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Fiscal Consolidation with Tax Evasion and Corruption

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Abstract

Cross-country evidence highlights the importance of tax evasion and corruption in determining the size of fiscal multipliers. We introduce these two features in a New Keynesian model and revisit the effects of fiscal consolidations. VAR evidence for Italy suggests that spending cuts reduce tax evasion, while tax hikes increase it. In the model, spending cuts induce a reallocation of production towards the formal sector, thus reducing tax evasion. Tax hikes increase the incentives to produce in the less productive shadow sector, implying higher output and unemployment losses. Corruption further amplifies these losses by requiring larger hikes in taxes to reduce debt. We use the model to assess the recent fiscal consolidation plans in Greece, Italy, Portugal and Spain. Our results corroborate the evidence of increasing levels of tax evasion during these consolidations and point to significant output and welfare losses, which could be reduced substantially by combating tax evasion and corruption.

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 sparked a considerable amount of research measuring the macroeconomic effects of fiscal consolidations.[4] This literature, however, has left aside two crucial political economy aspects, namely the presence of tax evasion and corruption. This is surprising, given that they are important features in many of the countries adopting consolidation policies, as seen in Figure 1. In addition, there is growing evidence that tax evasion and corruption have increased in recent years. For example, a recent report by the technical staff of the Spanish Finance Ministry (Gestha, 2014) indicates that the shadow economy in Spain increased by 6.8 percentage points between 2008 and 2012, reaching 24.6% of GDP. At the same time, a special Greek police task force reported in 2013 that

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

the number of cases of public corruption increased by 33% between 2011 and 2012.[5] The aim of this paper is to revisit the effects of government expenditure cuts and labor tax hikes on output, unemployment and welfare, when tax evasion and corruption are present.

We treat tax evasion as synonymous with the shadow economy, which, according to Buehn and Schneider (2012, p.175-176), 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". Fiscal policy has an impact on the size of the shadow economy since it affects the incentives to tax evade both directly, through the tax burden, and indirectly, through its effects on the formal economy. Thus, a fiscal consolidation can have important secondary effects if it generates a reallocation of resources between the formal and informal sectors.[6] Corruption, in our paper, refers to the embezzlement of public funds. The presence of corruption can hamper the ability of the government to raise revenue, and thus distort the effects of fiscal consolidations. Tax evasion and corruption often coexist and possibly interact. For instance, Buehn and Schneider (2012) indicate that there is a positive correlation between the two.

Many authors have studied whether it is preferable to rely on spending cuts or tax hikes when consolidating the public deficit. Overall, the findings are not conclusive. Using multi-year fiscal consolidation data for 17 OECD countries over the period 1980-2005, Alesina et al. (2013) show that expenditure-based adjustments are typically associated with mild and short-lived recessions, and in some cases with no recession at all, while tax-based corrections are followed by deep and prolonged recessions. On the other hand, Erceg and Lindé (2013) reach a different conclusion. Using a two-country Dynamic Stochastic General Equilibrium (DSGE) model of a currency union, they show that, in the short run, a spending cut depresses output by more than a labor tax hike, because of the limited accommodation by the central bank and the fixed exchange rate. However, this is reversed in the long run as real interest and exchange rates adjust towards their flexible price levels.

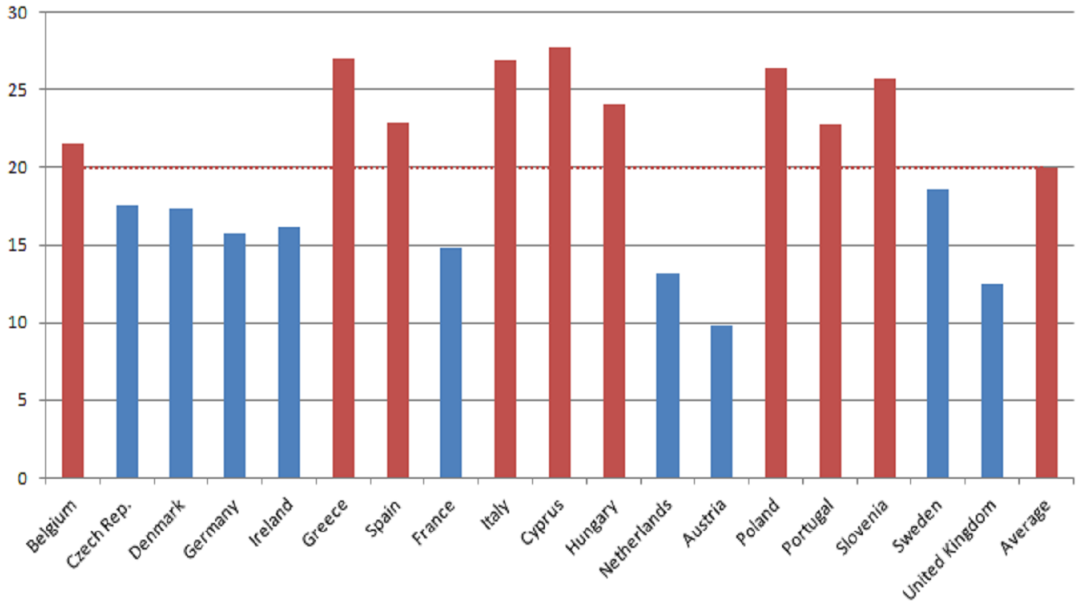
Indeed, there is strong evidence that the effects of fiscal consolidations are not yet fully understood. Blanchard and Leigh (2013) examine the impact of the recent fiscal consolidations in 26 OECD countries. They regress the forecast errors of output growth between 2010-2011 on the planned consolidation of public deficit, and find that the forecasts underestimate the size of fiscal multipliers. As shown in the next section, the underestimation of fiscal multipliers is more pronounced in countries with a higher level of tax evasion and/or corruption, suggesting that these two features amplify the effects of fiscal consolidations.

Reliable time series data on tax evasion is typically hard to get. Luckily, the Italian

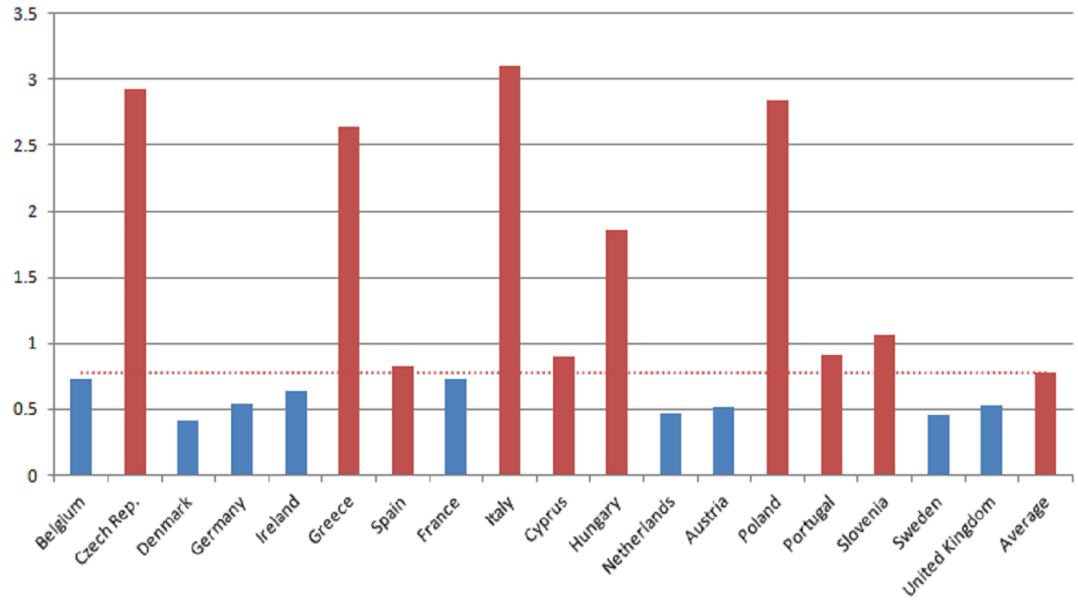
[5] See http://greece.greekreporter.com/2013/04/02/greek-police-public-worker-corruption-soars/

[6] For example, using a model calibrated to firm-level data for Greece, Pappadà and Zylberberg (2014) show that the increase in tax evasion can explain three quarters of the revenue leakages following the 2010 VAT hikes, when only half of the expected increase in revenue was realized. Colombo et al. (2014) also show empirical evidence of a rise in the shadow economy in recent years, although their focus is on the role of the banking crisis.

Figure 1: 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.

National Institute of Statistics (ISTAT) has created and regularly updated a time series of informal employment in Italy, which is consistent with international standards and, in particular, with the 1993 System of National Accounts. Apart from data availability, Italy is a fitting case for studying tax evasion and corruption. Firstly, there is abundant evidence of a large shadow economy, with estimates varying between 15% and 30% of GDP (see e.g. Ardizzi et al., 2012, Orsi et al., 2014, and Schneider and Buehn, 2012). Secondly, Busato and Chiarini (2004) have shown that incorporating the shadow economy in an RBC model for Italy considerably improves the fit to the data. Thirdly, Italy scores poorly in international rankings of institutional quality: it is currently ranked 72$^{\text{nd}}$ among 176 countries with a score of 42/100 in Transparency International's Corruption Perception Index and 25$^{\text{th}}$ among the 27 EU members in the index for the 'Quality of Government' (see Charron et al., 2012).[7]

In the first part of this paper, we incorporate the ISTAT series on informal employment in a VAR, and identify the effects of fiscal consolidations occurring through a fall in government consumption expenditure or an increase in direct taxes. We find that both types of shocks are contractionary, both reducing output and increasing unemployment. However, tax hikes significantly increase informal employment, while spending cuts reduce it.

To understand the mechanisms driving the results, we reassess the effects of fiscal consolidations in a model with price stickiness, search and matching frictions, endogenous labor force participation, tax evasion and corruption. The economy features a regular and an informal sector, and the transactions in the latter sector are not recorded by the government. Firms can hire informal labor to hide part of their production and evade payroll taxes. Households may also evade personal income taxation by reallocating their labor to the informal sector. In each period, there is a positive probability that irregular employment is detected, in which case the worker loses the job and the firm pays a fine. Corruption implies that a fraction of tax revenues is embezzled. Following Erceg and Lindé (2013), either labor tax rates or government consumption expenditures react to the deviation of the debt-to-GDP ratio from a target value. Fiscal consolidation occurs when this target is hit by a negative shock.

We find that the presence of tax evasion and corruption amplifies the negative effects of labor tax hikes on output and unemployment, while it mitigates those of expenditure cuts. Tax evasion and corruption imply that a larger increase in the tax rate is needed to reduce debt, and this amplifies the distortionary effects of the consolidation. Tax evasion further increases the output losses after a tax hike because workers and firms reallocate resources to the informal sector, increasing inefficiencies since this sector is less productive.

On the other hand, government spending cuts reduce tax evasion. The spending cut

[7] The Corruption Perception Index is based on a cross-country survey assessing the degree of transparency in public administration. The 'Quality of Government' index accounts for other pillars, such as protection of the rule of law, government effectiveness and accountability, in addition to corruption.

creates a positive wealth effect which increases consumption and investment and reduces labor force participation. Agents reallocate their labor search towards the formal sector, first because it is more productive, and second because the formal labor market has a higher matching efficiency and a lower job destruction rate. Hence, the share of shadow employment in total employment is reduced. Relative to standard models, tax evasion and corruption increase the size of this wealth effect, thereby increasing the crowding-in of private consumption, and reducing output losses.

Labor tax hikes are costly in terms of welfare, but spending cuts typically involve welfare gains, since private consumption increases and labor supply decreases. The latter result is reversed, however, if government spending directly enters the utility of households, or if agents are liquidity constrained.

We use our model to compare the recent consolidation policies in Greece, Italy, Spain and Portugal, all countries that are characterized by both high corruption and tax evasion. Despite the fact that the consolidation plans rely heavily on spending cuts, the model predicts increasing levels of tax evasion in all countries, as well as prolonged recessions. The largest output losses are observed in Portugal, due to the size of the tax hikes, and Greece, due to the severity of the austerity measures. There are also substantial welfare losses in all countries; the largest occurs in Portugal because of the significant tax hikes in the consolidation package.

There have been considerable discussions in the policy arena about combating both tax evasion and corruption. For example, members of the European Parliament organized an event focusing on corruption and tax evasion in Ljubljana in May 2013. The issue of reducing tax evasion also dominated the 2013 meeting of G8 leaders. To quantitatively evaluate the welfare gains from fighting tax evasion and corruption, we perform a counterfactual analysis of the consolidation plans when we reduce the degree of corruption and tax evasion. We find that both battles are worth fighting as they significantly reduce the welfare losses from fiscal consolidation.

The remainder of the paper is organized as follows. In the next section we present empirical evidence to motivate our work. In Section 3 we develop the model and its calibration. Section 4 discusses the main theoretical results. Section 5 presents the policy comparisons and Section 6 concludes.

2. Empirical Evidence

This section is divided into two parts. We first present evidence highlighting the importance of corruption and tax evasion in determining the size of fiscal multipliers. Here, we extend the cross-country regressions of Blanchard and Leigh (2013), henceforth BL (2013), controlling for tax evasion and public corruption, and we check the robustness of our conclusions by considering the output effects of narrative consolidation shocks. We then use the ISTAT data on shadow employment to run VAR regressions examining the effects of spending cuts and tax hikes on output, unemployment and shadow employment in Italy.

2.1. Do Tax Evasion and Corruption Matter?

To motivate our study, we replicate the BL (2013) regressions, controlling for tax evasion and public corruption. As a proxy for tax evasion we use the estimates of the share of shadow output to total GDP provided by Elgin and Öztunalı (2012), while for corruption we use the Corruption Perception Index. We group the 26 European countries considered by BL (2013) into either high and low tax evasion, or high and low corruption.[8] We then add to the BL (2013) regressions a dummy which is equal to one for the high corruption or tax evasion group. We also run the same regression using a dummy for both high corruption and tax evasion; in this case we drop three countries which do not fall into the same group across the two indices.[9]

The results are shown in Table 1. The first column replicates the findings 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). Thus, fiscal multipliers are underestimated. Columns 2 to 4 show the results when we include the interaction of the planned fiscal consolidation variable with our dummies for high tax evasion and corruption. While the coefficient is still significant at 5% when the dummy variables are included, it is lower in absolute value. On the other hand, the interaction term is always significant, showing that there is a significant difference in the coefficients between the two groups. Our estimates imply that the coefficient on the planned fiscal consolidation is -1.431 for the high tax evasion group, -1.540 for the high corruption group, and -1.518 for the high tax evasion and corruption group. In all cases, they are larger, in absolute value, than the baseline results of BL (2013), indicating that the implicit underestimation of fiscal multipliers is more pronounced in countries with higher tax evasion and/or corruption. In other words, these two features amplify the effects of fiscal consolidations.

The BL (2013) methodology has been criticized in a number of ways. Of particular importance for our study is the fact that the regression may not truly capture the effect of fiscal multipliers on forecast errors. Given that the forecasts are conditional not only on fiscal shocks but on the full set of information used by the forecaster, forecast errors may depend on factors other than underestimated fiscal multipliers.

[8] We use a two-mean clustering algorithm to endogenously group the countries. The resulting 'high tax evasion' group comprises Belgium, Bulgaria, Cyprus, Greece, Hungary, Italy, Malta, Poland, Portugal, Romania, Slovenia and Spain, while the 'low tax evasion' 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.

[9] An alternative way of carrying out this analysis would be to include the indices as controls in the regression. We have chosen to use the dummy variable approach because, although we have robust groupings of countries in terms of 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 to avoid issues of generated regressor bias, since both measures are estimates of the underlying variables of interest.

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

REGRESSORS	1 (Baseline)	2	3	4	5	6	7	8	9
Planned Fiscal Consolidation	-1.095***	-0.670**	-0.550**	-0.618**	-1.326***	-1.003**	-1.095***	-1.400**	-0.924***
	(0.255)	(0.268)	(0.259)	(0.268)	(0.152)	(0.349)	(0.261)	(0.562)	(0.301)
Interaction with:									
High Tax Evasion		-0.761**							
		(0.351)							
High Corruption			-0.990***						
			(0.333)						
High Tax Evasion and Corruption				-0.900**					
				(0.351)					
Poorly Functioning Financial System					0.511				
					(0.419)				
High Slack in Economy						-0.181			
						(0.517)			
Large Fiscal Consolidation							-0.064		
							(0.570)		
High Sovereign Debt								0.385	
								(0.614)	
High Sovereign Debt Risk									-0.253
									(0.445)
Constant	0.775*	0.918**	0.964**	0.925*	0.727*	0.820*	0.777*	0.781*	0.828*
	(0.383)	(0.414)	(0.415)	(0.450)	(0.383)	(0.416)	(0.404)	(0.400)	(0.401)
Observations	26	26	26	23	26	26	26	26	26
R-squared	0.496	0.557	0.600	0.607	0.525	0.499	0.496	0.507	0.501

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

In order to check whether the results we obtain are due to the particular methodology of BL (2013), we perform a different exercise using the narrative fiscal consolidation episodes identified by Devries et al. (2011) for a group of OECD countries. As above, we separate the sample of countries into high and low tax evasion and high and low corruption groups.[10] We then calculate the output responses to both expenditure-based and tax-based consolidations for each group by estimating an empirical model similar to Alesina et al. (2013). The results are shown in Figure 2. Tax evasion and corruption do not appear to significantly affect the response of output to expenditure-based consolidations, although the high tax evasion group has slightly lower output losses in the long run. In the case of tax-based consolidations, the output effects for high tax evasion and corruption countries are lower on impact, but significantly larger and more prolonged in the medium and long run. Hence, even with this alternative methodology, we find that tax evasion and corruption affect the size of fiscal multipliers, and amplify the output losses from tax adjustments in particular.

There is an important caveat to the exercises we have shown above, specifically that we could be omitting other factors which are common across the groups. In other words, the effects which we capture could be driven by other country characteristics that are correlated with tax evasion and corruption. To address this issue, we have attempted to control for several of the potential omitted factors. Columns 5 to 9 of Table 1 show the results of the BL (2013) regressions controlling for: i) sophistication of financial systems, ii) degree of slack in the economy, iii) size of the fiscal consolidation, iv) level of sovereign debt and v) level of sovereign risk.[11] We see that none of these controls can explain the results we had previously found. We have also carried out the same robustness checks for the second exercise shown above using the narrative fiscal consolidation episodes, and again we do not find that any of these controls can account for the differences we observe between countries with high and low tax evasion and corruption.[12] Whilst we cannot make causal statements from these results, we can clearly see that countries with high tax evasion or corruption have higher fiscal multipliers, and that this is not driven by five of the most likely potential omitted factors.

We also run regressions for the components of GDP, and for unemployment, to understand which variables are more significantly affected by the presence of these two features. The results are shown in the online appendix.[13] We find that the presence of corruption and tax evasion is particularly important for the effects of consolidations on the unemployment

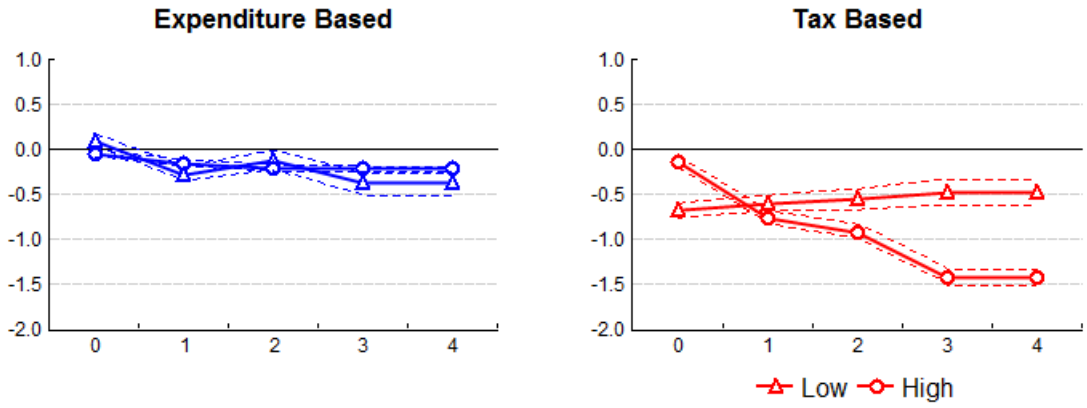
[10] In this case, the 'high tax evasion' group consists of Belgium, Ireland, Italy, Portugal and Spain, whilst the 'low tax evasion' group consists of Australia, Austria, France, the UK and the US. The 'high corruption' group consists of France, Italy, Japan, Portugal and Spain, and the 'low corruption' group consists of Australia, Austria, Denmark, Finland and Sweden.

[11] These are measured by i) the household debt-to-income ratio, ii) the unemployment rate, iii) the reduction in the structural deficit, where, following Alesina and Ardagna (2010), a consolidation is large if the deficit was reduced by more than 1.5% GDP, iv) the government debt-to-GDP level and v) the sovereign credit default swap spread, respectively.

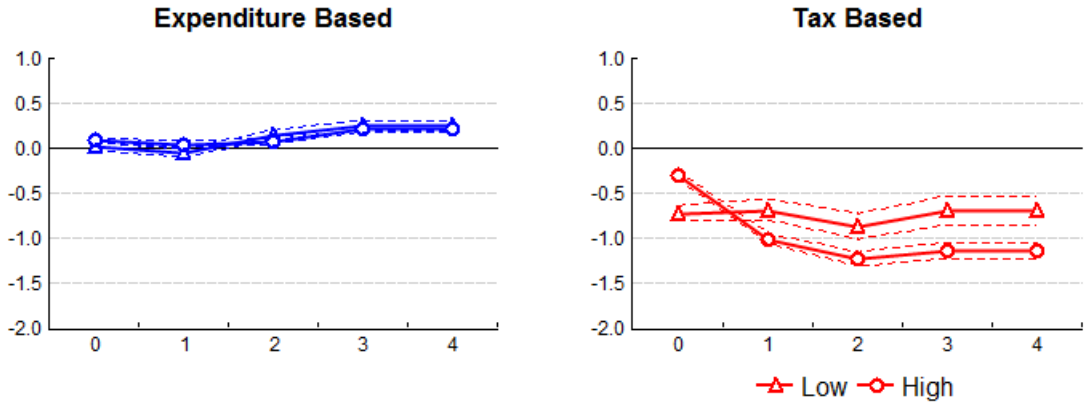
[12] These results are available from the authors upon request.

[13] The online appendix is available at: http://www.eui.eu/Personal/Pappa/

Figure 2: Output Responses to Narrative Consolidation Episodes



(a) High and Low Tax Evasion Groups



(b) High and Low Corruption Groups

Table 2: Baseline Sign Restrictions

Variable:	Govt Expenditure	Tax Revenue	Debt
Shock:	$t = 0, 1, 2$	$t = 0, 1, 2$	$t = 1, 2, 3$
Spending Cut	–	n/a	–
Tax Hike	n/a	+	–

rate and investment, but not for consumption, exports or imports.

2.2. Do Fiscal Consolidations Affect Tax Evasion?

The Italian statistical office provides estimates of the number of employees working in the informal sector using the discrepancies between reported employment from household surveys and firm surveys (see ISTAT, 2010). We use the share of informal workers in total workers as a measure of the size of the shadow economy, and enter this variable into a VAR to ascertain the effect of fiscal consolidations using different instruments.

To identify the effects of unexpected spending cuts, we run a VAR with GDP (or the unemployment rate), government final consumption expenditures, government debt and the share of informal workers in total workers as endogenous variables, and tax revenues as an exogenous variable. We use sign restrictions to identify a negative shock to government expenditure which lasts for 3 periods, and reduces debt with a lag. To identify the effects of unexpected labor tax hikes, we run a similar VAR which includes direct tax revenues as an endogenous variable and government expenditures as an exogenous control. We again use sign restrictions to identify a positive shock to tax revenues, lasting 3 periods, which reduces debt with a lag. The responses of all other variables are left unrestricted. The sign restrictions used are summarized in Table 2.

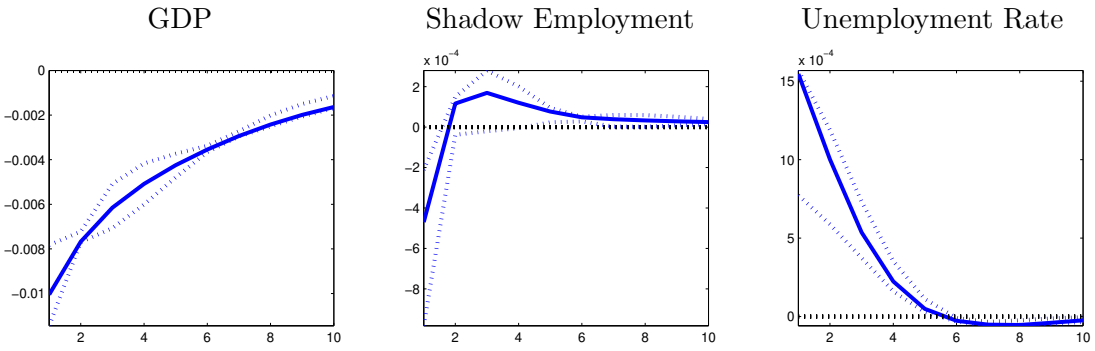
We use annual data from 1980-2006. Except for the ISTAT series, all data is taken from the AMECO database of the European Commission.[14] All fiscal variables are expressed as a ratio to GDP, and we include time trends and dummies for the start of the European Monetary Union, and for the mid-90s since there is a break in the debt series. We include one lag in the VAR, and also include interest rates as an exogenous variable in order to control for the effects of monetary policy. Given the small sample size, we estimate the VAR with Bayesian methods and present 68% posterior confidence bands.

The first panel of Figure 3 shows the resulting IRFs for the spending shocks, and Figure 4 shows the results for the tax shock.[15] After an expenditure cut, output decreases significantly at all horizons, while shadow employment falls significantly on impact. Following

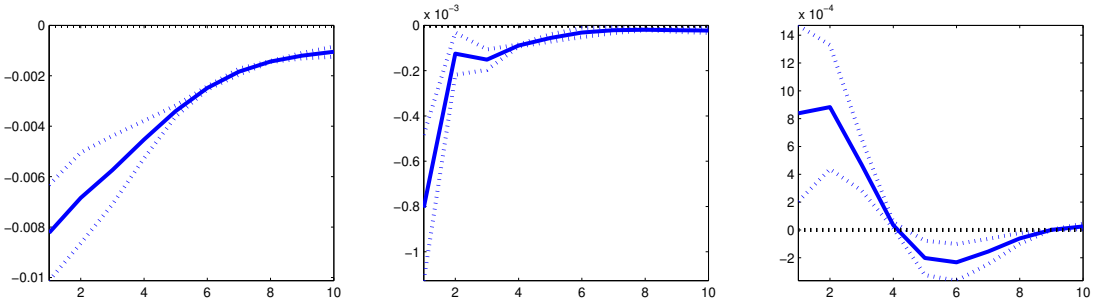
[14]The ISTAT data is available from http://www.istat.it/it/archivio/39522.

[15]For ease of exposition we show only the responses of the unrestricted variables in each case, and show only the shadow employment response in the VAR specification with GDP; the other responses are in line with the sign restrictions imposed, and the response of shadow employment is similar in all cases. The full results are presented in the online appendix.

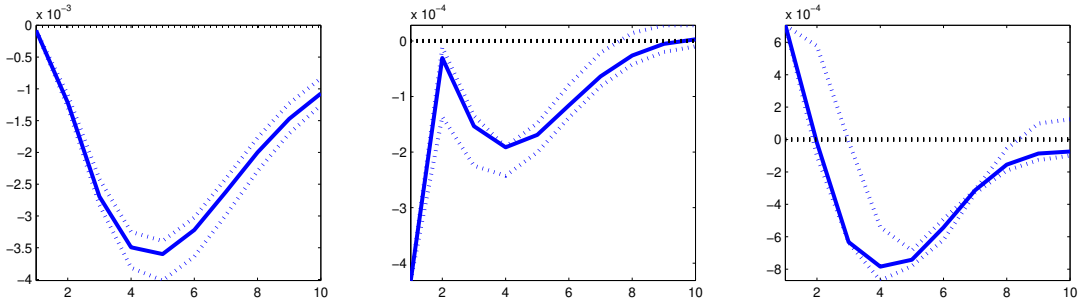
Figure 3: Empirical IRFs - Expenditure Shock



(a) Baseline Sign Restrictions

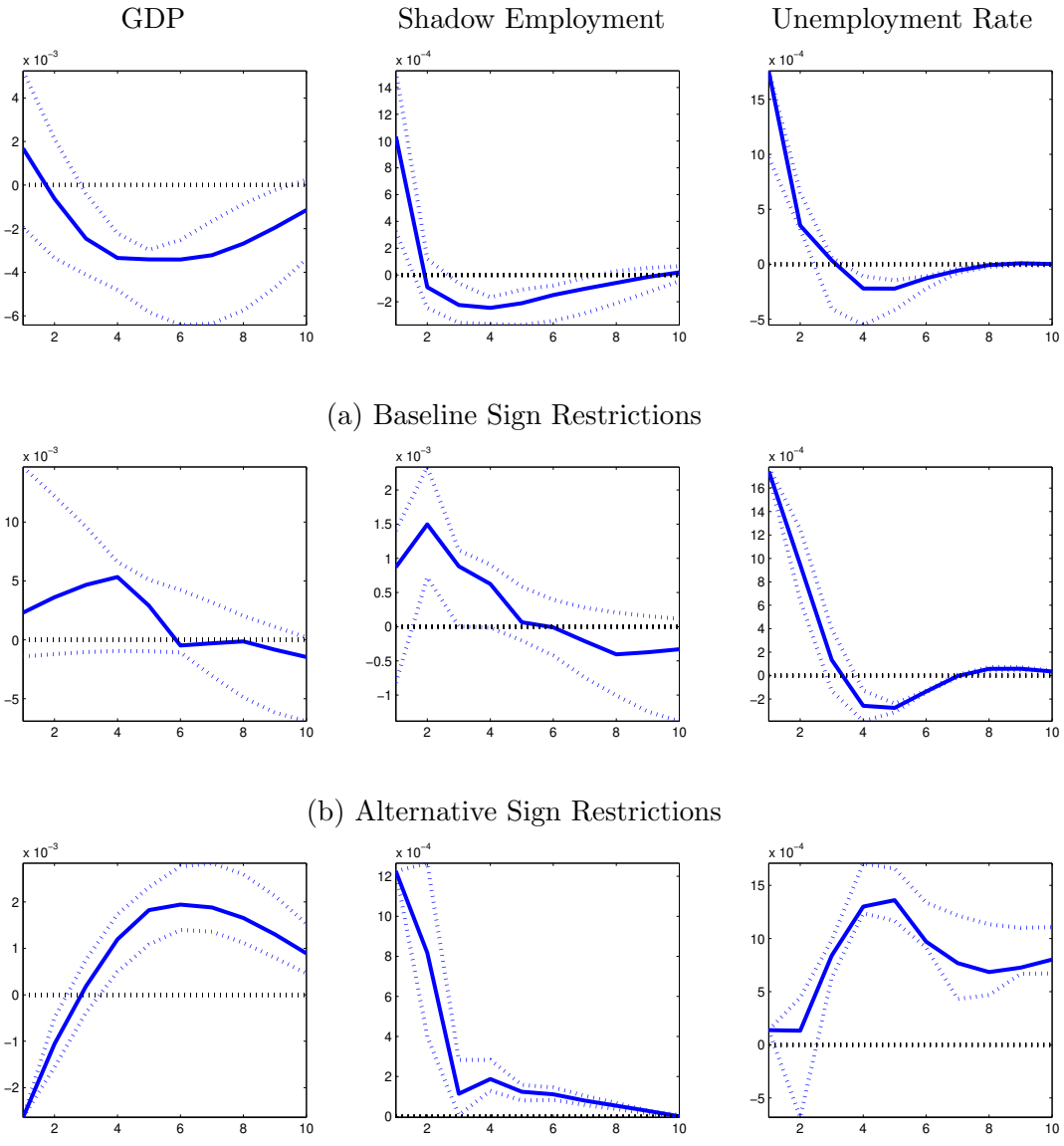


(b) Alternative Sign Restrictions



(c) Cholesky Decomposition

Figure 4: Empirical IRFs - Tax Shock



(a) Baseline Sign Restrictions

(b) Alternative Sign Restrictions

(c) Cholesky Decomposition

a tax hike, output does not fall on impact but the response is significantly negative in the medium run, and there is a significant rise in shadow employment on impact. When the unemployment rate is used instead of output, we see that it rises significantly after both types of consolidation.

The correct identification of fiscal shocks is highly contested in the literature, and there are justifiable concerns regarding the robustness of VAR results to different identification schemes. To demonstrate the robustness of our qualitative results, we examine their sensitivity to alternative identification schemes. The second panel of Figures 3 and 4 present responses when we use an alternative set of sign restrictions in which we jointly identify spending cuts and tax hikes in the same VAR regression, by assuming that they are uncorrelated. The final panel presents results when we use a simple Cholesky decomposition to identify the shocks, ordering government spending and tax revenues first in the system. Whilst the precise pattern of the responses can differ, the result broadly remains that consolidations are contractionary, and that spending-based consolidations reduce tax evasion whilst tax-based consolidations increase it. Since the zero restrictions imposed in both the alternative sign restrictions and the Cholesky are unlikely to hold in annual data, and we are restricted to using annual data due to the availability of data on shadow employment, we feel that our baseline sign restrictions are the most valid choice.[16]

Another potential problem with the SVAR methodology is whether the shocks we have identified can be anticipated. Dealing comprehensively with this issue is not straightforward, and is beyond the scope of this paper. As a first pass at ascertaining whether the shocks we have identified are truly unanticipated, we follow Perotti (2005) and regress the spending shocks, identified in our baseline sign restrictions, on forecast errors from professional forecasts of government expenditure, taken from the ECB's survey of professional forecasts. The first column of Table 3 shows the results from regressions using the "raw" forecast errors, and the second column shows the results using the residuals after regressing the forecast errors on the lag of the 4 variables in the VAR. We see that in both cases, the forecast errors are uncorrelated to our shocks, suggesting that our shocks are not predictable.

Thus the data robustly suggests that fiscal consolidation through expenditure cuts leads to a fall in shadow employment, while a consolidation through tax hikes increases shadow employment, and that both types of consolidations are contractionary. In the next section we develop a model with tax evasion and corruption to replicate these findings and understand how these frictions affect the propagation of fiscal shocks.

[16] We have also used the narrative fiscal consolidation episodes identified by Devries et al. (2011), however, given that they provide very few episodes for Italy alone, we do not find significant responses. Further details of all these exercises are provided in the online appendix.

Table 3: Anticipated Shocks

Dependent Variable: VAR Expenditure Shocks		
REGRESSOR	1	2
'Raw' Professional Forecast Errors	0.006	
	(0.005)	
'Purified' Professional Forecast Errors		-.001
		(0.005)
Constant	0.001	0.002
	(0.005)	(0.004)
R-squared	0.091	0.002

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

3. The Model

We construct a DSGE model featuring search and matching frictions, endogenous labor decisions, and sticky prices in the short run. Since, in Section 2, we found that corruption and tax evasion are not important for the effects of fiscal consolidation on exports or imports, we consider a closed economy. There are two types of firms in the economy: (i) competitive firms that produce intermediate goods in either the formal or informal sector, and (ii) monopolistic retailers that use all intermediate varieties to produce differentiated retail goods, which are then costlessly aggregated into a final consumption good. Price rigidities arise at the retail level, while labor market frictions occur in the production of intermediate goods. Intermediate firms can choose to produce in the informal sector in order to evade the payroll taxes paid on formal employment. In each period, they 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. Jobseekers can choose to search in the informal sector in order to evade income taxes. 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 markets

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, 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 follows:

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

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 of 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, ρ, that an informal employee loses their job due to an audit. 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 consists 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 labor force, l_t, and a consumption bundle, cc_t, defined as:

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

where g_t denotes public consumption, taken as exogenous by the household, and c_t is private consumption. The elasticity of substitution between the private and public goods is given by $\frac{1}{1-\alpha_2}$.[17] The instantaneous utility function is given by:

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

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 household 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

[17] 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.

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:

$$n_t^F + n_t^I + u_t + l_t = 1 \tag{4}$$

The household chooses the fraction of jobseekers searching in each sector: a share s_t of jobseekers look for a job in the informal 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:

$$k_{t+1} = i_t + (1-\delta)k_t - \frac{\omega}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t \tag{5}$$

where i_t is investment, 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:

$$(1+\tau_t^c)c_t + i_t + \frac{B_{t+1}\pi_{t+1}}{R_t} \leq r_t k_t + (1-\tau_t^n)w_t^F n_t^F + w_t^I n_t^I + \varpi u_t^F + B_t + \Pi_t^p - T_t \tag{6}$$

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 on capital, ϖ denotes unemployment benefits, available only to formal jobseekers (see e.g. 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 monopolistic retailers, 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 maximizes expected lifetime utility subject to (1) for each j, (2), (3), (4), (5), and (6). 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}.

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

$$V_{n^F t}^h = \lambda_{ct} w_t^F (1-\tau_t^n) - \Phi l_t^{-\varphi} + (1-\sigma^F)\lambda_{n^F t} \tag{7}$$

$$V_{n^I t}^h = \lambda_{ct} w_t^I - \Phi l_t^{-\varphi} + (1-\rho-\sigma^I)\lambda_{n^I t} \tag{8}$$

where $\lambda_{n^F t}$, $\lambda_{n^I t}$ and λ_{ct} are the multipliers in front of (2), (3) and (6) respectively.[18]

[18] The first order conditions of the household's problem and the derivations of equations (7) and (8) are presented in the online appendix.

3.3. Production

3.3.1. Intermediate goods firms

Intermediate goods are produced with two different technologies:

$$x_t^F = (A_t^F n_t^F)^{1-\alpha^F}(k_t)^{\alpha^F}$$

$$x_t^I = (A_t^I n_t^I)^{1-\alpha^I}$$

where A_t^j denotes total factor productivity in sector j. Following the literature, we assume that the informal production technology uses labor inputs only (see e.g. Busato and Chiarini, 2004).

Firms maximize the discounted value of future profits, subject to (2) and (3). That is, they take the number of workers currently employed in each sector, n_t^j, as given and choose the number of vacancies posted in each sector, υ_t^j, so as to employ the desired number of workers next period, n_{t+1}^j. 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 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. We assume that, once they are produced, there is no differentiation between intermediate goods from the different sectors. In other words, we assume that formal and informal goods are perfect substitutes, so that they are sold at the same price, p_t^x (see e.g. Orsi et al., 2014). Hence the problem of an intermediate firm is summarized by the following Bellman equation:

$$Q(n_t^F, n_t^I) = \max_{k_t, \upsilon_t^F, \upsilon_t^I} \Big\{ (1-\rho\gamma)\, p_t^x (x_t^F + x_t^I) - (1+\tau_t^s) w_t^F n_t^F - w_t^I n_t^I - r_t k_t \\ - \kappa^F \upsilon_t^F - \kappa^I \upsilon_t^I + E_t \left[\Lambda_{t,t+1} Q(n_{t+1}^F, n_{t+1}^I) \right] \Big\}$$

where τ_t^s is a payroll tax, κ^j is the cost of posting a new vacancy in sector j, and $\Lambda_{t,t+1} \equiv \beta \frac{U_{cc,t+1}}{U_{cc,t}} = \beta \left(\frac{cc_{t+1}}{cc_t} \right)^{-\eta}$ is a discount factor. The first-order conditions are:

$$r_t = (1-\rho\gamma)\, p_t^x \left(\frac{\alpha^F x_t^F}{k_t} \right) \tag{9}$$

$$\frac{\kappa^F}{\psi_t^{fF}} = E_t \Lambda_{t,t+1} \left[(1-\rho\gamma)\, p_{t+1}^x (1-\alpha^F) \frac{x_{t+1}^F}{n_{t+1}^F} - (1+\tau_{t+1}^s) w_{t+1}^F + \frac{(1-\sigma^F)\kappa^F}{\psi_{t+1}^{fF}} \right] \tag{10}$$

$$\frac{\kappa^I}{\psi_t^{fI}} = E_t \Lambda_{t,t+1} \left[(1-\rho\gamma)\, p_{t+1}^x (1-\alpha^I) \frac{x_{t+1}^I}{n_{t+1}^I} - w_{t+1}^I + \frac{(1-\rho-\sigma^I)\kappa^I}{\psi_{t+1}^{fI}} \right] \tag{11}$$

According to (9)-(11), the net value of the marginal product of private capital should equal the real rental rate and the expected marginal cost of hiring a worker 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.

For convenience, we define the value of the marginal formal and informal job for the intermediate firm:

$$V^f_{n^F t} = (1-\rho\gamma)\, p^x_t (1-\alpha^F)\frac{x^F_t}{n^F_t} - (1+\tau^s_t)w^F_t + \frac{(1-\sigma^F)\kappa^F}{\psi^{fF}_t} \tag{12}$$

$$V^f_{n^I t} = (1-\rho\gamma)\, p^x_t (1-\alpha^I)\frac{x^I_t}{n^I_t} - w^I_t + \frac{(1-\rho-\sigma^I)\kappa^I}{\psi^{fI}_t} \tag{13}$$

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^x_t, 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:

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

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

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

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

$$p_t = \left[(1-\chi)(p^*_t)^{1-\epsilon} + \chi(p_{t-1})^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}} \tag{14}$$

Firms that are able to reset their price choose p^*_{it} so as to maximize expected profits given by:

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

The resulting expression for p^*_{it} is:

$$p^*_{it} = \frac{\epsilon}{\epsilon-1}\frac{E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t,t+s} p^x_{t+s} y_{it+s}}{E_t \sum_{s=0}^{\infty} \chi^s \Lambda_{t,t+s} y_{it+s}} \tag{15}$$

3.4. Government

Government expenditure consists of consumption purchases and unemployment benefits, while revenues come 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:

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

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

The government budget constraint is given by:

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

We assume that T_t, τ_t^s, and τ_t^c are constant and fixed at their steady state levels, and we do not consider them as active instruments for fiscal consolidation. In our model, the effects of payroll taxes are very similar to labor income taxes. Consumption taxes can have different effects, but they generally constitute a relatively small source of tax revenues. Thus, in line with Erceg and Lindé (2013), the government has two potential fiscal instruments, g and τ^n. We consider each instrument separately, assuming that if one is active, the other remains fixed at its steady state value. For $\Psi \in \{g, \tau^n\}$, we assume fiscal rules of the form:

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

where $b_t = \frac{B_t}{y_t}$ is the debt-to-GDP ratio, and b_t^* is the target value for this ratio, given by the AR(2) process:

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

where ε_t^b is a white noise shock representing a fiscal consolidation.

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:

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

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

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

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

where the last term is the resource cost of corruption in the economy.[19]

The aggregate price index, p_t, is given by (14) and (15). The return on private capital, r_t, adjusts so that the capital demanded by the intermediate goods firm, given by (9), 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. 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 (7), (8), (12) and (13). As shown in the online appendix, wages are given by:

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

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

3.6. Calibrating the Model

We calibrate the model using annual Italian data for the period 1982-2006.[20] Table 4 displays the values used. We calibrate the labor force participation and unemployment rate in the formal sector to match the observed average values. Thus, we set official labor force participation, $lf \equiv n^F + u^F$, equal to 60% and the official unemployment rate to 10%. We fix the separation rate $\sigma^F = 0.07$. We set the probability of filling a vacancy in the formal sector $\psi^{fF} = 0.96$, and the matching elasticity with respect to vacancies $\mu_2 = 0.7$, which is close to the estimate obtained in Peracchi and Viviano (2004).

The capital depreciation rate, δ, is set equal to 0.088. Following the literature, we set the discount factor $\beta = 0.96$. The elasticity of demand for retail 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, A^F, is normalized to one, and the capital share $\alpha^F = 0.36$. We set the vacancy costs in the formal sector $\kappa^F = 0.14$, and the payroll tax rate $\tau^s = 16\%$, close to the value used in Orsi et al. (2014).

In the informal sector, we assume that TFP is lower than the formal sector by setting $A^I = 0.6$. According to Restrepo-Echavarria (2014), the fact that the informal sector has restricted access to credit leads to fewer resources being devoted to research and development, or to absorbing technology spillovers, which in turn reduces productivity. Also, both

[19] See the online appendix for full derivations.

[20] Details of the calibration exercise are in the online appendix.

Table 4: Baseline Calibration Values

Parameter	Description	Value
β	Discount Factor	0.96
δ	Depreciation Rate	0.088
α_1	Share of Private Consumption in Utility	1
η	Inverse Elasticity of Intertemporal Substitution	2
φ	Inverse Frisch Elasticity of Labor Supply	2
Φ	Relative Utility from Leisure	0.7
lf	Official Labor Force Participation	0.6
$\frac{u^F}{lf}$	Official Unemployment Rate	0.1
$\frac{u}{1-l}$	Actual Unemployment Rate	0.09
s	Share of Informal Jobseekers to Total	0.10
$\frac{n^I}{n}$	Share of Informal Employment to Total	0.13
σ^F	Exogenous Job Destruction Rate - Formal Sector	0.07
σ^I	Exogenous Job Destruction Rate - Informal Sector	0.0545
ρ	Auditing Probability	0.02
μ_1^F	Matching Efficiency - Formal Sector	0.85
μ_1^I	Matching Efficiency - Informal Sector	0.12
μ_2	Elasticity of Matching to Vacancies	0.7
ψ^{fF}	Probability of Filling a Vacancy - Formal Sector	0.96
ψ^{fI}	Probability of Filling a Vacancy - Informal Sector	0.05
ψ^{hF}	Probability of Finding a Job - Formal Sector	0.63
ψ^{hI}	Probability of Finding a Job - Informal Sector	0.91
A^F	TFP - Formal Sector	1
A^I	TFP - Informal Sector	0.6
α^F	Capital Share - Formal Sector	0.36
α^I	Production Function Parameter - Informal Sector	0.4
$\frac{y^I}{y}$	Share of Underground Output in Total	0.16
κ^F	Vacancy Costs - Formal Sector	0.14
$\frac{\kappa^F}{w^F}$	Vacancy Costs/Wage	0.21
κ^I	Vacancy Costs - Informal Sector	0.13
ϵ	Price Elasticity of Demand	5
ϑ^F	Firm's Bargaining Power - Formal Sector	0.22
ϑ^I	Firm's Bargaining Power - Informal Sector	0.80
$\frac{w^I}{w^F}$	Formal/Informal Wage Differentials	0.98
$\frac{g}{y}$	Government Expenditure-to-GDP Ratio	0.11
$\frac{\varpi}{w^F}$	Replacement Rate	0.35
τ^n	Labor Income Tax Rate	0.4
τ^s	Payroll Tax Rate	0.16
τ^c	Consumption Tax Rate	0.18
γ	Proportional Fine in Case of Auditing	0.3
ξ^{TR}	Embezzlement Rate	0.2
$\frac{DF}{y}$	Deficit-to-GDP Ratio	-0.04
b	Debt-to-GDP Ratio	1.03
ρ_1, ρ_2	Debt-to-GDP Target Parameters	0.85, 0.0001
χ	Price Stickiness	0.25
ω	Capital Adjustment Costs	0.5
ζ_π	Taylor Rule Parameter	1.5

Boeri and Garibaldi (2007) and Orsi et al. (2014) emphasize empirical evidence suggesting that the workers in the informal sector have lower education levels.[21]

Using the ISTAT data, we set the share of informal employment to total employment equal to 0.13, and we set $\alpha^I = 0.4$, implying the share of shadow output to total output $\frac{y^I}{y} = 16\%$. We set the exogenous job destruction rate in the informal sector $\sigma^I = 0.0545$, the probability of filling a vacancy in the informal sector $\psi^{fI} = 0.05$, and the vacancy cost in the informal sector $\kappa^I = 0.13$. These values yield a relatively small wage premium for the formal sector, $\frac{w^I}{w^F} = 0.98$, in line with the literature. The probability of audit and the fraction of total revenues paid as a fine in the event of an audit are set as follows: $\rho = 0.02$, close to the value used in Boeri and Garibaldi (2007), and $\gamma = 0.3$. For the probability of tax audit, we also consider alternative values ($\rho = 0.04$ and $\rho = 0.01$) in the sensitivity analysis.

We set the replacement rate $\frac{\varpi}{w^F} = 0.35$, close to the estimates in Martin (1996), and used by Fugazza and Jacques (2004). Government spending as a share of GDP and the remaining tax rates are set as follows: $\frac{g}{y} = 11\%$, $\tau^n = 40\%$, in line with Orsi et al. (2014), and $\tau^c = 18\%$. The steady state debt-to-GDP ratio $b = 103\%$. Regarding the embezzlement parameter, we set $\xi^{TR} = 0.2$ and study the sensitivity of our results to different values of this parameter.

We begin by assuming purely wasteful government expenditure, setting $\alpha_1 = 1$, and will consider utility enhancing government spending as an extension. Regarding the inverse elasticity of intertemporal substitution, η, much of the literature cites the econometric estimates of Hansen and Singleton (1983), which place it "between 0 and 2", and often choose a value greater than unity. In our calibration, we set $\eta = 2$ and we perform sensitivity analysis by considering η equal to 0.5 and 1. The inverse of the Frisch elasticity, φ, is set equal to 2 and we examine the sensitivity of our results to changes in this parameter. Finally, we set the inflation targeting parameter in the Taylor rule $\zeta_\pi = 1.5$, the capital adjustment costs $\omega = 0.5$ and the price-stickiness parameter $\chi = 0.25$.

4. Results

We present responses following a negative debt-target shock (following Erceg and Lindé, 2013). 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 government consumption expenditure, or a hike in labor tax rates.[22]

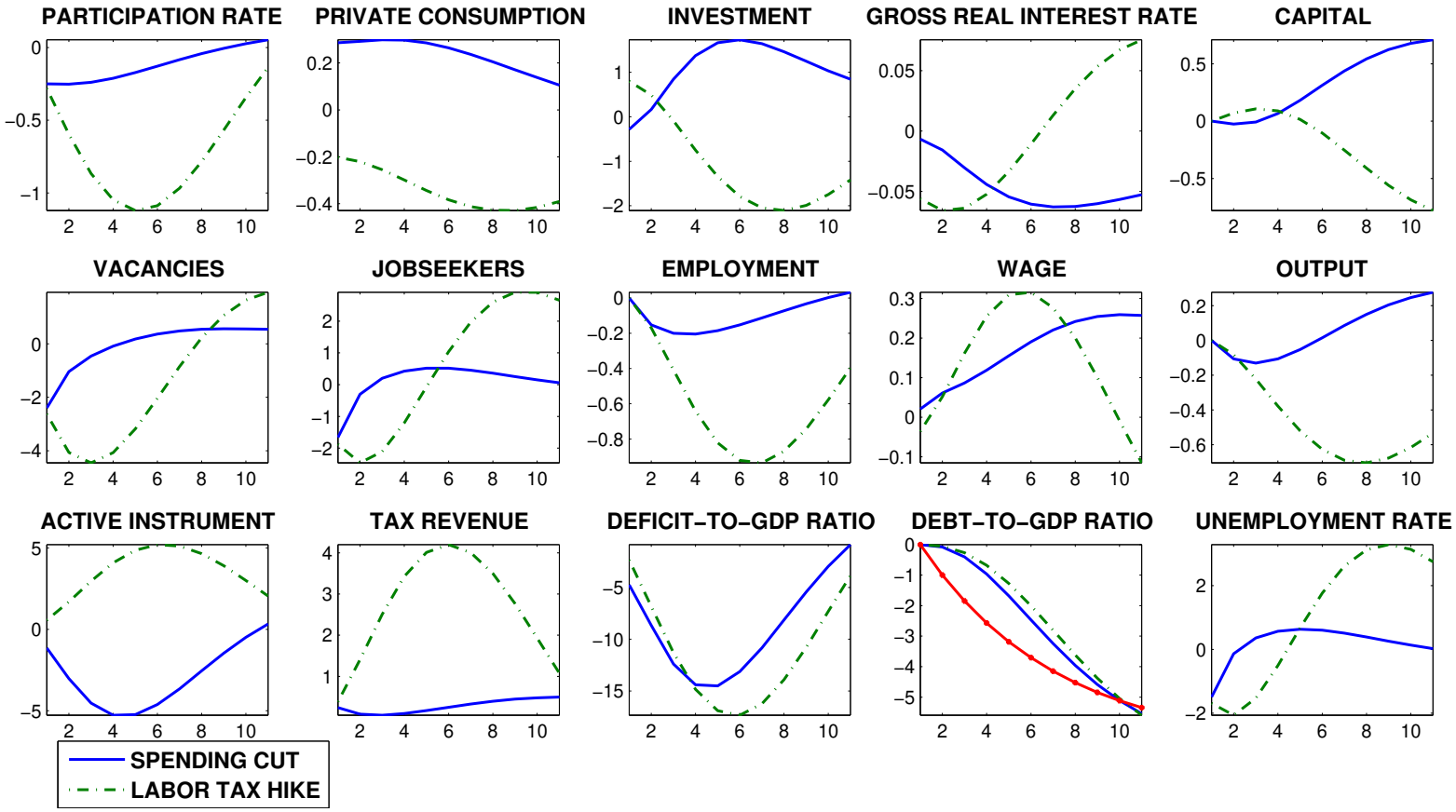
4.1. Dynamics in a Model without Tax Evasion and Corruption

As a benchmark, we begin by analyzing the responses of a standard model where tax evasion and corruption are absent, shown in Figure 5.

[21] Orsi et al. (2014) also note the equivalence of assuming lower productivity in the informal sector to assuming a cost for concealing production.

[22] For comparison purposes, throughout this section we adjust the parameters of the policy rules for each case to ensure that the debt target is met after 10 years.

Figure 5: IRFs of Benchmark Model (without Tax Evasion and Corruption)



A consolidation carried out through a fall in government spending has two effects. Firstly, there is a negative demand effect for firms, which leads, in the presence of nominal rigidities, to a fall in labor demand and hence in vacancies. Second, there is a positive wealth effect for the household, which increases consumption and investment and reduces labor force participation. Given the drop in both labor demand and supply, employment falls and the wage rate rises. Output falls in the short run, but increases in the medium and long run because investment, and hence the capital stock, increases. The unemployment rate reflects movements in the number of jobseekers: it falls on impact, but then increases as employment and wages adjust.

When the fiscal consolidation is carried out through a labor tax hike, there is a negative wealth effect for the household which makes consumption fall, and investment fall with a lag. However, as the return from employment falls, there is a substitution effect which outweighs the wealth effect, and leads to a decrease in labor force participation. The fall in private demand induces firms to contract their labor demand, again expressed through a drop in vacancies. Employment and output fall, and the responses are significantly larger and more persistent than in the case of spending cuts, due to the fall in investment.

Thus, our benchmark model seems to be consistent with the evidence of Alesina et al. (2013): spending cuts are accompanied by mild and short-lived recessions, while tax hikes lead to more prolonged and deep recessions.

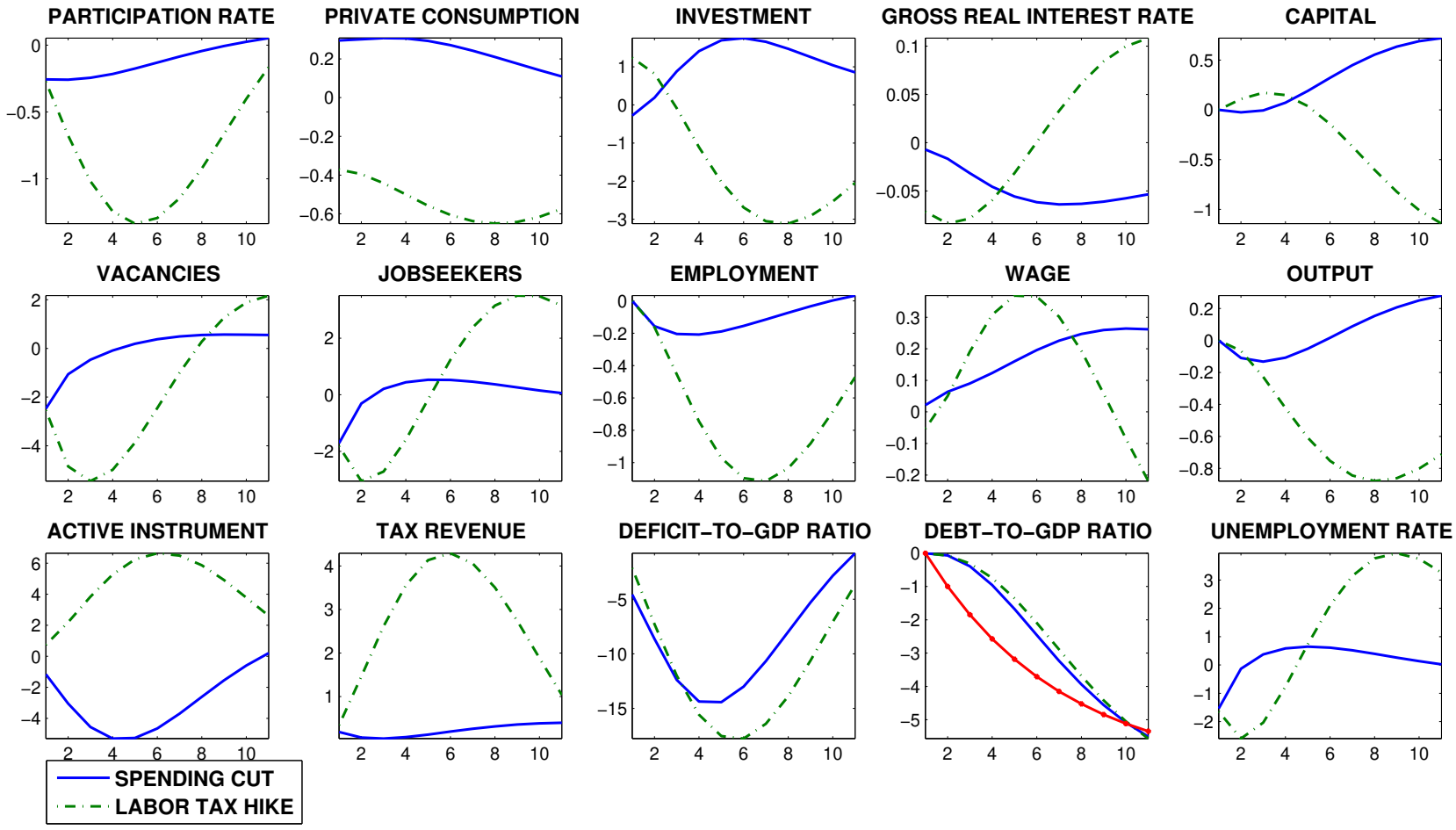
4.2. Dynamics in a Model with Corruption

Next, we study how the responses change when we introduce embezzlement of public funds in our model, shown in Figure 6. In our baseline calibration we set the embezzlement rate $\xi^{TR} = 0.2$.

The introduction of corruption does not alter the responses of the economy qualitatively. In the case of government spending cuts, the effects are negligible. However, in the case of labor tax rate hikes, there are notable quantitative differences. Given that a fraction of tax revenues are now lost through embezzlement, the change in the tax rates required to achieve debt consolidation is larger. This leads to an amplification of the effects observed in all variables.

We also check the sensitivity of this effect to the embezzlement rate. Informal accounts suggest that there are often large rents to be obtained in less developed economies, although precise estimates are difficult to obtain. Krueger (1974) estimates rents generated by import licenses alone to be in the range of 15% of GNP for Turkey in 1968; similarly large estimates are obtained by Gallagher (1991) for a sample of African countries from 1975 to 1987, ranging between 6% and 37% of GDP. Setting $\xi^{TR} = 0.2$ implies a value of embezzled tax revenues equal to 4.2% of GDP. Given the estimates for developing countries, we believe that a reasonable range of estimates of rent seeking as a percentage of GDP in Italy should be between 0.1% and 5%. This implies values for ξ^{TR} that vary between 0.05 and 0.25. Results for this sensitivity analysis, presented in the online appendix, show that

Figure 6: IRFs of Model with Corruption



with the higher the degree of corruption in the economy, the larger the tax hikes needed for consolidation and therefore the larger the amplification of the observed responses.

4.3. Dynamics in a Model with Tax Evasion

We now move to a model with tax evasion. Here, we incorporate the informal sector and set the corruption parameter again to zero. Figure 7 presents the responses of the formal sector and of fiscal variables, and Figure 8 shows the responses in the informal sector.

To start with, notice that the response of the formal sector is qualitatively similar to the benchmark model. However, there is an additional channel at play. For the case of tax hikes, unemployed jobseekers reallocate their labor supply and the intermediate firms reallocate their labor demand towards the informal sector. Tax hikes provide direct incentives for jobseekers to search in the informal sector because of the higher tax rates in the formal sector. At the same time, intermediate firms find it profitable to post vacancies in the informal sector because of the fall in the informal wage. The fall in investment, and hence the capital stock, lowers the productivity differential between the two sectors, and further provides incentives for agents to reallocate to the informal sector. As a result, shadow employment as a share of total employment increases.

For the case of expenditure cuts, the negative demand effect of the spending cut affects both formal and informal production, leading to a reduction in labor demand in both sectors. Similarly, as labor force participation falls, there is a reduction in unemployed jobseekers in both sectors. This causes a contraction in total employment. Moreover, there is a reallocation of labor towards the formal sector; shadow employment as a share of total employment falls, consistent with the evidence we presented in Section 2. This happens for two reasons. Firstly, the formal labor market has a higher matching efficiency, and a lower job destruction rate. Secondly, in addition to having a higher TFP level, the rise in the capital stock further increases the productivity of the formal sector relative to the informal sector. In order to take advantage of these efficiency gains, and thus mitigate the negative effects of the fiscal contraction, agents optimally choose to reallocate towards the formal sector.

4.4. A Model with Tax Evasion and Corruption

In this section we introduce both tax evasion and corruption and, in Figure 9, we compare the responses of output, the unemployment rate and welfare to the benchmark model.[23]

For spending cuts, shown in the top panel, the presence of tax evasion and corruption generates smaller losses in output, a drop in the unemployment rate at all horizons, and larger welfare gains. With tax evasion and corruption, the tax adjustments required to

[23] Welfare is computed as per-period steady state consumption equivalents. IRFs of all other variables are included in the online appendix.

Figure 7: IRFs of Model with Tax Evasion

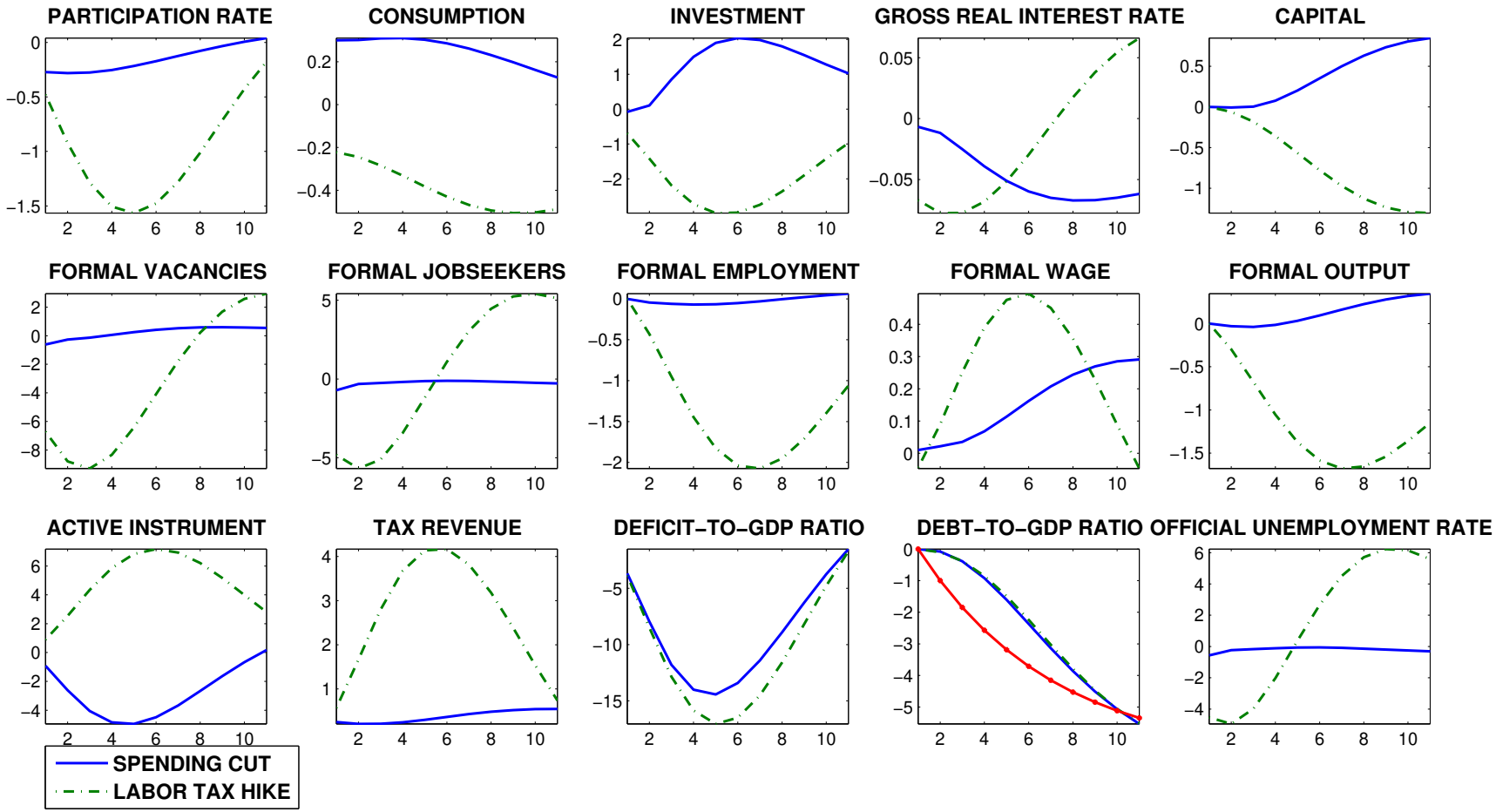


Figure 8: IRFs of Model with Tax Evasion - Informal Sector

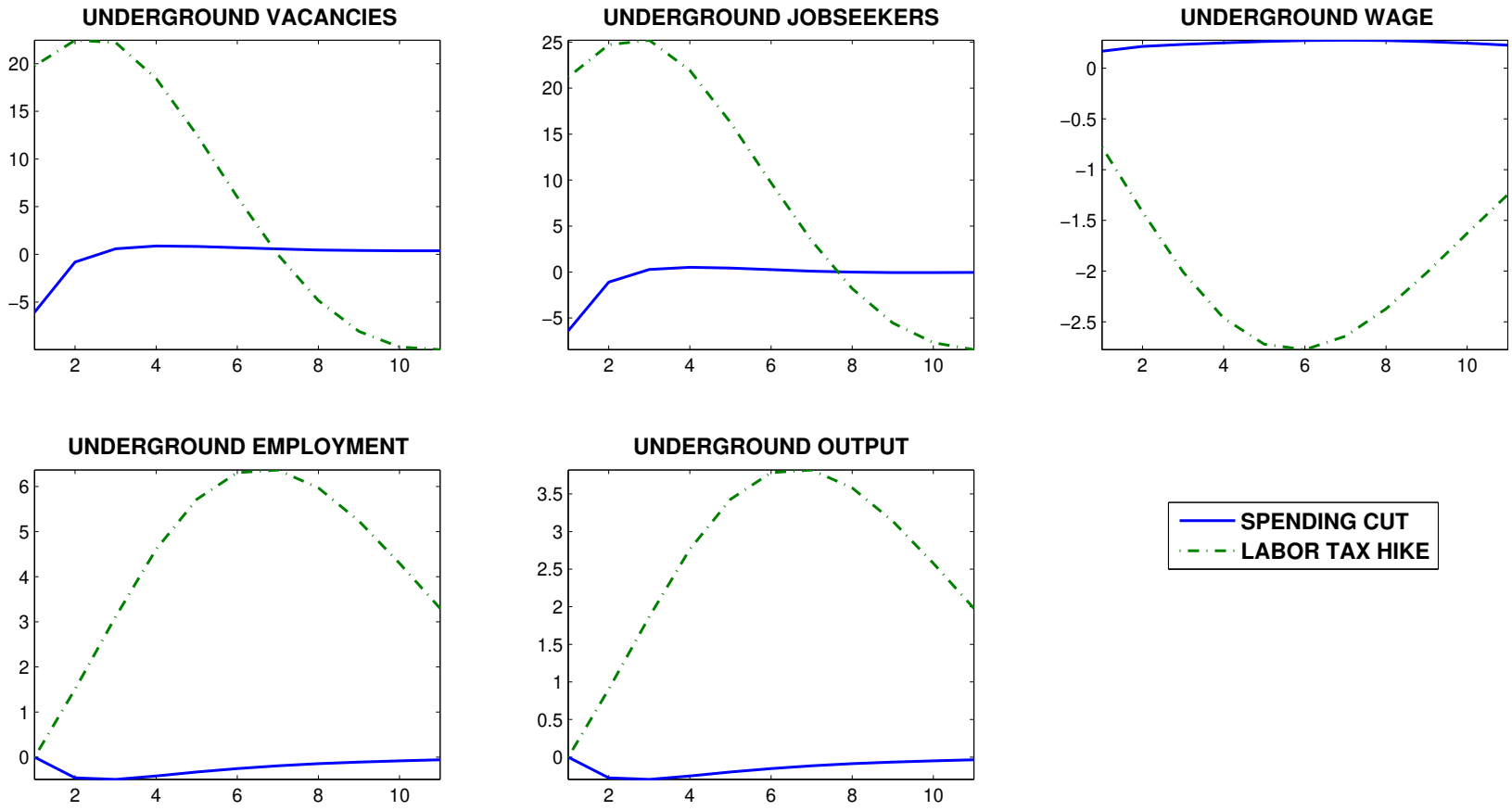
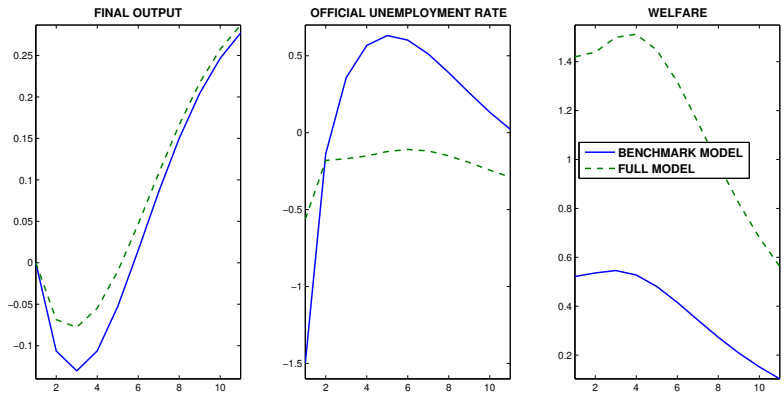
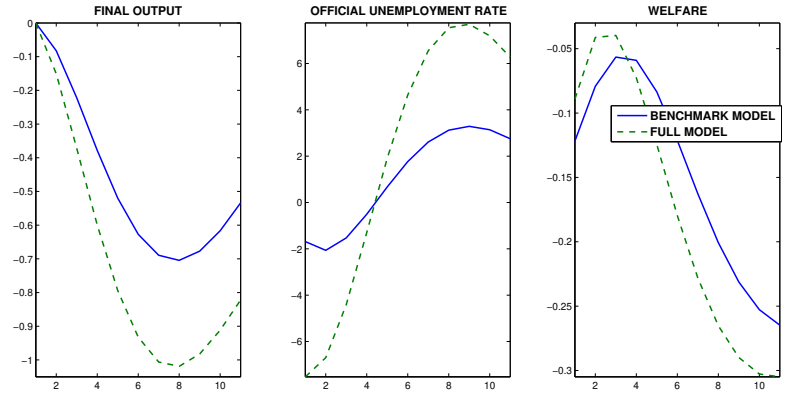


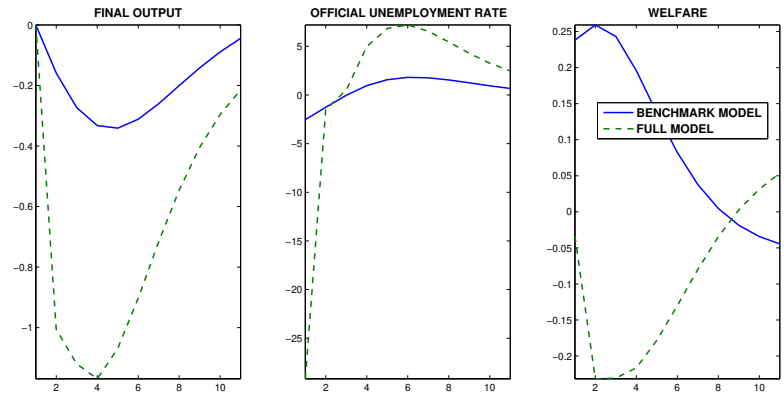
Figure 9: Comparison of Benchmark and Full Model



(a) Government Expenditure Cuts



(b) Labor Tax Hikes



(c) Mixed Consolidation

achieve a given change in deficit are larger, and thus, following a spending cut, taxes in the future are expected to fall by more. In other words, there is an amplification of the positive wealth effect. Hence the rise in consumption and the fall in labor force participation are larger relative to the model without tax evasion and corruption, making welfare gains larger. The increased crowding-in of private consumption mitigates the negative demand effect for the firms, thereby mitigating output losses. The larger reduction in labor force participation implies a fall in the number of formal jobseekers, and hence in the official unemployment rate, at all horizons.

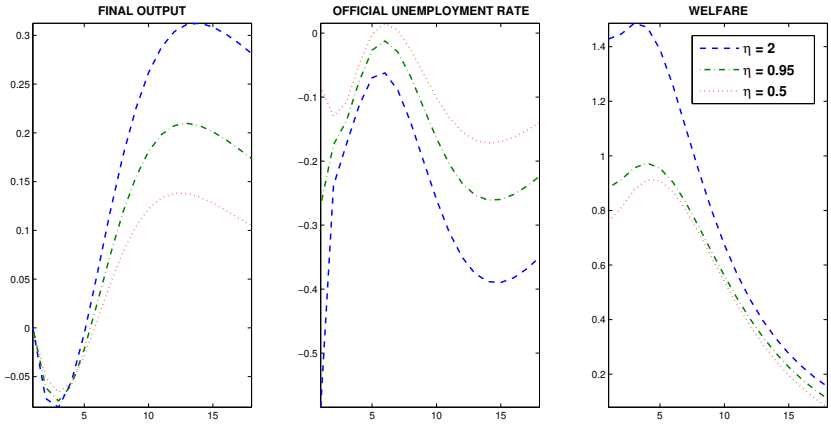
For tax hikes, shown in the middle panel, the presence of corruption and tax evasion amplifies the output losses, particularly in the long run. This is due to the loss of tax revenue from both corruption and tax evasion, implying that larger increases in tax rates are needed to reduce debt-to-GDP. This increases the distortionary effects of the consolidation, leading to a larger drop in labor force participation, private consumption and investment. In addition, the reallocation towards the informal sector increases the inefficiencies due to the lower productivity in this sector. Thus, there is a larger contraction in the formal sector, which is also evident in the response of the official unemployment rate: the initial fall is amplified as jobseekers drop out of the formal sector, and the rise in the long run is higher as firms post fewer vacancies in this sector. Furthermore, tax hikes lead to welfare losses. Initially, these losses are lower with tax evasion and corruption, but in the medium and long run, as consumption falls increasingly, we obtain higher losses.

The bottom panel depicts the responses in the case of a mixed consolidation. Here, we allow both policy instruments, g and τ^n, to move simultaneously to reduce the deficit, which follows the debt-targeting rule. We fix the policy mix such that a fraction a of the reductions in deficit come from expenditure cuts and $(1-a)$ from revenue enhancements, and set $a = 0.5$. In this case, the responses of consumption and investment are determined by the competing positive and negative wealth effects from the two instruments, and the presence of tax evasion and corruption plays an important role in determining this relative strength. In the benchmark model, the positive wealth effect of the expenditure cut is dominant and consumption rises for several periods. When there is tax evasion and corruption, this is no longer true and consumption and investment fall in all periods. Hence, as in the case of tax hikes, output and unemployment responses are amplified in the presence of tax evasion and corruption. This is in line with the evidence presented in Section 2. Moreover, the welfare gains obtained from mixed consolidation packages in the benchmark model turn into welfare losses in the model with tax evasion and corruption.

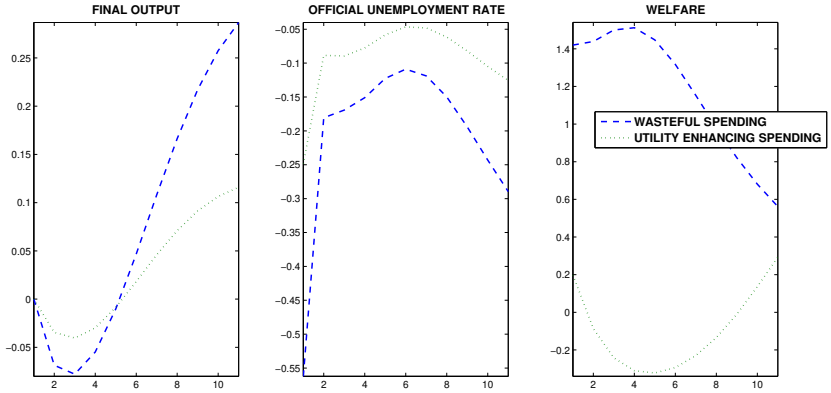
4.5. Sensitivity Analysis

Both the effects of labor tax hikes and expenditure cuts depend crucially on some modeling assumptions. In this section we present how the implications of fiscal consolidations change when we modify key assumptions or parameters of the model.

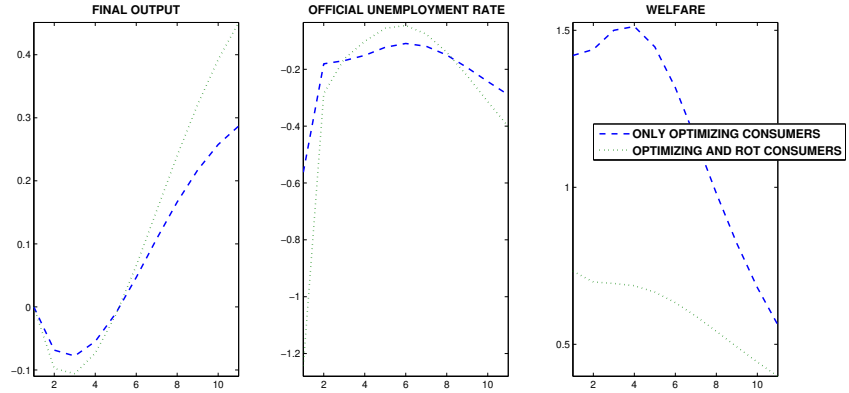
Figure 10: Sensitivity Analysis for Spending Cuts in the Full Model



(a) Intertemporal Elasticity of Substitution



(b) Utility Enhancing Government Spending



(c) Rule of Thumb (ROT) Consumers

4.5.1. Spending Cuts

Elasticity of Intertemporal Substitution. As we saw, the effects of the spending cuts depend crucially on the size of the wealth effect, which in turn depends on the elasticity of intertemporal substitution. As shown in the first panel of Figure 10, repeating the simulations using lower values for the inverse elasticity of intertemporal substitution, $\eta = 0.5$ and $\eta = 0.95$, yields qualitatively similar results. Quantitatively, for lower values of η, the risk aversion of agents is lower and after a spending cut we observe larger increases in consumption and smaller increases in investment, which dampens the long run expansion in output, as well as a larger drop in the labor force participation rate, which dampens the drop in the unemployment rate.

Utility-enhancing Government Spending. Assuming that government expenditures provide a public good, which is consumed by households, can change the welfare implications of spending cuts. To illustrate this point, we set $\alpha_1 = 0.85$ and $\alpha_2 = -0.25$, so that private and public spending are weak complements. The top panel of Figure 10 compares the results of this case with those obtained with wasteful government spending. In the case of utility-enhancing expenditures, a spending cut directly reduces the consumption bundle, and households are forced to offset this fall by further increasing private consumption. Thus, we see a larger crowding-in of private consumption, which mitigates the output and unemployment effects of spending cuts. However, the welfare effects are reversed: the drop in the consumption bundle causes welfare to fall for several periods.

Liquidity Constrained Agents. The presence of liquidity constrained consumers has been shown to play an important role in determining the response of private consumption to a government spending cut (see e.g. Galí et al., 2007). To explore how the presence of liquidity constrained consumers can affect our model, we assume a fraction of rule of thumb (ROT) household members, which we set equal to 44%, in line with the Italian household survey reported by Martin and Philippon (2014). As shown in the bottom panel of Figure 10, output and unemployment responses are amplified and welfare gains are mitigated following a spending cut. The presence of ROT agents reduces the positive wealth effect that the fiscal contraction generates, which implies a smaller increase in consumption and, hence, welfare, and a larger contraction in output.

4.5.2. Tax Hikes

The Elasticity of Taxable Income. A large body of the literature, initiated by Feldstein (1999), has argued that the costs of labor taxes can be summarized by the elasticity of taxable income with respect to the net of tax share. The magnitude of this elasticity can therefore yield further insights about the effects of tax hikes in the presence of tax evasion and corruption. We compute the taxable income elasticity by dividing the cumulative response of taxable income by the cumulative response of the net tax share, up to the point that tax rates return to steady state. For the benchmark model, the elasticity of taxable

income equals 0.23, while incorporating tax evasion and corruption in the analysis almost doubles this elasticity to 0.42.[24] This is not surprising, given that we are allowing workers to move out of taxable work, in the formal sector, not only by leaving the workforce but also by working in the informal sector. Data also suggests higher estimates of the taxable income elasticity in countries with more tax evasion and corruption. For example, Kleven and Schultz (2014) provide an estimate for Denmark equal to 0.09 for this elasticity and, using the same methodology, Arrazola et al. (2014) report a taxable income elasticity equal to 1.5 in Spain.

Of course many of our parameter choices affect the estimated value of the taxable income elasticity and so, in turn, our conclusions about the effects of tax hikes in a model with tax evasion and corruption. To investigate this, we first consider the inverse of the intertemporal elasticity of substitution, η. Smaller values of η imply higher values of the long run elasticity of taxable income: for $\eta = 0.95$ and 0.5, the corresponding elasticities are 0.43 and 0.44, respectively. Accordingly, the higher values of the taxable income elasticity, implied by the lower η, are associated with higher output and welfare losses, as well as higher unemployment in the medium and long run, as seen in the top panel of Figure 11.

Next, we use alternative values for the inverse of the Frisch elasticity of labor supply, φ. The value of the labor supply elastictity determines the size of the substitution effect following a tax hike and this, in turn, affects the taxable income elasticity in our model. Higher values of the labor supply elasticity, meaning lower values of φ, are associated with higher values of the taxable income elasticity, equal to 0.56, 0.36 and 0.34 for $\varphi = 0.5$, 5 and 8, respectively. Results presented in the second panel of Figure 11 indicate that output losses and medium and long run unemployment increase with the Frisch elasticity.[25]

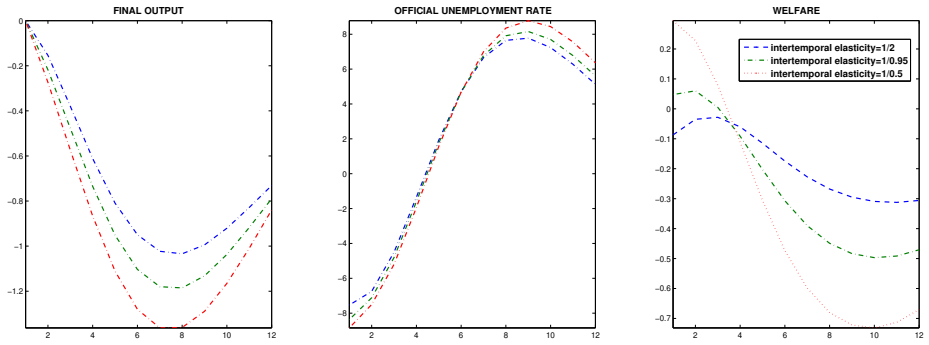
Finally, we consider the effects of a reduction in the ability of workers to reallocate between the two sectors, in particular by assuming a lower value for the matching efficiency parameter in the informal sector, $\mu_1^I = 0.05$ instead of 0.12. This modification reduces the taxable income elasticity to 0.29, close to the value in the benchmark model, and we see from the third panel of Figure 11 that the model dynamics also resemble the dynamics of the benchmark model. This is because reallocation to the informal sector is now more difficult, implying that the reallocation channel plays a smaller role in the dynamics.

The Detection Probability. In our model, the incentives to tax evade are also affected by the probability of detection. We investigate the role of the detection probability in the last panel of Figure 11. A higher detection probability reduces the output, unemployment, and welfare losses after a consolidation through tax hikes, since the incentives to reallocate to the informal sector are reduced. However, this effect is mostly seen in the short and

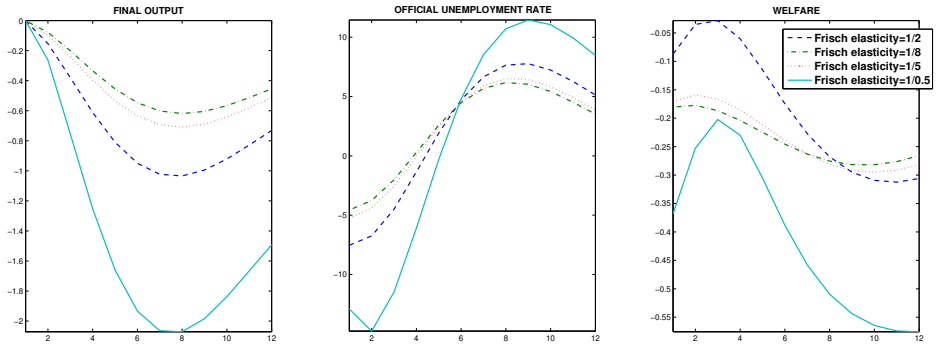
[24] Our estimates are broadly in line with those presented in recent studies that place the value of this elasticity in the $(0.2, 0.8)$ range. For a survey of the literature, see Saez et al. (2012).

[25] Welfare comparisons are more difficult when we change η and φ because these parameters have a direct impact on the relative weight of consumption and leisure in the utility function.

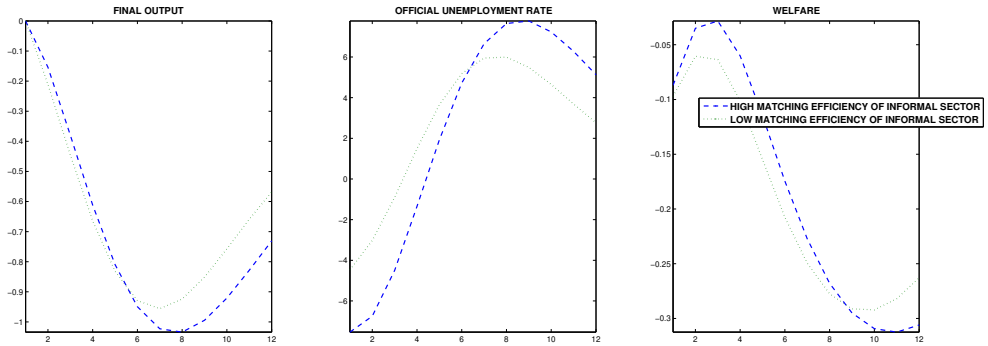
Figure 11: Sensitivity Analysis for Labor Tax Hikes in the Full Model



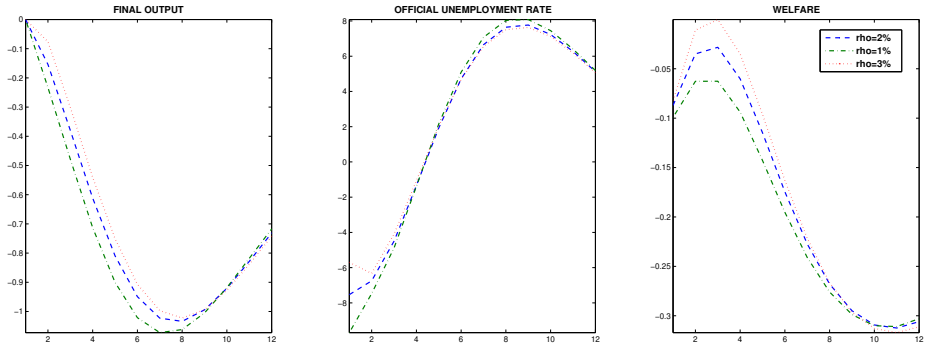
(a) Intertemporal Elasticity of Substitution



(b) Frisch Elasticity of Labor Supply



(c) Matching Efficiency of Informal Sector



(d) Detection Probability for Tax Evasion

medium run; in the long run, the results are similar for the different values of ρ.[26]

5. Policy Evaluation

Since the model qualitatively replicates the empirical evidence presented in Section 2, we employ it to evaluate the effects of consolidation packages implemented in southern European countries in recent years. We recalibrate the model for Greece, Portugal and Spain, three countries which are also characterized by high corruption and tax evasion, and analyze the effects of their recent consolidation packages.

5.1. Calibration

Using the information in OECD (2012), we adjust the size of the consolidation in each country to match the reduction in the deficit-to-GDP ratio implemented in 2010 and also replicate the announced consolidation volumes in the long run. Table 5 reports the consolidation in 2010 for each country and the intended consolidation to be implemented by 2015. We see that Greece implemented the most severe austerity package. The consolidation package of Italy in 2010 was small, but larger consolidation volumes were announced for 2015. The consolidation packages in Spain and Portugal were similar in 2010, but Portugal announced a slightly larger long run consolidation volume. In order to replicate the actual consolidation packages, we allow both instruments to move simultaneously, again using OECD (2012) to fix the relative contribution of the two instruments for each country. Portugal used more tax hikes than expenditure cuts, while the other countries used predominantly expenditure-based measures.[27]

Table 5 also summarizes the differences in the calibration for the various economies. We use the estimates of shadow output in Elgin and Öztunah (2012) to determine the relative share of shadow employment across countries, which gives comparable numbers, though slightly higher in Greece. Following the World Bank's Control of Corruption index, shown in Figure 1, we set the embezzlement rate in Greece and Italy higher than Spain and Portugal. According to the OECD statistics, Portugal has a notably healthier labor market, with the highest labor force participation rate and the lowest unemployment rate. According to the CEP-OECD database and the ICTWSS (Data Base on Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts, 1960-2011) indices, Italy and Greece have higher unionisation and coordination of bargaining, reflected in our model by lower bargaining power for firms, compared to Spain and Portugal. Also, according to the CEP-OECD database and the estimates in Martin (1996), replacement rates are lower in Italy and Greece relative to Spain and Portugal. Accordingly in Table 5 we assume replacement rates of 35% for Italy and Greece and 45% for Portugal and Spain. Spain

[26] Since the auditing probability affects the reallocation of workers between sectors, it could also affect the consolidation through spending cuts. However, the results under the alternative values of ρ do not change substantially compared to the results of the baseline calibration.

[27] See the tables on p.138, 166, 206, 226 of OECD (2012).

Table 5: Policy Evaluation: Calibration Values

	Greece	Italy	Spain	Portugal
Consolidation Volume - 2010 (% GDP)	7.8%	0.9%	2.7%	2.3%
Consolidation Volume - 2015 (% GDP)	18.5%	6.1%	7.3%	12.2%
Expenditure Share in Policy Mix	0.60	0.58	0.66	0.23
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
Formal Firm's Bargaining Power	0.22	0.20	0.27	0.32
Unemployment Benefit Replacement Rate	35%	35%	45%	45%
Debt (% GDP)	145.0	120.1	61.2	93.3
Government Consumption Spending (% GDP)	5	11	6	5

has the lowest debt-to-GDP ratio, while Greece and Italy both face debt well over 100% of GDP. Finally, the size of the government consumption expenditure as a percentage of GDP is higher in Italy than in the other countries.

5.2. Results

The simulation results are shown in Figure 12. Despite the substantial use of expenditure cuts, we see that tax evasion increases in all countries. With the use of tax hikes in the consolidation mix, the direct incentive to produce in the informal sector dominates the efficiency gains from producing in the formal sector, leading to a reallocation towards the informal sector. The relative size of the increase across countries is determined by the relative size of the tax hikes. Note that Portugal experiences the largest long run increase in the informal economy because of the heavy use of tax hikes in their consolidation.

The model predicts sizeable and persistent output losses following all consolidation packages. The relative size of these losses across countries reflects the size of the consolidation: Greece exhibits large losses, while in Italy the relatively small adjustment implies smaller effect. As a result, the unemployment rate increases in the long run in Greece, while the effects are negligible in Italy. However, note that Portugal experiences the largest output drop in the long run, because of the large share of tax hikes in the consolidation mix. Accordingly, Spain experiences much smaller output losses, despite the similar size of the consolidation package. Nonetheless, given the higher efficiency of labor markets in Portugal, these two countries experience similar unemployment outcomes. Finally, the fiscal consolidations induce welfare losses in all countries. Both the size of the consolidation and the composition of the package determines the magnitude of the losses. In particular, Italy experiences the lowest welfare losses, given the small consolidation, whilst Portugal experiences higher welfare losses than Greece due to the large use of tax hikes.

5.3. Counterfactual Analysis

The austerity packages implemented in recent years have sparked a debate about the need to fight tax evasion and corruption. It is therefore interesting to ask whether reforms

Figure 12: Cross-country Comparison of Fiscal Consolidation Plans

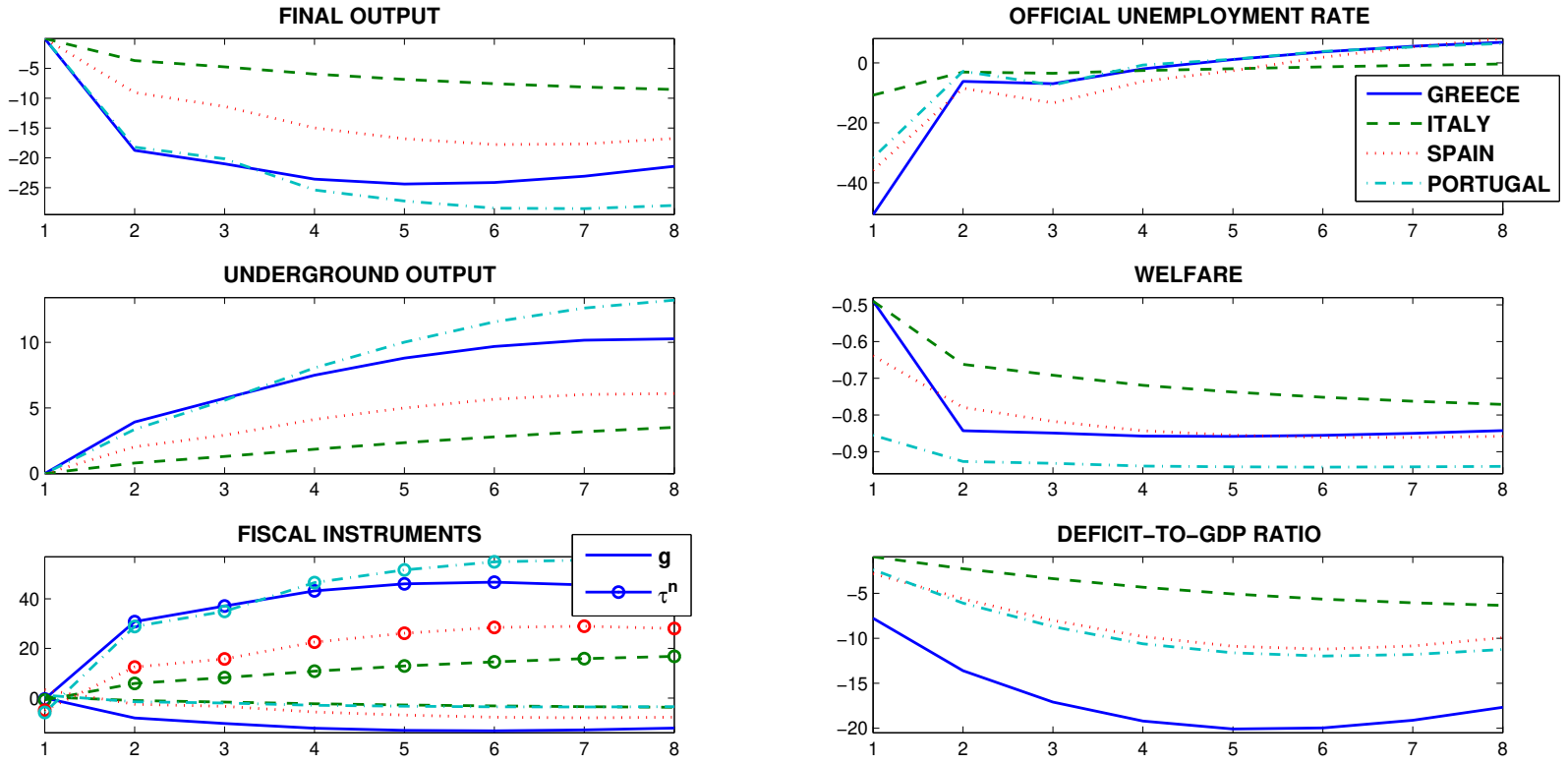
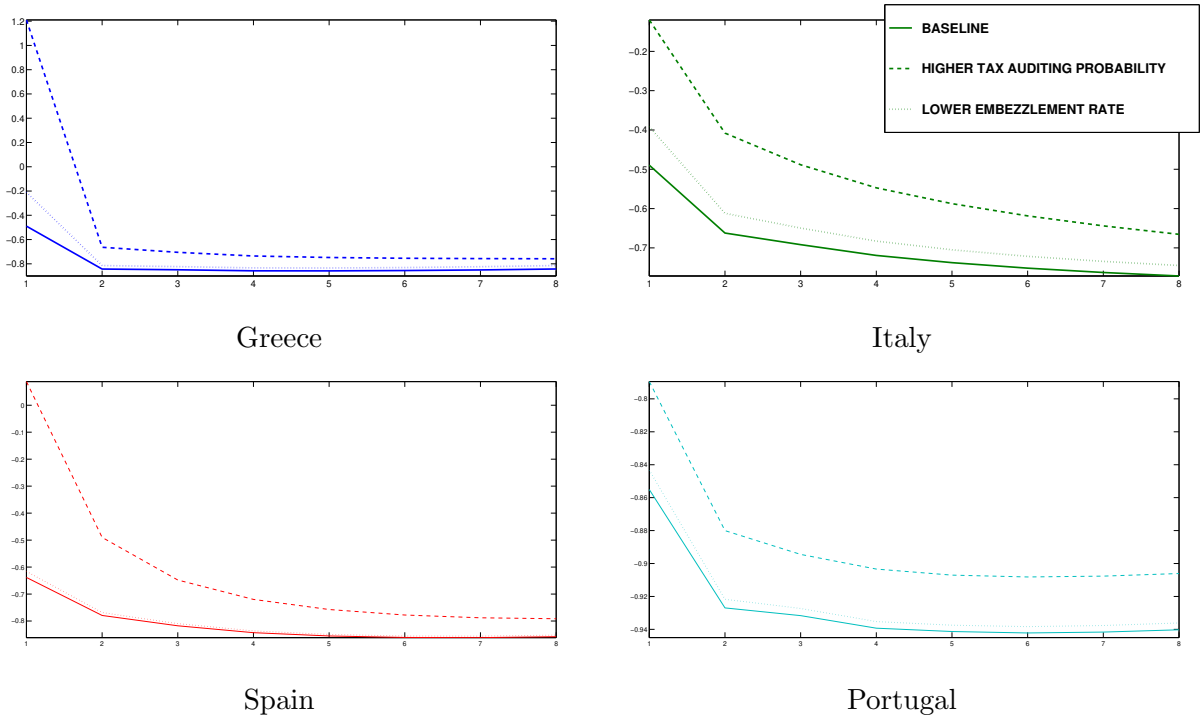


Figure 13: Welfare Effects of Fiscal Consolidation Plans: Counterfactual Analysis



aimed at reducing tax evasion and corruption may change the effects of the current consolidation plans. To investigate the issue, we carry out two counterfactual experiments: we simulate the fiscal consolidation plans first assuming that the tax auditing probability is doubled, and then assuming that the embezzlement rate is reduced by half. Figure 13 reports the welfare responses in the baseline calibration, in the case when the auditing probability is higher, and in the case when the embezzlement rate is lower, for each country.

We find that welfare losses would be mitigated by the reforms. Reducing tax evasion and corruption implies that the deficit reductions are achieved with lower hikes in the tax rate. With the reduction in tax evasion, there is a sizeable reduction in welfare losses in Italy and Portugal, and short run welfare gains for Greece and Spain, which have relatively more expenditure-based consolidation policies. When corruption is reduced, welfare improves substantially in Italy, and in Greece on impact, since these two countries have a higher degree of corruption. In Spain and Portugal, where the level of corruption is lower, the gains from reducing corruption are small relative to fighting tax evasion.

6. Conclusions

Empirical evidence indicates that accounting for tax evasion and corruption is key for understanding the effects of fiscal consolidation. A New Keynesian DSGE model with involuntary unemployment, an informal sector and public corruption, demonstrates that these two features amplify the contractionary effects of labor tax hikes, while they mitigate the effects of expenditure cuts. It also shows that the instrument used to achieve fiscal

consolidation affects the incentives of agents to produce in the informal sector. Consistent with VAR evidence obtained for Italian, spending cuts reduce the size of the informal economy, while tax hikes increase it.

Given the model's ability to reproduce the qualitative features of the data, we analyze how current fiscal consolidation plans in Greece, Italy, Portugal and Spain affect tax evasion, output, unemployment and welfare. The model predicts increasing levels of tax evasion during the consolidation in all countries, and prolonged output and welfare losses. Greece suffers heavy losses due to the severity of the austerity package implemented; Portugal experiences the largest drops in output and welfare because of the heavy use of tax hikes in their consolidation package. Furthermore, the welfare costs of these consolidations would have been smaller if tax evasion and corruption had been reduced. Hence, reforms aimed at fighting public corruption and tax evasion should go hand-in-hand with austerity measures in order to mitigate the welfare costs of fiscal consolidations.

Our exercise is the first attempt to analyze the effects of fiscal consolidation in the presence of tax evasion and corruption. Since the model is stylized, it leaves out important aspects of reality that could affect our conclusions. For example, in our economy there is a representative household, and so 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. Furthermore, our model does not allow for evasion of consumption taxes, which is an important component of tax evasion in southern European countries. Finally, the model treats the degree of public corruption as a parameter, which does not allow it to respond to cyclical factors or to interact with tax evasion. We leave these extensions for future research.

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