Fiscal Consolidation with Tax Evasion and Corruption

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Abstract

Using cross country data we show that tax evasion and corruption are highly important for determining the size of the fiscal multiplier. We introduce these two features in a New Keynesian model with search and matching frictions, in order to revisit the effects of tax and expenditure based consolidations. VAR evidence for Italy suggests that expenditure based consolidations reduce tax evasion significantly, while tax based ones increase it. In the model, expenditure cuts reduce demand for both formal and informal goods, and, thus, tax evasion. Tax hikes induce agents to work and produce more in the informal sector, which is less productive, and so imply higher output and welfare losses. We use the model to assess the losses from the recent fiscal consolidation plans in Italy, Spain, Portugal and Greece. Policy conclusions are sensitive to the model's assumptions. Counterfactual exercises highlight the benefit of fighting tax evasion and corruption in economies undertaking fiscal consolidation.

JEL classification: E32, F41

Keywords: DSGE model, matching frictions, shadow economy, corruption, fiscal consolidation, VAR, policy analysis.

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1 Introduction

When there is an income tax, the just man will pay more and the unjust less on the same amount of income. Plato, The Republic, Book I, 343-D

The recent fiscal crisis has excited renewed interest in research examining the macroeconomic impacts of fiscal consolidations.[1] Besides this increasing attention, two crucial aspects of political economy, namely the presence of tax evasion and corruption, have been left unnoticed. This is despite the fact that many countries undertaking such policies are characterized by high levels of both.[2] Tax evasion and corruption often coexist, in various forms, and possibly interact. Existing evidence suggests a positive correlation between the two (Buehn and Schneider (2012)). At the same time, there is growing evidence of a rise in tax evasion and corruption since the crisis. For example, a recent report by the union of the technical staff of the Finance Ministry of Spain (Gestha (2014)) calculates that the shadow economy has increased by 6.8 pp between 2008 and 2012, reaching 24.6% of GDP. Similarly, a Greek police special task force reported in 2013 that the number of cases of public corruption increased by 33% between 2011 and 2012.[3] The aim of this paper is to consider these two features and to revisit the effects of expenditure based (EB) and tax based (TB) fiscal consolidations on output, unemployment and welfare.

More specifically, we will consider tax evasion as synonymous with the shadow economy, which comprises "all market-based, lawful production or trade of goods and services deliberately concealed from public authorities in order to evade either payment of income, value added or other taxes, or social security contributions; to get around certain labor market standards, such as minimum wages, maximum working hours, or safety standards; or to avoid compliance with administrative procedures, such as filling out paperwork" (Buehn and Schneider (2012), p.175-176). Fiscal policy can affect the size of the shadow economy by exerting an impact on the incentives to tax evade, both directly through the tax burden, and indirectly through its effects on the regular economy. Thus, a fiscal consolidation can have a secondary effect on the economy by causing a reallocation between the formal and informal sector. We will consider corruption as the embezzlement of public funds, the presence of which can have important implications for the ability of governments to raise tax revenue, and so can alter the effects of fiscal consolidations.

Many authors have tried to assess whether EB and TB fiscal consolidations have different effects. Using multi-year fiscal consolidation data for 17 OECD countries over the period 1980-2005, Alesina et al. (2013) show that EB adjustments have been associated with mild and short-lived recessions, and in many cases with no recession at all, while TB corrections have been followed by deep and prolonged recessions. On the theoretical front, Erceg and Lindé (2013) demonstrate via a two-country Dynamic Stochastic General Equilibrium (DSGE) model that, given the limited accommodation by the central bank and the fixed exchange rates under a currency union, an EB

[1] The implementation of the Maastricht Treaty in the mid 1990s motivated a lot of research on the effects of consolidations. For examples, see the survey in Perotti (1996).

[2] See Figure 11 in Appendix A.

[3] See http://greece.greekreporter.com/2013/04/02/greek-police-public-worker-corruption-soars/

consolidation depresses output by more than a TB one, but this is reversed in the long run as real interest and exchange rates adjust towards their flexible price levels.

Nonetheless, there is strong evidence that the effects of fiscal policy are not yet fully understood. Blanchard and Leigh (2013), BL (2013) hereafter, carry out an analysis of the impact of the recent fiscal consolidations across 26 OECD countries. They regress the forecast errors of output growth between 2010-2011 on the planned consolidation of public deficit, and find that the forecasts of output growth implicitly underestimate the size of fiscal multipliers. As we demonstrate in the next section, this implicit underestimation of fiscal multipliers is more pronounced in countries with a higher shadow economy and/or corruption, suggesting that these two features amplify the effects of fiscal consolidations.

Ideally, having data for tax evasion could help us understand how fiscal consolidations are propagated. Luckily, the Italian National Institute of Statistics (ISTAT) has created and regularly updated a time series of informal employment, consistent with international standards and, in particular, with the 1993 System of National Accounts. Italy provides a fitting case for this study for several reasons. First, there is abundant evidence of a large shadow economy in this country, with estimates varying between 15% and 30% of GDP (see, for example, Boeri and Garibaldi (2007), Ardizzi et al. (2012), Orsi et al. (2014) and Schneider and Buehn (2012)). Second, Busato and Chiarini (2004) have shown that incorporating the underground economy in an RBC model improves the fit of the model to the data for Italy. Last but not least, Italy also scores poorly in international rankings of institutional quality: currently ranked 72nd among 176 countries with a score of 42/100 in Transparency International's Corruption Perception Index (CPI) and 25th among the 27 EU members in the recently created index for the 'Quality of Government' (see Charron et al. (2012)).[4]

We use the ISTAT data on shadow employment to assess the effects of TB and EB consolidations at least in Italy. In particular, we incorporate the shadow employment series in an annual VAR with government expenditure, tax revenues, a series for the debt-to-GDP ratio, and either real GDP or the unemployment rate as a measure of economic activity. We identify EB and TB consolidation shocks using sign restrictions: EB consolidations decrease the debt-to-GDP ratio with a lag and leave tax revenues unchanged on impact, while TB consolidations also decrease the debt-to-GDP ratio with a lag and leave government spending unchanged on impact. We find that both types of shocks are contractionary, in terms of reducing output and increasing unemployment. Moreover, TB consolidations cause a significant increase in tax evasion, while EB consolidations reduce tax evasion significantly. Results are robust to the method used to identify fiscal shocks, to the number of variables entering the VAR, and to alternative measures of the fiscal instruments.

In order to understand the mechanisms which drive these results we introduce tax evasion and corruption in a New Keynesian model with search and matching frictions and endogenous labor force participation, and reassess the effects of fiscal consolidations. The economy is divided into

[4]The CPI is based on a cross-country survey assessing the degree of transparency in public administration. The latter index accounts for other pillars, such as protection of the rule of law, government effectiveness and accountability, in addition to corruption.

a regular and an underground sector, and none of the transactions in the latter are recorded by the government authorities. Firms can therefore hire labor in the underground markets to hide part of their production and evade payroll taxes. Households may also evade personal income taxation by reallocating their labor supply to the underground sector, but without being entitled to unemployment benefits whilst searching in this sector. In each period of time, there is a positive probability that irregular employment is detected, in which case the match is dissolved and the firm pays a fine. Following Erceg and Lindé (2013), we specify either labor tax rates or government consumption expenditure to react to the deviation of the debt-to-GDP ratio from a target value. Fiscal consolidation occurs when the target value of debt is hit by an exogenous negative shock. The model is calibrated to the Italian economy over the period 1982-2006.

According to our model, the presence of tax evasion and corruption amplifies the negative effects of TB consolidations on output, while it mitigates those of EB consolidations. The presence of corruption implies that a bigger increase in distortionary taxation is needed to achieve consolidation, and this amplifies the negative effects of tax hikes. Tax evasion increases the output losses after a TB consolidation because both workers and firms, in their effort to avoid taxation, reallocate more resources to the underground sector, increasing inefficiencies arising from the fact that this sector is less productive, and also because tax evasion implies that a higher increase of the tax rate is required to meet the debt target. On the other hand, government spending cuts induce a fall in tax evasion. Spending cuts generate a negative demand effect that affects both formal and informal production. Rather than observing a reallocation of labor supply and labor demand between the two sectors, the EB consolidation induces unemployed jobseekers in both sectors to leave the labor force. Labor demand is also contracted and as a result both formal and informal employment fall. Since reductions in government consumption crowd-in private consumption and decrease the labor supply, EB consolidations typically involve welfare gains, whereas TB consolidations are costly in terms of welfare. Relative to standard models, tax evasion and corruption increase the size of the wealth effect from reductions in government spending and therefore induce smaller output losses and even higher welfare gains from spending cuts, while their presence implies higher output and welfare losses from TB consolidations.

Given the model's ability to match the empirical findings, we also analyse, through the lens of our model, the actual consolidation plans in Southern European countries (Greece, Italy, Spain, Portugal) that are characterized by both high corruption and tax evasion. We calibrate our model for different economies and show how the recent fiscal consolidations affect tax evasion in each country according to our model. We then assess the size of output, unemployment and welfare losses from the simulated consolidations. The higher levels of the debt-to-GDP ratio in Italy and Greece imply that the required changes in deficit are larger in these countries. As a result, the model predicts that the output losses and increases in unemployment and the shadow economy are more pronounced in Greece and Italy. In terms of welfare, results depend on the assumptions one is willing to accept about the composition of spending and population in these economies. If we assume government spending to be unproductive and agents identical in the economy, Italy stands out as the Southern European country most negatively affected by fiscal austerity, the other three countries gain from fiscal consolidations in terms of welfare. If we are willing to

accept that a big part of the population is financially constrained in these economies, then fiscal consolidations imply welfare losses in all countries, with Greece standing out as the biggest loser. Finally, if we believe that parts of the spending cuts involve utility enhancing goods, then again the model predicts welfare losses from the consolidations for all countries, with Spain suffering the least because of its low debt burden.

Many policy discussions have been centered around combating both tax evasion and corruption. For example, in May 2013, in Ljubljana, socialists and democrats in the European Parliament organized an event focusing on corruption and tax evasion. We perform a counterfactual exercise and study what would be the losses from fiscal consolidations if the Southern European countries were capable of reducing the degree of corruption and tax evasion in their economies. We find that both battles are worth fighting. A reduction in corruption and tax evasion mitigates the losses from fiscal consolidations. Following the conclusions of our policy analysis we can humbly paraphrase the quote of Plato: When there is a corrupt government and an income tax, both the just and the unjust man will pay more, with the just man paying the lion's share on the same amount of income. Policymakers should realize this and take immediate action.

The remainder of the paper is organised as follows. In the next section we present empirical evidence to motivate our work. In Section 3 we first present the workhorse model and then discuss the main theoretical results. Section 4 presents the policy exercises and Section 5 concludes.

2 Empirical Evidence

In this section, we first extend the BL (2013) cross country regressions, exploiting the available estimates for corruption and the share of shadow output in total GDP to investigate their effects on fiscal policy outcomes. We then use the ISTAT data on shadow employment in Italy to run VAR regressions to further examine the effects of EB and TB consolidations on output, unemployment and shadow employment.

2.1 A First Look at the Data

To motivate our study, we replicate the BL (2013) regressions, controlling for the size of the shadow economy and the extent of public corruption. For the size of the shadow economy we use estimates from Elgin and Öztunalı (2012), while for corruption we use the Corruption Perception Index (CPI) from Transparency International.[5] We separate the 26 European countries considered by BL (2013) into two groups with a high and low shadow economy, or corruption, respectively, by using a two-mean clustering algorithm to endogenously group the countries.[6] We then add,

[5] The results are robust to using other estimates, such as Schneider and Buehn (2012) for the shadow economy, or the World Bank's Control of Corruption Index for corruption.

[6] The 'high shadow economy' group comprises Belgium, Bulgaria, Cyprus, Greece, Hungary, Italy, Malta, Poland, Portugal, Romania, Slovenia and Spain, while the 'low shadow economy' group includes Austria, Czech Republic, Denmark, Finland, France, Germany, Iceland, Ireland, Netherlands, Norway, Sweden, Switzerland, Slovakia and the UK. The 'high corruption' group comprises Bulgaria, Cyprus, Czech Republic, Greece, Hungary, Italy, Malta, Poland, Portugal, Romania, Slovakia, Slovenia and Spain, while the 'low corruption' group includes Austria, Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Netherlands, Norway, Sweden, Switzerland, and the UK.

Table 1: Blanchard & Leigh (2013) Regressions with Additional Controls
Dependent Variable: Forecast Error of GDP growth

	1	2	3	4
REGRESSORS	(Baseline)			
Planned Fiscal Consolidation	-1.095***	-0.670**	-0.550**	-0.618**
	(0.255)	(0.268)	(0.259)	(0.268)
Interaction with:				
High Shadow Economy		-0.761**		
		(0.351)		
High Corruption			-0.990***	
			(0.333)	
High Shadow Economy				-0.900**
and Corruption				(0.351)
Constant	0.775*	0.918**	0.964**	0.925*
	(0.383)	(0.414)	(0.415)	(0.450)
Observations	26	26	26	23
R-squared	0.496	0.557	0.600	0.607

Robust standard errors in parentheses
$^{***}p \leq 0.01$, $^{**}p \leq 0.05$, $^{*}p \leq 0.1$

to the baseline regression of BL (2013), a dummy which is equal to one for the high corruption and tax evasion group. Finally, we also run the same regression using the intersection of the two groupings; in this case we drop three countries which do not fall into the same group across the two indices.[7] The results are shown in Table 1.

The first column replicates the baseline result of BL (2013). The planned fiscal consolidation variable is significant at 1% and has a coefficient of -1.095, implying that "for every additional percentage point of fiscal consolidation as a percentage of GDP, output was 1 percent lower than forecast" (BL (2013), p.8). Whilst this coefficient is still significant at 5% when the dummy variables are included, we see that the coefficients are much lower in absolute value, implying that for countries with a low shadow economy and public corruption, the forecasts were more accurate. On the other hand, the interaction term is always significant, showing that there is a significant difference in the coefficient across the two groups. The total coefficient on the planned

[7] An alternative way of carrying out this analysis would be to include the cross-section of the indices directly as controls in the regression. We have chosen to use the dummy variable approach because, although we have robust groupings of countries into high and low tax evasion and corruption, there is not enough cross-sectional variation in either index to add them directly in the regression, and also because both measures are estimated raising issues of generated regressor bias for this exercise.

fiscal consolidation is -1.431 for the High Shadow Economy group, -1.540 for the High Corruption group, and -1.518 for the High Shadow Economy and Corruption group. In all cases, this is well above the baseline BL (2013) coefficient in absolute value, suggesting that the forecast errors were significantly and systematically larger in these countries. In other words, the implicit underestimation of fiscal multipliers is more pronounced in countries with a higher shadow economy and/or corruption, suggesting that these two features amplify the effects of fiscal consolidations.

Following the analysis of BL (2013), we run the same regressions for the components of GDP and unemployment in order to understand which components of demand are more significantly affected by the presence of these two features. Table 2 summarizes the results. We see that the presence of corruption and tax evasion is particularly important for the effects of consolidations on the unemployment rate and investment, but not for consumption, nor for exports or imports.

2.2 VAR Evidence

In this section we present VAR regressions for Italy, for which we have annual time series available for the size of the underground sector. The Italian statistical office (ISTAT (2010)), calculates the number of employees working in the informal sector using the discrepancies between reported employment from household surveys and firm surveys. We use the percentage of informal workers in total workers as the measure of the size of the shadow economy, and enter this into a VAR with GDP, government final consumption expenditures, tax rates (calculated as the total tax burden over GDP) and government debt-to-GDP ratio.[8] We also run the same VAR replacing GDP with the unemployment rate.

We use a set of minimal sign restrictions to identify the fiscal disturbances. We identify two fiscal shocks, a government spending and a tax shock that both decrease the debt-to-GDP ratio. To do so, we impose that the debt-to-GDP ratio falls with a lag following both shocks. We use zero restrictions that ensure that in each case only one instrument is active during the consolidation. In other words, to identify an EB consolidation we assume that tax rates do not move on impact after the shock, while the opposite is assumed in the case of a TB consolidation. The responses of output, unemployment and shadow employment are left unrestricted. The sign restrictions used are summarised in Table 3.[9]

The resulting impulse response functions for the VAR with output are shown in Figure 1.[10] In the case of an EB consolidation both output and shadow employment decrease significantly at all horizons. For a TB consolidation, output does not fall on impact but is significantly negative

[8] The ISTAT data is available at http://www.istat.it/it/archivio/39522. All other data are taken from the AMECO database of the European Commission. We use annual data from 1980-2006, and de-trend the data by including in the VAR a cubic trend and a dummy for 1998 (the start of the European Monetary Union). We also include interest rates as an exogenous variable in order to control for the effects of monetary policy. Given the small sample size, we use Bayesian methods to estimate the VAR.

[9] As a robustness check, we run the VAR in the following order: government consumption expenditures, GDP, shadow employment, tax rates and debt-to-GDP, and use the Cholesky decomposition to identify the shocks. The results are shown in Appendix A, and are in line with the sign restrictions. These results need to be taken with caution since it is very difficult to justify the zero restrictions assumed on the reaction of the fiscal instrument to output changes on annual data.

[10] For ease of exposition we show only the responses of the unrestricted variables in each case; the other responses are in line with the sign restrictions imposed and are presented in Appendix A .

Table 2: Blanchard & Leigh (2013) Regressions with Additional Controls - Components of GDP and Unemployment

	DEPENDENT VARIABLE: Forecast error of the growth of				
REGRESSORS	Unemployment Rate	Priv. Consumption	Investment	Exports	Imports
Planned Fiscal Consolidation	0.562***	-0.285	-4.088***	-1.759	-2.072**
	(0.190)	(0.296)	(1.136)	(1.055)	(0.773)
High Shadow Economy	1.685**	-0.631	-13.324***	4.770	-4.630
and Corruption Dummy	(0.660)	(0.701)	(3.326)	(3.682)	(3.518)
Interaction	-0.147	-0.493	4.131***	0.422	3.312
	(0.349)	(0.334)	(1.367)	(2.285)	(2.150)
Constant	-0.787***	0.125	1.083	5.842***	7.362***
	(0.234)	(0.500)	(1.548)	(1.709)	(1.308)
Observations	23	23	23	23	23
R-squared	0.508	0.422	0.596	0.208	0.241

Robust standard errors in parentheses

$^{***}p \leq 0.01,\ ^{**}p \leq 0.05,\ ^{*}p \leq 0.1$

Table 3: Sign Restrictions

Variable: / **Shock:**	Govt Expenditure $t = 0, 1$	Tax Rate $t = 0, 1$	Debt-to-GDP $t = 2$
Expenditure Cut	–	0	–
Tax Hike	0	+	–

in the long run, and there is a significant rise in shadow employment in the second period.

The results of the VAR with the unemployment rate are shown in Figure 2. We see that the unemployment rate rises significantly after both types of consolidation, and, as before, shadow employment falls in the case of an EB consolidation, and rises in the case of a TB consolidation.

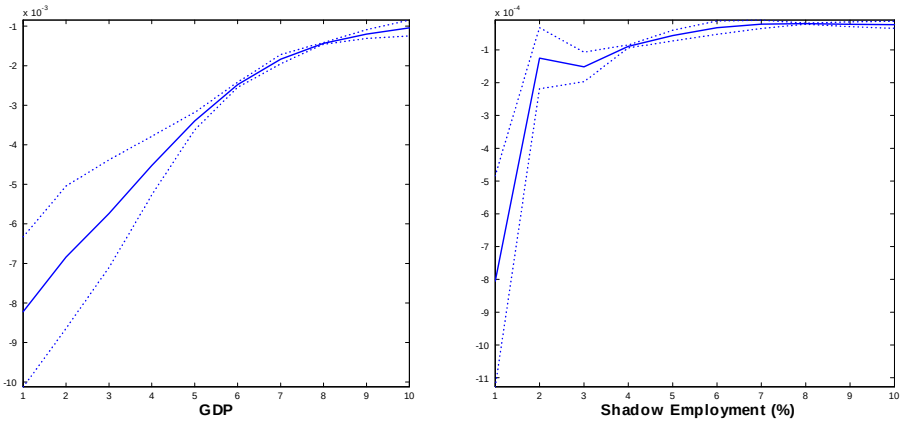
We have also performed exercises, that we do not present here for economy of space, in which we define the fiscal variables in the VAR as percentages of GDP, we replace GDP with a common factor for economic activity and we include alternative series for the size of the shadow economy provided by Elgin and Öztunah (2012). Results are robust to these changes.

Hence, the data robustly suggests that, for Italy, a consolidation through expenditure cuts leads to a fall in shadow employment, whilst a consolidation through tax hikes increases shadow employment. In the next section we construct a DSGE model with tax evasion and corruption and try to replicate these empirical findings in order to understand the transmission of fiscal shocks when the economy operates under such frictions.

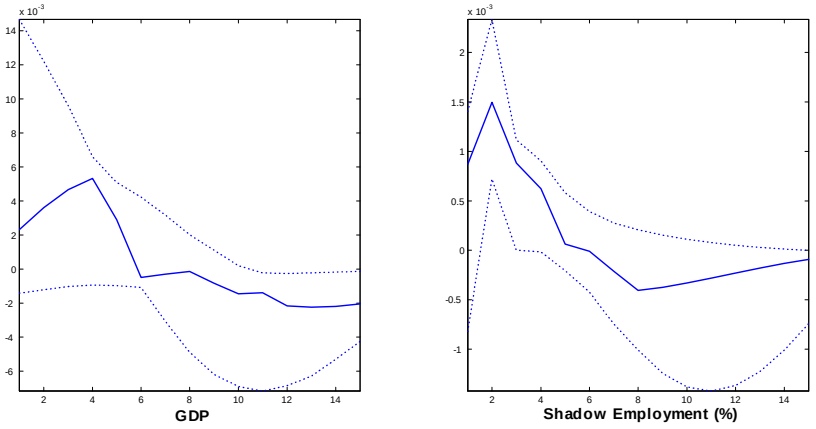
3 The Model

We consider a DSGE model with search and matching frictions, endogenous labor decisions, and sticky prices in the short run. Given that, in Section 2, we found no evidence that the presence of corruption and tax evasion is important for understanding the effects of fiscal consolidation on exports or imports, we consider a closed-economy model, thus, keeping the setup as simple as possible. The economy is divided into the formal and the informal sector, and none of the transactions occurring in the latter are recorded by government authorities. Firms therefore use factors from underground markets to hide part of their production for tax evasion purposes. There are two types of firms in the economy: (i) competitive intermediate firms that use capital and labor to produce intermediate goods with two different technologies: one associated with the regular sector and the other with the underground sector, and (ii) monopolistic competitive retailers that use all intermediate varieties to produce differentiated retail goods, which are then aggregated into a final consumption good. Price rigidities arise at the retail level, while search frictions occur in the production of intermediate goods. In each period of time, intermediate firms face a probability of being inspected by the fiscal authorities and convicted of tax evasion, in which case they pay a penalty, and the employment match is terminated. There is a representative household consisting of formal and informal employees, unemployed jobseekers and labor force non-participants. Formal employment is subject to an income tax, whilst this tax is evaded by

Figure 1: Empirical IRFs - Output and Shadow Employment

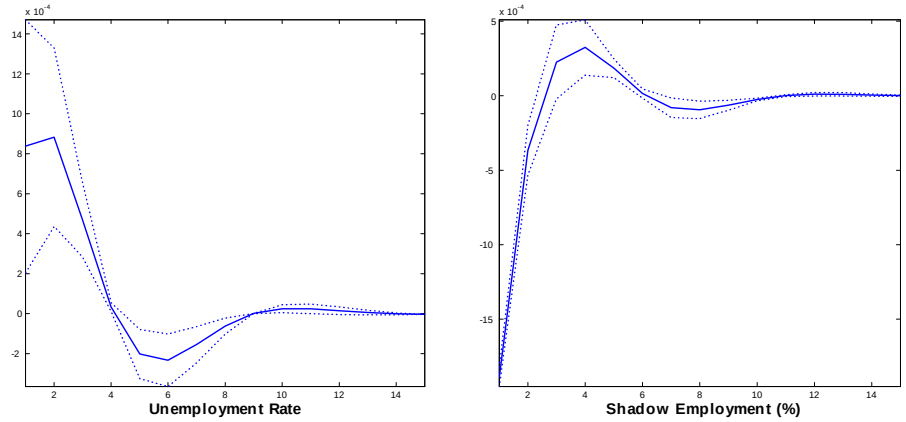


Expenditure Based Consolidation

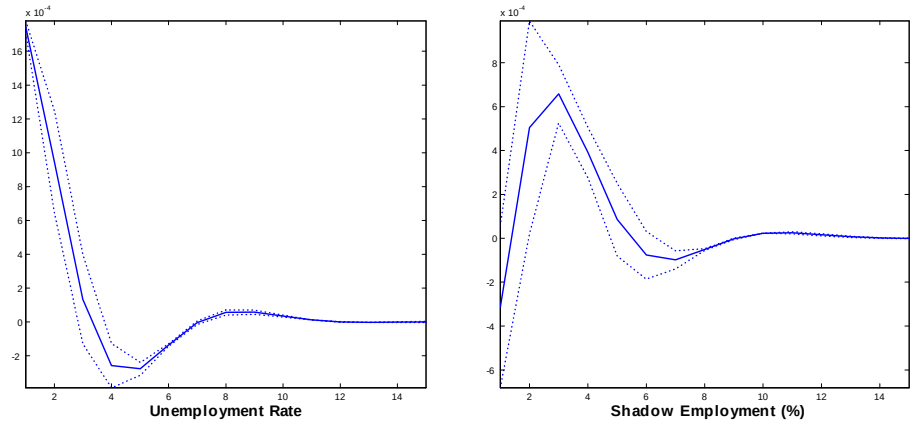


Tax Based Consolidation

Figure 2: Empirical IRFs - Unemployment Rate and Shadow Employment



Expenditure Based Consolidation



Tax Based Consolidation

the employees of the shadow economy. As well as their labor income, the household rents out its private capital to the intermediate firms, and purchases the final consumption good. The government collects taxes from the regular sector, embezzles a fraction of the revenues, and uses the remainder to finance public expenditures and the provision of unemployment benefits.

3.1 Labor market

Following the literature on labor market frictions, we account for the imperfections and transaction costs in the labor market by assuming that jobs are created through a matching function. For $j = F, I$ denoting the formal and informal sectors, we let v_t^j be the number of vacancies and u_t^j the number of jobseekers in each sector. We assume matching functions of the form:

$$m_t^j = \mu_1^j (v_t^j)^{\mu_2} (u_t^j)^{1-\mu_2} \tag{1}$$

where we allow for differences in the efficiency of the matching process, μ_1^j, in the two sectors. In each sector we can define the probability of a jobseeker being hired, ψ_t^{hj}, and of a vacancy being filled, ψ_t^{fj}, as well as the market tightness, θ_t^j, as follows:

$$\psi_t^{hj} \equiv \frac{m_t^j}{u_t^j}, \qquad \psi_t^{fj} \equiv \frac{m_t^j}{v_t^j}, \qquad \theta_t^j \equiv \frac{v_t^j}{u_t^j}$$

In each period, jobs in the formal sector are destroyed at a constant fraction, σ^F, and m_t^F new matches are formed. The law of motion f formal employment, n_t^F, is thus given by:

$$n_{t+1}^F = (1 - \sigma^F) n_t^F + m_t^F \tag{2}$$

In the informal sector there is an exogenous fraction of jobs destroyed in each period, σ^I, as well as a probability that an informal employee might lose their job due to an audit, which we denote by ρ. Therefore the law of motion of informal employment, n_t^I, is given by:

$$n_{t+1}^I = (1 - \rho - \sigma^I) n_t^I + m_t^I \tag{3}$$

3.2 Households

The representative household is made up of a continuum of infinitely lived agents. The members of the household derive utility from leisure, which corresponds to the fraction of members that are out of the labour force, l_t, and a consumption bundle, cc_t, defined as:

$$cc_t = [\alpha_1 (c_t)^{\alpha_2} + (1 - \alpha_1)(g_t)^{\alpha_2}]^{\frac{1}{\alpha_2}} \tag{4}$$

where g_t denotes public consumption, which is taken as exogenous by the household, and

$$c_t = \left[\gamma_1 (c_t^F)^{\gamma_2} + (1 - \gamma_1)(c_t^I)^{\gamma_2}\right]^{\frac{1}{\gamma_2}} \tag{5}$$

is the private consumption bundle, made up of the consumption goods produced in the formal and informal sector. The elasticity of substitution between the private and public goods is given by $\frac{1}{1-\alpha_2}$.[11] Similarly, the elasticity of substitution between the formal and informal consumption goods is given by $\frac{1}{1-\gamma_2}$. The instantaneous utility function is given by:

$$U(cc_t, l_t) = \frac{cc_t^{1-\eta}}{1-\eta} + \Phi \frac{l_t^{1-\varphi}}{1-\varphi} \tag{6}$$

where η is the inverse of the intertemporal elasticity of substitution, $\Phi > 0$ is the relative preference for leisure, and φ is the inverse of the Frisch elasticity of labor supply.

At any point in time a fraction n_t^F (n_t^I) of the representative household's members are formal (informal) employees. Campolmi and Gnocchi (2014), Brückner and Pappa (2012) and Bermperoglou et al. (2014) have added a labor force participation choice in New Keynesian models of equilibrium unemployment. Following Ravn (2008), the participation choice is modelled as a trade-off between the cost of giving up leisure and the prospect of finding a job. In particular, the household chooses the fraction of the unemployed actively searching for a job, u_t, and the fraction which are out of the labor force and enjoying leisure, l_t, so that:

$$n_t^F + n_t^I + u_t + l_t = 1 \tag{7}$$

The household chooses the fraction of jobseekers searching in each sector: a share s_t of unemployed looks for a job in the underground sector, while the remainder, $(1 - s_t)$, seek employment in the formal sector. That is, $u_t^I \equiv s_t u_t$ and $u_t^F \equiv (1 - s_t)u_t$.

The household owns the capital stock, which evolves over time according to:

$$k_{t+1} = i_t + (1-\delta)k_t - \frac{\omega}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t \tag{8}$$

where δ is a constant depreciation rate and $\frac{\omega}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t$ are adjustment costs.

The intertemporal budget constraint is given by:

$$(1+\tau_t^c)c_t + i_t + \frac{B_{t+1}\pi_{t+1}}{R_t} \leq r_t k_t + (1-\tau_t^n)w_t^F n_t^F + w_t^I n_t^I + \varpi u_t^F + B_t + \Pi_t^p - T_t \tag{9}$$

where $\pi_t \equiv p_t/p_{t-1}$ is the gross inflation rate, w_t^j, $j = F, I$, are the real wages in the two sectors, r_t is the real return to capital, ϖ denotes unemployment benefits, available only in the formal sector (see Boeri and Garibaldi (2007)), B_t is the real government bond holdings, R_t is the gross nominal interest rate, Π_t^p are the profits of the monopolistically competitive firms, discussed below, and τ_t^c, τ_t^n and T_t represent taxes on private consumption, labor income and lump-sum taxes respectively.

The household maximises expected lifetime utility subject to (1) for each j, (2), (3), (7), (8), and (9). Taking as given n_t^j, they choose u_t, s_t (which together determine l_t) and n_{t+1}^j, as well as c_t, k_{t+1} and B_{t+1}.

[11] Recall the following limiting cases: when α_2 approaches one, c_t and g_t are perfect substitutes. They are instead perfect complements if α_2 tends to minus infinity. $\alpha_2 = 0$ nests the Cobb-Douglas specification.

It is convenient to define the marginal value to the household of having an additional member employed in the two sectors, as follows:

$$V^h_{n^F t} = \lambda_{ct} w^F_t (1 - \tau^n_t) - \Phi l_t^{-\varphi} + (1 - \sigma^F)\lambda_{n^F t} \tag{10}$$

$$V^h_{n^I t} = \lambda_{ct} w^I_t - \Phi l_t^{-\varphi} + (1 - \rho - \sigma^I)\lambda_{n^I t} \tag{11}$$

where $\lambda_{n^F t}$, $\lambda_{n^I t}$ and λ_{ct} are the multipliers in front of (2), (3) and (9) respectively.[12]

3.3 Production

3.3.1 Intermediate goods firms

Intermediate goods are produced with two different technologies:

$$x^F_t = (A^F_t n^F_t)^{1-\alpha^F} (k_t)^{\alpha^F} \tag{12}$$

$$x^I_t = (A^I_t n^I_t)^{1-\alpha^I} \tag{13}$$

where $A^F_t > A^I_t$ denote total factor productivities. That is, we assume that the informal production technology is less efficient and uses labor inputs only (see e.g. Busato and Chiarini (2004)). More importantly, since households consume a final good, we are also implicitly assuming that the formal and informal goods are perfect substitutes. There is no differentiation between goods. Final goods are produced with some intermediates that are not declared by the firms.

Firms maximize the discounted value of future profits, subject to (2) and (3), taking the number of workers currently employed in each sector, n^j_t, as given and choosing the number of vacancies posted in the current period in each sector, υ^j_t, so as to employ the desired number of workers next period, n^j_{t+1}. Here, firms adjust employment by varying the number of workers (extensive margin) rather than the number of hours per worker (intensive margin). According to Hansen (1985), most of the employment fluctuations arise from movements in this margin. Firms also decide the amount of the private capital, k_t , needed for production. They face a probability, ρ , of being inspected by the fiscal authorities, convicted of tax evasion and forced to pay a penalty, which is a fraction, γ , of their total revenues. Hence the problem of an intermediate firm is:

$$Q(n^j_t) = \max_{k_t, \upsilon^j_t} \left\{ (1 - \rho\gamma)\, p^x_t (x^F_t + x^I_t) - (1 + \tau^s_t) w^F_t n^F_t - w^I_t n^I_t - r_t k_t - \kappa^F \upsilon^F_t - \kappa^I \upsilon^I_t + E_t \left[\Lambda_{t,t+1} Q(n^j_{t+1}) \right] \right\} \tag{14}$$

where p^x_t is the relative price of intermediate goods, τ^s_t is a payroll tax, κ^j is a cost associated with posting a new vacancy in each sector j, and $\Lambda_{t,t+1} \equiv \beta \frac{U_{cct+1}}{U_{cct}} = \beta \left(\frac{cc_{t+1}}{cc_t} \right)^{-\eta}$ is a discount

[12] The first order conditions of the household's problem and the derivations of equations (10) and (11) are presented in the Appendix.

factor. The first-order conditions are:

$$r_t = (1-\rho\gamma)\, p_t^x \left(\frac{\alpha^F x_t^F}{k_t}\right) \tag{15}$$

$$\frac{\kappa^F}{\psi_t^{fF}} = E_t \Lambda_{t,t+1} \left[(1-\rho\gamma)\, p_{t+1}^x (1-\alpha^F)\frac{x_{t+1}^F}{n_{t+1}^F} - (1+\tau_{t+1}^s) w_{t+1}^F + \frac{(1-\sigma^F)\kappa^F}{\psi_{t+1}^{fF}}\right] \tag{16}$$

$$\frac{\kappa^I}{\psi_t^{fI}} = E_t \Lambda_{t,t+1} \left[(1-\rho\gamma)\, p_{t+1}^x (1-\alpha^I)\frac{x_{t+1}^I}{n_{t+1}^I} - w_{t+1}^I + \frac{(1-\rho-\sigma^I)\kappa^I}{\psi_{t+1}^{fI}}\right] \tag{17}$$

According to (15)-(17), the net value of the marginal product of private capital should equal the real rental rate and the marginal cost of opening a vacancy in each sector j should equal the expected marginal benefit. The latter includes the net value of the marginal product of labor minus the wage, augmented by the payroll tax in the formal sector, plus the continuation value.

Again for convenience we present the expected values of the marginal formal and informal job for the intermediate firm:

$$V_{n^F t}^f \equiv \frac{\partial Q}{\partial n_t^F} = (1-\rho\gamma)\, p_t^x (1-\alpha^F)\frac{x_t^F}{n_t^F} - (1+\tau_t^s) w_t^F + \frac{(1-\sigma^F)\kappa^F}{\psi_t^{fF}} \tag{18}$$

$$V_{n^I t}^f \equiv \frac{\partial Q}{\partial n_t^I} = (1-\rho\gamma)\, p_t^x (1-\alpha^I)\frac{x_t^I}{n_t^I} - w_t^I + \frac{(1-\rho-\sigma^I)\kappa^I}{\psi_t^{fI}} \tag{19}$$

3.3.2 Retailers

There is a continuum of monopolistically competitive retailers indexed by i on the unit interval. Retailers buy intermediate goods and differentiate them with a technology that transforms one unit of intermediate goods into one unit of retail goods, and thus the relative price of intermediate goods, p_t^x, coincides with the real marginal cost faced by the retailers. Let y_{it} be the quantity of output sold by retailer i. The final consumption good can be expressed as:

$$y_t = \left[\int_0^1 (y_{it})^{\frac{\epsilon-1}{\epsilon}} di\right]^{\frac{\epsilon}{\epsilon-1}} \tag{20}$$

where $\epsilon > 1$ is the constant elasticity of demand for retail goods. The final good is sold at its price, $p_t = \left[\int_0^1 p_{it}^{1-\epsilon} di\right]^{\frac{1}{1-\epsilon}}$. The demand for each intermediate good depends on its relative price and aggregate demand:

$$y_{it} = \left(\frac{p_{it}}{p_t}\right)^{-\epsilon} y_t \tag{21}$$

Following Calvo (1983), we assume that in any given period each retailer can reset her price with a fixed probability $(1-\chi)$. Hence, the price index is:

$$p_t = \left[(1-\chi)(p_t^*)^{1-\epsilon} + \chi (p_{t-1})^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}} \tag{22}$$

The firms that are able to reset their price, p_{it}^*, choose it so as to maximize expected profits given by:

$$E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t,t+s}(p_{it}^* - p_{t+s}^x) y_{it+s}$$

The resulting expression for p_{it}^* is:

$$p_{it}^* = \frac{\epsilon}{\epsilon - 1} \frac{E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t,t+s} p_{t+s}^x y_{it+s}}{E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t,t+s} y_{it+s}} \tag{23}$$

3.4 Government

The government's expenditures consist of consumption purchases and unemployment benefits, whilst their revenue comes from the collected fines and the payroll, consumption, and labor income taxes, as well as the lump-sum taxes. The government deficit is therefore defined by:

$$DF_t = g_t + \varpi u_t^F - (1 - \xi^{TR}) TR_t - \rho\gamma p_t^x (x_t^F + x_t^I) \tag{24}$$

where $TR_t \equiv (\tau_t^n + \tau_t^s) w_t^F n_t^F + \tau_t^c c_t + T_t$ represents the tax revenues and $0 \leq \xi^{TR} < 1$ denotes the embezzlement rate in the presence of corruption in the economy.

The government budget constraint is defined by:

$$b_t + \frac{DF_t}{y_t} = R_t^{-1} b_{t+1} \pi_{t+1} g_{t+1}^y \tag{25}$$

where $b_t = \frac{B_t}{y_t}$ is the debt-to-GDP ratio and g_{t+1}^y is the growth rate of GDP.

We assume transfers, T_t, , τ_t^s, and τ_t^c are fixed at their steady-state level. Therefore the government potentially has the following fiscal instruments $\Psi \in \{g, \tau^n\}$, in line with Erceg and Lindé (2013). Although we have tried to incorporate various types of distortionary taxation in our framework, we present results for the varying labor tax only, since fiscal consolidations through payroll tax hikes have very similar effects in our model and since consumption tax hikes, though they have different effects from the other two types of taxes, do not constitute the major source of tax revenues in any of the economies we study.

We consider each instrument separately, assuming that if one is active, the others remain fixed at their steady-state levels. Following Erceg and Lindé (2013), we assume fiscal rules of the form:

$$\Psi_t = \Psi^{(1-\beta_{\Psi 0})} \Psi_{t-1}^{\beta_{\Psi 0}} \exp\{(1 - \beta_{\Psi 0})[\beta_{\Psi 1}(b_t - b_t^*) + \beta_{\Psi 2}(\Delta b_{t+1} - \Delta b_{t+1}^*)]\} \tag{26}$$

where b_t^* is the target value for this ratio and follows an AR(2) process:

$$\log b_{t+1}^* - \log b_t^* = \mu_b + \rho_1(\log b_t^* - \log b_{t-1}^*) - \rho_2 \log b_t^* + \varepsilon_t^b \tag{27}$$

where ε_t^b is a white noise process with variance σ_ε.

3.5 Closing the model

Monetary Policy There is an independent monetary authority that sets the nominal interest rate as a function of current inflation according to the rule:

$$R_t = R \exp\{\zeta_\pi(\pi_t - 1)\} \tag{28}$$

where R is the steady-state value of the nominal interest rate.

Goods Markets Total output must equal private and public demand. The resource constraint for output is thus given by:

$$y_t = c_t + i_t + g_t + \kappa^F \upsilon_t^F + \kappa^I \upsilon_t^I + \xi^{TR} TR_t \tag{29}$$

where the last term represents the resource costs in the economy due to corruption.[13]

The aggregate price index, p_t, is given by (22) and (23). The return on private capital, r_t, adjusts so that the capital demanded by the intermediate goods firm, given by (15), is equal to the stock held by the household.

Bargaining over wages Wages in both sectors are determined by ex post (after matching) Nash bargaining. Workers and firms split rents and the part of the surplus they receive depends on their bargaining power. For $j = F, I$ we denote by $\vartheta^j \in (0,1)$ the firms' bargaining power in sector j. The Nash bargaining problem is to maximize the weighted sum of log surpluses:

$$\max_{w_t^j} \left\{ (1-\vartheta^j) \log V_{n^j t}^h + \vartheta^j \log V_{n^j t}^f \right\}$$

where $V_{n^j t}^h$ and $V_{n^j t}^f$ are defined in equations (10), (11), (18) and (19). As shown in Appendix B.3, wages are given by:

$$w_t^F = \frac{(1-\vartheta^F)}{(1+\tau_t^s)} \left((1-\rho\gamma)\, p_t^x (1-\alpha^F) \frac{x_t^F}{n_t^F} + \frac{(1-\sigma^F)\kappa^F}{\psi_t^{fF}} \right) + \frac{\vartheta^F}{\lambda_{ct}(1-\tau_t^n)} \left(\Phi l_t^{-\varphi} - (1-\sigma^F)\lambda_{n^F t} \right) \tag{30}$$

$$w_t^I = (1-\vartheta^I) \left((1-\rho\gamma)\, p_t^x (1-\alpha^I) \frac{x_t^I}{n_t^I} + \frac{(1-\rho-\sigma^I)\kappa^I}{\psi_t^{fI}} \right) + \frac{\vartheta^I}{\lambda_{ct}} \left(\Phi l_t^{-\varphi} - (1-\rho-\sigma^I)\lambda_{n^I t} \right) \tag{31}$$

3.6 Calibration

We calibrate the model using annual data on the Italian economy over the period 1982-2006.[14] Table 4 displays the values used for the different parameters. We calibrate the labor force participation and unemployment rate in the formal sector to match the observed average values from the data. Thus we set official labor force participation, $lf = n^F + u^F$, equal to 60% and the official

[13] See Appendix B.2 for full derivations.

[14] Details of the calibration exercise are in Appendix C.

Table 4: Calibration Values

Parameter	Description	Full Model
A^F	Formal Sector TFP	1
A^I	Informal Sector TFP	0.25
α^I	Informal Sector Production Function Parameter	0.80
α^F	Formal Sector Capital Share	0.34
b	Debt-to-GDP Ratio	1.03
β	Discount Factor	0.96
β_{g0}, β_{g1}, β_{g2}	Fiscal Policy Rules Parameters - Expenditure	0.5, 3.5, 2.0
$\beta_{\tau^n 0}$, $\beta_{\tau^n 1}$, $\beta_{\tau^n 2}$	Fiscal Policy Rules Parameters - Tax Rates	0.8, 15, 12
χ	Price Stickiness	0.25
$\frac{DF}{y}$	Deficit-to-GDP Ratio	-0.04
δ	Depreciation Rate	0.088
ε	Price Elasticity of Demand	5
$\frac{g}{y}$	Government Expenditure-to-GDP Ratio	0.11
η	Inverse Elasticity of Intertemporal Substitution	2
κ^F	Formal Sector Vacancy Costs	0.14
$\frac{\kappa^F}{w^F}$	Vacancy Costs/Wage	0.22
κ^I	Informal Sector Vacancy Costs	0.13
$\frac{k}{y}$	Capital-to-GDP	2.09
$lf \equiv n^F + u^F$	Official Labor Force Participation	0.6
μ_1^I	Informal Sector Matching Efficiency	0.18
μ_1^F	Formal Sector Matching Efficiency	0.85
μ_2	Elasticity of Matching to Vacancies	0.7
$\frac{n^I}{n}$	Share of Informal Employment to Total	0.13
ω	Capital Adjustment Costs	3
Φ	Relative Utility from Leisure	0.04
ξ^{TR}	Embezzlement Rate	0.2
ψ^{fI}	Probability of Filling a Vacancy - Informal Sector	0.05
ψ^{fF}	Probability of Filling a Vacancy - Formal Sector	0.96
ψ^{hI}	Probability of Finding a Job - Informal Sector	0.85
ψ^{hF}	Probability of Finding a Job - Formal Sector	0.63
ρ	Auditing Probability	0.02
ρ_1, ρ_2	Debt-to-GDP Target Parameters	0.85, 0.0001
s	Share of Informal Jobseekers to Total	0.11
σ^I	Exogenous Job Destruction Rate in Informal Sector	0.0545
σ^F	Exogenous Job Destruction Rate in Formal Sector	0.07
τ^n	Labor Income Tax Rate	0.4
τ^s	Payroll Tax Rate	0.16
τ^c	Consumption Tax Rate	0.18
$\frac{u}{1-l}$	Actual Unemployment Rate	0.09
$\frac{u^F}{lf}$	Official Unemployment Rate	0.1
φ	Inverse Frisch Elasticity of Labor Supply	2
$\frac{\varpi}{w^F}$	Replacement Rate	0.35
ϑ^I	Informal Sector Firm's Bargaining Power	0.81
ϑ^F	Formal Sector Firm's Bargaining Power	0.22
$\frac{w^I}{w^F}$	Formal/Informal Wage Differentials	0.93
$\frac{y^I}{y}$	Share of Underground Ouput in Total	0.37
ζ_π	Taylor Rule Parameter	1.1
γ	Porportional Fine in Case of Auditing	0.3

unemployment rate to 10%. We fix the separation rate, σ^F, equal to 0.07. Since there is no exact estimate for the value of the formal vacancy-filling probability, ψ^{fF}, in the literature, we use what is considered as standard by setting it equal to 0.96. We set the matching elasticity with respect to vacancies, μ_2, equal to 0.7, close to the estimate for Italy in Peracchi and Viviano (2004).

The capital depreciation rate, δ, is set equal to 0.088. Following the literature, we set the discount factor, β, equal to 0.96. The elasticity of demand for intermediate goods, ϵ, is set such that the gross steady-state markup, $\frac{\epsilon}{\epsilon-1}$, is equal to 1.25, and the price of the final good is normalized to one. The TFP parameter in the formal sector is normalized to one, $A^F = 1$ and the capital share $\alpha^F = 0.34$. The probability of audit and the fraction of total profits paid as a fine in the event of an audit are set as follows: $\rho = 0.02$, which is close to the value used in Boeri and Garibaldi (2007), and $\gamma = 0.3$. We set the vacancy costs in the formal sector $\kappa^F = 0.14$ and the payroll tax rate $\tau^s = 0.16$, close to the value in Orsi et al. (2014).

In the informal sector, we assume that TFP is lower relative to the informal sector and set $A^I = 0.25$. Using the ISTAT data, we set the share of underground employment to total employment equal to 0.13. We set the value of α^I equal to 0.8. We set the exogenous job destruction rate in the informal sector $\sigma^I = 0.0545$ and set the probability of filling a vacancy in the informal sector $\psi^{fI} = 0.05$ and the vacancy cost in the informal sector $\kappa^I = 0.13$.

Next, we set the replacement rate, $\frac{\varpi}{w^F}$, equal to 0.35 close to the estimates in Martin (1996), also used by Fugazza and Jacques (2004). Government spending as a share of GDP and the tax rates are set as follows: $\frac{g}{y} = 11\%$, $\tau^n = 0.4$, in line with Orsi et al. (2014), and $\tau^c = 0.18$. The steady state debt-to-GDP ratio is taken from the data, $b = 103\%$. We set the corruption parameter $\xi^{TR} = 0.2$.

The intertemporal elasticity of substitution, $\frac{1}{\eta}$, is set equal to 0.5 and the inverse Frisch elasticity, φ, equals 2. Finally, we set the inflation targeting parameter in the Taylor rule, $\zeta_\pi = 1.1$, the capital adjustment costs $\omega = 3$ and the price-stickiness parameter $\chi = 0.25$. The fiscal policy parameters are set so as to achieve a 5% drop in the debt-to-GDP target 10 periods after a debt shock.

3.7 Results

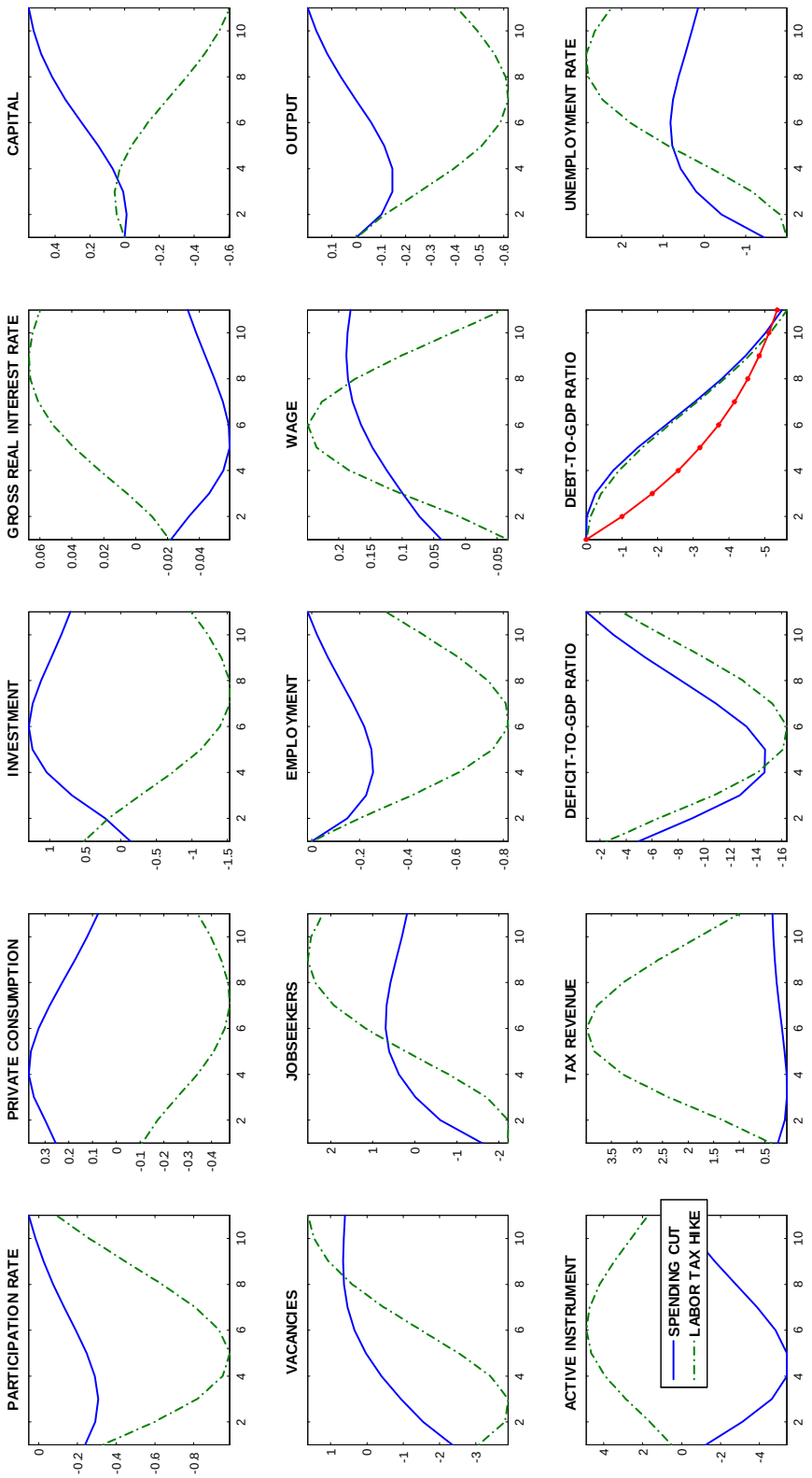
We now present the impulse responses following a negative debt-target shock. We compare the effects of a 5% reduction in the desired long-run debt target, which is achieved after 10 years, either through a fall in consumption expenditure or a hike in the tax rates.

3.7.1 Benchmark Model

In order to understand how tax evasion and corruption affect the transmission of fiscal shocks, we begin by analysing the response of the macroeconomy in a standard model where those two features are absent. The theoretical impulse responses are presented in Figure 3.

The consolidation carried out with a fall in government spending has two channels. First, there is a negative demand effect, leading to a fall in labor demand, which is translated into a fall in vacancies. Second, there is a positive wealth effect for the household, which increases

Figure 3: IRFs of Benchmark Model (Without Shadow Economy and Corruption)



consumption and investment and reduces labor force participation. Given the drop in both labor demand and supply, employment falls and the wage increases. Output falls in the short run, but increases in the medium and long run because of the increase in investment, which is translated into an increase in the capital stock. The unemployment rate reflects the movement in the number of jobseekers, which falls on impact, but then increases as employment adjusts.

When the fiscal consolidation is carried out through labor tax hikes, there is a negative wealth effect for the household which reduces consumption. The fall in consumption induces a fall in labor demand, expressed through a drop in vacancies. However, as the return from employment falls, there is a substitution effect which outweighs the wealth effect, and there is again a decrease in labor force participation. Employment and output fall, and the responses are significantly larger and more persistent than in the case of spending cuts, given the delayed drop in investment and, hence, capital.

Thus, the benchmark model confirms recent empirical evidence according to which EB consolidations are accompanied by mild and short-lived recessions, while TB consolidations lead to more prolonged and deep recessions (see Alesina et al. (2013)).

3.7.2 Model with Shadow Economy and Corruption

Next, we perform the same analysis for the economy with an underground sector and corruption. Figure 4 depicts the formal sector and fiscal variables in this modified model, and Figure 5 shows the underground sector.

First, we see from Figure 4 that the qualitative response of the formal sector is comparable with that of the benchmark model. For the TB consolidation there is an additional channel now at play as unemployed jobseekers reallocate their labor supply and the intermediate firms reallocate their labor demand from the formal to the informal sector. Tax hikes provide direct incentives for jobseekers to reallocate their search towards the underground sector because of the higher tax rates associated with formal employment. At the same time, intermediate firms find it profitable to reallocate the posted vacancies towards the underground sector because of the fall in the informal wage, as shown in Figure 5. Consequently, employment and production in the shadow economy increase.

The negative demand effect from spending cuts affects both formal and informal production. Rather than observing a reallocation of labor supply and labor demand between the two sectors, we see that unemployed jobseekers in both sectors decide to leave the labor force. Labor demand is again contracted and as a result, formal and informal employment fall, replicating the responses of the underground economy to a spending cut we observed for Italy in Subsection 2.2.

3.7.3 Comparisons and Sensitivity Analysis

Figure 6 shows the response of output, the unemployment rate and welfare for the benchmark model and the model with tax evasion and corruption, for EB and TB consolidations separately, as

Figure 4: IRFs of Model With Shadow Economy and Corruption

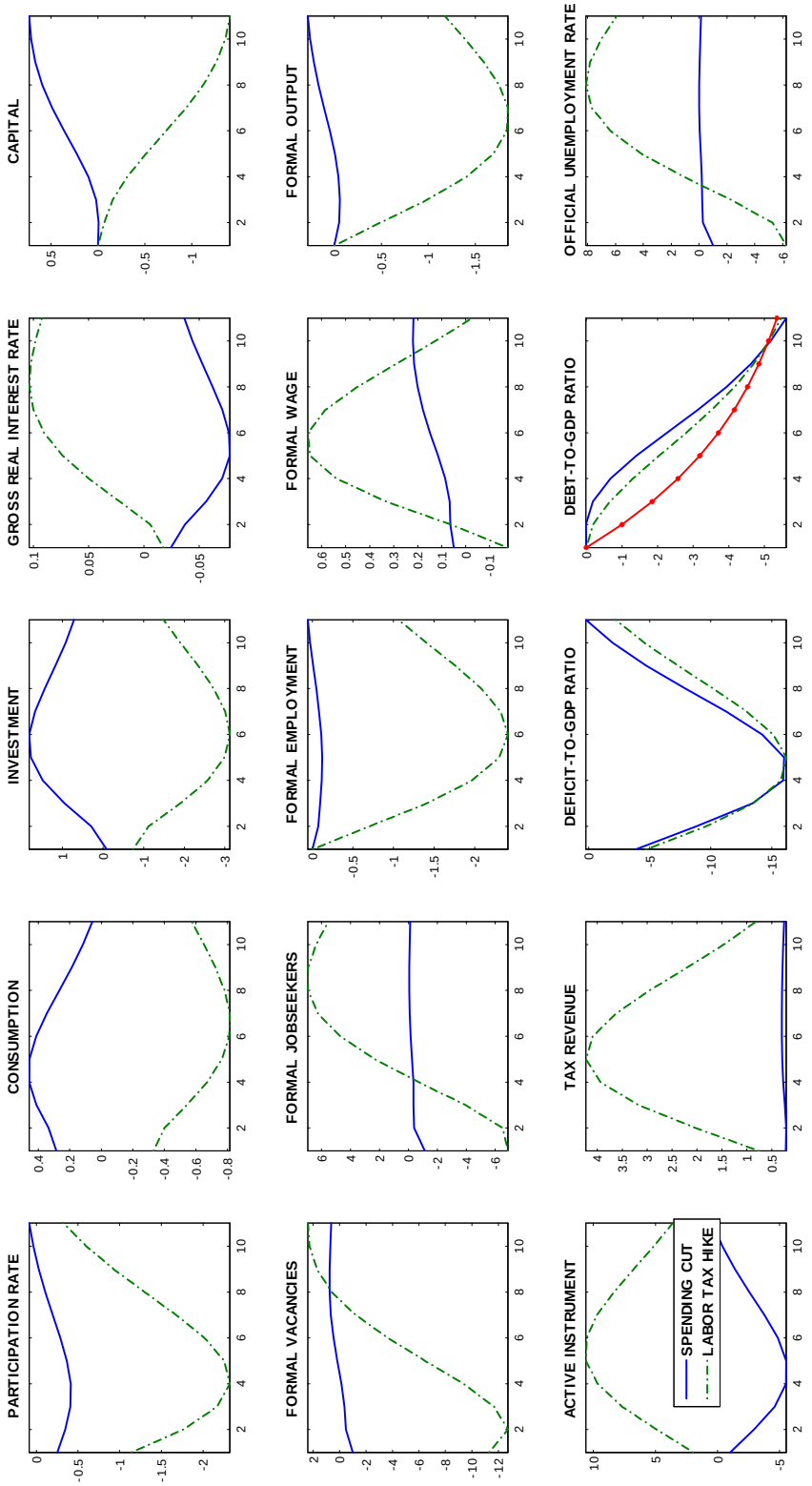
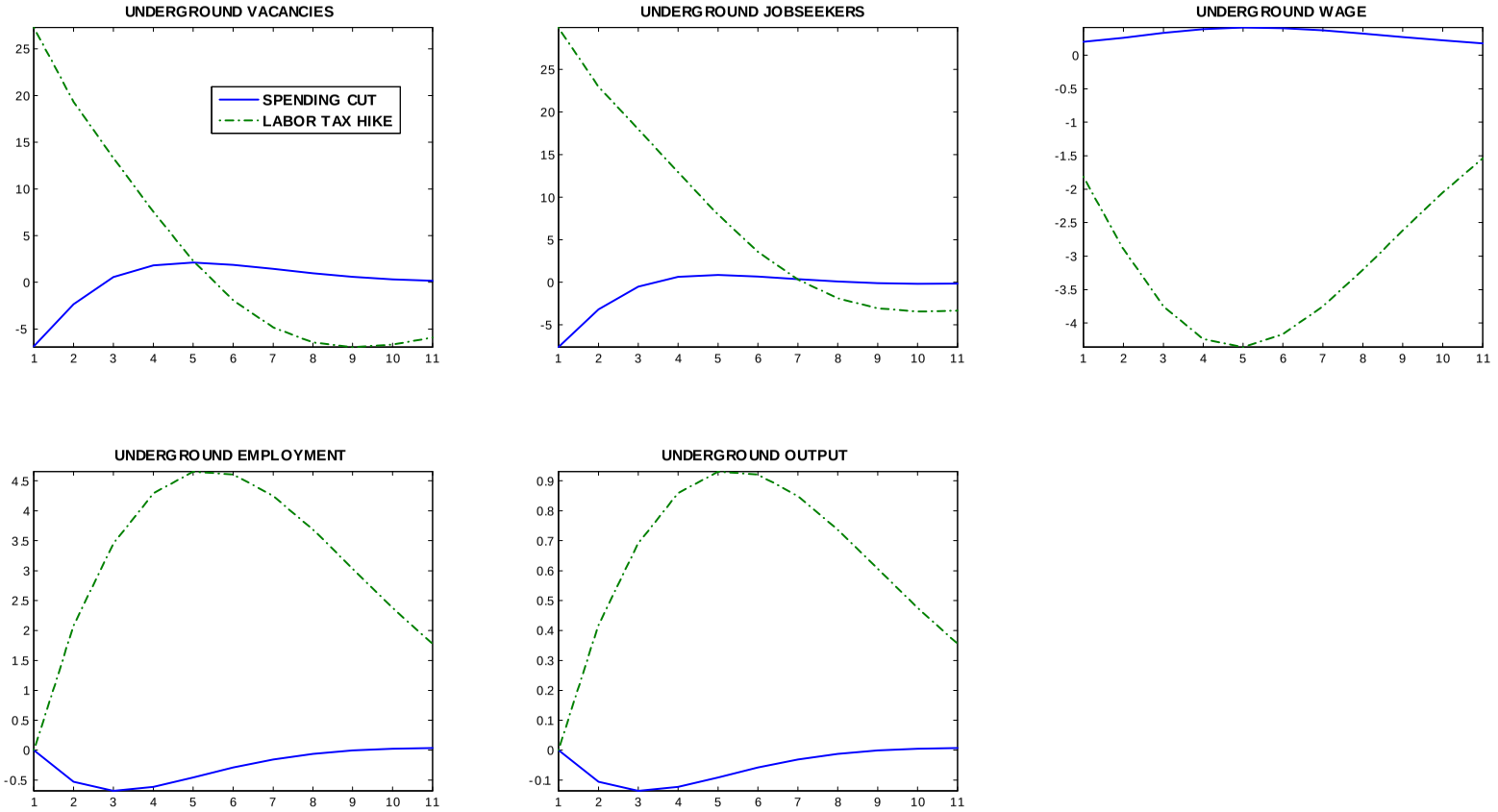


Figure 5: IRFs of Model with Shadow Economy and Corruption - Underground Sector



well as a mixed consolidation in which we allow both policy instruments to move simultaneously.[15] We fix the relative contribution of expenditure cuts and revenue enhancements to the reduction in deficit, based on the estimates of OECD (2012), which contains details of the recent fiscal consolidation plans for many OECD countries. For Italy the reported share of expenditure cuts in the consolidation plans is around 50%.

For spending cuts, shown in the top panel, we see that the presence of the shadow economy yields smaller short run losses of output and decreases the unemployment rate at all horizons. At the same time, consumption increases by more, and labor force participation falls by more, relative to the benchmark case without tax evasion and corruption. This seems to suggest that the presence of tax evasion and corruption amplifies the wealth effect. This is due to the fact that, when tax evasion and corruption are present, the tax adjustments required to achieve a given change in deficit are larger, and so, following a spending cut, taxes in the future are expected to fall by more. The amplification of the wealth effect increases the crowding-in of the private sector and reduces the negative demand effect of the fiscal contraction on output and unemployment. We also see that in both models the EB consolidation implies welfare gains, and that allowing for tax evasion and corruption increases welfare from EB consolidations. This is simply because of the amplification of the wealth effect, which increases the crowding-in of private consumption and the reduction of labor force participation.

For tax hikes, shown in the middle panel, we see that the presence of corruption and tax evasion amplifies the output losses for many horizons, as the recession caused in the formal sector is deeper. After the impact period, the rise in the official unemployment rate is amplified. Finally, we see that TB consolidation leads to welfare losses, because of the fall in consumption, which are amplified by the presence of tax evasion and corruption.

For the mixed consolidation, depicted in the bottom panel, we see that, similarly to the case of TB consolidation, the output losses and the increases in unemployment are amplified in the presence of tax evasion and corruption. This is in line with the evidence from our extension of the BL (2013) regressions in Section 2. Furthermore, the initial welfare gains are mitigated, but this is reversed after 6 years.

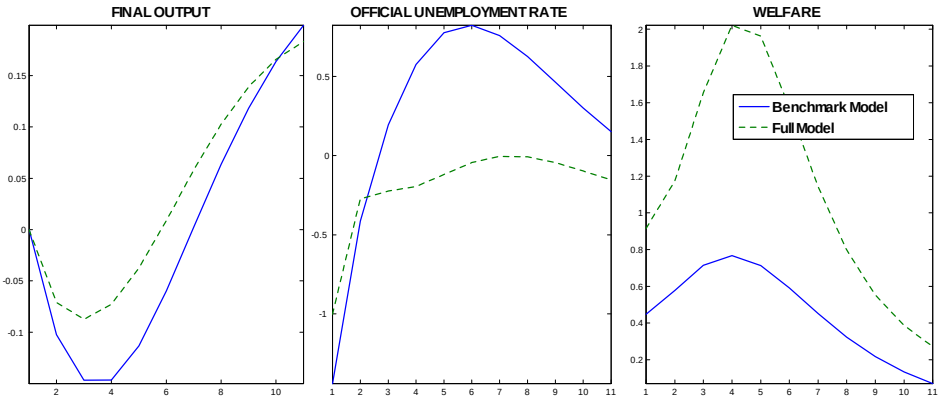
Whilst the effects of TB consolidations are robust to a broad set of parameter values, the effects of EB consolidations might depend crucially on some modelling assumptions. For instance, spending cuts can result in welfare losses if government expenditures are assumed to be utility enhancing. To investigate this, we conduct a sensitivity analysis by setting $\alpha_1 = 0.85$ and $\alpha_2 = -0.25$, so that private and public spending are complements. Results from an EB consolidation under this scenario are depicted in the top panel of Figure 7 in comparison to the case of wasteful government spending.[16] We see that output and unemployment effects are mitigated, while, as expected, the response of welfare is reversed.

In addition, the presence of rule of thumb (ROT) consumers in the economy may imply smaller

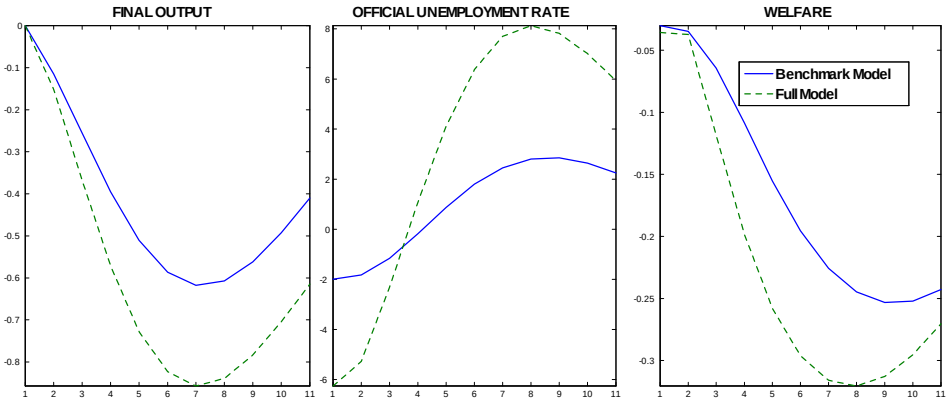
[15] Welfare is computed as per-period steady state consumption equivalents. IRFs of all other variables are included in Appendix A.

[16] Note that, for comparison purposes, in all our exercises we adjust the parameters of the policy rules so that the debt target is met after 10 years.

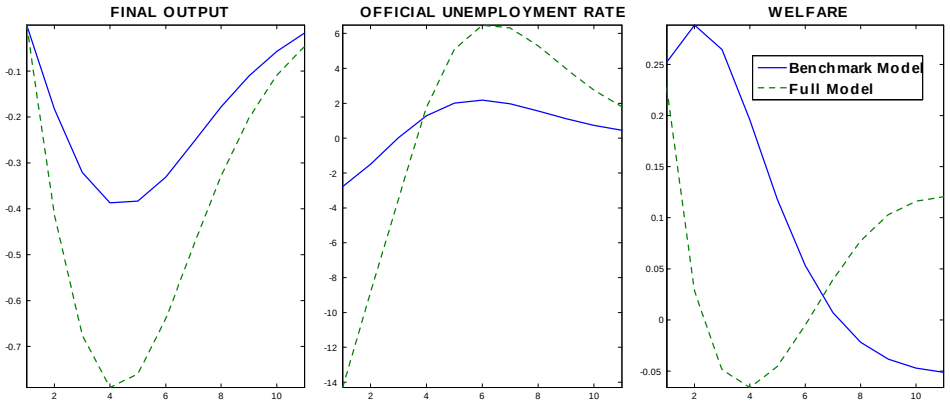
Figure 6: Comparison of Benchmark and Full Model



Expenditure Based Consolidation

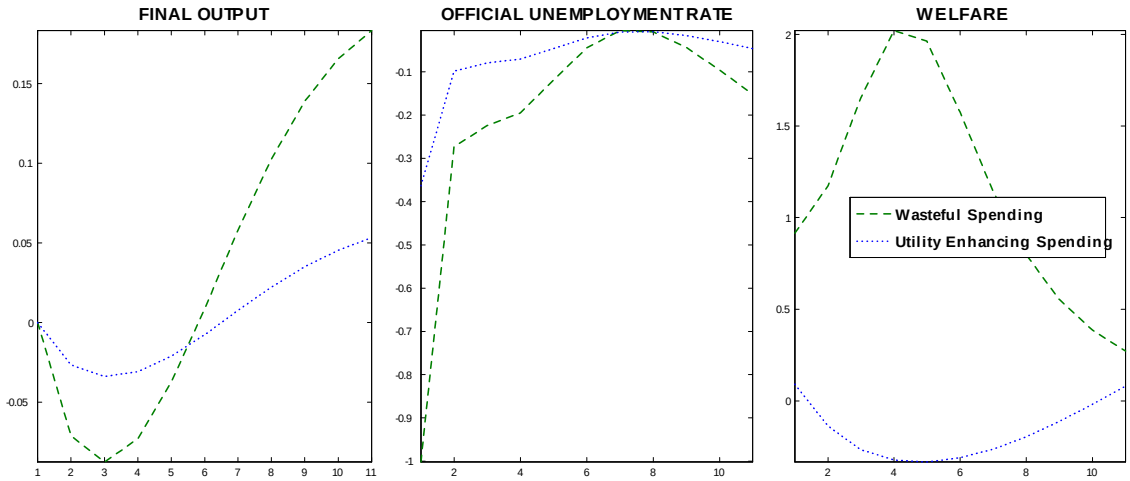


Tax Based Consolidation

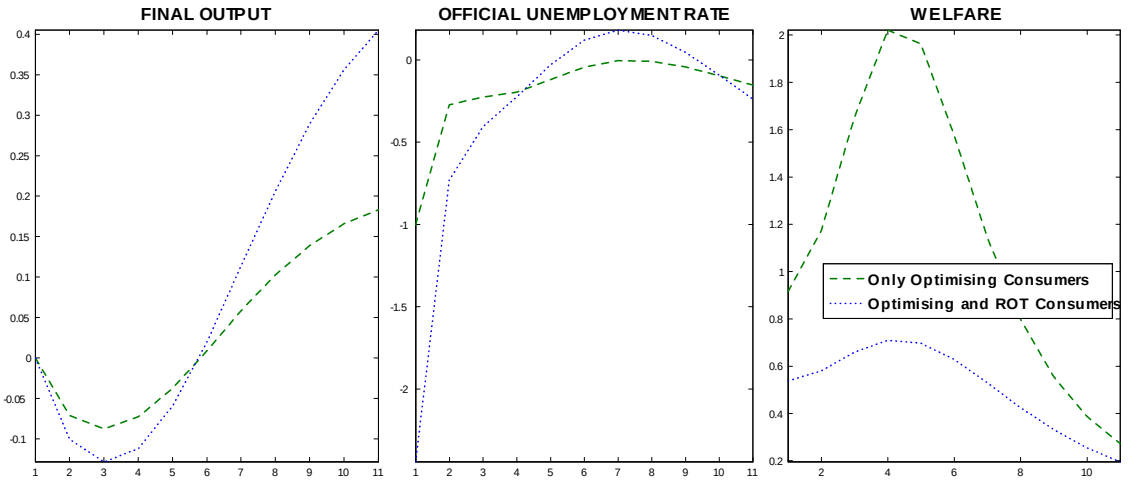


Mixed Consolidation

Figure 7: Sensitivity for Expenditure Based Consolidations in the Full Model



Utility Enhancing Government Spending



Rule of Thumb (ROT) Consumers

Table 5: Calibrated Values

	Greece	Italy	Spain	Portugal
Informal Employment (% Total Employment)	14	13	12.5	12.5
Embezzlement Rate	0.20	0.20	0.10	0.10
Unemployment Rate	0.10	0.10	0.15	0.07
Labor Force Participation Rate	0.64	0.60	0.65	0.70
Replacement Rate	0.30	0.35	0.35	0.35
Expenditure Share in Policy Mix	0.52	0.50	0.66	0.54
Government Consumption Spending (% GDP)	5	11	6	5
Debt (% GDP)	110	103	40	56

welfare gains from spending cuts, since these agents cannot adjust their consumption in the event of a consolidation and their presence mitigates the positive wealth effect induced by the fiscal contraction. To explore this channel, we incorporate in our model a fraction of non-optimising household members, which we set in our calibration equal to 44% in accordance with household surveys for Italy reported by Martin and Philippon (2014). As shown in the bottom panel of Figure 7, output and unemployment effects are amplified and welfare gains are mitigated, as expected.

4 Policy Evaluation

Given that the model is able to replicate qualitatively the empirical responses of output, unemployment and tax evasion in Italy, in this section we employ it in order to quantify the effects of actual fiscal consolidation plans proposed and implemented in recent years. In particular, we recalibrate our model for Greece, Spain and Portugal, all countries which are implementing sizeable consolidations and which are characterized by high corruption and tax evasion. In this section we consider both the effects of the consolidation plans on the size of the shadow economy, and also measure their output, unemployment and welfare effects.

For this exercise, in order to replicate the actual consolidation plans proposed in these countries, we allow both policy instruments, g and τ^n, to move simultaneously so as to bring the actual debt-to-GDP ratio down to the target after 10 years. We fix the relative contribution of expenditure cuts and revenue enhancements based on the estimates of OECD (2012), which contains details of recent fiscal consolidation plans for many OECD countries. Thus, for each country, we set a policy mix in which a fraction a of the reductions in deficit comes from expenditure cuts, and $(1-a)$ from revenue enhancements.

Table 5 summarises the values that differ in the calibration for the four economies of interest. The size of both informal employment and corruption is higher in Italy and Greece, relative to Spain and Portugal and the same is true for the debt-to-GDP ratios.[17] These two countries

[17] Given the absence of data for informal employment in the countries other than Italy, we use the information regarding the relative size of the shadow economy across countries, provided by the estimates of the share of shadow output in Elgin and Öztunalı (2012), to infer the relative size of informal employment. We use lower values for the corruption parameter for Spain and Portugal following the evidence from the World Bank Control of Corruption Index presented in Appendix A.

also have smaller labor force participation rates, while the size of the government consumption expenditures as a percentage of GDP is higher in Italy but lower in the other countries. In terms of the consolidation packages, the mix between expenditure cuts and tax revenue increases looks similar across the four economies, except for Spain that was dominated by expenditure cuts.

The results are shown in Figure 8.[18] The high level of the debt-to-GDP ratio in Italy and Greece implies that the required changes in taxation and government consumption spending and, thus, deficit, are larger in these countries. As a result, after the fiscal consolidation, output drops and the shadow economy increases by more in Greece and Italy. The same is true for unemployment. Although the output and unemployment responses in Italy and Greece are similar, Italy is the only country that suffers welfare losses in the medium run, as we saw in Figure 6. This is due to the lower share of expenditure cuts in the consolidation mix, $a = 0.5$, and therefore the higher increase in the tax rate, seen in the bottom left graph. In the other countries, fiscal consolidations induce welfare gains. These welfare gains are higher in Portugal and Spain, where the lower debt-to-GDP ratio implies smaller fiscal consolidations. For that reason, the effects on output, unemployment and the shadow economy are qualitatively similar but quantitatively smaller than in Italy and Greece.

As we saw previously, the presence of ROT consumers or utility enhancing government expenditures can modify the predictions of the model regarding the welfare effects of fiscal consolidations. For this reason, we examine the sensitivity of our policy evaluation conclusions when we incorporate these two features in our analysis. We use estimates for the fraction of ROT consumers across the four countries from Martin and Philippon (2014), setting this parameter to 65% for Greece, 44% for Italy, 54% for Spain and 50% for Portugal. For the case of utility enhancing spending, we again set $\alpha_1 = 0.85$ and $\alpha_2 = -0.25$ for all countries. The responses of welfare in each case are shown in Figure 9.

The introduction of rule-of-thumb consumers overturns our previous policy evaluation conclusions. First, the consolidation plans are associated with welfare losses for all countries, although it is again true that Spain and Portugal are less affected relative to Italy and Greece. If we take into account the presence of financially constrained individuals in the economy, Greece is the big loser from fiscal consolidation among these countries since its share of rule of thumb consumers is substantially higher relative to the other countries.

As expected, if government spending is assumed to complement private consumption, the welfare losses from fiscal consolidations are large for all the countries we consider since in this case both spending cuts and tax hikes negatively affect welfare. Under this scenario, the welfare losses from fiscal consolidations are comparable in Greece, Italy and Portugal and are somewhat smaller in the case of Spain, since the debt-to-GDP ratio is smaller in this country and smaller sacrifices are needed to meet the debt target.

Given the emphasis in recent years on deterring tax evasion and corruption hand-in-hand with carrying out fiscal consolidation, it is interesting to ask whether such reforms can change the

[18] Note that here we plot the deviation from steady state in levels, meaning, for example, that a value equal to 1 on the vertical axis does not signify 101% of steady state, but rather 1 unit above steady state. In this way, we control for the different steady states across countries, and responses are comparable.

Figure 8: Simulation of Fiscal Consolidation Mix

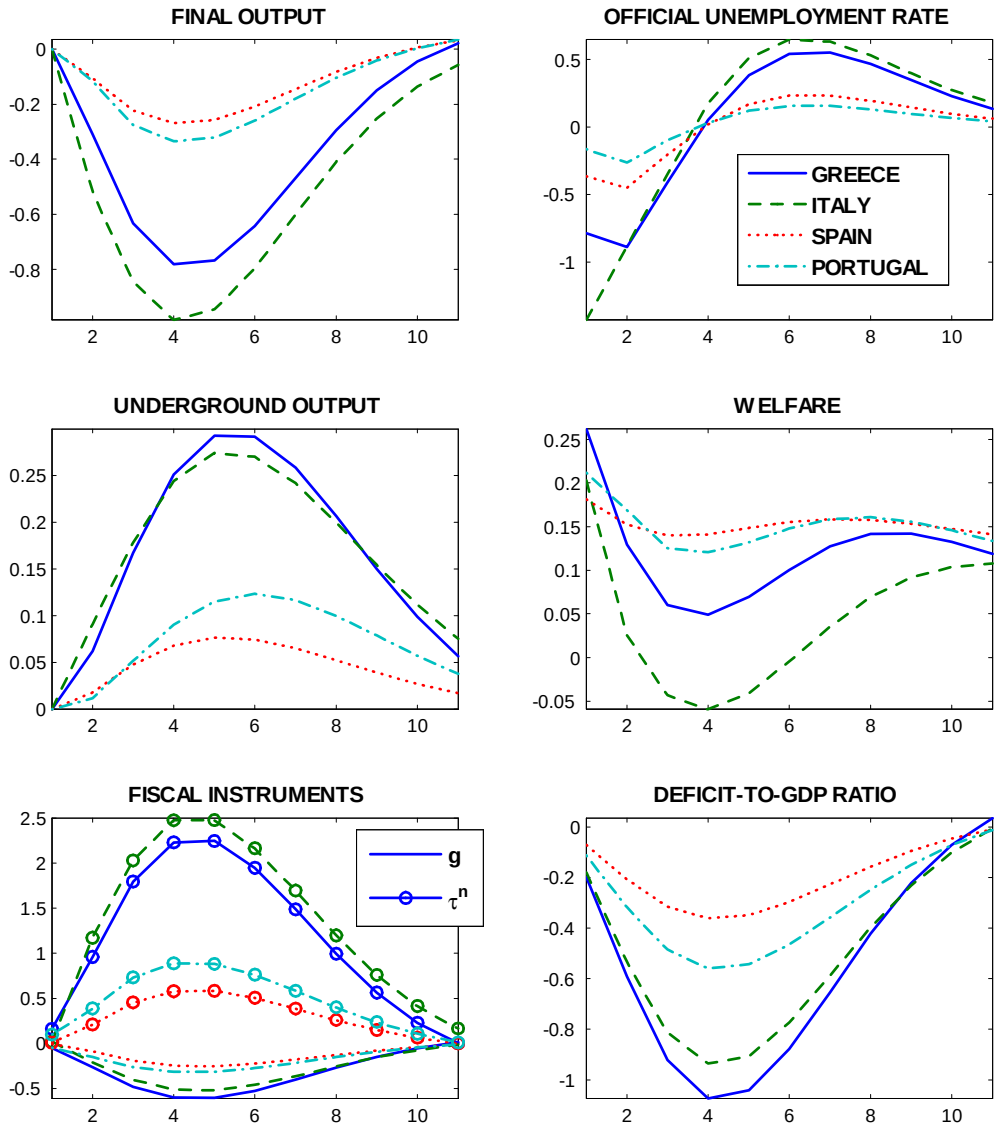
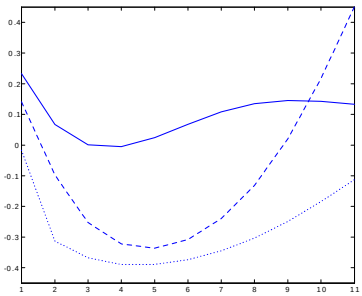
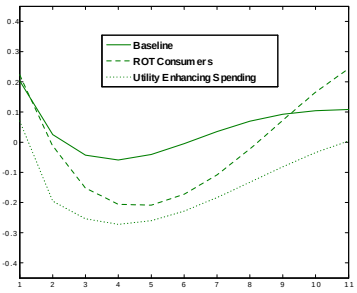


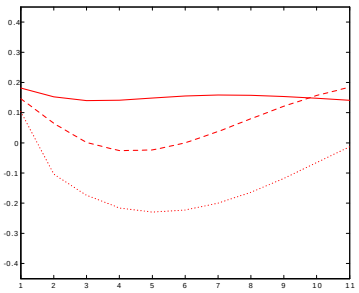
Figure 9: Welfare Effects of Fiscal Consolidation Mix: Sensitivity Analysis



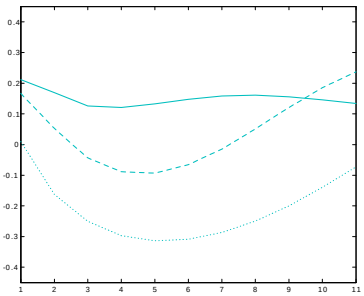
Greece



Italy

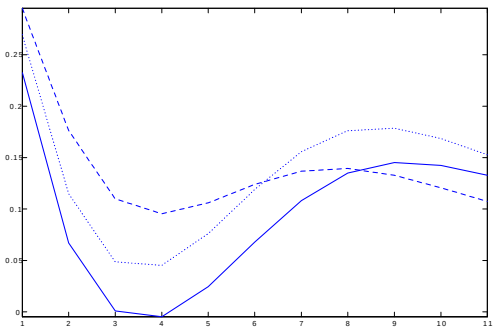


Spain

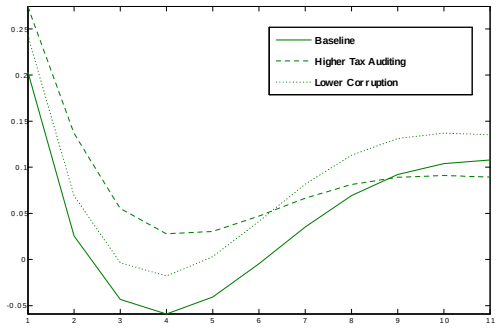


Portugal

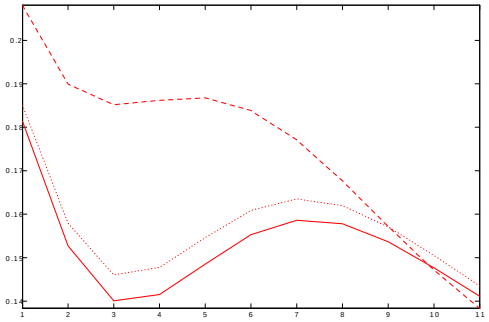
Figure 10: Welfare Effects of Fiscal Consolidations Counterfactual Analysis



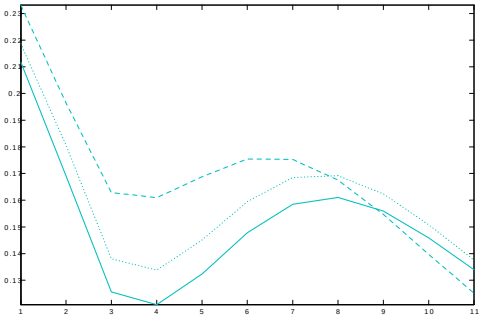
Greece



Italy



Spain



Portugal

effects of the consolidation plans currently being implemented. In order to investigate this, we use our model to carry out a counterfactual experiment. In particular, we again simulate the fiscal consolidation plans for the four economies, this time assuming that the auditing probability for tax evasion is double that of the previous calibration. Figure 10 depicts, for each country, the welfare losses in the baseline calibration with solid lines and when the auditing probability is higher with dashed lines. We see that since output losses are mitigated, for all of the countries, welfare gains are amplified. Moreover, the medium-run welfare losses in Italy become welfare gains, given that fighting tax evasion implies lower hikes in the tax rates needed to achieve the targeted consolidation.

In a similar manner, we carry out a counterfactual experiment, this time reducing by 50% the embezzlement rate, and so reducing the extent of corruption, in the underlying economies. Welfare losses are depicted with dotted lines in Figure 10. Reducing corruption improves welfare during the consolidations for all countries and most significantly so for Italy, where medium run welfare losses become very small, and Greece, since these two countries are calibrated to have a higher degree of public corruption. These results suggest that there should be an emphasis on fighting public corruption, particularly in the time of a consolidation, since output losses can be mitigated and welfare gains can be amplified significantly when healthier public institutions are in place.

5 Concluding Remarks

Cross country regressions suggest clearly that accounting for both tax evasion and corruption is key to understanding the effects of fiscal policy. Through a New Keynesian DSGE model with involuntary unemployment, an underground sector and corruption, we have been able to show that the presence of tax evasion and corruption amplifies the contractionary effects of tax based consolidations, whilst it mitigates the effects of expenditure based ones. Moreover, the type of fiscal consolidation affects the incentives of agents to produce in the shadow sector. In particular, expenditure based consolidations reduce the size of the shadow economy, whilst tax based consolidations increase it. These results match VAR evidence for Italy for which data on informal employment exists.

Given the model's ability to reproduce qualitatively the data patterns, we proceed to analyse the output, unemployment and welfare effects of actual fiscal consolidation plans in Italy, Greece, Spain and Portugal. Fiscal consolidations imply sizeable output and unemployment losses in Greece and Italy, both because these countries are characterized by higher level of public corruption and tax evasion, and also because the debt burden in these countries is higher, requiring higher sacrifices to achieve consolidation. Our policy conclusions depend on which assumptions one is willing to take on board as more realistic for describing these four economies. If government spending is assumed to be wasteful and we further assume that all agents are optimizers in the economy, Italy stands as the only loser from the fiscal consolidations in the medium run, because its consolidation mix relies more heavily on tax hikes. If we are willing to accept that some of the government spending cuts involve goods that are complements to private consumption, then the

welfare losses from austerity are large for all countries and Spain is the country suffering the least from these packages because its fiscal adjustment was limited. Finally, if we assume that agents are financially constrained in these countries, as suggested by Martin and Philippon (2014), then fiscal consolidations involve welfare costs for all countries and these are higher for Greece and Italy.

Given the recent policy concerns about the reduction of both tax evasion and corruption in Europe and the commitment of politicians to reduce both, we perform a counterfactual exercise in order to evaluate the impact of such reforms on the output, unemployment and welfare losses. The model predicts that fighting both public corruption and tax evasion should be at the top of the list of reforms government should pursue in order to reduce the costs of fiscal consolidations.

We view our exercise as a first attempt in analysing the effects of corruption and tax evasion on the size of the fiscal multiplier. Our model is stylistic and we have left out many important aspects that could affect our conclusions. For example, in our economy we consider a representative household and we cannot assess the effects of tax evasion and corruption on income inequality. Also, we consider only cuts in government consumption expenditures and not in other items of the government budget. Similarly, we consider only hikes in labor income taxes and not in other sources of tax revenue. Furthermore, our framework does not allow for tax evasion on consumption taxes, which is present in many economies. Finally, we do not endogenize the degree of public corruption and we do not make it interact with aspects of the political economy, such as the existence of two major predominant parties in the countries under consideration. We leave these issues for future research.

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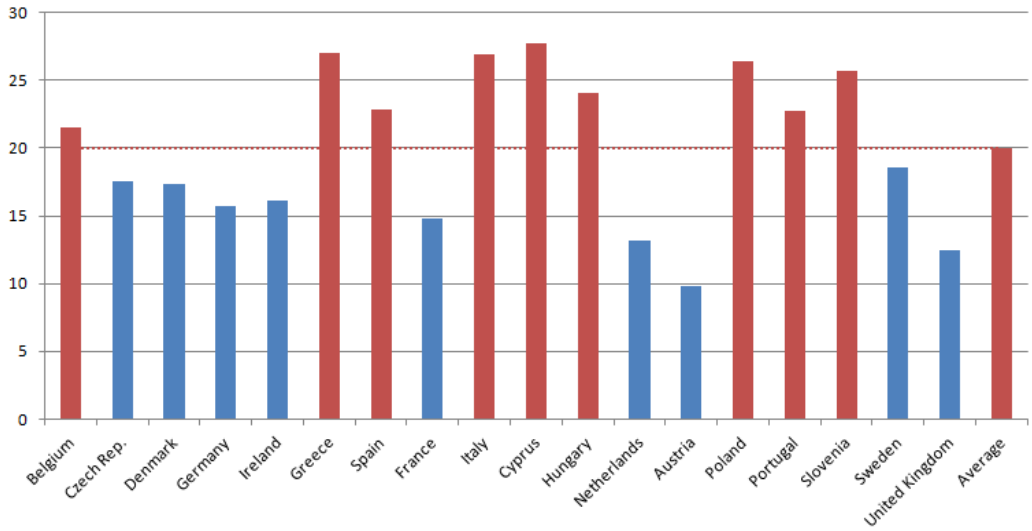
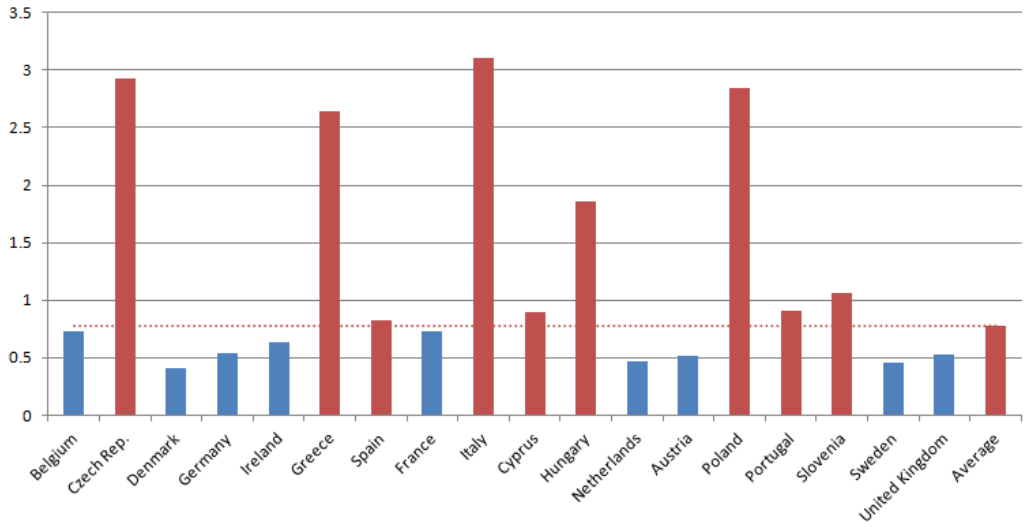
A Additional Figures

Figure 11: Shadow Economy and Corruption in European Countries



Shadow Economy (% GDP), Average over 1999-2010
Source: Schneider and Buehn (2012).



Control of Corruption Index, Average over 1998-2010
Source: World Bank Global Governance Indicators.

Note: The dotted line indicates the average for the countries considered.

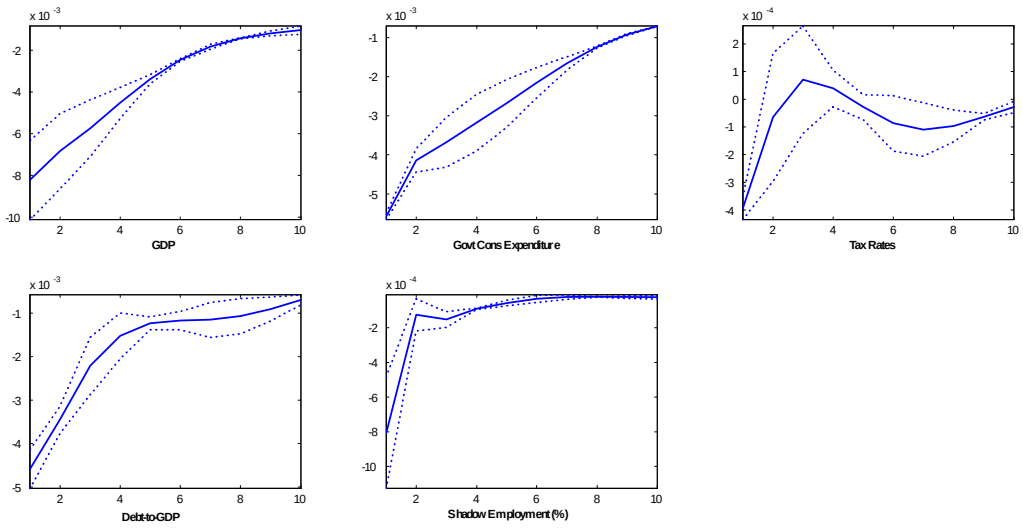


Figure 12: Empirical IRFs for Expenditure Based Consolidation - Sign Restrictions with Output

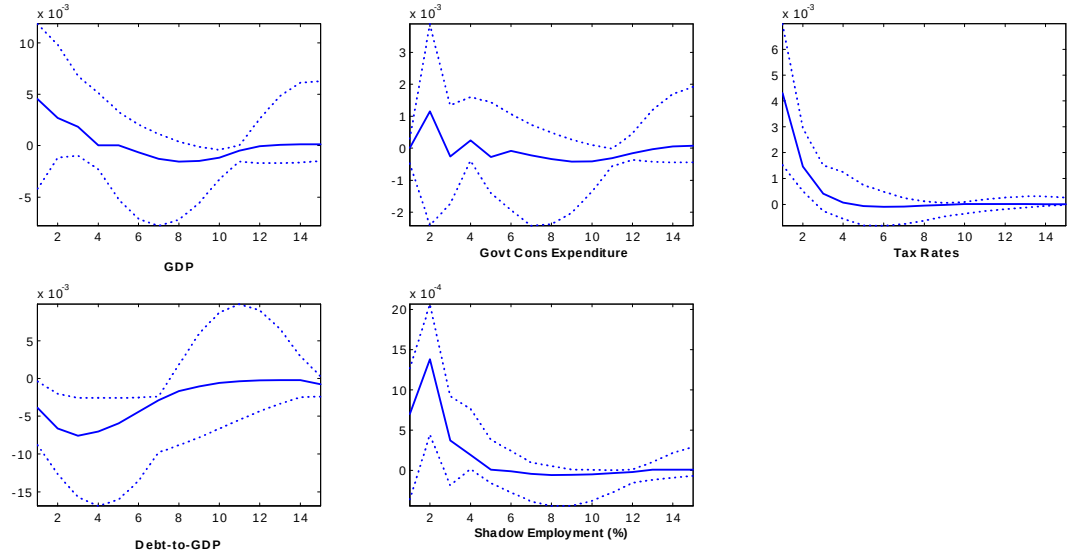


Figure 13: Empirical IRFs for Tax Based Consolidation - Sign Restrictions with Output

Figure 14: Empirical IRFs for Expenditure Based Consolidation - Cholesky Decomposition with Output

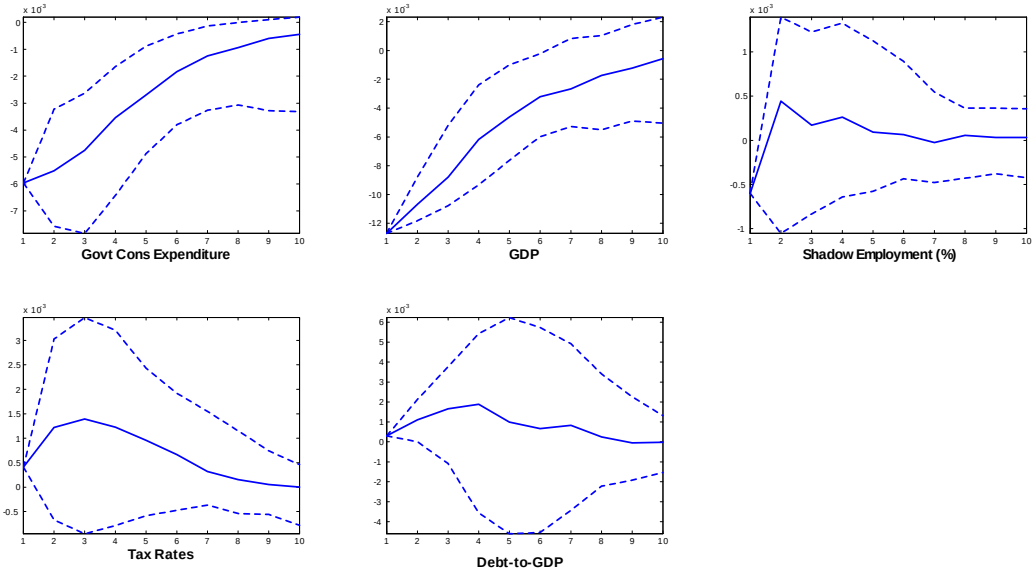


Figure 15: Empirical IRFs for Tax Based Consolidation - Cholesky Decomposition with Output

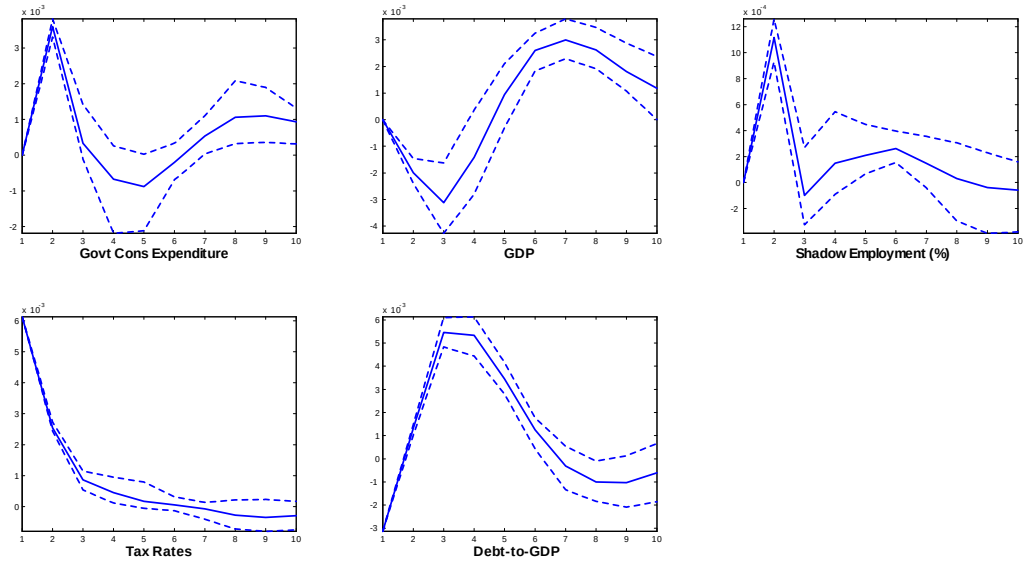


Figure 16: Comparison of Benchmark and Full Model - EB Consolidation

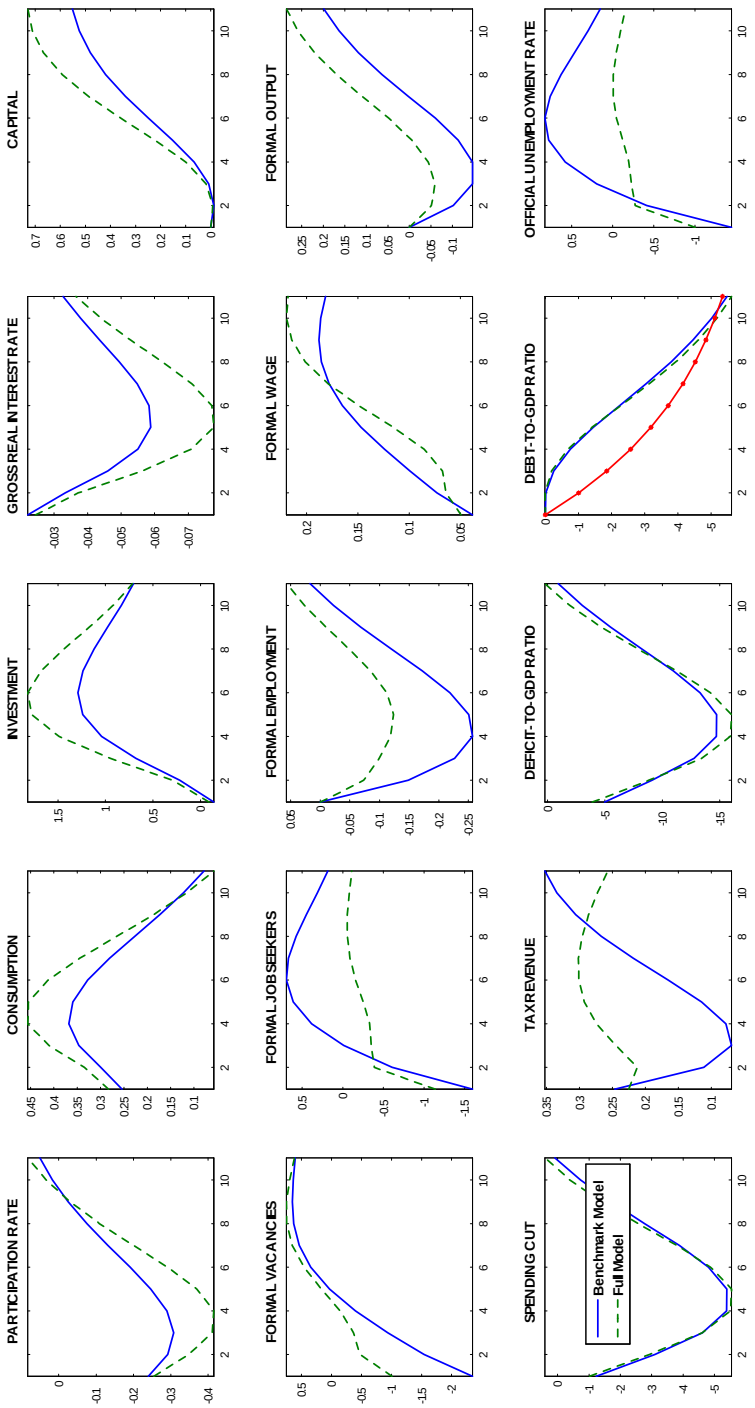
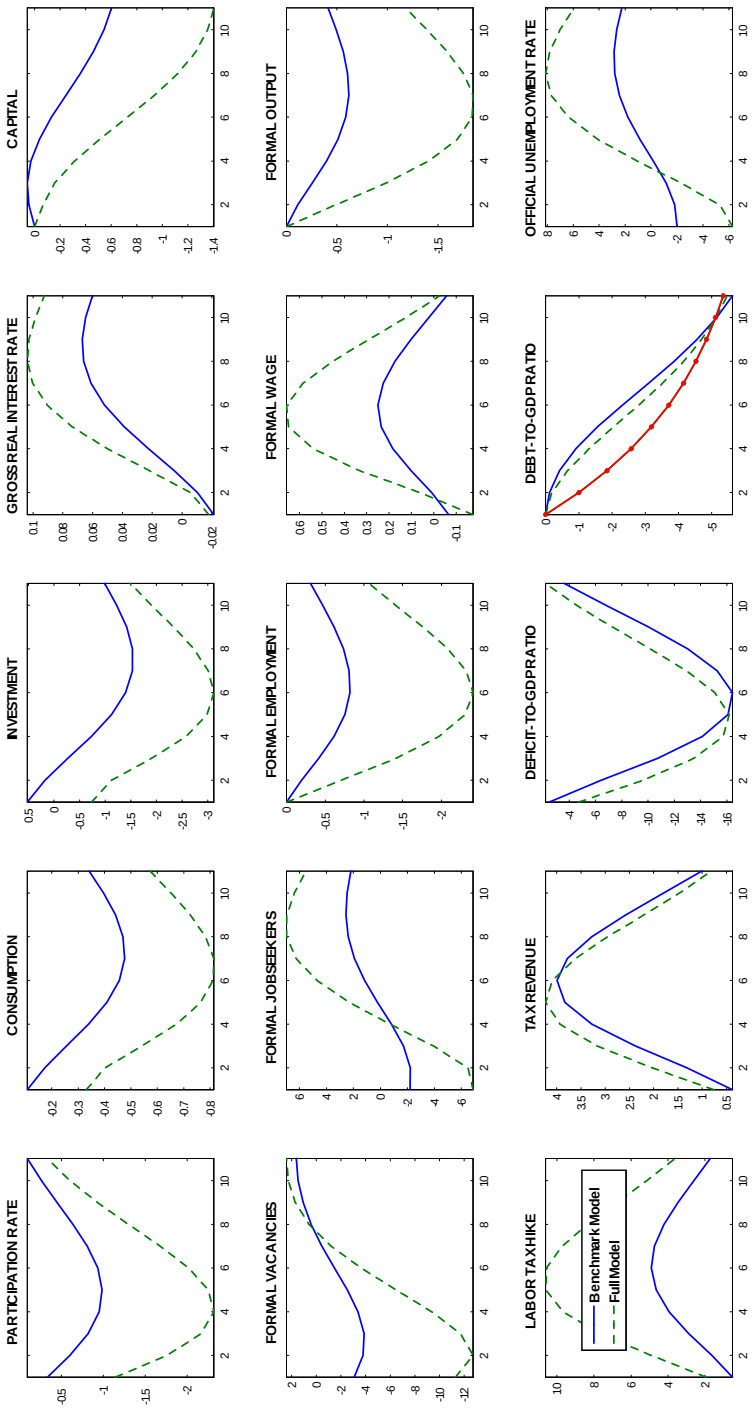


Figure 17: Comparison of Benchmark and Full Model - TB Consolidation



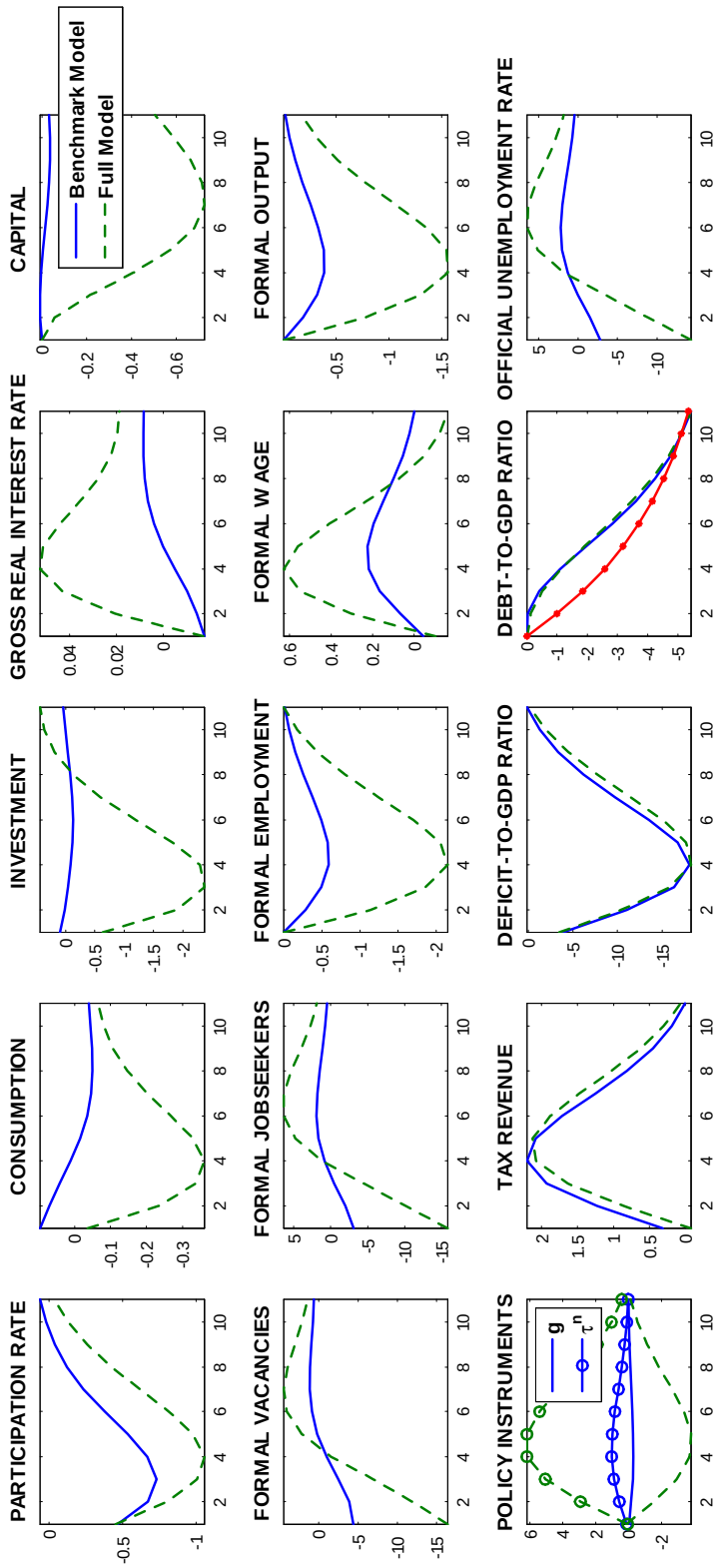


Figure 18: Comparison of Benchmark and Full Model - Mixed Consolidation

B Derivations

B.1 Household's maximisation problem

We can write in full the Lagrangean for the representative household's maximisation problem. Firstly, we can incorporate the composition of the household, equation (7), as well as the definition of the total effective consumption bundle, directly into the utility function of the household. Then, we can plug the definition of the matches $m_t^j = \psi_t^{hj} u_t^j$ into the law of motion of employment in each sector, and also replace i_t in the budget constraint using the law of motion of private capital. Then we are left with 3 constraints, and the following Lagrangean:

$$\begin{aligned}\mathcal{L} = E_0 \quad & \sum_{t=0}^{\infty} \beta^t \Bigg\{ \frac{\left[\alpha_1 (c_t)^{\alpha_2} + (1-\alpha_1)(g_t)^{\alpha_2}\right]^{\frac{1-\eta}{\alpha_2}}}{1-\eta} + \Phi \frac{\left[1 - u_t - n_t^F - n_t^I\right]^{1-\varphi}}{1-\varphi} \\ & -\lambda_{ct}\Big[(1+\tau_t^c)c_t + k_{t+1} - (1-\delta)k_t + \frac{\omega}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t + \frac{B_{t+1}\pi_{t+1}}{R_t} - r_t k_t \\ & -(1-\tau_t^n) w_t^F n_t^F - w_t^I n_t^I - \varpi(1-s_t)u_t - B_t - \Pi_t^p + T_t\Big] \\ & -\lambda_{n^F t}\Big[n_{t+1}^F - (1-\sigma^F) n_t^F - \psi_t^{hF}(1-s_t)u_t\Big] \\ & -\lambda_{n^I t}\Big[n_{t+1}^I - (1-\rho-\sigma^I) n_t^I - \psi_t^{hI} s_t u_t\Big] \Bigg\} \end{aligned} \tag{32}$$

The controls are c_t, k_{t+1}, B_{t+1}, n_{t+1}^F, n_{t+1}^I, u_t and s_t. The first order conditions are:
[wrt c_t]

$$c c_t^{(1-\eta-\alpha_2)} \alpha_1 c_t^{(\alpha_2-1)} - \lambda_{ct}(1+\tau_t^c) = 0 \tag{33}$$

[wrt k_{t+1}]

$$\lambda_{ct}\left[1 + \omega\left(\frac{k_{t+1}}{k_t} - 1\right)\right] - \beta E_t \lambda_{ct+1}\left[1 - \delta + r_{t+1} + \frac{\omega}{2}\left(\left(\frac{k_{t+2}}{k_{t+1}}\right)^2 - 1\right)\right] = 0 \tag{34}$$

[wrt B_{t+1}]

$$-\lambda_{ct}\frac{1}{R_t} + \beta E_t \lambda_{ct+1}\frac{1}{\pi_{t+1}} = 0 \tag{35}$$

[wrt n_{t+1}^F]

$$-\lambda_{n^F t} - \beta E_t\left[\Phi l_{t+1}^{-\varphi} - \lambda_{ct+1}(1-\tau_{t+1}^n) w_{t+1}^F - \lambda_{n^F t+1}(1-\sigma^F)\right] = 0 \tag{36}$$

[wrt n_{t+1}^I]

$$-\lambda_{n^I t} - \beta E_t[\Phi l_{t+1}^{-\varphi} - \lambda_{ct+1} w_{t+1}^I - \lambda_{n^I t+1}(1-\rho-\sigma^I)] = 0 \tag{37}$$

[wrt u_t]

$$-\Phi l_t^{-\varphi} + \lambda_{ct}\varpi + \lambda_{n^F t}\psi_t^{hF}(1-s_t) + \lambda_{n^I t}\psi_t^{hI} s_t = 0 \tag{38}$$

[wrt s_t]

$$-\lambda_{n^F t}\psi_t^{hF} u_t + \lambda_{n^I t}\psi_t^{hI} u_t - \lambda_{ct}\varpi = 0 \tag{39}$$

Equations (33)-(35) are the arbitrage conditions for the returns to consumption, private capital and bonds. Equations (36) and (37) relate the expected marginal value from being employed in the each sector to the wage, accounting for the income tax in the regular sector, the utility loss from the reduction in leisure, and the continuation value, which depends on the separation probability. Equation (38) states that the value of being unemployed (rather than enjoying leisure), $\lambda_{ct}\varpi$, should equal the marginal utility from leisure minus the expected marginal values of being employed in each sector, weighted by the respective job finding probabilities and shares of jobseekers. Equation (39) is an arbitrage condition according to which the choice of the share, s_t, is such that the expected marginal values of being employed, weighted by the job finding probabilities, are equal across the two sectors.

We can define the marginal value to the household of having an additional member employed in the two sectors, as follows:

$$\begin{aligned} V^h_{n^F t} &\equiv \frac{\partial \mathcal{L}}{\partial n_t^F} = \lambda_{ct} w_t^F (1-\tau_t^n) - \Phi l_t^{-\varphi} + (1-\sigma^F)\lambda_{n^F t} \\ &= \lambda_{ct} w_t^F (1-\tau_t^n) - \Phi l_t^{-\varphi} + (1-\sigma^F)\beta E_t(V^h_{n^F t+1}) \end{aligned} \tag{40}$$

$$\begin{aligned} V^h_{n^I t} &\equiv \frac{\partial \mathcal{L}}{\partial n_t^I} = \lambda_{ct} w_t^I - \Phi l_t^{-\varphi} + (1-\rho-\sigma^I)\lambda_{n^I t} \\ &= \lambda_{ct} w_t^I - \Phi l_t^{-\varphi} + (1-\rho-\sigma^I)\beta E_t(V^h_{n^I t+1}) \end{aligned} \tag{41}$$

where the second equalities come from equations (36) and (37) respectively.

B.2 Derivation of the resource constraint

Consider the household's budget constraint:

$$(1+\tau_t^c)c_t + i_t + \frac{B_{t+1}\pi_{t+1}}{R_t} \leq r_t k_t + (1-\tau_t^n) w_t^F n_t^F + w_t^I n_t^I + \varpi u_t^F + B_t + \Pi_t^p - T_t \tag{42}$$

Recall the government's budget constraint:

$$\frac{B_{t+1}\pi_{t+1}}{R_t} - B_t = DF_t$$

Plugging this into (42):

$$(1+\tau_t^c)c_t + i_t + DF_t \leq r_t k_t + (1-\tau_t^n) w_t^F n_t^F + w_t^I n_t^I + \varpi u_t^F + \Pi_t^p - T_t \tag{43}$$

Recall also the definition of the deficit:

$$DF_t = g_t + \varpi u_t^F - (1-\xi^{TR})\left[(\tau_t^n + \tau_t^s) w_t^F n_t^F + \tau_t^c c_t + T_t\right] - \rho\gamma p_t^x x_t$$

Plugging this directly into equation (43):

$$\begin{aligned}(1+\tau_t^c)c_t + i_t + g_t + \varpi u_t^F - (1-\xi^{TR})\left[\tau_t^c c_t + (\tau_t^n + \tau_t^s) w_t^F n_t^F + T_t\right] - \rho\gamma p_t^x x_t = \\ r_t k_t + (1-\tau_t^n) w_t^F n_t^F + w_t^I n_t^I + \varpi u_t^F + \Pi_t^p - T_t\end{aligned}$$

Cancelling out the taxes and unemployment benefits, we have:

$$c_t + i_t + g_t - \rho\gamma p_t^x x_t = r_t k_t + (1 + (1-\xi^{TR})\tau_t^s - \xi^{TR}\tau_t^n) w_t^F n_t^F - \xi^{TR}\left(\tau_t^c c_t + T_t\right) + w_t^I n_t^I + \Pi_t^p \quad (44)$$

Recall now that (i) the price of the final good is normalised to 1, (ii) the retail firms turn x_t units of the intermediate good into y_t units of the final good, and (iii) the differentiated retail goods are costlessly aggregated into the final consumption good. Then by definition, the profit from the retail firm can be written as:

$$\Pi_t^p = y_t - p_t^x x_t \quad (45)$$

Substituting this into equation (44), we obtain:

$$c_t + i_t + g_t = r_t k_t + (1 + (1-\xi^{TR})\tau_t^s - \xi^{TR}\tau_t^n) w_t^F n_t^F - \xi^{TR}\left(\tau_t^c c_t + T_t\right) + w_t^I n_t^I + y_t - (1-\rho\gamma) p_t^x x_t \quad (46)$$

The price of the intermediate good, p_t^x, is determined by the zero-profit condition of the intermediate goods producing firm. That is, it satisfies:

$$\underbrace{(1-\rho\gamma)\, p_t^x x_t}_{\text{Revenue of intermediate firms}} - \underbrace{\left[(1+\tau_t^s) w_t^F n_t^F + w_t^I n_t^I + r_t k_t + \kappa^F v_t^F + \kappa^I v_t^I\right]}_{\text{Costs of intermediate firms}} = 0$$

Plugging this into equation (46):

$$\begin{aligned}c_t + i_t + g_t \;=\; & r_t k_t + (1 + (1-\xi^{TR})\tau_t^s - \xi^{TR}\tau_t^n) w_t^F n_t^F - \xi^{TR}\left(\tau_t^c c_t + T_t\right) \\ & + w_t^I n_t^I + y_t - \left[(1+\tau_t^s) w_t^F n_t^F + w_t^I n_t^I + r_t k_t + \kappa^F v_t^F + \kappa^I v_t^I\right] \quad (47)\end{aligned}$$

Cancelling terms we have:

$$c_t + i_t + g_t = y_t - \left(\kappa^F v_t^F + \kappa^I v_t^I\right) - \xi^{TR}\left(\tau_t^c c_t + T_t + (\tau_t^s + \tau_t^n)\, w_t^F n_t^F\right) \quad (48)$$

Rearranging terms we get the final expression:

$$y_t = c_t + i_t + g_t + \kappa^F v_t^F + \kappa^I v_t^I + \xi^{TR} TR_t$$

B.3 Derivation of the wages

For each sector $j = F, I$ the Nash bargaining problem is to maximize the weighted sum of log surpluses:

$$\max_{w_t^j} \left\{ (1-\vartheta^j) \ln V_{n^j t}^h + \vartheta^j \ln V_{n^j t}^f \right\}$$

where $V_{n^j t}^h$ and $V_{n^j t}^f$ are defined as:

$$V_{n^F t}^h = \lambda_{ct} w_t^F (1-\tau_t^n) - \Phi l_t^{-\varphi} + (1-\sigma^F)\lambda_{n^F t} \tag{49}$$

$$V_{n^I t}^h = \lambda_{ct} w_t^I - \Phi l_t^{-\varphi} + (1-\rho-\sigma^I)\lambda_{n^I t} \tag{50}$$

$$V_{n^F t}^f \equiv \frac{\partial Q}{\partial n_t^F} = (1-\rho\gamma)\, p_t^x (1-\alpha^F)\frac{x_t^F}{n_t^F} - (1+\tau_t^s) w_t^F + \frac{(1-\sigma^F)\kappa^F}{\psi_t^{fF}} \tag{51}$$

$$V_{n^I t}^f \equiv \frac{\partial Q}{\partial n_t^I} = (1-\rho\gamma)\, p_t^x (1-\alpha^I)\frac{x_t^I}{n_t^I} - w_t^I + \frac{(1-\rho-\sigma^I)\kappa^I}{\psi_t^{fI}} \tag{52}$$

The first order conditions of these optimization problems are:

$$\vartheta^F (1+\tau_t^s) V_{n^F t}^h = (1-\vartheta^F)\lambda_{ct}(1-\tau_t^n) V_{n^F t}^f \tag{53}$$

$$\vartheta^I V_{n^I t}^h = (1-\vartheta^I)\lambda_{ct} V_{n^I t}^f \tag{54}$$

Plugging the expressions for the value functions into these FOCs, we can rearrange to find expressions for w_t^F and w_t^I. Using (49), (51) and (53), we can solve for w_t^F, which yields:

$$w_t^F = \frac{(1-\vartheta^F)}{(1+\tau_t^s)} \left((1-\rho\gamma)\, p_t^x (1-\alpha^F)\frac{x_t^F}{n_t^F} + \frac{(1-\sigma^F)\kappa^F}{\psi_t^{fF}} \right) + \frac{\vartheta^F}{\lambda_{ct}(1-\tau_t^n)} \left(\Phi l_t^{-\varphi} - (1-\sigma^F)\lambda_{n^F t} \right) \tag{55}$$

Similarly using (50), (52) and (54), we can solve for w_t^I, which yields:

$$w_t^I = (1-\vartheta^I) \left((1-\rho\gamma)\, p_t^x (1-\alpha^I)\frac{x_t^I}{n_t^I} + \frac{(1-\rho-\sigma^I)\kappa^I}{\psi_t^{fI}} \right) + \frac{\vartheta^I}{\lambda_{ct}} \left(\Phi l_t^{-\varphi} - (1-\rho-\sigma^I)\lambda_{n^I t} \right) \tag{56}$$

C Calibration strategy

We calibrate the model using annual data on the Italian economy over the period 1982-2006.

C.1 Formal Labor market

We calibrate the labor-force participation and the unemployment rates that are related to the formal market to match the observed average values from the data. We set $lf \equiv n^F + u^F = 60\%$

and $\frac{u^F}{lf} = 10\%$. Then using definitions we can get:

$$u^F = \frac{u^F}{lf} lf$$

$$n^F = lf - u^F$$

We fix the separation rate, σ^F, equal to 0.07 and we can derive:

$$m^F = \sigma^F n^F$$

and

$$\psi^{hF} = \frac{m^F}{u^F}$$

Since there is no exact estimate for the value of the formal vacancy-filling probability, ψ^{fF}, in the literature, we use what is considered as standard by setting it equal to 0.96. Hence, we can also derive:

$$\upsilon^F = \frac{m^F}{\psi^{fF}}$$

We set the matching elasticity with respect to vacancies, μ_2, equal to 0.7, close to the estimate for Italy in Peracchi and Viviano (2004). Then the matching efficiency parameter for the formal sector can be set to satisfy:

$$\mu_1^F = \frac{m^F}{(\upsilon^F)^{\mu_2} \left(u^F\right)^{1-\mu_2}}$$

C.2 Formal Production

We set the capital depreciation rate, δ, equal to 0.088. Then we derive $\frac{i}{k}$:

$$\frac{i}{k} = \delta$$

Following the literature, we set the discount factor, β, equal to 0.96. Next, we get R:

$$R = \frac{1}{\beta}$$

and

$$r = R - 1 + \delta$$

The elasticity of demand for intermediate goods, ϵ, is set such that the gross steady-state markup, $\frac{\epsilon}{\epsilon - 1}$, is equal to 1.25, and the price of the final good is normalized to one. Then p^x is determined

by:

$$p^x = \frac{\epsilon - 1}{\epsilon}$$

We set the TFP parameter in this sector $A^F = 1$ and the capital share $\alpha^F = 0.34$. We set the probability of audit and the fraction of total profits paid as a fine in the event of an audit as follows: $\rho = 0.02$, which is close to the value used in Boeri and Garibaldi (2007), and $\gamma = 0.3$. Then we can obtain from the firms' FOC with respect to capital:

$$\frac{y^F}{k} = \frac{r}{(1 - \rho\gamma)\, p^x \alpha^F}$$

From the production function in the regular sector we have:

$$\frac{n^F}{k} = \frac{1}{A^F}\left(\frac{y^F}{k}\right)^{\frac{1}{1-\alpha^F}}$$

Using definitions we can then obtain:

$$k = n^F \left(\frac{n^F}{k}\right)^{-1},\ y^F = \frac{y^F}{k}k,\ i = \frac{i}{k}k$$

We set the vacancy costs in the formal sector $\kappa^F = 0.14$ and the payroll tax rate $\tau^s = 0.16$ close to the value used in Orsi et al. (2014). Then we have:

$$w^F = \left[(1 - \rho\gamma)\, p^x (1 - \alpha^F)\frac{y^F}{n^F} - (R - 1 + \sigma^F)\frac{\kappa^F}{\psi^{fF}}\right] /(1 + \tau^s)$$

C.3 Informal Production

We set the TFP in the informal sector $A^I = 0.25$ and $\alpha^I = 0.8$. Using Istat data we set $\frac{n^I}{n} = 0.13$ and we can derive:

$$n^I = \frac{\frac{n^I}{n}}{1 - \frac{n^I}{n}} n^F$$

Then by definition we have:

$$y^I = (A^I n^I)^{1-\alpha^I},\ y = y^F + y^I$$

C.4 Informal Labor Market

We set the exogenous job destruction rate in the informal sector $\sigma^I = 0.0545$. We denote by $\tilde{\sigma}^I$ the total steady state separation rate in the underground sector, that is:

$$\tilde{\sigma}^I \equiv \sigma^I + \rho$$

Then we have

$$m^I = \tilde{\sigma}^I n^I$$

Then we set $\psi^{fI} = 0.05$ and get:

$$\upsilon^I = \frac{m^I}{\psi^{fI}}$$

We set the vacancy cost in the informal sector $\kappa^I = 0.13$ and derive

$$w^I = (1 - \rho\gamma)\, p^x (1 - \alpha^I) \frac{y^I}{n^I} - (R - 1 + \tilde{\sigma}^I) \frac{\kappa^I}{\psi^{fI}}$$

C.5 Fiscal Variables

Next, we set the replacement rate, $\frac{\varpi}{w^F}$, equal to 0.35 close to the estimates in Martin (1996), also used by Fugazza and Jacques (2004). Then by definition:

$$\varpi = \frac{\varpi}{w^F} w^F$$

We set government spending and the tax rates as follows: $\frac{g}{y} = 11\%$, $\tau^n = 0.4$, in line with Orsi et al. (2014), and $\tau^c = 0.18$. Then by definition:

$$g = \frac{g}{y} y$$

We set the steady state debt-to-GDP ratio from the data, $b = 103\%$ and using the law of motion of debt-to-GDP we derive

$$\frac{DF}{y} = (\beta - 1) b$$

and by definition

$$DF = \frac{DF}{y} y$$

We set the corruption parameter $\xi^{TR} = 0.2$. Then using the definition of the deficit we derive

$$TR = \frac{g + \varpi u^F - \rho\gamma p^x y - DF}{1 - \xi^{TR}}$$

Then using the resource constraint we have:

$$c = y - i - g - \kappa^F \upsilon^F - \kappa^I \upsilon^I - \xi^{TR} TR$$

and from the definition of tax revenues we have

$$T = TR - \left(\tau^n + \tau^s\right) w^F n^F - \tau^c c$$

C.6 Household

We set the intertemporal elasticity of substitution, $\frac{1}{\eta}$, equal to 0.5 and the weight of private consumption in effective consumption, $\alpha_1 = 1$ for the case of wasteful government spending. For the case of utility-enhancing spending we set $\alpha_1 = 0.85$ and $\alpha_2 = -0.25$, so that private and public spending are complements. This gives us the consumption bundle by definition:

$$cc = [\alpha_1 (c)^{\alpha_2} + (1 - \alpha_1)(g)^{\alpha_2}]^{\frac{1}{\alpha_2}}$$

and also:

$$\lambda_c = \frac{cc^{(1-\eta-\alpha_2)} \alpha_1 c^{(\alpha_2 - 1)}}{1 + \tau^c}$$

We then use the following three equations:

$$[1 - \beta(1 - \sigma^F) + \beta\psi^{hF}]\lambda_{n^F} = \beta\lambda_c \left[(1 - \tau^n)w^F - \frac{u^F}{u^F + u^I}\varpi\right]$$

$$[1 - \beta(1 - \tilde{\sigma}^I) + \beta\frac{m^I}{u^I}]\lambda_{n^I} = \beta\lambda_c \left[w^I - \frac{u^F}{u^F + u^I}\varpi\right]$$

$$\lambda_{n^I}\frac{m^I}{u^I} = \lambda_{n^F}\psi^{hF} + \lambda_c\varpi$$

to solve for the three unknowns λ_{n^F}, λ_{n^I} and u^I. This gives us, by defintion:

$$\psi^{hI} = \frac{m^I}{u^I}$$

$$l = 1 - lf - n^I - u^I$$

$$u = u^F + u^I$$

$$s = \frac{u^I}{u}$$

$$\mu_1^I = \frac{m^I}{(v^I)^{\mu_2}\left(u^I\right)^{1-\mu_2}}$$

We set the value of leisure in the utility function, φ, equal to 2. Then we can derive Φ to satisfy:

$$\Phi = \left(\lambda_c\varpi + \lambda_{n^F}\psi^{hF}\right) l^{\varphi}$$

We set the bargaining power parameters in the two sectors to satisfy:

$$\vartheta^F = \frac{\Omega_1^F - w^F}{\Omega_1^F - \Omega_2^F}$$

$$\vartheta^I = \frac{\Omega_1^I - w^I}{\Omega_1^I - \Omega_2^I}$$

where $\Omega_1^F \equiv \left[(1-\rho\gamma)\, p^x (1-\alpha^F)\frac{y^F}{n^F} + \frac{(1-\sigma^F)\kappa^F}{\psi^{fF}}\right]/(1+\tau^s)$, $\Omega_1^I \equiv \left[(1-\rho\gamma)\, p^x (1-\alpha^I)\frac{y^I}{nI} + \frac{(1-\tilde{\sigma}^I)\kappa^I}{\psi^{fI}}\right]$, $\Omega_2^F \equiv \left[\Phi l^{-\varphi} - (1-\sigma^F)\lambda_{n^F}\right]/\left(\lambda_c\,(1-\tau^n)\right)$, $\Omega_2^I \equiv \left[\Phi l^{-\varphi} - (1-\tilde{\sigma}^I)\lambda_{n^I}\right]/\lambda_c$.

C.7 Other Parameters

The steady state debt-to-GDP target is set equal to the actual debt-to-GDP ratio, $b^* = b = 103\%$. In order to achieve a 5% drop in the debt-to-GDP target 10 periods after a shock, we set $\rho_1 = 0.85$ and $\rho_2 = 0.0001$. We set the inflation targeting parameter in the Taylor rule, $\zeta_\pi = 1.1$, the capital adjustment costs $\omega = 3$ and the price-stickiness parameter $\chi = 0.25$. Finally, we set the parameters of the fiscal policy rule in each case to ensure that we meet the target after 10 periods (see Table 4).