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Comments Welcome

Abstract

The recent sovereign debt crisis has renewed the interest in fiscal consolidation policies and the associated output losses they entail. However, countries that adopted such policies are also plagued by persistent unemployment, and debt reduction ought to magnify the problem. This paper extends the standard neoclassical growth model to *(i)* the presence of public debt and *(ii)* the search and matching frictions in the labor market and quantifies the output and employment losses associated with fiscal consolidation episodes. The main results indicate that these losses can be substantially high. For instance, a 25% debt reduction yields a 50% increase in unemployment along the adjustment path. The paper also shows that policymakers need to carefully consider the intertemporal trade–off between short–run losses and long–run gains from the lower debt in their design of fiscal consolidation plans. Its timing, its size, the choice of fiscal instruments used to achieve it, and the role of monetary policy, also matter.

Keywords: Fiscal consolidation, Fiscal rules, Nominal rigidities,.

JEL Codes: E24, E32, E62.

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1 Introduction

The recent sovereign debt crisis has brought back fiscal consolidation in the policy debate. Between 2004 and 2012 the sovereign debt to GDP has increased around 35 percentage points for France, Greece, and United States; and for countries like Portugal and United Kingdom this increase has been around 60 percentage points (see Table (1)). Such high levels of public debt are not without consequences for these economies in particular in terms of growth (see Reinhart and Rogoff (2010)). Governments in most advanced economies have acknowledged the problem and have been making efforts to design and implement fiscal consolidation plans in an attempt to reduce public debt. These plans have been implemented by either a reduction in government expenditure or by increasing the tax rates (either labor, consumption, or capital tax rates).

Table 1: Sovereign debt (% of GDP)

	France	Greece	Iceland	Italy	Portugal	Spain	UK	US
2004	71.4	128.1	50.4	110.6	67.4	41.7	43.5	56.4
2012	103.8	164.3	117.5	131.1	126.2	67.6	103.2	93.8
Change	32.4	36.2	67.1	20.5	58.8	25.9	59.7	37.4

Source: The World Bank, World Development Indicators. Note: Changes in ratio are expressed in percentage point.

There exists a sizable literature that studies that effect of fiscal consolidation on the economy (e.g. Perotti (1996), Alesina et al. (2014), among others). This literature has shown that the effects of fiscal consolidation episodes on output vary a lot with the fiscal instrument used to achieve the fiscal consolidation, the timing, the speed and the size of the consolidation. The identification of the consolidation plan also plays a role. While the output loss and the associated sacrifice ratio have been extensively analyzed, the effect of fiscal consolidation episodes on the employment remains largely unaddressed in the literature. This is however interesting for at least two main reasons. First, most of the countries that undergo a fiscal consolidation are countries that experience high and persistent unemployment rate (*e.g.* Spain, Italy, France,...), it is then critical to evaluate *(i)* the potential employment loss (rise in unemployment) associated with the effort required to achieve the debt reduction and *(ii)* the persistence of this loss. Second, countries in which employment is still at a low level may also need to evaluate the potential output loss for monetary considerations. For instance, the Federal reserve, on September, 17, 2014, the FOMC re-affirmed the existence of an "FOMC's objective of maximum sustainable employment", which, in the context of fiscal consolidation, makes it critical to evaluate employment losses for the conduct of monetary policy. The objective of this paper is therefore to offer a minimal theoretical framework –a dynamic general equilibrium model– that allows to evaluate the employment loss associated with debt reduction plans.

This paper is related to the literature that studies fiscal consolidation within DSGE models. In particular, it relates to the seminal paper by Erceg and Lindé (2012) which investigated to what extent and how fiscal consolidation can harm output in a monetary union. In their setting, given the constraints imposed by monetary union and the focus of the central bank on area wide aggregate, monetary policy cannot accommodate the fiscal consolidation. In this setting, they find that an expenditure-based consolidation depresses output by more than a tax-based consolidation for several years. They also show that the "optimal strategy"—in terms of minimization of sacrifice ratio— is to mix sharp–temporary tax raise with gradual spending costs. The present paper builds upon their analysis, in particular in terms of the design of the fiscal consolidation process. It however fundamentally departs from their analysis in two important ways. First of all, I consider a real closed economy as my benchmark setting. Closing the economy, I can focus the mechanisms at work within the economy that prevail during the adjustment path toward the new level of debt. By considering a real economy, I initially abstract from any interplay between monetary and fiscal policy, thereby isolating the mere fiscal mechanisms. I however also consider, as a sensitivity analysis, a nominal version of the model which enables to retrieve the interplay between the two types of policies. A second important point of departure from their analysis lies in the fact that the labor market of the economy considered in this paper features search and matching frictions. The existence of frictions on the labor market permits to study employment dynamics and to derive a measure of employment loss associated with fiscal consolidation episodes. In that respect, this paper is also related to the paper by Pappa et al. (2014), who also analyzes the effects of fiscal consolidation episodes within a DSGE model featuring labor market frictions. However, their analysis focuses on the role of rent seeking and tax evasion during spending cuts and tax hikes episodes more so than evaluating the role of labor market frictions. Doing so their analysis is relevant for Southern countries in which these phenomena prevail.

The model builds on the textbook neoclassical growth model extended to *(i)* the presence of public debt and *(ii)* the existence of search and matching frictions à la Mortensen and Pissarides (1994) and Shimer and Rogerson (2010) on the labor market. The motivations for these two basic assumptions are grounded in the question addressed in this paper: the evaluation of employment (and output) loss generated by fiscal consolidation. There are several ways of generating (un)employment fluctuations in a general equilibrium framework (gift exchange, shirking, implicit contracts, search...); in this paper, I follow Merz (1995), Andolfatto (1996) Fève and Langot (1996) by integrating this search and matching setup in a general equilibrium model to explain the cyclical behavior in wages and employment fluctuations. Within this framework, the matching of workers and firms is costly, which results in a surplus for existing jobs and a bargaining situation over the wage. The model is otherwise standard.

Following Erceg and Lindé (2012), the government aims at reducing its debt to output ratio.

It is reasonable to assume that policymakers would reduce the debt target gradually to help avoid potentially large adverse consequences on output. The main experiment assumes an initial 100% debt/GDP level which is then gradually reduced to 75%, which, thus, reflects 25% reduction in *desired* debt target –debt to output ratio. Its implementation is reached by adjusting the fiscal revenue to keep both the debt to output and deficit close to its target path. This is captured by a simple fiscal rule that fiscal authority abides by. The fiscal revenue adjustments are administered through the distortionary time varying taxation. In the baseline experiment, only the labor tax rate is allowed to adjust and government spendings are kept constant over time. Given that the model does not consider stochastic shocks, the model is solved under perfect foresight, and all potential non-linearities affecting the adjustment dynamics are preserved. Later, the model is also extended to incorporate nominal rigidities. Specifically, it integrates price stickiness and standard Taylor rule allowing for a potential interaction between fiscal and monetary policies.

The fiscal austerity is accompanied by a recession in an attempt to achieve the debt reduction objective. Thus, both employment and output decrease. At the trough of the recession (4.5 years following the beginning of the adjustment), output is 1.5% below its initial steady state. In the benchmark experiment, the initial unemployment rate is 5.5% and it climbs up to 7.3% after 3.35 years following the commencement of fiscal consolidation. Thus, at its peak the employment loss reaches 1.9 percentage points in deviations from its steady state. The employment losses are persistent and lasting on average 12 years.

The mechanism at work is as follows. A debt reduction requires that tax revenue increase in order to finance the constant flow of government expenditures. This implies that tax revenues have to increase in order to finance the constant flow of government expenditures. The government substitutes debt for tax revenues, therefore creating a negative wealth effect on the agents. As will become clear later, the presence of the negative wealth effect will lead to a decrease in consumption and investment –and therefore capital accumulation– which will affect negatively the tax base. Tax rates have to adjust. Given that both the consumption tax, the capital income tax and lump sum taxes are held constant, the labor tax has to increase to permit the increase in the tax revenues. The tax increases from 25% to about 30% at the peak. As the debt reduction process approaches completion, the effort in debt reduction is compensated by a reduction in debt services. Tax revenues can then be lowered, which translates eventually into a reduction in the labor tax that eventually reaches a lower level of 23.8%.

Higher labor tax rate, then, leads to an increase in the wage. This reflects the fact that the household uses the Nash bargaining process to be compensated for the increase in the tax burden. The increase in the wage reduces the marginal value of employment for the firm, which then cut on their vacancy postings. This therefore increases unemployment, and its

duration. Hence the persistent drop in employment in the economy.

Over the whole adjustment (from period t to ∞), the cumulative employment losses amount to 41.2% and for output it amounts to 53.6% (the discounted cumulative losses are 17%, given the discount factor of household), meaning that the short–run losses outweigh the long run gains. As the beneficial effects of fiscal consolidation kick in, the losses do recede. However, it takes 58 years for the cumulative output losses to cancel out and eventually turn into gains, 45 years for employment. This points to the existence of an intertemporal trade off between the long–run gains of debt reduction on the one hand, and the short–run employment and output losses generated by fiscal consolidation. In a nutshell, the main results reveal that fiscal consolidation episodes are costly in the short to medium run, both in terms of output and in terms of employment. Thus, households have to be patient enough to experience the gains associated to such policies.

To provide a better understanding of consolidation dynamics, the robustness of these findings is then assessed to alternative settings for the consolidation policy. In particular, the sensitivity to the state of the business cycle, the speed and size of the debt reduction, the presence of alternative instruments (government spendings, and other taxes) and the timing of the consolidation are investigated. The robustness analysis shows the losses tend to be higher during recessions due to the opposing demands placed on the labor tax adjustment by *(i)* fiscal consolidation and *(ii)* output stabilization. Faster debt consolidation comes at the cost of a bigger initial adjustment which magnifies the employment loss in the short–run. A slower adjustment allows for smooth debt adjustment that limits the initial employment loss, but in that case it lasts longer and the economy, thus, suffers longer. Moreover, the paper shows that endogenous government spending, the type of tax instrument used to achieve fiscal adjustment, and expected future debt reduction also matter. Finally, the interplay between fiscal and monetary policy is analyzed. The monetary policy is non neutral and it affects the fiscal consolidation process. The central bank by adjusting the nominal interest rate affects the value of debt used by households to transfer wealth from one period to the next. Higher nominal interest rate increases the value of debt, which then reduces its demand by households. This aids the whole debt reduction process and, thus, speeding up the fiscal consolidation in the short–run.

The plan of the paper is as follows. Section 2 presents the benchmark real model. Section 3 details the model calibration. Section 4 investigates the implications of fiscal consolidation in terms of output and employment loss and shades light on the main mechanisms at work in the model. Section 5 conducts a sensitivity analysis of our results to changes in the way the fiscal consolidation is achieved. In particular, I investigate how the choice of the fiscal instruments, the timing, the size of the debt reduction matter. I also study how sensitive are the results to the state of the business cycle. Section 6 extends the model to the presence

of nominal rigidities, thereby allowing to address the interplay between fiscal and monetary policies. In this section the sensitivity analysis for a nominal economy is performed: it studies the nominal aspect for an alternative fiscal instrument –consumption tax–, the degree of price rigidity, and the responsiveness of central bank to output fluctuations and price stabilization. A last section offers concluding remarks.

2 Model

This section presents a standard neoclassical model extended to *(i)* the presence of public debt and *(ii)* the existence of search and matching frictions à la Mortensen and Pissarides (1994) and Shimer and Rogerson (2010) on the labor market. The motivations for these two basic assumptions are grounded in the question addressed in this paper: the evaluation of employment (and output) loss generated by fiscal consolidation. Given that the fiscal consolidation considered in this paper takes the form of a reduction in the sovereign debt to output ratio, the model includes public debt. Given that we are interested on the effects on (un)employment, the model shall feature a motive for the existence unemployment. There are several ways of generating (un)employment fluctuations in a general equilibrium framework (gift exchange, shirking, implicit contracts, search...); In this paper, I follow Merz (1995), Andolfatto (1996) Fève and Langot (1996) who showed, in various frameworks, how search and matching frictions provide with a fairly good representation of unemployment fluctuations in the business cycle. The model is otherwise standard.

2.1 Labor Market Frictions

Following Mortensen and Pissarides (1994), we assume that trade on the labor market is costly and subject to coordination failures that are captured by the existence of search and matching frictions. There exists a continuum of mass 1 of individuals who, in each and every period, can be either employed (a fraction n_t) or unemployed ($u_t = 1 - n_t$). All individuals are assumed to possess the same skills and abilities, implying that their status on the labor market is not determined by their relative productivity, but by the outcome of a random search process. Given this ex-post heterogeneity across individuals, and given that these individuals will accumulate assets as a way to transfer wealth across periods, the wealth distribution in the economy is potentially a state variable. In order to avoid dealing with a distributions and face a typical Krusell and Smith's (1998) problem, we assume that all individuals are members of a single representative household and meet at the end of the period and pool resources –therefore implementing a perfect risk sharing environment. This way the only relevant state variable pertaining to wealth accumulation will be the level of assets, and not their distribution.

The existence of search and matching frictions on the labor market are captured by the existence of a matching function that relates the number of successful matches, M_t, to the number of unemployed, u_t, and the number of vacancies, v_t, posted by firms

$$M_t = m(u_t, v_t)$$

which is strictly increasing, concave in both u_t and v_t and exhibits constant returns to scale.[1] Following Hagedorn and Manovskii (2008a), we use the following matching function

$$m(u_t, v_t) = \frac{v_t(1-n_t)}{(v_t^{\xi} + (1-n_t)^{\xi})^{1/\xi}} \tag{1}$$

where the matching function parameter is $\xi \in (0,1)$. The evolution of aggregate employment can then be described as follows. At the beginning of period t, n_t individuals are employed. During period t, M_t new matches are formed and add to the existing level of employment. Finally a constant fraction $\psi \in (0,1)$ of individuals separate from their employer. Hence, the level of employment available as of $t+1$ is given by

$$n_{t+1} = M_t + (1-\psi)n_t \tag{2}$$

Note that, because the matching function depends on aggregate quantities that are out of control of the individuals, this equation captures all externalities at work in the search and matching process.

Consider the case of a individual looking for a job. Using the law of large numbers, this individual has a probability

$$s_t = \frac{M_t}{u_t} = \frac{m(u_t, v_t)}{u_t}$$

of finding a job. This individual faces two types of externalities. First it benefits from a positive trade externality created by firms: by posting more vacancies on the market, firms increase the probability that an individual will find a job ($\partial s_t/\partial v_t > 0$). Second, it suffers a congestion externality: when more individuals are searching, the probability of finding a job decreases ($\partial s_t/\partial u_t < 0$). Given the existence of constant returns to scale, the probability of finding a job rewrites

$$s_t = s(\theta_t)$$

where $\theta = v_t/u_t$ is a measure of labor market tightness. It should also be clear from the previous discussion that $s'(\cdot) > 0$.

Likewise, consider a firm posting v_t vacancies. Using the law of large numbers, the probability of filling a vacancy is given by

$$q_t = \frac{M_t}{v_t} = \frac{m(u_t, v_t)}{v_t}$$

[1] This assumption of matching function exhibiting constant returns to scale is consistent with the empirical findings reported by Blanchard and Diamond (1989) for US data and by Pissarides (1986) for UK data.

Like the case of an individual, each firm faces two types of externalities. First it benefits from a positive trade externality created by unemployed workers: The larger the pool of workers the firm faces, the larger the probability it will fill a vacancy ($\partial q_t/\partial u_t > 0$). Second, it also faces a congestion externality created by the other firms: may match with, by posting more vacancies on the market, firms increase the probability that an individual will find a job ($\partial s_t/\partial v_t > 0$). Second, it suffers from a congestion externality: the larger the number of vacancies the smaller the probability the firm will fill its vacancy ($\partial q_t/\partial v_t < 0$). Note that this probability can also be expressed in terms of labor market tightness as $q_t = q(\theta_t)$ where $q'(\cdot) < 0$. In that context the employment level of firm j, $n_t(j)$, evolves as

$$n_{t+1}(j) = q_t v_t(j) + (1-\psi)n_t(j) \tag{3}$$

The fact that q_t is beyond the control of the firm captures the existence of externalities.

2.2 Households

There exists a representative household who is composed of a continuum of individuals. At the beginning of period t, the members of the household visit the labor market. As explained in the previous section, a fraction n_t of these members are employed. These individuals supply inelastically 1 unit of labor. The complementary fraction is unemployed and performing search activities. At the end of the period, all these members go back to the household and pool their resources, therefore enabling perfect risk sharing. As explained in the previous section, this assumption simplifies our analysis as it allows us to ignore any distributional issue.[2] The household has preferences over consumption and leisure described by the following intertemporal utility function[3]

$$\sum_{t=0}^{\infty} \beta^t \left(\log c_t - \vartheta \frac{n_t^{1+\nu}}{1+\nu} \right) \tag{4}$$

where $\nu > 0$ and $\vartheta > 0$. c_t denotes the household's consumption and n_t is the fraction of employed household members, which is determined by the matching process and is beyond the control of the household.

The household enters a period with some initial financial wealth b_{t-1} that yields a gross real return r_{t-1}, earns a wage w_t per unit of labor, pays a proportional labor tax $\tau_t^w \in (0,1)$, such that the total after tax labor income is given by $(1-\tau_t^w)w_t n_t$. The household leases capital

[2] An alternative way of dealing with this issue would be to create a perfect unemployment insurance market. At the beginning of the period, each household buys an insurance contract that insures her against labor market risk. Assuming that insurance companies are risk neutral, this insurance mechanism is perfect in the sense that be she employed or not the household would enjoy the same marginal utility of consumption. Therefore, all household would accumulate the same and the distribution of asset would be irrelevant for the solution.

[3] Implicit in this formulation of the utility is that the household's disutility of labor is determined by the disutility of the aggregate labor supplied by her members rather that the aggregation of the disutilities. This assumption is consistent with the fact that individuals pool resources within the household.

at the after–tax rental rate $(1-\tau_t^k)z_t$, where $\tau_t^k \in (0,1)$ denotes the capital income tax. Each member also receives a share of the profits of all firms, Π_t, and a lump–sum government transfer, T_t. This income is then used to consume, c_t (net of consumption of tax $\tau_t^c \in (0,1)$), invest, i_t, and purchase assets, b_t, as a way to transfer wealth towards next period. She therefore faces the following budget constraint

$$(1+\tau_t^c)c_t + i_t + b_t = r_{t-1}b_{t-1} + (1-\tau_t^w)w_t n_t + (1-\tau_t^k)z_t k_t + \Pi_t + T_t \tag{5}$$

Investment, i_t leads to the formation of the capital stock, k_t, whose law of motion is described by

$$k_{t+1} = \left(1 - \phi\left(\frac{i_t}{i_{t-1}}\right)\right) i_t + (1-\delta)k_t \tag{6}$$

where $\delta \in (0,1)$ denotes the rate of depreciation of capital. Implicit in this formulation is that capital accumulation is subject to convex investment adjustment costs, $\phi(\cdot)$, à la Christiano et al. (2005). These costs satisfy $\phi(1) = \phi'(1) = 0$, such that these costs are inoperative in the steady state, and $\varphi \equiv \phi''(1) > 0$. [4]

The household determines her consumption, investment and accumulation plans by maximizing her utility subject to her budget constraint (5), transition equation for capital (6), and given the perceived law of motion of employment (2) (which remains beyond her control at this stage of the problem). In doing so, a household takes as given prices, taxes and transfers, and aggregate quantities.

The household's optimal behavior is then characterized by the set of Euler conditions

$$\frac{1}{c_t(1+\tau_t^c)} = \beta \frac{r_t}{c_{t+1}(1+\tau_{t+1}^c)} \tag{7}$$

$$q_t^i = \beta \frac{c_t(1+\tau_t^c)}{c_{t+1}(1+\tau_{t+1}^c)}(z_{t+1}(1-\tau_{t+1}^k) + q_{t+1}^i(1-\delta)) \tag{8}$$

$$1 = q_t^i\left(1 - \phi\left(\frac{i_t}{i_{t-1}}\right) - \left(\frac{i_t}{i_{t-1}}\right)\phi'\left(\frac{i_t}{i_{t-1}}\right)\right) + \beta\frac{c_t}{c_{t+1}} q_{t+1}^i \phi'\left(\frac{i_{t+1}}{i_t}\right)\left(\frac{i_{t+1}}{i_t}\right)^2 \tag{9}$$

where q_t^i is the marginal Tobin's Q associated with the capital decision. Equation (7) is the standard consumption saving intertemporal arbitrage condition, which is just distorted by the presence of the consumption tax. Equation (8) describes the standard consumption investment tradeoff faced by the household. As in the case of the consumption savings decision, this arbitrage condition is also affected by the tax. The last equation describes the evolution of the marginal Tobin's Q, q_t^i, which differs from unity due to the presence of investment adjustment costs. The presence of potentially time varying taxes in the optimal decisions of the household highlights how fiscal consolidation will affect the economy.[5] Fiscal

[4] Note that for the quantitative analysis, the costs will take the form

$$\phi(x) = \frac{\varphi}{2}(x-1)^2$$

where $\varphi \in \mathbb{R}_+$ control for the size of the costs.

[5] As will become clear later, the wage faced by the household will also be affected by variations in a tax.

consolidation, in the form of a reduction of the debt to output ratio, requires the government to find alternative ways of financing its public expenditures. This will then require some adjustment in the tax rates, which will in turn affect the optimal consumption, investment and savings decisions of the household.

2.3 Firms

There exists a continuum of firms, indexed by $j \in (0,1)$, which produce a homogenous good that can be either consumed or invested by means of capital and labor. The technology exhibits constant returns to scale and can be described by the Cobb–Douglas production function

$$y_t(j) = A_t k_t^{\alpha}(j) n_t(j)^{1-\alpha} \tag{10}$$

where $\alpha \in (0,1)$. A_t denotes the total factor productivity of the firm, which sequence, $\{A_t\}_{t=0}^{\infty}$, is exogenously given. Note that given that firms all face the same technology and that there does not exist any idiosyncratic uncertainty, firms will be identical ex-post. Contrary to the standard neoclassical framework, the existence of labor market frictions implies that firms that enter in period t with employment $n_t(i)$ have to post vacancies $v_t(j)$ should it want to increase its level of employment to be used in the next period. However posting a vacancy involves paying a constant unit cost $a > 0$. The firm has a probability q_t (beyond the control of the firm) of filling this vacancy, and faces a probability ψ that a employee separates. The law of motion of employment in firm i is therefore described by Equation 3. The firm decides its production and vacancy posting plans by maximizing its intertemporal discounted profit subject to the law of motion of employment

$$\max \sum_{t=0}^{\infty} \Psi_{0,t} \left(y_t(j) - z_t k_t(j) - w_t n_t(j) - a v_t(j) \right) \tag{11}$$

subject to Equation (3). $\Psi_{0,t}$ denotes the discount factor of the firm between periods 0 and t, given that, in the model, the interests of the manager of the firm are aligned with those of the shareholder –the household– the proper discount factor is given by $\Psi_{0,t} \propto \beta^t (1+\tau_t^c) \frac{\partial U(c_t, n_t)}{\partial c_t}$.

The optimal production and vacancy posting plans are characterize by the following optimality conditions

$$z_t = \alpha \frac{y_t(j)}{k_t(j)} \tag{12}$$

$$\frac{a}{q_t} = \beta \frac{c_t(1+\tau_t^c)}{c_{t+1}(1+\tau_{t+1}^c)} \left((1-\alpha) \frac{y_{t+1}(j)}{n_{t+1}(j)} - w_{t+1} + (1-\psi) \frac{a}{q_{t+1}} \right) \tag{13}$$

The first condition is the standard demand for capital. The second condition determines the optimal vacancy posting behavior–and hence the optimal employment level. Firms j chooses the number of vacancies such that the marginal advertising costs equalizes the expected

discounted future payoff. The expected payoff is conditional on the marginal vacancy leading to a match with probability q_t. The left hand side of (13) captures effective marginal hiring costs, which a firm trades off against the surplus over wage payments it can appropriate and against the benefit of not having to hire someone next period. Note that, in a symmetric equilibrium, it must be the case that $x_t(j) = x_t(i) = x_t$, with $x \in \{k, n, v\}$.

2.4 Wage determination

The existence of labor frictions implies that there does not exist an auctioneer that would set the wages competitively. A mechanism to determine the wage must be specified. In this paper, I follow the literature (see e.g. Mortensen and Pissarides (1994), Merz (1995), Andolfatto (1996) among others) and assume that wages are determined as the outcome of a bilateral bargaining process between workers and firms. Since the workforce is homogeneous without any differences in skill, for instance, each worker is marginal when bargaining with the firm. Both parties choose wage rates to maximize the joint surplus generated from their employment relationship: surpluses accruing to the matched parties are then split according to a Nash bargaining mechanism.

The surplus of a firm, Ω_t^F, is given by

$$\Omega_t^F = (1-\alpha)\frac{y_t}{n_t} - w_t + (1-\psi)\frac{a}{q_t}$$

and corresponds to the marginal value –expressed in terms of goods– of a match, which corresponds to the marginal product of employment net of the wage paid to the new hired, to which adds the marginal benefit of not having to hire a new worker in the next period.

The before tax surplus of the household, Ω_t^H, is given by the marginal utility value of a match, expressed in terms of goods by dividing by the marginal utility of consumption. The marginal utility value of a match can be found by comparing the options available to the worker. When the worker is employed, she contributes to the household value by earning a wage w_t, but suffers a disutility from working and forfeits an outside option payment X_t. This is weighted against next period's expected utility. The marginal utility value of a match is thus given by

$$\Omega_t^H = w_t - \frac{X_t}{1-\tau_t^w} - \frac{\vartheta c_t n_t^\nu}{1-\tau_t^w} + \beta\frac{(1+\tau_{t+1}^c)c_{t+1}}{(1+\tau_t^c)c_t}\frac{1-\tau_{t+1}^w}{1-\tau_t^w}\Omega_{t+1}^H(1-\psi-q_t\theta_t)$$

where I made use of the expression for the marginal utility of consumption, and the derivative of next period employment with respect to current employment.

The joint surplus, S_t, is then given by

$$S_t \equiv \Omega_t^{H\eta}\Omega_t^{F1-\eta} \tag{14}$$

where $\eta \in [0,1]$ represents the relative bargaining power of workers. The wage is then set so as to maximize the joint surplus, which leads to the surplus sharing

$$(1-\eta)\Omega_t^H = \eta\Omega_t^F$$

Substituting of the individual surpluses values results, after tedious algebra, in the following wage setting:

$$w_t = \frac{\eta\left((1-\alpha)\frac{y_t}{n_t} + a\theta_t + (1-\psi)\frac{a}{q_t}\right) + (1-\eta)\left((1-\tau_t^w)X_t + \vartheta n_t^\nu c_t(1+\tau_t^c)\right)}{1-\tau_t^w(1-\eta)} \tag{15}$$

As is typical in models with surplus sharing, the wage is a weighted average of the payments accruing to workers and firms, with each party appropriating a fraction of the other's surplus. The bargained wage also includes mutual compensation for costs incurred, namely hiring costs and the utility cost of working. The bargaining weight determines how close the wage is to either the marginal product or to the outside option of the worker, the latter of which has two components, unemployment benefits and the consumption utility of leisure. Note that the wage setting rule is fundamentally affected by the labor tax rate. It can be readily verified that as long as the worker's outside option X_t is smaller than the wage –which would be the case is the outside option is a fraction of the wage, like unemployment benefits– this function is increasing in the tax. It is then clear that should fiscal consolidation lead to an increase in the labor tax, as a way to substitute debt for tax revenues when financing public expenditures, this would put upward pressure on the bargained wage rate and will, in turn, reduce the labor demand and increase equilibrium unemployment. Likewise the consumption tax ought to have a similar effect, should it be used to financed public expenditures.

2.5 Fiscal policy and Debt adjustment

Fiscal authorities collect taxes (f_t) and issue public bonds (b_t) as a way to finance an exogenously given sequence of government spending $\{g_t\}_{t=0}^{\infty}$. Accordingly, the government budget constraint is given by

$$b_t = r_{t-1}b_{t-1} + g_t - f_t \tag{16}$$

Tax revenues, f_t, comprise consumption tax revenues, $\tau_t^c c_t$, labor tax revenues, $\tau_t^w w_t n_t$, capital tax revenues, $\tau_t^k z_t k_t$ and the lump–sum tax, T_t, such that

$$f_t = \tau_t^c c_t + \tau_t^w w_t n_t + \tau_t^k z_t k_t + T_t \tag{17}$$

Given this setting, I am now in a position to describe the fiscal consolidation process. Policymakers are assumed to use the proceeds from taxation to control the path of public debt. More precisely, let us denote $b_t^\star$ the target debt to output ratio, then the fiscal authorities set the tax revenues according to the simple rule

$$\log(f_t) = \log(\overline{f}) + \gamma_1\left(\log\left(\frac{b_{t-1}}{y_t}\right) - \log(b_t^\star)\right) \tag{18}$$

where $\gamma_1 > 0$. This rule stipulates that any positive (negative) deviation of the debt/output ratio from its targeted value leads to an increase (decrease) in tax revenues that the government should collect ($\gamma_1 > 0$). That way the government substitute debt for tax revenues (and vice versa). Let us then consider the case where, initially, public debt is on target ($b_{t-1}/y_t = b_t^\star$), and assume that the targeted value of the debt/output ratio, $b_t^\star$, is shifted downward. As aforementioned, given that debt is predetermined, the debt/output gap increases leading to an upward adjustment of tax revenues. Then, given that the government spending are given, Equation 16 implies that the debt b_t adjust downward. This adjustment requires one or several tax rates to be adjusted. Which of the tax should be adjusted is *a priori* indeterminate. In this paper, I adopt a purely positive approach to the problem. Following Haavelmo's rule, only one instrument will be used to achieve this increase in tax revenues. In the sequel, as a benchmark experiment, the labor tax will be used to adjust tax revenues, holding all other tax rates (and the lump sum tax) constant.[6] Adjustment in the consumption tax will also be considered in a separate experiment as a sensitivity analysis exercise.

The adjustment in the debt/output ratio remains to be described. Following Erceg and Lindé (2012), policymakers are assumed to reduce public debt gradually to avoid large adverse consequences for output. This is implemented by assuming that the targeted debt/output ratio, $b_t^\star$, follows the exogenous process

$$b_t^\star = \rho_b b_{t-1}^\star + (1-\rho_b)\left(\log\left(\frac{\overline{b}}{\overline{y}}\right) + \varepsilon_t^b\right) \tag{19}$$

where $\overline{b}/\overline{y}$ denotes the initial steady state value of the debt/output ratio and $\{\varepsilon_t^b\}_{t=0}^\infty$ is an exogenous sequence that will control for the fiscal consolidation. This process is akin to a simple AR(1) process where the persistence is controlled by parameter ρ_b. For instance, should ε_t^b be a purely transient shock (*e.g.* $\{\varepsilon_t^b\}_{t=0}^\infty = \{\varepsilon^b, 0, \ldots\}$) with $\varepsilon^b < 0$, $b_t^\star$ would drop on impact and converge back to $\log(\overline{b}/\overline{y})$ monotonically. Fiscal consolidation in this setting will then be implemented by considering the sequence $\{\varepsilon_t^b\}_{t=0}^\infty = \{\varepsilon^b, \varepsilon^b, \ldots\}$, with $\varepsilon^b < 0$, implying that $b_t^\star$ will converge smoothly to $\log(\overline{b}/\overline{y}) + \varepsilon^b < \log(\overline{b}/\overline{y})$. The coefficient ρ_b controls the speed of debt target adjustment such that high values of ρ_b lead to slower adjustments.

2.6 General Equilibrium

A competitive general equilibrium is a sequence of prices $\mathscr{P}_t \equiv \{r_{t+i}, z_{t+i}\}_{i=0}^\infty$, a sequence of wages $\mathscr{W}_t \equiv \{w_{t+i}\}_{i=0}^\infty$, a sequence of taxes $\mathscr{T}_t \equiv \{\tau_{t+i}^w, \tau_{t+i}^c, \tau_{t+i}^k, T_{t+i}\}_{i=0}^\infty$, a sequence of policy

[6] Note that things are a bit more subtle. In a general equilibrium, tax revenues will adjust for two reasons: *(i)* adjustment in the tax instrument (the margin) and *(ii)* adjustment in the taxed revenue (general equilibrium effect).

instruments $\mathscr{G}_t \equiv \{g_{t+i}, f_{t+i}, b^{\star}_{t+i}\}_{i=0}^{\infty}$ and a sequence of quantities $\mathscr{Q}_t \equiv \{c_{t+i}, y_{t+i}, k_{t+i}, n_{t+i}, v_{t+i}, b_{t+i}\}_{i=0}^{\infty}$ such that

1. for a given sequence of prices, $\mathscr{P}_t$, a sequence of wages, $\mathscr{W}_t$, a sequence of taxes, $\mathscr{T}_t$ and a sequence of policy instruments, $\mathscr{G}_t$, the sequence of quantities, $\mathscr{Q}_t$, solves the optimization problems of the agents,

2. for a given sequence of prices, $\mathscr{P}_t$, a sequence of taxes, $\mathscr{T}_t$, a sequence of policy instruments, $\mathscr{G}_t$, and a sequence of quantities, $\mathscr{Q}_t$, the sequence of wages, $\mathscr{W}_t$, is set according to the wage bargaining process,

3. for a sequence of quantities, $\mathscr{Q}_t$, a sequence of wages, $\mathscr{W}_t$, a sequence of taxes, $\mathscr{T}_t$ and a sequence of policy instruments, $\mathscr{G}_t$, the sequence of prices, $\mathscr{P}_t$, clears the capital and good markets,

4. for a sequence of quantities, $\mathscr{Q}_t$, a sequence of wages, $\mathscr{W}_t$, a sequence of quantities, $\mathscr{Q}_t$ and a sequence of policy instruments, $\mathscr{G}_t$, the sequence of taxes, $\mathscr{T}_t$, implies that the government budget constraint is satisfied.

3 Model calibration

The model does not admit an analytical solution and is therefore solved numerically, using Dynare. This requires the structural parameters to be assigned values. The model is calibrated for the post-WWII US economy at the quarterly frequency. Table 2 reports the parameter values.

The parameters pertaining to preferences and technology are standard and borrowed from the Real Business Cycle literature. The psychological discount factor, β, is set such that the rental rate of capital is about 4% ($\beta = 0.99$). The capital elasticity in the production function, α is set to match the capital share of income in the National Income and Product Accounts ($\alpha = 0.33$).[7]. The capital depreciation rate, δm is set such that the annual depreciation rate is equal 10 percent ($\delta = 0.025$). The investment adjustment cost parameter, φ, is set to be 2, which lies in the range of values considered in the DSGE literature.

[7]Note that since the wage rate in this model economy does not correspond to the marginal product of labor, $1 - \alpha$ is not equal to the labor share of total income. $(1 - \alpha)$ equals the sum of the labor share of total income and the return to investing in job search. Contrary to the standard neoclassical growth model in which labor's share of income is constant, the model with labor frictions in the labor market exhibits a labor share that varies over the business cycle, thereby mirroring this variable's behavior in the data.

Table 2: Model parametrization

Parameter	Value	Interpretation	Target
β	0.990	discount rate	4% annual interest rate
α	0.330	capital input elasticity of output	33% capital share of income
δ	0.025	depreciation rate of capital	10% annual depreciation rate
G/Y	0.201	steady state government spending in output ratio	Average government spending to GDP ratio
τ^w	0.250	steady state labor income tax rate	Estimate of average effective labor income tax rate by Mendoza et al. (1994)
τ^c	0.060	steady state consumption tax rate	Estimate of average effective consumption tax rate by Mendoza et al. (1994)
τ^k	0.430	steady state capital income tax rate	Estimate of average effective capital income tax rate by Mendoza et al. (1994)
s_t	0.8094	probability of finding a job	
q_t	0.9469	probability of filling a vacancy	
ψ	0.0648	separation rate	
θ		labor market tightness	
v		vacancy	
a	0.07	vacancy posting cost	
η	0.05	worker's bargaining power	
X		outside option	
n	0.945	steady state employment	
ν	2	labor disutility parameter	–

Annual debt is assumed to amount to 100% of GDP, which, on a quarterly basis, implies a debt to output ratio of 4. This amount of debt is raised to financed government spendings which represent 20% of GDP –the average government share over the post-WWII period in the US. The steady state level of taxes is borrowed from Mendoza et al. (1994), who sets τ^w, τ^c and τ^k, equal to the average effective US tax rates for labor, consumption and capital income: 0.25, 0.06 and 0.43 respectively. The parameters pertaining to the rules (18) and (19) will be given when we describe the baseline experiment.

The parameters pertaining to the labor market are set following the approach outlined in Shimer and Rogerson (2010) and Hagedorn and Manovskii (2008b).[8] Their approach amounts to set the parameters of the labor market to match, as closely as possible, the volatility of market tightness in the data. This can be achieved as long as the model must also be able to replicate the data along the other dimensions, namely the volatility of vacancies, the volatility of unemployment, and the correlation between vacancies and unemployment. The data indicate that the probability of finding a job (s_t) within the quarter is 0.8094, and that to fill a vacancy, q_t, is 0.9469. They also give the separation rate to be $\psi = 0.0648$. Using the probability of finding a job, the separation rate and the law of motion of aggregate

[8]Note that Hagedorn and Manovskii (2008b) calibrated the model on a weekly basis, their approach is modified to accommodate the quarterly frequency.

employment in the steady state, the level of employment is

$$n = \frac{s(\theta)}{\psi + s(\theta)} = 0.945$$

implying an unemployment rate of 5.5%.

Given a value for the steady state employment, the other labor market variables are solved using the remaining equations and the remaining parameters can be set. The elasticity in the disutility of labor, ν, is set to 2, which lies well within the range of values used in the literature.[9] Following Hagedorn and Manovskii (2008b) the total cost of posting a vacancy, in terms of average quarterly labor productivity, is set to 4.67 percent. Given the labor's share of income averages to 0.66 in US data, this implies a quarterly vacancy posting cost, a, of 0.07. Also, following Hagedorn and Manovskii (2008b), the worker's bargaining power, η is set at 0.05. Using the wage setting equation, and the combination of low vacancy posting costs, together with a bargaining power favoring firms, leads to a disutility parameter, ϑ of 0.349. Finally, the outside option is calibrated as X_t = labor replacement rate $\times\, w_t(1-\tau_t^w)$.[10]

4 Results

This section discusses our baseline experiment and presents our main results.

4.1 Transition Analysis

In this paper, fiscal consolidation takes the form of a permanent 25% decrease in the debt to output ratio ($\varepsilon^b = -0.25$). However, this reduction in the size of debt is achieved smoothly. More precisely, the persistence parameter of the debt target process (19), ρ_b, is set such that half of this adjustment is performed within a business cycle –*e.g.* 6 years[11] ($\rho_b = 0.875$).[12] In the fiscal rule the parameter governing the reaction of fiscal receipts to debt adjustments, γ_1 is set to 0.8, such that tax revenues are reactive to the initial jump in the target. Given the importance of this parameter, variations in its value will be considered in Section 5. Given that the model does not consider stochastic shocks, the model is solved under perfect foresight using the relaxation method proposed by Boucekkine (1995), as implemented in Dynare. This approach allows to preserve all potential non-linearities affecting the adjustment dynamics. Finally, on the baseline experiment, only the labor tax rate is allowed to adjust and government spendings are kept constant over time.

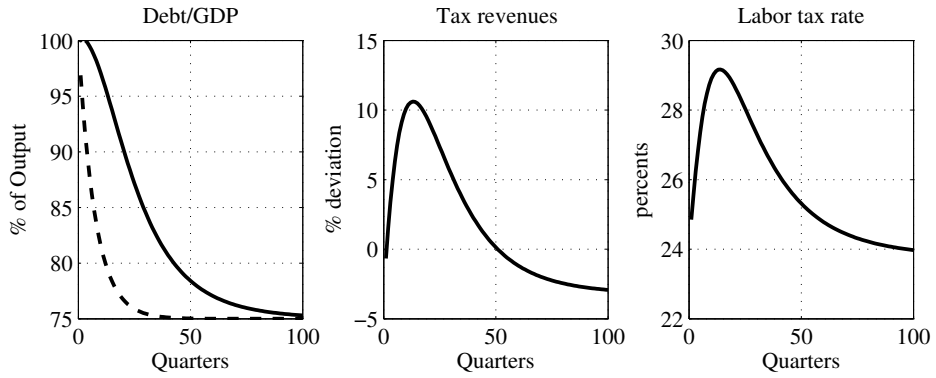
[9] Although this parameter does not correspond to the inverse Frisch elasticity, it is reminiscent of it. Estimates for this elasticity range from 0.333 in representative macroeconomic studies to 100 for microeconomic studies.

[10] The statistics on labor market replacement rate comes from Bureau of Labor Statistics and is set at 0.6.

[11] This value corresponds to the average duration of a complete business cycle from trough to trough (or from peak to peak) for the post–war US economy, as reported by the NBER.

[12] In Section 5, other levels and speed of debt reduction will also be considered as a way to provide with a better understanding of the consolidation dynamics.

Figure 1: Fiscal Consolidation

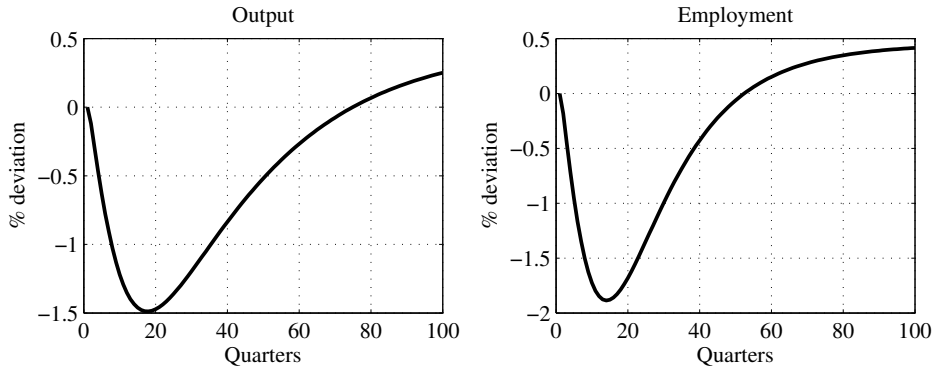


The left panel of Figure 1 reports *(i)* the evolution of the debt target ratio, $b_t^\star$, (dashed line) alongside *(ii)* the evolution of the actual debt to GDP ratio in the economy (plain line). For the sake of interpretation, the debt/output ratio is expressed in annualized terms. Initially, the actual debt/output ratio is on target, 100% of GDP. As of the next period, the target debt ratio starts adjusting toward its new long run level, 75%. Note the target debt ratio adjusts much quicker to its new long–run value than the actual debt ratio. For instance, half of the adjustment of the target has to be done within 6 quarters for the actual debt ratio to achieve half of its adjustment in 6 years. This can be interpreted as the willingness of the policymaker to anchor the expectations of the agents to the new target in a relatively short time. This lag in the actual debt adjustment implies that the gap in the dynamics of actual and target debt ratio is positive, immediately after the implementation of the policy, and remains positive throughout the transition. This implies that tax revenues have to increase in order to finance the constant flow of government expenditures (see middle panel of Figure 1). The government substitutes debt for tax revenues, therefore creating a negative wealth effect on the agents. As will become clear later, the presence of the negative wealth effect will lead to a decrease in consumption and investment –and therefore capital accumulation– which will affect negatively the tax base. Tax rates have to adjust. Given that both the consumption tax, the capital income tax and lump sum taxes are held constant, the labor tax has to increase to permit the increase in the tax revenues (see right panel of Figure 1). The tax increases from 25% to about 30% at the peak. As the debt reduction process approaches completion, the effort in debt reduction in compensated by a reduction in debt services Tax revenues can then be lowered, which translates eventually into a reduction in the labor tax that eventually reaches a lower level of 23.8%.

Figure 2 illustrates the effects of fiscal consolidation on output and employment, and reports the percentage deviations of both variables from their initial steady state level. Output and employment are left unaffected on impact as both employment and capital are predetermined

in the model. As of the second period, both employment and output decrease. The government therefore creates a recession in order to achieve its debt reduction objective. At the trough of the recession (4.5 years following the beginning of the adjustment), output is 1.5% below its initial steady state. The employment reaches its trough of 1.9 percentage points in deviations from its steady state after 3.35 years. The negative effects on employment and output are persistent. Employment reaches back its steady state after 12.9 years, and

Figure 2: Evolution of Output and Employment following 25% debt reduction



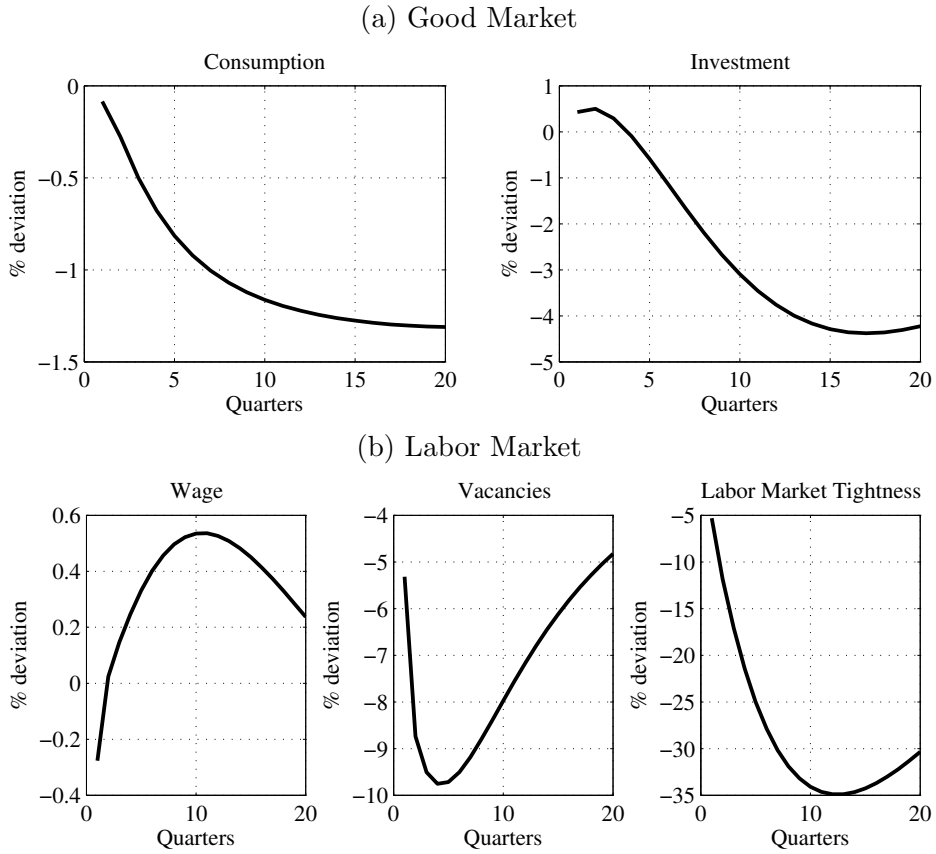
only after this date the economy starts to benefit from its fiscal consolidation effort, and see both its employment level and output be above the initial steady state. There clearly is an intertemporal tradeoff the policymaker has to consider. Reduction of debt requires to plunge the economy in a recession for a long period, before output increases and unemployment recedes in the longer run.

As aforementioned, the fiscal consolidation process entails an increase in the labor tax rate. The associated increase in the tax burden creates a negative wealth effect that, everything else equal, reduces both consumption and investment (see Figure 3). This is the standard effect, also present in the standard neoclassical model, that reduces the demand for goods and triggers a recession. The increase in the labor tax has another effect on the economy that is fundamentally related to the presence of labor frictions. From the wage setting equation (15), we have

$$\frac{\partial w_t}{\partial \tau_t^w} = \frac{(1-\eta)(w_t - X_t)}{1-\tau_t^w(1-\eta)} > 0 \Longleftrightarrow w_t > X_t$$

Given that the outside option corresponds to a fraction of the wage in the model, an increase in the labor tax leads to an increase in the wage. This reflects the fact that the household uses the Nash bargaining process to be compensated for the increase in the tax burden. The increase in the wage reduces the marginal value of employment for the firm, which then cut on their vacancy postings (see middle of Panel (b) in Figure 3). Given that unemployment is predetermined, the labor market conditions improve (θ_t decreases, see left of Panel (b) in Figure 3). On the one hand this improves the situation of firms that then face a larger prob-

Figure 3: Macroeconomic responses (Benchmark Experiment)



ability of filling a vacancy, q_t (positive trade externality). On the other hand, the situation of the household deteriorates as she now faces a lower probability of finding a job, s_t (congestion effect). This therefore increases unemployment, and its duration. Hence the persistent drop in employment in the economy.

As already outlined in Section 3, the above described transitional dynamics are obtained starting from a 5.5% unemployment rate. If, instead, higher unemployment rates are considered —as observed in southern European countries— the results are, if at all, barely affected. In other words, these results are not affected by the initial steady state level of unemployment, and our analysis remains valid whether the economy is initially started from a high or low unemployment rate.

4.2 Cumulative losses

This section offers a quantitative representation of the adjustment dynamics described in the previous section. More precisely, cumulative losses of output an employment are computed. The cumulative loss, $\ell(y,k)$, of output (respectively employment, $\ell(n,k)$) at horizon k is given by

$$\ell(y,k) = -100 \times \sum_{j=0}^{k} \left(\frac{y_{t+j} - y_t}{y_t} \right)$$

such that $\ell(y,k)$ is a positive number –expressed in percentages– that corresponds to the cumulative losses the economy experience, in terms of output (resp. employment), between period t and period $t+k$. In the case of output, the discounted loss, $\ell(y;\beta)$ is also computed

$$\ell(y;\beta) = -100 \times \sum_{j=0}^{\infty} \beta^j \left(\frac{y_{t+j} - y_t}{y_t} \right)$$

where $\beta \in (0,1)$ is the psychological discount factor of the household.

Table (3) report the cumulative output and employment losses associated to the fiscal consolidation process at various horizons. Inspection of Table (3) reveals that fiscal consolidation

Table 3: Cumulative Losses

Horizon	1 quarter	1 Year	2 Years	5 Years	20 Years	50 Years	Discounted
Output	0.12	0.88	4.23	20.93	56.14	12.98	17.37
Employment	0.18	1.35	6.33	27.86	43.70	-8.88	–

episodes are costly in the short to medium run, both in terms of output and in terms of employment. For instance, after one year, the economy would have experienced about 1% output loss and would have, in total, lost 2.3 percentage points employment. Given the persistence of the recession, these losses amplify over time, and after 5 years, the cumulative loss

in terms of output is about 21%, 30% for employment. Losses recedes as the horizon increases since the beneficial effects of fiscal consolidation kick in. It takes 58 years for the cumulative output losses to cancel out and eventually turn into gains, 45 years for employment. This, once again, points to the existence of an intertemporal trade off between the long–run gains of debt reduction on the one hand, and the short–run employment and output losses generated by fiscal consolidation. In the case of output, the discounted loss is still sizable, 17%, over the whole adjustment (from period t to ∞), meaning that, given the discount factor of the household, the short–run losses outweigh the long run gains.

5 Sensitivity analysis

The preceding results have shown that the output and employment costs of reducing public debt can be sizable in the short to medium run, and that agents have to be patient enough to experience the gains associated to such policies. This section assesses the robustness of the previous findings to alternative settings for the consolidation policy. In particular, the sensitivity to the state of the business cycle, the speed and size of the debt reduction, the presence of alternative instruments (government spendings, and other taxes) and the timing of the consolidation are investigated.

5.1 Recessions

The recent fiscal consolidation episode takes place in a particular economic environment: most economies experience a recession. This section investigates the role of the state of the business cycle for the impact of debt reducing policies on employment and output. To this end, we compare the response of output and employment to the fiscal consolidation policy described in the previous section when the economy is started from steady state to the case where the economy is plunged into a recession initially. The recession is triggered by a downward shift in total factor productivity A_t that brings output 2.5% below trend on impact. Figure 4 reports the dynamics of output and employment during the fiscal consolidation episode. The plain dark line corresponds to the benchmark experiment described in the previous section, the red line corresponds to the deviation of output from its path in recession during fiscal consolidation. The results indicate that reducing debt in a recession does not generate significantly larger, although still marginally larger, output and employment losses than when the economy is started from its steady state. The cumulative losses are marginally larger in recession than in the benchmark experiment in the short-run, as witnessed by Table 4. As time goes on, the losses increase a bit more during a recession. For instance, fiscal consolidation yields a 30% cumulative employment loss when the fiscal consolidation is started in a recession, 28% when started from steady state. The reason is that in recession

Figure 4: Output and employment responses during recession

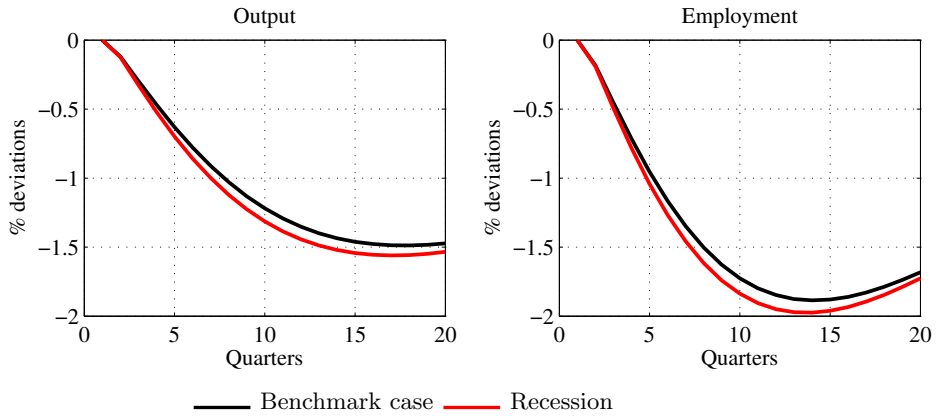


Table 4: Cumulative losses due to fiscal consolidation

Horizon	1 quarter	1 Year	2 Years	5 Years	20 Years	50 Years	Discounted
Output	0.12	0.97	4.65	22.32	58.08	14.47	18.93
Employment	0.19	1.47	6.86	29.38	44.74	-8.20	–

fiscal policy is constrained as there is a direct trade off between the fiscal consolidation and output stabilization in the recession. Thus, there are two opposing demands on the labor tax adjustment; the fiscal consolidation demanding a hike in wage tax while the output stabilization calling for a fall in wage tax. Consequently, the fiscal consolidation will be slower in recession compared to the benchmark scenario, reflecting a direct trade off between the fiscal consolidation and output stabilization.

5.2 Consumption taxes

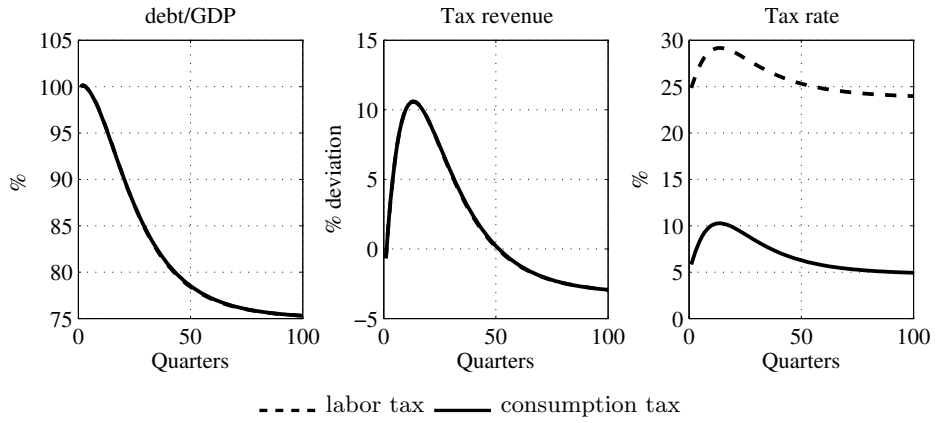
In the benchmark experiment, the debt reduction was achieved by adjusting the labor tax rate holding the other taxes —namely consumption and capital taxes— constant, at their steady state levels. In this section, I investigate the effects of fiscal austerity as achieved through adjustment of the consumption tax rate (for example, retail sales tax, a value-added tax, and a consumption-type flat tax) instead.[13]

Figure 5 reports the adjustment dynamics of fiscal aggregates and the tax rate during the fiscal consolidation. The consumption tax increases from 6% —its steady state level in the initial regime— to about 10.3% at the peak (reached in 3.5 years following the beginning of fiscal austerity) — a 4.3 percentage points increase which is of the same order as the increase in the labor tax. As the debt reduction process approaches completion, the effort in debt

[13]Such a consumption tax adjustment was recently put forward in France as a way to obtain a social V.A.T. (see Fève et al. (2010)).

reduction in compensated by a reduction in debt services. Tax revenues can then be lowered, which translates eventually into a reduction in the consumption tax that eventually reaches a lower level of 4.75%.

Figure 5: Fiscal Consolidation: Consumption Tax (I)



The initial increase in the consumption tax makes consumption relatively more expensive. As a way to smooth their consumption over time, the households extract a greater surplus during the wage bargaining process which puts upward pressure on the real wage (see equation 15 which is an increasing function of the consumption tax). The real wage increases, but the marginal value of a new employee for the firm decreases which leads to a fall in vacancies. However, this effect is not as direct as the increase in the labor tax and leads to a lower adjustment of the wage and vacancy posting which drop less than in the labor tax case. Hence, the permanent income of the agents is not as affected and consumption decreases less than in the benchmark case, even though the adjusting tax is the consumption tax. Likewise the adjustment of investment is dampened. Employment reaches back its steady state after 12.9 years, and only after this date the economy starts to benefit from its fiscal consolidation effort, and see both its employment level and output be above the initial steady state. Just as in our benchmark case, the policy maker faces an intertemporal tradeoff: plunging the economy in a recession for a long period, before output increases and unemployment recedes in the longer run.

Inspection of Figure 7 reveals, that compared to the labor tax rate, the use of consumption tax generates *(i)* lower output loss –it stands at 1.01% deviations from its initial steady state compared to it is 1.5% for labor tax (reached in 4.5 years following the commencement of fiscal austerity), *(ii)* lower employment loss of 1.28% after 3.5 years – for labor tax rate this is 1.9% deviations from its steady state after 3.35 years. The negative effects on employment and output are persistent.

Figure 6: Macroeconomic responses (Consumption Tax Experiment)

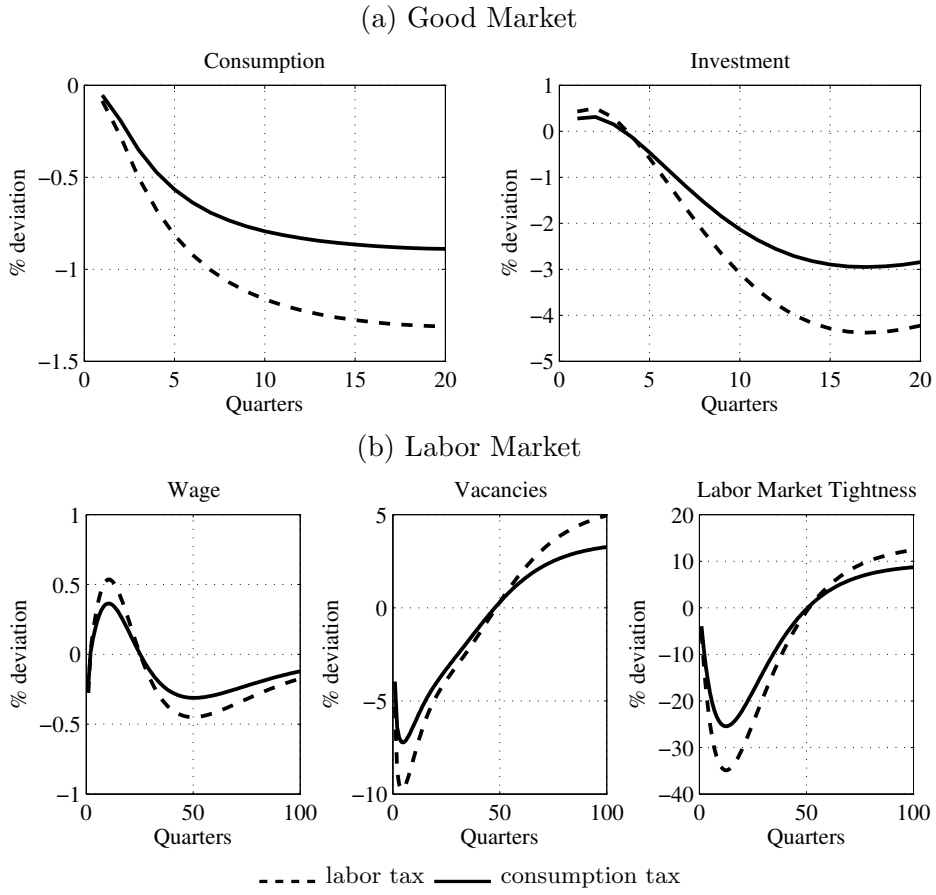
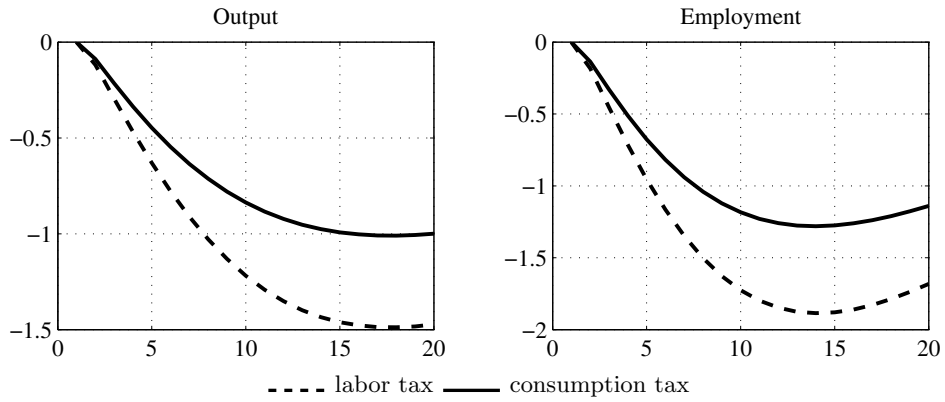


Figure 7: Evolution of Output and Employment (II)



This is confirmed by inspection of Table (5) which reveals that, when government adjusts the consumption tax rate, fiscal consolidation episodes are less costly in the short to medium run, both in terms of output and in terms of employment. For instance, after two years, the economy would have experienced about 3% output loss and would have, in total, lost 4.5 percentage points employment–when using the labor tax the output loss is around 4% and employment loss is about 6%. Given the persistence of the recession, these losses amplify over time. In the long run, after 50 years, the economy experiences cumulative gain of 9.2% for employment – in labor tax case these are lower and stand at 8.9%. Losses recedes as the horizon increases since the beneficial effects of fiscal consolidation kick in. Under the consumption tax adjustments, it takes one year less for the cumulative output losses to cancel out and eventually turn into gains, 57 years versus 58 years under the labor tax adjustments. In the case of output, the discounted loss is still sizable, 10.2%, over the whole adjustment (from period t to ∞), but much lower than for labor tax, 17%. On the other hand, for both tax regimes, it takes the same length of time for the cumulative employment losses to cancel out – that is 45 years.

Table 5: Cumulative losses: Consumption Tax Adjustment

Horizon	1 quarter	1 Year	2 Years	5 Years	20 Years	50 Years	Discounted
Output	0.09	0.64	2.98	14.36	37.97	6.08	10.17
Employment	0.14	0.98	4.45	19.11	29.25	-9.15	–

For the consumption tax adjustments, the intertemporal trade off between the long–run gains of debt reduction on the one hand, and the short–run employment and output losses generated by fiscal consolidation, is still present, however these tend to be smaller compared to the labor tax adjustments. These results indicate that, in terms of employment and output losses, the consumption tax is better suited for fiscal austerity.

5.3 Speed versus Amplitude

The fiscal consolidation is characterized by *(i)* the persistence and *(ii)* the amplitude of the debt adjustment. In particular, as already explained above, the higher the persistence, the smaller the amplitude effect, and vice versa. Intuitively, either by becoming more "aggressive" or by speeding up the reduction of public debt has the advantage of reducing the time period during which the economy experiences output and employment losses. However, a larger effort may be required in the beginning of the fiscal consolidation given that the same adjustment has to be performed in a shorter time. To strike the right balance between the two effects and, thus, to face the most intertemporal tradeoff in terms of potency of the reform, the government can achieve it by varying *(i)* the speed of debt adjustment, ρ_b, and *(ii)* its own "aggressiveness" towards the debt adjustment, γ_1.

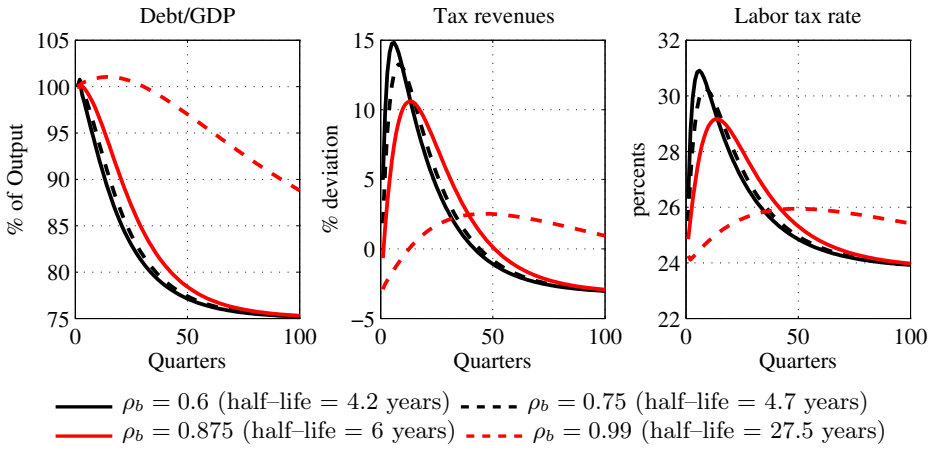
As a way to investigate this issue, Panels (a) of Figure 8–9 report the transition dynamics of fiscal instruments, output and employment as the speed of the debt adjustment is varied, with a half–life ranging from 4 to 27 years. This adjustment is controlled by changing ρ_b in the range 0.6 to 0.99 –the benchmark case setting being $\rho_b = 0.875$. Panels (b) of Figure (12) illustrate the transitional paths when the initial amplitude of the debt adjustment. This is achieved by controlling the degree of "aggressiveness" of fiscal authority to debt reduction, γ_1, which is varied from 0.2 to 0.99 – with the benchmark case set at 0.8.

The main implications of varying the speed of the adjustment can be obtained from Figure 8. Faster fiscal consolidation (lower ρ_b) requires that larger tax revenues be raised upfront (see middle panel of Panel (a) of Figure 8), leads to a larger and shorter increase of the labor tax rate (see right panel of Figure 8). For instance, the peak in the evolution of the labor tax rate in our experiment occurs 3.5 years after the beginning of the consolidation and amounts to a tax rate of 29.2% (25% in the initial steady state). When the half life of the debt ratio adjustment is shortened to 4.2 years ($\rho_b = 0.6$), this peak is reached after 1.5 year for a labor tax of 31%. Very similar results obtain when, instead, the government increases the amplitude of the initial debt reduction, This is achieved by increasing its own attitude to debt reduction, γ_1. In the benchmark experiment, $\gamma_1 = 0.8$, the labor tax rate amounts to 29.14% of income at the peak of the tax rate adjustment, which occurs 3.75 years after the commencement of fiscal consolidation. When the government adopts more aggressive approach to debt reduction, $\gamma_1 = 0.99$, this peak is reached in 3.25 years in the labor tax of 29.92%. In that context, the household needs to be given extra compensation in the wage bargaining process, the wage increases more relative to the benchmark experiment. Firms post relatively less vacancies and the employment loss is larger (see right panel of Figure 9). Likewise, and for similar reasons, the output loss is also larger.

Most of the adjustment being accomplished over a shorter period of time, the increase in tax is shorter. Accordingly the employment loss is less persistent. These results are reflected in

Figure 8: Varying the Speed and "Aggressiveness" of Debt Adjustment (I)

(a) Varying the Speed of Debt Adjustment



(b) Varying the Fiscal Authority "Aggressiveness"

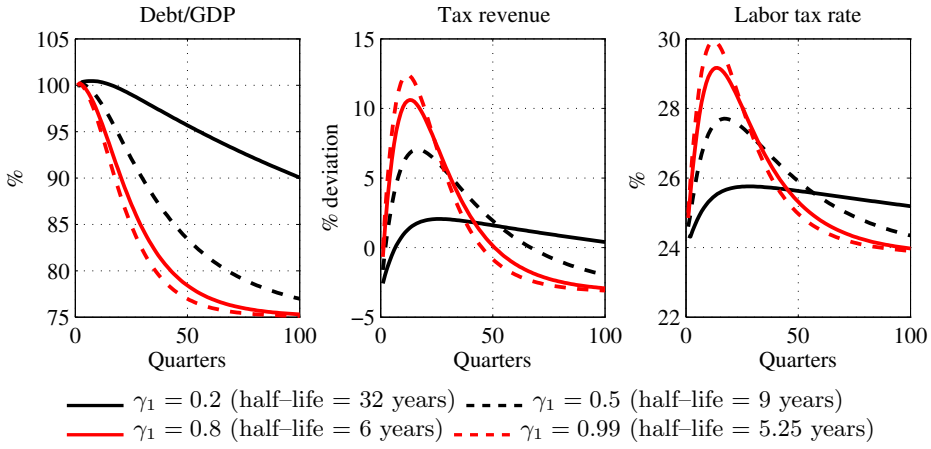
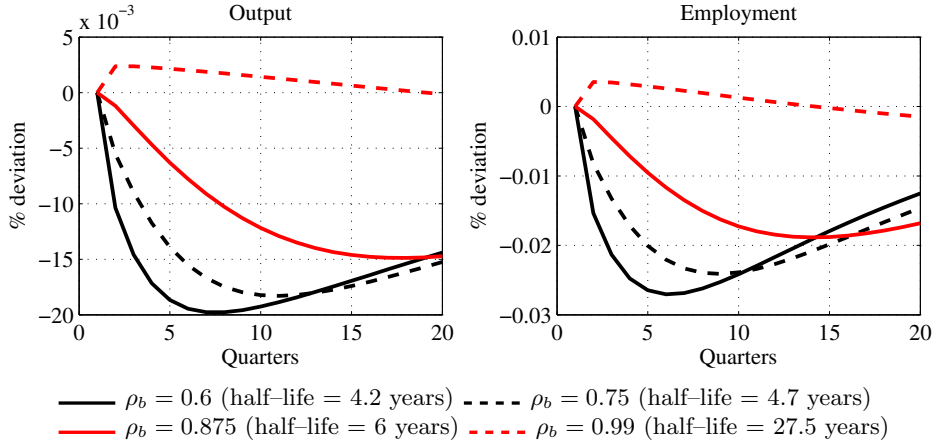


Figure 9: Varying the Speed and "Aggressiveness" of Debt Adjustment (II)

(a) Varying the Speed of Debt Adjustment



(b) Varying the Fiscal Authority "Aggressiveness"

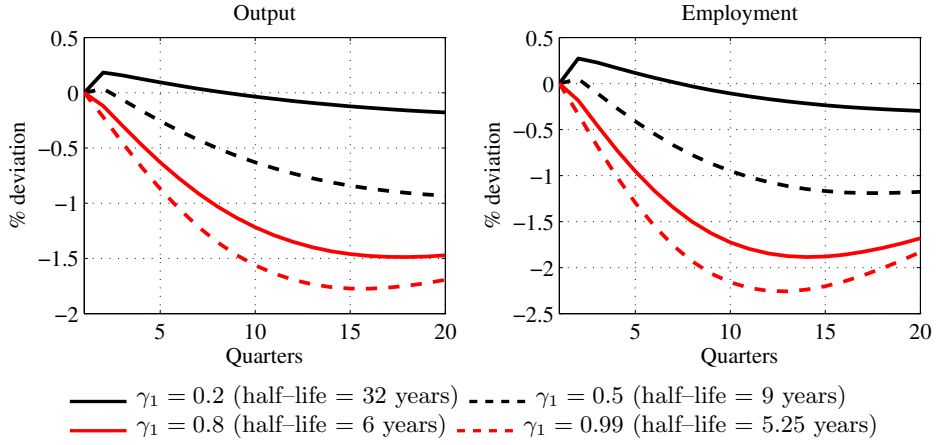


Table 8 which reports the cumulative output and employment losses associated with these experiments. The table clearly indicates that faster debt reduction is associated with larger losses in the short run (1.54 percentage point for the case $\rho_b = 0.6$ versus 0.18 percentage point in the benchmark), but these employment losses tend to recede quicker. For instance, the cumulative employment loss canceled out after 45 years in the benchmark experiment, 43 years in the fast adjustment case. Interestingly, while the tax adjustment is much quicker in the $\rho_b = 0.6$ case compared to the benchmark, this decrease in persistence does not transmit to employment, nor to output. The reason for this is found in the matching process which generates a lot of persistence in the model.

As the speed of debt adjustment is reduced –say $\rho_b = 0.99$– the reverse mechanisms are at play. However, interestingly, a slower fiscal consolidation is accompanied by an increase in debt in the short run. This is made possible by the fact that the government can spread the debt adjustment over a long period, and that way achieve some form of tax smoothing. The tax raises by much less in the transition (0.26 at the peak), and can even be lowered in the short run. This initial fall in the tax rate puts downward pressure on the wage, which in turn leads the firms to post more vacancies and hire more employees. Hence, in the short run, employment losses turn into employment gains, and fiscal consolidation actually generates mild employment and output gains. These gains are however short lasting and turn into employment losses after 7 years and persist longer 56 additional years.

Table 6: Cumulative losses: Varying Speed

Horizon	1 quarter	1 Year	2 Years	5 Years	20 Years	50 Years	Discounted
Output							
$\rho_b = 0.600$	1.04	4.21	11.98	32.53	58.18	12.53	20.45
$\rho_b = 0.750$	0.55	2.62	8.98	29.65	58.53	13.52	20.30
$\rho_b = 0.875$	0.12	0.88	4.23	20.93	56.14	12.98	17.37
$\rho_b = 0.990$	-0.24	-0.70	-1.47	-2.33	13.07	18.93	1.30
Employment							
$\rho_b = 0.500$	1.54	6.15	16.81	39.27	40.66	-12.68	–
$\rho_b = 0.750$	0.82	3.87	12.81	36.82	42.08	-11.09	–
$\rho_b = 0.875$	0.18	1.35	6.33	27.86	43.70	-8.88	–
$\rho_b = 0.990$	-0.35	-1.02	-1.98	-1.95	18.36	15.13	–

Similar findings hold if the government instead decides to control its assertiveness to fiscal consolidation, γ_1. As it is evident from the results presented in Table 7, the more assertive government is about its fiscal consolidation plan, the larger are losses in the short-run (for $\gamma_1 = 0.2$ we have employment gains of 0.27% while for the benchmark case, $\gamma_1 = 0.8$, these are translated into employment losses of 0.18%). But these employment losses tend to disappear quicker. For lower government assertiveness, $\gamma_1 = 0.2$, it takes 36.5 years for the cumulative

employment losses to be canceled out compared to the benchmark experiment where it takes only 17.25 years.

Table 7: Cumulative losses: Varying Fiscal "Aggressiveness"

Horizon	1 quarter	1 Year	2 Years	5 Years	20 Years	50 Years	Discounted
Output							
$\gamma_1 = 0.2$	-0.18	-0.47	-0.67	0.63	14.40	15.64	2.56
$\gamma_1 = 0.5$	-0.04	0.19	1.72	11.28	45.57	13.18	11.44
$\gamma_1 = 0.8$	0.12	0.88	4.23	20.93	56.14	12.98	17.37
$\gamma_1 = 0.99$	0.22	1.34	5.83	26.17	59.36	13.83	20.06
Employment							
$\gamma_1 = 0.2$	-0.27	-0.67	-0.83	1.69	16.46	11.34	–
$\gamma_1 = 0.5$	-0.05	0.32	2.73	15.99	40.61	-3.58	–
$\gamma_1 = 0.8$	0.18	1.35	6.33	27.86	43.70	-8.88	–
$\gamma_1 = 0.99$	0.33	2.02	8.56	33.95	43.63	-10.21	–

These transitional paths suggests that steady but gradual consolidation may be the strategy that has the lowest cost in terms of lost output and employment. Cutting too much debt today could throw economy into a deep recession. Cutting it slowly creates a much milder recession, but a more persistent one. This is reminiscent of the gradualist versus "cold turkey" approaches described by Sargent (1983). On one hand, a gradualist approach yields smaller losses with longer persistence. On the other hand, "cold turkey" approach is associated with larger losses in the short–run but with shorter duration. Thus, the policymakers face a choice of two different approaches when deciding the policy which is best suited for its fiscal consolidation plan, each with its own tradeoffs.

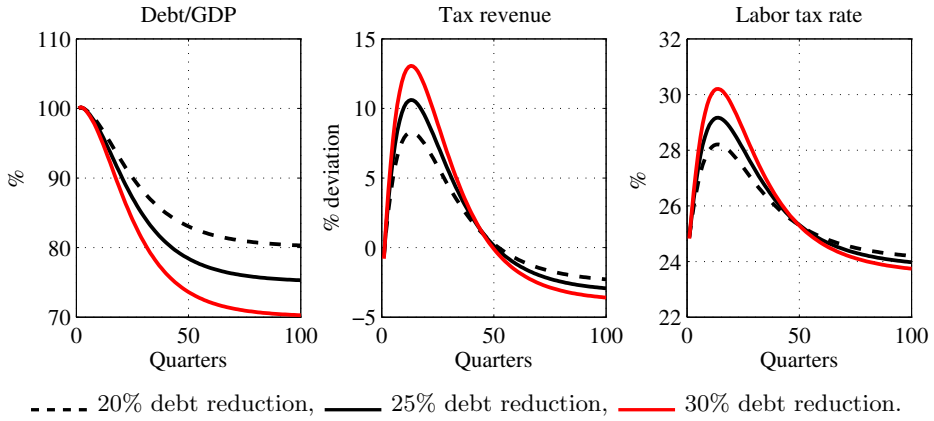
5.4 The size of debt adjustment

Naturally, the intertemporal tradeoffs that describe the fiscal consolidation –short–run employment (output) losses versus long–run gains– would be also present when the size of debt adjustment is varied.

Understandably, the sizable reduction in the public debt requires more effort by the fiscal authority and is more costlier in terms of employment (output) losses, but likewise, the long–run gains are also larger. However, one question remains open: do proportional debt adjustments generate proportional or disproportional losses? Figures 10–11 explore the (dis)proportional effect of fiscal consolidation by a way of reporting the transitional paths of fiscal instruments, employment and output as the size of debt adjustment, $b_t^\star$, is varied in the range of 20% to 30% – the benchmark case involves 25% debt adjustment. As expected, larger fiscal consolidations require larger adjustment in the tax revenues and the labor tax rate. For instance moving from a 20 to a 30% fiscal consolidation implies that the tax rate varies from 28 to 30%

at the peak of its adjustment dynamics. Interestingly, the peaks reached in each experiment are concomitant. However, given that the size of the tax rate adjustment vary with the size of the debt reduction, the dynamics of debt are different. For instance, a 20% reduction having a half life of 8 years, while a 30% consolidation having a half life of 5 years. In other words, the dynamics are sensitive to the size of the debt reduction. To investigate the (dis)proportional

Figure 10: Varying the Size of Debt Adjustment (I)



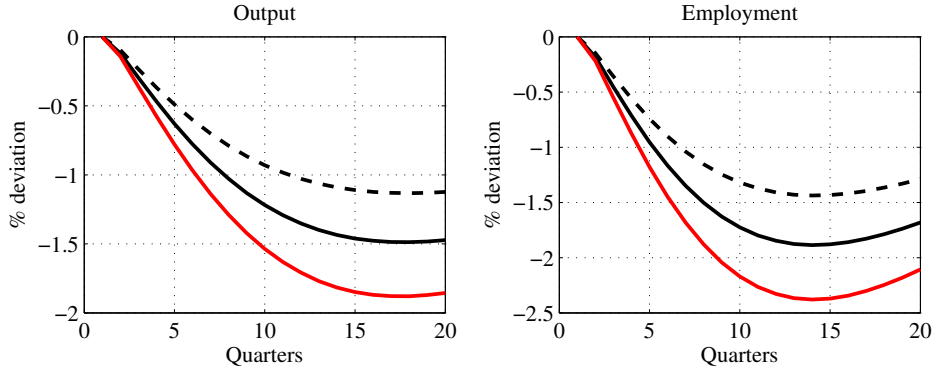
effects of the size in debt adjustment we plot in Panel (a) of Figure (11) the employment and output losses corresponding to 20, 25 and 30% fiscal consolidation. A government wanting to implement 20% debt reduction experiences the employment loss of 1.44% and output loss of 1.1%, at the peak of its responses in 3.5 years. The government desires to implement our benchmark debt reduction of 25% would then have to bear an additional employment loss of 0.45% (and an additional output loss of 0.34%). But yet an extra 5% increase in desired debt reduction would amount to an additional 0.49% in employment losses (and an additional 0.38% for output losses). So as expected from previous results, the size of employment (output) losses is positively related to the amplitude of the fiscal consolidation. Panel (b) of the figure reports the ratio of employment (output) losses corresponding to 20% and 25% debt reduction, and 25% and 30% debt reduction. This figure clearly shows that employment losses increase proportionally with the level of the debt reduction. Fiscal consolidation does not involve strong nonlinear effects.[14]

These results are also reflected in Table (8) which reports the cumulative output and employment losses associated with these experiments. The table clearly points to the existence of larger employment and output losses as we increase the desired debt reduction from 20% to 25% and then to 30%. In the short-run increasing debt reduction from 20% to 25% translates into 0.03% larger employment losses, but increasing a desired debt reduction for another 5%

[14]A bit of qualification is in order. Employment and output losses are linearly related with the size of the fiscal consolidation. In that sense the process does not display any nonlinearities. However, while the dynamics of employment and output losses are proportional, those of debt are not. The differential adjustment of debt (and hence some form of nonlinearities)actually insures the linearity in losses.

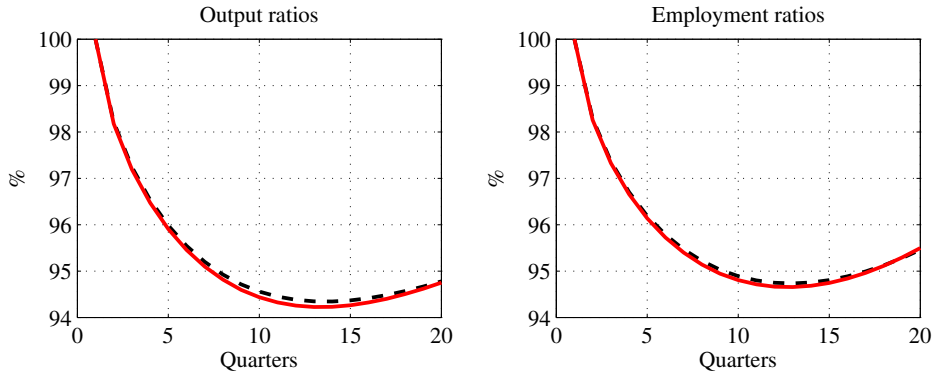
Figure 11: Varying the Size of Debt Adjustment (II)

(a) Output and Employment



20% debt reduction, 25% debt reduction, 30% debt reduction.

(b) Output and Employment Ratios



20%/25% adjustment ratio, 25%/30% adjustment ratio

amounts to an additional 0.04% employment losses –the net difference of 0.01%. These tiny differences are explained by the way tax rate affects the wage in a nonlinear fashion.

Table 8: Cumulative losses: Varying Size

Horizon	1 quarter	1 Year	2 Years	5 Years	20 Years	50 Years	Discounted
Output							
20%	0.10	0.70	3.28	15.99	43.92	9.72	13.02
25%	0.12	0.88	4.23	20.93	56.14	12.98	17.37
30%	0.14	1.08	5.25	26.34	68.86	16.71	22.25
Employment							
20%	0.15	1.07	4.91	21.35	34.60	-7.36	–
25%	0.18	1.35	6.33	27.86	43.70	-8.88	–
30%	0.22	1.65	7.84	34.94	52.95	-10.15	–

5.5 Endogenous government spending rule

So far, government spendings have been held constant over time, $g_t = \overline{g}\ \forall\, t = 0, \ldots, \infty$.[15] As our previous results indicated, fiscal consolidation plunges the economy into a recession. The government may then use government spending as an "automatic stabilizer" (Blanchard (1984)) to dampen the adverse effects of debt reduction. A new tradeoff then emerges: fiscal consolidation versus output stabilization. The government may use government spendings to fight the recession, but by doing so it hinders the fiscal consolidation process. To investigate this tradeoff, this section considers the case where government expenditures follow a simple rule

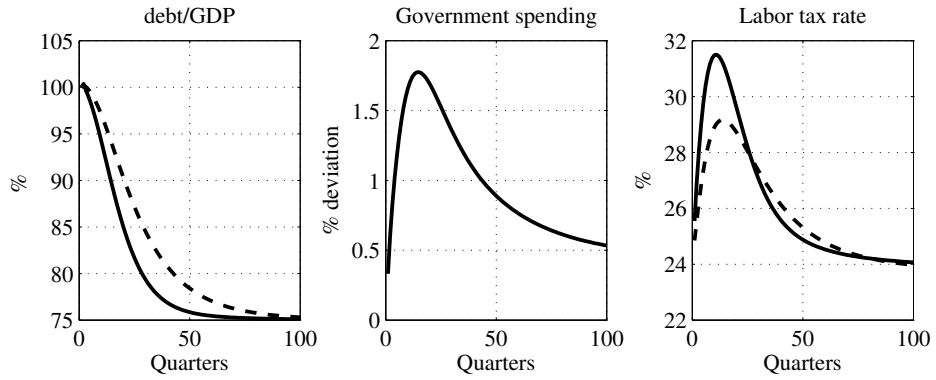
$$\log(g_t) = \rho_g \log(g_{t-1}) + (1 - \rho_g) \log(\bar{g}) + r_g \log\left(\frac{y}{\bar{y}}\right) \tag{20}$$

where $\rho_g \in (0, 1)$ and $r_g < 0$. The form of this rule stipulates that, in an attempt to influence the dynamics of output, the government raises public expenditures whenever output falls below its steady state level. Hereafter, I set $\rho_g = 0.5$ and $r_g = -0.5$.

Figures 12–13 compare the transitional paths of fiscal instruments, output and employment with exogenous government spendings (dashed line) —the benchmark experiment described in the previous sections— and those obtained when the government uses an active policy rule (plain line). As explained previously, the fiscal consolidation process triggers a recession. A government that has a concern for output stabilization then sees output falling below its steady state level and, according to rule (20), expands its expenditures. The financing of this policy cannot be achieved by issuing government bonds —this would obviously go against the fiscal consolidation— and calls for an increase in taxes. For instance, at the peak of

[15] The government spending is set at its steady state value of $\overline{g} = 0.2\overline{y}$.

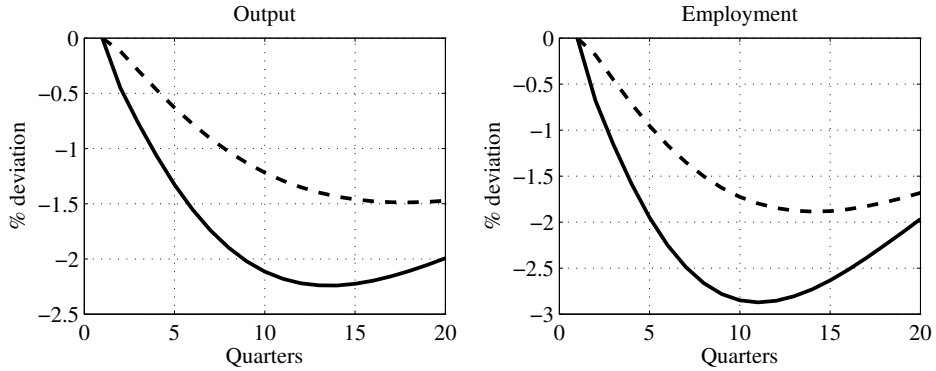
Figure 12: Varying Government Spending Rule (I)



Exogenous government spending rule (benchmark), Endogenous government spending rule.

its adjustment path, the labor tax rate reaches 31.5% compared to the 29% with constant government spending. This has two main consequences. First, the larger tax income collection accelerates the debt reduction process Second, and more importantly, higher taxes magnify employment (output) losses. For instance, under constant government spendings, the maximal employment (resp. output) loss was 1.8 percentage points (resp. 1.3%), under the active policy the maximal employment (resp. output) loss is 2.9 percentage points (resp. 2.2%)— a 60% increase. In other words, by pursuing the active loss, the government actually exaggerates the recession. Note however, that again the persistence/magnitude tradeoff occurs, as while the recession is deeper it lasts longer, as the debt reduction is faster.

Figure 13: Varying Government Spending Rule (II)



Exogenous government spending rule (benchmark), Endogenous government spending rule.

These findings are also confirmed by results in Table (9) which reports the cumulative output and employment losses for this experiment. It is evident that in the short-run employment (and output) losses are more than twice as large than when the government spending follows exogenous process. For example, the employment losses are 0.68% compared to 0.18% in the baseline experiment (the output losses are 0.12% relative to 0.45% in the baseline case).

Table 9: Cumulative losses: Endogenous Government Responses

Horizon	1 quarter	1 Year	2 Years	5 Years	20 Years	50 Years	Discounted
Output	0.45	2.29	8.81	34.57	69.43	26.51	30.70
Employment	0.68	3.42	12.78	43.55	46.85	-5.22	–

The results imply that the government pushes the economy into a deeper recession as it tries to pursue two conflicting goals: *(i)* debt reduction and *(ii)* output stabilization. Thus, the government needs to consider carefully the tradeoff between the two goals and its use of "automatic stabilizers".

5.6 Announced Fiscal Consolidations

The preceding sections considered scenarios where the government started the fiscal consolidation plan as soon as it announces it. This section investigates the case where the government announces in period t that it will implement a debt reduction policy starting in $t+4$.[16] In such a situation, agents expectations play a key role and may affect the adjustment path.

From a technical point of view, announcement amounts to introduce a shock that is revealed to the agents 4 periods in advance in the debt target law of motion as

$$b_t^\star = \rho_b b_{t-1}^\star + (1-\rho_b)\left(\log\left(\frac{\overline{b}}{\overline{y}}\right) + \varepsilon_{t-4}^b\right) \tag{21}$$

where, as previously, $\overline{b}/\overline{y}$ denotes the initial steady state value of the debt/output ratio and $\{\varepsilon_{t+4}^b\}_{t=0}^{\infty}$ is an exogenous sequence that will control for the fiscal consolidation. ρ_b controls for the speed of fiscal consolidation adjustment.

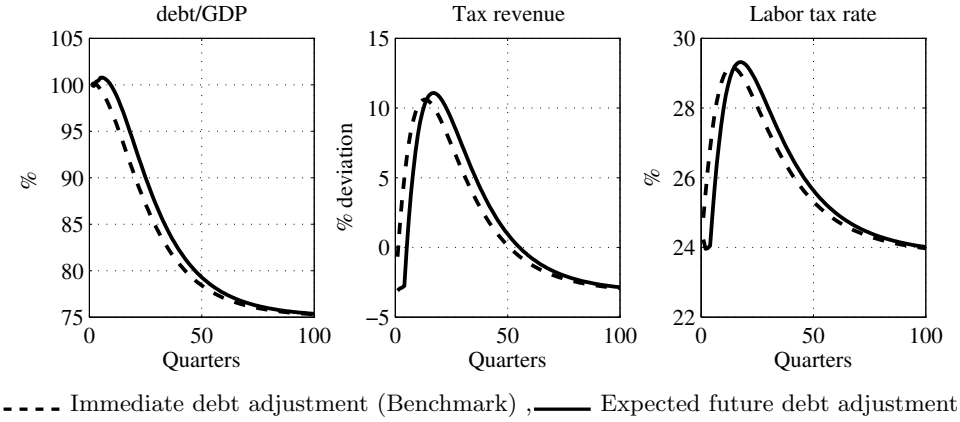
At the time the government makes the announcement, and for the next 4 periods, the target debt ratio remains unchanged —100% of GDP– and only starts adjusting in $t+4$. The adjustment dynamics that follow can then be better understood by splitting the adjustment into two sub–periods. The first one starts at the time of the announcement and ends with the implementation of the fiscal consolidation, and captures the mere effect of the announcement. During this period only announcement effects are at play. The second one starts with the effective implementation of the fiscal consolidation.

During the first sub–period, agents, who have perfect foresight, correctly expect that, as of period $t+4$, the target debt ratio will start converging to its new long-run level, 75%. Agents then expect higher future tax rates (see middle and right panels of Figure 14 and therefore that they will suffer a negative wealth effect in the future. The consumption smoothing behavior of the household makes her *(i)* cut on her consumption at the time of the announcement, and

[16]Note that full commitment and time consistency of the announcement will be assumed throughout. Departure from these assumptions is left for future research.

(ii) start accumulating more wealth, as a way to cushion themselves from higher taxes. In the current model, the agent has two ways to accumulate wealth: capital and bonds. Investment increases in the short-run as a way to accumulate capital. But, more interestingly for the purpose of this paper, the household also purchases government bonds. As shown in the left panel of Figure 14 public debt actually increases during that period. This leads to actual debt building up, which relaxes the government budget constraint. This explains why, in the few periods that follow the announcement, tax revenues and the labor tax rate fall (see middle and right panels of Figure 14). In other words, the announcement of the plan allows the government to substitutes tax revenue for debt, therefore mitigating the negative wealth effect on the agents. As already explained, the fall in the labor tax rate leads to a decrease

Figure 14: Expected Future Debt Adjustment (I)

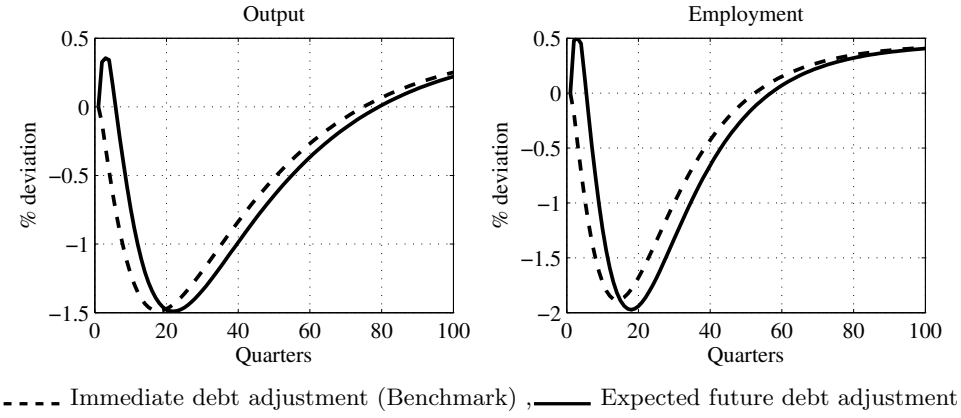


in the wage which increases the marginal value of employment for the firm, which then posts more vacancies. On the one hand, firms prospect of filling a vacancy falls as they face more competition from other firms in the labor market and as the probability of filling vacancy, q_t falls (congestion externality). On the other hand, the households find it, at first, easier to find the job as the probability of finding a job, s_t increases (positive trade externality). This, therefore, initially increases employment. The peak employment gain is reached in third quarter and amounts to 0.46%. In other words, the mere announcement of the fiscal consolidation ameliorates the labor market conditions in the very short-run.

After 4 periods, the actual debt reduction commences and the adjustment dynamics enter in the second sub-period, during which the mechanisms at work are identical to those detailed in Section 4. The results indicate that the whole dynamics is essentially postponed by 4 quarters. For example, the peak in the evolution of the labor tax rate occurs 4 years after the fiscal consolidation commences, and 4 quarters later than in the baseline experiment, and amounts to 29.2% (exactly the same as in the baseline experiment). Employment reaches the trough after 4 years (once again 4 quarters later than in the baseline experiment) but are slightly higher than in the baseline experiment and amount to 1.95% in deviations from the

steady state (compared to just 1.9% in the baseline experiment). The output losses are also slightly higher than in the baseline case and amount to 1.49% (1.48% in baseline case).

Figure 15: Expected Future Debt Adjustment (II)



Given the preceding discussion, it comes as no surprise that the government's announcement of its future fiscal consolidation plans is accompanied, in the short-run, by a boost translated into employment (and output) gains. For instance, there is employment cumulative gain of 1.43% (and output cumulative gain of 1.02%) recorded (see Table 10). These initial gains will be translated into lower overall cumulative losses than under the baseline scenario. For example, the discounted cumulative losses of output are 15.6%, which amounts to 1.8% reduction relative to baseline case. This reduction is due to the prevailing negative wealth effect in the first sub-period that creates an economic boom which is then translated into the employment (and output) gains in the short-run and relatively lower losses in the future.

Table 10: Cumulative losses: Future Anticipated Debt Reduction

Horizon	1 quarter	1 Year	2 Years	5 Years	20 Years	50 Years	Discounted
Output	-0.33	-1.02	-0.51	13.41	55.12	13.68	15.63
Employment	-0.48	-1.43	-0.18	20.31	45.97	-6.08	–

These transitional paths suggest that announcements about future fiscal consolidation might be a policy that generates lower cost in terms of employment (and output) losses. This is obviously conditional on the maintained assumption that the government fully commits to implement the plan.

6 Monetary and Fiscal Policies

The preceding sections have investigated the adjustment dynamics to a fiscal consolidation episode in a real economy. The emphasis was put on the real aspects of such events, ignoring the potential nominal dimension of public debt reduction. However, the interplay between fiscal and monetary policy ought to have important consequences for the macroeconomy as monetary policy —by affecting the nominal interest— may hinder or ease fiscal consolidation. This section investigates this issue.

For monetary policy to matter, the model is amended in three ways. First, two types of firms are introduced in the economy. Final goods retailers sell a homogeneous good, which is an aggregate bundle of a set of intermediate goods that are produced by intermediate goods producers. Because each and every good is fully differentiated and is purchased by the final good producer, the intermediate goods producers have monopoly power. They are therefore price setter. Second, these price setters face nominal rigidities in the form of price adjustment costs.[17] Finally, the central bank pursues an active monetary policy. Before going to the results, we describe how the model was changed to introduced the non neutral nominal dimension in the model.

6.1 Towards a Nominal Model

6.1.1 Final Goods-Producing Firm

There exists a representative final good producers that bundles a continuum of intermediate goods $y_t(j)$, $j \in (0,1)$, each purchased at price $P_t(j)$ on a competitive market. This final retailer produces the homogenous good y_t that can be either consumed or invested using the technology

$$y_t = \left(\int_0^1 y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{22}$$

where $\varepsilon > 1$ is the elasticity of substitution between intermediate goods. The demand for each good j, as obtained by profit maximization, is then given by

$$y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\varepsilon} y_t \tag{23}$$

where P_t is the aggregate price level. Competition in the market for the final good drives the representative firm's profit to zero. The zero-profit condition, along with Equation (23), determines P_t as

$$P_t = \left(\int_0^1 P_t(j)^{1-\varepsilon} dj \right)^{1/(1-\varepsilon)} \tag{24}$$

[17] Our results would be the same should a Calvo price setting mechanism be considered instead.

6.1.2 Intermediate Good Producers

There is a continuum of intermediate goods producers that each produce a specific intermediate good $j \in (0,1)$ by means of capital and labor according to the constant return technology described in Equation (10). Given the imperfect substitutability between intermediate goods, each good $j \in (0,1)$ is demanded in positive quantity and each firm has local monopoly power. Thus, the intermediate good producers sets the price $P_t(j)$ for its output. However, changing prices entails a convex cost (in terms of the final good)[18] à la Rotemberg (1982), which takes the form

$$\frac{\phi}{2}\left(\frac{P_t(j)}{P_{t-1}(j)} - 1\right)^2 y_t \tag{25}$$

where $\phi \in \mathbb{R}_+$ controls for the size of these costs, and is a measure of the degree of price stickiness. In particular, $\phi = 0$ corresponds to the flexible price economy, $\phi = +\infty$ implies the existence of constant prices. Given that the steady state inflation level is zero ($\pi = 1$), it is clear from Equation (25) that the cost is nil in the long-run. Firm j set its price so as to maximize its intertemporal profits

$$\max \sum_{t=0}^{\infty} \Phi_{t,t+1}\Big(\frac{P_t(j)}{P_t} y_t(j) - \Psi_t(j) y_t(j) - \frac{\phi}{2}\left(\frac{P_t(j)}{P_{t-1}(j)} - 1\right)^2 \overline{y}_t\Big) \tag{26}$$

subject to the demand it faces (Equation 23). $\Phi_{t,t+1}$ is the appropriate discount factor of the firm defined in Section 2.3, $\Psi_t(j)$ is the real marginal cost of the firm. In a symmetric equilibrium, The price setting equation gives rise to a standard Phillips curve

$$(1-\varepsilon) y_t + \varepsilon \Psi_t y_t - \pi_t \phi \left(\pi_t - 1\right) y_t + \beta \frac{1+\tau_t^c}{1+\tau_{t+1}^c} \frac{c_t}{c_{t+1}} \phi \pi_{t+1} \left(\pi_{t+1} - 1\right) \overline{y}_{t+1} = 0 \tag{27}$$

where $\pi_t = P_t / P_{t-1}$. The real marginal cost is given by the gap between the rental rate of capital and the marginal product of capital

$$z_t = \Psi_t \alpha \frac{y_t(j)}{k_t(j)} \tag{28}$$

Finally, the monopoly power of each firm affect its vacancy posting policy as

$$\frac{a}{q_t} = \beta \frac{c_t(1+\tau_t^c)}{c_{t+1}(1+\tau_{t+1}^c)} \left(\Psi_{t+1}(1-\alpha)\frac{y_{t+1}(j)}{n_{t+1}(j)} - w_{t+1} + (1-\psi)\frac{a}{q_{t+1}}\right) \tag{29}$$

6.1.3 Monetary Authority

The monetary authority conducts monetary policy by adjusting short-term nominal interest rate R_t in response to deviations of inflation π_t from its steady–state value and changes in

[18] This implies that the resource constraint of the economy must be changed to

$$y_t = c_t + i_t + a v_t + \frac{\phi}{2}\left(\frac{P_t}{P_{t-1}} - 1\right)^2 \overline{y}_t$$

the output gap. The monetary policy is assumed to be described by the simple Taylor-type interest rate rule

$$R_t = \rho_r R_{t-1} + (1-\rho_r)\left(\overline{R} + \kappa_y \log\left(\frac{y_t}{\overline{y}}\right) + \kappa_\pi \log\left(\frac{\pi_t}{\overline{\pi}}\right)\right) \tag{30}$$

where $\rho_r \in [0,1]$, $\kappa_y \in \mathbb{R}_+$ and $\kappa_\pi > 1$.

6.2 Results

In this section, we discuss the adjustment dynamics to a fiscal consolidation episode in a nominal economy. However, before preceding to the results, we outline first the relevant parametrization that remains outstanding. In particular, the elasticity of substitution between differentiated goods, ε, is set at 6 implying a steady state markup rate of 20%. The price adjustment cost parameter, ϕ, is set to 58.[19] Given its importance, we will conduct later the sensitivity analysis around its value. In a monetary rule, the parameter governing the reaction of the interest rate to output, κ_y, is set to 0.1, and the response to inflation, κ_π, is set to 1.5. The persistence parameter in the monetary policy rule, ρ_r, is fixed at 0.8.

The Figure 16–17 compare the transitional paths of fiscal instruments, output and employment for a flexible price (dashed line)–the benchmark experiment described in the previous section– and sticky price (solid line) setups. As already explained, the commencement of fiscal consolidation brings about a negative wealth effect, which plunges the economy in a recession. The concern for output stabilization instructs the central bank to lower the interest rate, which pushes both consumption and investment upward and therefore creates some inflation. But, the concern for inflation makes the central bank increase the interest rate to tame the increase in prices. The inflation starts to raise in the second quarter and reaches a plateau at 0.44%, 3.25 years after fiscal consolidation commencement, and remains at that level for the following 7 quarters, before it starts to fall.

The raising inflation requires *(i)* that government raises higher tax revenue to achieve its debt target, and *(ii)* the central bank to raise nominal interest rates to stabilize prices. The peak in the evolution of labor tax takes place 3.5 years after the fiscal consolidation commences and reaches the value of 29.87% (29.17% in the benchmark case). The long-run tax rate is reduced to 23.5% while in the benchmark case it is 23.8%. Higher labor tax rate and nominal interest rate induce "crowding out" effects on household consumption and investment (as the cost of capital rises). In turn, the employment (and output) losses are larger than in the real benchmark model. The peak in the evolution of output losses occurs at 4.5 years and it amounts to 1.7 percent deviations – 0.22% higher than in the benchmark case. The unemployment reaches its trough earlier at 3.5 years and it is 2.2% (compared to 1.89% in the benchmark case).

[19] The choice of $\phi = 58$ is dictated by the fact that it yields the same inflation persistence as a Calvo price setting model with an average duration of price contracts of 3 quarters.

Figure 16: Fiscal Consolidation: Sticky Prices (I)

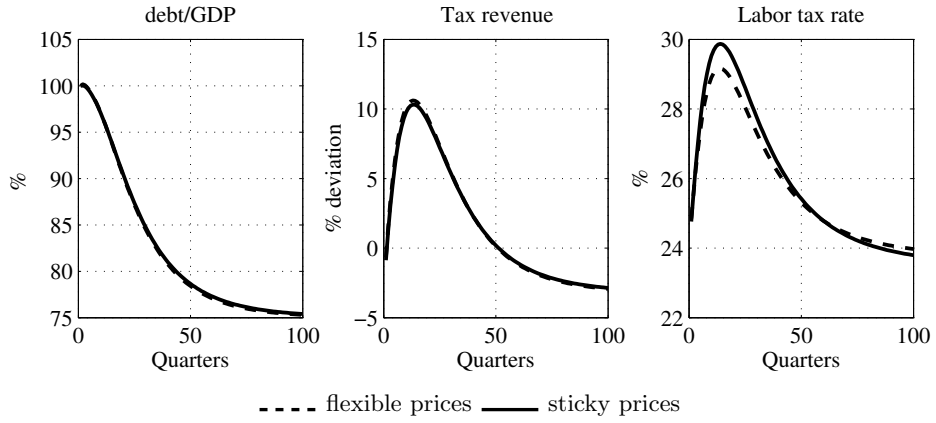
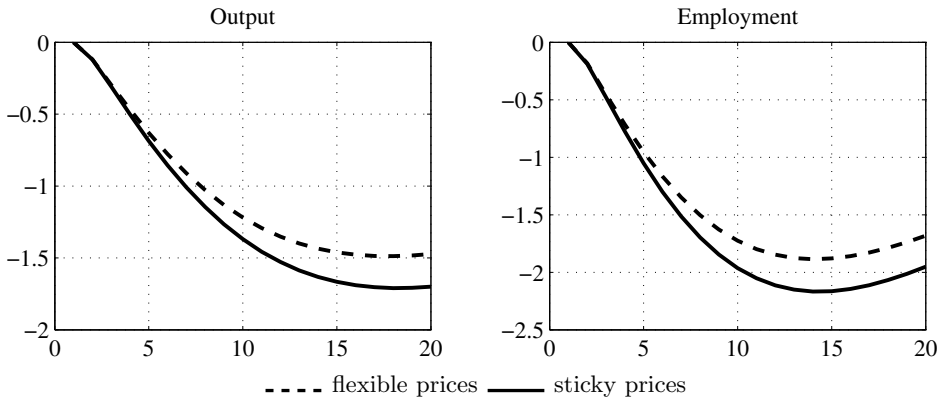


Figure 17: Evolution of Output and Employment (II)



These findings are confirmed by results in Table (11), which shows that the cumulative employment (and output) losses are larger than under the benchmark case. The discounted output losses are 21.05% – 3.68% higher than in the benchmark case. Likewise, the employment losses are higher across all of the horizons. For example, at 5 years 31.75% – 3.89% higher than in the benchmark case. The results indicate that the price stickiness does play a

Table 11: Cumulative losses: Sticky Prices

Horizon	1 quarter	1 Year	2 Years	5 Years	20 Years	50 Years	Discounted
Output	0.12	0.93	4.63	23.65	66.26	16.86	21.05
Employment	0.19	1.44	7.01	31.75	51.32	-9.07	–

role in the fiscal adjustment process, which comes at higher output and employment losses. The interplay between of fiscal and monetary policy is relevant for the policy consideration as there is a direct trade off between the fiscal consolidation and price stabilization.

6.3 Sensitivity analysis

The preceding results have shown that the interplay between fiscal and monetary policy can hinder fiscal consolidation, and that the output and employment costs of reducing public debt can be sizable in the short to medium run. This section assesses the robustness of the previous findings to alternative settings for the consolidation policy. In particular, the sensitivity to an alternative choice of fiscal instruments (namely, consumption tax), the degree of price rigidity, and the different degree of monetary authority responsiveness to output and price stabilization are investigated.

6.3.1 Consumption tax

The preceding section investigated the implications for employment and output of a reduction in nominal debt accommodated by adjusting labor tax rate. In this section, fiscal consolidation is obtaned through adjustments in the consumption tax instead. Figures 18 and 19 report the transitional path of employment, output and fiscal instruments obtained in this case. As the predominant interest of this section is to explore the nominal aspect of fiscal consolidation, we compare an economy with sticky prices (plain line) to an economy with flexible prices (dashed line) when, in both cases, the fiscal adjustment is performed by changes in the consumption tax rate. The right panel of Figure 18 shows, to achieve the same debt transition path, government needs to follow the identical tax revenue path by adjusting its consumption tax. The peak in the evolution of consumption tax rate, in the nominal economy, occurs at 3.5 years after the fiscal consolidation begins –same as in the real economy– and it amounts to 9.98% –a marginally smaller adjustment than for a real economy, 10.3%.

Figure 18: Fiscal Consolidation: Sticky Prices (I)

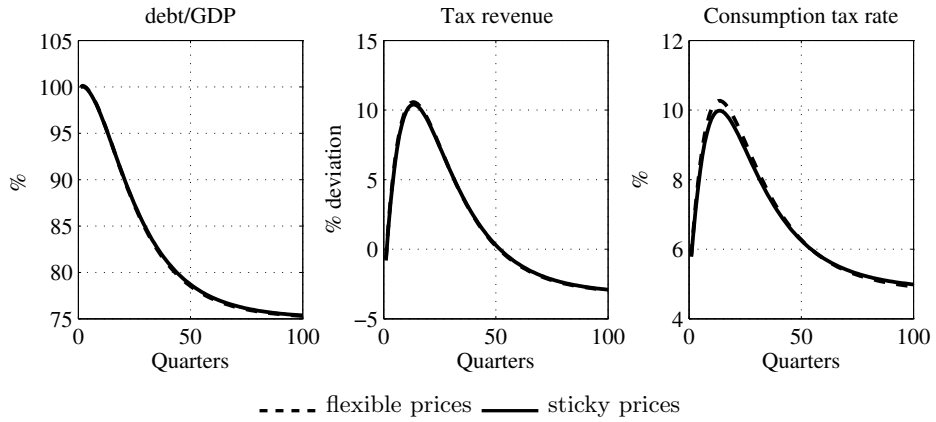
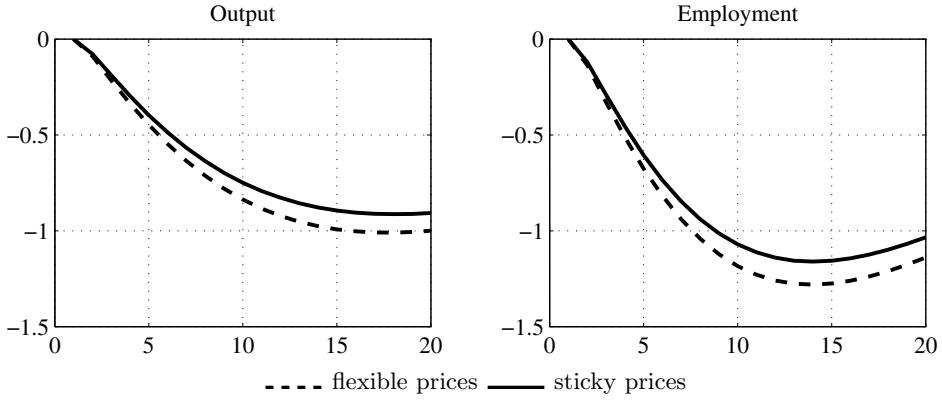


Figure 18 indicates that employment (and output) losses are smaller in the nominal economy. The employment losses reach its peak after 3.5 years and are 1.1% – compared to 1.28% in the real economy. The output reaches its trough after 4.5 years and amount to 0.91% – this is smaller than for a case of flexible prices, which is 1.01%.

Figure 19: Evolution of Output and Employment (II)



These findings are further confirmed by the results shown in Table (12) where adjusting the consumption tax produces than it was the case in real economy. For example, the employment cumulative losses in two years are 4.16% – while we previously had it 4.45%, in the real economy.

These results suggest that, when the consumption tax is an instrument of choice, the nominal dimension of fiscal austerity cannot be ignored, but it is, nevertheless, less prominent than for the labor tax. Thus, it is possible for a government to minimize the hindering effects of monetary policy on its fiscal consolidation effort by adjusting consumption tax.

Table 12: Cumulative losses: Consumption Tax Adjustment Under Sticky Prices

Horizon	1 quarter	1 Year	2 Years	5 Years	20 Years	50 Years	Discounted
Output	0.08	0.60	2.77	13.29	35.32	5.67	9.50
Employment	0.13	0.92	4.16	17.75	26.56	-8.96	–

6.3.2 The degree of price rigidity

In this section we investigate how the degree of nominal rigidities affects the fiscal consolidation. Figure 20 – 21 show the transitional paths of fiscal instruments, output and employment as the degree of price rigidity, ϕ, varies in the range from 0 to 200 –the benchmark experiment is set at $\phi = 58$.[20] From the right panel of Figure 20 we see that the major difference in the labor tax, across different degrees of price rigidity, is in the first quarter. The larger the degree of nominal sluggishness the larger the initial increase in the tax, as the inflation tax cannot be used to generate more tax revenues. Once inflation adjusts further, the effect of price rigidity on the response of labor tax vanishes. On one hand, for a very low price rigidity, $\phi = 0$, the initial response of labor tax is a fall from its steady state level – from 25% to 24.6% – before it starts to increase. On the other hand, for a very high degrees of price rigidities, $\phi = 200$, the labor tax sharply increases from its steady state level – from 25% to 29.2% – but from the second quarter the labor tax adjustment is about the same as for other cases. The peak responses in the evolution of labor tax occurs after 3.5 years following the fiscal austerity and it is only slightly higher for flexible prices – 29.9% as opposed to 29.4% for highly sticky prices.

Figure 20: Fiscal Consolidation: Sticky Prices (I)

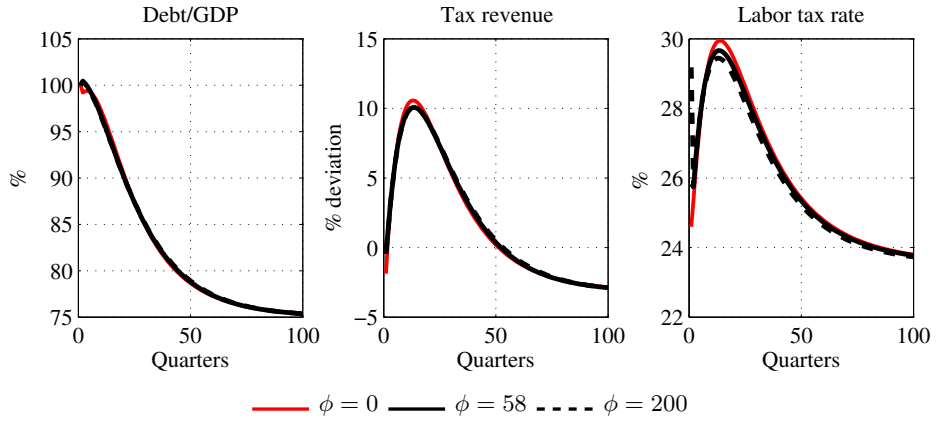
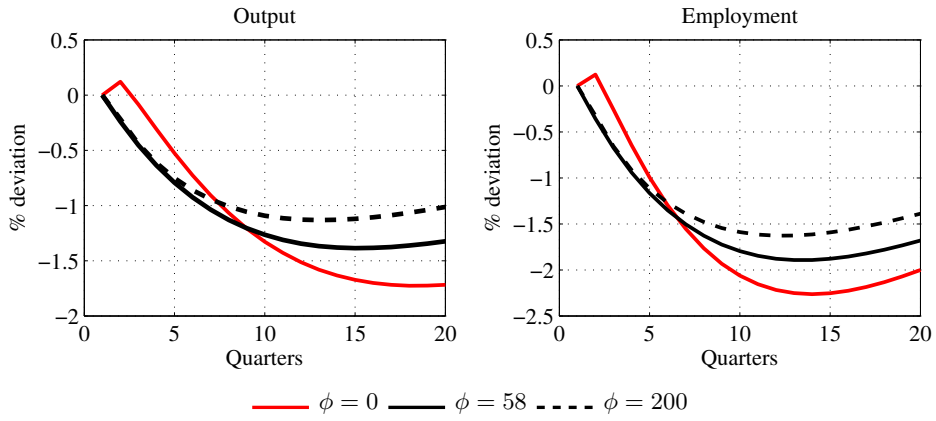


Figure 21 illustrates that, for flexible prices, $\phi = 0$, the employment (and output) losses

[20]Note that the case $\phi = 0$ does not exactly correspond to our benchmark economy as the benchmark economy did not feature imperfect competition.

are smaller in the first few quarters but consequently are more profound than for the sticky prices. The results indicate that the employment and output are both falling in the degree of price rigidity, but those deviations are smaller for a higher degrees of price rigidities.

Figure 21: Evolution of Output and Employment: Sticky Prices (II)



As we have previously seen for a real economy, when prices are able to fully adjust, the intertemporal substitution effect will push inflation up straight away in the first quarter following the fiscal consolidation. The central bank then reacts to stabilize prices by increasing the nominal interest rate. The consumption drops sharply in the first quarter and investment at first increases in the attempt by households to smooth their future consumption. This produces profound employment and output losses. Contrary, when prices are slow to adjust the response of the households will be muted, thus, producing smaller employment and output losses.

Table 13: Cumulative losses: Varying Price Stickiness

Horizon	1 quarter	1 Year	2 Years	5 Years	20 Years	50 Years	Discounted
Output							
$\phi = 0$	-0.12	0.27	3.50	22.45	65.21	15.78	20.00
$\phi = 58$	0.24	1.33	5.22	21.27	50.79	0.31	8.64
$\phi = 200$	0.22	1.27	4.84	17.93	32.99	-20.01	-6.10
Employment							
$\phi = 0$	-0.12	0.78	6.39	32.14	51.98	-8.38	–
$\phi = 58$	0.36	1.97	7.62	29.40	45.92	-15.14	–
$\phi = 200$	0.32	1.89	7.15	25.76	35.91	-26.07	–

These results are confirmed by the cumulative employment and output losses presented in Table (13). For example, the discounted cumulative output losses are highest for flexible prices and in fact turn into cumulative gains for very high degree of price rigidities – 20% employment losses for $\phi = 0$ versus 6.1% employment gains for $\phi = 200$. After 5 years follow-

ing the beginning of debt reduction, there is negative relationship between the employment losses and the degree of price rigidity. For example, for fully flexible prices the employment loss is about 32% but this is reduced down to about 26% for high degree of price rigidity, $\phi = 200$.

These results indicate that when prices are flexible the monetary policy is non neutral and the central bank in its effort to stabilize prices can significantly hinder the fiscal consolidation efforts.

6.3.3 The conduct of monetary policy

This section explores if the central bank, through its concern for inflation and output fluctuations, affects the process of fiscal consolidation. Figure 22 shows the evolution of output and employment as we vary the degree of reactiveness by central bank to inflation, κ_π, and output fluctuations, κ_y.

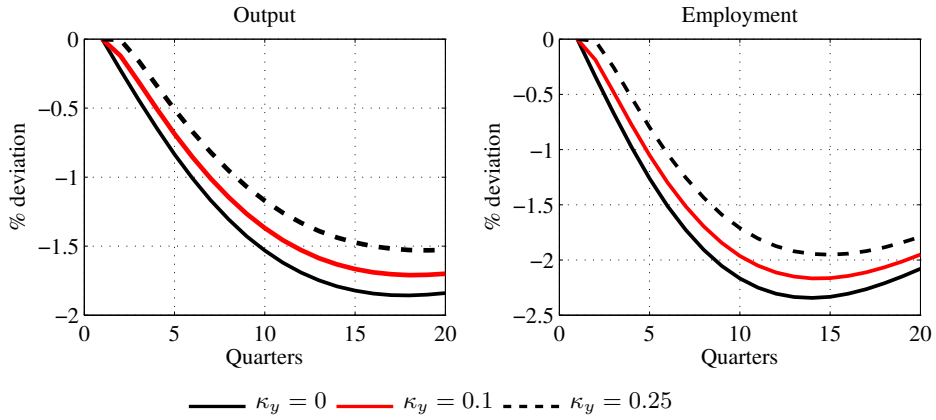
The degree of responsiveness to output fluctuations, κ_y, varies in the range from 0 to 0.25 –the benchmark experiment is set at $\kappa_y = 0.1$. Naturally, greater emphasis on output stabilization is expected to bring about smaller losses in output and employment. This is confirmed by results shown in Panel (a) of Figure 22 where an increase in the reaction of monetary authority to the output fluctuations leads to smaller output and employment losses. Under this policy, the inflation increases and subsequently prompts the central bank to increase nominal interest rate. Higher nominal interest rate makes the public debt more expensive and instigates the households to decrease its debt holdings. Subsequently, this effect aids the whole debt reduction. Consequently, the fiscal revenue required to retire the public debt will not be as high as previously and, thus, the labor tax rate adjustment is lower. For example, with $\kappa_y = 0$ the peak in the evolution of tax rate is 30.25% while with $\kappa_y = 0.25$ it is 29.4% (after 3.5 years following the commencement of fiscal consolidation).

To explore the effect of price stabilization on the fiscal consolidation, the degree of responsiveness to output fluctuations, κ_π, is varied in the range from 1.01 to 2.5 –the benchmark experiment is set at $\kappa_\pi = 1.5$– and to facilitate the exposition a policy rule with $\kappa_y = 0$ is used. Naturally, reaction by central bank to subdue inflation by increasing nominal interest rates will suppress the output and employment further. This is affirmed by Panel (b) of Figure 22 which depicts the evolution of employment and output as a function of the reaction to inflation, κ_π. An increased emphasis on price stability leads to higher output and employment losses. This points to the existence of another trade off between price stabilization and fiscal consolidation effort.

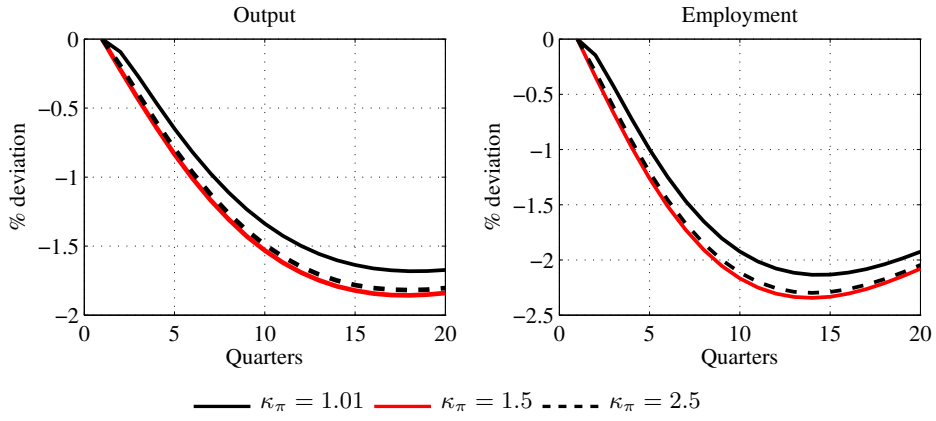
The cumulative output losses as presented in Table (14) similarly point out that greater emphasis on the output stabilization leads to lower output and employment losses in the

Figure 22: Evolution of Output and Employment: Varying κ_π and κ_y

(a) Reaction to Output Gap (κ_y)



(b) Reaction to Inflation (κ_π)



short– and medium–run. For example, for the higher reactiveness by central bank to output fluctuations, $\kappa_y = 0.25$, after 1 years following the beginning of fiscal consolidation we have 0.5% loss in output –0.93% in the benchmark experiment – and 0.8% in employment – 1.44% in the benchmark experiment.

Table 14: Cumulative losses: Varying Response to Output

Horizon	1 quarter	1 Year	2 Years	5 Years	20 Years	50 Years	Discounted
Output							
$\kappa_y = 0$	0.22	1.30	5.62	26.50	72.31	22.91	26.15
$\kappa_y = 0.1$	0.12	0.93	4.63	23.65	66.26	16.86	21.05
$\kappa_y = 0.25$	0.01	0.50	3.45	20.19	58.91	9.60	14.90
Employment							
$\kappa_y = 0$	0.34	1.99	8.40	35.21	55.98	-4.70	–
$\kappa_y = 0.1$	0.19	1.44	7.01	31.75	51.32	-9.07	–
$\kappa_y = 0.25$	0.02	0.80	5.33	27.52	45.58	-14.35	–

Table 15: Cumulative losses: Varying Response to Inflation

Horizon	1 quarter	1 Year	2 Years	5 Years	20 Years	50 Years	Discounted
Output							
$\kappa_\pi = 1.01$	0.09	0.83	4.39	23.05	64.74	15.22	19.76
$\kappa_\pi = 1.5$	0.22	1.30	5.62	26.50	72.31	22.91	26.15
$\kappa_\pi = 2.5$	0.19	1.20	5.35	25.75	70.50	20.83	24.55
Employment							
$\kappa_\pi = 1.01$	0.15	1.30	6.67	31.02	50.01	-10.35	–
$\kappa_\pi = 1.5$	0.34	1.99	8.40	35.21	55.98	-4.70	–
$\kappa_\pi = 2.5$	0.30	1.83	8.02	34.29	54.44	-6.36	–

The results indicate that the interplay between fiscal and monetary policies is non neutral. One one hand, the central bank's effort to stabilize the output fluctuations can ease the recession brought by fiscal consolidation but it prolongs the whole process of the debt reduction. On the other hand, the price stabilization efforts hinder the public debt reduction process and, thus, leads to greater output and employment losses.

7 Conclusion

This paper offers a quantitative evaluation of employment (and output) losses generated during fiscal consolidation episodes. It does this in the context of a textbook neoclassical growth model featuring —search and matching á la Mortensen and Pissarides (1994) and Shimer and Rogerson (2010)— frictions on the labor market. Sovereign debt reduction is achieved

by imposing fiscal authority, either by tax hikes or government expenditures cuts, which plunges the economy in a persistent recession and therefore generates output and employment losses.In the baseline experiment —a targeted 25% debt reduction— unemployment increases by about 50%, starting from 5.5% and reaching 7.3% after 3.35 years. These employment losses are persistent and last on average 12 years. Furthermore, at the trough of the recession (4.5 years following the beginning of the adjustment), output is 1.5% below its initial steady state.

These losses are found to be especially acute during times of recession as there are competing goals placed on the labor tax adjustment by *(i)* fiscal consolidation and *(ii)* output stabilization. The sensitivity analysis indicates further that sizable and speedier debt adjustments are associated with bigger employment and output losses. The front–loading of debt reduction brings bigger initial adjustment which magnifies the employment loss in the short–run. However, economy recovers quicker compared to gradualist approach. A slower adjustment allows for smooth debt adjustment that limits the initial employment loss, but in that case it lasts longer and the economy, thus, suffers longer. Likewise, the more determined fiscal authority is to front–load its debt, the bigger are employment and output losses, but the painful adjustment period is shorter. These findings point to the existence of an intertemporal trade–off between short–run losses from fiscal consolidation and long–run gains from reduced debt.

Moreover, the paper shows that, as already found in the econometric literature (see e.g. Alesina et al. (2014)), the exact details of the consolidation plan do matter; government spending cut versus tax hikes, the type of tax instrument used to achieve fiscal adjustment, and the timing of the plan. Finally, monetary policy interplays with fiscal policy. The central bank, by adjusting the nominal interest rate, affects the value of debt used by households to transfer wealth from one period to the next. Higher nominal interest rate increases the value of debt, which then reduces its demand by households. This aids the whole debt reduction process and, thus, speeding up the fiscal consolidation in the short–run.

The results of this paper suggest that debt reduction should be accompanied with reforms on the labor market to tame down labor market frictions. This is left for future research.

References

Alesina, A., Favero, C., and Giavazzi, F. (2014). The output effect of fiscal consolidation plans. Technical report.

Andolfatto, D. (1996). Business cycles and labor-market search. *American Economic Review*, 86(1):112–32.

Blanchard, O. J. (1984). A reexamination of the theory of automatic stabilizers income stability and economic efficiency under alternative tax schemes: Comments on christiano and miller. Technical Report 1.

Blanchard, O. J. and Diamond, P. (1989). The beveridge curve. *Brookings Papers on Economic Activity*, 20(1):1–76.

Boucekkine, R. (1995). An alternative methodology for solving nonlinear forward-looking models. *Journal of Economics Dynamics and Control*, 19(4):711–34.

Christiano, Lawrence, J., Eichenbaum, M., and Evans, C. L. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy*, 113(1):1–45.

Erceg, C. and Lindé, J. (2012). Fiscal consolidation in a currency union: Spending cuts vs. tax hikes. Technical report.

Fève, P., Matheron, J., and Sahuc, J. (2010). La tva social: Bonne ou mauvaise idée? *Economie et Prévision*, 193:1–19.

Fève, P. and Langot, F. (1996). Unemployment and the business cycle in a small open economy: G.M.M. estimation and testing with French data. *Journal of Economic Dynamics and Control*, 20(9-10):1609–1639.

Hagedorn, M. and Manovskii, I. (2008a). The cyclical behavior of equilibrium unemployment and vacancies revisited. *American Economic Review*, 98(4):1692–1706.

Hagedorn, M. and Manovskii, I. (2008b). The cyclical behavior of equilibrium unemployment and vacancies revisited. Technical Report 4.

Krusell, P., Smith, A. A., and Jr. (1998). Income and Wealth Heterogeneity in the Macroeconomy. *Journal of Political Economy*, 106(5):867–896.

Mendoza, E. G., Razin, A., and Tesar, L. L. (1994). Effective tax rates in macroeconomics: cross-country estimates of tax-rates of factor incomes and consumption. *Journal of Monetary Economics*, 34(3):297–323.

Merz, M. (1995). Search in the labor market and the real business cycle. *Journal of Monetary Economics*, 36:269–300.

Mortensen, D. T. and Pissarides, C. A. (1994). Job creation and job destruction in the theory of unemployment. *The review of economic studies*, 61(3):397–415.

Pappa, E., Sajedi, R., and Vella, E. (2014). Fiscal consolidation with tax evasion and rent seeking: Spending cuts versus tax hikes. Technical report.

Perotti, R. (1996). Fiscal consolidation in the europe: Composition matters. *American economic review*, 86(2):105–110.

Pissarides, C. (1986). Unemployment and vacancies in britain. *Economic policy*, 1(3):499–559.

Reinhart, C. M. and Rogoff, K. S. (2010). Growth in a time of debt. *American economic review*, 100(2):573–578.

Rotemberg, J. J. (1982). Sticky prices in the united states. *Journal of Political Economy*, 90:1187–1211.

Sargent, T. J. (1983). Stopping moderate inflations: The methods of poincare and thatcher. In Dornbusch, R. and Simonsen, M. H., editors, *In Inflation, debt, and indexation*. Cambridge, Mass.: MIT Press.

Shimer, R. and Rogerson, R. (2010). Search in macroeconomic models of the labor market. In Ashenfelter, O. and Card, D., editors, *Handbook of Labor Economics*, volume 4A, pages 619–700.

Yellen, J. (2014). Chair yellen's press conference, september, 17, 2014. Technical report.

—APPENDIX—

A Model

A.1 Household

The household has preferences over consumption and leisure described by the following intertemporal utility function

$$\sum_{t=0}^{\infty} \beta^t \left(\log c_t - \vartheta \frac{n_t^{1+\nu}}{1+\nu} \right) \tag{31}$$

subject to the budget constraint, the law motion of capital and the law motion of employment, respectively,

$$(1+\tau_t^c)c_t + i_t + b_t = r_{t-1}b_{t-1} + (1-\tau_t^w)w_t n_t + (1-\tau_t^k)z_t k_t + \Pi_t + T_t \tag{32}$$

$$k_{t+1} = \left(1 - \frac{\varphi}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 \right) i_t + (1-\delta)k_t \tag{33}$$

The optimality conditions are given as

$$\lambda_t = \frac{1}{c_t(1+\tau_t^c)} \tag{34}$$

$$\lambda_t = \beta \lambda_{t+1} r_t \tag{35}$$

$$\zeta_t = \beta \left(\lambda_{t+1}(1-\tau_{t+1}^k)z_{t+1} + \zeta_{t+1}(1-\delta) \right) \tag{36}$$

$$\lambda_t = \zeta_t \left(1 - \frac{\varphi}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 - \varphi \left(\frac{i_t}{i_{t-1}} - 1 \right) \frac{i_t}{i_{t-1}} \right) + \beta \zeta_{t+1} \varphi \left(\frac{i_{t+1}}{i_t} - 1 \right) \left(\frac{i_{t+1}}{i_t} \right)^2 \tag{37}$$

where λ_t and ζ_t are the Lagrange multipliers associated, respectively, to the budget constraint and the capital equation. This system rewrites as The household's optimal behavior is then characterized by the set of Euler conditions

$$\frac{1}{c_t(1+\tau_t^c)} = \beta \frac{r_t}{c_{t+1}(1+\tau_{t+1}^c)} \tag{38}$$

$$q_t^i = \beta \frac{c_t(1+\tau_t^c)}{c_{t+1}(1+\tau_{t+1}^c)} (z_{t+1}(1-\tau_{t+1}^k) + q_{t+1}^i(1-\delta)) \tag{39}$$

where $q_t^i = \zeta_t/\lambda_t$ denotes the marginal Tobin's Q.

A.2 Firm

The firm decides its production and vacancy posting plans by maximizing its intertemporal discounted profit subject to the law of motion of employment

$$\max \sum_{t=0}^{\infty} \Psi_{t,0} \left(A_t k_t^{\alpha}(j) n_t(j)^{1-\alpha} - z_t k_t(j) - w_t n_t(j) - a v_t(j) \right) \tag{40}$$

subject to

$$n_{t+1}(j) = q_t v_t(j) + (1-\psi) n_t \tag{41}$$

$\Psi_{t,0}$ denotes the discount factor of the firm between periods 0 and t, given that, in the model, the interests of the manager of the firm are aligned with those of the shareholder –the household– the proper discount factor is given by $\Psi_{t,0} \propto \beta^t (1+\tau_0^c) \frac{\partial U(c_t, n_t)}{\partial c_t} / (1+\tau_t^c) \frac{\partial U(c_0, n_0)}{\partial c_0}$. The optimality conditions are then given as

$$\mu_t(j) = \Psi_{t+1,t} \left\{ (1-\alpha) \frac{y_{t+1}(j)}{n_{t+1}(j)} - w_{t+1} + (1-\psi) \mu_{t+1}(j) \right\} \tag{42}$$

$$a = q_t \mu_t(j) \tag{43}$$

$$z_t = \alpha \frac{y_t(j)}{k_t(j)} \tag{44}$$

where $\mu_t(j)$ denotes the Lagrange multiplier associated to the law of motion of employment.

The optimal production and vacancy posting plans are characterized by the following optimality conditions

$$z_t = \alpha \frac{y_t(j)}{k_t(j)} \tag{45}$$

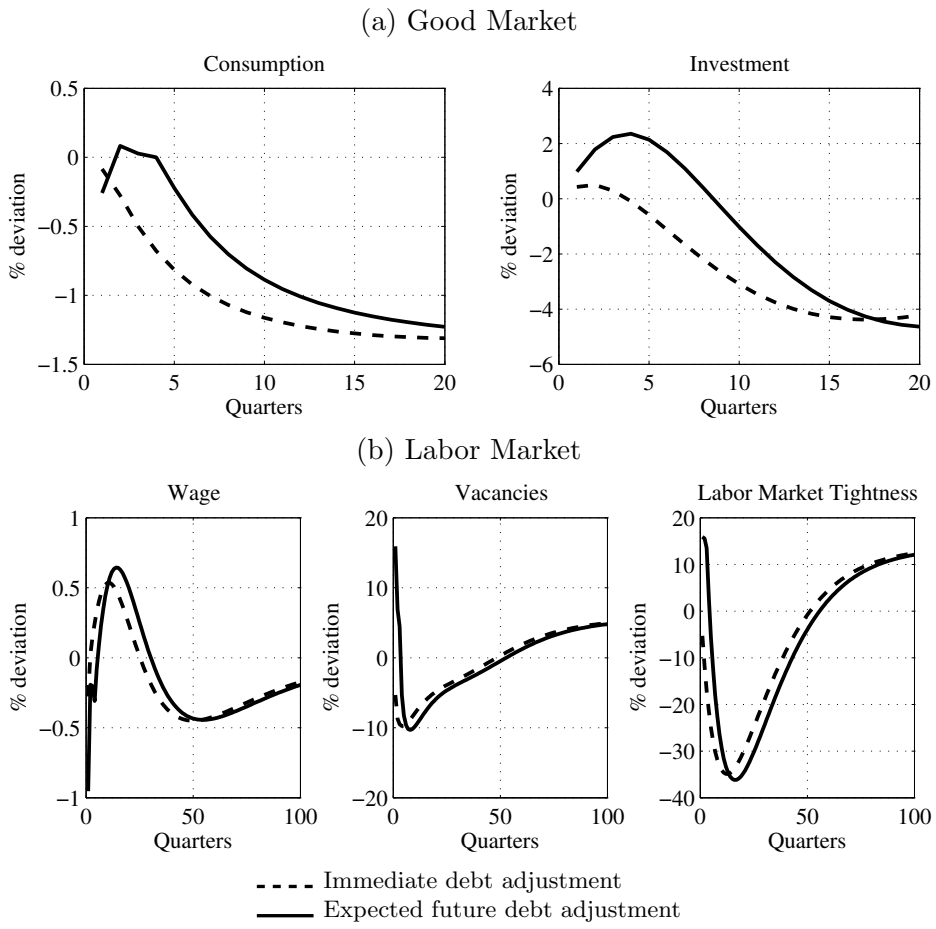
$$\frac{a}{q_t} = \beta \frac{c_t(1+\tau_t^c)}{c_{t+1}(1+\tau_{t+1}^c)} \left((1-\alpha) \frac{y_{t+1}(j)}{n_{t+1}(j)} - w_{t+1} + (1-\psi) \frac{a}{q_{t+1}} \right) \tag{46}$$

The first condition is the standard demand for capital. The second condition determines the optimal vacancy posting behavior–and hence the optimal employment level.

B Additional Figures

B.1 Real Model

Figure 23: Macroeconomic responses (Anticipated Debt Reduction Experiment)



B.2 Sticky Price Model

Figure 24: Macroeconomic responses (Sticky Prices Experiment)

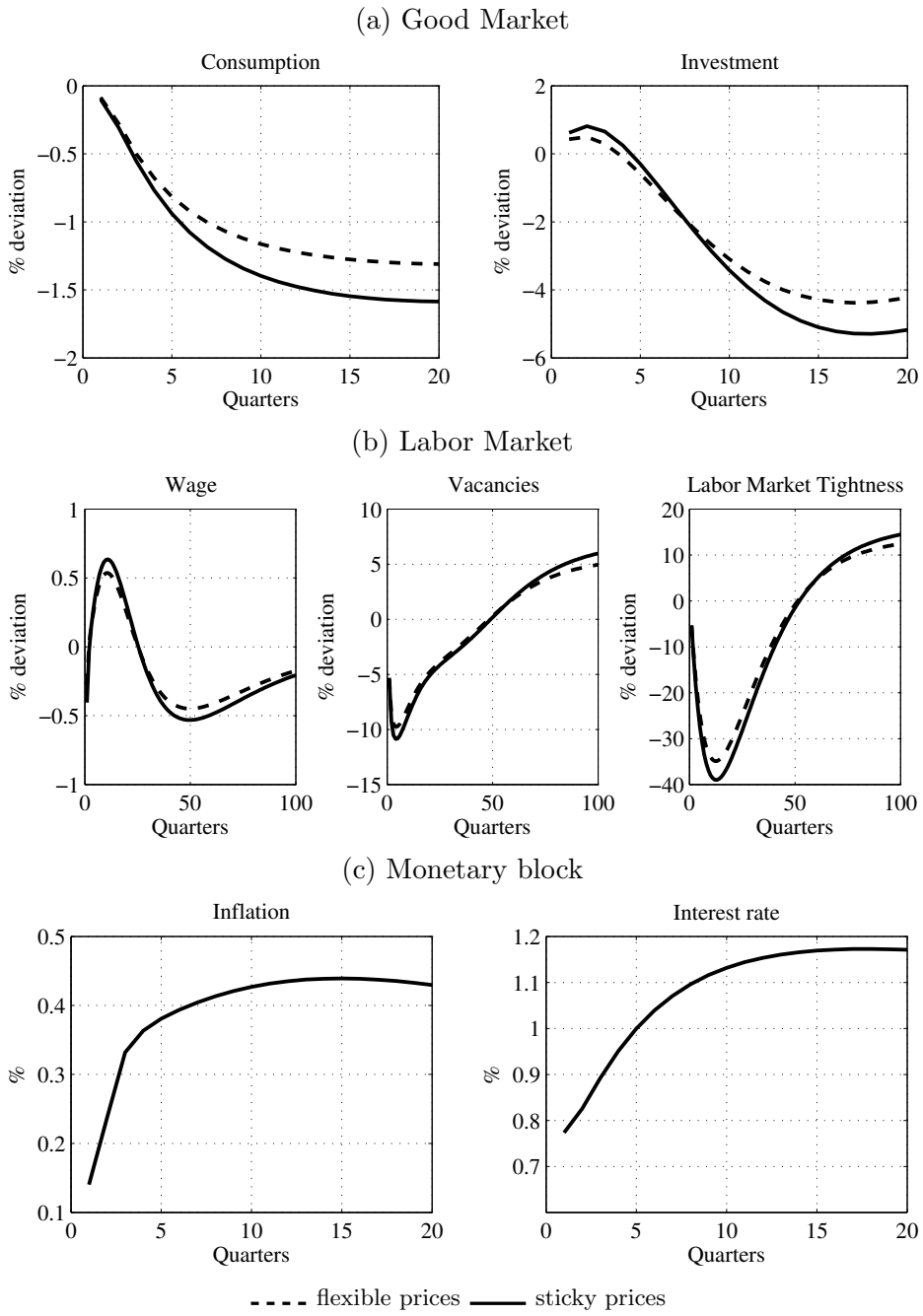


Figure 25: Macroeconomic responses: Adjusting Consumption Tax Rate

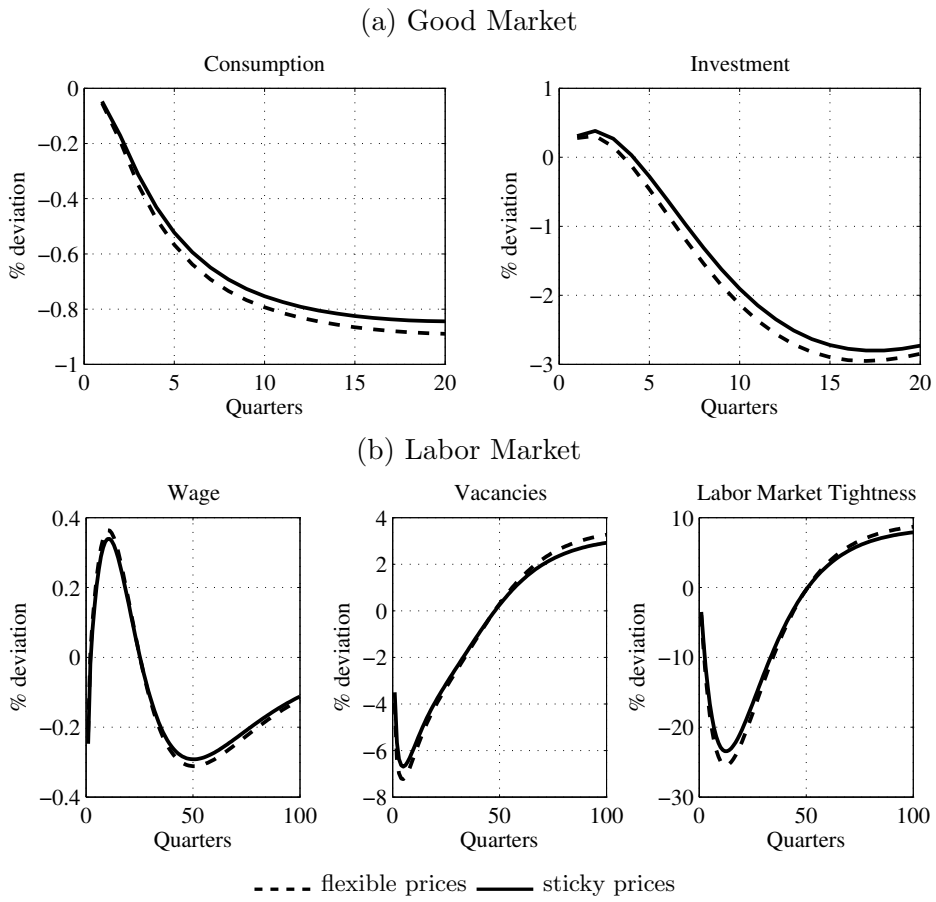


Figure 26: Macroeconomic responses: Varying the degree of price rigidity

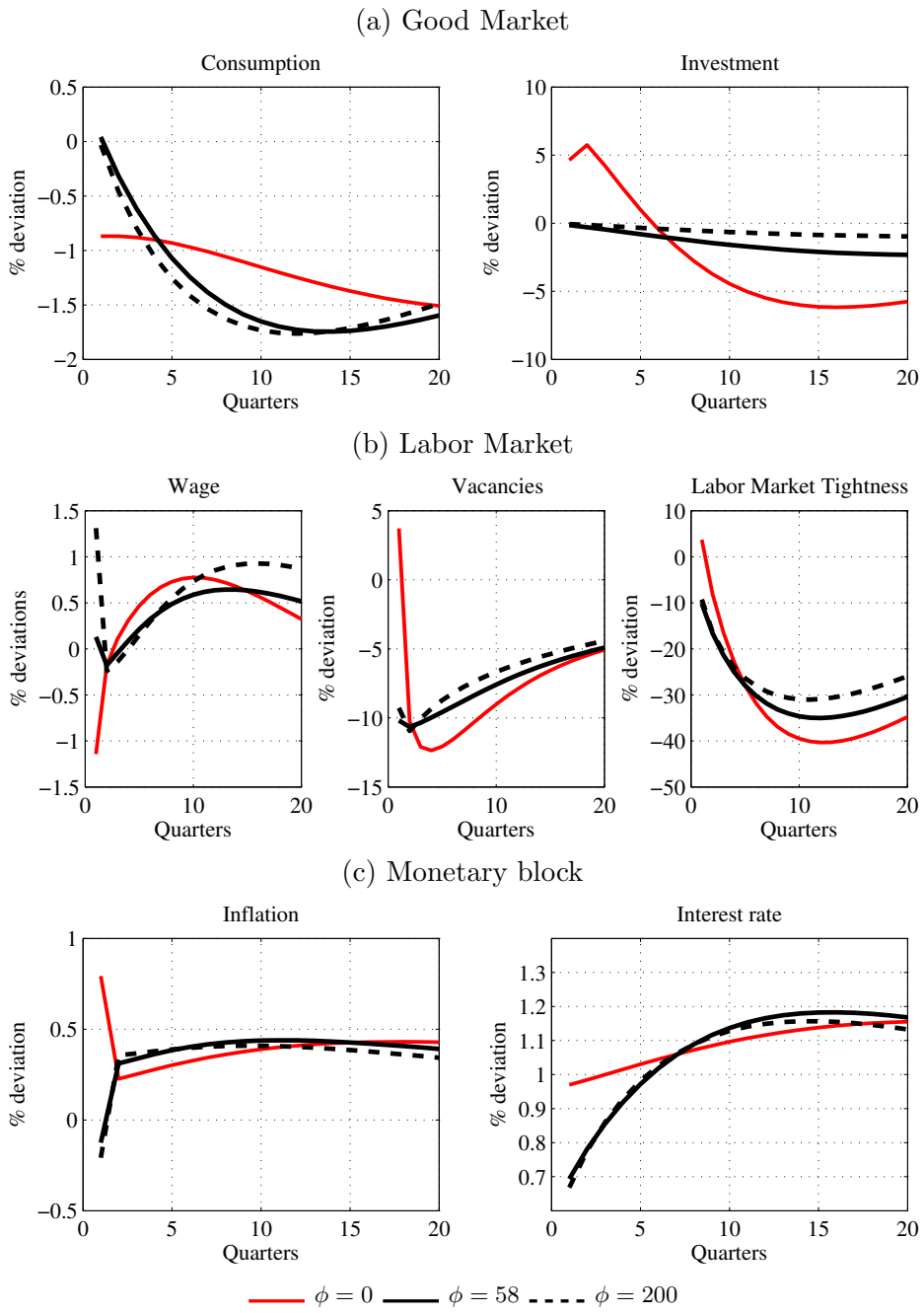


Figure 27: Fiscal Consolidation: Reaction to Output Gap

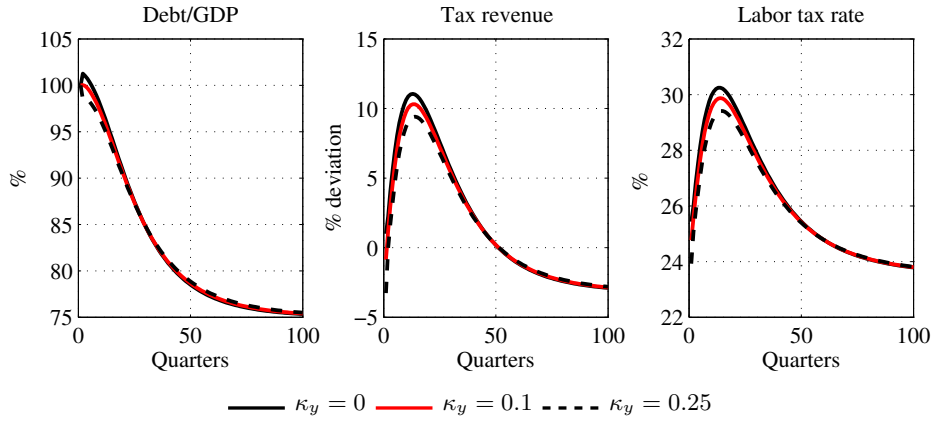


Figure 28: Macroeconomic responses: Reaction to Output Gap

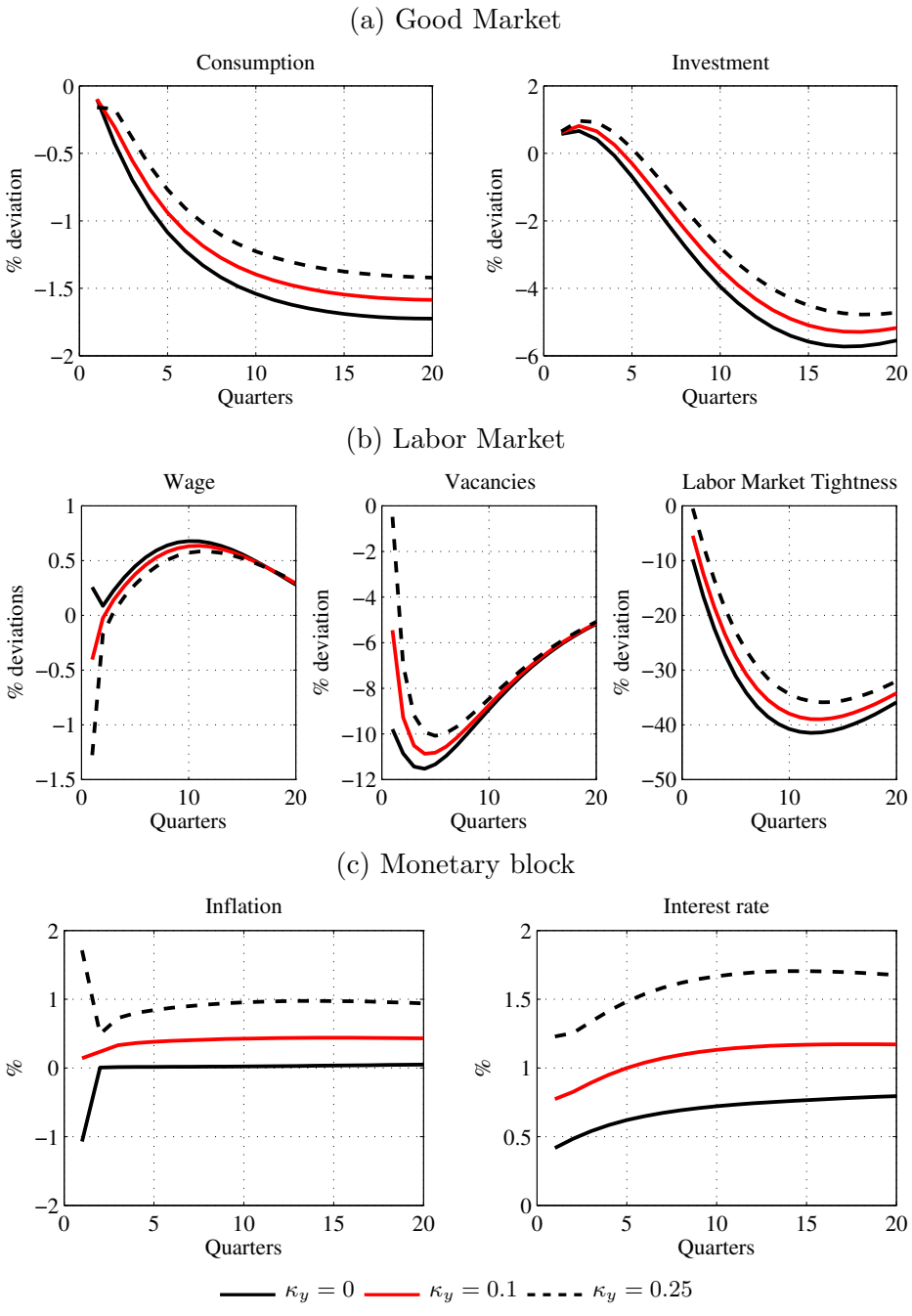


Figure 29: Fiscal Consolidation: Reaction to Inflation

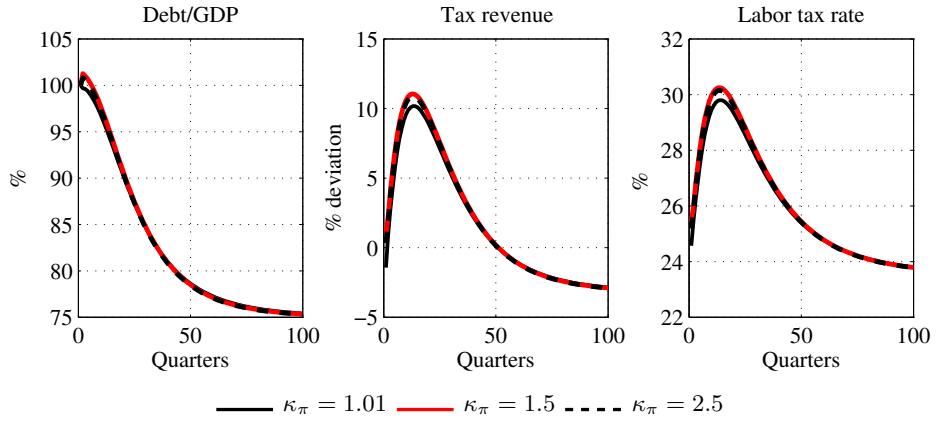


Figure 30: Macroeconomic responses: Reaction to Inflation