

Steady state Laffer curve with the underground economy.*

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Abstract

This paper studies equilibrium effects of fiscal policy within a dynamic general equilibrium model where tax evasion and underground activities are explicitly incorporated. In particular, we show that a dynamic general equilibrium with tax evasion may give a rational justification for a variant of the Laffer curve for a plausible parameterization. In this respect, the paper also identifies the different parameterization of the model formulation with tax evasion under which a Laffer curve exist. From a revenue maximizing perspective, the key policy messages are that bringing tax payers to compliance would be better than announcing to punish them if convicted, and that an economy without problems of compliance is much more sensitive to myopic behavior.

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1 Introduction

As stressed by Schneider and Enste (2002), Schneider (2007) and by several authors within the well known Economic Journal symposium (E.J. vol. 109, 1999), the underground economy is a sizeable and increasing phenomenon both in terms of output produced and labor input employed in all the OECD economies.

Although the existing wide range of analysis, a serious lack in the literature concerns its effects and implications over the existence and the shape of steady state Laffer curves, especially within the context of (dynamic) general equilibrium models. A very recent and interesting contribution of Uhlig and Trabandt (2006) fills the former gap, still not addressing the impact of tax evasion and underground economy. This is again surprising since over the past decades, in many countries, tax increases and tax cuts have been remarkably unsuccessful in terms of achieving the desired effect over fiscal revenues and, therefore, in helping to balance the budgets.

This paper precisely addresses that point. It aims at clarifying the implication for such a curve when there exist a sizeable underground sector, using a well-defined economic structure. We, therefore, distinguish not only between the standard arithmetic effect (i.e. movements along the Laffer curve via tax rates) and the economic effect (i.e. shifts of the curve via tax base) but we explicitly elicit a compliance effect driven by the reallocation labor input from the regular to the irregular sector and vice versa.

In this context, revenue responses to a tax rate changes are linked to the characteristic of the irregular production, its size, the ability of the firms to shift labor input between the two sectors, the tax system (i.e. tax rates, probability to be detected and surcharged), the households' preferences and the incentives that the tax system provides them to offer labor input in the two sectors. This complex relationship between tax rates and revenues conveys important policy implications and it is investigated performing the model with a wide range of simulations.

While setting out a two sector dynamic general equilibrium model, we accomplish this task calculating and depicting the geometrical expression of a reduced form of the equilibrium model concerning the relationship between tax rates and the government revenues (Laffer curve). There exist a vast literature on the Laffer curve. Here we quote the contributions of Agell and Persson (2001) who study dynamic Laffer effects in an endogenous growth model and Sanyal, Gang and Goswami (2000), who show how a Laffer curve may arise under corruption.

The paper is organized as follows. Section 2 presents the model, Section 3 properly calibrate the model, and Section 4 numerically derive the steady state Laffer curves with and without the contribution of the underground economy; the same Section also discusses a sensitivity analysis with respect the main parameters of the model. Eventually Section 5 reports a policy discussion and concludes the paper.

2 The Model's Structure

We use a dynamic general equilibrium model. There are three agents in the model: the firms, the households, and the government. In addition there are two sectors: the regular and the underground sectors. Firms and households are subject to distortionary taxation, but they can use the underground sector to evade taxes, by reallocating labor services across sectors.

The firms produce an homogeneous good by combining three production factors: physical capital, regular and irregular labor services. The latter represents the channel through which tax evasion is undertaken. The households choose consumption, investment, and hours to work on each date and in each sector (official and unofficial) to maximize the expected discounted value of utility, subject to a sequence of budget constraints, a proportional tax rate on “regular income”, and the law of motion for capital stock.¹ Finally, government levies proportional taxes on revenues and incomes, and balances its budget (in expected terms) for each period.

2.1 Firms

2.1.1 Production Technologies

Suppose there exists a representative firm that produces an homogenous good with two different technologies, one used in the regular sector and the other in the underground sector. Denote regularly-produced output as $y_{r,t}$, underground-produced output as $y_{u,t}$. Technologies are specified as follows, in the spirit of Busato and Chiarini (2004):

$$y_{r,t} = k_t^\alpha n_{r,t}^{1-\alpha} \quad \text{and} \quad y_{u,t} = n_{u,t}. \quad (1)$$

The regular output, $y_{r,t}$, is the result of capital, k_t , and regular labor, $n_{r,t}$, applied to a Cobb-Douglas technology. The underground output, $y_{u,t}$, is produced with a production function which uses only underground labor services, $n_{u,t}$.

This technology specification is equivalent to a more general set-up where both production functions use capital and labor, for example $y_{r,t} = k_t^\alpha n_{r,t}^{1-\alpha}$ and $y_{u,t} = k_{u,t}^\beta n_{u,t}^{1-\beta}$. From Uzawa (1965) and Lucas (1988) if $\beta < \alpha$ we can set the smaller elasticity to zero without loss of any generality. Since underground activities are labor intensive, we can simplify the model and preserve the main economic intuition by assuming that the underground sector produces using only labor.

A possible intuition for this argument is that even though one technology may be more efficient than the other, the tax wedge cancels out its relative advantage. Moreover, the second sector offers an additional dimension along which firms optimize labor inputs allocation, and by this end, maximize profits. In fact, it would be *feasible* to have only one sector (the most productive) ever producing, in the sense that only resources constraints are satisfied. However, it is *optimal* for the agents in this model to use both sectors to allocate their resources.

2.1.2 Firm revenues and Tax Evasion

Denote a price vector for this economy as $\langle q_t, w_{M,t}, w_{U,t}, r_t \rangle$, where q_t represents the price for the homogenous consumption good, $w_{r,t}, w_{u,t}$ denote labor wages, and r_t is returns of capital (see below). Normalizing the commodity price q_t to unity, the normalized price vector supporting the equilibrium equals $\langle 1, w_{M,t}^*, w_{U,t}^*, r_t^* \rangle$, where $w_{M,t}^*, w_{U,t}^*$ and r_t^* denote equilibrium real wage rates and the real return on capital. Since $q_t = 1$ holds in the equilibrium, we can impose it along the solution. Aggregate output equals therefore the sum of regular and underground produced output: $y_t = y_{r,t} + y_{u,t}$.

¹The “regular income” comprises income flows generated in the regular sector, including also returns on capital stock. These are declared to the Internal Revenues Services (IRS); on the contrary, income flow generated from underground sector is not included into tax-base.

Regularly-produced revenues, $\mathcal{R}_{r,t} = (1 - \tau_F)y_{r,t}$, are taxed at the rate τ_F , $\tau_F \in (0, 1)$. Firms do not pay taxes on underground produced revenues, $\mathcal{R}_{u,t} = y_{u,t}$. Firms, however, may be discovered evading, with probability $p \in (0, 1)$, and forced to pay the tax rate, τ_F , increased by a surcharge factor, $s > 1$, applied to the standard tax rate.² The effective tax rate paid when firms are detected is higher than the statutory one ($\tau_F s > \tau_F \Rightarrow s > 1$), but it also suggests that the expected paid when evading should be less than the statutory one ($\tau_F s p < \tau_F \Rightarrow s p < 1$), otherwise there would be not tax evasion. We assume $s > 1$; $s p < 1$.

$$\begin{array}{l} \mathcal{R}_t \rightarrow \text{Detected } (\sim p) \quad \mathcal{R}_{D,t} = (1 - \tau_F)y_{r,t} + (1 - s\tau_F)y_{u,t} \\ \searrow \\ \text{Not Detected } \sim (1 - p) \quad \mathcal{R}_{ND,t} = (1 - \tau_F)y_{r,t} + y_{u,t} \end{array}$$

To compute total expected revenues, applying linear projection, yields $\mathbb{E}_t \mathcal{R}_t = p \mathcal{R}_{D,t} + (1 - p) \mathcal{R}_{ND,t}$. Simplifying, we obtain:

$$\mathbb{E}_t \mathcal{R}_t = (1 - \tau_F)y_{r,t} + (1 - p s \tau_F)y_{u,t}. \quad (2)$$

with the following assumption $(1 - p s \tau_F) \geq 0$. Notice that a firm cannot go bankrupt, since $1 - p s \tau_F$ is non negative in equilibrium. Here the parameter s represents the surcharge on the standard tax rate that a firm, detected employing workers in the underground sector, must pay. The costs' structure is presented below.³

2.1.3 Costs' Structure and Profit Maximization

Following Prescott and Mehra (1980), we assume that the representative firm solves a myopic profit maximization problem, on a period-by-period basis, subject to a technological constraint, and to the possibility that it may be discovered producing in the unofficial economy, convicted of tax evasion and subject to a penalty surcharge. We assume optimizing and price taking behavior on the part of all agents, consumers and firms. Specifically, firms maximize profits on a period by period basis.

The cost of renting capital equals its marginal productivity r_t , net of capital depreciation, δ . The cost of labor is represented by the wage paid for hours worked.⁴ At each date t , representative firm maximizes period expected profits:

$$\begin{aligned} \max_{(n_{r,t}, n_{u,t}, k_t)} \mathbb{E}_t \pi_t &= \mathbb{E}_t \mathcal{R}_t - w_r n_{r,t} - w_u n_{u,t} - r_t k_t \\ \text{s.t.} \quad y_{r,t} &= k_t^\alpha n_{r,t}^{1-\alpha}, \quad y_{u,t} = n_{u,t} \\ \mathbb{E}_t \mathcal{R}_t &= (1 - \tau_F)y_{r,t} + (1 - p s \tau_F)y_{u,t} \end{aligned} \quad (3)$$

Firm's optimality first order conditions are presented below (eq. 11)

²This quantity is chosen by relying on the Italian Tax Law, because we calibrate the model for this economy. More detailed are presented in the Appendix B.

³Irregular production can be ruled either by a completely irregular firm (defined as ghost firm) or by a firm which acts only partially in the underground sector (defined as moonlighting firm). See Cowell 1990, among others.

⁴A more general structure would account for labor costs, too (e.g. social security contributions). This would be mean a worker's cost is augmented by social security contributions only for the regular working time, while there is no tax wedge on his remaining *hidden hours*. This model, however, abstracts from this additional tax rate, and leaves its analysis to future investigations.

$$\begin{aligned}
(1 - \tau_F)(1 - \alpha)k_t^\alpha n_{r,t}^{-\alpha} &= w_{r,t} \\
(1 - ps\tau_F) &= w_{u,t} \\
(1 - \tau_F)\alpha k_t^{(\alpha-1)} n_{r,t}^{1-\alpha} &= r_t
\end{aligned} \tag{4}$$

2.2 Households and Preferences

The representative agent has preferences over consumption and labor services. For most of our analysis we specialize momentary utility to have the form, in the spirit of Clarida, Gali and Gertler (2002), Gali (2002), King and Rebelo (1999) or Merz (1995):

$$\mathcal{U}_t = \log(c_t) + B_M \frac{(1 - n_{r,t} - n_{u,t})^{1-\rho}}{1 - \rho} - B_U \frac{n_{u,t}^{1+\xi}}{1 + \xi}, \quad B_M, B_U \geq 0,$$

where c_t denotes the private consumption profile of the representative household, $n_{r,t}$ her regular labor services supply, and $n_{u,t}$ her underground labor supply; this utility function is separable between consumption and labor/leisure and allows to study how the household allocates its labor services between the regular and the underground sectors. Beside the classical consumption component, $B_M \frac{(1 - n_{r,t} - n_{u,t})^{1-\rho}}{1 - \rho}$ denotes the utility from leisure $\ell_t = 1 - n_{r,t} - n_{u,t} = 1 - n_t$, whereas $B_U \frac{n_{u,t}^{1+\xi}}{1 + \xi}$ represents the idiosyncratic disutility of supplying labor services into the underground market. For simplicity, we assume that $n_{r,t}$ is a fraction ω_t of total labor supply, and that $n_{u,t}$ is the remaining counterpart $1 - \omega_t$. Further simplifying the structure of the utility function, assume, next, that $n_t = 1$; utility function reads:⁵

$$\mathcal{U}_t = \log(c_t) - B_U \frac{(1 - \omega_t)^{1+\xi}}{1 + \xi}, \quad B_U \geq 0, \tag{5}$$

In each period the representative household faces the customary budget constraint, properly modified to accommodate income tax evasion:

$$c_t + i_t = (1 - \tau_Y)(w_{r,t}\omega_t + r_t k_t) + w_{u,t}(1 - \omega_t), \tag{6}$$

where $w_{r,t}$ and $w_{u,t}$ represent the regular earnings and the earnings from the underground sector, respectively; income generated from the underground sector $w_{u,t}(1 - \omega_t)$ is absconded away from income taxation.

Finally, investment increases the capital stock according to a customary state equation:

$$k_{t+1} - (1 - \delta)k_t = i_t,$$

where δ denotes a quarterly depreciation rate for private capital stock.

The representative household's problem is therefore the following:

⁵Notice that a more general formulation would include, simultaneously, the labor/leisure choice and the allocation across sectors. In this case the utility function should read as follows: $\mathcal{U}_t = \log(c_t) + B_M \frac{(1 - n_t)^{1-\rho}}{1 - \rho} - B_U \frac{((1 - \omega_t)n_t)^{1+\xi}}{1 + \xi}$. We think, however, that this would not add much to our steady state analysis; in particular, it would just re-scale the equilibrium allocation for labor services.

$$\begin{aligned}
& \max_{(c_t, i_t, \omega_t)_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \mathcal{U}_t & (7) \\
s.t. : & \quad c_t + k_{t+1} - (1 - \delta)k_t = (1 - \tau_Y) (w_{r,t}\omega_t + r_t k_t) + w_{u,t} (1 - \omega_t) \\
& \quad k_0, \text{ given, } c_t > 0, \omega_t \in (0, 1]
\end{aligned}$$

First order conditions are reported below

$$\begin{aligned}
& -B_U (1 - \omega_t)^\xi (-1) + (c_t)^{-1} [(1 - \tau_Y) w_{r,t} - w_{u,t}] = 0 \\
& (1 - \tau_Y) (w_{r,t}\omega_t + r_t k_t) + w_{u,t} (1 - \omega_t) - c - k_{t+1} + (1 - \delta)k_t \\
& (c_t)^{-1} = \beta \mathbb{E}_t (c_{t+1})^{-1} ((1 - \tau_Y) r_{t+1} + 1 - \delta)
\end{aligned}$$

2.3 Equilibrium characterization and government

2.3.1 Equilibrium characterization

This analysis focuses on the deterministic steady state; therefore we impose certainty equivalence and aggregate consistency. Technically this implies that individual quantities coincides with the aggregate counterparts (for example, $k_t = K_t$), and that there is no dynamics in the model, and we can drop time subscript from now on (i.e. $K_t = K$ for all t).

Under these assumptions and imposing market clearing conditions, we can rewrite the first order conditions for households and firm as follows:

$$\begin{aligned}
B_U (1 - \omega)^\xi &= (C)^{-1} \left[(1 - ps\tau_F) - (1 - \tau_Y) (1 - \tau_F) (1 - \alpha) \left(\frac{K}{\omega}\right)^\alpha \right] \\
(1 - \tau_Y) (1 - \tau_F) (K)^\alpha (\omega)^{1-\alpha} &+ (1 - ps\tau_F) (1 - \omega) + \delta K = C & (8) \\
1 &= \beta \left((1 - \tau_Y) (1 - \tau_F) \alpha \left(\frac{K}{\omega}\right)^{\alpha-1} + 1 - \delta \right)
\end{aligned}$$

System (13) describes the steady state optimal allocation for equilibrium consumption C , equilibrium capital stock K and equilibrium allocation into the regular (underground) sector $\omega (1 - \omega)$.

2.3.2 Government

Government spending is assumed wasteful, and determined endogenously in equilibrium to balance the public budget constraint.⁶ In the steady state collected tax revenues are denoted by G , and read

$$C_G = K^\alpha \omega^{1-\alpha} \tau_Y (1 - \tau_F) + \tau_F [ps (1 - \omega) + K^\alpha \omega^{1-\alpha}]. \quad (9)$$

2.3.3 Stationary Equilibrium

Proposition 1 shows that the model has a unique stationary state for capital stock, a unique equilibrium value for regular and underground labor services.

⁶Notice that this paper does not present an “optimal taxation exercise”. In this respect our framework departs from Chari, Christiano and Kehoe (1995), while it follows McGrattan (1994).

Proposition 1 *There exists a unique stationary capital stock $K^* > 0$, and a unique stationary equilibrium for regular labor share ω , and underground labor share $1 - \omega$ such that:*

$$\begin{aligned} \omega^* \text{ solves } (1 - ps\tau_F) + \mathbf{AA}\omega &= \mathbf{BB}(1 - \omega)^{-\xi} \\ \left[\frac{\beta^{-1} - 1 + \delta}{(1 - \tau_Y)(1 - \tau_F)\alpha} \right]^{\frac{1}{\alpha-1}} \omega^* &= K^*, \end{aligned}$$

where $\mathbf{AA} = \left[[(1 - \tau_Y)(1 - \tau_F)(K)^\alpha(\omega)^{-\alpha} + \delta \frac{K}{\omega}] - (1 - ps\tau_F) \right]$, and $\mathbf{BB} = \frac{[(1 - ps\tau_F) - (1 - \tau_Y)(1 - \tau_F)(1 - \alpha)(\frac{K}{\omega})^\alpha]}{B_U}$

Proof. See Appendix. ■

Once we have equilibrium values for the stationary capital stock and labor inputs, the remaining quantities (consumption, output, investments) are derived from the budget constraint, the production functions and the capital accumulation constraint, all evaluated at the steady state.

3 Calibration

The model is parameterized for the Italian economy, for two scenarios, with and without underground sector. Notice that the all calibrated values, but those directly related to the underground economy (i.e. p and s), would fit a calibration for the EU-15 economy, as suggested by a recent work by Uhlig and Trabandt (2006).

The system of equations we use to compute the dynamic equilibria of the model depends on a set of nine parameters. **Five** parameters pertain to household preferences ($B_M, B_U, \beta, \xi, \rho$); **two** to the structural-institutional context (the probability of a firm being detected p and the surcharge factor s), and the remaining **two** parameters refer to technology (the capital share in the production function α , the private capital stock quarterly depreciation rate δ).

Labor supply parameters (B_M, B_U, ξ, ρ): the disutility parameters B_M^* and B_U^* are calibrated equal to 0.95 and 1.5, respectively, to match the steady state value for regular and underground labor services. The inverse total labor supply elasticity is set to 0.5 which is qualitatively consistent with Domeij and Floden (2006), Kniesner and Ziliak (2005) (that estimate a Frisch labor supply elasticity of 0.5), Chari, Kehoe and McGrattan (2000) (that find an elasticity of 0.8) and Kimball and Shapiro (2003) who obtain a Frisch elasticity close to 1. The underground labor supply elasticity, on the other hand, it set to unity. This is typically a free parameter, since we are not aware of available estimates. The larger calibrated values is based on the fact that underground sector is typically more flexible, and not subject to labor market rigidities. The robustness of the results is discussed through a sensitivity analysis exercise in the sequel.

Preference and Technology (α, β, δ) are set to commonly used values in this literature (e.g. Fiorito and Kollintzas 1994, Mendoza and Tesar 1998, King and Rebelo 1999, Uhlig and Trabandt, 2007). More precisely, we set $\beta^* = 0.984$, $\delta^* = 0.048$, and $\alpha^* = 0.3$.

The **probability of being detected** is set to $p^* = 0.03$, and the **penalty factor** is calibrated to $s^* = 1.3$, as suggested by Busato and Chiarini (2004). A sensitivity analysis exercises discusses the consequences of different detection and punishment scheme.

Table 1: **Actual and calibrated “great ratios”**

$\left(\frac{C}{Y}\right)^* = 0.86$	$\left(\frac{CG}{Y}\right)^* = 0.4632$	$\left(\frac{I}{Y}\right)^* = 0.1157$	$\left(\frac{YU}{Y}\right)^* = 0.1209$	$\left(\frac{NU}{N}\right)^* = 0.2144$
$\widehat{\left(\frac{C}{Y}\right)} = 0.77$	$\widehat{\left(\frac{CG}{Y}\right)} = 0.38(?)$	$\widehat{\left(\frac{I}{Y}\right)} = 0.08$	$\widehat{\left(\frac{YU}{Y}\right)} = 0.16$	$\widehat{\left(\frac{NU}{N}\right)} = 0.25$

Notes: $\frac{C}{Y}$ denotes the ratio between aggregate consumption and aggregate GDP; $\frac{I}{Y}$: ratio between net investments and aggregate GDP; Sources: National Statistical Institute (ISTAT) (www.istat.it/english); National Account Data; 1970-2004. $\frac{YU}{Y}$: underground production share; $\frac{NU}{N}$: underground employment share; National Statistical Institute (ISTAT) for the sample 1993:2006.

Concerning the **steady state corporate tax rate**, in Italy, corporations are subject to a proportional tax rate (called IRES) equal to 27.5 percent of tax base. We calibrate the steady state value of the corporate tax rate to $\tau_F^* = 0.275$.

The **steady state income tax** system is more complex, since Italy has five tax rates, spanning from 23 percent to 43 percent. More precisely, the structure of the tax rates is the following as of 2008. For incomes less than 15,00 Euros the tax rate is 23 percent, for incomes between 15,000 Euros and 28,000 Euros the tax rate is 27 percent, for incomes between 20,000 Euros and 55,000 Euros the tax rate is 38 percent, for incomes between 55,000 Euros and 75,000 Euros the tax rate is 41 percent and, finally, for incomes above 75,000 Euros the tax rate is 43 percent. We calibrate the steady state value of the income tax rate to the average between these figures, excluding the latter tax rate; precisely calibrated value reads: $\tau_Y^* = 0.325$.

Finally, notice that the model we use for assessing the consequences of fiscal policy along the stationary equilibria is consistent with the selected long-run statistics measured for the Italian economy. In this sense, the model could be consistently used for undertaking fiscal policy experiments. In particular, Table 1 presents selected “equilibrium ratios” generated from the model (starred quantities) and estimated for the Italian economy (hat quantities).

The table suggests that the calibrated ratios are qualitatively consistent with the actual figures, over the sample 1993:2006.

4 Steady state Laffer curves

The way in which tax revenues relate the rate of tax has attracted much attention in the last 30 years, both theoretically and empirically, generating much controversy among economists (amongst other, see the classical paper by Laffer, 1981). Literature has drawn attention to the importance of the existence and the shape of the Laffer curve, of the way Government spends revenues; the progressivity of the tax system, the elasticity of supply; the preference for untaxed output, etc. Here we suggest that in addition to the above structural and fiscal system effects, underground economy and tax evasion also affect the Laffer curve.

One of the most controversial issues in tax policy analysis is whether a tax cut will boost economic activity to such an extent that the government’s budget actually improves (this often referred as to a Laffer’s Curve Effect). A Laffer curve can be defined as curve which supposes that for a given economy there is an optimal income tax level to maximize

tax revenues. That happens at the peak of the curve. If the tax rate is set below this level, raising taxes will increase tax revenue. And if the tax level is set above this level, then lowering taxes will increase tax revenue. Although the theory claims that there is a single maximum and that the further you move in either direction from this point the lower the revenues will be, in reality this is only an approximation. This paper is interested in evaluating this theory in an neoclassical economy characterized by the existence of the underground sector, which offers tax evasion opportunities to the corporate sector.

Figure 1 below separately plots 's Laffer curves for an economy with and without underground sector, for the baseline parameterization. The "curves" are derived from the optimality equilibrium conditions evaluated at the stationary state derived in Proposition 1, using the calibration of the described in Section 3. The model shows that, given the parameterization, a Laffer curve exist with and without an underground sector. Each panel reports the average tax rate and the peak of the curve, which reflects the maximum revenues.

A casual glance at the previous figure suggests that, for the average income tax, there is a large gap between revenues actually collected and those that could potentially be collected in a perfectly compliant economy. The figures suggest that, for the baseline parameterization, the loss of tax revenues with the underground sector is remarkable; for example, at the average income tax rate of 32.25 percent, the revenue gap is close to 8 percentage point of aggregate GDP.

Comparing the two figures, it is interesting to notice that the Laffer curve for corporate taxes (i.e. top panel) does not end at zero for $\tau_F = 1$. This is the consequence of the fact, even when taxes collect all the outcome produced in the regular economy (which eventually collapses to zero), the underground sector is still producing. This latter production is subject, in expected terms, to distortionary taxation τ_F , weighted with the detection probability p and the surcharge factor s . In this sense, this hidden production produces a tax-revenues cash flow in expected terms.

The Laffer curve under tax evasion is completely beneath the no-evasion Laffer curve for almost all tax rates. The figures shows that for very high income and corporate tax rates, the Laffer curve of the model augmented with the underground sector is above the regular counterpart.

The basic idea behind the relationship, distinguishes between (i) movement along the Laffer's curve (arithmetic effect), and (ii) shifts of the curve itself (economic effect). The *arithmetic* effect is simply that if tax rates are increased, tax revenues (per euro of tax base) will be increased by the amount of the increase in the rate. The reverse is true. On the other hands, the *economic* effect takes into account the negative impact that higher tax rates have on equilibrium labor services and output and, thereby on the reduced tax base. Raising tax rates has the opposite economic effect by penalizing participation in the regular economy. Also here the reverse is true.

The conjecture that if tax rates were increased tax revenues would increase has become a recurrent policy stand in countries with high deficits and debts.⁷ If the arithmetic and economic effects make the issue not so easy, in presence of tax evasion, the tax policy is even more problematic: relatively higher tax rates under tax evasion certainty do not guarantee fiscal solvency. In an economy with tax evasion, since the economic and the arithmetic

⁷A wide body of a literature state that large fiscal adjustments in the Euro area cannot be avoided, and provides estimates of the required adjustments, often referred to as "tax gaps": which means how much taxes have to rise to repay or stabilize public debt. See, for a survey European Commission (2007)

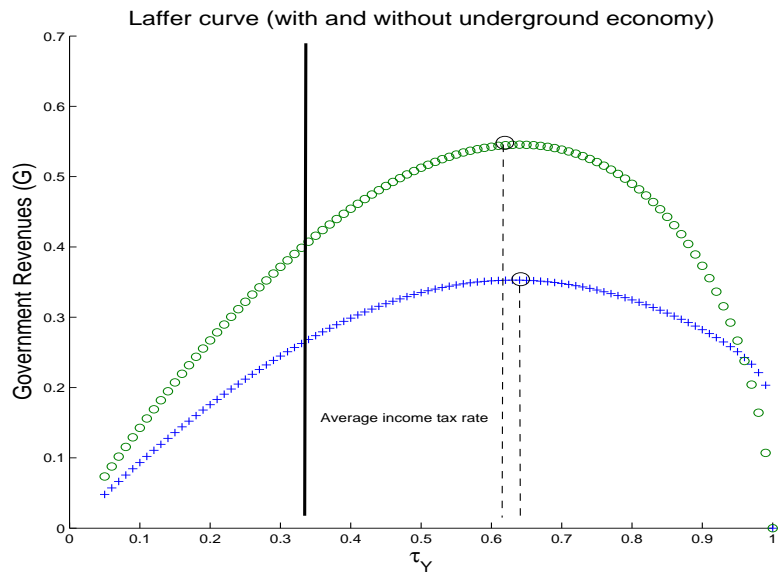
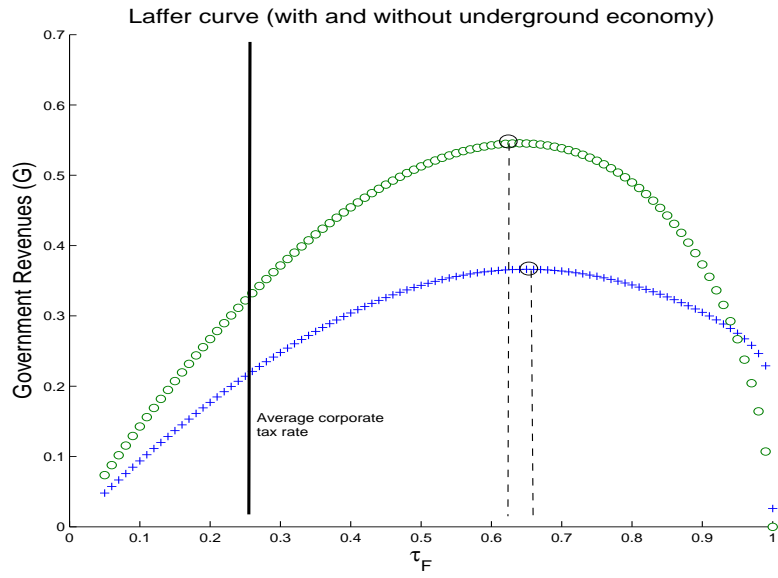


Figure 1: **Laffer Curve with (without) Tax Evasion.** Top Panel: Laffer curves for corporate tax rate; Bottom panel: Laffer curves for personal income tax rate; Circles: Laffer curve without underground sector; Cross: Laffer curves with underground activities. The circle on top denotes the Laffer curve peak; average income tax rate equals 36%, while average corporate tax rate equals 27%.

effects of tax-rate changes are combined, the consequences of the change in tax rates on total tax revenues are no longer quite so obvious.

In this context with a sizeable underground sector, there exist a further effect to be considered whenever fiscal policy is undertaken: *the compliance effects* (see for instance Papp and Takats, 2008). The underground sector, and therefore tax evasion, allows for shifts of the curve itself. Revenue responses to a tax rate change will depend upon the tax system (tax rates and the characteristics of the irregular production, probability to be detected, surcharge factors etc), the ease of movement into underground activity, the size of these activities, the level of the tax rates already in place and the agents' preferences and constraints. The relationships graphed in the Figures are a useful tool since they are derived from an underlying general model which is able to cope with optimal agents behavior in an underground economy context.

The sequel of the discussion highlights, through a sensitivity analysis, selected characteristics of the model and the implication of the Laffer curve. The sensitivity analysis exercise distinguishes between parameters affecting the firms' behavior, and the households' behavior as well.

4.1 Sensitivity on the firm's side

Concerning the firm side, there are mainly two interesting parameters/effects to consider: the surcharge factor s and the detection probability p , representing different channels through which the Institutions (try to) control tax evasion activities. By this end they have an impact on the existence and the shape of the Laffer curve under tax evasion.⁸

A first aspect it is interesting to examine is how selected institutional policies for detecting and for eventually punishing dodgers impact the existence and the shape of a Laffer mechanism in the steady state. To address this issue we perform a sensitivity analysis exercise with respect the surcharge factor s and the detection probability p .⁹

Top panel of **Figure 2** presents the relationship between corporate tax revenues and government revenues for two different values of $s = (1.3; 2.0)$. These are the two values that are actually in place for the Italian economy. A surcharge of $s = 1.3$ implies that the convicted dodger pays a 30 percent more than the due value, and it applies when the tax evaders confesses and accepts to pay the penalty to the Internal Revenues Service. The latter value of $s = 2.0$ implies that the convicted dodger pays a 100 percent more than the due value, and it applies when the tax evaders is eventually convicted and force to pay the fine after having judicially fought against the action of the IRS.

The bottom panel, next, plots the case for a more articulate policy exercise, depicting the consequences of more severe fines that ranges from $s = 5.0$ to $s = 20.0$. The casual inspection of the figure suggests that the surcharge factor does not affect the firm's decision to operate in the underground economy and, therefore tax revenues, unless the fine is

⁸There would a third parameter to consider, i.e. the capital depreciation rate δ . Increasing (decreasing) this parameter lowers (pushes up) the curve without marginally affecting the tax evasion choice in the steady state. For this reason, we leave available upon request this exercise. Of course, in a dynamic context this would not be true anymore.

⁹For the former parameter we consider a vector of values ranging from $s = 1.3$ (baseline parameterization) to $s = 20.0$, which is representative for a very large punishment for a tax evader. The latter punishment is close to the opening of a failure chapter for the convicted firm. A penalty factor of 20 implies that the fine equals 1000 percent the evaded tax base. The threshold value for s being which a convicted and punished firm fails is $\hat{s} \geq (\tau_F p)^{-1}$; for the baseline parameterization $\hat{s} \geq 121.21$.

extremely high. For a penalty close to $s = 20.0$ and higher the Laffer mechanism tend to disappear. Notice that collected revenues almost monotonically grow up to $\tau_F = 0.964$ and then suddenly collapse.

Figure 3 presents the response of the steady state Laffer curve for corporate tax rate to a sensitivity analysis exercise with respect the detection probability. The figure suggests that an increase in the detection probability does not significantly affect the Laffer curve for relative low level of tax rates, while it matters for relatively higher tax rates. In other words, an increase in detection probability shifts to the right the maximum of the curve, and by this end its slippery slope. When detection probability gets even higher (i.e. above $p = 50\%$) the Laffer curve almost disappears, replaced by a monotonically growing schedule. The maximum is achieved for $\tau_F = 0.98$, suddenly dropping afterwards.

This is the consequence of the fact that the effective penalty, i.e. ps , becomes sufficiently binding for the dodger only when is larger than 50%.

4.2 Sensitivity on the household's side

Figure 4 describes the consequences over the Laffer curve of a variation in B_u , which is the parameter that is measuring the utility cost in supplying labor into the underground sector. This is an important parameter, identifying the personal cost in operating into the underground economy.¹⁰

Increasing the idiosyncratic costs of working in the informal sector (e.g. social and health insurance, tax moral) has two effects: first it shifts the labor supply over the ground for relatively lower tax rate levels; in this case more revenues will be collected for the same tax rate, *ceteris paribus*. The second effect is a right-shift in the peak of the Laffer curve evaluated under tax evasion (cross line in the figure).

The disutility parameter B_u reflects, in some sense, the role of compliance. Its effect can be compared with the consequences of changes into the **enforcement** parameters s and p . The compliance effect and a more extensive and prolonged arithmetic effect (i.e. the rightward shift of the peaks) follows from the combined effect of a tax increase under a higher disutility from allocating labor services to the underground sector.

Given the technology structure, the comparison between Figure 2 and Figure 4 clearly suggests that a tight policy against the underground sector based on punishment and fines would not be as effective as a policy operating through the disutility parameter into the utility function.

For example increasing the social cost of offering labor supply into underground activities and an ethical policy convincing that operating into the underground economy is socially deprecated, would ensure a higher tax revenues profile. The key policy message is that to bring tax payers to compliance would be better, from a revenues maximizing perspective, than announcing to punish them if convicted.

Eventually, **Figure 5** presents the consequences of a reduction of the deterministic **intertemporal** discount factor β to 0.92 from the baseline value of 0.96.

Increasing the steady state value for the interest rate (i.e. reducing the discount factor) provides an interesting result: a drop of the regular economy Laffer curve (and tax revenues) and a small reduction for the evasion Laffer curve. Thus an economy without problems of compliance is much more sensitive to a myopic behavior: more consumption today and less

¹⁰Qualitatively speaking, this would have the same consequences of a variation in ξ , i.e. the inverse elasticity of underground labor services.

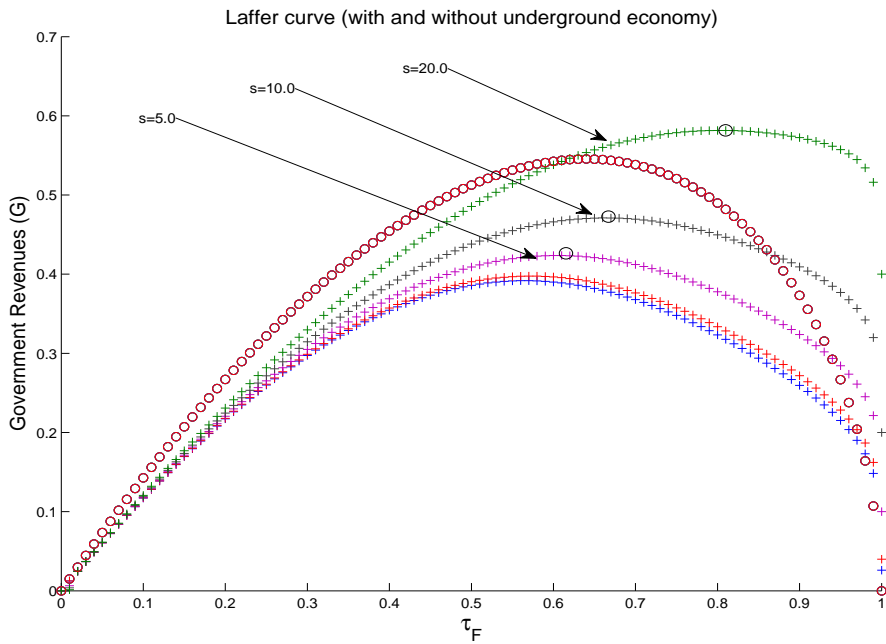
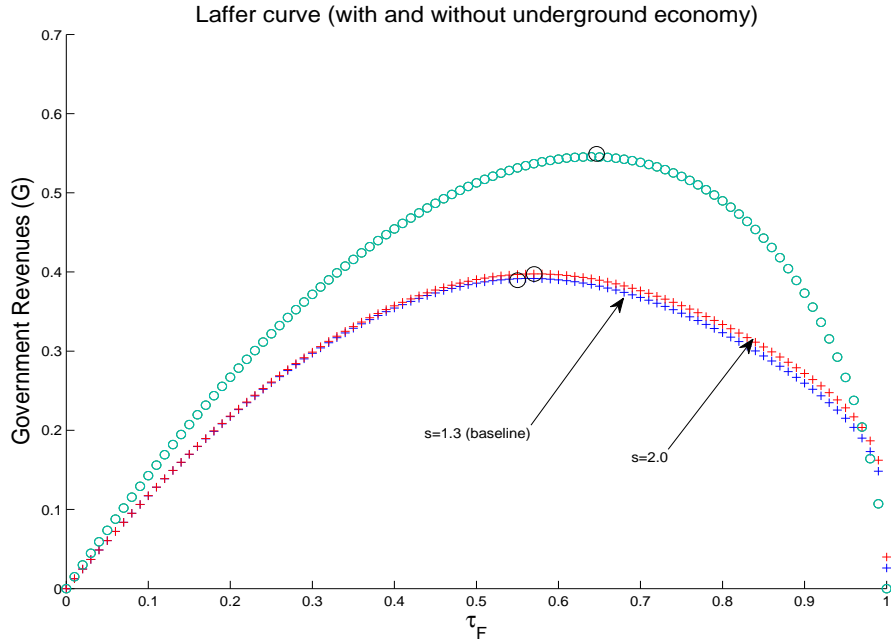


Figure 2: **Sensitivity exercise with respect to surcharge factor s** ; Circles: Laffer curve without underground sector; Cross: Laffer curves with underground activities, where the relatively higher curves depict the schedule for the surcharge factor ranging from $s = 1.3$, $s = 2.0$, $s = 5.0$, $s = 10.0$ to $s = 20.0$. The circle on top denotes the Laffer curve peak.

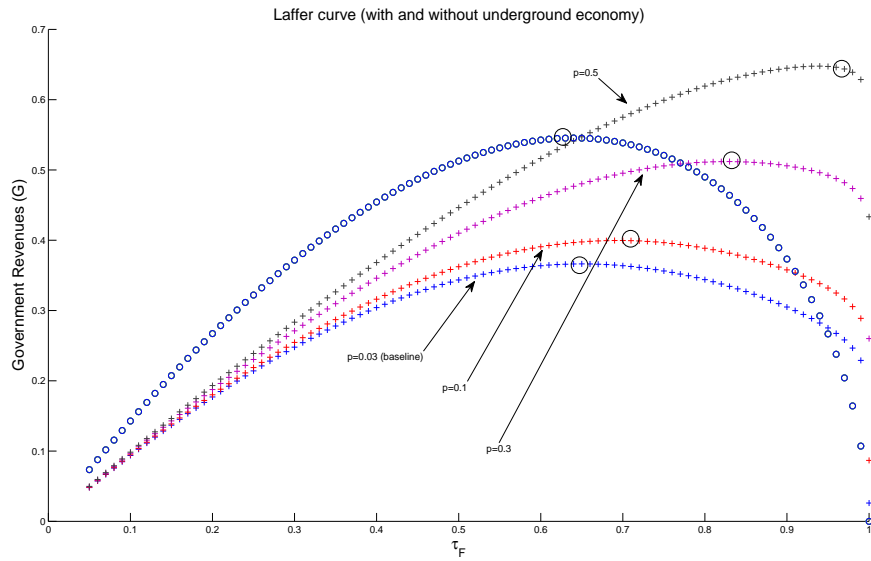


Figure 3: **Sensitivity exercise with respect to detection probability p** ; Circles: Laffer curve without underground sector; Cross: Laffer curves with underground activities, where the relatively lower (higher) curves depicts the schedule for $p = 0.03$, $p = 0.1$, $p = 0.3$, $p = 0.5$. The circle on top denotes the Laffer curve peak.

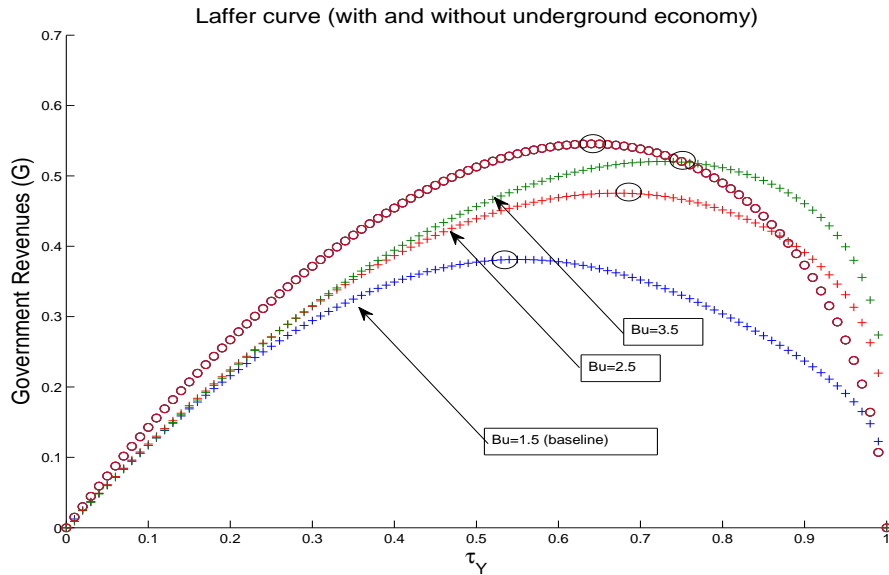


Figure 4: **Sensitivity exercise with respect to disutility costs**; Circles: Laffer curve without underground sector; Cross: Laffer curves with underground activities, where the relatively lower (higher) curves depicts the schedule for $\beta = 0.92$. The circle on top denotes the Laffer curve peak.

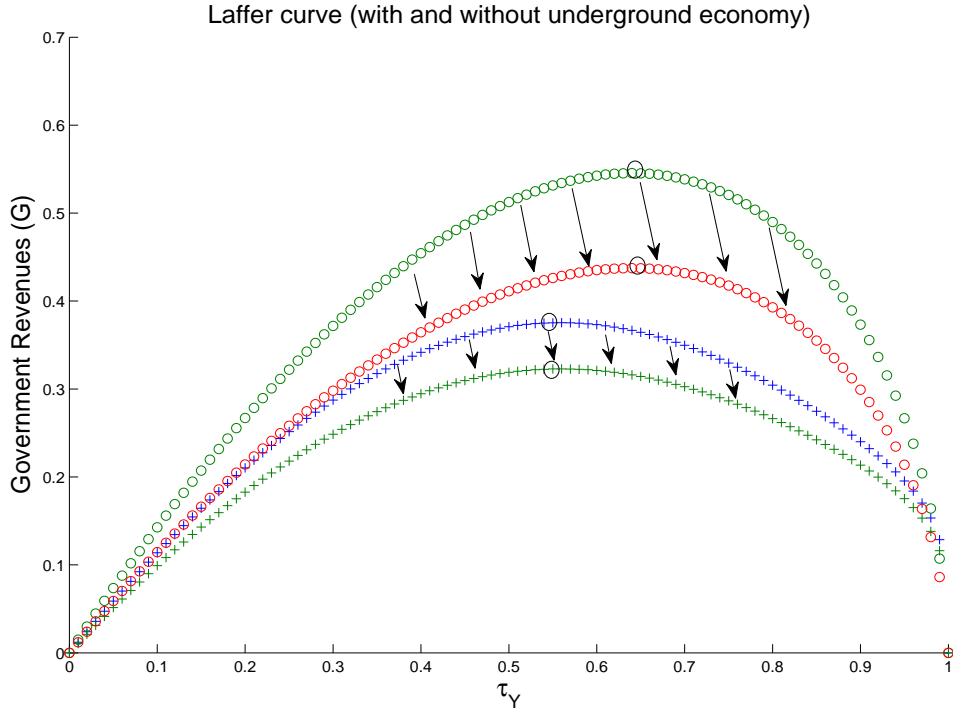


Figure 5: **Sensitivity exercise with respect to interest rate (intertemporal discount factor)**; Circles: Laffer curve without underground sector; Cross: Laffer curves with underground activities, where the relatively lower (higher) curves depicts the schedule for $\beta = 0.92$, and $\beta = 0.96$, $B_u = 3.5$. The circle on top denotes the Laffer curve peak.

investment tomorrow reduce income and tax base. In an economy with an underground sector this effect is offset by the labor shift to the irregular market. In this sense the irregular sector provide a sort of insurance for bad times.

5 Conclusions and policy discussion

The interesting policy implication of our analysis is that a government, neglecting the revenues effects of tax evasion, may dazzle itself. When assessing the impact of tax legislation, our model suggests that it is imperative to start the measurement effect of the tax policy only after a serious analysis of the re-allocation mechanism among sectors (over and under the ground) and the existing incentives and disincentives which drive the shadow behaviors.

This suggestion is trivial when the size of the tax evasion is remarkable. Although many countries (such as Italy) present underground sectors that range from 15 to 27% of GDP, is hard to find trace of this reasoning in the government's policy documents and in the setting of tax policy measures. In these circumstances, the government policies which rely on estimates tax effects neglecting the underground economy are not convincing.

If we assume the economy locates on the downward sloping segment of the Laffer curve, a tax increase provides misleading effects on revenues. In fact, revenues are dramatically lowered by the shrinking of the Laffer curve, pushing people to allocate as much as possible

resources in the underground sector. The economic effects of tax policy would create an incentive to drop output, employment and production in the official sector, increase tax evasion and outweigh the arithmetic effect of the tax increase upon government revenues.

If we assume that the economy is on the upward-sloping segment of the curve, and the government neglects the shadow sector, the increase in tax rates dramatically overestimates the outcome in terms of revenues. Precisely, it fails to estimate the economic effect (in the official GDP the underground component is taken into account) and therefore, the policy effect reduces to achieve only the arithmetic effect of the underground Laffer curve.

References

- [1]Agell J. and M. Persson, 2001, On the Analytics of the Dynamic Laffer Curve, *Journal of Monetary Economics*, 48, 397-414.
- [2]Baxter M. and R. King, 1993, Fiscal policy in general equilibrium, *American Economic Review* 83, 315-334.
- [3]Blundell R. and T.E. MaCurdy, 1999, Labor Supply: a review of alternative approaches, *Handbook of Labor Economics*, 3A, Elsevier Science Amsterdam eds.
- [4]Busato, F. and B. Chiarini, 2004, Market and underground activities in a two-sector dynamic equilibrium model, *Economic Theory*, 23, 831-861.
- [5]Busato, F., B. Chiarini and G.M. Rey, 2005, Macroeconomic implications of fiscal policy under tax evasion, University of Aarhus, School of Economics and Management, Working Paper Series.
- [6]Busato, F., B. Chiarini and E. Marchetti, 2005, Indeterminacy, underground activities and tax evasion, University of Aarhus, School of Economics and Management, Working Paper Series.
- [7]Chari V.V, Christiano L.J. and Kehoe P., 1995, Policy analysis in business cycle models, in Cooley T.F. (ed.), *Frontiers of Business Cycle Research*, Princeton University Press, Princeton NJ.
- [8]Chari, V. V. and Kehoe, P. J. and McGrattan, E. R. (2000): Sticky Price Models of the Business Cycle: Can the Contract Multiplier Solve the Persistence Problem?, *Econometrica*, Vol. 68, pp. 1151-1180.
- [9]Christiano L.J. and Eichenbaum M., 1994, Current real business cycle theories and aggregate labor market fluctuations, *American Economic Review*, 82, 430-50.
- [10]Clarida, R. and Gali, J. and Gertler, M. (2002): A Simple Framework for International Monetary Policy Analysis, *Journal of Monetary Economics*, vol. 49, n 5, 879-904, 2002.
- [11]Cowell F.A., 1990, *Cheating the Government: The Economics of Evasion*, Cambridge Mass: MIT Press.
- [12]Domeij D. and Floden M. (2006): The labor-supply elasticity and borrowing constraints: Why estimates are biased, *Review of Economic Dynamics*, 9, 242-262.
- [13]European Commission, 2007, *Public Finance in EMU 2007*, *European Economy*, 3, Brussels.
- [14]Fiorito R. and T. Kollintzas, 1994, Stylized Facts of Business Cycles in the G7 from a Real Business Cycles Perspective, *European Economic Review*, 38, 235-269.
- [15]Fiorito R. and T. Kollintzas, 2004, Public goods, merit goods, and the relation between private and government consumption, *European Economic Review*, 48, 1367-1398.
- [16]Gali, J. (2002): New Perspectives on Monetary Policy, Inflation, and the Business Cycle, in *Advances in Economic Theory*, edited by: M. Dewatripont, L. Hansen, and S. Turnovsky, vol. III, 151-197, Cambridge University Press 2003.
- [17]King, R. S. and Rebelo S.T. (1999): Resuscitating Real Business Cycles, *Handbook of Macroeconomics*, edited by J. B. Taylor and M. Woodford, Volume 1B, 9271007. Amsterdam: Elsevier
- [18]Kimball, M.S. and Shapiro, M.D. (2003): Labor Supply: Are the Income and Substitution Effects Both Large or Small?, manuscript
- [19]Kniesner, T. J. and Ziliak, J. P. (2005): The Effect of Income Taxation on Consumption and Labor Supply, manuscript.
- [20]Laffer A.B., 1981, Supply-side economics, *Financial Analysts Journal*, sept-oct, 1-16
- [21]Lucas R.E.Jr.: On the Mechanics of Development Planning. *Journal of Monetary Economics* 22, 3-42 (1988).
- [22]McGrattan E.R., 1994, The Macroeconomic Effects of Distortionary Taxation, *Journal of Monetary Economics* 33, 559-71;
- [23]Merz, M. (1995): Search in the LaborMarket and the Real Business Cycle, *Journal of Monetary Economics*, 36, 269-300.
- [24]Mendoza, E. G. and Tesar, L. L. (1998): The International Ramifications of Tax Reforms: Supply-Side Economics in a Global Economy, *American Economic Review*, 88, 402-417
- [25]Papp T.K. and E Takts, 2007, Tax Rate Cuts and Tax Compliance The Laffer Curve Revisited, IMF Working paper 08/07

- [26]Prescott E.C., Mehra R., 1980, Recursive Competitive Equilibrium: the Case of Homogenous Household, *Econometrica*, 1365-79.
- [27]Sanyal, Amal Gang, Ira N Goswami, Omkar, 2000. " Corruption, Tax Evasion and the Laffer Curve," *Public Choice*, Springer, vol. 105(1-2), pages 61-78.
- [28]Schneider F. and D. Enste, 2000, Shadow Economies: Size, Causes, and Consequences, *Journal of Economic Literature* XXXVIII, 77-114.
- [29]Schneider F., The size of the shadow economies of 145 Countries all over the world: first results over the period 1999-2003, *Journal of Population Economics*, 2007, 20, 495-526
- [30]Mathias Trabandt and Harald Uhlig, 2006, How Far Are We From The Slippery Slope? The Laffer Curve Revisited, SFB 649 Discussion Paper 2006-023 <http://sfb649.wiwi.hu-berlin.de>
- [31]Uzawa H.: Optimal Technical Change in an Aggregative Model of Economic Growth, *International Economic Review* 6, 18-31 (1965).

Appendix

Step 1: firm's side.

Given the production function:

$$y_{r,t} = k_t^\alpha n_{r,t}^{1-\alpha} \quad \text{and} \quad y_{u,t} = n_{u,t}, \quad (10)$$

and the tax evasion structure:

$$\begin{array}{l} \mathcal{R}_t \rightarrow \text{Detected } (\sim p) \quad \mathcal{R}_{D,t} = (1 - \tau_F)y_{r,t} + (1 - s\tau_F)y_{u,t} \\ \quad \searrow \\ \quad \text{Not Detected } \sim (1 - p) \quad \mathcal{R}_{ND,t} = (1 - \tau_F)y_{r,t} + y_{u,t} \end{array}$$

combining and deriving the first order conditions, we have

$$\begin{aligned} (1 - \tau_F)(1 - \alpha)k_t^\alpha n_{r,t}^{-\alpha} &= w_{r,t} \\ (1 - ps\tau_F) &= w_{u,t} \\ (1 - \tau_F)\alpha k_t^{\alpha-1} n_{r,t}^{1-\alpha} &= r_t \end{aligned} \quad (11)$$

Step 2: consumer's side.

Given the utility function,

$$\mathcal{U}_t = \log(c_t) + B_M \frac{(1 - n_{r,t} - n_{u,t})^{1-\rho}}{1 - \rho} - B_U \frac{n_{u,t}^{1+\xi}}{1 + \xi}, \quad B_M, B_U \geq 0,$$

the representative household's problem is therefore the following:

$$\begin{aligned} & \max_{(c_t, i_t, \omega_t)_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \mathcal{U}_t \\ \text{s.t.} \quad & c_t + k_{t+1} - (1 - \delta)k_t = (1 - \tau_Y)(w_{r,t}\omega_t + r_t k_t) + w_{u,t}(1 - \omega_t) \\ & k_0, \text{ given, } c_t > 0, \omega_t \in (0, 1], \end{aligned} \quad (12)$$

and the first order conditions are reported below

$$\begin{aligned} -B_U(1 - \omega_t)^\xi(-1) + (c_t)^{-1}[(1 - \tau_Y)w_{r,t} - w_{u,t}] &= 0 \\ (1 - \tau_Y)(w_{r,t}\omega_t + r_t k_t) + w_{u,t}(1 - \omega_t) - c - k_{t+1} + (1 - \delta)k_t^\gamma \\ (c_t)^{-1} &= \beta \mathbb{E}_t (c_{t+1})^{-1} ((1 - \tau_Y)r_{t+1} + 1 - \delta) \end{aligned}$$

Step 3: deterministic steady state of a recursive competitive equilibrium

We, next, impose certainty equivalence and aggregate consistency. Technically this implies that individual quantities coincides with the aggregate counterparts (for example, $k_t = K_t$), and that there is no dynamics in the model, and we can drop time subscript from now on (i.e. $K_t = K$ for all t).

$$\begin{aligned} B_U(1 - \omega)^\xi &= (C)^{-1} \left[(1 - ps\tau_F) - (1 - \tau_Y)(1 - \tau_F)(1 - \alpha) \left(\frac{K}{\omega}\right)^\alpha \right] \\ (1 - \tau_Y)(1 - \tau_F)(K)^\alpha (\omega)^{1-\alpha} + (1 - ps\tau_F)(1 - \omega) + \delta K &= C \\ 1 &= \beta \left((1 - \tau_Y)(1 - \tau_F)\alpha \left(\frac{K}{\omega}\right)^{\alpha-1} + 1 - \delta \right) \end{aligned} \quad (13)$$

Step 4: steady state government

Government spending is assumed wasteful, and determined endogenously in equilibrium to balance the public budget constraint. In the steady state collected tax revenues are denoted by G , and read

$$C_G = K^\alpha \omega^{1-\alpha} \tau_Y (1 - \tau_F) + \tau_F [ps(1 - \omega) + K^\alpha \omega^{1-\alpha}]. \quad (14)$$

Step 5: steady state derivation-numerical procedure

Notice that in equilibrium the ratio $\frac{K}{\omega} = \left(\frac{\beta^{-1} - 1 + \Omega}{(1 - \tau_Y)(1 - \tau_F)\alpha} \right)^{\frac{1}{\alpha-1}}$, which is given, the first step is to compute numerically the share of regular labor ω , such that

$$\begin{aligned} \omega^* \text{ solves } (1 - ps\tau_F) + \mathbf{A}\mathbf{A}\omega &= \mathbf{B}\mathbf{B}(1 - \omega)^{-\xi} \\ \left(\frac{\beta^{-1} - 1 + \Omega}{(1 - \tau_Y)(1 - \tau_F)\alpha} \right)^{\frac{1}{\alpha-1}} \omega^* &= K^*, \end{aligned}$$

where $\mathbf{A} = \left[[(1 - \tau_Y)(1 - \tau_F)(K)^\alpha (\omega)^{-\alpha} + \Omega \frac{K}{\omega}] - (1 - ps\tau_F) \right]$, $\mathbf{B} = \frac{[(1 - ps\tau_F) - (1 - \tau_Y)(1 - \tau_F)(1 - \alpha) \left(\frac{K}{\omega}\right)^\alpha]}{B_U}$.

Once we have ω^* , we can compute $\left(\frac{\beta^{-1} - 1 + \Omega}{(1 - \tau_Y)(1 - \tau_F)\alpha} \right)^{\frac{1}{\alpha-1}} \omega^* = K^*$, and all other equilibrium quantities.