Working Papers

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CESIFO WORKING PAPER NO. 6015
CATEGORY 6: FISCAL POLICY, MACROECONOMICS AND GROWTH
JULY 2016

ISSN 2364-1428

CESifo *Working Paper No. 6015*

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Abstract

This paper contributes to the GDP-consumption comovement puzzle literature investigating the role of tax evasion in explaining the consumption path after a Marginal Efficiency of Investment shock. We use an otherwise standard medium-scale New Keynesian DSGE model combining tax evasion with financial frictions à la Bernanke, Gertler, Gilchrist (1999). The main result of our paper shows that tax evasion can considerably shrink the GDP-*consumption comovement puzzle* area.

JEL-Codes: E220, E320, E440, E510, E620, G100, G210, G300, H200.

Keywords: tax evasion, investment shocks, DSGE modelling, financial frictions, GDP-consumption comovement puzzle.

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July, 2016
We thank Barbara Annichiarico and Roberta Cardani for useful comments and suggestions.

1 Introduction

Since Sims (1980) and Kydland and Prescott (1982), explaining the sources of economic fluctuations is one of the most debated issues in the macroeconomic literature. Structural VAR studies (Fisher, 2006) and contributions using both Bayesian (Justiniano et al., 2010, 2011; Khan and Tsoukalas, 2012) and classical techniques (Christensen and Dib, 2008) have provided evidence that Marginal Efficiency of Investment shocks (MEI shocks, hereafter) are the main drivers of economic fluctuations in the post-war US data (see also Furlanetto, Natvik, Seneca, 2013). However, since the seminal paper by Barro and King (1984) it is well known that consumption falls after an expansionary MEI shock (that reduces capital installation costs), or equally rises after a recessionary MEI shock. This is at odds with the empirically identified business cycles (King and Rebelo, 1999) and generates the so-called *GDP-consumption comevement puzzle*. Therefore the consumption response to MEI shocks has gained considerable attention in the New Keynesian literature.

Several contributions aim to overcome the puzzle introducing different mechanisms: variable capacity utilization in production (Greenwood et al., 1988; Khan and Tsoukalas, 2011); non separable preferences with price rigidities (Furlanetto and Seneca, 2013); rule of thumb consumption in a standard DSGE model (Furlanetto et al., 2013); financial frictions in a sticky price model (Reza, 2014).

Our paper contributes to this literature investigating the role of an alternative important channel, namely tax evasion, to explain the consumption path after a negative MEI shock.

As a matter of fact, since the seminal papers by Allingham and Sandmo (1972) and Yitzhaki (1974), the scarce literature on tax evasion has spread out over time given its far from negligible effects on the key macroeconomic variables, both in the short- and in the long-run (Slemrod and Yitzhaki, 2002). Actually, tax evasion represents a relevant phenomenon to explain business cycles (Busato and Chiarini, 2004). Other important contributions focused on tax evasion, or more in general on informal economy, in DSGE frameworks are Conesa Roca et al. (2001), Granda-Carvajal (2010), Orsi et al. (2013), Annichiarico and Cesaroni (2016).

Meanwhile, after the recent financial crises, several studies (see Christiano, Motto, Rostagno 2004, 2008, 2010, 2014 (CMR, hereafter); Christiano, Trabandt, Walentin, 2011) have emphasized the crucial role of financial factors too as prime determinants of business fluctuations.

This paper simulates a negative MEI shock within a DSGE model in the spirit of Smets and Wouters (2003) and Christiano et al. (2005), combining tax evasion with financial frictions à la Bernanke, Gertler, Gilchrist (1999), (BGG henceforth). In particular, our reference paper is CMR. We replicate this model augmented with tax evasion, aiming to analyze its role in explaining the business cycle.

There are actually very few other contributions linking informal economy and financial factors. They are Colombo et al. (2015) who, assuming that financial operations are costly, extend the DSGE model by Carlstrom and Fuerst (1997) to consider both official and unofficial sectors of the economy. Moreover, the paper by Mitra (2014) analyzes a DSGE model accounting for formal and informal firms distinguishing each other for paying or not taxes. In their model financial frictions endogenously arise as in Kiyotaki and Moore (1997).

We depart from these not many contributions for two aspects. Besides joining tax evasion with the financial accelerator mechanism à la BGG, we introduce tax evasion at subcontracting level. In other words, we assume that the evading agent is not the firm producing output, as it is standard in the underground economy literature. Differently, we account for tax evasion implemented by the entrepreneur, who is the key player in the financial accelerator framework because he runs up debts with bank and his loans are risky. In this setting, tax evasion provides to the entrepreneur additional financial resources to his net worth and an alternative to bank loans. Actually, self-financing and tax evasion are directly correlated through two crucial channels:

- first: tax evasion directly affects the entrepreneur's rate of return on capital, entailing therefore his net worth variatons (self-financing effect);

-second: tax evasion is directly correlated with the entrepreneur's ability to survive, which, in turn, impacts on his net worth (survival effect).

Overall, this means that the tax evasion mechanism we have modeled is far from being neutral with respect to the BGG framework.

As a matter of fact, the effects produced by tax evasion on the driving force of the financial accelerator, namely the entrepreneurial net worth, via the two transmission mechanisms mentioned above, importantly conditions the households' decisions about their intertemporal consumption profile. In fact the CMR model, assumes that the net worth of entrepreneurs exiting the economy is addressed to households, as lump-sum transfers, and then consumed.

In a nutshell, the main result of our paper is the sizable shrinkage of the GDP-consumption comovement puzzle area via the entrepreneurial tax evasion.

The rest of the paper is organized as follows. Section 2 describes the model, mainly focusing on tax evasion aspects and less lingering on the financial frictions feaures well explained in the existing literature (see BGG, CMR, 2010, 2014). Section 3 reports some U.S. stylized facts on American tax evasion. Section 4 presents the parameters' calibration. Section 5 shows the results focusing on the *GDP-consumption comovement puzzle* phenomenon. Section 6 reports some robustness. Finally, section 7 concludes.

2 The U.S. Stylized Facts on the American Tax Evasion

Our paper refers to the U.S. tax evasion, although this is a global phenomenon. Alm (1999), Andreoni, Erard, and Feinstein (1998), and Slemrod and Yitzhaki (2002), Maffezzoli (2011), Cebula and Feige (2011) importantly contribute to the literature on tax evasion in the U.S.

Although it is not often highlighted, the role of the underground economy and tax evasion for the US economy is certainly not negligible. Determining the extent of tax evasion is not straightforward for obvious reasons. However, some estimates report a significant and complex phenomenon. In the United States, the Internal Revenue Service (IRS, 2012) estimate of the 2001 tax gap was $345 billion($290 billion net). Slemrod (2007) breaks down the aggregate estimates and describes in details the complexity and the extension of the phenomenon in the U.S. (see also Johns and Slemrod 2010). The IRS noncompliance estimations of corporation income tax in 2001 amount to $30 billion (17% of amount that should have been reported). The Bureau of Economic Analysis calculates that the annual measure for 2000 of the ratio of corporate tax misreporting to actual liability is about 14%. Similar estimates are reported in Hanlon, Mills and Slemrod (2005). These authors, using a dataset of audit and appeals records, matched with tax returns and financial statements of several thousand corporations, find that noncompliance is generally a progressive phenomenon, meaning that noncompliance as a fraction of a scale measure increases with the size of the company.

The IRS (2012, 2016) estimates that the net tax gap in 2006 was $385 billion, rising to 406 billion in tax years 2008-2010. (Americans underreported $450 and $458 billion in taxes, but the IRS recovered $65 and 52 billion in 2006 and in 2008-2010, respectively). In the IRS report emerges that most evasion takes the form of underreporting and underpayment, not non-filing. The amount of dollars lost to underreporting rose by 32% between 2001 and 2006; one-third of that increase came in the corporate income tax. Of the $450 billion gross tax gap, $376 billion of it comes from underreporting income. $235 billion is on individual income tax, of which $122 billion is business income (in addition, $57 billion in self-employment tax that is underreported). Finally, $67 billion of corporate income tax due was underreported (this is only illegal tax evasion, abusive corporate tax avoidance, some of which will be declared illegal retroactively, would add many billions more).

Cebula and Feige (2011), employing a version of the Feige's (1989) general currency ratio model, estimate the 2008 tax gap in the range of $450 to $500 billion, and unreported income to be approximately $2 trillion.Thus, 18 to 19 percent of total reportable income is not properly reported to the IRS.

These data are largely based on operational audits, and one should be cautious in their analysis. However, the data show that evasion in business plays an important role in U.S.

3 The Model

In this section, beyond providing an overview of the CMR model, we especially focus on the innovative aspects we introduce about tax evasion[1]. Therefore, the model embodies tax evasion in a medium-scale Dynamic Stochastic General

[1] In the rest of the paper, we use the term underground production and tax evasion as synonymous.

Equilibrium Model (DSGE) augmented with the financial accelerator mechanism à la BGG. Although the majority of parts of the model can be found in CMR, we include them anyhow so that presentation may be self-contained[2].

There are seven agents populating the economy: households, firms, entrepreneurs, capital producers, a representative retail bank, the government sector and the monetary policy authority.

Households consume, supply labor services in monopolistic competition to intermediate good firms and allocate savings to the bank, then receiving the interests.

The bank uses households deposits to generate liquidity services provided to entrepreneurs.

Monopolistic intermediate good firms use labor and capital services to produce a continuum of differentiated goods. Perfectly competitive final good firms buy the intermediate goods and produce the final output, then converted into consumption goods, investment goods and public goods.

Capital producers, whose profits accrue to households, combine investment goods and raw capital purchased by final firms and entrepreneurs respectively to produce new capital.

In turn, entrepreneurs purchase new capital, using two sources of finance:

- their own net worth augmented with expected additional profits originating from tax evasion;

- external finance from the bank.

As in BGG, there exists a problem of asymmetric information. In fact, entrepreneurial loans are risky because returns on the underlying investments are subject to idiosyncratic shocks. While the entrepreneur observes his actual payoff costlessly, the bank must pay a monitoring cost. To mitigate problems stemming from the asymmetric information issue, bank and entrepreneurs sign a debt contract. Under this contract, the enterpreneur commits to paying back the loan and a non-default interest rate, unless it declares default. In the latter case, the bank supports a costly verification of the residual value of the enterpreneur's asset that are evaluated as a partial compensation of the loss.

After entrepreneurs purchase new capital from capital producers, they optimally choose the capacity utilization of capital and then rent it out to intermediate firms. At this stage, entrepreneurs can decide to declare only a share of the total capital utilization thus saving capital tax liabilities, if not detected. Otherwise, they must pay the tax and and an over-tax to the government.

Public spending represents a fraction of total output and is financed by lump-sum taxes levied to households. It's assumed that government budget constraint is always balanced.

The monetary policy authority follows a standard Taylor rule to set the nominal interest rate.

[2] However, for further clarifications about the general model, see CMR and the CMR appendix on line.

3.1 Firms

Final output, $Y_{t,}$is produced by a perfect competitive firm according to the following technology:

$$Y_t = \left[\int_0^1 Y_{jt}^{\frac{1}{\lambda_{f,t}}} dj \right]^{\lambda_{f,t}}, 1 \leq \lambda_{f,t} < \infty \tag{1}$$

where $\lambda_{f,t}$ is the intermediate goods shock.

The intermediate goods firms monopolistically produce intermediate output Y_{jt} using the following technology:

$$Y_{jt} = \epsilon_t \left(u_{tj} K_{tj} \right)^{\alpha} \left(z_t l_{jt} \right)^{(1-\alpha)} - \Phi z_t^* \tag{2}$$

where Φz_t^*denote the fixed costs in production.

Equation (2) holds if $\left(u_{tj} K_{tj} \right)^{\alpha} \left(z_t l_{jt} \right)^{(1-\alpha)} > \Phi z_t^*$. Otherwise, $Y_{jt} = 0$.

K_{tj} and l_{jt} represent the services of capital and homogeneous labor, u_{tj} is the utilization rate of capital. ϵ_t is a stationary shock to technology and z_t denotes the persistent component of technology, having the following representation:

$$z_t = \mu_{z,t} z_{t-1}$$

where $\mu_{z,t}$ is a stationary stochastic process.

The fixed costs of production are summarized by the parameter Φ that is proportional to z_t^*. This is the growth rate of output determined by the following condition:

$$z_t^* = z_t \Upsilon^{\left(\frac{\alpha}{1-\alpha} t \right)}, \Upsilon > 1$$

where Υ is the investments growth parameter.

Y_{jt} is monopolistically supplied according to the Calvo (1983) sticky price mechanism. Hence, in each period a fraction $(1 - \xi_p)$ of firms is able to update prices and a fraction ξ_p is not able to adjust and set the price according to $P_{jt} = \widetilde{\pi}_t P_{jt-1}$, where the indexation term $\widetilde{\pi}_t$ evolves following: $\widetilde{\pi}_t = \left(\pi_t^{\text{target}} \right)^{\iota} \left(\pi_{t-1} \right)^{(1-\iota)}$. In particular, $\pi_{t-1} \equiv \frac{P_{t-1}}{P_{t-2}}$, P_t is the price of Y_t and π_t^{target} is the target inflation rate in the monetary policy rule.

3.2 Capital Producers

There is a large number of identical capital producers, which are owned by households, who receive profits in terms of lump-sum transfers.

At the end of period t, capital producers purchase investment goods I_t from final firms and the undepreciated fraction of capital, x, from entrepreneurs[3]. Then, they combine them to produce new capital x' to resell to the entrepreneurs. Therefore, the capital producer solves the following maximization problem:

[3] x is previously used in the period t production process from entrepreneurs.

$$\max_{\{I_{t+j},x_{t+j}\}} E_t \left\{ \sum_{j=0}^{\infty} \beta^j \lambda_{t+j} \Pi_{t+j}^k \right\} \tag{3}$$

where E_t is the mathematical expectation term at time t, β^j is the subjective discount factor and λ_{t+j} denotes the Lagrange multiplier on the household's budget constraint. Π_{t+j}^k is defined as follows:

$$\Pi_t^k = Q_{k,t}\left[x + \left(1 - S\left(\zeta_{i,t} I_t / I_{t-1}\right)\right) I_t\right] - Q_{k,t}x - \frac{P_t}{\Upsilon^t \mu_{\Upsilon,t}} I_t \tag{4}$$

where $Q_{k,t}$ is the price of the new and used capital[4]. $S\left(\zeta_{i,t} I_t / I_{t-1}\right)$ represent the installation costs where a positive $\zeta_{i,t}$ is a negative disturbance to the marginal efficiency of investments. Hence it raises installation costs, leading the economy in a recessionary phase[5]. $\mu_{\Upsilon,t}$ is the stationary shock to the relative price of investment.

Solving the capital producer's problem, the optimality condition reads as:

$$E_t\left[\lambda_t Q_{k,t} F_{1,t} - \lambda_t \frac{P_t}{\Upsilon^t \mu_{\Upsilon,t}} + \beta \lambda_{t+1} Q_{k,t+1} F_{2,t+1}\right] = 0 \tag{5}$$

where the price of installed capital $Q_{k,t}$ is linked to the price of investment goods $\frac{P_t}{\Upsilon^t \mu_{\Upsilon,t}}$[6].

Moreover, the aggregate stock of physical capital evolves according to:

$$\overline{K}_{t+1} = (1-\delta)\overline{K}_t + \left(1 - S\left(\zeta_{i,t} I_t / I_{t-1}\right)\right) I_t \tag{6}$$

where δ is the capital depreciation parameter.

3.3 Entrepreneurs

The entrepreneur supplies capacity utilization of capital to the intermediate firms. In this model, entrepreneur is the main agent both because he is the key player of the financial accelerator mechanism and because he is assumed to evade taxes. The reason for the assumption about this additional self-financing source is the following. We want to stress the self-financing component tax evasion/bank loans alternative in a financial frictions framework. The idea is that the self-financing component tax evasion directly affects the entrepreneurial net worth. Therefore, if net worth increases the necessity to borrow decreases and viceversa.

We can summarize the entrepreneur's actions as follows. At the end of each period t, the entrepreneur purchases new physical capital $\overline{K}_{t+1}$ from capital

[4] The marginal rate of transformation from previously installed capital to new capital is unity.

[5] According to Christiano, Eichenbaum ed Evans (2005), S satisfies the following properties: $S = S' = 0$ and $S'' > 0$

[6] See Verona (2012) for functional forms.

producers using three financing sources. They are two self-financing sources, namely net worth and profits originating from lower tax liabilities due to tax evasion (if there's no detection) plus the bank loans. Among these, the entrepreneurial loan is risky by definition. In fact, the entrepreneur faces an idyosincratic productivity shock ω such that the purchased capital $\overline{K}_{t+1}$ actually is $\omega\overline{K}_{t+1}$[7]. At time $t+1$, after he has observed the shock, he optimally chooses the level of capacity utilization of capital to supply to the intermediate firm. At this time, the decision of tax evasion enters in the analysis, since the entrepreneurs' profits are subject to taxation with a marginal tax rate τ_t^k. The entrepreneur is given the possibility to engage in tax evasion. In other words, he can decide to declare only a part of his profits, the henceforth called *market* capacity utilization u_t^m, while the *underground* capacity utilization remains unreported. In doing so, we assume that he is able to relate two components, market and underground, to a specific part of the costs of production.

Moreover,

$$u_{t+1}^m + u_{t+1}^u = u_{t+1} \tag{7}$$

where u_{t+1} is the aggregate capital utilization. Thus, the entrepreneur rents out capital services in competitive markets to the intermediate firms, namely $u_{t+1}^m\overline{K}_{t+1}$ and $u_{t+1}^u\overline{K}_{t+1}$. However, in each period he faces a probability, $\rho \in (0,1)$, of being inspected and forced to pay back the total amount evaded, increased by an over-tax $s > 1$[8]. Following the American tax laws, penalty is imposed on the evaded tax (see Sandmo, 2005). Moreover, since we want to limit tax evasion behavior only to the entrepreneur, in order to purely stress how his three financing sources get along with each other, we assume that the entrepreneurial tax evasion does not affect firms' behavior. In fact, firms don't care about the type of capital utilization rate they receive and pay r_t^k, whatever the component is. More specifically, although the entrepreneur produces one single output, namely the capacity utilization sold at price r_t^k to the intermediate firm, the after tax price he receives from the two components is different. In this sense, the tax evading entrepreneur is similar to a firm producing in a multiproduct setting, with a separable production function (see Gravelle and Rees, 1988).

High capital utilization entails high costs in terms of goods. Hence the following convex function, which for simplicity, is defined to be equal both for the market and the underground component, reads as[9]:

$$P_{t+1}\Upsilon^{-(t+1)}\tau_{t+1}^{oil}a\left(u_{t+1}^m\right)\omega\overline{K}_{t+1} \tag{8}$$

[7] ω is a unit mean, lognormally distributed random variable across all entrepreneurs.

[8] In order to avoid corner solutions we set the following restriction on s such that $s > 1$ and $\rho < (1/s)$ (see Chiarini et al., 2011). Moreover $\rho < (1/s)$ guarantees to avoid to pay an higher tax on the underground component.

[9] According to the the U.S. data, we assume that $u^m = 0.92$ and $u^u = 0.08$.Therefore, as in the literature (see, among the others, CMR), $u = 1$. Moreover, for the market component, we assume that $a(u^m) = 0$, $a'(u^m) = r^k$ and $a''(u^m) = \sigma_a r^k$. Equally, for the underground component: $a(u^u) = 0$, $a'(u^u) = r^k$ and $a''(u^u) = \sigma_a r^k$.

where $a', a'' > 0$ and

$$P_{t+1}\Upsilon^{-(t+1)}\tau_{t+1}^{oil}a\left(u_{t+1}^{u}\right)\omega\overline{K}_{t+1} \tag{9}$$

where $a', a'' > 0$[10] and τ_{t+1}^{oil} is an exogenous process relative to the real price of oil.

Literature on tax evasion generally assumes that tax payer is risk neutral (see Sandmo 2005). In the light of that, we assume that the entrepreneur maximizes the expected profits, choosing u_{t+1}^{m} and u_{t+1}^{u}[11]:

$$\max_{u_{t+1}^{m},u_{t+1}^{u}} \left(1-\tau^{k}\right)\left[u_{t+1}^{m}r_{t+1}^{k}-\tau_{t+1}^{oil}a\left(u_{t+1}^{m}\right)\right]\Upsilon^{-(t+1)}\omega\overline{K}_{t+1}+$$
$$+\left(1-\tau^{k}\rho s\right)\left[u_{t+1}^{u}r_{t+1}^{k}-\tau_{t+1}^{oil}a\left(u_{t+1}^{u}\right)\right]\Upsilon^{-(t+1)}\omega\overline{K}_{t+1}$$

The two capital utilization rates are derived from the following system:

$$r_{t+1}^{k}=\tau_{t+1}^{oil}a'\left(u_{t+1}^{m}\right) \tag{10}$$

$$r_{t+1}^{k}=\tau_{t+1}^{oil}a'\left(u_{t+1}^{u}\right) \tag{11}$$

where equation (11) holds only if $\rho s < 1$. In other words, equation (11) states that for tax evasion to be optimal from the entrepreneur's viewpoint, it's a necessary and sufficient condition that the expected penalty rate is less than the regular tax rate[12].

For a risk neutral entrepreneur receiving the idiosyncratic productivity shock ω, at the end of time t, the rate of return on capital (i.e. the total capital gain deriving both from renting capital services to intermediate firms and from selling undepreciated capital to capital producers), augmented with the enforcement parameters, reads as:

$$R_{t+1}^{k}=\left[\frac{E_{t+1}\Pi_{t+1}+(1-\delta)\,q_{t+1}}{\Upsilon q_{t}}\right]\pi_{t}+\tau^{k}\delta-1 \tag{12}$$

---

[10] Following Verona (2012), for the market component it holds: $a\left(u_{t}^{m}\right)=\frac{r^{k}}{\sigma_{a}}\left\{\exp\left[\sigma_{a}\left(u_{t}^{m}-u^{m}\right)\right]-1\right\}$ and $a'\left(u_{t}^{m}\right)=r^{k}\left\{\exp\left[\sigma_{a}\left(u_{t}^{m}-u^{m}\right)\right]\right\}$.

Equally, for the underground component: it holds: $a\left(u_{t}^{u}\right)=\frac{r^{k}}{\sigma_{a}}\left\{\exp\left[\sigma_{a}\left(u_{t}^{u}-u^{u}\right)\right]-1\right\}$ and $a'\left(u_{t}^{u}\right)=r^{k}\left\{\exp\left[\sigma_{a}\left(u_{t}^{u}-u^{u}\right)\right]\right\}$. r^{k} is the steady state value of the rental rate of capital.

[11] Here, we are attributing a large technology advantage to the tax evading agent that is able to split adjustment costs.

In fact, we are assuming that:

$$a(u_{t+1})=u_{t+1}^{m}a(u_{t+1}^{m})+u_{t+1}^{u}a(u_{t+1}^{u})$$

where the adjustment is the weighted sum of the two components and the weight is the instantaneous capital utilization rate of the two sectors.

On the other hand, this assumption, although not neutral, is necessary to allow to disentangle the market and the underground contribution to profits. Moreover, it is consistent with the hypothesis of a separable production function.

[12] See Sandmo (2005) for further details about the empirical evidences about this condition.

where

$$
\begin{aligned}
E_{t+1}\Pi_{t+1} \quad \equiv \quad & (1-\tau^k)\left[u^m_{t+1}r^k_{t+1}-\tau^{oil}_{t+1}a\left(u^m_{t+1}\right)\right]+ \\
& +(1-\tau^k\rho s)\left[u^u_{t+1}r^k_{t+1}-\tau^{oil}_{t+1}a\left(u^u_{t+1}\right)\right]
\end{aligned}
$$

and $\left(1-\tau^k\rho s\right)\left[u^u_{t+1}r^k_{t+1}-\tau^{oil}_{t+1}a\left(u^u_{t+1}\right)\right]$ denotes an additional profits component that is in place only if tax evasion works, or equally if $\boldsymbol{\rho}\mathbf{s}<\mathbf{1}$. Moreover, R^k_{t+1} contributes to the net worth formation. Therefore, if the return on capital increases, it positively affects the self-financing and reduces the necessity to borrow. This is the first channel through which tax evasion has a direct impact on the net worth, the self-financing effect.

Following BGG, entrepreneur also needs external finance to purchase capital. As a matter of fact, in our context, both net worth and tax evasion are not sufficient to cover capital costs. Therefore he borrows from the bank. While entrepreneur costlessly observes his idiosyncratic shock, the bank must pay a monitoring cost to observe it. To deal with the agency problem at work, entrepreneur and bank sign a debt contract. Under this contract, the entrepreneur commits to pay back the principal plus a non-default interest rate, unless he declares default. In the latter case, the bank conducts a costly verification of the entrepreneur's assets, withdrawing these ones as partial compensation. Hence, the debt contract determines a loan amount B_{t+1} and a gross interest rate Z_{t+1} to be paid if ω is high enough. In fact, there is a cutoff level $\overline{\omega}_{t+1}$ under which the entrepreneur cannot make the required payment and all his output goes to the bank. The cutoff level expression reads as:

$$\overline{\omega}_{t+1}\left(1+R^k_{t+1}\right)q_{t+1}\overline{K}_{t+1}=Z_{t+1}B_{t+1} \tag{13}$$

As equation (13) highlights, tax evasion does not directly affects the cutoff level of default. However, an indirect effect works via R^k_{t+1}, since tax evasion impacts profits but not the probability of default.

Once the entrepreneur has settled his debt and he has resold the capital to capital producers at time $t+1$, his net worth is determined. In particular, the average net worth across entrepreneurs features the following law of motion:

$$N_{t+1}=\gamma_t\left\{\left(1+R^k_t\right)q_{t-1}\overline{K}_t-\left[1+R^e_t+\mu\frac{\int_0^{\overline{\omega}_t}\omega dF_t(\omega)\left(1+R^k_t\right)q_{t-1}\overline{K}_t}{q_{t-1}\overline{K}_t-N_t}\right]*\left(q_{t-1}\overline{K}_t-N_t\right)\right\}+W^e \tag{14}$$

The first term in the braces of (14) denotes the total revenues by entrepreneurs from selling capital. The term in square brackets represents the average payments by entrepreneurs to banks[13]. Moreover, γ_t reflects that at the end of time t, entrepreneur survives to continue another period of activity with probability

[13] For further details about this equation, see CMR.

γ_t and with probability $1-\gamma_t$ he exits the economy. In the latter case, a fraction Θ of total net worth is consumed by entrepreneurs, while the remaining fraction $1-\Theta$ is destined to households as lump-sum transfers, and then consumed. In other words, the total net worth of entrepreneurs closing the business becomes consumption and importantly affects households consumption decisions via their budget constraint. In each period new $1-\gamma_t$ entrepreneurs enter the economy such that the population of entrepreneurs remains constant. Moreover, new entrepreneurs receive a "start-up" transfer W^e[14].

3.3.1 The Survival Effect

As it can be noticed by equation (14), the entrepreneurial net worth directly depends upon the probability of survive γ_t. In the CMR model γ_t denotes an exogenous shock explained by a shock equation. Differently, in our model, once we have introduced tax evasion, we cannot also neglect that tax evasion importantly affects the entrepreneur's ability to survive. In the light of that, we endogenize the probability of survive γ_t for the entrepreneurs, according to the following law of motion:

$$\gamma_t = \gamma\left(1+\epsilon_t^{\gamma}\right) f\left(u_t^u - u^u\right) + \rho^{\gamma}\left(\gamma_{t-1}-\gamma\right) \tag{15}$$

where we assume the following functional form for $f\left(u_t^u - u^u\right)$: $f\left(u_t^u - u^u\right) \equiv \exp\left[\eta\left(u_t^u - u^u\right)\right]$ and $\eta \equiv \frac{1}{u^{m2}}$.

The term $f()$ is our novelty compared to CMR, and it denotes the second channel through which tax evasion affects net worth: the survival effect. Although it does not influence the steady state of the survival function (by definition $f()$ is equal to 1 in steady state), it has important consequences for its short run dynamics. Actually, the survival rate is assumed to be a positive and convex function of the underground capacity utilization. As equation 15 shows, the probability of survive is an AR(1) process, whose steady state value is affected by a stochastic exogenous shock. The deviation of lagged term γ_{t-1} from the steady state value of γ_t is amplified by the persistence parameter ρ^{γ}.

With respect to the shock equation in the CMR model, we leave unchanged the stochastic component since there do exist shocks affecting the survive ability without being some way attributable to the control of fiscal authorities. The difference between our model and CMR is that we introduce the relationship between underground capacity utilization and survival: the larger the cyclical deviation of the underground capital utilization, the more intense is the deviation of the survival from the steady state value. In addition, by introducing the term η, we suggest that this cyclical effect might be amplified in economies characterized by a large share of tax evasion/underground production. Hence, the survival effect suggests that, when the underground capacity utilization reduces, the entrepreneur experiences a lower probability of survival, thus bringing

[14] The initial endowment $W^e$is small such that financial frictions cannot be avoided. See CMR for further details.

about a lower amount of net wealth to the next period. Actually, in a multi-product setting, with a separable production function, tax evasion provides to the entrepreuner a larger capability of coping with exogenous shocks impinging on the gamma function.

Several considerations led us to model the survival as a function of the share of unreported production.

First, this assumption well matches with literature and stylized facts who refer to tax evasion as a survival mechanism for less efficient firms and/or infant activities (Palda, 2001; Censis, 2005; Garofalo and Marzano, 2015)[15].

Second, Friedman et al. (2000) have shown that excess regulation and corruption induce firms to operate in the unofficial economy, thus suggesting that this latter is an escape to allow firms to keep on producing whilst coping with a poor quality of the institutions. Put it differently, producing in the unofficial economy is a way to survive in a context of poor institutions and weak rule of law.

Although both the issues above commented seem to be correlated to marginal and less efficient firms, there is another possible explanation that is immediately related to the role of financial markets, and hence it is particularly well suited for the framework we are adopting.

In fact, a recent stream of literature suggests that financial implications are an important explanation for tax evasion, in addition to taxation and rule of law (Straub, 2005; Gobbi and Zizza, 2007; Dabla-Norris and Feltenstein, 2005; Blackburn et al., 2012). The larger are the transaction costs in the credit market, the more agents are pushed to engage in tax evasion practices. This is consistent with the evidence that in the aftermath of the financial turmoil, in the developed US economy, an increase of the shadow economy has been recorded during the recession. This is possibly related not only to short run dynamics, but also to a tightening of the financial markets conditions. In other terms, income under-reporting is also an answer to financial constraints. This suggests that, in an economy with financial frictions, underground economy and tax evasion may mitigate these constraints, allowing firms to better cope with exogenous shocks.

3.4 Banks

There is a representative, competitive bank issuing entrepreneurial loans. The amount of credit supplied to entrepreneurs B_{t+1}, the related gross interest rate Z_{t+1} and the risk-free interest rate R^e_{t+1} need to maximize the entrepreneurial net worth subject to the following zero profit condition for the bank:

[15] At this regard, we highlight that we are talking about the survive's ability that is not linked to the control of tax evasion activities. Rather we refer to the probability of survive as a buffer stock against adverse shocks.

$$1-F_t\left(\overline{\omega}_{t+1}\right) Z_{t+1}B_{t+1}+(1-\mu)\int_0^{\overline{\omega}_{t+1}} \omega dF_t\left(\omega\right)\left(1+R^k_{t+1}\right) q_t\overline{K}_{t+1} \geq \left(1+R^e_{t+1}\right) B_{t+1} \tag{16}$$

On the left hand side, $1 - F_t\left(\overline{\omega}_{t+1}\right)$ denotes the number of non-bankrupt entrepreneurs multiplied by the interest and principal payment by each entrepreneur. The second term represents the funds received by the entrepreneurial-loan subsidiary from bankrupt entrepreneurs, net of monitoring costs. Therefore, according to (16), the funds received in each period $t+1$ must be no less then the funds paid to households in the same period (see CMR).

As shown in (16), the zero profit condition for the bank is written in terms of total capital. Hence we are assuming that the decision to evade does not influence the asymmetric information problem between banks and entrepreneurs. In particular, this assumption not only concerns the probability of default, as mentioned about equation (13), but also the monitoring cost μ, as equation (16) emphasizes[16].

Given our hypothesis of a risk neutral entrepreneur, tax evasion works as an additional source of aggregate risk in the rate of return on capital, R^k_t. In presence of aggregate uncertainty, the financial contract guarantees to the lender, in case of non-default, a state-contingent payment such that the expected (lender) return is equal to the risk free rate.

Therefore, from the point of view of the lender, tax evasion is not matter to be worried about. Actually, in this version of the financial accelerator mechanism, there is not a credit rationing issue, neither a problem of collateral. The external finance premium is motivated by a "costly state verification", that, according to BGG (1999) is a reasonable and simple enough explanation of the fact that "uncollateralized external finance may be more expansive than internal finance ".

Hence, differently from some recent literature (Dabla-Norris and Feltenstein, 2005; Blackburn et al., 2012) tax evasion does not expose firms to credit rationing originating from a lower level of collateral. Rather, it is a source of additional financial resources, allowing for increased self-financing and mitigating the external finance premium faced by the entrepreneur.

In addition, what we are implicitly assuming, is that the agency costs paid to observe the borrower's realized return on capital allow the lender to observe the true idiosyncratic productivity shock and the full production of the entrepreneur, the market and the underground ones. In this sense, we are assuming that the technology of monitoring of the bank is more efficient than the technology of the Internal Revenue Service.

[16] We choose to leave unchanged the debt contract with respect to BGG original model. For this reason, we leave for future research the assumption of endogenous monitoring cost.

3.5 Households

There is a continuous of households, indexed by $j \in (0,1)$. Households consume, supply monopolistically labor services to intermediate firms and allocate savings across assets. Moreover, they own capital producers. Their preferences are defined over per capita consumption and labor, as follows:

$$E_0 \sum_{t=0}^{\infty} \beta^t \varsigma_{c,t} \left\{ \log\left(C_t - bC_{t-1}\right) - \psi_L \int_0^1 \frac{h_{i,t}^{1+\sigma_L}}{1+\sigma_L} di \right\}, b, \sigma_L > 0 \tag{17}$$

where $\varsigma_{c,t}$ is a preference shock and b denotes the internal habit parameter. Households' funds include bank deposits paying interest R_t^a, time deposits paying interests R_t^e, after-tax wage payments $\left(1-\tau^l\right) W_{j,t} h_{j,t}$, the net worth of the entrepreneurs exiting the economy in the current period $(1-\Theta)(1-\gamma_t) V_t$, where $V_t \equiv \frac{N_{t+1}-W^e}{\gamma_t}$, profits Π_t, from producers of capital and finally lump-sum transfers, $Lump_t$. The representative household uses its funds to purchase consumption goods $(1+\tau_c) P_t C_t$ and to acquire time deposits T_t. Moreover, households pay a lump-sum tax W^e, which denotes the initial endowment for γ_t entrepreneurs who survive and $1-\gamma_t$ newly born entrepreneurs. Hence, households' budget constraint reads as:

$$\begin{gathered}(1+R_t^a) D_t^h + (1+R_t^e) T_{t-1} + \left(1-\tau^l\right) W_{j,t} h_{j,t} + (1-\Theta)(1-\gamma_t) V_t + \\ +\Pi_t + Lump_t \geq (1+\tau_c) P_t C_t + T_t + W^e\end{gathered} \tag{18}$$

Following Erceg, Henderson and Levin (2000), CMR model the labor market as follows. The j^{th} household faces the following labor demand:

$$h_t^j = \left(\frac{W_t^j}{W_t}\right)^{\frac{\lambda_w}{1-\lambda_w}} l_t, 1 \leq \lambda_w \tag{19}$$

where W_t is the aggregate wage index and W_t^j is the j^{th} households wage. In each period the j^{th} household can optimally choose its wage rate, W_t^j, with probability $1-\xi_w$. With probability ξ_w it cannot reoptimize and sets its wage rate as follows: $W_t^j = \widetilde{\pi}_{w,t} \left(\mu_z^*\right)^{(1-\vartheta)} \left(\mu_{z,t}^*\right)^{\vartheta} W_{t-1}^j$, where $0 \leq \vartheta \leq 1$ and $\widetilde{\pi}_{w,t} \equiv \left(\pi_t^{\text{target}}\right) \iota^w \left(\pi_{t-1}\right)^{(1-\iota^w)}$, $0 < \iota^w < 1$. π_t^{target} is the target inflation rate in the monetary policy rule.

Therefore, households maximize (17) subject to (18), Calvo wage setting frictions and the demand for labor.

3.6 Monetary Policy

According to CMR, monetary authority follows the rule:

$$R_t - R = \rho_p \left(R_{t-1} - R\right) + \left(1 - \rho_p\right) \left[\alpha_\pi \left(\pi_{t+1} - \pi_t^*\right) + \alpha_{\Delta y} \frac{1}{4} \left(g_{y,t} - \mu_z^*\right)\right] + \frac{1}{400} \epsilon_t^p \tag{20}$$

where ϵ_t^p is the monetary policy shock and ρ_p is the lagged interest rate parameter; $(\pi_{t+1} - \pi_t^*)$ is the deviation of anticipated quarterly inflation from the central bank's inflation target and $(g_{y,t} - \mu_z^*)$ is the quarterly growth in GDP.

3.7 Market Clearing

Clearing the goods market of the economy, we get:

$$Y_t = D_t + C_t + G_t + \frac{I_t}{\mu_{\Upsilon,t}} + \Theta \frac{1 - \gamma_t}{\gamma_t} \left[N_{t+1} - W^e\right] + \tau_t^o a\left(u_t\right) \frac{\overline{K}_t}{\Upsilon \mu_{z,t}^*} \tag{21}$$

where $G_t = z_t^* g_t$[17] and D_t denote the resources used up in monitoring. $\left[N_{t+1} - W^e\right] / \gamma_t$ represent the entrepreneurial asset net of the start-up endowment W^e.

4 Parameters

In this section we mainly focus on the enforcement parameters of tax evasion, calibrating them mostly referring to the IRS (Internal Revenue Service) estimates.

As for structural parameters of the model, we borrow the estimates by CMR (2010), as in Verona (2012), who provides some useful notes and codes on the CMR model implementation. In the Appendix, table A1 reports the parameter values with their description and also the steady state values of the market and underground component of capital utilization. To this aim, according to the world accounting data on the underground economy, we set the underground component u^u to 8% and the market component u^m to 92%.

4.1 The enforcement parameters of tax evasion: the IRS data

The probability of being inspected in the U.S. features a notable variability, according to different income levels. The IRS has emphasized that in 2014 taxpayers reporting \$25,000 to \$200,000 in adjusted gross income had a below-average (less than 0.9 percent) chance of getting audited. From there, audit rates rose steadily with income: to 1.75 percent for those making between \$200,000 and \$500,000 all the way up to 16.22 percent for those making \$10 million or more. However, people making more than \$200,000 accounted for only 3.6 percent of all tax returns filed in 2013.

Aside from these statistics, the IRS does not disclose what triggers an audit. Since, these estimates belong to a very large range and refer to the total

[17] z_t^* is a stochastic process.

taxpayers population, we set the probability of being detected at 5%, following Busato and Chiarini (2004).

Concerning the penalty rate, according to the IRS, if a taxpayer fails to pay the balance due shown on the tax return by the due date (even if the reason of nonpayment is a bounced check), there is a penalty of 0.5% of the amount of unpaid tax per month (or partial month), up to a maximum of 25%. Hence, in our baseline model we set the penalty at 25%.

5 Results: The Consumption Puzzle

5.1 Inspecting the transmission channels of the consumption puzzle after a MEI shock

Although MEI shocks are considered to account even for 60% of the variance of output and hours (see Justiniano et al., 2010), arguing that investment shocks are among the most important drivers of macroeconomic fluctuations is not easy (Furlanetto et al., 2013). In fact, DSGE models are not able to explain the comovement between consumption and the other macroeconomic variables found in the post-war U.S. data.

In standard models, after a negative MEI shock, households trading in financial makets reduce their investments and increase consumption. An intertemporal substitution effect between current consumption and investment is in place, entailing the puzzle. Therefore a wealth effect is at work. This paper actually stresses this line of research. As we are going to show, introducing tax evasion shrinks such a wealth effect and the consumption puzzle area, as well. At this regard, several contributions argue that a small wealth effect is a sufficient condition to achieve macroeconomic co-movement (see, among the others, Greenwood et al., 1988; Jaimovich and Rebelo (2009) and Schmitt-Grohé and Uribe (2012). In our model the reduced wealth effect moves in the same direction since the puzzle area notably lessens.

The mechanism behind the puzzle in neoclassical models has been first justified by Barro and King (1984). In a nutshell, if there exists an efficient equilibrium, the marginal rate of substitution between consumption and leisure must equal the marginal product of labor. This condition implies that, with exogenous shocks that only indirectly affect the marginal product of labor, as MEI shocks actually do, consumption and hours move in opposite directions.

However, such a comovement problem has been highlighted even in contributions supporting the idea of MEI shocks as the driving forces of business cycles (see Justiniano et al., 2010, 2011; Gertler et al., 2008). On the other hand, nominal rigidities, i.e. sticky prices and wages, play a crucial role in the transmission of these shocks (see, among the others, Justiniano et al., 2010; Reza, 2014). This creates room at least to shrink the consumption puzzle area, or even to solve the comovement problem.

5.2 Consumption Puzzle and Tax Evasion

In this subsection, we show the impulse response functions after a MEI shock of the key macroeconomic variables. In particular we present a negative disturbance to the marginal efficiency of investments that raises installation costs, comparing the baseline financial accelerator model without (solid line) and with (dashed line) tax evasion. Dynamics are reported in percentage deviation from the steady state. We simulate the MEI shock by numerically solving the model in DYNARE[18].

In a DSGE model with financial frictions (solid line), the MEI shock produces conterfactual effects. In fact, after the shock, capital producers demand less investment goods to final firms and therefore supply less capital to entrepreneurs (**Figure 1**). The shock reduces the capital utilization rate (**Figure 2**) and the rental rate of capital, as well. Under the assumption of convex adjustment costs, a lower capital utilization rate entails the opportunity cost to disinvest. In other words, the more the capacity utilization decreases, the higher is the capital gain for the entrepreneurs. Importantly, the shadow value of capital q_t, which is a forward variable anticipating capital and investment dynamics, increases (**Figure 2**). This entails that the entrepreneurs' total return on capital R_t^k rises, pushing up their net worth (**Figure 3**). Therefore, a countercyclical net worth softens the cyclical impact that the MEI shock generates via the financial contract (see equations (12) and (14)). Hence, in a model with financial frictions the MEI shock acts as cyclical smoother of the business cycle (see CMR). As it has been explained above, at the end of each period, the accumulated net worth of the entrepreneurs exiting the economy is consumed, both by entrepreneurs closing the business and by households receiving a lump-sum transfer (see equation (18)). With an exogenous and constant probability of survive γ_t, as it is in CMR, (**Figure 3**), the increase in net worth translates into a consumption boom. A positive wealth effect is in place, because households feel richer, i.e. they consume more and work less. The *consumption-GDP comovement puzzle* is in place, as in a standard DSGE model. In fact, consumption increases while output, investment and hours decrease.

In the financial frictions model with tax evasion (dashed line), the MEI shock impacts on the macroeconomic variables rather differently with respect to the baseline. In particular, in our model, the shock reduces the underground component of capital utilization more than the market one. This is only due to a pure scale effect. With respect to the baseline, this result entails (see **Figures 2 and 3**):

- a reduction of the probability of survive γ_t (see equation (15));
- a weakening of the increase in the return on capital R_t^k. In fact, the potential additional profits component deriving from tax evasion is not sufficient to cover a lower increase of the forward shadow value of capital q_t. In other words, the endogenous countercyclical increase in the purchasing power of entrepreneurs in the baseline is now limited.

[18] For further details on DYNARE see the webpage: http://www.cepremap.cnrs.fr/dynare/.

Both previous outcomes generate a sizable dampening of the net worth boom (see equation (14)), partially cushioning the conterfactual effect of MEI shock, as it is clear from the paths of the return on capital and net worth.

The damping of net worth increase notably softens the consumption increase. Moreover, the consumption path declines faster compared to the baseline model. **Figure 1** clearly shows how the positive wealth effect, characterizing the baseline, weakens. In fact, since there is less net worth to carry on to the next period and thus less net wealth V_t to consume (see equation (18)), households change their decisions about their intertemporal consumption profile: consumption increase does considerably holds back and supplied hours reduce just less. The latter also explains a minor fall of output, that furthermore is mainly determined by the countercyclical tax evasion (see Busato and Chiarini, 2004). Moreover, we can notice a reallocation between consumption and investment. In fact, along the path, the damped reduction of investments reflects the damped consumption increase. Furthermore, results importantly emphasize the alternative self-financing/ borrowing. In fact, **Figure 3** shows that since the minor increase of net worth, entrepreneurs are forced to borrow more. This justifies higher total loans with respect to the baseline along the path.

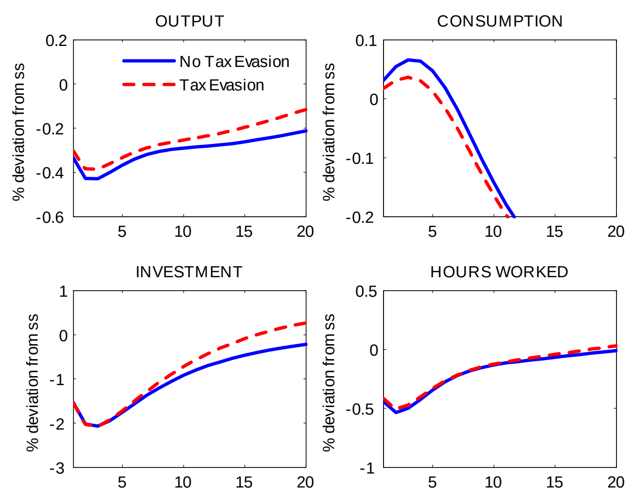

Fig.1 - MEI shocks effects

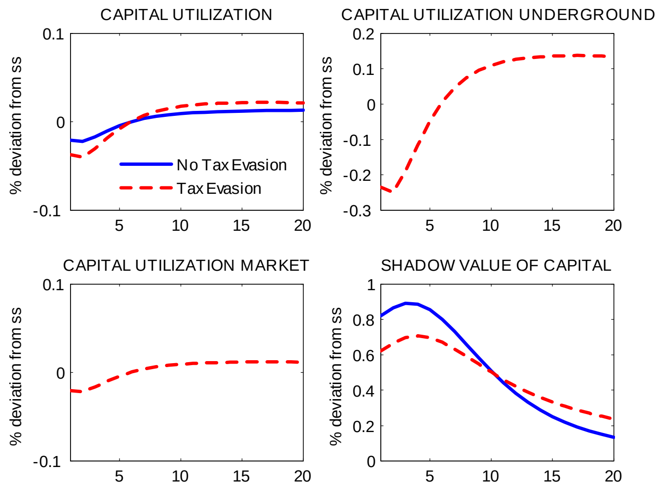

Fig. 2 - Transmission Channels (1)

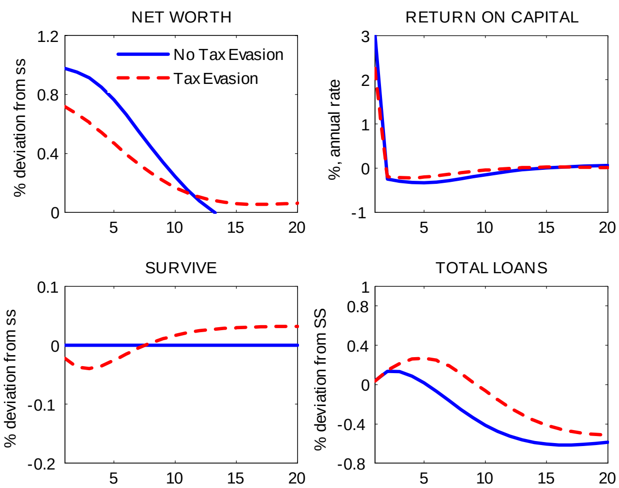

Fig. 3 - Transmission Channels (2)

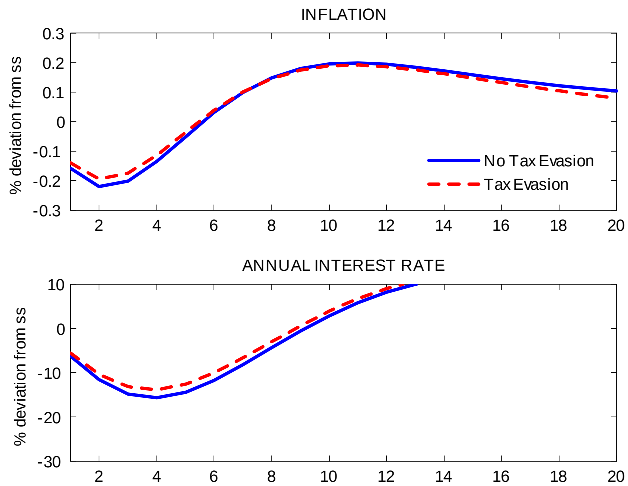

Fig. 4 - Monetary Authority

Although the MEI shock is a supply shock because it affects the capital producers' behavior, with financial frictions it looks like a demand shock. In fact output and inflation move in the same direction (compare Figures 1 and 4), (see CMR). Therefore, after a MEI shock, the reduction of inflation brings down the nominal interest rate, as well. This implies a large degree of liquidity accomodation and a lower time deposits return in the households' budget constraint. Comparing the two models, notice that a minor fall of output in presence of tax evasion also entails a minor decrease of inflation and, in turn, of nominal interest rate. This produces a positive effect on consumption. However, it is not sufficient to hinder the shrinkage of the consumption puzzle area stemming from the tax evasion channel.

6 Robustness/Extention

In this section we implement some robustness exercises.

First of all, we investigate the amplifying effect of cyclical fluctuations on the survival variable in equation (15), the survival effect**.** In **Figure 5**, the solid line represents the baseline tax evasion case in which the steady state value of the capital underground component is 8%. The dashed line, being the underground component equal, represents the case of an higher degree of the survival function convexity[19].

[19] We assume to increase the convexity degree of the survive equation increasing up to 10 the exponent of the market component in η.

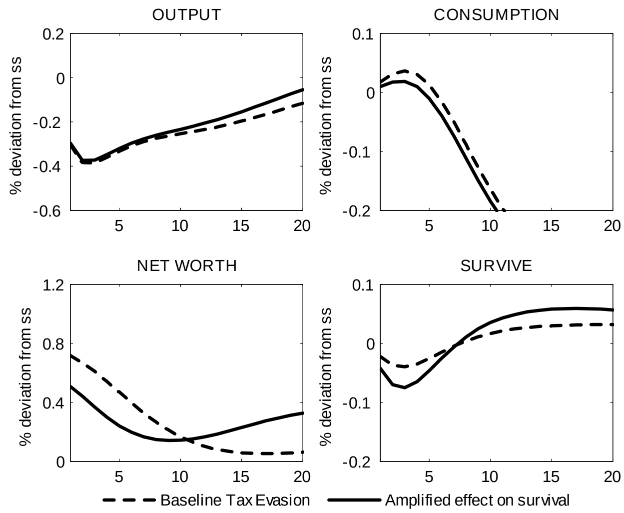

Fig.5 - Amplification effect of cyclical fluctuations on the survive

It's worth noting that increasing the degree of convexity of the survival function:

- Our results are robust according to different degree of convexity of the survival function;

- The higher is the degree of convexity of the survival function the more the consumption puzzle area shrinks.

Once ascertained the important role played by the amplification effect of cyclical fluctuations of tax evasion on the survival rate of the entrepreneur, we investigate whether the variation of the steady state values of the market/underground components play a role in explaining the consumption puzzle. Indeed, in an economy characterized by a large unreported production, tax evasion is expected to play a crucial role in influencing the entrepreneur survival.

In a recent contribution, Enste (2015) reports the shadow economy's share of GDP in industrial countries in the period 2003 - 2013. Starting from this study, we compare the U.S. underground economy's share (dashed line) with the Italian one (solid line) (**Figure 6**)[20], taking into account the largest convexity degree of the survival function we considered above. This allows us to compare, in a context characterized by an high survival effect, countries characterized by a different level of equilibrium of tax evasion.

[20] Of course, this comparison is only an example . We can compare other different tax evasion regimes.

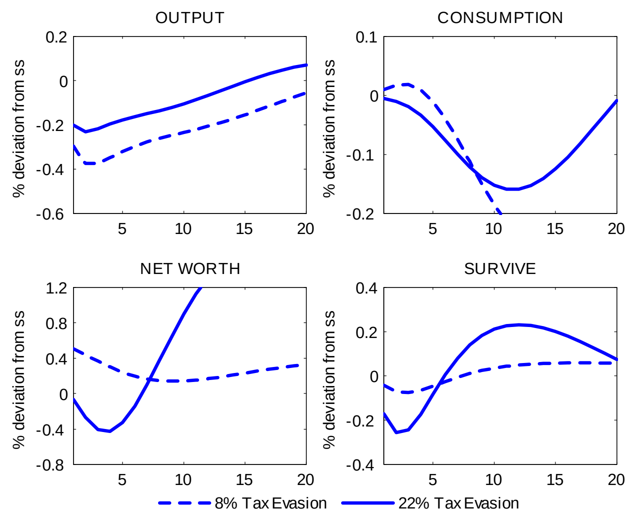

Fig. 6 - Comparing American and Italian tax evasion under the assumption of higher convexity degree of the survival equation.

It follows that:

- our results are robust to different values of tax evasion.

- The joint operating of the degree of convexity in the survival function (working through the power index in the eta parameter) and of the steady state value of the unreported production (the basis of the power index in the eta parameter), implies, for reasonable parametrizations, the solution of the GDP-consumption comovement puzzle.

- the higher is the steady state value of the underground capacity utilization of capital the more the recessionary effect dampens. This is consistent with the literature in the field arguing that tax evasion acts as a buffer (or insurance) against the recessive shocks (see Busato and Chiarini, 2004). In addition, the increase in the steady state value of tax evasion produces an appreciable effect on the net worth dynamics. In fact, following the survive path, the entrepreneurial net worth now decreases. It is the case of a total annulment of the conterfactual effect of the MEI shock mentioned in the introduction.

These robustness results importantly highlight the ability of a financial friction DSGE model with tax evasion to well explain the business cycle, especially the procyclicality of the consumption path.

The last but not least aspect to consider is that changes in steady state values of the underground components produce also sizable effects on the steady state of the model. In particular, it's not feasible to consider a steady state value of the underground capital utilization which is higher than 24%. The intuition behind such a limit of the model is the following. Increasing tax evasion means increasing the self-financing sources for the entrepreneur. Therefore, the entrepreneurial self-financing rises such a lot so that there is no more necessity to borrow to purchase capital. Hence the financial accelerator mechanism fails to work.

7 Conclusions

This paper importantly contributes to the literature on the *GDP-consumption comovement puzzle* investigating the role of tax evasion in a DSGE model with financial frictions when a MEI shock hits the economy.

Our contribution is twofold. First, introducing tax evasion allows to remove and, under particular assumptions, even to solve the comovement problem. These result hightlights that disregarding tax evasion into business cycle fluctuation studies is not so obvious. Rather, it does represent a crucial channel to capture what actually the real business cycle is.

Second, introducing the assumption that the key player of the financial accelerator mechanism is also the evading agent, besides being a novelty in the literature of the field, emphasizes how three different financing sources, namely tax evasion, net worth and necessity to borrow get along with each other.

References

[1] Allingham, M. G. & Sandmo, A., 1972. Income tax evasion: a theoretical analysis. *Journal of Public Economics*, 1 (3-4), 323-338.

[2] Alm, J., 1999. Tax Compliance and Administration. In *Handbook on Taxation*, ed. W. Bartley Hildreth and James A. Richardson, 741– 68. New York: Mercel Dekker.

[3] Andreoni, J., Erard, B. and Feinstein, J., 1998. Tax Compliance. *Journal of Economic Literature*, June, 36(2): 818–60.

[4] Annicchiarico, B. & Cesaroni, C., 2016. Tax Reforms and the Underground Economy: A Simulation-Based Analysis. *CEIS Research Paper 366*, Tor Vergata University, CEIS, revised 10 Feb 2016.

[5] Barro, R.J. & King, R.J., 1984. *The Quarterly Journal of Economics*, 99 (4), 817-839.

[6] Bernanke, B. S. & Gertler, M. & Gilchrist, S., 1999. The financial accelerator in a quantitative business cycle framework. *Handbook of Macroeconomics*, in: J. B. Taylor & M. Woodford (ed.), Handbook of Macroeconomics, edition 1, volume 1, chapter 21, pages 1341-1393 Elsevier.

[7] Blackburn K., Bose N., Capasso S., 2012. Tax evasion, the underground economy and financial development. *Journal of Economic Behavior & Organization* 83, pp. 243-253.

[8] Busato, F. & Chiarini, B., 2004. Market and underground activities in a two-sector dynamic equilibrium model. *Economic Theory*, Springer, vol. 23(4), pages 831-861, May.

[9] Carlstrom, C. & Fuerst, T., 1997. Agency Costs, Net Worth, and Business Fluctuations: A Computable General Equilibrium Analysis. *American Economic Review*, 87 (5), 893–910.

[10] Cebula, R. & Feige, E. L 2011. America's Underground Economy: Measuring the Size, Growth and Determinants of Income Tax Evasion in the U.S. *MPRA Paper 29672*, University Library of Munich, Germany.

[11] Censis,2005. Un Nuovo Ciclo di Sommerso. Supporto Conoscitivo ai Servizi per l'Impiego, Rome, in www.censis.it

[12] Christensen I. & Dib A, 2008. The Financial Accelerator in an Estimated New Keynesian Model. *Review of Economic Dynamics*, Elsevier for the Society for Economic Dynamics, vol. 11(1), pages 155-178, January.

[13] Christiano L. J. & Eichenbaum, M. & Evans C. L., 2005. Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy. *Journal of Political Economy*, University of Chicago Press, vol. 113(1), pages 1-45, February.

[14] Christiano, L. J. & Motto, R. & Rostagno, M., 2004. The Great Depression and the Friedman-Schwartz hypothesis. *Working Paper 0318*, Federal Reserve Bank of Cleveland.

[15] Christiano, L. J. & Motto, R. & Rostagno, M., 2008. Shocks, structures or monetary policies? The Euro Area and US after 2001. *Journal of Economic Dynamics and Control*, Elsevier, vol. 32(8), pages 2476-2506, August.

[16] Christiano, L. J. & Motto, R. & Rostagno, M., 2010. Financial factors in economic fluctuations. *Working Paper Series 1192*, European Central Bank.

[17] Christiano, L. J. & Motto, R. & Rostagno, M., 2014. Risk Shocks. *American Economic Review*, 104 (1): 27-65.

[18] Christiano, L. J. & Trabandt, M. & Walentin, K, 2011. Introducing financial frictions and unemployment into a small open economy model. *Journal of Economic Dynamics and Control*, Elsevier, vol. 35(12), pages 1999-2041.

[19] Colombo, E. & Onnis, L. & Tirelli, P., 2016. Shadow economies at times of banking crises: Empirics and theory. *Journal of Banking & Finance*, Elsevier, vol. 62(C), pages 180-190.

[20] Conesa Roca, J. C., Moreno C.D., and Galdn Snchez J. E., 2001. Underground economy and aggregate fluctuations. *Spanish Economic Review*, 3 (1), 41–53.

[21] Dabla-Norris E., Feltenstein A., 2005. The Underground Economy and its Macroeconomic Consequences. *The Journal of Policy Reform*, Vol. 8, No. 2, 153–174, June 2005.

[22] Enste, D. H., 2015. The shadow economy in industrial countries. IZA World of Labor 2015: 127.

[23] Erceg, C.J., Henderson, D.W. and Levin A.T., 2000. Optimal Monetary Policy with Staggered Wage and Price Contracts. *Journal of Monetary Economics*, 46(2), October, pages 281-313.

[24] Feige, E. L. 1989. Monetary Methods of Estimating Informal Activity in Developing Nations. In Demographic Change and Economic Development, ed. Alois Wenig and Klaus F. Zimmerman, 211–32. Berlin: Springer Verlag.

[25] Fisher, J.D.M., 2006. The dynamic effect of neutral and investment-specific technology shocks. *Journal of Political Economy*, 114 (3), 413-451.

[26] Friedman, E., Johnson, S., Kaufmann, D., Zoido-Lobaton, P., 2000. Dodging the grabbing hand: the determinants of unofficial activity in 69 countries. Journal of Public Economics,76; 459-493.

[27] Furlanetto, F.& Natvik, G. J. & Seneca, M., 2013. Investment shocks and macroeconomic co-movement. *Journal of Macroeconomics*, Elsevier, vol. 37(C), pages 208-216.

[28] Furlanetto F. & Seneca M., 2012. Rule-of-Thumb Consumers, Productivity, and Hours. *Scandinavian Journal of Economics*, Wiley Blackwell, vol. 114(2), pages 658-679, 06.

[29] Garofalo, A., Marzano, E., 2015. L'analisi economica dell'economia sommersa: evidenza empirica ed implicazioni di policy, in Formez, (edited by), Le dimensione del sommerso in ambito locale: un'indagine multidisciplinare, Collana Azioni di sistema per la Pubblica Amministrazione, Roma.

[30] Gertler, M., Sala, L., Trigari, A., 2008. An estimated monetary DSGE model with unemployment and staggered nominal wage bargaining. *Journal of Money, Credit and Banking* 40, 1713–1764.

[31] Gobbi G., Zizza, R. 2007. Does the underground economy hold back financial deepening? Evidence from the Italian credit market, Banca d'Italia, *Temi di discussione, 646.*

[32] Granda-Carvajal, C., 2010. The Unofficial Economy and the Business Cycle: A Test for Theories. *International Economic Journal*, 24 (4), 573–586.

[33] Gravelle, H., Rees, R., 1988. Microeconomics. *Longman*; Seventh Impression.

[34] Greenwood, J., Hercowitz, Z., Huffman, G.W., 1988. Investment, capacity utilization, and the real business cycle. *American Economic Review* 78 (3), 402–417.

[35] Hanlon, M., Mills, L., Slemrod, J.,2005. An Empirical Examination of Corporate Tax Noncompliance. Ross School of Business Working Paper Series Working Paper No. 1025 June 24, 2005.

[36] Internal Revenue Service (IRS), 2012. Tax Gap for Tax Years 2008-2010. Overview Jan. 6, 2012. https://www.irs.gov/uac/the-tax-gap.

[37] Internal Revenue Service (IRS), 2016. Tax Gap for Tax Year 2006. https://www.irs.gov/uac/the-tax-gap.

[38] Jaimovich, N., Rebelo, S., 2009. Can news about the future drive the business cycle. *American economic Review* 99, 1097–1118.

[39] Johns, A., Slemrod, J., 2010. The Distribution of Income Tax Noncompliance. National Tax Journal, 397-418.

[40] Justiniano, A., Primiceri, G. E., Tambalotti, A., 2010. "Investment shocks and business cycles," *Journal of Monetary Economics*, Elsevier, vol. 57(2), pages 132-145, March.

[41] Justiniano, A., Primiceri, G. E., Tambalotti, A., 2011. Investment shocks and the relative price of investment. *Review of Economic Dynamics*, 14 (1), 102-121.

[42] Khan H. & Tsoukalas J., 2012. The Quantitative Importance of News Shocks in Estimated DSGE Models. *Journal of Money, Credit and Banking*, Blackwell Publishing, vol. 44(8), pages 1535-1561, December.

[43] King, R.G., Rebelo, S.T., 1999. Resuscitating real business cycles. In: Taylor, J.B., Woodford, M. (Eds.), *Handbook of Macroeconomics.* Elsevier, Amsterdam, 927-1007.

[44] Kiyotaki, N. and Moore, J., 1997. Credit Cycles. *The Journal of Political Economy*, Vol. 105, No. 2 (Apr., 1997), pp. 211-248

[45] Kydland, F.E., Prescott, E.C., 1982. Time to build and aggregate fluctuations. *Econometrica,* 50 (6), 1345-1370.

[46] Maffezzoli, M., 2011. Tax Evasion under Market Incompleteness. *Working Papers 378*, IGIER (Innocenzo Gasparini Institute for Economic Research), Bocconi University.

[47] Mitra, S., 2014. Tax Evasion, Tax Policies and the Role Played by Financial Markets. *MPRA Paper 58977*, University Library of Munich, Germany.

[48] Orsi, R. & Raggi, D. & Turino, F., 2014. Size, Trend, and Policy Implications of the Underground Economy. *Review of Economic Dynamics*, Elsevier for the Society for Economic Dynamics, vol. 17(3), pages 417-436, July.

[49] Palda, K. F., 2001. Tax Evasion and Firm Survival in Competitive Markets. Edward Elgar Publishing.

[50] Reza A, 2014. Consumption response to investment shocks under financial frictions. *Economic Letters*, vol.123, Issue 1, Pages 50-53.

[51] Sandmo A., 2005. The Theory of Tax Evasion: A Retrospective View. *National Tax Journal*, Vol. 58, No.4; pp. 643-663.

[52] Schmitt-Grohé, S., Uribe, M., 2012. What's news in business cycle? *Econometrica* 80, 2733–2764.

[53] Sims, C.A., 1980. Macroeconomics and Reality. *Econometrica,* 48 (1), 1-48.

[54] Slemrod, J., 2007. Cheating Ourselves: The Economics of Tax Evasion, *Journal of Economic Perspectives*; Volume 21, Number 1-Winter 2007; Pages 25–48

[55] Slemrod, J. and Yitzhaki, S., 2002. Tax avoidance, evasion and administration. A. J. Auerbach and M. Feldstein (eds.), *Handbook of Public Economics*, Volume 3. Amsterdam: Elsevier Science.

[56] Smets F. & Wouters, R., 2003. An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area. *Journal of the European Economic Association,* MIT Press, vol. 1(5), pages 1123-1175, 09.

[57] Straub, S. 2005. Informal sector: the credit market channel. *Journal of Development Economics*, 78(2), 299–321.

[58] Yitzhaki, S., 1979. A Note on Optimal Taxation and Administrative Costs. *American Economic Review*, 69(2):475-480.

8 Appendix

Table 1: Parameters Values

Parameter	Description	Value
	Household sector	
β	Discount rate	0.9966
ψ_L	Weight on disutility of labor	endogenous
σ_L	Curvature on disutility of labor	1
b	Internal habit persistence	0.63
λ_w	Steady-state markup, labor supply	1.05
	Good producing sector	
μ_z	Growth rate of technology	1.0036
δ	Capital depreciation rate	0.025
α	Share of capital in production	0.40
λ_f	Steady-state markup, good producing firms	1.20
Φ	Production fixed costs	0.07
	Entrepreneurs	
γ	Probability to survive next quarter	0.9762
μ	Fraction of realized profits lost in bankruptcy	0.94
var $\log(\omega)$	Variance of log of idiosyncratic productivity	0.24
Θ	Fraction of net worth consumed in case of exit	0.1
W^e	Initial endowments	0.009
	Fiscal Policy	
τ^c	Tax rate on consumption	0.05
τ^k	Tax rate on capital income	0.32
τ^l	Tax rate on labor income	0.24
η_g	Share of public consumption to GDP	0.20
	Monetary Policy	
α_π	Weight on inflation	1.817
$\alpha_{\Delta y}$	Weight on output growth	0.31
ρ_ρ	Interest rate smoothing parameter	0.877
	Tax Evasion	
u^m	Market component of capital utilization	0.92
u^u	Underground component of capital utilization	0.08
ρ	Probability of audit	0.05
s	Penalty rate	1.25