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Fiscal Consolidation Plans with Underground Economy

Abstract

Fiscal consolidation literature often neglects that there are economies with a sizable underground sector and that most of time it is accounted in GDP statistics. This produces non negligible effects on fiscal multipliers. This paper explores a fiscal consolidation plan calling for a downsizing of the underground sector as well. The analysis refers to the Italian economy that, among European countries, is the second for high public debt and has one of the highest size of tax evasion. Results show that it is possible to both reduce public debt and tax evasion through a temporary cut in public spending associated with a permanent drop in tax rates. In this context a reallocation of resources from the underground to market sector operates.

JEL-Codes: E260, E320, E620, E630, H260.

Keywords: fiscal consolidation plans, underground economy, DSGE modelling.

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1 Introduction

Fiscal consolidation is one of the most debated issues in the recent macroeconomic literature. Recently, in the aftermath of the increasing financing needs, due to the containment measures implemented after the COVID-19 pandemic, the debt to GDP ratio has achieved 97.3% in the Euro area (Eurostat, 2021). Hence, being far from the compliance with the Maastricht Treaty and the Stability Growth Path prescriptions, forcing Member States to not exceed the 60% of the debt to GDP ratio, today more than ever fiscal consolidation is a key concern of the political debate.

In this regard, the empirical evidence has often expressed in favor of spending-based adjustments rather than revenue-based consolidation efforts (Alesina and Ardagna, 2010; Nickel et al., 2010**;** Alesina et al., 2012, Herranz and Turino., 2022)[1]**.** Recently, Alesina et al. (2019) have collected and analyzed 170 consolidation plans implemented by governments of 16 OCSE countries from 1981 to 2014. The study shows that fiscal plans mainly based on spending cuts lead to a lower slowdown and a more effective stabilization of the debt to GDP ratio, compared with those mainly based on tax increases. Accordingly, on theoretical ground, Ferrara and Tirelli (2017) propose equitable fiscal consolidations based on spending cuts in a two-agent New Keynesian model where it is possible to reduce public debt and stimulate consumption of liquidity constrained households, pushing up the aggregate demand.

However, this literature does not take into account two important questions. First, there are economies with a sizable underground sector. Second, these economies account for this sector in GDP statistics, with important consequences on fiscal multipliers (Basile et al., 2015). This can not at all be neglected in fiscal policy analyses and turns out to be even more relevant for Italy that, within the Euro area, features a debt ratio equal to 154.2%, being only second with respect to Greece with 199.9% (Eurostat, 2021), and has one of the highest size of tax evasion (Kelmanson et al., 2019). Hence, Italian policy makers have to cope with high public debt and high tax evasion. The solutions to the two evils are strictly connected since downsizing the underground sector releases resources that can potentially be used for public finances and to obtain a lower debt. On the other hand, reducing public debt improves the budgetary position of the government and frees up resources that can be used to lower taxes and, hence, incentivize compliance[2].

[1] One exception is the paper by Acocella et al. (2020) arguing that tax increases based consolidation efforts are more effective than spending cuts based strategies.

[2] Papageorgiou and Vourvachaki (2017) reach the same conclusion for the Greek economy, in a context without tax evasion.

In light of that, the aim of this paper is to explore, for the Italian economy, a fiscal consolidation plan calling for a reduction of tax evasion[3] as well. According to the empirical evidence suggestions, we design a spending-based consolidation plan that, unlike tax-based strategies, not only produces less output losses, but importantly does not incentivize tax evasion. To these purposes, we develop a two-sector Dynamic Stochastic General Equilibrium (DSGE) model à la Orsi et al. (2014) augmented with sticky prices, investigating the short- and long-run real effects of fiscal consolidation. Results show that it is possible to both reduce public debt and tax evasion through a temporary cut in public spending associated with a permanent drop in tax rates. In the context of forward-looking households, their future expectations about lower taxes generate a positive wealth effect that stimulates the aggregate demand[4]. In our tax evasion model, both in the short- and in the long-run a reallocation of resources from underground to regular sector operates. In particular, in the short-run, this amplifies the positive wealth effect with further increase of the aggregate demand. Accordingly, the presence of tax evasion allows for dampening the recessionary effect of consolidation. It is worth noting that here we are not supporting the idea of "positive effects" of not compliant behaviors, rather we aim to evaluate the important role of tax evasion during a consolidation process. The above mentioned results are even reinforced with an active fiscal policy allowing taxes working as automatic stabilizers undershooting their target steady state values.

In addition, in our underground economy model, the probability of being detected by fiscal authorities plays a non-negligible role in reducing tax evasion, and consequently, public debt. In fact, consistently with the stylized facts, increasing auditing reduces tax evasion, allowing for a more efficient consolidation plan. The idea is that increasing inspection implies a higher compliance, a saving of public resources that, in turn, contribute to reduce public debt (Argentiero and Cerqueti, 2021)[5].

This paper is akin to Pappa et al. (2015) that, differently, investigate the role of tax evasion and corruption in a DSGE model augmented with search

[3]In this paper we interchangeably use the concepts of underground economy and tax evasion following the OECD (2012) manuscript definition of underground economy. It states that underground economy includes productive and legal activities that are intentionally concealed to fiscal authorities to avoid tax payments and/or social security contributions or meeting some legal standards as minimu wage, number of hours, and so on. In addition, we refer as regular/irregular production to market/underground production.

[4]In one sector DSGE models this is a standard result (see Linnemann and Shabert, 2003; Ferrara and Tirelli, 2017).

[5]Different real results are explained in Glomm et al. (2018). However, it is a different framework dealing with overalpping generations and, importantly, the underground sector is absent.

and matching frictions. To this purpose, they implement a business cycle analysis simulating temporary spending and tax shocks and obtaining impulse response functions of the key macroeconomic variables. Beside to the structure of the model, our study departs from Pappa et al. (2015) carring out a growth cycle analysis in a deterministic environment and studying the transition dynamics of the macroeconomic variables during the fiscal consolidation plan. Our paper is also close to Annichiarico and Cesaroni (2017) who evaluate effects of several tax reforms in an economy with underground sector. However, unlike us, they assume that the real stock of public debt is kept constant at its initial baseline level.

The paper is organized as follows. The next section describes the model, summarizes the implementation of the fiscal consolidation experiment, and reports the fiscal parameters' calibration. Results, organized as long-run results and short-run dynamics, are reported and explained in section 3. Finally, section 4 concludes the paper.

2 The Fiscal Consolidation Plan

In this section first we draw up a summary of the DSGE model we develop. In particular here we focus on the main characteristics of the model, especially focusing on aspects related to the underground economy, while in Appendix A we report the details[6]. Secondly we explain the fiscal consolidation plan we carry on and, thirdly, we report fiscal parameters' calibration.

2.1 A summary of the two-sector model

We develop a two-sector dynamic general equilibrium model that includes explicit modeling of the underground economy à la Orsi et al. (2014) and augment it with sticky prices à la Calvo (1983). The economy is populated by four agents: firms, households, fiscal and monetary authorities. In addition, there are two sectors, regular and underground. In particular, firms, beside to operating in the regular sector, they employ factors from the underground one to hide part of their production, elude taxation and therefore earn additional profits on that. As well, households may evade personal income taxes reallocating their resources and supplying labor and capital to the underground sector. Finally, in order to finance public spending and balance its budget constraint at each point in time, the Government levies taxes from

[6]Structural characteristics of our model are quite standard in DSGE literature with underground sector. Hence, we prefer to focus on the main aspects of the model in the main text, while, for the sake of completeness, we reserve details in the appendix.

households and firms and detects tax-evading producers obliging them to pay back the total amount evaded augmented by a penalty surcharge. In what follows, we focus on the agents' optimal choices, denoting the transmission channels, and on fiscal sector.

2.2 Optimal choices

For a better understanding of the results explained below, we report in this subsection the optimal conditions; while the entire model will be discussed in detail in Appendix A.

Final firms choose capital and labor services both in the regular and in the underground sector, to maximize their expected profits. The solution to the maximization problem is represented by the following first-order conditions:

$$(1-\alpha)\left(\frac{y_{i,t}^{m}}{k_{i,t}^{m}}\right)mc_t = \frac{r_t^m}{(1-\tau^f)}; \tag{1}$$

$$(1-\alpha_u)\left(\frac{y_{i,t}^{u}}{k_{i,t}^{u}}\right)mc_t = \frac{r_t^u}{(1-ps\tau^f)}; \tag{2}$$

$$(\alpha)\left(\frac{y_{i,t}^{m}}{n_{i,t}^{m}}\right)mc_t = \frac{(1+\tau^{f,s}-\tau^f)w_t^m}{(1-\tau^f)}; \tag{3}$$

$$(\alpha_u)\left(\frac{y_{i,t}^{u}}{n_{i,t}^{u}}\right)mc_t = \frac{(1+ps\tau^{f,s}-ps\tau^f)w_t^u}{(1-ps\tau^f)}. \tag{4}$$

where mc_t represents the marginal costs, $y_{i,t}^m$ and $y_{i,t}^u$ denote the regular and irregualar technology, respectively. Equation (1) describes the demand for regular capital $k_{i,t}^m$ as function of the rental rate to rent a unit of regular capital r_t^m. Instead, equation (2) represents the capital demand in the underground sector where r_t^u denotes the rental rate of irregular capital $k_{i,t}^u$. Equations (3) and (4) represent the demand for regular and underground labor ($n_{i,t}^m$, $n_{i,t}^u$), respectively. Firms pay w_t^m for one unit of regular labor services and w_t^u for one unit of irregular labor services. Moreover, they face a stochastic probability p of being inspected and forced to pay both the social security contribution rate $\tau^{f,s}$, and the production tax rate τ^f, augmented by a penalty surcharge factor s.

Households' maximization problem implies the following first order conditions:

$$(1-\tau_t^h)w_t^m = \frac{H\left(n_t^m+n_t^u\right)^{\varphi}}{\lambda_t} \tag{5}$$

$$w_t^u = \frac{H\left(n_t^m + n_t^u\right)^{\varphi} + H_1\left(n_t^u\right)^{\eta}}{\lambda_t} \tag{6}$$

$$\lambda_t = \beta_t E_t \lambda_{t+1}\left[(1-\tau_{t+1}^h) r_{t+1}^m + (1-\delta)\right] \tag{7}$$

$$\lambda_t = \beta_t E_t \lambda_{t+1}\left[r_{t+1}^u + (1-\delta)\right] \tag{8}$$

where λ_t represents the Lagrange multiplier and τ_t^h denotes the income tax rate paid by households. Equations (5) and (6) describe the (total) labor supply schedule and the optimal allocation of time for working activities in the underground sector, respectively. Instead, equations (7) and (8) determine the optimal allocation of capital in each sector, implying that at equilibrium the real rate r_t^u is equal to the net-of-tax rental rate of official capital r_t^m. The optimal allocation of hours between the two sectors evolves according to the following equation:

$$n_t^u = \boldsymbol{\lambda}_t^{\frac{1}{\eta}}\left(\frac{w_t^u - w_t^m(1-\tau_t^h)}{H_1}\right)^{\frac{1}{\eta}} \tag{9}$$

which clearly shows that a marginal variation in the tax rate changes the relative convenience to operate in the two sectors and generates a reallocation between them.

2.3 Fiscal sector and the consolidation policy

In each period the Government finances an exogenous stream of expenditures by issuing risk free bonds and by collecting distortionary taxes. Hence, the period government budget constraint is described as follows:

$$\begin{aligned} G_t + b_t^g &= \tau_t^h(r_t^m k_t^m + w_t^m n_t^m) + (\tau^{f,s}) w_t^m n_t^m + (ps\tau^{f,s}) w_t^u n_t^u \\ &\quad + \tau^f(y_t^m - w_t^m n_t^m) + ps\tau^f(y_t^u - w_t^u n_t^u) + \frac{b_{t+1}^g}{R_t} \end{aligned} \tag{10}$$

where b_t^g is the outstanding stock of debt. $\tau_t^h(r_t^m k_t^m + w_t^m n_t^m)$ represent the total fiscal revenues from personal income taxation, $(\tau^{f,s}) w_t^m n_t^m + (ps\tau^{f,s}) w_t^u n_t^u$ is total fiscal revenues from social security contributions and finally, the term $\tau^f(y_t^m - w_t^m n_t^m) + ps\tau^f(y_t^u - w_t^u n_t^u)$ is total fiscal revenues from corporate taxation.

Our fiscal consolidation experiment follows Ferrara and Tirelli (2017) where a permanent reduction of the debt ratio is achieved via a temporary cut of public spending, according to the following rule:

$$\frac{g_{y,t}}{g_y} = \left(\frac{b^g_{y,t}}{b^{g**}_y}\right)^{-\phi_{\mathbf{g}}} \tag{11}$$

where $g_{y,t} \equiv G_t/y^{**}$ and $b^g_{y,t} \equiv b^g_t/y^{g**}$ denote time t levels of public consumption and debt in terms of post-consolidation steady-state output.

We study the model transition dynamics starting from an initial steady state where the debt ratio is set at 70% to a new steady state associated to the 60% target of the debt to GDP ratio, as prescribed by the Maastricht Treaty and the Stability and Growth Path. In that framework, the public spending ratio returns to the initial steady-state level that is set at 18% while saving on interest payments are used to reduce the tax rate. More specifically, in modeling transition dynamics of tax rates we assume that the social security contribution rate paid by employers ($\tau^{f,s}$) and the stochastic corporate tax rate (τ^f) are constant over the consolidation process and fixed at their steady-state levels. A separate discussion is reserved to the income tax rate. Since we want to explore in which way fiscal consolidation affects the aggregate demand, we assume that the public saving on interest payments is used to reduce the income tax rate. In our tax evasion model, the reduction in the income tax rate immediately impacts the disposable income of households, incentivizing them to supply capital and labor services in the regular sector. Consequently, also firms are incentivized to demand resources in the regular sector rather than in the underground sector. In other words, the income tax rate dynamic indirectly influences firms even.

As mentioned above, for the government budget constraint to be satisfied, a spending cut consolidation process sooner or later calls for a reduction of taxes and associated distortions. In this framework, we assume that the income tax rate reduces over the transition in order to achieve the new and lower steady state. To model that, we consider two different tax rules:

$$\tau^h_t = (1-\phi^\tau)\tau^h_{t-1} + \phi^\tau \tau^h \tag{12}$$

$$\left(\frac{\tau^h_t}{\tau^h}\right) = \left(\frac{y_t}{y}\right)^{\phi^\tau} \tag{13}$$

Equation (12) captures the inertia of income tax to achieve the new steady state allowing to investigate the effect of permanent reduction of income tax rate in presence of tax evasion, while according to equation (13) income tax is modeled as automatic stabilizer, as in Colciago et al. (2008), allowing to investigate the role of a countercyclical fiscal policy dealing with tax evasion in stabilizing the economy during the consolidation process[7].

In this setting, the probability of inspection assumes a fundamental role. The increase in the probability of firms being detected by fiscal authorities reduces tax evasion, and consequently, public debt. In other words, increasing inspection implies higher compliance. This, in turn, increases the saving of public resources contributing to reducing public debt. To model that, we assume that the probability of detection increases from 0.0217 to 0.03, evolving according to the following rule:

$$\rho_t = (1 - \phi^{\rho})\rho + \phi^{\rho}\rho_{t-1}. \tag{14}$$

Note that in our tax evasion model, we assume that only firms face the probability of being detected, as it is a common practice in the literature[8].

2.4 Calibration of fiscal sector parameter

In this subsection we report the quarterly calibration of fiscal sector' parameters[9]. Their description is summarized in the Table 1.

The parameter denoting the penalty surcharge factor s is calibrated at 1.30, in line with the Italian Tax Law (Busato and Chiarini (2004)). The probability p that a firm is inspected, is set equal to 0.0217 consistently with the estimate reported by Orsi et al (2014)[10]. Moreover, we assume that the social security contribution rate paid by employers $\tau^{f,s}$, and the stochastic corporate tax rate τ^{f}, are constant over the consolidation process. More specifically, as in Annichiarico and Cesaroni (2017), these taxes are fixed at 0.13 and 0.02, respectively. Instead, the income tax rate τ_t^h is calibrated such that the fiscal authority's budget is balanced at the debt-to-GDP target[11]. Following Ferrara and Tirelli (2017), the public spending g, that is the

[7] This analysis follows Ferrara and Tirelli (2017) but refers to the different framework with tax evasion.

[8] See, for instance, Busato and Chiarini (2004), Orsi et al. (2014), Pappa et al. (2015). Two exceptions are the papers by Annichiarico and Cesaroni (2017) and Argentiero and Bollino (2015). They assume that both households and intermediate firms have to face the same probability of being inspected.

[9] The baseline calibration of structural parameters follows Orsi et al. (2014). In appendix B we report the details.

[10] In the model with dynamic detection, the second steady-state value of ρ equal to 0.03, corresponds to the estimate reported by Busato and Chiarini (2004) using data published by the Italian Ministry of Labor. Moreover, the parameter governing the inertial behaviour of probability of detection, ϕ^{ρ} in (14), is calibrated at 0.9544 corresponding to the estimate reported by Orsi et al (2014).

[11] Being the income tax rate determined endogenously, it changes accordingly to the different models. Specifically, in the model with dynamic detection, the second steady-

constant public consumption-to-GDP target ratio G^*/Y^*, is fixed at 0.18, in line with the national accounts data for Euro Area countries. The parameter governing the debt stabilization $\phi_{\mathbf{g}}$ in the fiscal rule (11) is calibrated at 1. Instead, the parameter governing the behavior of the income tax rate ϕ^{τ} in (12) and (13), is set at 0.5.

Table 1

Fiscal sector' parameter values

b_y^{g*}	70%	Debt-to-output ratio target (annual old target)
b_y^{g**}	60%	Debt-to-output ratio target (annual new target)
$g^*= g^{**}$	0.18	Government expenditure ratio
$\phi_{\mathbf{g}}$	1	Debt stabilization
τ^{h*}	0.19	Income tax rate (old target)
τ^{h**}	0.179	Income tax rate (new target)
$\tau^{f,s}$	0.13	Employers' social security contribution implicit tax rate
τ^{f}	0.02	Business implicit tax rate
ϕ^{τ}	0.5	Tax rate dynamics
p	0.0217	Probability of a firm being inspected
s	1.30	Penalty rate for tax evading firms
ϕ^{ρ}	0.9544	Probability of detection dynamics

3 Results

In this section, we discuss the role of tax evasion both during the consolidation process and once the plan has been over. To our purpose, we compare a baseline dynamic stochastic general equilibrium model with our tax evasion model. Our long and short-run results emphasize a reallocation process of resources from the underground to the regular sector, increasing tax compliance. This effect is even more amplified both when we assume an increase in the probability of inspection and if we consider an active role in fiscal policy.

3.1 Long-run results

Table 2 reports the steady-state percentage variations of key macroeconomic variables once the consolidation process has been completed. Within the government budget, the consolidation plan releases resources that can be used to

state value of τ^h is equal to 0.229534. Instead, in the model without tax evasion, the first- and second-steady state values of the income tax rate, are equal to 0.200217 and 0.191851, respectively.

reduce taxation. In that framework, households' disposable income increases entailing a larger consumption, although the losses in public debt service payments. Households reallocate capital and labor supply from the irregular to regular sector. Accordingly, firms reallocate capital and labor demand towards the formal sector, as well. It follows that the increase in regular capital entails a positive variation of investments, in the long run. As a result, regular output grows up. On the other hand, the drop of irregular labor and capital determines a fall of the irregular output[12]. The regular output expansion due to the reallocation effects of tax evasion more than compensates the recessionary effect in the underground sector, entailing therefore an increase of the total output. Summing up, a fiscal consolidation plan implemented through a temporary reduction in public spending, with a consequent decrease of taxation, beside to produce expansionary effects, reduces tax evasion and increases compliance. Such an expansionary effect turns out to be restrained in a model that does not take into account tax evasion where there can be no reallocation between sectors. Importantly, compared to the baseline, our tax evasion model emphasizes that, with an equal consolidation plan, an increase in tax compliance allows the government to reduce more the income tax rate. In turn, this implies larger disposable income and an amplification of the positive wealth effect with consequent larger aggregate demand and output expansion.

[12] As shown in Table 2, the long-run negative variation in underground capital, in working hours, and in production, is the same. The reason why this happens is that irregular firms are not subject to the direct effect of a reduction in the income tax rate. Since we assume that the total number of hours worked in the economy is fixed at 0.19, the irregular working hours decrease due to the reallocation effect towards the regular sector. The following steady-state equations explain why the irregular capital and output reflect the same variation of the irregular working hours, in the long run. Knowing the steady-state eq. value of r^u via eq. (8) as function of parameters, we can compute the ratio $\frac{k^u}{n^u}$ from the eq. (2), as follows:

$$A^u = \frac{k^u}{n^u} = \left(\frac{r^u}{((1-\alpha^u)mc(1-\rho s \tau^f))} \right)^{\alpha^u}.$$

Then, by multiplying A_u for n^u, we obtain the steady-state value of the underground capital. In this way, the long-run variation in k^u reflects the long-run negative variation in n^u. Finally, we compute y^u via equation (A2).

Table 2

Steady state percentage variations after consolidation

Variables	With tax evasion	Baseline
Total output	1.754	1.072
Regular output	3.067	1.072
Irregular output	-6.944	-
Irregular wage	0	-
Regular wage	1.053	0.593
Irregular work	-6.944	-
Regular work	1.993	0.477
Consumption	1.473	0.811
Regular capital	4.987	2.130
Irregular capital	-6.944	-
Investment	3.103	2.129
Rental rate of regular capital	-1.829	-1.035
Rental rate of irregular capital	0	-
Income tax rate	-5.769	-4.178

3.2 Short-run results

The next step is a discussion of the short-run effects of fiscal consolidation. First, we evaluate the role of tax evasion simulating our proposed consolidation process comparing the baseline DSGE model and our tax evasion model. In this analysis, we assume that taxes, achieving the new and lower steady state, follow a simple announcement rule of tax reduction. This allows to capture how tax evasion works while public debt is reducing. Second, assuming a time-varying detection process as in Orsi et al. (2014), our results can explain the stylized fact according to which increasing detection entails a downsizing of the underground sector. Third, we investigate an active role of fiscal policy considering that tax reduce according to an automatic stabilizers' rule.

In what follows each panel shows the transition dynamics of the endogenous variables, expressed in percentage deviation from the initial steady state.

3.2.1 The role of tax evasion

Figure 1 shows that in a full compliance framework (blue line) the temporary reduction in public spending entails a temporary recession up to the fifith quarter. Then, a positive wealth effect operates since forward-looking households, discounting future tax reductions, work less and consume more, stimulating aggregate demand. The positive effect on consumption, following an expenditure-based fiscal consolidation, is a typical result of standard DSGE models (see, among others, Linnemann and Shabert, 2003; Ferrara and Tirelli, 2017).

In an economy with tax evasion (red line) the aforementioned result is even stronger. As a matter of fact, the positive wealth effect on worked hours is now counterbalanced by substitution between regular/underground hours. The channel is the following: triggered by lower income tax rates, regular net wage increases (see eq. 5). Accordingly, worked hours raise in the regular sector and fall down in the underground one. The idea is that increasing net real regular wage reduces the incentive to elude the income tax rate by supplying labor services in the underground sector (see eq. 9)[13]. Overall, the underground sector downsizes. Furthermore, the reduction of the tax involves a reduction in the gross rental rate of regular capital via equation (7). In turn, this causes an increase in the underground rental rate of capital that is none other than the net regular rental rate of capital that households draw from the regular sector (see eq. 7 and 8). Consequently, households increase capital supply in the regular sector downsizing irregular capital. Overall, consistently with the literature, tax evasion acts as a buffer that releases capital and labor services emphasizing their reallocation towards regular economy.

Therefore comparing the two models in Figure 1, due to the reallocation of resources from the underground to the regular sector, the initial output recession is milder in the model with tax evasion. In fact, consistently with the literature in the field (see, for instance, Pappa et al., 2015; Annichiarico and Cesaroni, 2017) the underground sector mitigates fiscal distortions and mitigates the response of production to restrictive or expansive fiscal changes.

In our fiscal consolidation framework, the reallocation of resources from the underground to the regular sector increases tax compliance both in the long- and in the short-run. With these premises, with the same fiscal consolidation, the government is able to balance its budget constraint with a larger tax reduction in an economy with tax evasion.

[13] A similar mechanism is in Colombo et al. (2019) who develop and estimate an informal economy model.

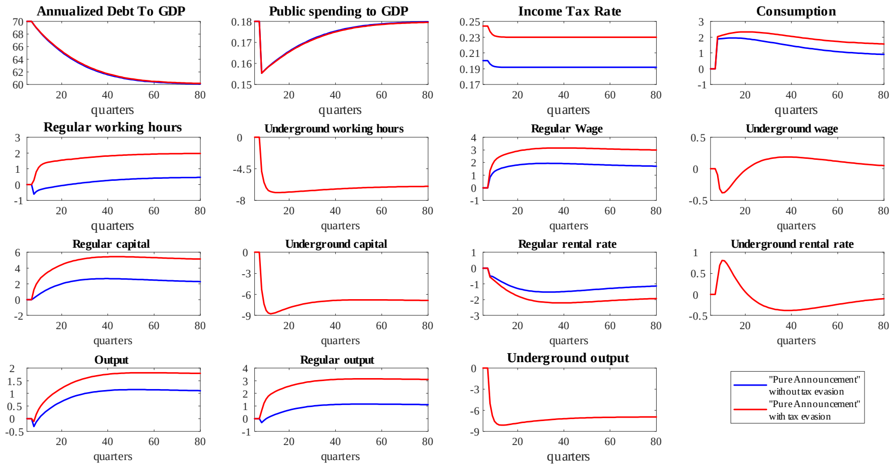

Fig.1 Short-run effects of fiscal consolidation with and without tax evasion.

3.2.2 The role of detection

Figure 2 shows the transition dynamics of endogenous variables in case of constant (red line) and increasing (blue line) probability of detection on firms. Equation (10) is the channel through which the fiscal authority can finance inspection activity. The increasing probability of detection directly affects firms that are incentivized to be more compliant (see equations 1-4), according to the empirical evidence. Therefore, beside our spending-based consolidation plan entailing a tax rates reduction, a higher detection denotes another political tool to downsize tax evasion. Our results show that combining these two devices, the redistributive process of resources between the sectors is stronger.

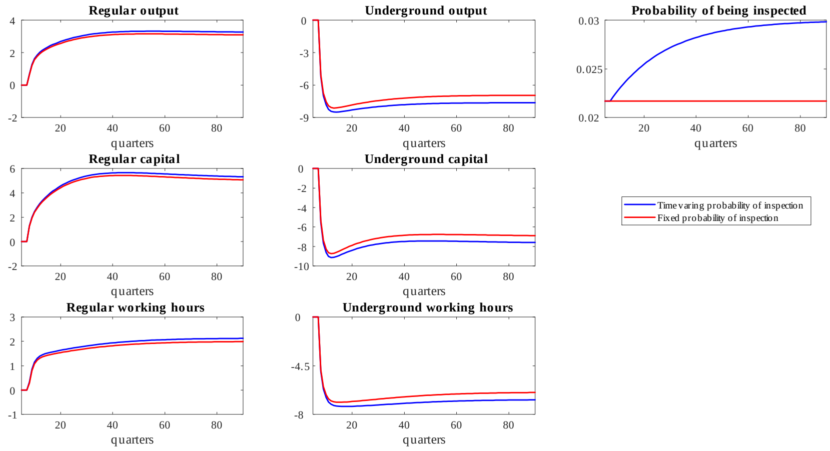

Fig.2 Short-run effects of fiscal consolidation with time varing and fixed detection.

3.2.3 The role of fiscal policy and automatic stabilizers

In this subsection we investigate the role of an active fiscal policy that employs automatic stabilizers to hamper the recessionary effect stemming from fiscal consolidation. To this purpose in Figure 3 we compare results obtained with the two alternative tax rules (eq. 12 and 13) presented in Subsection 2.3. With tax stabilizers (blue line), taxes undershoot their new steady state. In that case, the reallocation of resources from the underground to the regular sector is even more pronounced, as emphasized by the underground output dynamics. Therefore, introducing automatic stabilizers while a consolidation plan works in an economy with underground sector not only solves the recessionary effect, as it happens in an economy without tax evasion (Ferrara and Tirelli, 2017), but implies a boom. This is due to the buffer effect of reallocation of resources stemming from the work of automatic stabilizers that is added to the presence of irregular sector.

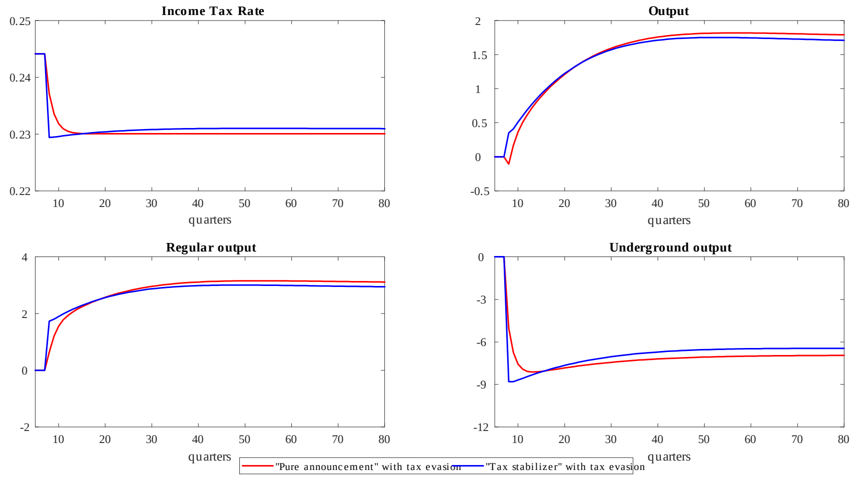

Fig.3 Tax reduction "announcement" vs tax stabilizers

4 Conclusions and Policy Messages

This paper investigates the effects of fiscal consolidation for the Italian economy, characterized by a high level of public debt and a sizable tax evasion. In this context, we design a spending-based consolidation plan, associated with a permanent drop in the income tax rate, in a two-sector DSGE model. Our results show that the reduction in the income tax rate incentivizes the agents to reallocate their resources from the underground sector towards the regular one, both in the short- and in the long-run. This, in turn, increases tax compliance by allowing the government to reduce more the income tax rate and balance its budget constraint.

Hence, what could policy makers make out of the conclusions of this paper? We provide a threefold policy message. First, it is possible to implement a consolidation plan that can both reduce public debt and tax evasion via a reallocation of resources from the underground to the regular sector. Second, such a reallocative effect is even stronger with increasing detection. Third, in this context an active fiscal policy employing automatic stabilizers can avoid the albeit slight output losses due to a spending-based fiscal consolidation.

Our exercise is the first attempt to analyze the effects of fiscal consolidation in a deterministic model characterized by tax evasion. In our model, the fiscal consolidation plan works in presence of a tax evasion that turns out to be very responsive to changes in fiscal maneuvers. Hence, we refer to particular cases in which operating in the market or in the underground sector is driven only by the economic aspect. In other words, we refer to a convenience tax evasion, as actually most of the Italian tax evasion presents itself, rather than to a survival tax evasion. In that sense, our paper provides a new perspective of tax evasion as an amplifier of the fiscal space. It is worth notitng to highlight here that the aim is not to support fiscal elusion phenomena. Instead, it is to demonstrate that accounting for tax evasion is crucial to better understand the effects of fiscal adjustment plans. The key point is to find out the appropriate incentives that allow the reallocation of resources from the underground to the regular sector. In that sense, our paper could fit in the context of proposals for re-emergence policies.

Our work leaves out several important issues as distributional effects among heterogeneous agents and detection activities on households' behavior. We leave these extensions for future research.

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5 Appendix A: The Model

5.1 Firms

As in Orsi et al. (2014)[14], each firm i uses regular labor, $n^m_{i,t}$, and regular capital, $k^m_{i,t}$, to produce regular output via a Cobb–Douglas production function

$$y^m_{i,t} = \left(n^m_{i,t}\right)^{\alpha} \left(k^m_{i,t}\right)^{1-\alpha} \tag{A1}$$

where $\alpha \in (0,1)$. Each unit of corporate income, defined as output produced net of labor costs, is taxed at the stochastic corporate tax rate, $\tau^f < 1$. However firms can evade taxes producing underground output. To do that, they use unofficial labor $n^u_{i,t}$, and irregular capital $k^u_{i,t}$ as follows:

$$y^u_{i,t} = \left(n^u_{i,t}\right)^{\alpha_u} \left(k^u_{i,t}\right)^{1-\alpha_u} \tag{A2}$$

where $\alpha_u \in (0,1)$ and $\alpha_u > \alpha$.

Goods produced in the unofficial sector are identical to regular goods and that therefore, their prices are the same and normalized to 1 in equilibrium. The total final output $y_{i,t}$ produced by a firm i at time t, can be defined as follows:

$$y_{i,t} = y^m_{i,t} + y^u_{i,t} \tag{A3}$$

A firm can produce a total output using only regular technology and therefore it uses informal technology only if it takes advantage of the opportunity that tax evasion provides.

Hence, net expected revenues $\Lambda_{i,t}$, of firm i at time t are:

$$E\left[\Lambda_{i,t}\right] = (1-\tau^f)y^m_{i,t} + (1-ps\tau^f)y^u_{i,t} + \tau^f w^m_t n^m_{i,t} + ps\tau^f w^u_t n^u_{i,t} \tag{A4}$$

where E_t denotes the mathematical expectation operator conditional on information available at time t, w^m_t and w^u_t are the wages paid for one unit of regular and unofficial labor services respectively. Firms face a stochastic probability $p \in (0,1)$ of being inspected and forced to pay the tax rate τ^f on the underground production (net of labor costs), augmented by a penalty surcharge factor $s > 1$.

Expected total cost, namely $\Phi_{i,t}$, are then given by:

$$E\left[\Phi_{i,t}\right] = (1+\tau^{f,s})w^m_t n^m_{i,t} + (1+ps\tau^{f,s})w^u_t n^u_{i,t} + r^m_t k^m_{i,t} + r^u_t k^u_{i,t} \tag{A5}$$

[14] See also Annichiarico and Cesaroni (2017).

where $\tau^{f,s} < 1$ denotes the social security contribution rate paid by employers, r_t^m and r_t^u are the rental rates to rent a unit of capital from the regular and underground market, respectively.

The representative firm's behavior is described by the first order conditions for the (expected) profit maximization, with respect to $k_{i,t}^m$, k_{it}^u, $n_{i,t}^m$ and $n_{i,t}^u$:

$$(1-\alpha)\left(\frac{y_{i,t}^m}{k_{i,t}^m}\right) mc_t = \frac{r_t^m}{(1-\tau^f)}; \tag{A6}$$

$$(1-\alpha_u)\left(\frac{y_{i,t}^u}{k_{i,t}^u}\right) mc_t = \frac{r_t^u}{(1-ps\tau^f)}; \tag{A7}$$

$$(\alpha)\left(\frac{y_{i,t}^m}{n_{i,t}^m}\right) mc_t = \frac{(1+\tau^{f,s}-\tau^f)w_t^m}{(1-\tau^f)}; \tag{A8}$$

$$(\alpha_u)\left(\frac{y_{i,t}^u}{n_{i,t}^u}\right) mc_t = \frac{(1+ps\tau^{f,s}-ps\tau^f)w_t^u}{(1-ps\tau^f)}. \tag{A9}$$

where mc_t represents firm i nominal marginal cost. Equations (1) and (2), respectively, describe the demand for regular and irregular capital, while equations (3) and (4) respectively denote the demand for regular and irregular labor.

From equations (2) and (4) a necessary condition for an interior solution guaranteeing the existence of underground production is $(1-ps\tau^f) > 0$, meaning that real revenues from using underground factors are expected to be positive. This is the only case in which firms are incentivized to operate underground to produce final output. Otherwise, total output is entirely produced with regular technology, and therefore, firms do not evade.

5.2 Price setting equations

According to Calvo (1893), in each period firms face a probability $\left(1-\alpha^P\right)$ of changing price. Firms that with α^P probability are not allowed to optimally set the nominal price of their goods, index their price to a geometric average of past inflation and steady-state inflation:

$$P_{i,t} = P_{i,t-1}\left(\frac{P_{t-1}}{P_{t-2}}\right)^{\chi}\pi^{(1-\chi)} = P_{i,t-1}\left(\pi_{t-1}\right)^{\chi}\pi^{(1-\chi)}$$

The optimal price $\tilde{p}_t$ is chosen in order to maximize the discounted value of expected future profits. The firms' maximization problem is:

$$\max_{\tilde{p}_t} E_t \sum_{s=0}^{\infty} \left(\alpha^P \beta\right)^s \frac{P_t}{\lambda_t} \frac{\lambda_{t+s}}{P_{t+s}} \left(\tilde{p}_t \prod_{k=1}^{s} \pi_{t+k-1}^{\chi} \pi^{1-\chi} - P_{t+s} mc_{t+s} \right) y_{i,t,t+s}$$

subject to:

$$y_{i,t,t+s} = \left(\frac{\tilde{p}_t \prod_{k=1}^{s} \pi_{t+k-1}^{\chi} \pi^{1-\chi}}{P_{t+s}} \right)^{-\varepsilon} y_{t+s}^d$$

where y_t^d represents the aggregate demand and $\frac{\lambda_{t+s}}{\lambda_t}$ is the discount factor of households.

The first order condition respect to $\tilde{p}_t$ is:

$$E_t \sum_{s=0}^{\infty} \left(\alpha^P \beta\right)^s \frac{\lambda_{t+s}}{\lambda_t} \left(\frac{\prod_{k=1}^{s} \pi_{t+k-1}^{\chi} \pi^{1-\chi}}{\prod_{k=1}^{s} \pi_{t+k}} \right)^{-\varepsilon} y_{t+s}^d \left(\frac{\tilde{p}_t}{P_t} \right)^{-\varepsilon-1}$$
$$\left[\left(\frac{\tilde{p}_t}{P_t} \right) \left(\frac{\prod_{k=1}^{s} \pi_{t+k-1}^{\chi} \pi^{1-\chi}}{\prod_{k=1}^{s} \pi_{t+k}} \right) + \frac{\varepsilon}{1-\varepsilon} mc_{t+s} \right]$$

where the term $\frac{\varepsilon}{1-\varepsilon}$ represent the mark up in the absence of price stickiness.

By writing this first-order condition recursively, we can define:

$$x_t^1 = \left(\frac{\tilde{p}_t}{P_t} \right)^{-\varepsilon-1} E_t \sum_{s=0}^{\infty} \left(\alpha^P \beta\right)^s \frac{\lambda_{t+s}}{\lambda_t} \left(\frac{\prod_{k=1}^{s} \pi_{t+k-1}^{\chi} \pi^{1-\chi}}{\prod_{k=1}^{s} \pi_{t+k}} \right)^{-\varepsilon} y_{t+s}^d mc_{t+s}$$

$$x_t^2 = \left(\frac{\tilde{p}_t}{P_t} \right)^{-\varepsilon} E_t \sum_{s=0}^{\infty} \left(\alpha^P \beta\right)^s \frac{\lambda_{t+s}}{\lambda_t} \left(\frac{\prod_{k=1}^{s} \pi_{t+k-1}^{\chi} \pi^{1-\chi}}{\prod_{k=1}^{s} \pi_{t+k}} \right)^{1-\varepsilon} y_{t+s}^d.$$

By expressing recursively:

$$x_t^1 = y_t^d mc_t \tilde{p}_t^{-\varepsilon-1} + E_t \left[\left(\alpha^P \beta\right) \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{\tilde{p}_t}{\tilde{p}_{t+1}} \right)^{-\varepsilon-1} \left(\frac{\pi_t^{\chi} \pi^{1-\chi}}{\pi_{t+1}} \right)^{-\varepsilon} x_{t+1}^1 \right] \tag{A10}$$

$$x_t^2 = y_t^d \tilde{p}_t^{-\varepsilon} + E_t \left[\left(\alpha^P \beta\right) \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{\tilde{p}_t}{\tilde{p}_{t+1}} \right)^{-\varepsilon} \left(\frac{\pi_t^{\chi} \pi^{1-\chi}}{\pi_{t+1}} \right)^{1-\varepsilon} x_{t+1}^2 \right]. \tag{A11}$$

It is possible to rewriting the price setting equation as follows:

$$x_t^1 = \frac{\varepsilon - 1}{\varepsilon} x_t^2. \tag{A12}$$

5.3 Households

There exists a continuum of households, uniformly distributed over a unit interval, whose preferences are defined over private (c_t) and public (G_t) consumption, regular (n_t^m) and underground (n_t^u) labour:

$$U_{i,t} = E_{t=0}^{\infty}\beta_t \left(\frac{(c_t)^{1-q}}{1-q} - H\frac{(n_t^m + n_t^u)^{1+\varphi}}{1+\varphi} - H_1\frac{(n_t^u)^{1+\eta}}{1+\eta} + \xi G_t \right) \quad \text{(A13)}$$

where β is a discount factor and $q > 0$ is the inverse of the intertemporal elasticity of substitution. The terms $H\frac{(n_t^m+n_t^u)^{1+\varphi}}{1+\varphi}$ and $H_1\frac{(n_t^u)^{1+\eta}}{1+\eta}$ spectively reflect the overall disutility of working and the idiosyncratic cost of working in the underground sector. Hence H and H_1 are preference parameters controlling for the disutility of total and underground working activities. Parameters denoting the inverse of labor supply elasticities of aggregate and underground labor supplies respectively are $\varphi > 0$ and $\eta > 0$. Finally, ξ is the weight of public spending in the utility function.

The capital stock, k_t, own by households, evolves according to the following law of motion:

$$k_{t+1} = i_t + (1-\delta)k_t \quad \text{(A14)}$$

where i_t denotes the investment at time t, and $\delta \in [0,1]$ is the capital depreciation rate.

Households' budget constraint reads as:

$$c_t + i_t + R_t^{-1}b_{t+1}^g = (1-\tau_t^h)(w_t^m n_t^m + r_t^m k_t^m) + w_t^u n_t^u + r_t^u k_t^u + b_t^g \quad \text{(A15)}$$

where $w_t^u n_t^u + r_t^u k_t^u$ is the underground-produced income flows that is not subject to the stochastic income tax rate τ_t^h. This assumption implies that households might elude income taxes by supplying capital and labor services in the underground market. In addition, households are assumed to purchase nominally riskless bonds b_{t+1}^g in period t and maturing at $t+1$. The price at time t of these assets is equal to R_t^{-1}, which is the inverse of the risk-free nominal (gross) interest rate. The capital stocks supplied by households in the regular and underground markets satisfy the following:

$$k_t = k_t^m + k_t^u. \quad \text{(A16)}$$

Households' maximization problem implies the following optimal conditions:

$$\lambda_t = (c_t)^{-q} \tag{A17}$$

$$(1-\tau_t^h)w_t^m = \frac{H\,(n_t^m + n_t^u)^{\varphi}}{\lambda_t} \tag{A18}$$

$$w_t^u = \frac{H\,(n_t^m + n_t^u)^{\varphi} + H_1\,(n_t^u)^{\eta}}{\lambda_t} \tag{A19}$$

$$\lambda_t = \beta_t E_t \lambda_{t+1}\left[(1-\tau_{t+1}^h)r_{t+1}^m + (1-\delta)\right] \tag{A20}$$

$$\lambda_t = \beta_t E_t \lambda_{t+1}\left[r_{t+1}^u + (1-\delta)\right] \tag{A21}$$

$$\lambda_t = \beta_t E_t \lambda_{t+1} R_t^{-1}. \tag{A22}$$

where λ_t is the Lagrange multiplier for the constraint (A15).

Equations (5) and (6) describe the (total) labor supply schedule and the optimal allocation of time for working activities in the underground sector, respectively. Equation (7) is the Euler equation for regular capital, while Equation (8) determines the optimal allocation of capital supplied to the irregular market, implying that at equilibrium the real rate r_t^u is equal to the net-of-tax rental rate of official capital.

By combining equations (5) and (6) and solving for n_t^u, we obtain:

$$n_t^u = \boldsymbol{\lambda}_t^{\frac{1}{\eta}} \left(\frac{w_t^u - w_t^m(1-\tau_t^h)}{H_1}\right)^{\frac{1}{\eta}} \tag{A23}$$

if $w_t^u - w_t^m(1-\tau_t^h) > 0$; otherwise, $n_t^u = 0$.

Equation (9) means that households supply labor services in the underground sector if the wage that they earn from this activity is higher than the net real regular wage.

5.4 Aggregation

In equilibrium, all firms produce the same quantity of goods, using the same amount of regular and irregular factors. Hence the following conditions are satisfied for all t:

$n_t^m = \int_0^1 n_{i,t}^m\, di$; $n_t^u = \int_0^1 n_{i,t}^u\, di$; $k_t^m = \int_0^1 k_{i,t}^m\, di$; $k_t^u = \int_0^1 k_{i,t}^u\, di$; $y_t^m = \int_0^1 y_{i,t}^m\, di$; $y_t^u = \int_0^1 y_{i,t}^u\, di$.

The market clearing condition for the goods follows:

$$c_t + i_t + G_t = y_t \tag{A24}$$

where $y_t = \int_0^1 y_{i,t}\, di$.

Finally, the aggregate consumption is:

$$y_t^d = c_t + i_t + G_t \tag{A25}$$

where $y_t^d = \int_0^1 y_{i,t}^d\, di$.

5.5 Market clearing

The equilibrium in the good market is given by:

$$y_t = y_t^d * s_t \tag{A26}$$

where s_t represents the price dispersion in the Calvo model. It follows:

$$s_t = (1 - \alpha^P)\tilde{p}_t^{(-\varepsilon)} + \alpha^P \left(\frac{\pi_t}{\pi_{t-1}^{\chi} \pi^{(1-\chi)}} \right)^{\varepsilon} s_{t-1} \tag{A27}$$

where $\tilde{p}_t$ is the aggregate price index that satisfy:

$$1 = \alpha^P \pi_t^{(\varepsilon-1)} \left(\pi_{t-1}^{\chi} \pi^{(1-\chi)} \right)^{(1-\varepsilon)} + (1 - \alpha^P)\tilde{p}_t^{(1-\varepsilon)}. \tag{A28}$$

5.6 Fiscal sector

In each period the Government finances an exogenous stream of expenditures by issuing risk free bonds and by collecting taxes. Hence, the period government budget constraint is described as follows:

$$\begin{aligned} G_t + b_t^g &= \tau_t^h (r_t^m k_t^m + w_t^m n_t^m) + (\tau^{f,s}) w_t^m n_t^m + (ps\tau^{f,s}) w_t^u n_t^u \\ &\quad + \tau^f (y_t^m - w_t^m n_t^m) + ps\tau^f (y_t^u - w_t^u n_t^u) + \frac{b_{t+1}^g}{R_t} \end{aligned}$$

where b_t^g is the outstanding stock of debt. $\tau_t^h(r_t^m k_t^m + w_t^m n_t^m)$ represent the total fiscal revenues from personal income taxation, $(\tau^{f,s})w_t^m n_t^m + (ps\tau^{f,s})w_t^u n_t^u$ is total fiscal revenues from social security contributions and finally, the term $\tau^f(y_t^m - w_t^m n_t^m) + ps\tau^f(y_t^u - w_t^u n_t^u)$ is total fiscal revenues from corporate taxation.

5.7 Monetary Policy

We assume that the Central Bank sets the nominal interest rate according to the following standard rule:

$$\frac{R}{R^*} = \left(\frac{\pi}{\pi^*}\right)^{\phi_\pi^R} \tag{A29}$$

where $R^*$and π^* respectively represent the target nominal interest rate and the steady state inflation rate.

6 Appendix B: Baseline Calibration

Parameters values and their description are summarized in Table 3. The baseline calibration of structural parameters follows Orsi et al. (2014) who estimate a DSGE model for the Italian economy. More specifically, the discount factor, β, is set equal to 0.984 and the capital depreciation rate, δ, is calibrated at 0.0355. The preference parameters φ and η are estimated to be equal to 1.7333 and 0.9297, respectively. The parameter denoting intertemporal elasticity of substitution, q, is fixed at 0.9985. The steady-state value of the total number of hours worked in the economy $n^m + n^u = 0.19$, is consistent with previous studies (Orsi et al (2014) and Annichiarico and Cesaroni (2017))[15]. Furthermore, the parameter ξ, representing the weight of public spending in the utility function, is set at a level such that g is optimal related to the social planner choice[16].

The elasticity of labor in the regular technology, α, is assumed to be equal to 0.6379. Instead, the elasticity of labor in the underground production function, α_u, is set at 0.6665.

Regarding the price-setting parameters, we set the elasticity of substitution between tradable goods ε at 6, and the degree of price stickiness α^Pat 0.69, following Annichiarico and Cesaroni (2017).

As for monetary policy, the parameter governing inflation stabilization ϕ_π^R in (A29) is set at 1.5 according to the value that is commonly used in literature.

[15]Specifically, as in Orsi et al. (2014), we set the first steady-state level of the total number of hours worked in the underground sector ($\frac{n^u}{n}$) equal to 0.13 so that the first steady-state value of n^m and n^u is equal to 0.1653 and 0.0247, respectively. This calibration delivers implicit the first steady-state values for the scale parameters regulating labor disutility in the agents' preferences (H, H_1).

Instead, in the model without tax evasion the total number of hours worked (0.19) is totally ascribed to the regular sector.

[16]Being the weight of public spending in the utility function determined endogenously, it changes accordingly to the different frameworks. Specifically, in the model without tax evasion, the weight of public spending in the utility fucntion is equal to 3.3443. Instead, in the model with dynamic detection, it is equal to 3.4338.

Table 3

Parameter Values

Households		
β	0.984	Discount factor
δ	0.0355	Capital depreciation rate
η	0.9297	Inverse of elasticity of underground labor supply
φ	1.7333	Inverse of elasticity of total labor supply
q	0.9985	Intertemporal elasticity of substitution
ξ	3.4346	Weight of public spending in the tax evasion model
Firms		
α	0.6379	Regular technology parameter
α_u	0.6665	Underground technology parameter
α^P	0.69	Calvo price
ε	6	Price elasticity of demand for a specific good variety
χ	0.5	Price indexation
Monetary authority		
ϕ_π^R	1.5	Inflation stabilization