrated values of the preference parameter ϕ signify that uncovered secondary sector yields higher disutility from work than the covered primary sector i.e. $\phi > 1$, then the two effects operate in opposite directions, making the overall effect an empirical question. Our counterfactual experiments reveal that, even when the uncovered sector yields higher disutility of work, the income effect *dominates*, compensating for the disutility from more work in the uncovered sector when τ^s is increased. These results suggest that in terms of comparative statics there are welfare and fiscal gains from changing the proportions between τ^s and τ^n for most analyzed cases.

4.3 How optimal is the expected penalty for tax avoidance?

We perform a second set of counter factual experiments where we vary the expected penalty from zero to one. In our model and calibration, the probability of being caught p and the surcharge $\bar{s}$ are non-separable, i.e. the two parameters always enter the model as the product $p\bar{s}$. We change the expected penalty $p\bar{s}$ from the steady state value to unity, wich we assume to be the maximum expected penalty a government can impose. This means that either the audit rate p or the surcharge $\bar{s}$ increases. We summarize the findings in Figures 8 and 9.

Figure 8: Alternative policy mix: fiscal revenues with changing expected penalty



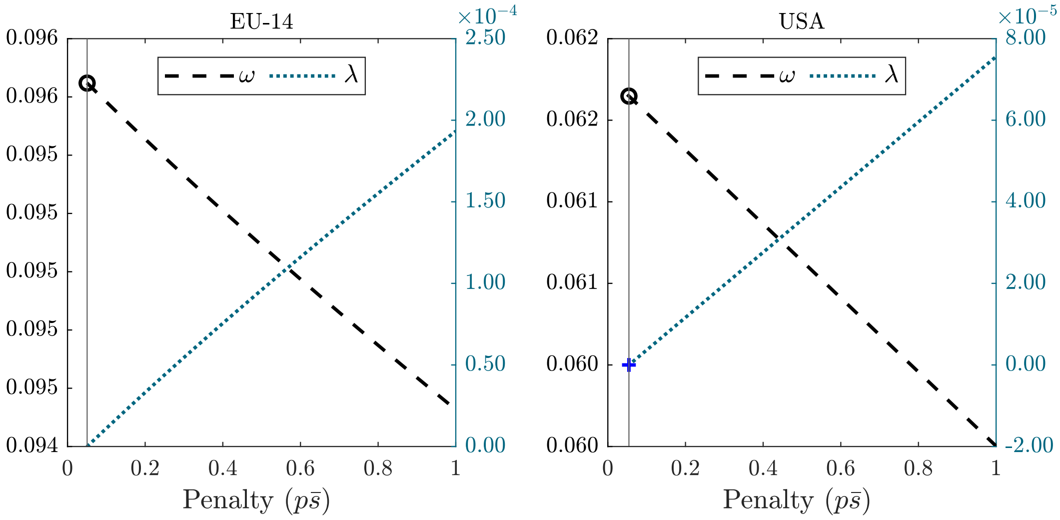
Notes: Tax revenues refers to overall tax revenues T. The dashed line is the tax revenue when the parameter ϕ is fixed at the steady state level. The vertical line and circle indicate the steady state value of $p\bar{s}$ and the corresponding tax revenue.

Figure 8 shows the effect on tax revenues as the expected penalty $p\bar{s}$ increases to the maximum in the static equilibrium. Figure 9 shows the size of the secondary sector implied by the model and the static welfare effects associated with such reform. There are very modest changes in tax revenues, welfare or the size of the underground sector. This suggests that the threat of higher or more severe penalties has very little effect on the labor supply and demand decisions. One possible explanation for this result is that we do not include any disutility from being "caught" avoiding SSC.

4.4 Transition paths for policy experiments

In line with insights from the previous sections, we study transitions for two potential policy changes: adjusting the share of avoidable taxes in total labor tax wedge and changing the

Figure 9: Alternative policy mix: Employment and welfare with changing expected penalty



Notes: See note under Figure 7 Appendix B. The vertical line and circle indicate the steady-state values of ω and τ^s respectively.

expected penalty from social security contributions avoidance. These experiments begin in the actual steady state and the policy change is announced at $t = 0$ and implemented at $t = 10$. All reforms are once-and-for-all.

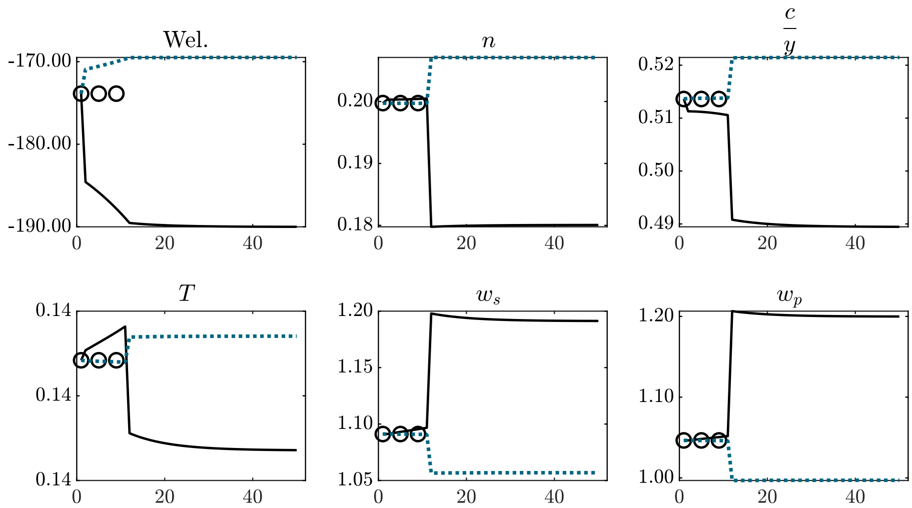
4.4.1 Changing the mix of avoidable and unavoidable labor taxation

We analyze two policy experiments, portrayed in Figure 10 for the EU and in Figure 11 for the US. In the first experiment labor is taxed with a general labor tax, but there are no separate employer SSC, a scenario which we refer to as Denmark(DNK) , because these are effective proportions in this country. This reform makes all labor equally expensive, reducing the incentives to offer "secondary contracts". Aggregate labor demand falls, which leads to declines in output and consumption.[17] Overall, tax revenues decrease because of downward adjustment in the labor and capital tax bases, despite an increase in the consumption tax base. Although consumption taxes are the largest share of tax revenues, they are not enough to compensate for the effect of increased labor taxation. The major difference is a stark increase in wages for both segments of the labor market. Although the US economy starts from much lower tax rates and much lower employer contributions, the policy experiments yield the same outcomes. We obtain similar results for the other 13 economies which suggests that the results are not driven by any specific calibration.

In the second policy experiment we take the opposite direction and set the share of SSC in labor tax at 50%. This is similar to the SSC rate in the three countries with the highest

[17] Although the steady-state value of the capital stock is unaffected (this follows from the fact that τ^n and τ^s do not appear in the steady state Euler equation (11)) adjustment in consumption cause adjustments in capital stock over time. Variations in the capital stock helps smooth consumption over time.

Figure 10: Policy experiments transition paths: tax mix for EU-14



Notes: This figure shows responses to a foreseen once-and-for-all change in the ratio of taxes, i.e. from $\tau^s = 0.147$ to $\tau^s = 0.0$ (black/solid line - Policy 1: DNK) and to 0.204 (blue/dotted line - Policy 2: FRA), τ^n adjusts accordingly. The change occurs at period $T = 10$, where $t = 1$ is the initial time period. Circles indicate steady state values. Results for the US in Figure 11.

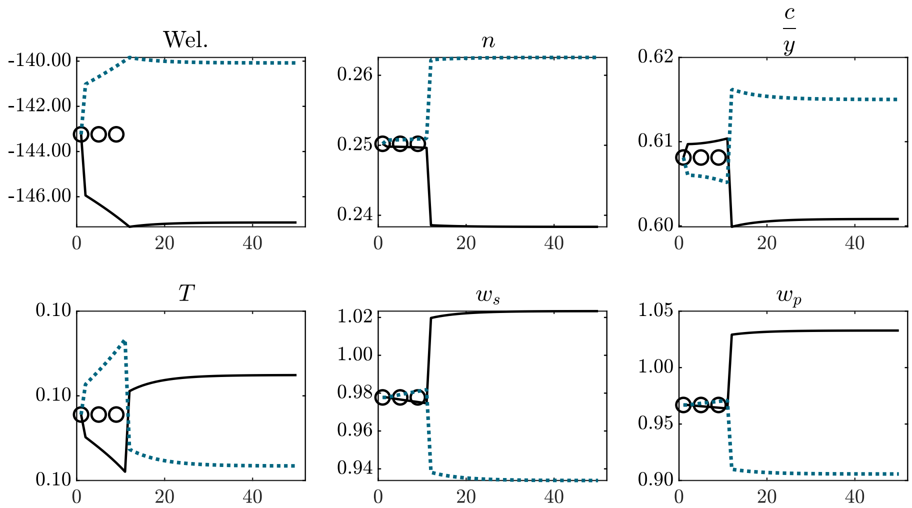
proportion of τ^s in the data (France, Italy and Spain).[18] This reform raises employer gains from offering "secondary contracts," leading to an increase in aggregate labor demand. While reducing the scope for tax avoidance reduces tax revenues in the US, there is an increase in labor supply, output and welfare. In both the EU-14 and the US, an increase in the avoidable SSC component results in welfare gains equivalent to approximately 3% of lifetime consumption. In contrast, a policy of reducing SSC (which yields higher tax revenues in the US), reduces welfare; causing approximately 7% utility loss in consumption equivalent terms for EU-14 consumers (2% for the US). Clearly, the welfare effects are the outcome of two opposing adjustments. First, a change in hours worked and consumption affect the utility in the reform scenarios, relative to baseline. However, it is also the composition of work that matters. In fact, increasing work in the uncovered sector yields more disutility than an equivalent increase in hours worked with full coverage. This second order effect is non-negligible.

4.4.2 Changing the expected penalty for SSC avoidance

Finally, we change the expected penalty for tax avoidance. Specifically, we vary expected penalty from the steady value in a given country to the maximum of $p\bar{s} = 1$. This is a substantial reform, in most countries the estimated internally consistent values of expected penalty is roughly 20 times lower (see the third column of Table A.3). Figures 12 and 13 summarize the change in outcomes once an economy has attained a new steady state for EU14 and the US, respectively.

[18] The situation in France may in fact be a consequence of mechanisms similar to those described in our paper, for an empirical treatment of 2003 reform in France and its consequences for employment see Bunel and L'Horty (2012).

Figure 11: Policy experiments transition paths: tax mix for USA



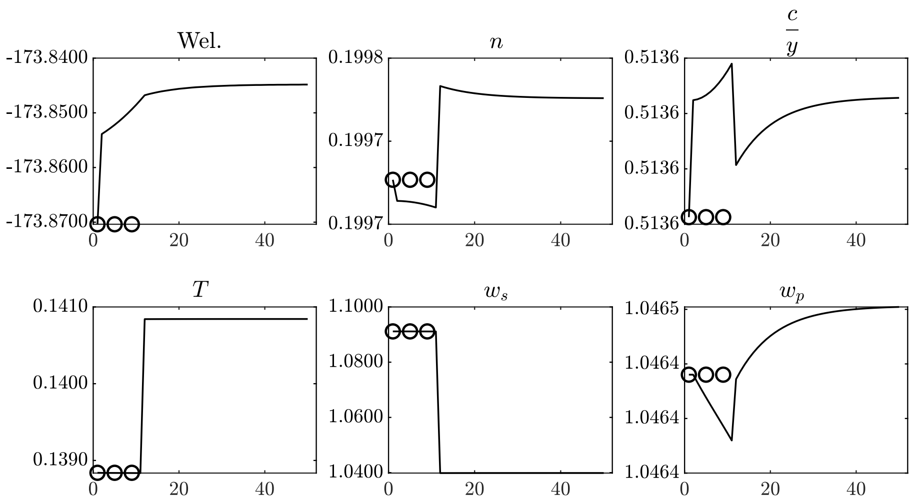
Notes: See Figure 10, the tax rates change from $\tau^s = 0.068$ changes to $\tau^s = 0.0$ (Policy 1) and to $\tau^s = 0.14$ (Policy 2), τ^n adjusts accordingly.

Despite reform being of enormous scale, the estimated effects are negligible. Adjustments in wages are only transitory, which reflects the features of the production function – until firms change technology, there is little room for adjustments, so marginal products in primary sector will remain unaffected and workers will "pay" part of the penalty costs increase in lower wages. Total labor demand does not change. Since ϕ remains fixed at the steady state level, there is no change in welfare or consumption; just a transfer from secondary contract workers to the budget.

4.5 Discussion of results

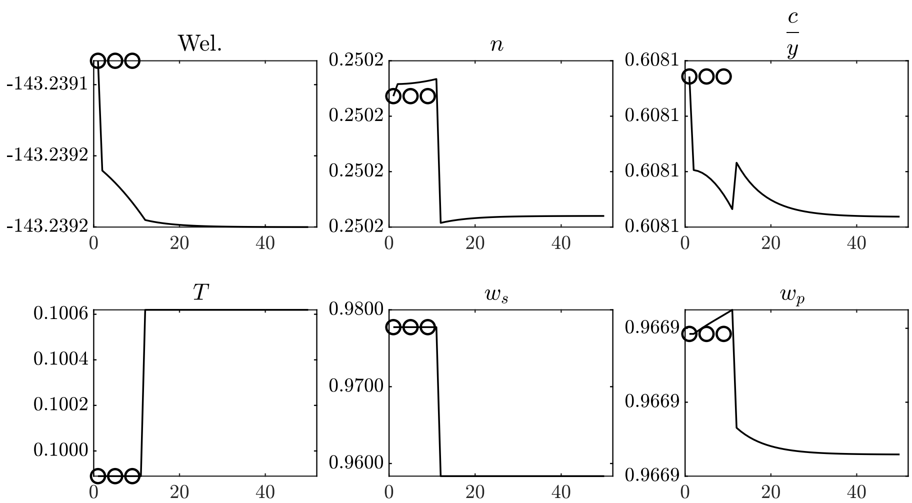
The results of our model and subsequent policy experiments suggest three important conclusions. First, there is substantial room for welfare improvement by adjusting the tax mix, if one acknowledges that at least in some countries non-standard employment contracts may aid employers in evading taxes rather than reflect the flexibility needed by both sides of the contract. Second, the staggering asymmetry in the mix of labor taxation between avoidable and unavoidable taxes is reflected to a large extent in how our model projects the static and dynamic effects of policy changes. While generally reforms making countries more similar to Denmark – low avoidable taxes and high unavoidable taxes – are detrimental to welfare, the scale of these costs differs substantially across countries. Similar conclusions hold for reforms which increase the share of avoidable taxes in total labor taxation: welfare gains range from a small percentage of lifetime consumption to even 10-20%, as summarized in Figure 14, which shows the change in welfare after transitioning to a new steady state. Third, against this background, the often invoked policies of increasing the institutional capacity to audit and penalize cases of abuse on

Figure 12: Policy experiments transition paths: avoidance penalty for EU-14



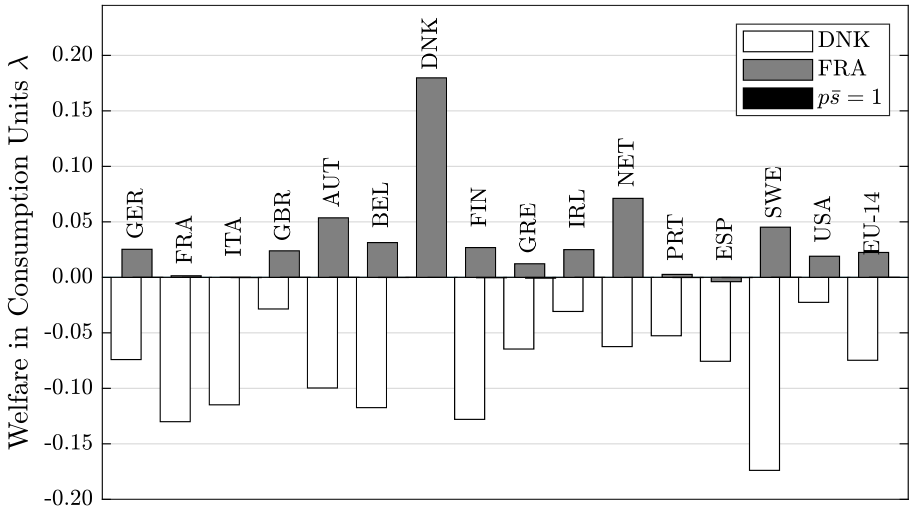
Notes: Expected penalty is increased from $p\bar{s} = 0.050$ to $p\bar{s} = 1$. The change occurs at period $t = 10$, where $t = 1$ is the initial time period. Results for the US in Figure 13.

Figure 13: Policy experiments transition paths: avoidance penalty for USA



Notes: See notes under Figure 12. The change in the penalty is from $p\bar{s} = 0.0543$ to $p\bar{s} = 1$.

Figure 14: Policy experiments transition summary in consumption units



Notes: This figure summarizes the welfare effects of each policy experiments reported in the main text. The bars represent welfare changes in equivalent consumption units (see equation B.4 in Appendix B) at the end of transitioning to a new steady state.

the side of employer are not likely to deliver comparable gains. Even complete detection, as is our policy experiment, yields marginal welfare effects, admittedly positive. The exceptions from this rule are the few cases where our model is relatively less successful in fitting an economy's features.

Some caution is necessary in interpreting our findings. First, it is a fairly stylized representation of the economy, with a passive government without any objective. Typically, the structure of taxation is a political economy question similar to that of the total labor tax wedge. There is also path dependence in a sense: the asymmetric features of labor taxation in many countries stem from sequences of partial reforms in labor markets and social security systems. Most of these reforms are usually in response to fiscal or equality challenges. Hence, our experiments can only serve as a suggestion of what could be optimal – not a policy recommendation that would be feasible. Second, while households optimize labor supply (and consumption) our model does not include features such as bargaining over compensated market work and usually uncompensated home work. Nor do we account for rather frequent phenomenon of kinks in marginal taxation of labor in the case of couples (or couples with children). Such features may be easily represented in a study focused on one country with the use of our proposed approach, but until then, we recognize that the final effects of general changes in labor tax mix may indeed differ from a single representative household solution. Third, in our setting an avoidable tax is calibrated to reflect the social security, because non-standard contracts such as self-employment or non-employment contracts are exempt (fully or partially). However, in a longer term horizon agents may become increasingly inclined to contribute to a pension system if the internal rate of return is favorable in comparison to the capital markets (i.e. if there is an implicit subsidy in a pension system, conditional on contributions). Analogously, if workers would rather evade contributions (e.g. because of an implicit taxation in a pension system) then we are likely to overstate the benefits of symmetric coverage. Our model has infinitely lived agents rather than aging agents in an overlapping generations structure. Hence, we cannot account for this additional, tacit value of avoidable taxes to the workers in ways other than calibrated disutility of work. If that treatment falls short of adequately addressing the issue – e.g. due to life-cycle patterns – then our results may be biased downward or upwards, depending on the sign of deviation.

Despite the overall fiscal gains from changing the labor income taxation policy mix, an initial and transitory fiscal costs to implementing an optimal labor taxation mix exists and are non-negligible. Although labor taxation is typically a smaller share of fiscal revenues across advanced economies, in the light of relatively stringent fiscal situation in most EU countries after the global financial crisis (Bozio et al. 2015), our results are not likely to be reflected in policy changes. Also, one could emphasize that the choice of labor income taxation policy mix may reflect societies' norms (Torgler and Schneider 2007, Cummings et al. 2009, Lago-Peñas and Lago-Peñas 2010, Konrad and Qari 2012, Kountouris and Remoundou 2013) as well as perception of fairness and efficiency (Barone and Mocetti 2011, Doerrenberg and Peichl 2013). In such cases, policy reforms as advocated in this study may have additional, negative welfare effects, unaccounted for in our model. However, increasing evidence seems to suggest, that cross-cultural and cross-country differences in morale need not be as deeply rooted as they are portrayed (Lefebvre et al. 2015, Pascual-Ezama et al. 2015, Gächter and Schulz 2016)

5 Conclusions

It is common in public economics to discuss the optimal rate of taxation. However, with the diversity of employment and taxation forms, more understanding on the interplay between the forms of taxation and the forms of employment is needed. In many advanced economies, contracts without full social protection, and thus exempt from social security contributions, are used and often abused. This form of labor market duality has been analyzed from many angles in the labor economics literature, but so far little attention was devoted to the optimal composition of various labor taxes from the fiscal and welfare perspective.

In this paper we have developed a general equilibrium model with substitutability between workers in a primary labor market where employers make social security contributions and those in a secondary market where employers avoid contributions but face a non-zero probability of detection and a penalty. Our model implies that there is some labor on which the total tax wedge is unavoidable and some labor on which part of the burden of social security contributions can be avoided. The assumption of partial avoidance of the labor income tax burden leads to Laffer curves that are more responsive to changes in tax rates: our Laffer curves are steeper and peek at a lower labor income tax rate than in an economy without avoidance. We offer three important policy implications. First, in many countries, labor tax revenues may be increased without changing the overall taxes but by adjusting the mix labor income tax that falls on employees and employers. Secondly, welfare enhancing policies are not necessarily detrimental to tax revenues. Finally, labor market duality is not always undesirable – reducing the size of secondary labor market to zero is not always optimal, from either a fiscal or welfare perspective.

Our approach may be extended to a framework with a fully "informal" sector with a segment of the labor market avoiding the entire labor tax wedge. Such an extension would not alter the general findings concerning the optimal proportion between avoidable and unavoidable labor taxes. The model may also be extended to incorporate a labor market mechanism explicitly separating primary from secondary labor markets, with frictions, idiosyncratic shocks and insurance. In a deterministic economy with no implicit savings in the form of social security contributions, agents may have little intrinsic motivation to *choose* between primary and secondary employment. Disentangling the insurance motive and asymmetric costs of obtaining employment in the two segments of the labor market would further enrich the policy relevance of similar studies. We leave these interesting avenues open for future research.

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A Calibration

A.1 Tax rates

In Mendoza et al. (1994), effective tax rates are computed based on Revenue Statistics and National Accounts Tables from the OECD. Some of the variables used are as follows:

Table A.1: OECD Revenue Statistics

1100 =	Taxes on income, profits, and capital gains of individuals,
2000 =	Total social security contributions,
2200 =	Employer's contribution to social security,
3000 =	Taxes on payroll and workforce,
	National Accounts
$OSPUE$ =	Operating surplus of private unincorporated enterprises,
PEI =	Household's property and entrepreneurial income,
W =	Wages and salaries,

The tax on labor income, τ^l is computed as:

$$\tau^l = \frac{\tau^h W + 2000 + 3000}{W + 2200}; \text{ with } \tau^h = \frac{1100}{OSPUE + PEI + W}$$

where τ^h is the household's average tax rate on total income. We need to split τ^l into τ^n and τ^s as used in our paper and reported in Table A.2 below. To do this, we compute

$$\tau^n = \frac{\tau^h W + 2000 + 3000 - 2200}{W + 2200} \text{ and } \tau^s = \frac{2200}{W + 2200}.$$

Table A.2: Tax rates used for calibration

	τ^s	τ^k	τ^n	τ^c
GER	0.143	0.233	0.269	0.155
FRA	0.225	0.355	0.231	0.183
ITA	0.232	0.340	0.234	0.145
GBR	0.070	0.356	0.208	0.163
AUT	0.146	0.240	0.354	0.196
BEL	0.180	0.424	0.307	0.173
DNK	0.000	0.506	0.474	0.349
FIN	0.191	0.313	0.296	0.271
GRE	0.161	0.160	0.245	0.154
IRL	0.068	0.207	0.199	0.257
NET	0.090	0.293	0.348	0.194
PRT	0.147	0.234	0.166	0.208
ESP	0.190	0.296	0.165	0.144
SWE	0.208	0.409	0.351	0.255
USA	0.068	0.364	0.212	0.047
EU-14	0.147	0.327	0.260	0.170

Notes: Computed based on OECD figures (averaged over 1985-2010, or longest available time series).

A.2 Substitution, dis-utility and audit parameters

There are four non-standard parameters that we need to calibrate. These are: the expected penalty for avoiding social security contributions ($p\bar{s}$), the dis-utility of working in the informal sector (ϕ), and the parameters that control the substitutability and complementarity of primary and secondary labor in the production function (ω and ρ). In order to pin down these parameters, we use three equations, two of which have corresponding data counterparts to calibrate $p\bar{s}$, ω and ρ. From the producer optimization, wages are given by: $w_P = \frac{1}{1+\tau^s}(1-\alpha)(1-\omega)^{1+\rho}\frac{y}{n_P}$ and $w_S = \frac{1}{1+p\bar{s}\tau^s}(1-\alpha)\omega^{1+\rho}\frac{y}{n_S}$. Using these wage rates to compute the labor tax revenue (LTR) and firms social security contributions (FSS) we have the following equations:

$$\text{FSS} = \tau^s(w_P n_P + p\bar{s} w_S n_S) = \tau^s(1-\alpha)\left(\frac{(1-\omega)^{1+\rho}}{1+\tau^s} + \frac{p\bar{s}\omega^{1+\rho}}{1+p\bar{s}\tau^s}\right), \tag{A.1}$$

$$\text{LTR} = \tau^n(w_P n_P + w_S n_S) = \tau^n(1-\alpha)\left(\frac{(1-\omega)^{1+\rho}}{1+\tau^s} + \frac{\omega^{1+\rho}}{1+p\bar{s}\tau^s}\right). \tag{A.2}$$

Dividing both sides of the CES aggregator for labor, $n = ((1-\omega)n_P^\rho + \omega n_S^\rho)^{\frac{1}{\rho}}$, by n and using the definition of weights $n_S = \omega n$ and $n_P = (1-\omega)n$ we obtain:

$$1 = \omega^{1+\rho} + (1-\omega)^{1+\rho}. \tag{A.3}$$

The three equations (A.1), (A.2) and (A.3) are used to pin down the two producer side parameters ω and ρ and the policy parameter $p\bar{s}$. LTR and FSS are obtained from government revenue statistics as reported in the OECD database and averaged over the available period. Once the three producer side parameters are solved for, the consumer side parameter ϕ can be obtained from the equilibrium condition for labor supply and demand expressed in equation (6).

In our policy experiments, we need to obtain out of the steady state values of the parameter ω. We use a polynomial approximation for this purpose. Specifically, we assume that ω is a function of the weight of social security tax to total labor income tax: $\omega = f\left(\frac{\tau^s}{\tau^s+\tau^n}\right)$. We know this ratio and the corresponding values for ω at the steady state from our calibration and exploit this knowledge to obtain an approximating polynomial for different weights of the tax ratio. We hold the ratio constant while picking different values of τ^s and τ^n and computing firms' social security contribution (FSS) as given by equation (A.1) . We compute the approximation $\widehat{\text{FSS}}$ using:

$$\widehat{\text{FSS}} = \tau^s(1-\alpha)\left(\frac{(1-\widehat{\omega})^{1+\rho}}{1+\tau^s} + \frac{p\bar{s}\widehat{\omega}^{1+\rho}}{1+p\bar{s}\tau^s}\right)$$

where $\widehat{\omega} = P_m\left(\frac{\tau^s}{\tau^s+\tau^n}; \epsilon_m\right)$ is a polynomial of degree m with coefficients ϵ_m.[19] We choose the

[19] In making approximations of the value of ω outside the steady state when changing the expected penalty $p\bar{s}$,

Table A.3: Calibrated parameter values

	α	δ	$p\bar{s}$	ρ	ϕ	ω
GER	0.3690	0.0667	0.0551	0.0134	1.0923	0.0578
FRA	0.4075	0.0686	1.1462	-0.0009	0.9754	0.1382
ITA	0.3889	0.0704	0.0398	0.0094	1.2037	0.1802
GBR	0.3574	0.0641	0.0539	0.0109	1.0355	0.0656
AUT	0.3887	0.0707	0.0604	0.0516	0.9221	0.0172
BEL	0.3910	0.0837	0.0575	0.0153	1.1123	0.0394
DNK	0.3959	0.0923	0.1060	0.4605	0.1242	0.0107
FIN	0.3372	0.0697	0.0528	0.0188	1.1252	0.0775
GRE	0.3991	0.0609	0.0300	0.0122	1.1413	0.2720
IRL	0.3577	0.0861	0.0440	0.0116	1.0442	0.1538
NET	0.3819	0.0771	0.3556	1.7997	0.0000	0.0030
PRT	0.3876	0.0977	0.0485	0.0039	1.1295	0.1124
ESP	0.4242	0.0855	0.0545	0.0007	1.1757	0.0636
SWE	0.3617	0.0478	0.0610	0.0215	1.0850	0.0121
USA	0.3473	0.0833	0.0543	0.0131	1.0272	0.0616
EU-14	0.3812	0.0702	0.0505	0.0111	1.1099	0.0956

Notes: α and δ are computed to exactly match the capital output ratio. $p\bar{s}$, ρ, ϕ, ω are computed jointly from four non-linear equations. We assume that the labor tax revenue consists of tax contributions and proceeds from penalizing the tax evaders. Using the equation for labor tax revenue and the form of the production function, we get four non-linear equations in the four parameters. We solve for the parameters using non-linear least squares in `MATLAB`.

coefficients of the polynomial by minimizing $\frac{1}{2m}\sum_{j=1}^{m}\left(\mathrm{FSS}_j - \widehat{\mathrm{FSS}_j}\right)^2$ over m grid points using a quasi-Newton minimization routine in `MATLAB` ($fminunc$ with BFGS Quasi-Newton). Given a new value of τ^s, we approximate a new value of ω and using these estimates we could also compute a new value of ϕ following equation (6). In the out of steady state simulations, we show results for cases where we hold the parameter ϕ constant. For computing Laffer curves we hold all estimated parameters constant at steady state.

B Model solving

Given the model parameters, we first solve for the capital-to-output ratio $\frac{k}{y}$ and productivity $\frac{y}{n}$ given in equation (11). We use these to express (9) as a function of the labor supply n. We then equate equation (9) to equation (10) which gives a single nonlinear function of n. We solve this equation using the trust region reflective algorithm in `MATLAB`. Once we have solved for n, we solve for all other model variables. First we solve for output y, then use the budget constraint to obtain the consumption output ratio $\frac{c}{y}$. We then compute tax revenues as given by equation (8).

We make welfare evaluations using the present value of lifetime consumption in the baseline scenario to its value under a reform. Expressed in consumption equivalent units consumers

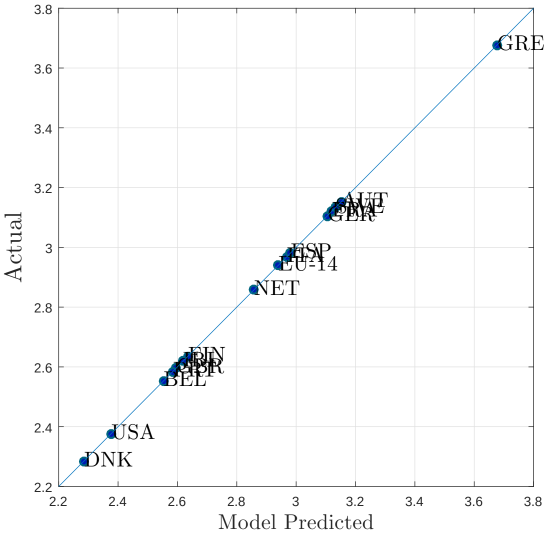
we use a tensor product polynomial in two variables: $\widehat{\omega} = P_m\left(\frac{\tau^s}{\tau^s+\tau^n}, p\bar{s} \times \tau^s; \epsilon_m\right)$. This is because $p\bar{s}$ enters the equation for FSS multiplied by the tax rate τ^s.

would be willing to give up λ to avoid a change from baseline to reform:

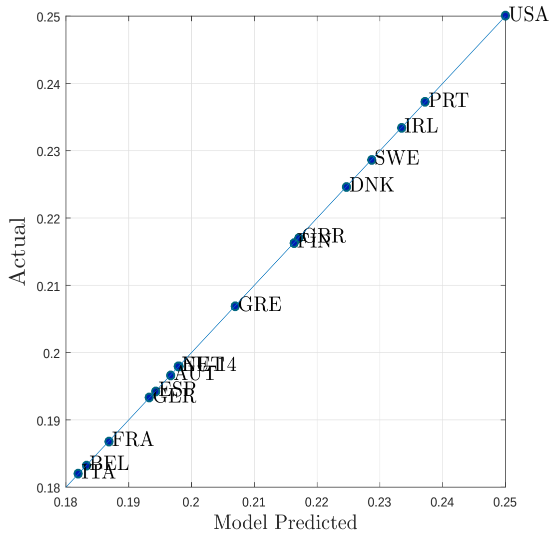
$$\lambda = 1 - \left(\frac{1 + (1-\beta)(1-\eta)\text{Welfare}_{baseline}}{1 + (1-\beta)(1-\eta)\text{Welfare}_{reform}} \right)^{\frac{1}{\eta-1}}. \tag{B.4}$$

Welfare is computed as utility of consumers defined by equation (4).

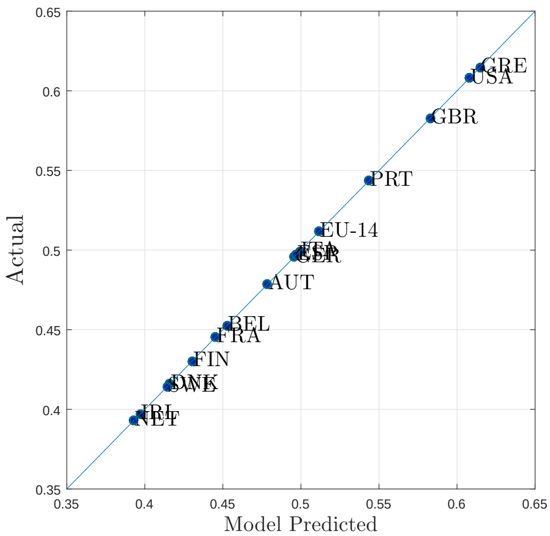
Figure B.1: Model fit



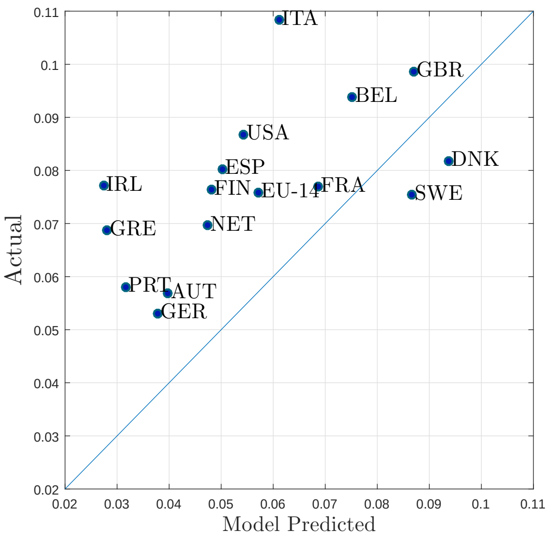
(a) Capital to output ratio



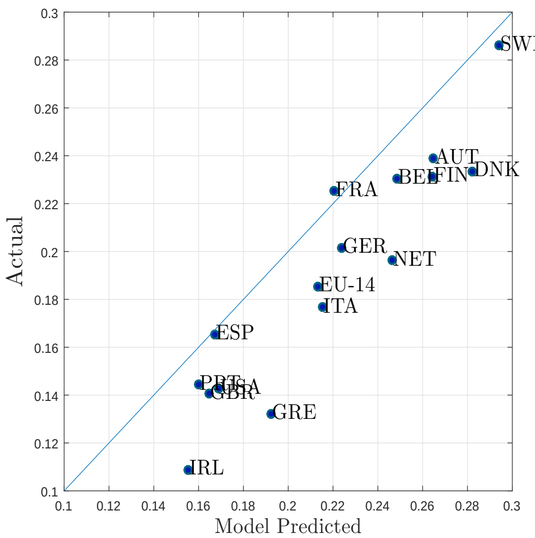
(b) Labor supply



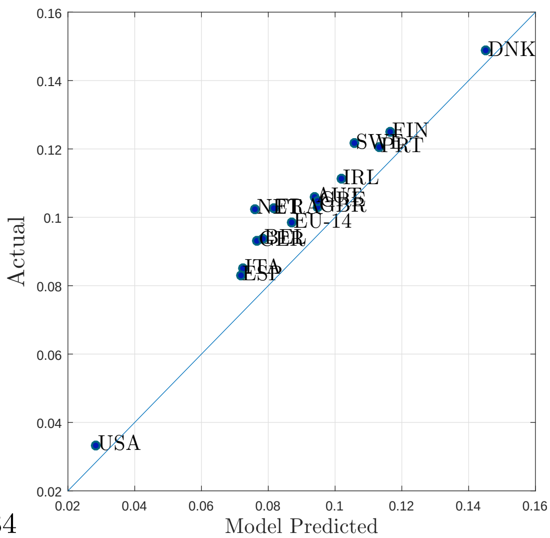
(c) Consumption to output ratio



(d) Capital tax revenues



(e) Labor tax revenues



(f) Consumption tax revenues