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Date *January 29, 2014*

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Contents

List of Figures

List of Tables

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Abstract

My PhD thesis studies the impact of fiscal policy on economic activity and redistribution, focusing on the size of the government spending multiplier. The first chapter, 'Fiscal Policy in Bad and Good Times', contributes to the discussion on whether increase in government purchases has asymmetric effects in recessions and booms, using a model with heterogeneous agents and aggregate uncertainty. It shows that decrease in consumption and increase in labor supply is larger if the positive government purchases shock occurs in a recession, because more households have low wealth in such times and these are the households that react stronger to changes in policy. However, quantitatively the differences between good and bad states are found to be small.

The second chapter, 'On the Relationship between Government Spending Multiplier and Welfare', answers the question whether higher government spending multiplier implies higher increase in social welfare. In a representative agent economy the overall aggregate output effect of fiscal policy, summarized by the long-run cumulative multiplier, is positively related to welfare increase. When heterogeneity across households is taken into account, redistributive aspects of the increase in government purchases become relevant. The paper shows that these aspects play an important quantitative role in social welfare evaluation of fiscal policy, and they can move welfare in the opposite direction than the multiplier effect if the welfare of the poor is given enough weight in the social welfare function.

The third chapter, 'Output and Employment Fiscal Multipliers over the Medium Term', examines the impact of fiscal consolidations on output growth over the medium term. The main finding is that during prolonged economic contractions spending-based consolidations have a large and persistent negative impact on GDP growth and employment, and increase the actual and non-accelerating inflation unemployment rates (NAIRU).

Introduction

My PhD thesis studies the impact of fiscal policy on economic activity and redistribution. In particular, I focus on government spending and the corresponding multiplier. I explore several dimensions of this topic. The impact of government purchases on economic activity and its variation over the business cycle is one of the avenues my research has taken. Another direction is exploration of welfare implications of the government spending multiplier. Finally, I look at the effect of fiscal consolidations on output and employment.

The first chapter, 'Fiscal policy in bad and good times', studies asymmetries in consumption and output response to a government purchases shock depending on whether this shock arrives in bad or good times, which differ by aggregate productivity level and unemployment process. I use a small open economy version of a model with incomplete markets and idiosyncratic risk (Bewley-Huggett-Aiyagari) with aggregate uncertainty a-la Krusell and Smith (1998) and fiscal policy. The mechanism, which allows for an asymmetric response to a government purchases shock, relies on the differences in consumption, asset and labour supply choices across different agents, and how the distribution of these agents evolves in good and bad times. I find that decrease in consumption and increase in labour supply is larger if the positive government purchases shock occurs in a recession. However, quantitatively the differences between good and bad states are found to be small.

The second chapter is named 'On the relationship between government spending multiplier and welfare'. While aggregate output effect of fiscal stimulus, summarized by the size of the multiplier, has been extensively studied in recent years, little attention has been given to understanding the welfare content of this statistic. The paper answers the question whether higher government spending multiplier implies higher increase in social welfare. In a representative agent economy the effects of increase in spending on aggregate output are easily mapped into changes in consumption and hours, and therefore into welfare of the representative agent. When heterogeneity across households is taken into account, redistributive aspects of the increase in government purchases become relevant. The paper shows that these aspects play an important quantitative role in welfare evaluation of fiscal policy. I find that certain combinations of structural parameter values can produce a higher cumulative multiplier but also a larger dispersion of welfare gains, with the poorest households losing the most. The real interest rate behavior is the main factor defining how gains and losses are divided between wealth rich and wealth poor. This result is in contrast to a representative agent model, in which the cumulative output effect of government spending is a good indicator for welfare change.

The third chapter, 'Output and Employment Fiscal Multipliers over the Medium Term', is co-authored with Marcos Poplawski-Ribeiro and Salvatore Dell'Erba, IMF. While the literature has tended to focus on the short-run fiscal multiplier, this paper examines the impact of fiscal consolidations on output growth over the medium term. We estimate the impact of tax hikes and spending cuts on real GDP per capita growth over a horizon of up to 5 years for a sample of 17 OECD countries. Consolidation episodes are identified using the DeVries et al. (2011) dataset based on a narrative approach. We find that during prolonged economic contractions spending-based consolidations have a large and persistent negative impact on GDP growth and employment, and increase the actual and non-accelerating inflation unemployment rates (NAIRU). Our results suggest that a hysteresis effect in the labor market could be an important mechanism to explain the persistent decline in GDP.

Chapter 1

Fiscal Policy in Bad and Good Times

1.1 Introduction

By how much does output in an economy go up if the government temporarily increases its purchases of goods and services? The question has been a subject of a long debate among academics and policy makers, both in theory and empirical work. The global financial crisis brought renewed interest to this issue as governments in many developed countries used large stimulus packages trying to bring the economies out of recession. Recent studies in this area started to explore if the multiplier can be larger in some circumstances, for example depending on the monetary policy (zero bound), debt levels or output growth rates[1].

The question I would like to address with this paper is whether the response of aggregate consumption and output to an increase in unproductive government purchases is quantitatively different in different states of the economy. I refer to these states as bad and good times, which differ by aggregate productivity level and unemployment process. I use an incomplete markets, heterogeneous agents small open economy model with aggregate uncertainty. The model allows to consider also a variety of effects of government consumption shock across different types of agents.

The latter not only has potentially important implications for the response of aggregate variables, but is an interesting issue in itself. It has been well documented that real economies are characterized by a high degree of heterogeneity among agents along several dimensions (Krueger et al. (2010)). The relatively unexplored question is how heterogeneity among agents affects the transmission mechanism of government spending shocks, and what are the consequences of these shocks for different groups of agents.

[1] Christiano et al. (2009), Hall (2009), Woodford (2011), Mankiw and Weinzierl (2011), Corsetti et al. (2010), Mertens and Ravn (2010), Auerbach and Gorodnichenko (2012) to name just a few recent papers.

I analyze government consumption increase financed by lump-sum taxes. If prices are flexible the only effect this policy has is the negative wealth effect due to increased taxes. In a representative agent model with flexible prices it does not matter when the government spending shock occurs, in good or bad times, since the agent behaves as a Ricardian consumer, only the total amount of taxes to be collected matters.

In my model the mechanism, which allows for an asymmetric response to a government purchases shock, relies on the differences in consumption, asset and labor supply choices across different, ex-post heterogeneous agents, and how the distribution of these agents evolves in good and bad times. Presence of idiosyncratic uncertainty and borrowing constraints implies that the consumption policy function is concave in wealth (Carroll and Kimball (1996)), which translates into a convex policy function for labor. The combination of policy functions' non-linearity and changes in wealth distribution over the business cycle delivers asymmetric size of aggregate consumption and output responses to fiscal shocks in different phases of the cycle.

I show that the responses of consumption and hours to government purchases increase financed by lump-sum taxes differ across heterogeneous agents and across aggregate states even under flexible goods prices. I find that decrease in consumption and increase in labor supply is larger if the positive government purchases shock occurs in a recession, and the change of output on impact is larger if taxes balance the budget each period compared to issuing debt. A larger response of labor supply in a recession leads to a larger response in output when prices are flexible. However, quantitatively the differences between good and bad states are small. One dollar increase in government spending leads to a 40 cents increase in output in good times and 46 cents in bad times; consumption falls by 30 cents in the first case and 38 cents in the second case. The small difference in multipliers arises because labor supply counteracts movements in aggregate productivity, i.e. labor supply expands by more in bad times in reaction to tax increases, but low aggregate productivity of each additional hour worked mitigates the effect on output.

The rest of the paper is organized in the following way. Section 1.2 relates this work to relevant strands of literature. Section 1.3 presents the model with aggregate uncertainty and defines the equilibrium. In Section 1.4 I proceed with discussing the numerical techniques I use to solve for the model's steady state and the dynamics during the transition after a fiscal shock. In Section 1.5 I describe the benchmark calibration and discuss properties of the model. Main results are presented in Section 1.6. Finally, Section 1.7 discusses further ways to extend this research.

1.2 Literature review

This paper can be related to different strands of literature. First, building on the vast empirical literature on the size of the government spending multiplier (Blanchard and Perotti (2002), Perotti (2008), Ramey and Shapiro (1998), Ramey (2011), Romer and Romer (2010), Perotti (2011)), a number of recent papers address the question of differences in fiscal policy multiplier in different states of the economy. Barro and Redlick (2011) find that defense spending multiplier is 0.6-0.7 at median unemployment rate, and it rises to 1 when unemployment is about 12 %. Tagkalakis (2008) documents that fiscal policy is more effective in boosting private consumption in recession due to presence of liquidity constraints, and the effect is more pronounced in countries with less developed credit markets. The IMF, based on analysis by Blanchard and Leigh (2013), updated its view on multipliers after 2009, stating that while before the crisis the number was around 0.5, after 2009 the multiplier is likely to be in the range 0.9-1.7.

Auerbach and Gorodnichenko (2012) find that the government spending multiplier after several quarters is larger in recessions than in expansions, although impact multiplier is the same. On the contrary, Ramey and Zubairy (2013) show that for the U.S. there is no statistically significant different between multipliers in good and bad times, which they define based on unemployment dynamics. The paper shows that although the impulse responses to a government spending shock are different in the two states, the cumulative multipliers are not. The reason is that the response of government expenditures is also larger in a bad state. The paper argues that Auerbach and Gorodnichenko (2012) results are driven by their assumption on the duration of the bad state, which they assume to be 20 quarters. The methodology used by Ramey and Zubairy (2013) instead does not require assumptions on the duration of the recession. Interestingly, Owyang et al. (2013) apply Ramey and Zubairy (2013) analysis to Canadian economy and find statistically significant differences in multiplier, with cumulative multipliers being larger in the bad state. Therefore, empirically the question of whether the size of the multiplier is state dependent remains an open question.

Second, many studies investigated the size of the multiplier using structural models. Starting from the seminal work of Baxter and King (1993) on the effects of fiscal policy in a standard RBC model, there have been a number of important contributions concerning the size of the multiplier in alternative frameworks. One noticeable strand of literature (Galí et al. (2007), Monacelli and Perotti (2008), Bilbiie (2009)) is aimed at building a model which could generate a positive response of consumption to a government purchases shock, which would be consistent with empirical findings from structural VARs.

The financial crisis of 2008 which brought the monetary policy to hitting the zero bound on the nominal interest rate triggered a rapidly growing interest in the effects of fiscal policy under these circumstances. A number of authors find that government spending multiplier is larger when the monetary policy cannot stabilize the economy due to the situation of a liquidity trap (Christiano et al. (2009), Hall (2009),Woodford (2011), Eggertsson (2011)). Contrary to this, Mertens and Ravn (2010) point out that the multiplier might be even smaller than in normal times if the liquidity trap is driven by expectations.

Finally, there have been recent important developments in the literature on the cost of business cycles (Krusell et al. (1998), Mukoyama and Sahin (2006), Krusell et al. (2009)), originated by Lucas (1987). These papers are relevant for two reasons: first, my work heavily builds on the framework with aggregate uncertainty, first introduced by Krusell et al. (1998). Second, these papers find that the costs of aggregate fluctuations might be particularly high for some groups of households (poor and low skilled workers), therefore fiscal policy impact on welfare of different groups of agents is potentially very important. In a similar framework Heathcote (2005) analyzes the effects of changes in the timing of taxes and finds that period-to-period changes in consumption are about one third of the tax change which suggest large departures from Ricardian equivalence.

1.3 Model

I build a small open economy model where agents are ex-ante identical, but ex-post heterogeneous due to drawing different sequences of idiosyncratic shocks to labor productivity and employment status. Since markets are incomplete, agents cannot fully insure against these idiosyncratic shocks and the only source of insurance available is building a buffer stock of saving to smooth consumption over time. My model is an extension of model proposed by Huggett (1993), incorporated into the framework with aggregate uncertainty of Krusell et al. (1998), and allows for endogenous labor supply and fiscal policy.

1. Preferences

   There is a continuum of workers with identical preferences but different idiosyncratic labour productivity and employment statuses. Utility function takes the form

$$E\sum_{t=0}^{\infty}\beta^t u(c_t, l_t) \tag{1.1}$$

   where $\beta \in (0,1)$, c_t is level of consumption, l_t is proportion of time devoted to working activities, and $u(c_t, l_t)$ is instantaneous utility.

Each agent's employment status $\xi \in \{e, u\}$ evolves according to a two-state Markov process, with transition probability depending on the current and next period aggregate state. I denote the transition probability matrix Γ, where $\Gamma_{ij} = Pr(\xi_{t+1} = \xi_j | \xi_t = \xi_i)$ is the probability that next period employment status is ξ_j given that current employment status is ξ_i.

If the agent is employed, her idiosyncratic productivity x_t follows a stationary Markov process with 3 states and a transition probability matrix Π, where $\Pi_{ij} = Pr(x_{t+1} = x_j | x_t = x_i)$. The set of possible productivity values is $X = \{x_1, x_2, x_3\}$, where $x_1 < x2 < x3$. I assume that the idiosyncratic productivity process is independent of the aggregate states and of the transition between them. When an unemployed agent finds a job, she draws her idiosyncratic productivity shock from the time-invariant distribution p^*, induced by Π.

To sum up, given a particular aggregate state ('bad times','normal times' or 'good times'), there are four possible individual states for each agent $\{ex_1,\ ex_2,\ ex_3,\ u\}$, where

$$
\begin{aligned}
ex_1 &= \text{employed with low productivity} \\
ex_2 &= \text{employed with middle productivity} \\
ex_3 &= \text{employed with high productivity} \\
u &= \text{unemployed.}
\end{aligned}
$$

Period t employment status and productivity level are realized before period t decisions are made.

Given an aggregate state, the transition matrix between idiosyncratic states takes the form

$$\Psi = \begin{bmatrix} \Psi_{ee} & \Psi_{eu} \\ \Psi_{ue} & \Psi_{uu} \end{bmatrix}$$

with four sub-matrices given by

$$
\begin{aligned}
\Psi_{ee} &= \Gamma_{ee}\Pi & \qquad \Psi_{eu} &= \Gamma_{eu} I_{N\times 1} \\
\Psi_{ue} &= \Gamma_{ue} p^* & \qquad \Psi_{uu} &= \Gamma_{uu} I_{1\times 1}
\end{aligned}
$$

Asset markets are incomplete, so agents cannot fully insure themselves against idiosyncratic shocks. There is only one asset that agents can use to smooth consumption. Entering period t with a_t units of the asset entitles the agent to $(1+r)a_t$ units of consumption in period t. To have $(1+r)a_{t+1}$ units of consumption next period the agent must buy a_{t+1} units of asset in the current period. Asset holdings of an agent are allowed to take negative values, i.e. whenever an agent chooses $a_t < 0$ she borrows.

The budget constraint is

$$a_{t+1} + c_t = z_t + (1 + r)a_t \tag{1.2}$$

where r is the risk-free interest rate (same for borrowing and lending), and z_t is the current labor income of an agent. If an agent is employed, she is endowed with the following production technology

$$y_t = A_t x_t l_t. \tag{1.3}$$

After-tax income of an employed agent is $z_t = A_t x_t l_t - \tau_t$, where $A_t \in A$ is the aggregate productivity shock taking three values $A = \{A_h, A_m, A_l\}$. If the agent is currently unemployed, her non-capital income is $z_t = u_t - \tau_t$, where u_t is home production[2].

Agents are subject to the following borrowing constraint

$$a_{t+1} \geq -\bar{a}, \quad \bar{a} > 0 \tag{1.4}$$

where $\bar{a} = min\left\{b, \frac{z_{min}}{r}\right\}$ with b being an arbitrary "ad hoc" borrowing limit, and $\frac{z_{min}}{r}$ being the "natural" borrowing limit (equivalent of No-Ponzi-game).

2. Aggregate uncertainty

I introduce aggregate uncertainty similar to Krusell et al. (2009), namely I assume that transition probabilities between employment and unemployment Γ_{ij} are different in good and bad times, and also for transition between good and bad times. High and medium realizations of aggregate productivity, A_h and A_m, correspond to good times and normal times respectively, and low realization of aggregate productivity A_l corresponds to bad times.

Transition matrix between employment and unemployment states given the current aggregate state $q \in \{g, n, b\}$[3], when next period state is $q' \in \{g, n, b\}$ is

$$\Gamma^{qq'} = \begin{bmatrix} \Gamma^{qq'}_{ee} & \Gamma^{qq'}_{eu} \\ \Gamma^{qq'}_{ue} & \Gamma^{qq'}_{uu} \end{bmatrix}$$

[2] Income of the unemployed agent, u_t, could also be interpreted as an unemployment benefit. I interpret it as home production in order to avoid including it into the government budget constraint, and therefore to use taxes only as a means to finance government spending. Positive home production ensures that the natural borrowing limit is different from zero.

[3] In the rest of the paper 'g' refers to 'good times', 'n' refers to 'normal times' and 'b' refers to 'bad times'.

Transition matrix $\Gamma^{qq'}$ is the same for good and normal times. The differences in transition probabilities in good and bad times are the following: $\Gamma^{bg}_{ee} > \Gamma^{gg}_{ee} > \Gamma^{bb}_{ee} > \Gamma^{gb}_{ee}$, and $\Gamma^{bg}_{uu} < \Gamma^{gg}_{uu} < \Gamma^{bb}_{uu} < \Gamma^{gb}_{uu}$.

Thus, a good (normal) state means a state in which it is more probable to be employed and less probable to be unemployed, i.e. overall an agent has better employment prospects, and also the aggregate productivity is higher.

Transition matrix between aggregate states is

$$\Phi^{aggr} = \begin{bmatrix} \Phi_{gg} & \Phi_{gn} & \Phi_{gb} \\ \Phi_{ng} & \Phi_{nn} & \Phi_{nb} \\ \Phi_{bg} & \Phi_{bn} & \Phi_{bb} \end{bmatrix}$$

To summarize, I have 4×3 possible states for each agent: $S = \{s_{1:3} = emp,\ good; s_4 = unemp,\ good\ ; s_{5:7} = emp,\ normal; s_8 = unemp,\ normal; s_{9:11} = emp,\ bad; s_{12} = unemp,\ bad\}$. For example, state s_3 means that an individual is employed, has high idiosyncratic productivity and the current aggregate state is good.

Transition matrix of the 4×3 Markov chain is P with $P_{ij} = Pr(s_{t+1} = s_j | s_t = s_i)$. For example, $Pr(\{x_{t+1} = x_1, e, good\} \,|\, \{x_t = x_3, e, good\}) = \Phi_{gg}\Gamma^{gg}_{ee}\Pi_{13}$.

3. Recursive representation of the agent's problem

$$\begin{aligned} V(a,s) = \max_{c,l,a'} \quad & u(c,l) + \beta \sum_{s} \text{Prob}(s'|s)V(a',s') \\ \text{s.t.} \quad & c = z + (1+r)a - a' \\ & z = I_{\xi=e}Axl + I_{\xi=u}u - \tau \\ & a' \geq -\bar{a} \\ & l \in [0,1] \\ & c \geq 0 \end{aligned}$$

4. Joint wealth-productivity distribution

Each agent's position at each point in time is defined by the individual state vector (a,s), where $a \in E = [-\bar{a}, a_{max}]$ [4] and $s \in S = \{s_1, \cdots, s_{12}\}$. I do not need to include current aggregate state separately in the vector of states, because the current aggregate productivity level and transition between employment and unemployment are already incorporated into current individual state s and transition matrix P, and

[4] a_{max} is the highest possible amount of assets agents can hold, and is set high enough to never restrict the amount of savings of any agent in equilibrium.

the interest rate is fixed[5]. Therefore the component in the law of motion of wealth-productivity distribution added by aggregate uncertainty is purely exogenous.

Unconditional distribution of (a_t, s_t) pairs is $\lambda_t(a,s) = \text{Prob}(a_t = a, s_t = s)$. Denote $\Omega = E \times S$. The probability measure $\lambda(a,s)$ is defined over the Borel σ-algebra of Ω. The law of motion for the distribution is

$$\begin{aligned}\lambda_{t+1}(a,s) &= \text{Prob}(a_{t+1} = a, s_{t+1} = s)\\ &= \sum_{a_t}\sum_{s_t} \text{Prob}(a_{t+1} = a' | a_t = a, s_t = s) \cdot \text{Prob}(s_{t+1} = s' | s_t = s)\\ &\cdot \text{Prob}(a_t = a, s_t = s)\\ &= \sum_{a}\sum_{s} I(a', s, a)\text{Prob}(s_{t+1} = s' | s_t = s)\lambda_t(a,s)\end{aligned}$$

where $I(a', s, a)$ is the indicator function, which takes the value of 1 if $a' = k(a,s)$, i.e. a' is the optimal asset choice for next period, and 0 otherwise.

The law of motion for $\lambda_t(a,s)$ can also be rewritten as

$$\lambda_{t+1}(a,s) = \sum_{s} \sum_{a:a'=k(a,s)} \text{Prob}(s_{t+1} = s' | s_t = s)\lambda_t(a,s) \tag{1.5}$$

In what follows I will denote $\lambda_t^q(a,s)$ the distribution of asset holdings and individual states at time t, conditional on being in an aggregate state $q \in \{g, n, b\}$ at time t, and $\Omega^q = E \times S^q$, $S^q = \{s_1, \cdots, s_4\}$ if $q = g$, $S^q = \{s_5, \cdots, s_8\}$ if $q = n$ and $S^q = \{s_9, \cdots, s_{12}\}$ if $q = b$.

5. Government

The government collects lump-sum taxes to finance government spending. Her budget constraint in period t reads

$$\tau_t = g_t \tag{1.6}$$

6. Markets

Capital market equilibrium at a given world interest rate r implies

$$a_{t+1}^F + \int_{\Omega^q} k_t(a,s) d\lambda_t^q(a,s) = 0 \tag{1.7}$$

where a_{t+1}^F is the net foreign asset position of the rest of the world. If $\int_{\Omega^q} k_t(a,s) d\lambda_t^q(a,s) > 0$, i.e national savings are positive, net foreign asset position is negative, which means

[5] In Krusell et al. (1998) the role of the aggregate state in agent's state vector is to allow her to forecast future prices, which are fixed in my case.

that the country is net lender and the rest of the world is a net borrower, and vice versa.

I define aggregate variables conditional on a particular aggregate state $q \in \{g, b\}$ in the following way

$$y_t^q = \int_{\Omega^q} y_t d\lambda_t^q(a,s)$$
$$l_t^q = \int_{\Omega^q} l_t d\lambda_t^q(a,s)$$
$$c_t^q = \int_{\Omega^q} c_t d\lambda_t^q(a,s)$$

where $y_t = I_{\xi=e} A_t x_t l_t + I_{\xi=u} u_t$, and $I_{\xi=e} = 1$ if employed and 0 otherwise, $I_{\xi=u} = 1 - I_{\xi=e}$.

Capital market clearing then implies

$$y_t^q = c_t^q + g_t + CA_t^q \tag{1.8}$$

where the current account CA_t^q is equal to the change in the foreign asset position $-(a_{t+1}^F - (1+r)a_t^F)$.

7. Equilibrium

Given an "ad hoc" borrowing limit b, a risk-free interest rate r and fiscal policy $\{\tau, g\}$, a stationary equilibrium is policy functions for assets $a' = k(a,s)$, labor $l = h(a,s)$ and consumption $c = f(a,s)$ and a time-invariant distribution $\lambda(a,s)$ such that:

(a) $a' = k(a,s)$, $l = h(a,s)$ and $c = f(a,s)$ are optimal decision rules for the agent's problem, given the interest rate r and fiscal policy $\{\tau, g\}$;

(b) Time-invariant distribution $\lambda(a,s)$ is induced by P and $k(a,s)$.

1.4 Solving the model

1.4.1 Computation of the policy functions and time-invariant distribution

I solve the equilibrium using discrete value function iteration. I discretize the state space, constructing a grid for the asset holdings from -0.3 (the "ad hoc" borrowing limit) to 6. I use a grid of 701 points.

I solve the model for a fixed level of the interest rate. This allows me to obtain a time-invariant distribution of assets in the stochastic steady state, therefore aggregate variables in the steady state are also time-invariant and depend only on the aggregate state, but not the whole history of aggregate states. This is an important simplification of Krusell et al. (1998) framework, in which prices are endogenous and the distribution of assets in each period depends on all previous history of aggregate shocks.

To solve for the endogenous choice of labor supply I derive a solution for labor as a function of the states, $l(a, a', s)$, from the agent's intratemporal optimality condition and budget constraint

$$\begin{aligned}
\gamma c &= Ax(1-l) \\
c &= Axl + (1+r)a - a' \\
\Rightarrow \quad l(a, a', x) &= \frac{\gamma}{Ax(1+\gamma)} \left[a' - (1+r)a + \frac{Ax}{\gamma} + \tau \right]
\end{aligned}$$

Labor is restricted to take values between 0 and 1, therefore whenever $l < 0$ I set it to 0, and whenever $l > 1$ I set it to 1. However, in equilibrium 0 or 1 are never optimal choices and the solution is always internal. Labor supply of the unemployed agents is set to zero. Once labor supply $l(a, a', s)$ is computed, I plug it into the budget constraint to compute consumption for each point on the asset grid and each possible individual state. The rest of the procedure is a standard value function iteration starting with an initial guess $V_0(a, s)$.

To compute the time-invariant distribution $\lambda(a, s)$ I iterate on eq. (1.5), starting from an initial guess $\lambda_0(a, s)$.

1.4.2 Computation of the transition after a shock

I analyze temporary but persistent shocks to government consumption financed by lump-sum taxation. The transition after the initial shock lasts for 100 periods. The model is solved backwards, imposing that in the last period of the transition the economy arrives in the initial stochastic steady state, which means that it is in a good state with probability p_Φ^g, in a normal state with probability p_Φ^n and in a bad state with probability $p_\Phi^b = 1 - p_\Phi^g - p_\Phi^n$, and p_Φ^g, p_Φ^n and p_Φ^b constitute the stationary distribution induced by Φ. I assume perfect foresight about paths for all exogenous variables.

For the benchmark experiment, I set that in the period when the shock occurs the economy is either in a good, normal or a bad state, and from the next period onwards the aggregate state evolves according to the Markov process. Then the distribution of asset holdings and states evolves according to the transition across joint (a, s) states, given by the matrix $\sum_a \sum_s I(a', s, a)\text{Prob}(s_{t+1} = s'|s_t = s)$ starting from a time-invariant distribution $\lambda^q(a, s)$, $q \in \{g, n, b\}$. $\lambda^q(a, s)$ can be interpreted as a long-run time-invariant distribution of assets and individual states after the economy had a long sequence of aggregate shocks being equal to q.

As an alternative experiment, I set that during the first four periods from the shock (that is one year after the shock occurs) the economy stays in the same state as it were when the temporary change in fiscal policy happened, and starting from the fifth period the aggregate state evolves according to the Markov process.

I compute the impact change in aggregate variables and variables specific for each type of agent as the difference between their impact change when no fiscal shocks occur, i.e. there is only the transition from a particular aggregate state to the stochastic steady state, and the impact change during the same transition with a fiscal shock.

1.5 Calibration and properties of the model

1.5.1 Calibration

The time period of the model is 1 quarter.

PREFERENCES

I use a log utility function separable in consumption and leisure as in Baxter and King (1993):

$$u(c_t, l_t) = \log(c_t) + \gamma \log(1 - l_t) \tag{1.9}$$

The discount factor β is set to 0.99. The benchmark value for parameter γ governing the labor supply is 1.5, this obtains hours worked to be roughly 40% of total time endowment normalized to 1.

I choose the "ad hoc" borrowing limit to be -0.3, which corresponds to about two months average earnings of an employed agent. The world interest rate is set to 0.5% (which implies annual interest rate of about 2%). It is crucial that $\beta(1+r) < 1$, otherwise consumption and asset holdings diverge. Together these two parameters imply a share of agents with negative wealth in the steady state to be 20%, and the share of agents at the borrowing limit is 0.17% in my model[6].

IDIOSYNCRATIC PRODUCTIVITY PROCESS

[6] The shares are weighted averages across bad, normal and good times.

Following Floden and Linde (2001), I assume that the idiosyncratic productivity process follows

$$\log(x_t) = \omega + \vartheta_t$$
$$\vartheta_t = \rho\vartheta_{t-1} + \eta_t$$

where ω is a permanent component, and ϑ_t is a temporary component which evolves stochastically over time with persistence ρ, η_t is *i.i.d.* $N(0, \sigma_{2\eta)}$ and ω and ϑ_t are orthogonal. I assume the permanent component is absent, i.e. $\omega = 0$, thus individual productivity shocks are purely transitory shocks[7]. Realizations x_t are independent across agents, therefore the cross-sectional distribution of idiosyncratic productivity at any point in time and in any aggregate state is log normal with mean 1.

I set $\rho = 0.9$ and $\sigma_\eta = 0.1$. The continuous productivity process is approximated by a 3 state Markov chain using Tauchen (1986) method.

The value of home production is $u = 0.2$, so that $u/E(x) = 0.2$. Shimer (2005) uses a value of unemployment benefit to average wage equal to 0.4, while Krusell et al. (1998) in their heterogeneous agent framework set it to about 0.1. Imrohoruglu (1989) uses 0.25. I set it to 0.2 so that on the one hand there is some partial insurance to an unemployed person (and the natural borrowing limit is strictly positive), and on the other hand the unemployment state differs substantially from low productivity state not only in terms of transition probabilities to other states, but also in terms of income.

Fiscal policy

The lump-sum tax is set to 0.1 to roughly match the historical ratio $g/Y = 0.2$ for the U.S. (it is 0.22 in my model).

Table 1 summarizes the parameter values discussed above.

Employment status

Transition between employment and unemployment is given by four 2×2 matrices, each corresponding to a pair (s, s') of aggregate states (Krusell et al. (2009)). Transition matrices are identical for good and normal states, so I present here only matrices for the good state.

[7] In general this is not the case, because the permanent component might be related to age, skill level, etc. I do not include these features in my model.

Table 1.1: Parameter values

Parameter	Value	Interpretation
β	0.99	discount factor
γ	1.5	disutility of labor parameter
b	-0.3	"ad hoc" borrowing limit
r	2 %	world interest rate (annual)
τ	0.1	lump-sum tax
u	0.2	home production
ρ	0.9	persistence of idiosyncratic productivity process
σ_η	0.1	standard deviation of the innovation
		to the idiosyncratic productivity process
ρ	0.7	persistence of aggregate productivity process
σ_η	0.0098	standard deviation of the innovation
		to the aggregate productivity process

$$\Gamma^{gg} = \begin{bmatrix} 0.97 & 0.03 \\ 0.67 & 0.33 \end{bmatrix} \quad \text{for } (s,s') = (g,g)$$

$$\Gamma^{gb} = \begin{bmatrix} 0.93 & 0.07 \\ 0.25 & 0.75 \end{bmatrix} \quad \text{for } (s,s') = (g,b)$$

$$\Gamma^{bg} = \begin{bmatrix} 0.98 & 0.02 \\ 0.75 & 0.25 \end{bmatrix} \quad \text{for } (s,s') = (b,g)$$

$$\Gamma^{bb} = \begin{bmatrix} 0.96 & 0.04 \\ 0.40 & 0.60 \end{bmatrix} \quad \text{for } (s,s') = (b,b)$$

The above specified transition probabilities imply an average duration of unemployment spell of 1.5 quarters in good and normal times and 2.5 quarters in bad times[8].

Aggregate uncertainty

I assume that the aggregate productivity process follows an AR(1) process in logs:

$$\log(A_t) = \rho_A \log(A_{t-1}) + \eta_{At}$$

I set $\rho_A = 0.7$ and $\sigma_{\eta_A} = 0.0098$, and approximate the continuous productivity process by a 3 state Markov chain using Tauchen (1986) method. I get $A = \{1.03, 1, 0.97\}$.

[8]Average duration is computed according to the formula $D = \frac{1}{1-Prob}$

Table 1.2: Properties of the model

	'Good times'	'Normal times'	'Bad times'
Aggregate consumption	0.36	0.36	0.34
Aggregate asset holdings	0.35	0.29	0.24
Aggregate hours	0.45	0.44	0.42
Aggregate output	0.47	0.46	0.43
Share of agents with negative wealth	17 %	20 %	24 %

The highest and lowest realizations are slightly more extreme than numbers in Krusell et al. (2009), who set $A_g = 1.01$ and $A_b = 0.99$ to match the magnitude of postwar U.S. macroeconomic fluctuations. Krusell et al. (2009) have only these two aggregate states, and allow their economy to constantly fluctuate between the two. I instead allow for a third state, 'normal times', in which the economy spends most of the time, and recessions and expansions are seen as rare, more extreme deviations from the normal state. Approximated process implies an average duration of good/bad state equal to 5 quarters, and of normal state to 7 years.

1.5.2 Model properties

Table 1.2 summarizes the properties of the stochastic steady state. A bad (normal, good) state can be interpreted as a long-run bad (normal, good) state in which the economy arrives after a long sequence of bad (normal, good) aggregate shocks.

Aggregate consumption, asset holdings and aggregate hours are higher in good times than in bad times. Differences in aggregate consumption in good and bad times are small, which indicates that *on average* agents can self insure well against consumption fluctuations. This outcome is achieved by accumulation of a buffer stock of savings and adjustment in labor supply, as we can see from larger differences in asset holdings and hours between the three aggregate states.

The share of agents with negative wealth (average across bad, normal and good times) is 20 % which is in line with the U.S. data. Wolff (2007) based on the data from Survey of Consumer Finances (SCF) 2007 suggests that the percent of households with zero or negative net worth is 18.6 %. The share of total wealth held by the bottom 40 % is -2.8 % of total wealth (average across bad, normal and good times) in my model, which is generally compatible with numbers computed by Wolff (2007), which are 0.2 % for net worth and -1.0 % for non-housing wealth.

Share of agents who hit the borrowing limit is small, because in this model agents form

Table 1.3: Differences across borrowers and savers

	'Good times'		'Normal times'		'Bad times'	
	borrowers	savers	borrowers	savers	borrowers	savers
Consumption	0.35	0.37	0.34	0.36	0.32	0.35
Asset holdings	-0.06	0.43	-0.01	0.38	-0.10	0.34
Hours	0.47	0.44	0.46	0.43	0.44	0.41

a buffer stock of saving and become borrowing constrained only after a long sequence of negative idiosyncratic shocks. It is not obvious how to compare this number with existing empirical estimates, because in reality households' balance sheets are much more complicated than in my model, in which the only available instrument is a liquid one-period asset. Jappelli (1990) uses SCF data and finds that the share of borrowing constrained agents is about 20 %, which seems to be a consensus number. However, these estimates include households who have been rejected credit for all purposes, including illiquid assets such as housing, which suggests that the share of households constrained in liquid wealth might be smaller. On the other hand, Kaplan and Violante (2011) claim that the share of agents with zero/negative liquid wealth is even larger, about 44 %, because it is costly to transform illiquid assets into liquid ones in short amounts of time.

Although it is still an open question what is the share of agents constrained in liquid wealth in the U.S. economy, the number I get from the model looks implausibly small. Still, what matters for the size of the responses of agent's consumption and hours to a wealth shock is how close she is to the borrowing limit, with response being the strongest at the limit. Because the share of agents with zero/negative wealth is high and in line with the data, having a small share of agents *at* the borrowing limit should not be a major problem.

Table 1.4 gives more detailed information on different types of agents. Agents with higher idiosyncratic productivity consume more, work more and earn higher income. They are also net savers. High saving of these agents stems from precautionary motives, as agents want to insure themselves against future drops in income due to drawing a low idiosyncratic productivity shock or an unemployment shock. More productive agents work more hours because each additional hour worked brings higher marginal income when productivity is higher. Finally, higher consumption of these agents stems from higher earnings and higher asset holdings.

Employed agents with lowest productivity are net borrowers, because they expect a possibility of a future increase in income after drawing a higher productivity shock. They also work more hours than middle productivity workers, because low asset holdings do

Table 1.4: Properties of the model, different agents

	'Good times'				'Normal times'				'Bad times'			
	ex_1	ex_2	ex_3	u	ex_1	ex_2	ex_3	u	ex_1	ex_2	ex_3	u
Cons.	0.26	0.37	0.48	0.29	0.26	0.36	0.47	0.28	0.25	0.35	0.47	0.23
Assets	-0.07	0.22	2.26	0.07	-0.10	0.16	2.11	0.04	-0.12	0.13	1.97	-0.01
Hours	0.48	0.47	0.48	0	0.48	0.46	0.47	0	0.48	0.46	0.46	0
Income	0.37	0.48	0.67	0.2	0.35	0.46	0.64	0.2	0.34	0.45	0.61	0.2
Share	0.08	0.80	0.08	0.04	0.08	0.80	0.08	0.04	0.07	0.77	0.07	0.09

not allow them to smooth consumption. Labor supply as a function of productivity is therefore U-shaped: low productivity and high productivity agents work more hours, the former due to lack of self insurance via assets and the latter due to higher marginal return to each additional hour worked, while middle productivity individuals work less. Labor supply is higher in good times than in bad times because agents tend to work more in states when the earning per hour are higher in order to accumulate a buffer stock of assets. Unemployed agents hold on average zero assets.

Table 1.3 shows differences between borrowers and savers in the steady state. Savers have higher consumption in all aggregate states, and work fewer hours. Their asset holdings are higher in the good state than in the bad state due to precautionary saving. Borrowers consume less and work more than savers. Their average borrowing is higher in bad times than in normal and good times due to lower labor income in a bad state because aggregate productivity is low.

Figure 1.1 shows the distributions of agents across asset levels (cumulative) conditional on good, normal and bad times. The wealth distributions are skewed to the left, and the more so for bad times. However the difference between them is small. The distributions are very concentrated because an approximation of a continuous process with a 3-state Markov process is not very precise and a high share of middle productivity workers determines to a large extent the shape of the distribution.

Figure 1.2 plots individual policy functions for all possible individual and aggregate states. Policy functions for consumption are concave, especially for unemployed agents. The slope of consumption policy functions is steeper for lower asset levels, whereas for high asset levels the function is almost linear. This is a typical feature of buffer stock models, as is shown by Carroll and Kimball (1996). Consumption and labor supply are related through the intratemporal optimality condition of households, therefore the concavity of the consumption policy function translates into convexity of the policy function for hours. This is what we see at the top Figure 1.2.

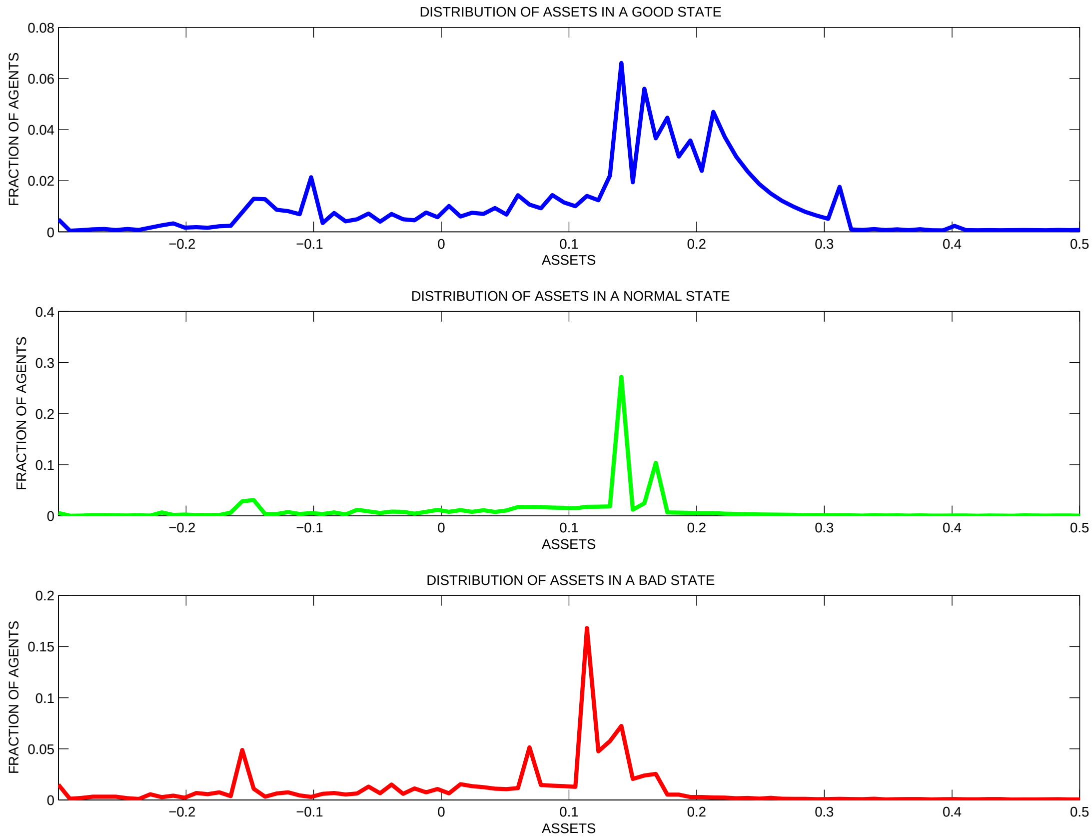

Figure 1.1: Time invariant distribution of assets

Non-linearity of consumption and labor policy functions is crucial for generating asymmetric responses to fiscal policy across different agents and in different aggregate states. The same change in wealth leads to changes of different size in consumption and hours for low- and high-wealth households. Because the distribution of asset holdings is different in good and bad times, and consumption policy function is more concave for low asset holdings (so labor supply function is more convex), changes in aggregate consumption and hours in response to changes in fiscal variables will differ both on the intensive margin (how much a particular type of agents adjusts her consumption and labor supply) and on the extensive margin (how the share of agents of different types evolves).

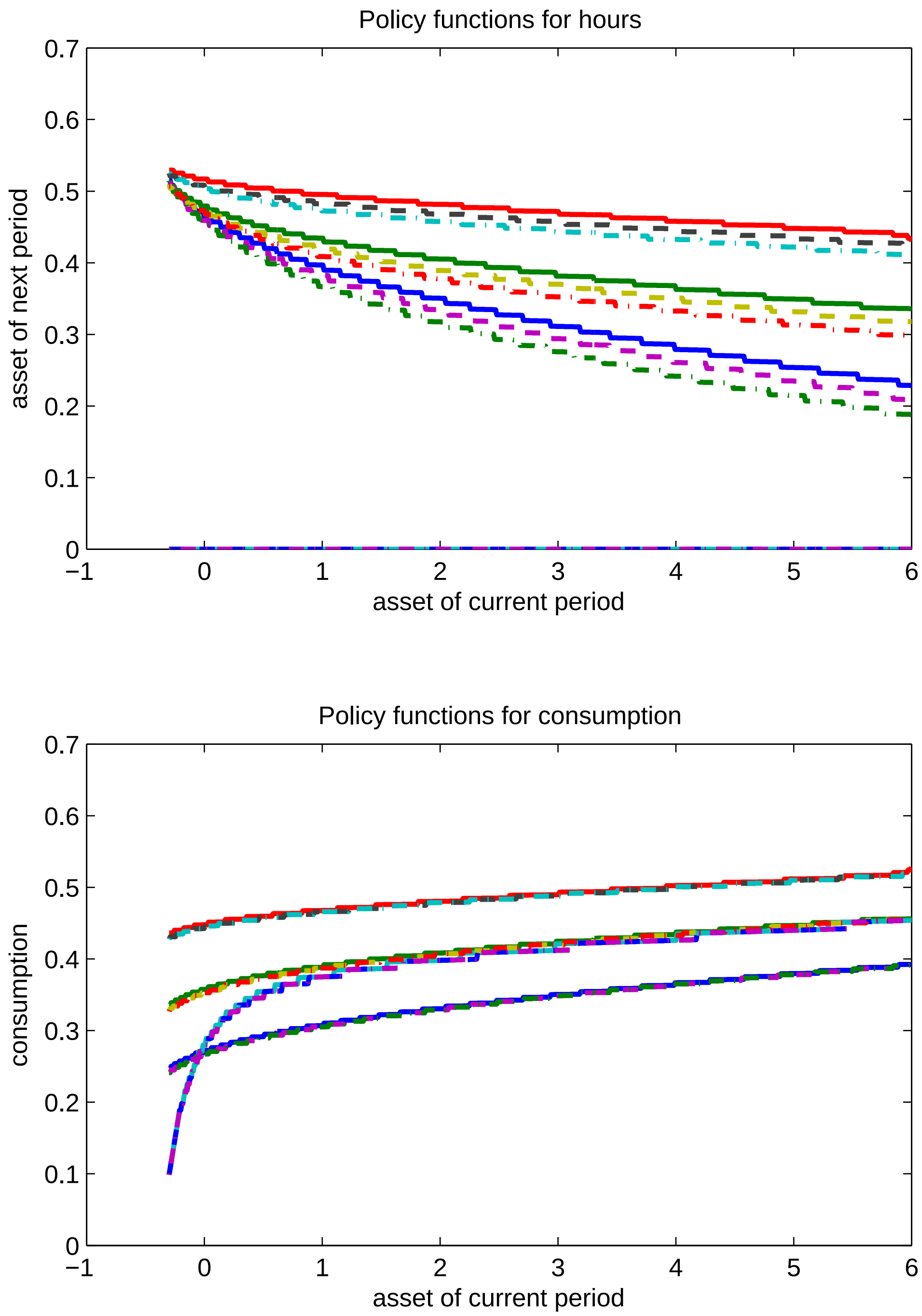

Figure 1.2: Consumption and hours policy functions

1.6 Results

1.6.1 Temporary change in g_t financed by lump-sum taxes, benchmark

I analyze the effects of a persistent 10% of output (average across bad, normal and good times) increase in pure waste government consumption financed by an increase in lump-sum taxes to keep the budget balanced period-by-period. The tax rule takes the form

$$\tau_t = \tau_0 + (g_t - g_0) \qquad \forall t \tag{1.10}$$

where g_t follows an AR(1) with persistence 0.9.

In Table 1.5 I present results for the impact multipliers of government spending depending on which is the initial aggregate state at the time of the shock. Changes starting from period 2 onwards depend on a particular history of aggregate states, and are not presented here. Change in hours is the absolute change, while other variables are expressed as changes relative to initial g_t shock, i.e. if g_t in period 1 goes up by 1 unit, the variable changes by the number of units given in the table.

Aggregate consumption and asset holdings fall. Labour supply increases, which leads to an increase in aggregate output. The drop in consumption and the increase in hours is larger in bad times, while in good times agents adjust assets by a higher amount. This means that in good times agents can self-insure better against unexpected shocks to their labour income. Increase in output is larger in bad times due to a bigger shift out of the labour supply.

However, the difference in impact output multipliers is not large. The reason is that low aggregate productivity in bad times dampens the effect of increased hours on output. Another feature of the model which contributes to dampening the difference in output multipliers is related to individual response of agents of different types. This information is summarized in Table 1.6.

Most of the increase in hours comes from relatively poor low productive workers, while high productive workers prefer to adjust asset holdings instead of hours. The contribution of the former in aggregate output is relatively small due to their low productivity, therefore changes in labour supply by this group of agents has little effect on output multiplier.

Consumption of relatively poorer households falls more, especially those with lowest productivity. For agents with high productivity consumption reacts little indicating that highly productive households can smooth consumption well, and their behaviour is similar to behaviour of Ricardian households. Unemployed agents react to increase in taxes by sharply decreasing consumption because they are unable to increase labour supply.

Table 1.5: Impact effect, balanced budget

Variable	Good	Bad
Consumption	-0.30	-0.38
Asset holding	-0.31	-0.16
Hours	0.018	0.022
Output	0.40	0.46

Note: Size of the initial shock: $g = 0.1y$. Changes in all variables except for hours are expressed as multipliers. Change in hours is in absolute value.

Table 1.6: Impact response across agent types, balanced budget

	'Good times'				'Bad times'			
	ex_1	ex_2	ex_3	u	ex_1	ex_2	ex_3	u
Cons.	-0.34	-0.29	-0.12	-0.73	-0.35	-0.35	-0.15	-0.85
Assets	-0.15	-0.28	-0.69	-0.27	-0.13	-0.12	-0.63	-0.15
Hours	0.030	0.019	0.006	0	0.033	0.025	0.008	0
Income	0.51	0.43	0.18	0	0.52	0.53	0.22	0

Note: Size of the initial shock: $g = 0.1y$. Changes in all variables except for hours are expressed as multipliers. Change in hours is absolute.

These patterns become more clear if we look at a graphical representation. Figure 1.3 shows averaged shifts of consumption and hours policy functions as a function of wealth in the period when government purchases shock occurs. The lines are not smooth because the model is solved by value function iteration on a discretized grid, however the general pattern of changes can be understood. Consumption decreases by more and hours go up by more in bad times at low asset levels, while changes for wealthy households are essentially the same.

Summary

Different types of agents adjust to a temporary change in lump-sum taxes in different manners, with relatively poor agents decreasing consumption and working more hours, and relatively rich agents decreasing their savings. These asymmetries in reaction have different aggregate implications depending on when the initial shock arrives. There are more wealth poor agents in a bad state who increase their labor supply more dramatically in response to tax increase, which delivers higher increase in aggregate output in a bad state. However, the difference in output multipliers between bad and good times is negligible.

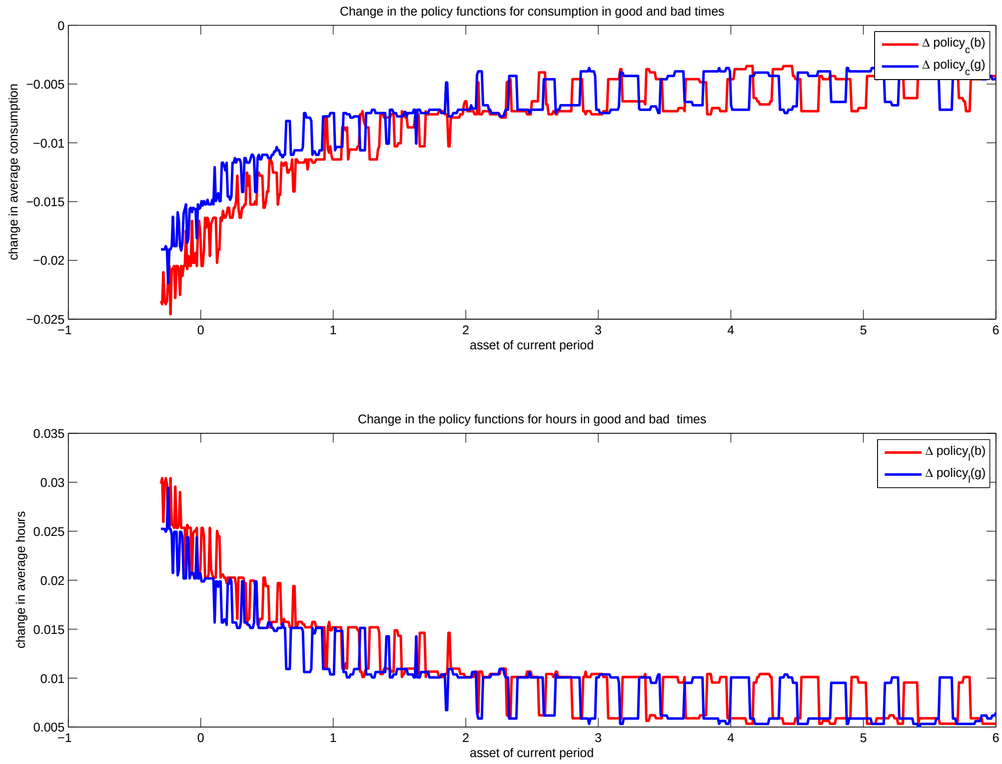

Figure 1.3: Consumption and hours policy functions shifts

To explain the intuition behind these results I would like to discuss the following simple case. Consider a representative agent closed economy without capital. There is a riskless bond in zero net supply, which means that in equilibrium asset holding are zero. The model is essentially static, the only choice a household makes is an intratemporal choice of consumption and labor supply in each period. The agent's problem is

$$\begin{aligned} \max \quad & u(c_t, l_t) = log(c_t) + \gamma log(1 - l_t) \\ \text{s.t.} \quad & c_t = y_t - g_t \\ & y_t = z_t l_t \end{aligned}$$

where z_t is aggregate productivity at time t, and g_t is a lump-sum tax that finances unproductive government spending so that budget is balanced every period.

Combining consumption-leisure choice with the budget constraint, and taking a total differential yields the following result

$$\frac{\Delta l_t}{\Delta g_t} = \frac{\gamma}{z_t(1+\gamma)}.$$

This implies that optimally chosen labor supply in reaction to higher taxes offsets movements in productivity: in order to smooth consumption the agent should work more time when return to each hour worked is low. The output multiplier in this case is

$$\frac{\Delta y_t}{\Delta g_t} = z_t \frac{\Delta l_t}{\Delta g_t} = \frac{\gamma}{1+\gamma}.$$

Output multiplier is *independent* of the aggregate state of the economy, labor supply changes to exactly compensate for movements in productivity to keep labor income unchanged.

This case is of course an extreme situation where adjusting labor supply is the only available mechanism to smooth consumption. However it provides useful intuition for situations when agents don't have access to a full set of state-contingent securities to insure against consumption fluctuations and use labor supply as a mechanism to smooth consumption.

Asymmetric effects stemming from non-linearities in consumption and labor policy functions and movements in the distribution of assets turn out to be relatively small, and the outcome is driven mainly by the simple effect described above. There might be several features in my model which are responsible for producing asymmetric effects of small size.

First, because fluctuations between bad and good states are recurrent and expected by agents, they are incorporated in their policy decisions.

Second, the timing of the benchmark experiment is such that the initial shock arrives in either a good or a bad state, but from second period onwards the economy evolves stochastically between the two aggregate states, converging over time to the stochastic steady state. This means that after several periods the differences in the initial state become not important.

I do an alternative experiment, results from which are presented in the next subsection. I assume the economy stays in the initial aggregate state for four periods (i.e. one year) with probability one, and only starting from the fifth period it evolves stochastically across aggregate states. Agents have perfect foresight about the path of all exogenous variables and about probabilities of aggregate states at each point in time.

1.6.2 Temporary change in g_t financed by lump-sum taxes, longer duration of the initial aggregate state

Even when I allow for a longer duration of the initial state the difference in multipliers is essentially unchanged, and still not very large. The reaction of the economy conditional on the initial state being good, normal or bad is the same if duration of this state is 4 quarters or only one as in the benchmark computations.

Table 1.7: Impact effect, balanced budget, 4 quarters of initial aggregate state

Variable	Good	Bad
Consumption	-0.30	-0.39
Asset holding	-0.29	-0.15
Hours	0.019	0.022
Output	0.41	0.46

Note: Size of the initial shock: $g = 0.1y$. Changes in all variables except for hours are expressed as multipliers. Change in hours is in absolute value.

1.7 Conclusion

This paper shows that a purely neoclassical wealth effect of government spending can generate somewhat different multipliers in different states of the business cycle. The mechanism relies on behavior of households with different degree of reaction to increase in lump-sum taxes (collected to finance higher spending), and the evolution of the distribution of the households over the business cycle. The presence of idiosyncratic uncertainty and borrowing constraints implies that the consumption policy function is concave in wealth, which translates into a convex policy function for labor. The combination of policy functions' non-linearity and changes in wealth distribution over the business cycle delivers asymmetric size of aggregate consumption and output responses to fiscal shocks in different phases of the cycle.

Numerically, the difference is response of output to spending between good and bad states are small. The impact multiplier is 0.40 in good times and 0.46 in bad times; consumption multiplier is 0.30 cents in the first case and 0.38 cents in the second case. The small difference in multipliers arises because labor supply counteracts movements in aggregate productivity, i.e. labor supply expands by more in bad times in reaction to tax increases, but low aggregate productivity of each additional hour worked mitigates the effect on output.

Appendix

1.A Debt financing

I analyze the same shock to government spending, but taxes each period only partially respond to current increase in g_t and partly offset accumulated debt up to period t. The tax rule takes the form

$$\Delta\tau_t = \phi_b B_t + \phi_g \Delta g_t \qquad \forall t \tag{1.11}$$

where $B_t = (1+r)B_{t-1} + (g_t - \tau_t)$ and there is no debt in the steady state, i.e. $B_0 = B_T = 0$ if 0 and T are the first and the last periods of the transition respectively.

I set $\phi_g = 0.13$ (estimate of Blanchard and Perotti (2002), also in line with estimates of Galí et al. (2007)) and ϕ_b is set to 0.1 to allow taxes to adjust slowly to debt to make a starker comparison to balanced budget case. The paths for government spending and taxes are plotted in Figure 1.A.1.

Table 1.A.1: Impact response, debt

Variable	Good	Bad
Consumption	-0.15	-0.17
Asset holding	0.24	0.26
Hours	0.010	0.010
Output	0.21	0.22

Note: Size of the initial shock: $g = 0.1y$. Changes in all variables except for hours are expressed as multipliers. Change in hours is absolute.

Table 1.A.1 shows the results for debt financed increase in government purchases. Compared to balanced budget financing, the impact response of all variables is smaller because the major part of taxes is collected in subsequent periods. Most agents are not Ricardian so the timing of taxes matters. Aggregate consumption falls by a larger amount in bad times than in good times. Aggregate asset holdings increase because agents save to pay future taxes, and the effect is more pronounced in bad times because more agents have low wealth and expect to have low wealth in the near future. Increase in hours is the same in both cases. Output multipliers are essentially the same, and slightly higher in bad and good times compared to normal due to higher hours in the first case, and higher productivity in the second.

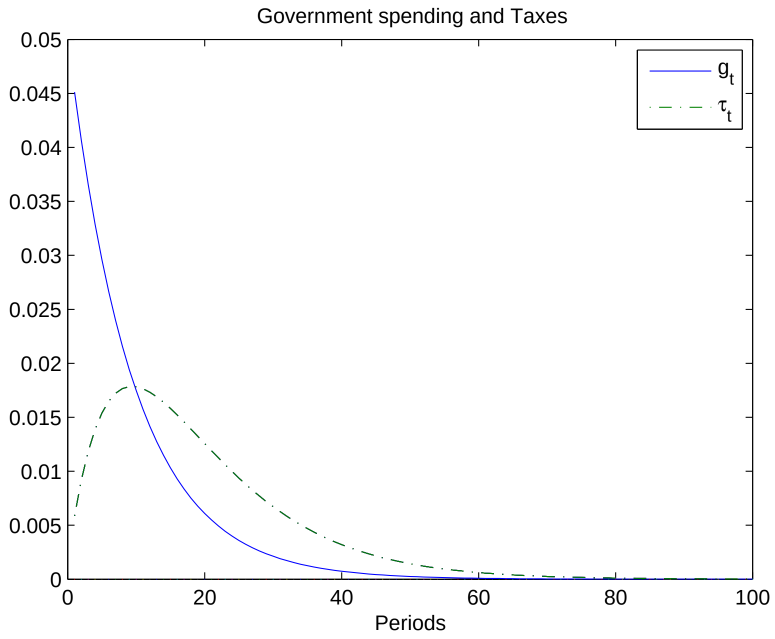

Figure 1.A.1: Government spending and lump-sum taxes

Chapter 2

On the Relationship Between Government Spending Multiplier and Welfare

2.1 Introduction

Fiscal issues have been in the spotlight of academic and policy debate in recent years, with particular focus set on the size of the governemnt spending multiplier, i.e. the amount of extra GDP generated per unit increase in government spending. Substantial attention has been given to the problem of identifying exogenous changes in government spending and taxation in the data, as various identification schemes produce alternative results[1]. Many authors explored multipliers in structural models with different features[2]. However, little attention has been given to understanding the welfare content of the multiplier statistic. It remains unclear whether the size of the multiplier can provide broader information on the impact of fiscal policy.

The present work aims at establishing a relation between the size of the spending multiplier and the change in social welfare, induced by increase in government spending. In particular, the papers assesses whether there exists monotonicity between the change in welfare and change in aggregate output so that a higher multiplier implies a higher welfare gain from a particular fiscal policy. The type of government spending I study is government purchases of goods and services[3]. An important assumption is that these

[1] Blanchard and Perotti (2002), Ramey and Shapiro (1998), Ramey (2009), Perotti (2011) are just a few examples.

[2] See, for example, Galí et al. (2007), Monacelli and Perotti (2008), Bilbiie (2009), Uhlig (2010), Christiano et al. (2009), Drautzburg and Uhlig (2011).

[3] In general government spending includes government purchases, transfers and interest payments.

purchases enter private utility in a separable manner, and they do not affect productivity of private resources in production.

In a representative agent model, adopted by many studies on the multiplier, the effects of increase in spending on aggregate output are easily mapped into changes in consumption and hours, and therefore into welfare of the representative agent. I start my analysis by demonstrating that in this environment change in welfare is proportional to the long-run cumulative multiplier[4] with the size of the labor wedge. The intuition behind this positive monotone relationship is that increase in government spending pushes output up, bringing it closer to the efficient level, and thus reducing welfare losses from the causes that made output inefficient in the first place (monopoly pricing or distortionary taxation in my model).

While the representative agent framework establishes a clear relationship between the multiplier and welfare, it does not take into account heterogeneity and market incompleteness. Both features are realistic and have been found relevant by previous literature[5]. Redistributive issues are also an important part of the recent policy discussion, as austerity measures in Europe and debate over marginal tax rates for the rich in the US have brought into light the problem of winners and losers of fiscal adjustments. If the economy is characterized by an unequal distribution of capital and labor income across households, then changes in current and future taxation as well as wages and real interest rates induce uneven distribution of gains and losses from change in fiscal policy. Naturally, in such environment the aggregate output response to a policy might be not be sufficient to draw welfare-related conclusions.

I use a framework with heterogeneity across agents (Aiyagari-Huggett-Bewley) and distortionary taxation. The fiscal shock is a persistent increase in government spending, financed by increase in public debt with delayed debt stabilization via labor income tax. I study multipliers and expected welfare gains for different combinations of intertemporal elasticity of substitution and Frisch elasticity of labor supply. These parameters, unlike for example the level of the price mark-up or share of government spending in GDP, cannot be easily computed from the data, and there is little agreement in the literature about their values. Their choice turns out to have important implications for the relation between multiplier and welfare gains of a particular fiscal policy.

Depending on the values of structural parameters, the same policy can result in different aggregate and redistributive effects. What matters for the redistribution of wealth is

[4]A long-run cumulative multiplier captures overall dynamic effect of a fiscal expansion. In a model with departures from Ricardian equivalence, such as the one studied in this paper, the short- and the long-run multipliers generally different from each other.

[5]See, for example, Attanasio and Davis (1996).

the real interest rate behavior. A smooth path of output and earnings over the transition after the spending shock results in a large increase in the real interest rate because the desire of agents for self-insurance via accumulation of a buffer stock of savings is moderate so they have to be compensated more for holding government debt. Redistribution from wealth poor to wealth rich is high even though the long-run cumulative multiplier might be large. On the contrary, if output expands strongly in the short run but also declines significantly in the future as taxes increase, then agents' desired buffer stock of saving is high, which eliminates the need for the interest rate to increase dramatically. Therefore a lower long-run cumulative multiplier does not necessarily correspond to a more unequal distribution of gains nor lower welfare gains at the bottom.

The main message of the paper is that the size of government spending multiplier, even if one looks at its cumulative long-run value, can be of limited use in evaluating welfare implications of a temporary fiscal expansion. There exist plausible combinations of structural parameter values, across which monotonicity between the multiplier and welfare in a heterogeneous agent environment is not preserved. It is possible that a higher cumulative multiplier can be associated with a larger welfare loss for the poorest households in the economy. Therefore, the policymakers should evaluate gains and losses for different groups of population, on top of evaluating aggregate output expansion.

Although the welfare consequences of government spending have great importance for policy analysis, little effort has been made so far to relate the study of (predominantly short-run) effects of fiscal policy on aggregate activity to private welfare. Previous research in this area has been limited to few studies (Woodford (2011), Mankiw and Weinzierl (2011), Sims and Wolff (2013)), and has been restricted to a representative agent framework with lump-sum taxation. Woodford (2011) establishes two benchmark results. First, he shows that in a static model without frictions optimal government purchases satisfy equality of marginal utility of public and private consumption. Second, Woodford (2011) shows that there is a scope for fiscal stabilization policy if output is suboptimal (in his example output is below efficient in a time of recession due to inability of prices and wages to react), and change in welfare is proportional to the change in output with the size of the wedge in consumption/leisure optimality condition.

Mankiw and Weinzierl (2011) examine alternative fiscal policies (government spending vs. investment subsidy financed by lump-sum taxes) aimed at restoring full employment in a two-period model with sticky prices and zero lower bound. Mankiw and Weinzierl (2011) find that the policy that is best for welfare, which includes optimal mix of increase in spending and large increase in investment subsidy in the first period, is worst according to the multiplier metric. An important message of the paper is that the "bang-for-thebuck" calculations do not take into account the composition of GDP.

The paper most related to the current analysis is Sims and Wolff (2013). Their study focuses on the relationship between the multiplier and welfare at different points of the business cycle. The paper shows that a fiscal policy enacted during a recession driven by a negative productivity shock results in a modest reaction of output, however the increase in welfare is larger because marginal utility of consumption is high. On the contrary, fiscal policy enacted during a downturn driven by preference shock is associated to a higher multiplier but a lower scope for welfare improvement because the marginal utility of consumption is low.

The work by Monacelli and Perotti (2011) on the consequences of tax burden distribution for the size of the multiplier is another important study relevant for current analysis. The main result of the paper is that in environment with sticky prices it matters for the size of output response to a government spending shock which type of agent bears the major part of taxation. The multiplier is larger if (lump sum) taxes are levied mainly on the unconstrained savers as opposed to credit constrained borrowers.

This paper differs from the previous literature in several aspects. First, the relationship between the multiplier and welfare is the primary focus of this paper, while previous work focused on the size of the multiplier (Woodford (2011)) or on the optimal fiscal (Mankiw and Weinzierl (2011)) and mix of monetary and fiscal policies (Woodford (2011)). Second, a distinctive feature of my analysis is taking into account heterogeneity of agents and importance of distributional effects (vs. business cycle aspect as in Sims and Wolff (2013)). Third, instead of doing comparisons across alternative fiscal policies (Mankiw and Weinzierl (2011),Monacelli and Perotti (2011)) or states of the economy (Sims and Wolff (2013)), I explore the consequences of uncertainty about structural parameters. Instead of focusing on the composition of GDP or nature of the recessionary shock to the economy as the culprit of poor welfare performance of the multiplier, I bring forward redistributional aspect of fiscal expansion.

The paper is organized as follows. Section 2.2 sets up the heterogeneous agent environment. Benchmark findings from a representative agent model are established in Section 2.3. Section 2.4 presents welfare decomposition in a heterogeneous agent framework. I proceed with describing numerical analysis and its results in Section 2.5. Finally, Section 2.6 concludes.

2.2 Model

I use a framework similar to Huggett (1993). There is continuum of infinitely lived agents of measure 1, who receive idiosyncratic shocks to labor income against which they cannot fully insure. Agents maximize their expected discounted utility by choosing optimal amounts of consumption and labor supply. Savings are invested in one-period government debt which yields a risk-free return. Since the paper is focused on the effects of increase in government spending, the model does not feature any other sources of aggregate risk such as productivity shock. The shock to government spending is a one-time unexpected shock with a deterministic transition back to the steady state.

2.2.1 Households

Each agent's productivity $s \in S = \left\{s^1, \cdots, s^N\right\}$ evolves according to an N-state Markov process. I denote the transition probability matrix Π, where $\Pi_{ij} = Pr(s_{t+1} = s^j | s_t = s^i)$ is the probability that next period productivity is s^j given that current productivity is s^i. Period t productivity level is realized before period t decisions are made. Let $s^t = \{s_0, ..., s_t\}$ denote a history of idiosyncratic shocks from date 0 to date t, originating from s_0, and $P(s^t)$ denote the probability of this history.

Denote the set of possible values for individual wealth a_t as $E = [-\bar{a}, a_{max}]$. Denote $X = E \times S$ the set all possible individual states. An element of this set x is a pair of individual (endogenous and exogenous) states (a, s), characterizing each agent's position at each point in time. Unconditional distribution of (a, s) pairs is $\lambda_t(x) = \text{Prob}(a_t = a, s_t = s)$. The probability measure $\lambda(x)$ is defined over the Borel σ-algebra of X.

At time 0 each agent is characterized by her initial wealth and initial productivity level, summarized by $x_0 = (a_0, s_0)$. Agents have identical preferences over consumption, hours and government consumption sequences, described by the following expected discounted utility

$$\sum_{t=0}^{\infty} \beta^t \sum_{s^t} P(s^t) u(c_t(x_0, s^t), l_t(x_0, s^t), g_t) \tag{2.1}$$

where $\beta \in (0, 1)$, $c_t(x_0, s^t)$ is level of consumption, $l_t(x_0, s^t)$ is proportion of time devoted to working activities, and g_t is government consumption.

The budget constraint is given by

$$c_t(x_0, s^t) + a_{t+1}(x_0, s^t) = (1 + r_t)a_t(x_0, s^{t-1}) + (1 - \tau_t^l)s_t w_t l_t(x_0, s^t) + \Gamma_t \quad \forall s^t, t, \tag{2.2}$$

where r_t is the risk-free interest rate, Γ_t is the profits of firms redistributed to households as dividends, and $(1 - \tau_t^l) w_t s_t l_t(x_0, s^t)$ is the after tax labor income of an agent.

Financial markets are incomplete, and the only asset agents can use to smooth consumption is a one-period risk-free government bond, which they trade subject to a borrowing constraint

$$a_{t+1}(x_0, s^t) \geq -\bar{a}, \quad \bar{a} > 0 \tag{2.3}$$

where $\bar{a} = min\left\{b, \sum_{j=0}^{\infty} \frac{\Gamma_{t+j}}{\prod_{i=0}^{j}(1+r_{t+i})}\right\}$ with b being an arbitrary "ad hoc" borrowing limit, and $\sum_{j=0}^{\infty} \frac{\Gamma_{t+j}}{\prod_{i=0}^{j}(1+r_{t+i})}$ being the "natural" borrowing limit.

Measure λ_0 describes the distribution of agents across the joint individual state (a, s) at time 0. The social welfare function is defined as

$$V = \sum_{x_0} \sum_{t=0}^{\infty} \beta^t \sum_{s^t} P(s^t) u(c_t(x_0, s^t), l_t(x_0, s^t), g_t) \lambda_0(x_0) \tag{2.4}$$

Equation (2.4) describes the average lifetime discounted utility, where each individual's utility is given the same weight. Therefore it can be considered a utilitarian welfare function. This welfare criterion can be also thought of as ex-ante welfare of a household at the steady state, i.e. welfare of a household before it learns its initial asset position and productivity level[6].

2.2.2 Firms

A. Final good producer. A perfectly competitive firm produces the final good using differentiated varieties y_{it} with the following technology

$$Y_t = \left(\int_0^1 y_{it}^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}}. \tag{2.5}$$

The production function is a CES function, where $\theta > 1$ is the elasticity of substitution across intermediate varieties.

Denoting p_t the price of good Y_t and p_{it} the price of y_{it}, demand for each variety from the final good producer, derived from profit maximization problem, is

$$y_{it}^d = \left(\frac{p_{it}}{p_t}\right)^{-\theta} Y_t \tag{2.6}$$

B. Intermediate goods producers. There is monopolistic competition in the intermediate goods sector. Under the assumption of flexible prices, each producer sets

[6] For more discussion about this welfare criterion see Aiyagari and McGrattan (1998).

the price according to the profit maximization problem

$$\max_{p_{it}} \quad p_{it}y_{it} - W_t l_{it},$$
$$s.t. \quad y_{it} = \left(\frac{p_{it}}{p_t}\right)^{-\theta} Y_t,$$
$$y_{it} = l_{it},$$

where Y_t is the final good, p_t is the aggregate price level, and W_t is the nominal wage, and technology is linear in labor.

If the firm is able to choose its price freely, the optimal price is set as a constant mark-up over the nominal wage

$$p_{it} = \frac{\theta}{\theta - 1} W_t = \mu W_t.$$

Under assumption that all firms are symmetric, they will charge the same price, therefore $p_{it} = p_{kt} = p_t$. The real wage is then simply the inverse of the mark-up

$$w_t = \frac{W_t}{p_t} = \frac{\theta - 1}{\theta} = \frac{1}{\mu}$$

.

C. Mark-up behavior. Galí et al. (2007), Monacelli and Perotti (2008) and Woodford (2011), among others, point out that response of the mark-up to the business cycle can affect the size of the multiplier. In particular, if one assumes that nominal prices of intermediate goods are sticky and nominal wages are flexible, the real wages increase in reaction to a positive government spending shock while firms' mark-ups decline. This mechanism facilitates producing a positive consumption multiplier, found in empirical literature[7], because increase in real wages makes it possible for the marginal utility of consumption to decrease as hours expand[8]. This mechanism could be potentially important for my question, because the size of output expansion affects aggregate welfare gain from a policy and increase in real wages also has redistributive implications for households with different productivity.

To take into account this effect of fiscal policy on real wages I allow for movements in the mark-up in response to government spending shock. However I use a short cut for modeling this part of the environment. Similar to Hall (2009), I assume that the mark-up is a constant elasticity function of output:

$$\mu_t = \tilde{\mu} Y_t^{-\omega}. \tag{2.7}$$

[7]Blanchard and Perotti (2002), Perotti (2008), Galí et al. (2007) are a few examples.

[8]Recall the first order condition: $-u_l(c,l) = wu_c(c,l)$.

A positive ω implies a countercyclical mark-up. If one has in mind a model with sticky goods prices[9] and flexible nominal wages, parameter ω captures both the degree of price rigidity and the degree of monetary policy accommodation in response to a fiscal shock. Note that this formulation is compatible with any explanation of a negative relationship between output and mark-ups. [10].

Hall (2009) compares multipliers from a model using the stylized mark-up equation and a New Keynesian model with monetary policy and price rigidity and concludes that the functional form (2.7) is adequate for inferring effects of government spending on output and consumption. Given that building a large empirically relevant model is beyond the scope of this paper, the simple functional form above suffices for the question I address.

2.2.3 Government

The government collects taxes to finance an exogenously given level of government spending and interest payments on outstanding government debt. The government budget constraint in real terms is

$$\tau_t^l w_t L_t + B_{t+1} = (1 + r_t)B_t + g_t. \tag{2.8}$$

Government consumption behaves according to the following process

$$g_t = (1 - \rho_g)\bar{g} + \rho_g g_{t-1} \tag{2.9}$$

$$g_0 = \bar{g} + \epsilon_0 \tag{2.10}$$

where ϵ_0 is the unexpected shock to spending at the beginning of period 0. After the shock occurs, the transition back to the steady state is deterministic.

The government issues short-term debt to finance higher level spending, adjusting the taxes according to the rule $\tau_t^l = \tau_0^l + \phi_b (B_t - B_0)$. This tax rule is similar to the one used by Uhlig (2010). The difference is that Uhlig (2010) specifies the rule in terms of overall tax revenue from labor income tax, while here the rule is specified in terms of the tax rate.

[9] The relationship between sticky prices and countercyclical mark-ups has been studied, for example, by Rotemberg and Woodford (1992).

[10] It remains an open question whether in reality mark-ups show a countercyclical behavior. Bils (1987) finds that mark-up of price over marginal cost decreases in booms and goes up in recessions. Nekarda and Ramey (2013) revisit this finding with new data and arrive to a conclusion that mark-ups behave procyclically.

2.2.4 Market clearing

Capital market equilibrium implies that total asset holdings (total net saving) of the private sector is equal to the government debt

$$A_{t+1} = \sum_x \sum_{s^t} P(s^t) a_{t+1}(x_0, s^t)\lambda_t(x) = B_{t+1}.$$

Labor market equilibrium analogously implies equality of total effective hours supplied by households to total labor demand by intermediate goods producers

$$L_t^s \equiv \sum_x \sum_{s^t} P(s^t) s_t l_t(x_0, s^t)\lambda_t(x) = \int_0^1 l_i di \equiv L_t^d.$$

The final goods market equilibrium condition follows from the two conditions above and integration of individual budget constraints

$$Y_t = C_t + g_t,$$

where $C_t = \sum_x \sum_{s^t} P(s^t) c_t(x_0, s^t)\lambda_t(x)$.

2.3 Representative agent benchmark

It is useful to start with multiplier and welfare analysis in a representative agent model. In this simple model there is clear link between the size of the output response and change in welfare if output is below its efficient level[11].

2.3.1 Welfare

The representative agent maximizes her value function by choosing optimal sequences of consumption, hour worked and asset holdings. All variables are functions of ϵ_0, the shock to government spending process, meaning that whenever $\epsilon_0 = 0$ they are at their steady state level, and whenever ϵ_0 is different from zero, they take they values of the t-th period

[11] Subsection 2.3.1 extends some baseline results in Woodford (2011), Sections 5.1 and 5.2., who relates the change in welfare to the output effect of fiscal expansion.

of transition. The problem of the representative agent is:

$$
\begin{aligned}
V_0^*(\epsilon_0) = & \max_{\{C_t(\epsilon_0),L_t(\epsilon_0),A_{t+1}(\epsilon_0)\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t u(C_t(\epsilon_0), L_t(\epsilon_0), g_t(\epsilon_0)) \\
\text{s.t.} \quad C_t(\epsilon_0) + A_{t+1}(\epsilon_0) = & (1 + r_t(\epsilon_0))A_t(\epsilon_0) + (1 - \tau_t^l(\epsilon_0))w_t(\epsilon_0)L_t(\epsilon_0) + \Gamma_t(\epsilon_0) \\
& L_t(\epsilon_0) \in [0, 1] \\
& C_t(\epsilon_0) \geq 0 \\
& A_0 \text{ is given} \\
& \lim_{T\to\infty} \frac{A_{T+1}}{(1 + r)^{T+1}} \geq 0.
\end{aligned}
$$

The maximum value of the problem above is given by

$$
V_0^*(\epsilon_0) = \sum_{t=0}^{\infty} \beta^t u(C_t^*(\epsilon_0), L_t^*(\epsilon_0), g_t(\epsilon_0)), \tag{2.11}
$$

where $C_t^*(\epsilon_0)$ and $L_t^*(\epsilon_0)$ satisfy optimality condition

$$
(1 - \tau_t^l(\epsilon_0))w_t(\epsilon_0)u_{C_t^*(\epsilon_0)} + u_{L_t^*(\epsilon_0)} = 0. \tag{2.12}
$$

I use $u_{C_t^*}$ and $u_{L_t^*}$ as a short notation for $u_c(C_t^*, L_t^*, g_t)$ and $u_l(C_t^*, L_t^*, g_t)$ respectively. Furthermore, $C_t^*(\epsilon_0)$ and $L_t^*(\epsilon_0)$ satisfy the market clearing condition[12]

$$
L_t^*(\epsilon_0) = C_t^*(\epsilon_0) + g_t(\epsilon_0) \tag{2.13}
$$

In what follows I drop the superscript *, keeping in mind that all variables' sequences are optimal choices of the representative agent. I will use a variable *without* subscripts to indicate its value at $\epsilon_0 = 0$, i.e. its steady state value, $C = C(0)$, and I will use a variable *with* subscript t to indicate the value of the variable at the t-th period of transition, $C_t = C_t(\epsilon_0)$.

The change in welfare of a representative agent can be derived by differentiating the maximum value of the problem with respect to ϵ_0, having substituted into it the budget constraint, and applying the envelope theorem. The resulting expression is

$$
\frac{dV_0}{d\epsilon_0} = \sum_{t=0}^{\infty} \beta^t \frac{dg_t}{d\epsilon_0}(u_g - u_C) + u_C \sum_{t=0}^{\infty} \beta^t \left(1 + \frac{u_L}{u_C}\right) \frac{dY_t}{d\epsilon_0} \tag{2.14}
$$

The first term $\sum_{t=0}^{\infty} \beta^t \frac{dg_t}{d\epsilon_0}(u_g - u_C)$ is related to the difference between marginal utilities of public and private consumption. In a model without inefficiencies the optimal level of

[12] Recall that technology is linear, i.e. $Y_t^*(\epsilon_0) = L_t^*(\epsilon_0)$.

government spending is such that $u_g = u_C$ (Woodford (2011)), which means that marginal reallocation of resources between public and private consumption should not affect welfare. If agents do not value government spending, $u_g = 0$ and this term represents a pure welfare loss due to taking resources away from private consumption and wasting them.

The term $\upsilon \equiv \left[1 - \left(-\frac{u_L}{u_C}\right)\right]$ is the difference between the marginal rate of transformation $f_L' = 1$ and the marginal rate of substitution $-\frac{u_L}{u_C}$, which represents a wedge in the first order condition for consumption/leisure choice. Efficiency implies this wedge should be zero, i.e. MRS=MRT. In a model with distortions, like the one considered here, this difference is positive. The size of $\upsilon = (1 - (1 - \tau_l)/\mu)$ reflects the level of inefficiencies in the economy, which stem from monopoly power of firms, and distortionary taxation if taxes are proportional. There exists space for welfare improvement due to increase in spending in this case. Potential welfare gains come from the reduction of the dead weight loss, arising from distortions, as output moves closer to its efficient level[13].

While the first term depends only on how agents value welfare and the size of the shock, the second term is proportional to the change in output. Notice that this decomposition of welfare change does not depend on the type of taxation nor on the way of financing increase in spending.

2.3.2 Multipliers

Government spending multiplier is defined as the change in GDP per unit change in government spending. I distinguish between a short-run multiplier, by which I mean impact multiplier, defined as

$$M_0 = \frac{dY_0}{d\epsilon_0}, \tag{2.15}$$

and a cumulative multiplier, computed according to

$$M_t = \frac{\sum_{s=0}^{t}(1+r)^{-s}\frac{dY_s}{d\epsilon_0}}{\sum_{s=0}^{t}(1+r)^{-s}\frac{dg_s}{d\epsilon_0}}. \tag{2.16}$$

I define the long-run multiplier as the cumulative multiplier after a sufficiently high number of periods T, when the transition after the shock is over and the economy is approximately back at the steady state

$$M_T = \frac{\sum_{s=0}^{T}(1+r)^{-s}\frac{dY_s}{d\epsilon_0}}{\sum_{s=0}^{T}(1+r)^{-s}\frac{dg_s}{d\epsilon_0}}. \tag{2.17}$$

[13]These results can be related to the discussion in Hendren (2013). He shows that welfare impact of a policy includes a causal effect of the behavioral response to the policy change on government's budget, which is a term similar to $\upsilon\frac{dY_t}{d\epsilon_0}$. This effect is related to the presence of a fiscal externality, since the agent does not take into account the effect of her behavior on the government's budget constraint.

With the multiplier definitions above, $\frac{dY_t}{d\epsilon_0}$ can be written as

$$\frac{dY_t}{d\epsilon_0} = (1+r)K_{t-1}\left[M_t - M_{t-1}\right] + \rho_g^t M_t, \quad K_t = \sum_{i=0}^{t}(1+r)^i \rho_g^{t-i}.$$

Then the welfare decomposition (2.14) takes the following form

$$\frac{dV_0}{d\epsilon_0} = \sum_{t=0}^{\infty}\beta^t \frac{dg_t}{d\epsilon_0}(u_g - u_C) + u_C\upsilon(1-\beta(1+r))\lim_{T\to\infty}\sum_{t=0}^{T-1}\beta^t K_t M_t + u_C\upsilon \lim_{T\to\infty}\beta^T K_T M_T. \quad \textbf{??} sub@-$$

In a representative agent model the steady state interest rate satisfies $\beta(1+r) = 1$, therefore the term $u_C\upsilon(1-\beta(1+r))\lim_{T\to\infty}\sum_{t=0}^{T-1}\beta^t\Omega_t M_t$ is equal to zero. Given that M_T is the long-run multiplier, summarizing the whole transition of output back to the steady, it remains unchanged as T increases. Then it can be shown that

$$u_C\upsilon\lim_{T\to\infty}\beta^T K_T M_T = u_C\upsilon\frac{1+r}{1+r-\rho_g}M_T.$$

Proposition 1. *Let υ be the labor wedge and M_T the long-run multiplier. Then the change is welfare is*

$$\frac{dV_0}{d\epsilon_0} = \sum_{t=0}^{\infty}\beta^t\frac{dg_t}{d\epsilon_0}(u_g - u_C) + u_C\upsilon\frac{1+r}{1+r-\rho_g}M_T. \tag{2.18}$$

Corollary 1. *In a representative agent model with suboptimal output ($\upsilon > 0$) the change in welfare due to a government spending shock is proportional to the long-run multiplier with a positive coefficient $\upsilon\frac{1+r}{1+r-\rho_g}$, where υ is the labor wedge.*

Welfare decomposition 2.18 allows to address the question whether the threshold of 1 for the output multiplier has a welfare content. This value has been widely discussed in the fiscal policy literature. From the resource constraint $Y_t = C_t + g_t$ it follows that if the multiplier is greater than one, an increase in government spending has a positive effect on consumption. This increase in consumption might lead one to a false conclusion that in this situation increase in government spending is welfare-improving, even if it is a pure waste.

Corollary 2. *GDP multiplier of pure waste government spending above 1 does not imply that increase in spending improves welfare.*

If the government spending is not valued by agents, marginal utility of government spending is zero ($u_g = 0$). Using $\frac{dg_t}{d\epsilon_0} = \rho_g^t$, we can rewrite welfare decomposition (2.18) as follows

$$\frac{dV_0}{d\epsilon_0} = u_C\frac{1+r}{1+r-\rho_g}\left[\upsilon M_T - 1\right].$$

It is straightforward to see that the condition for welfare improvement in this case is

$$M_T > \frac{1}{\upsilon}. \tag{2.19}$$

The welfare-improving size of the multiplier therefore depends on the size of the inefficiencies. The size of the labor wedge has been estimated by Shimer (2005) at about 0.40 in normal times and 0.45 in recessions. This size can be reproduced in a model with inefficiencies stemming from mark-ups and distortionary taxes like the one presented here. If the share of profit is 20% and the labour income tax is 28%, the wedge $1 - \frac{1-\tau_l}{\mu} = \frac{1.2-0.72}{1.2}$ is 0.40. The multiplier should be above 2.5 to obtain an increase in welfare.

Indeed, (2.19) makes it clear that the only possibility for the multiplier of 1 to be threshold for a positive effect of policy on welfare is if $\upsilon = 1 - \frac{1-\tau_l}{\mu}$ is equal to 1, which is only possible if either $\tau_l = 1$ or $\mu = \infty$. Neither is a realistic case. Therefore, the question of whether the short-run multiplier is greater or smaller than 1 can only be related to the effect of government spending on aggregate consumption, while it is not a relevant number for welfare considerations even in the simplest model.

I proceed with discussing the determinants of the short-run and long-run multipliers. The size of the multiplier depends on the type of taxation the government uses. I wish to start with a short discussion of the multipliers when government spending is financed by lump-sum taxes to establish some benchmark results. I then proceed by studying multipliers and welfare in a model with labor income tax.

A. Lump-sum taxation. In a representative agent model with lump sum taxes Ricardian equivalence holds, which implies that the timing of taxes does not matter. All debt is held by the representative agent, and what affects agent's optimization problem is only the total amount of government expenditure, which needs to be financed. The multiplier and the welfare decomposition do not depend on the presence of debt.

In a model with lump-sum taxes therefore the impact multiplier is equal to multipliers at all other horizons, i.e.

$$M_0 = M_t = M_T, \quad \forall t.$$

Corollary 3. *In a representative agent model with lump-sum taxes and suboptimal output the change in welfare due to a government spending shock is proportional to the* ***short-run*** *multiplier with a positive coefficient* $\upsilon \frac{1+r}{1+r-\rho_g}$.

The proof follows from the welfare decomposition (2.18) and the equality of the short-run multiplier to the long-run multiplier.

The expression for the multiplier under lump-sum taxes is[14]

$$M_0^{ls} = \frac{\sigma}{\sigma + (1 - s_g)\left[\psi - \omega\right]}, \tag{2.20}$$

where σ is the inverse of intertemporal elasticity of substitution (IES) of consumption, ψ is the inverse of Frisch elasticity of labor supply, and s_g is the share of government spending in output.

One important conclusion from a model with lump sum taxes is that the set of factors, affecting the multiplier such as the monetary policy or parameters of the model, and the set of factors, affecting the change in welfare, given the multiplier, such as the size of the wedge $\upsilon = 1 - 1/\mu$, the steady state interest rate r, and persistence of the shock ρ_g, do not intersect. Therefore higher multiplier implies a higher positive effect on welfare. Thus, in a representative agent model with lump-sum taxes and suboptimal output the relationship between multiplier and change in welfare is positive monotone.

B. Distortionary taxation. *i. Static model.* I start by presenting multipliers in a static model. In this model the only choice an agent makes is between consumption and leisure, and the only way to finance increase in spending is to collect taxes in the same period. This simple case provides us with a useful starting point to build on.

In a static model the impact multiplier is equal to multipliers at all other horizons

$$M_0 = M_t = M_T, \quad \forall t,$$

therefore the change in welfare due to a government spending shock is proportional to the short-run multiplier.

The expression for the multiplier under distortionary taxes is

$$M_0^{dist} = \frac{(1 - \tau^l)\sigma - \mu(1 - s_g)}{(1 - \tau^l)\sigma + (1 - s_g)\left[\psi(1 - \tau_l) - \omega - \tau_l\right]}. \tag{2.21}$$

The sign and the size of the multiplier under distortionary taxes depend on the combination of parameters. However, three structural parameters σ, ψ and ω do not affect the monotonicity of multiplier and welfare relationship, because it is only the multiplier that depends on them. Any variation in one of these parameters, which drives up the multiplier, also increases welfare.

On the other hand, both the multiplier and the labor wedge depend on the size of the product mark-up μ and the labor tax τ^l. Variation in these parameters can potentially move the multiplier and the change in welfare in opposite directions.

[14]For the derivation of the multiplier in a representative agent model with lump-sum taxes one can refer to Hall (2009), who also provides a comprehensive discussion of the determinants of the size of the multiplier in that model.

Numerical results suggest this can be a relevant matter. I use the following benchmark values for parameters: $\sigma = 2$, $\psi = 1$, $\omega = 0.5$. The remaining three parameters, $\left\{s_g, \mu, \tau^l\right\}$ are calibrated jointly, because the government budget constraint imposes a relationship between them: $\tau^l/\mu = s_g$. I set $s_g = 0.25$ and $\mu = 10/9$ and then find value for τ_l, which makes the budget constraint hold.

The impact of varying μ, and adjusting τ_l to balance the budget[15] on the multiplier and welfare depends on the combination of structural parameter values, such as σ, ψ, and ω. One plausible combination of parameters, under which monotonicity breaks, is $\sigma = 4$, $\epsilon = 1$ and $\omega = 0.5$. Higher steady state mark-up decreases the multiplier, but increases the labor wedge to the extent that the overall effect on the welfare is positive[16]. Alternatively, I keep the mark-up constant and vary the labor tax τ_l, allowing the share of government spending adjust to balance the budget. The computations suggest that in this case monotonicity is preserved for combinations of realistic structural parameter values.

The break of monotonicity across the size of the mark-up is a potentially important case, showing that the same factors that lead to a smaller expansion in output can also increase the scope for welfare improvement as aggregate output expands, resulting in overall positive effect on welfare despite decline in the multiplier. However, this might be not the most empirically relevant problem. The wedge depends on parameters, which one can calculate from the data, such as the mark-up level (defines the share of profits in final output) and the labor income tax. This way one knows the scope for welfare improvement, given the multiplier. A more interesting case, related to variety in estimates of structural parameter values, such as σ and ψ, can be explored in a dynamic framework.

ii. Dynamic model. In a model with distortionary taxes the presence of government debt makes a difference in two ways. First, if some amount of debt exists in the steady state, even if the government keeps it constant after increase in spending, variation in the real interest rate might call for a higher increase in income tax rate, because the government needs to finance not only higher spending but also higher interest payments. Unlike in the lump-sum taxes case, under distortionary taxation higher taxes affect optimal consumption and hours choice, and therefore affect the multiplier.

[15] Another possibility is to allow s_g, the share of government spending, to adjust in response to μ. The results are qualitatively the same.

[16] The intuition behind this non-monotonicity is the following. Increase in μ, accompanied by an increase in τ_l, increases the wedge, and therefore the change in welfare for a given multiplier. However, higher steady state mark-up implies lower steady state real wage. Increase in the tax rate $\frac{d\tau_0^l}{d\epsilon_0}$, needed to finance higher spending, is proportional to the steady state wage and hours (tax base), meaning that the lower is the wage, the higher is the needed increase in taxes. A higher increase in tax then translates into a lower multiplier due to the dampening effect on labor supply.

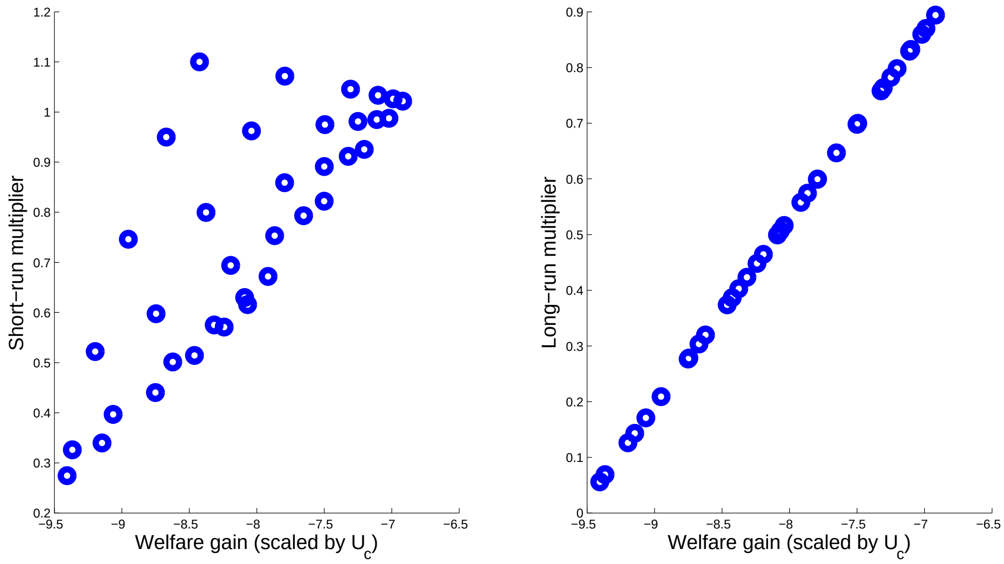

Figure 2.3.1: Short-run and Long-run Multipliers and Welfare Gains across IES ($1/\sigma$) and Frisch elasticity ($1/\psi$)

Second, timing of taxes matters due to intertemporal substitution effect on labor supply, allowing for time-dependent dynamic multipliers. Positive short run effect of increase in spending financed by a temporary budget deficit, reflected in a relatively high impact multiplier, can be turned over by negative effect of higher tax burden in the future, which should be captured by the long run multiplier.

As I have shown earlier, what matters for the change in welfare in a representative agent environment is the long-run multiplier, which summarizes all output dynamics before the economy returns back to the steady state. In a dynamic environment with non-lump-sum taxes the size of the multiplier varies across different horizons, therefore the short-run multiplier might be a misleading statistic for welfare evaluation, unless it is a good predictor for the welfare-relevant long-run multiplier. I compute short-run and long-run multipliers numerically[17].

Figure 2.3.1 shows short-run and long-run multipliers and welfare changes[18] for different pairs of two structural parameters, σ and ψ. Other parameters take values: $\mu = 10/9$, $\tau_l = 0.233$, $s_g = 0.2$, $\phi_b = 0.5$, $\beta = 0.995$, $\rho_g = 0.9$, $\omega = 0.5$. The choice of the two structural parameters, σ and ψ, is motivated by the fact that they cannot be readily computed from the data, and their estimates vary substantially across empirical studies. If the multipliers depended only on parameters easy to recover from the data, such as the level of

[17]The system of equations which is solved numerically is presented in Appendix 2.B.

[18]Welfare change is scaled by marginal utility of consumption.

the mark-up or share of government spending in GDP, it would have been straightforward to evaluate the welfare content of the short-run multiplier, once the size of the wedge and the fiscal and monetary policy is known. This vast uncertainty in structural parameters however poses a problem.

Empirical work has found Frisch labor supply elasticities as low as 0.1 (MaCurdy (1981)) and as high as 4 (Imai and Keane (2004)). Estimates using household level data typically find lower values, in range of 0.2 to 1. Domeij and Floden (2006) argue that the true value of elasticity might be twice the estimated value if the econometrician does not take into account the presence of borrowing constraints. Studies taking into account movements in and out of employment and labor force (Rogerson and Wallenius (2009)) usually find high macro elasticity. I set a range for ψ between 0.25 to 5, implying a range for Frisch elasticity between 0.2 and 4. Studies of intertemporal elasticity of substitution (the inverse of σ) have little agreement on its value as well. Attanasio et al. (1995) use US household survey data and estimate IES around 0.7 with a relatively large standard error. Barsky (1997) find low elasticity around 0.2, while Guvenen (2006) suggests that this elasticity can be 1 for certain agents. I pick a range for σ from 1.5 to 6, which corresponds to intertemporal elasticity of substitution between slightly below 0.2 to 0.67.

The right panel of Figure 2.3.1 shows the relationship between the long-run multiplier and welfare change, which is positive and monotone as expected. The left panel plots the relationship between the short-run multiplier and welfare change. This relationship is not monotone and there are many cases in which a higher short-run multiplier corresponds to a lower welfare gain. This means that the short-run multiplier is not a perfect predictor for the long-run multiplier, and therefore for the welfare gain. Consider an example. If $\sigma = 1.5$ and $\psi = 1$ the short-run multiplier is 0.76, while its long-run counterpart is 0.23. If instead σ is set to 4 and ψ to 2, the short-run multiplier is the same as in the previous case and equals to 0.76, while the long-run multiplier at 0.60 is almost three times as high.

The intuition behind these numbers relies on the opposite effects of ψ and σ on the multiplier. For a given σ, increase in ψ means that labor becomes less elastic, compressing the size of the hours response. For a given ψ, increase in σ lowers intertemporal elasticity of substitution so consumption is depressed less. Increase in both, σ and ψ, leaves the short-run multiplier almost unchanged, suggesting that the opposing driving forces, i.e. modest reaction of hours vs. modest reaction of consumption, compensate each other. In the medium run output is higher if both σ and ψ are high. First, low elasticity of labor supply implies that hours fall less in response higher taxes. Second, this path of hours, and hence wages and payroll, is favorable for public finances. The level of governemnt debt is lower, and the increase in the tax rate is smaller as well. This further prevents a strong decline in output in the medium run.

2.4 Heterogeneous agents

In this Section I study marginal welfare impact of change in fiscal policy in a model model with heterogeneity and market incompleteness and show that this framework allows for additional welfare effects of increase in government spending compared to the representative agent framework.

The welfare criterion (2.4) assigns and equal weight to each agent's welfare. Assuming that the weights are not affected by changes in government spending, the aggregate marginal welfare change is the weighted average of individual marginal welfare changes. Thus, I start with evaluating welfare impact of increase in government spending for an agent with state $x_0 = (a_0, s_0)$ at the time of the shock $t = 0$. The maximization problem of this agent in sequential form is

$$\begin{aligned}
V_0^*(x_0, \epsilon_0) &= \max_{\{c_t, l_t, a_{t+1}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \sum_{s^t} P(s^t) u(c_t(x_0, s^t, \epsilon_0), l_t(x_0, s^t, \epsilon_0), g_t(\epsilon_0)) \\
\text{s.t. } \; c_t(x_0, s^t, \epsilon_0) + a_{t+1}(x_0, s^t, \epsilon_0) &= (1 + r_t(\epsilon_0)) a_t(x_0, s^{t-1}, \epsilon_0) \\
&\quad + (1 - \tau_t^l(\epsilon_0)) s_t l_t(x_0, s^t, \epsilon_0) w_t(\epsilon_0) + \Gamma_t(\epsilon_0) \\
a_{t+1}(x_0, s^t, \epsilon_0) &\geq -\bar{a}, \quad \bar{a} > 0 \\
l_t(x_0, s^t, \epsilon_0) &\in [0, 1] \\
c_t(x_0, s^t, \epsilon_0) &\geq 0 \\
a_0, s_0 &\text{ are given.}
\end{aligned}$$

For convenience I denote the right hand side of the budget constraint as

$$\begin{aligned}
&Y_t(x_0, s^t, \epsilon_0) \\
&\quad \equiv (1 + r_t(\epsilon_0)) a_t(x_0, s^{t-1}, \epsilon_0) + (1 - \tau_t^l(\epsilon_0)) s_t l_t(x_0, s^t, \epsilon_0) w_t(\epsilon_0) + \Gamma_t(\epsilon_0). \qquad (2.22)
\end{aligned}$$

All variables are functions of ϵ_0, the initial shock to government spending. If $\epsilon_0 = 0$, the economy is at the steady state, and all variables are at their steady state levels[19]. When ϵ_0 is different from zero, the variables take their values of the t-th period of transition. After

[19]Notice, however, that in this model the steady state does not imply that individual variables, such as consumption or labor supply, are constant. Due to idiosyncratic shocks agents adjust their consumption and labor supply decisions every period even in the absence of aggregate shocks. The key difference from the transition is that in the steady state individual decisions follow time invariant decision rules.

the shock occurs, the transition back to the steady state is deterministic. The sequences of prices, profits and taxes at all periods are deterministic, and known to agents.

The consumer problem is therefore a maximization problem with a parameter, and I study how the maximum value of the problem changes with the parameter. To do this, I differentiate V_0^*, the value function of an agent with initial state $x_0 = (a_0, s_0)$ at time $t = 0$, with respect to the parameter ϵ_0 which is the initial shock to spending.

The maximum value of the agent's problem is

$$V_0^*(x_0, \epsilon_0) = \sum_{t=0}^{\infty} \beta^t \sum_{s^t} P(s^t) u(c_t^*(x_0, s^t, \epsilon_0), l_t^*(x_0, s^t, \epsilon_0), g_t(\epsilon_0))$$

where $\{c_t^*(x_0, s^t, \epsilon_0), l_t^*(x_0, s^t, \epsilon_0)\}_{t=0}^{\infty}$ are optimal sequences for consumption and labor supply. To simplify notation, in what follows I denote

$$\begin{aligned} u_t^*(x_0, s^t, \epsilon_0) &\equiv u(c_t^*(x_0, s^t, \epsilon_0), l_t^*(x_0, s^t, \epsilon_0), g_t(\epsilon_0)), \\ u_{c_t}^*(x_0, s^t, \epsilon_0) &\equiv \frac{\partial u_t^*(x_0, s^t, \epsilon_0)}{\partial c_t^*(x_0, s^t, \epsilon_0)}. \end{aligned}$$

The welfare impact of increase in government spending is[20]

$$\frac{\partial V_0^*(x_0, 0)}{\partial \epsilon_0} = \sum_{t=0}^{\infty} \beta^t \sum_{s^t} P(s^t) \left\{ u_{g_t}^*(x_0, s^t, 0) \frac{\partial g_t(\epsilon_0)}{\partial \epsilon_0} + u_{c_t}^*(x_0, s^t, 0) \frac{\partial \tilde{Y}_t(x_0, s^t, \epsilon_0)}{\partial \epsilon_0} \right\}$$

where $\frac{\partial \tilde{Y}_t}{\partial \epsilon_0}$ stands for the change in Y_t due to change in variables which the agent takes as given (prices, taxes, dividends).

The welfare evaluation above shows that the increase in welfare stems from direct increase in utility due to increase in valued government consumption g, and from increase in total resources available for consumption due to changes variables taken as given by the consumer.

Let $\Lambda_t(x_0, 0) = \tilde{\phi}_t \sum_{i=t+1}^{\infty} \beta^{i-t} R^{i-t-1} \sum_{s^i} P(s^i) u_{c_i}^*(x_0, s^i, \epsilon_0) \frac{s_i l_i^*(x_0, s^i, 0)}{L_i(0)}$, where $\tilde{\phi}_t = \phi w_t(0) L_t(0)$, and $R = 1 + r_t(0) - \tilde{\phi}_b$. It represents the marginal private utility cost in period t of a unit increase in government spending at time t for an agent with initial state x_0 after history s^t, given that the taxes are collected via a proportional labor income tax and government finances increase in spending by running a short-run budget deficit.

Private net benefit of G. The first term in the welfare decomposition relates the marginal utility of public and private consumption:

$$\sum_{t=0}^{\infty} \beta^t \frac{\partial g_t(\epsilon_0)}{\partial \epsilon_0} \left[u_{g_t}^*(x_0, s^t, 0) - \Lambda_t(x_0, 0) \right]$$

[20] See Appendix 2.C for derivation.

It can be interpreted as the net willingness to pay for an additional unit of government spending. The marginal benefit is proportional to the expected marginal utility of government consumption. The marginal cost $\Lambda_t(x_0, 0)$ is the individual expected utility cost of a unit increase in tax revenues, which the government has to collect to finance increase in spending. If taxes are lump-sum, and the level of government debt does not change in response to policy, this cost is simply the expected marginal utility of 1 unit of foregone consumption. Under proportional labor income taxation the cost of unit increase in tax revenue is unequally distributed across individuals and is higher for those with high working hours. If the government responds to increase in spending by running budget deficits in the short-run, the individual cost of g is lower. Ricardian equivalence does not hold in this model, and delayed taxation is favorable for agents' welfare as the cost is discounted[21].

Redistribution due to change in the real interest rate and the real wage. The next two terms describe redistributional effects due to changes in prices:

$$\sum_{t=0}^{\infty} \beta^t \frac{\partial r_t(\epsilon_0)}{\partial \epsilon_0} \left[\sum_{s^t} P(s^t) u^*_{c_t}(x_0, s^t, 0) a^*_t(x_0, s^{t-1}, 0) - \Lambda_t(x_0, 0) B_t(0) \right]$$
$$+ \sum_{t=0}^{\infty} \beta^t \frac{\partial w_t(\epsilon_0)}{\partial \epsilon_0} \left[\sum_{s^t} P(s^t) u^*_{c_t}(x_0, s^t, 0) \left(1 - \tau^l_t(0)\right) s_t l^*_t(x_0, s^t, 0) \right.$$
$$\left. - L_t(0) \left(\sum_{s^t} P(s^t) u^*_{c_t}(x_0, s^t, 0) - \tau^l_t(0) \Lambda_t(x_0, 0) \right) \right]$$

If the interest rate increases, agents with low asset holdings suffer a welfare loss, while wealthier agents gain. The expected marginal welfare change is related to the difference between $a^*_t(x_0, s^{t-1}, 0)$, individual asset holdings, and $B_t(0)$, the amount of government debt equal to the average asset holdings. An increase in the interest rate provides more resources for consumption (given that $a^*_t(x_0, s^{t-1}, 0) > 0$), while it also implies that the government has to pay higher interest on her debt and needs to increase taxation. The first effect is proportional to the individual asset holdings, while the second is related to the level of government debt (average asset holdings). The difference across agents stems not only from being a borrower or a saver, but from having assets above or below than average, which is typically greater than 0. Borrowers lose the most. Similarly, if the real wage goes up, agents who work relatively more hours (wealth poor) gain, while those working relatively less lose. This difference comes from the fact that increase in wage increases resources for consumption proportionately to individual hours worked, while it decreases aggregate profits proportionately to aggregate hours.

[21] The model has a steady state property $\beta(1 + r) < 1$

Impact on government revenue and firms' profits. Finally, the last term is similar to the wedge term, discussed in a representative agent framework:

$$\sum_{t=0}^{\infty} \beta^t \frac{\partial L_t(\epsilon_0)}{\partial \epsilon_0} \left[\sum_{s^t} P(s^t) u^*_{c_t}(x_0, s^t, 0) \left(1 - w_t(0)\right) + \tau^l_t(0) w_t(0) \Lambda_t(x_0, 0) \right]$$

It captures the behavioral impact of increase in spending on government tax revenue and firms profits. Increase in aggregate output, caused by a unit increase in spending, raises aggregate profits by $(1 - w_t(0)) \frac{\partial L_t(0)}{\partial \epsilon_0}$ and raises aggregate tax revenues by $\tau^l_t(0) w_t(0) \frac{\partial L_t(0)}{\partial \epsilon_0}$. If profits were zero and taxes were lump sum, this term would not be present, because the response of hours to the shock would not affect any of the two. The presence of mark-ups and proportional taxes make the right hand side of the individual budget constraint depend on the response of aggregate hours to policy.

The overall expected marginal welfare increase is given by

$$\frac{\partial V^*_0(x_0, 0)}{\partial \epsilon_0} = \underbrace{\sum_{t=0}^{\infty} \beta^t \frac{\partial g_t(\epsilon_0)}{\partial \epsilon_0} \left[u^*_{g_t}(x_0, s^t, 0) - \Lambda_t(x_0, 0) \right]}_{\text{Private net benefit of G}} \tag{2.23}$$

$$+ \underbrace{\sum_{t=0}^{\infty} \beta^t \frac{\partial r_t(\epsilon_0)}{\partial \epsilon_0} \left[\sum_{s^t} P(s^t) u^*_{c_t}(x_0, s^t, 0) a^*_t(x_0, s^{t-1}, 0) - \Lambda_t(x_0, 0) B_t(0) \right]}_{\text{Redistribution due to change in real interest rate}} \tag{2.24}$$

$$+ \underbrace{\sum_{t=0}^{\infty} \beta^t \frac{\partial w_t(\epsilon_0)}{\partial \epsilon_0} \left[\sum_{s^t} P(s^t) u^*_{c_t}(x_0, s^t, 0) \left(1 - \tau^l_t(0)\right) s_t l^*_t(x_0, s^t, 0) \right.}_{\text{Redistribution due to change in real wage}}$$

$$\underbrace{\left. - L_t(0) \left(\sum_{s^t} P(s^t) u^*_{c_t}(x_0, s^t, 0) - \tau^l_t(0) \Lambda_t(x_0, 0) \right) \right]}_{\text{Redistribution due to change in real wage (cont'd)}} \tag{2.25}$$

$$+ \underbrace{\sum_{t=0}^{\infty} \beta^t \frac{\partial L_t(\epsilon_0)}{\partial \epsilon_0} \left[\sum_{s^t} P(s^t) u^*_{c_t}(x_0, s^t, 0) \left(1 - w_t(0)\right) + \tau^l_t(0) w_t(0) \Lambda_t(x_0, 0) \right]}_{\text{Impact on government revenue and firms' profits}}. \tag{2.26}$$

I integrate individual welfare changes with respect to the stationary distribution $\lambda_0(x_0, 0)$ to get change in aggregate ex ante welfare.

2.5 Quantitative analysis

2.5.1 Parameterization

The model period is one quarter. Table 2.5.1 presents parameter values in quarterly terms. The model parameters and calibration targets are chosen to match US data.

A. Preferences. Utility function is separable and isoelastic in consumption, hours and government purchases

$$u(c,l,g) = \frac{c^{1-\sigma}}{1-\sigma} - \gamma \frac{l^{1+\psi}}{1+\psi} + \chi \log(g),$$

where $\sigma > 0$ is the coefficient of relative risk aversion and the inverse of the intertemporal elasticity of substitution, $\psi > 0$ is the inverse of the Frisch elasticity of labor supply, $\gamma > 0$ defines the disutility of work, and χ captures how agent values public purchases of goods and services.

The discount factor β is calibrated to deliver a yearly interest rate of 2% in the steady state. Parameter γ is set to match average hours of work to be equal to 0.40. Relative preference for govenment consumption χ is set to 0, i.e. governemnt spending is a pure waste. Since the focus of the study is on monotonicity properties between the multiplier and change in welfare, the size of χ does not matter for the main results of the paper because utility is separable in governemnt consumption.

I evaluate multipliers and changes in welfare for three values for the coefficient of relative risk aversion, $\sigma = \{2, 4, 6\}$, and four values for the Frisch elasticity of labor supply, $1/\psi = \{0.2, 0.5, 1, 4\}$. Parameters are recalibrated for each combination of σ and ψ. In Table 2.5.1 only two sets of parameter values, for $(\sigma, 1/\psi) = (2, 1)$ and $(\sigma, 1/\psi) = (4, 0.5)$, are presented.

B. Idiosyncratic productivity process and credit market. Following Floden and Linde (2001), I assume that the idiosyncratic productivity process follows an $AR(1)$ in logs

$$\log(s_t) = \varpi + \vartheta_t$$
$$\vartheta_t = \rho \vartheta_{t-1} + \eta_t$$

where ω is a permanent component, and ϑ_t is a temporary component which evolves stochastically over time with persistence ρ, η_t is $i.i.d.$ $N(0, \sigma_\eta^2)$ and ϖ and ϑ_t are orthogonal. I assume the permanent component is absent, i.e. $\varpi = 0$, thus individual productivity shocks are purely transitory shocks[22]. Realizations s_t are independent across agents, therefore the cross-sectional distribution of idiosyncratic productivity at any point in time and in any aggregate state is log normal with mean 1.

Following Floden and Linde (2001) estimate individual wage process using yearly PSID data, and find a coefficient of autocorrelation for the transitory component to be 0.9136

[22]In general this is not the case, because the permanent component might be related to age, skill level, etc. I do not include these features in my model.

Table 2.5.1: Parameter values

Parameter	Value		Calibration target
$(\sigma, 1/\psi)$	$(2,1)$	$(4,0.5)$	
β	0.9848	0.9799	annual interest rate $r = 2\%$
γ	14.44	292.03	average hours are 0.40
χ	0		pure waste spending
ρ	0.9777		persistence of prod-ty process
σ_η	0.0117		variance of prod-ty process
$pr(s' \in S \mid s \in S)$	0.9		prob of keeping positive prod-ty
$pr(s' = 0 \mid s = 0)$	0.5		prob of keeping zero prod-ty
ϕ	-1.0678	-1.6002	share with neg wealth is 25%
θ	10		share of profits is 10%
ω	0.5		Hall (2009)
$\bar{g}$	0.08		share of G in Y is 20%
τ_l	0.2333		annual debt-to-GDP ratio is 50%
ϕ_b	0.5		response of tax rate to debt

and variance to be 0.0426. The individual productivity process at quarterly frequency is calibrated to match these moments in yearly data. The continuous productivity process is approximated by a 7 state Markov chain using Tauchen (1986) method.

Individual productivity process also allows for state in which the productivity is equal to zero. This state can be interpreted as unemployment. Transition to and from this state is calibrated following Krusell et al. (1998). The transition probabilities imply an average duration of unemployment spell of 1.5 quarters[23], and an average duration of a job of 2.5 years.

The borrowing limit ϕ is set such that the share of agents with zero or negative wealth is about 25%, which roughly corresponds to US data in 2007 (not taking into account illiquid wealth). The share of agents close to the borrowing limit is important for both the size of the multiplier and the evaluation of welfare. For the former it matters because agents with low wealth have stronger wealth effects. For the latter it matters because changes in the interest rate affect these agents differently than savers.

C. Technology and mark-ups. Intermediate goods technology is assumed to be linear in labor

$$y = l \tag{2.27}$$

[23]Duration is computed according to the formula $D = \frac{1}{1-Prob}$

The elasticity of substitution across intermediate varieties θ is set to 10, which corresponds to a 10% share of profits in final output in the steady state. I set $\omega = 0.5$ in line with Hall (2009).

D. Fiscal policy. Pre-shock level government spending is set to 20% of final output, corresponding to the historical share of total US government spending in GDP. The labour income tax τ_l was chosen to be 0.2333, which delivers government debt-to-GDP ratio of 50%. This value for the tax is roughly in line with historical US data. The shock to government spending that I consider is 1 % of GDP.

The choice of ϕ_b, which governs the delay in tax collection, is important for the results. To the best of my knowledge the literature does not provide a definitive suggestion on how to chose this parameter, so I set it to have a persistent debt dynamics and insure stability at the same time.

E. Solution method. The model is solved using policy function iteration on an endogenous grid. The details are discussed in Appendix 2.D.

F. Welfare measures. Together with the expected marginal welfare change, I compute a welfare gain of a household with initial state $x_0 = (a_0, s_0)$ which is defined as the constant percentage increase in consumption in the case the economy stays in the steady state that gives the household the same expected utility as when the government temporarily increases spending[24]. Let $c_t^*(x_0, s^t, \epsilon_0)$ be the optimal equilibrium consumption of a household with initial state x_0 if there is an increase in government spending at $t = 0$, and $c_t^*(x_0, s^t, 0)$ the same thing in case the economy stays in the steady state. Then the welfare gain δ_{x_0} solves the following equation:

$$\sum_{t=0}^{\infty} \beta^t \sum_{s^t} P(s^t) u(c_t^*(x_0, s^t, \epsilon_0), l_t^*(x_0, s^t, \epsilon_0), g_t(\epsilon_0))$$
$$= \sum_{t=0}^{\infty} \beta^t \sum_{s^t} P(s^t) u((1 + \delta_{x_0}) c_t^*(x_0, s^t, 0), l_t^*(x_0, s^t, 0), g_t(0))$$

The welfare gains for households with different initial wealth and productivity are computed by creating a large artificial population, where each household starts with a different combination of assets and productivity, and simulating the economy forward under two scenarios: 1) the economy stays in the steady state forever; 2) there is a temporary increase in government spending.

The average welfare gain in the economy is defined as the constant percentage increase in consumption (the same for everybody) if the economy stays in the steady state that

[24] For example, see Domeij and Heathcote (2004).

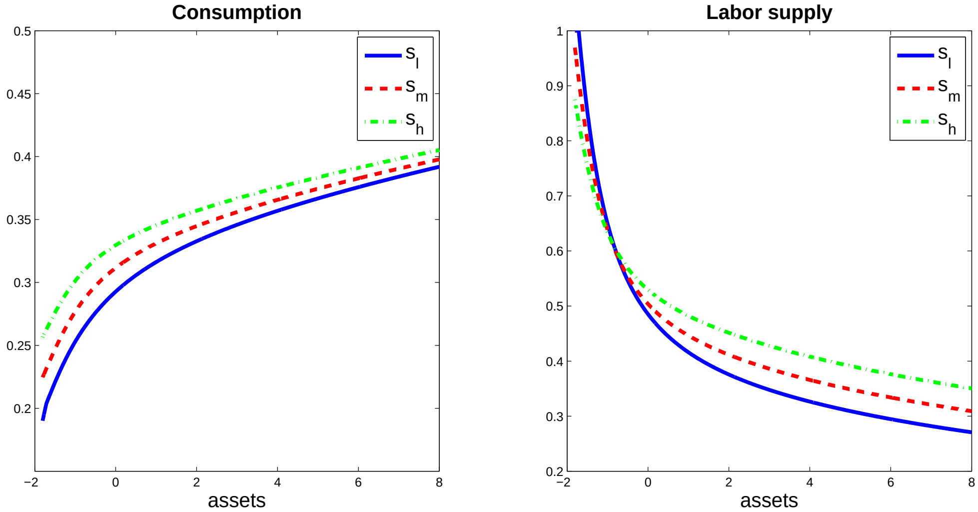

Figure 2.5.1: Optimal consumption and labor in the steady state

delivers the same aggregate utility under welfare criterion (2.4) as when there occurs a temporary change in fiscal policy. The average welfare gain δ solves the following equation:

$$\sum_{x_0}\sum_{t=0}^{\infty}\beta^t\sum_{s^t}P(s^t)u(c_t^*(x_0,s^t,\epsilon_0),l_t^*(x_0,s^t,\epsilon_0),g_t(\epsilon_0))\lambda_0(x_0)$$
$$=\sum_{x_0}\sum_{t=0}^{\infty}\beta^t\sum_{s^t}P(s^t)u((1+\delta)c_t^*(x_0,s^t,0),l_t^*(x_0,s^t,0),g_t(0))\lambda_0(x_0)$$

2.5.2 Steady state

I briefly discuss the properties of agents' policy functions in the steady state. Figure 2.5.1 presents optimal consumption and labor supply decision of agents in the steady state as a function of their asset holdings. Policy functions are plotted for the lowest positive (s_l), medium (s_m) and highest (s_h) levels of productivity.

There are substantial differences in consumption and labor supply across agents with different levels of assets. agents at the top of the wealth distribution consume almost twice as much and work three times as little as those at the bottom. Policy functions' curvature also changes along the distribution. While the consumption optimal decision is almost linear in wealth for agent with a high buffer stock of saving, it becomes concave as we move down the asset distribution. This is a typical feature of buffer stock models, as was shown by Carroll and Kimball (1996). Consumption and labor supply are related through the intratemporal optimality condition, therefore the concavity of the consumption policy function translates into convexity of the policy function for hours. For the wealth poor a higher productivity is associated with a lower labor supply because the income effect

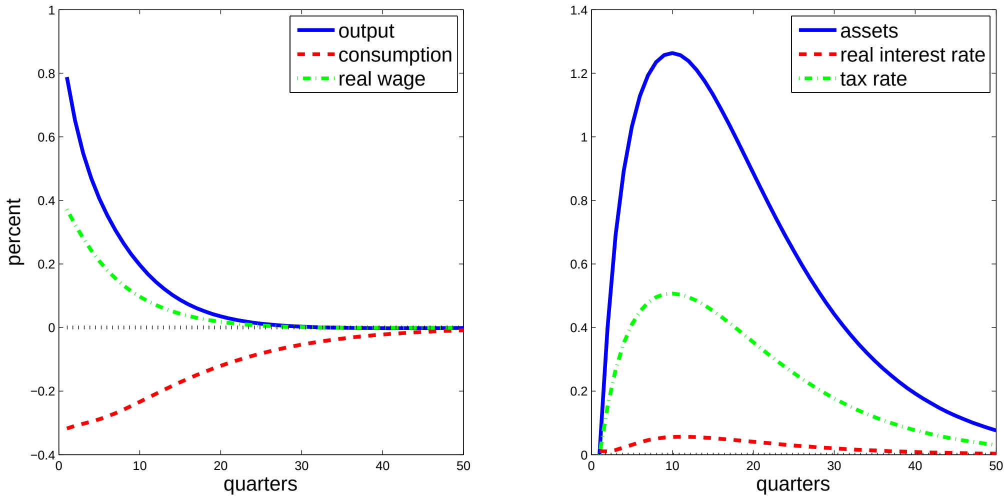

Figure 2.5.2: Transition dynamics of main variables

of higher wage dominates the substitution effect. For richer agent the substitution effect turns out to be larger, and higher wage (stemming from high productivity) makes the agent be willing to work more.

2.5.3 Results

A. Transition path. Figure 2.5.2 describes the behavior of output, consumption, assets, real interest rate and real wage during a transition after a persistent increase in government spending following a 1 percent of GDP shock ϵ_0 in period 0, financed by increase in labor income tax starting from period 1, with tax following a rule $\partial\tau_t^l/\partial\epsilon_0 = \phi_b \partial B_t/\partial\epsilon_0$. This an example of a typical behavior of the main variables during the transition path, with parameter values chosen for this exposition being $(\sigma, \psi) = (4, 2)$.

Output peaks at $t = 0$ and goes back to the steady state as the impact of the the shock dies out[25]. Consumption mirrors output dynamics, falling at the time of the shock and then recovering gradually. Asset holdings in equilibrium are equal to the amount of government debt, which builds up at the the beginning of transition and starts decreasing when the tax rate adjusts to bring debt back to its steady state level. The interest rate shows a similar pattern: as the level of debt increases, the return on it goes up to make agents willing to hold this quantity of debt.

Both the real wage and the real interest rate reach their respective peaks in the short-run. The wage response is highest on impact, while the real interest rate reaches its

[25]Under some parameterizations, which imply a strong reaction of hours to after-tax real wage, output is going below the steady state when taxes increase.

maximum point in about 10 quarters. This suggest that most of the redistribution due to prices happens in the short-run. Given the persistence of productivity process, the initial position of the agent in the distribution over productivity and wealth is important in determining individual expected welfare gains.

B. Multiplier and Welfare. Central results from the model with heterogeneous agents are summarized in Figures 2.5.3 and 2.5.4. Figure 2.5.3 describes the relationship between short- and long-run multipliers and average welfare gains (top panel) and the standard deviation of individual welfare gains (bottom panel). The short-run multiplier has a non-monotone relationship with both average welfare gain and the dispersion of individual gains. On the other hand, the average welfare gain is monotone increasing in the long-run multiplier for most of parameter values (the exception is $1/\psi = 0.2$, which implies very inelastic labor supply). Some parameterizations are associated with high multipliers at all horizons and low variation of welfare gains across agents, while others result in low multipliers and highly uneven distribution of gains. However, there are several cases in between, for which the relationship between short-run multiplier, long-run multiplier and distribution of welfare gains changes with parameter values. Figure 2.5.4 suggest why this can happen. While the short-run multiplier characterizes output response on impact and the long-run multiplier takes into account its cumulative change, the distribution of welfare gains depends on the distribution of taxation burden, and changes in real wage and real interest rate. While transition dynamics of the wage repeats the shape of output response and therefore is related to the multiplier, the behavior of the interest rate is determined by the pattern of government debt and saving decisions of agents.

The top panel of Figure 2.5.4 plots multipliers against the impact on revenues and profits (component 2.26 in welfare decomposition), the panel in the middle shows the net benefit of increase in government spending (component 2.23), and finally the bottom panel describes redistributional components (components 2.24 and 2.25). All components are scaled by the average marginal utility of consumption. Impact on revenues and profits has a positive monotone relationship with the long-run multiplier. This is the only component related to the size of the multiplier in the representative agent model. Net benefit of government spending and redistribution due to changes in prices have a non-monotone relationship with the long-run multiplier. Why is this so?

i. Frisch elasticity of labor supply. More elastic labor supply leads to a stronger output reaction on impact, as hours increase by more in response to higher real wage and relatively low income tax rate. The size of the long-run multiplier depends on the relative strength of two opposing effects. First, as taxes start to increase in response to

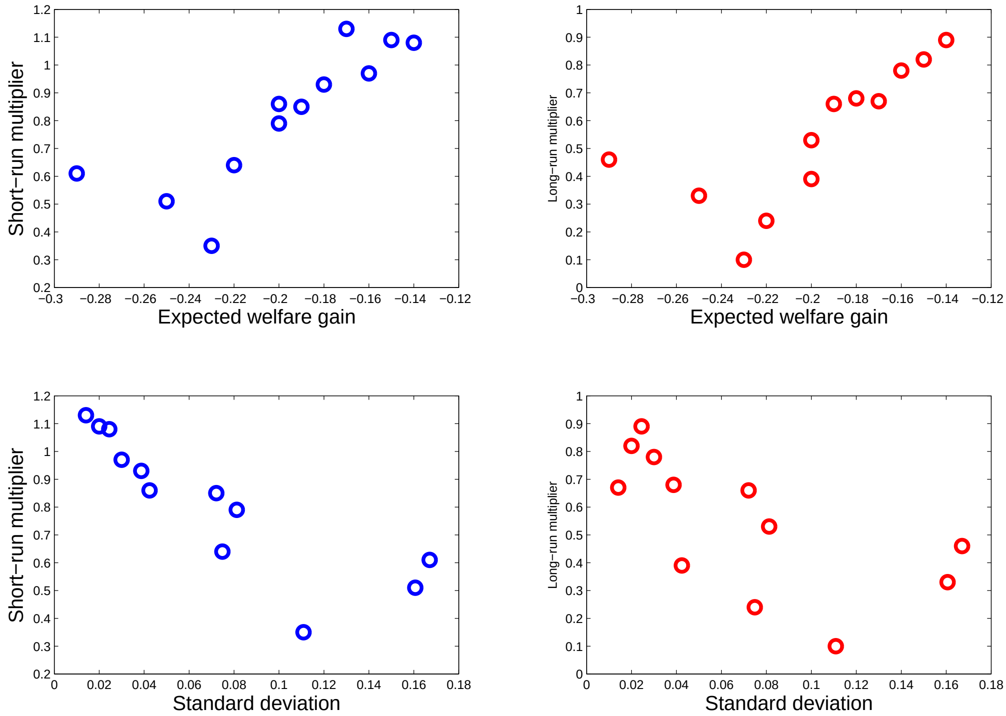

Figure 2.5.3: Multipliers and expected average welfare gain, and standard deviation of individuals gains

higher debt level, hours fall by more if labor supply is elastic. Second, if initial increase in output was large, the level of debt accumulated in the short-run is lower, which leads to a lower tax rate increase. This mitigates the negative effect of taxes on hours. Under parameterizations I use in this paper, the second effect appears to be larger and more elastic labor results in both short- and long-run multipliers being higher.

Since multipliers are higher at all horizons, the transition is characterized by a lower level of public debt and a smaller increase of the real interest rate. This path for the real rate is more favorable for the wealth poor than for wealth rich, resulting in a narrower distribution of welfare gains. Therefore a higher Frisch elasticity is associated to a less negative redistributional component.

Higher Frisch elasticity also corresponds to a larger net benefit of spending at lower level of σ, but to a lower net benefit when σ is high. More elastic labor supply implies that in the steady state hours of work are more unequally distributed across agents with different asset holdings, with relatively poorer agents working more hours. The cost of financing increase in spending is higher for poorer agents. First, the tax is proportional to the labor supply, therefore in absolute terms wealth poor agents pay more income

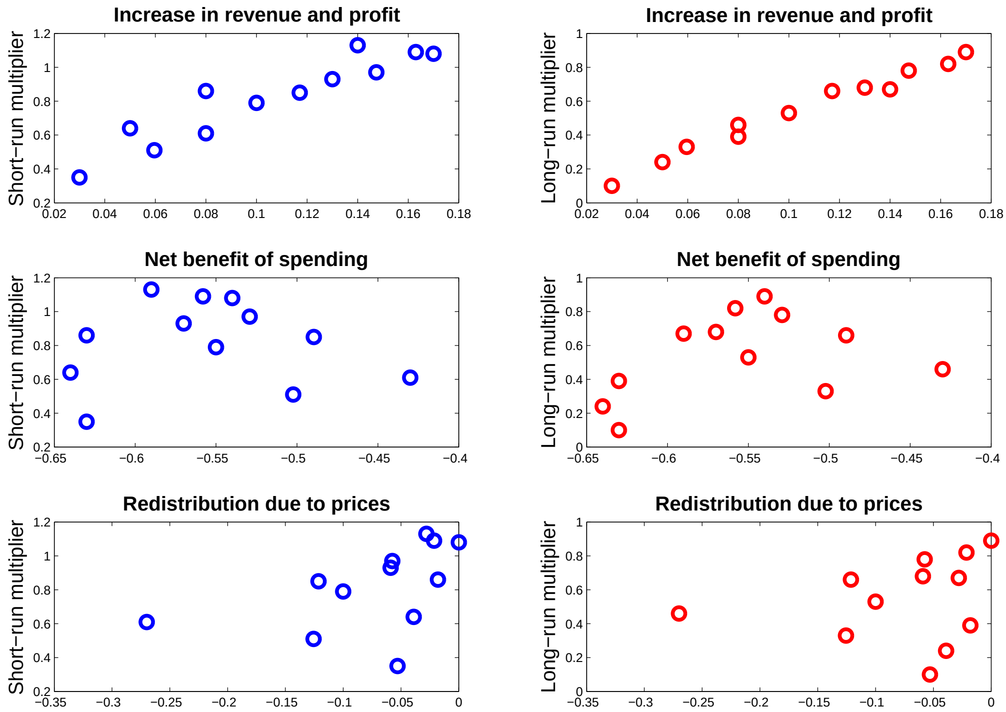

Figure 2.5.4: Multipliers and components of expected marginal welfare gain

taxes than wealth rich (given the same productivity and wage). Second, agents with little assets have lower steady state consumption than those with more assets, meaning that an equal decrease in consumption translates into a higher utility cost for them. Thus, the poor bear a disproportionately larger cost of financing fiscal policy than the rich. The size of decline in marginal utility is proportional to the initial consumption, which is more equal across agents with different levels of wealth if the Frisch elasticity is high, since they adjust hours rather than consumption in response to idiosyncratic shocks. This mitigates the effect of elastic labor supply on the utility cost of the poor, since consumption is more equally distributed. The size of the two effects depends on the strength of consumption smoothing motive. If this motive is weak, i.e. σ is low, inequality in hours is low and the second effect (utility cost) dominates. On the contrary, if agents prefer to keep their consumption profile smooth across time and states, then hours vary substantially across asset levels. In this case, the first effect (taxation cost) is larger, and more elastic labor supply implies more negative net benefit of government spending.

ii. Intertemporal elasticity of substitution. A smaller value of the intertemporal elasticity of substitution (IES) results in a higher short-run multiplier. This parameter affects the income effect on consumption, which is large when IES is low. The long-run multiplier

Table 2.5.2: Comparison of multipliers and welfare gains

	'High elasticity'	'Low elasticity'
$(\sigma, 1/\psi)$	$(2, 1)$	$(4, 0.5)$
Short-run Multiplier	0.86	0.79
Long-run Multiplier	0.37	0.52
Welfare gain, average	-0.20	-0.19
Welfare gain, bottom 10 %	-0.24	-0.30
Welfare gain, top 10 %	-0.12	-0.05

Expected welfare gain is measured as percentage of steady state consumption.

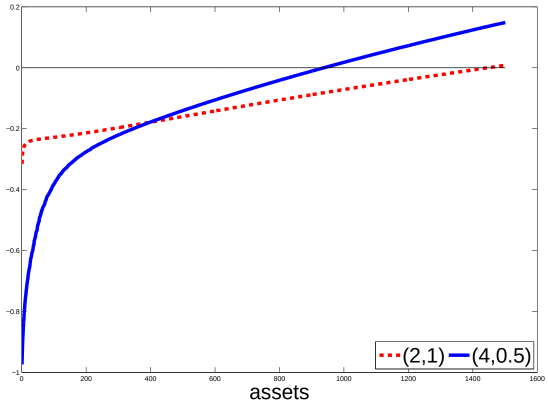

Figure 2.5.5: Expected welfare gain across asset levels

is high as well because the initial large expansionary effect on output leads to a lower level of debt and taxation over the transition, which delivers a higher path for output despite a larger negative income effect of higher taxes. Although a smaller IES generates a lower debt transition path, it is accompanied by a stronger reaction of the real interest rate. This can be explained by the tendency of agents to smooth consumption, which is strong when IES is low. As taxes increase to stabilize debt, agents prefer to dissave rather than decrease consumption. They therefore require a higher interest rate to be willing to hold the same quantity of debt compared to the situation when the desire for consumption smoothing is weak.

The stronger real interest rate response explains why the redistributional component of change in welfare is more negative when IES is low. Lower IES also corresponds to a higher net benefit of spending because consumption inequality in the steady state is smaller (consumption smoothing over states) which reduces the utility cost of financing increase in spending at the bottom of the distribution by more than it increases it at the top.

C. Example. To explain how choices of parameters interact with each other and why different combinations can produce a non-monotone relationship between the long-run multiplier and welfare gain, I focus on comparing multipliers and expected welfare gains for two sets of structural parameters. Table 2.5.2 presents multipliers and expected welfare gains in case when both IES and Frisch elasticity are high ("high elasticity", $(\sigma, 1/\psi) = \{2, 1\}$) and when both elasticities are low ("low elasticity", $(\sigma, 1/\psi) = \{4, 0.5\}$).

The short-run multipliers are similar. The long-run multiplier is 0.37 in the 'high elasticity' case and 0.52 when both elasticities are low. The average welfare gain in the elastic case is equivalent to a permanent 0.20 % decline in consumption, with decline for the bottom ten percent of agents being 0.24 % and decline for top ten percent being 0.12 %. Under the 'low elasticty' parameterization the average gain in welfare is similar and corresponds to a permanent 0.19 % decline in consumption, but in contrast to the previous case the welfare decline for the bottom ten percent is 0.30 % and decline for the top ten percent is 0.05 %.

Figure 2.5.5 shows the distribution of welfare gains across agents with different asset levels. In the 'high elasticity' case the distribution of welfare gains is more equal, agents' expected gains are between approximately 0.30% and 0% permanent loss in consumption depending on their initial wealth level. In the 'low elasticity' case the distribution of gains is more uneven, despite the average being the same. While those at the top of the income distribution gain due to increase in governemnt spending, agents at the bottom lose an equivalent of up to 0.90% of their consumption permanently. Thus, despite the long-run multiplier being higher and the average welfare gain similar when both intertemporal substitution and Frisch elasticities are high, individual welfare gains are more dispersed and are larger for the poorest agents in the economy.

To understand why the parameterizations differ in their welfare implications of the size of the multiplier, we first look at the dynamics of output, consumption, assets and the real interest rate after the shock, summarized in Figure 2.5.6. In the 'high elasticity' case, the short-run multiplier is (a little) higher and the long-run multiplier is lower because the intertemporal labor substitution is strong. Consumption initially falls less because labor response is stronger, but then it continues to decrease as output falls, and starts rebounding only when output starts to go back to the steady state. This consumption path implies that the interest rate falls on impact, and then shoots above the steady state (see Figure 2.5.6). In the 'low elasticity' case the interest rate is above the steady state during the whole transition path, and its peak is above that of the elastic case. The interest rate in this case remains high throughout the transition because the quantity of government debt is higher while the desire for precautionary saving is lower since output

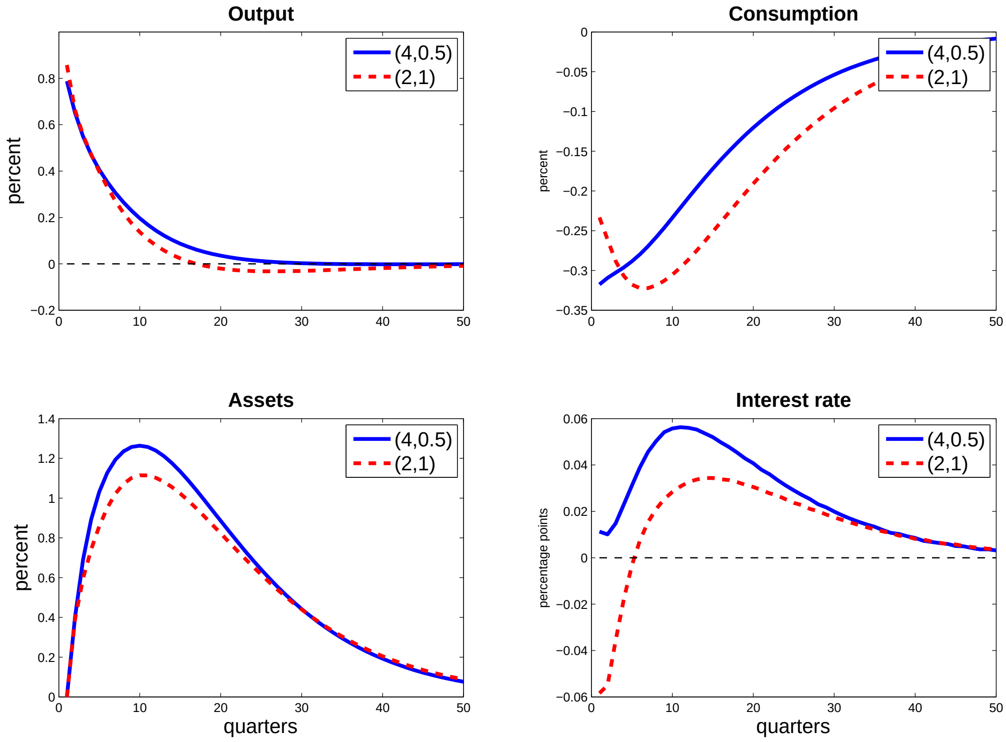

Figure 2.5.6: Response to a 1 percent of GDP government spending shock

path is more smooth. On the contrary, in the elastic case the debt is lower while the desire for accumulating a buffer stock saving is strong, implying that the agents are willing to hold government debt even at a low return.

Figure 2.5.7 shows marginal changes in welfare for agents with different levels of asset holdings and productivity at time 0. The net benefit of government spending in lower for wealth poor in both cases, and more equally distributed across agents with different assets in the 'high elasticity' case. However, the impact on revenue and profits is lower, especially for the poor, since the long-run multiplier is low. The largest difference in welfare gains between agents at different ends of the distribution is due to the changes in prices. The reason why welfare gains are lower at the bottom and larger at the top in the 'high elasticity' case is that the interest rate path is more favorable for the wealth poor. The poor benefit from lower real interest rate transition path while the rich lose, which results in an overall more equal distribution of welfare gains.

D. Wage vs. Real interest rate. An agent with high productivity gains when the real wage increases because increase in earnings offsets decline in dividend income, while the agent with low productivity loses for the same reason. A high productivity agent is also trying to accumulate wealth rapidly in order to self-insure against a bad

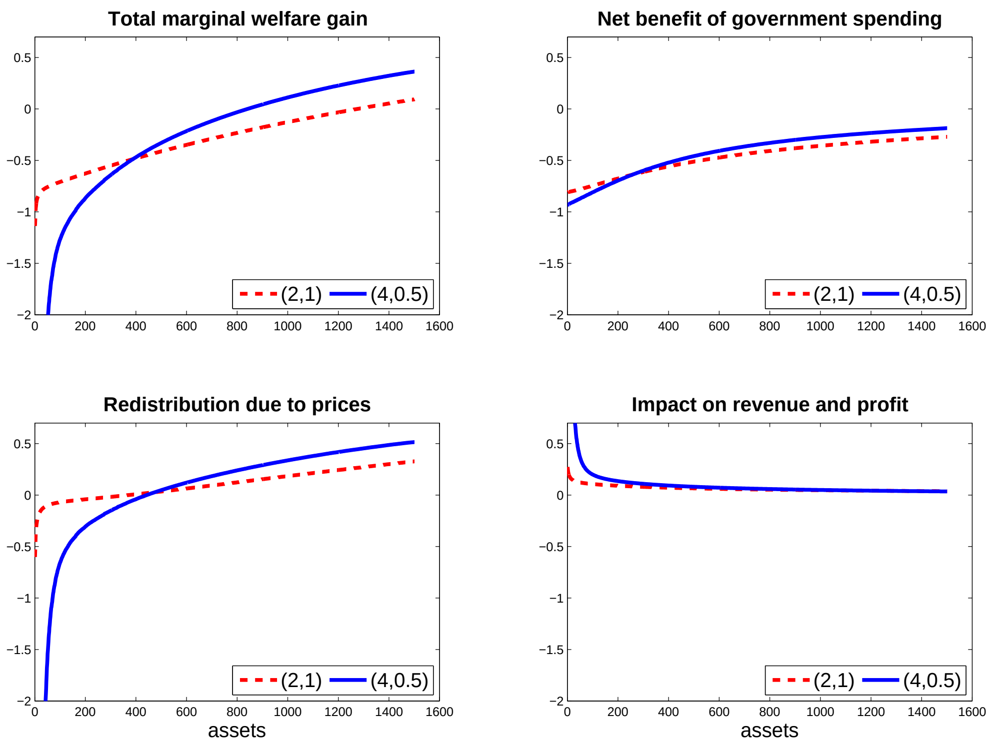

Figure 2.5.7: Marginal welfare gains

productivity shock, thus expecting to gain from future increase in the interest rate. A low productivity agent is typically using their wealth to smooth current consumption, and therefore is expected to suffer losses from future interest rate increase. These losses are larger at the bottom of the distribution as the current assets are already low. It is clear from Figure 2.5.8 that the movement in the real wage cause little redistribution apart from the very bottom[26], and the change in welfare due to it is similar between parameterizations. On the contrary, the main difference in welfare gains between different sets of parameter values is explained by the redistribution stemming from the behavior of the real interest rate.

2.5.4 Robustness

So far I used a utilitarian welfare criterion, which assigned a weight of unity to each agent. In the light of the previous discussion about distribution of gains and losses from temporary increase in spending I check how results change when the welfare criterion gives different weights to the rich and the poor. I use two alternative weighting schemes.

[26]The negative marginal welfare gain at the bottom comes from the losses of agents with low/zero productivity, who suffer from a decline in dividends as the wage increases.

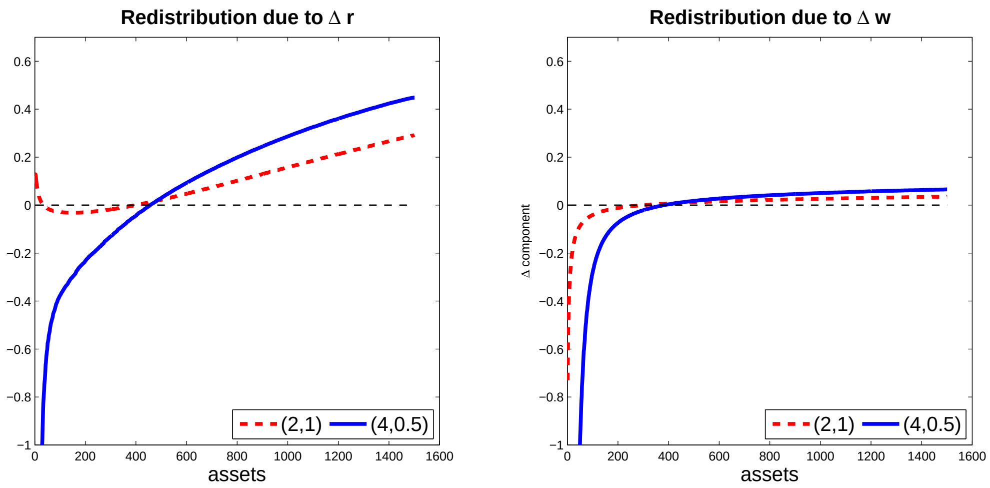

Figure 2.5.8: Marginal welfare gain, redistributional components

According to the first one each agent's welfare is included in the aggregate with a weight proportional to the square of their initial consumption. This assignment of weights implies that richer agents get a higher weight than poorer ones ('pro-rich'). The second scheme weights each agent proportionally to the inverse of the square of their initial consumption, this way giving more weight to the poor ('pro-poor'). Results are presented in Figure 2.5.9.

The bottom panel shows relationship between short- and long-run multipliers and average expected welfare gain under the 'pro-rich' welfare criterion. Variation in expected welfare gain is moderate, and for most combinations of structural parameter values the welfare gain is monotone increasing in the long-run multiplier. On the contrary, under the 'pro-poor' welfare criterion the average expected welfare gain is more dispersed and non-monotone in the long-run multiplier. This leads to a conclusion that while the long-run multiplier can be informative of the average welfare gain (under most parameterizations), this relationship relies on the welfare gains of the richer part of the economy. The welfare gains at the bottom are less predictable from the high value of the long-run multiplier.

2.6 Conclusion

This paper looks at the relationship between the size of government spending multiplier in the short and in the long run and welfare gain resulting from increase in spending. I show that while in the representative agent framework the welfare gain is proportional to the long-run (cumulative present discounted value) multiplier, allowing for differences across agents in terms of their asset holdings, consumption and labor supply can change the welfare implications of the size of the government spending multiplier. Redistributive effects of fiscal policy and its general equilibrium effects might go in opposite directions.

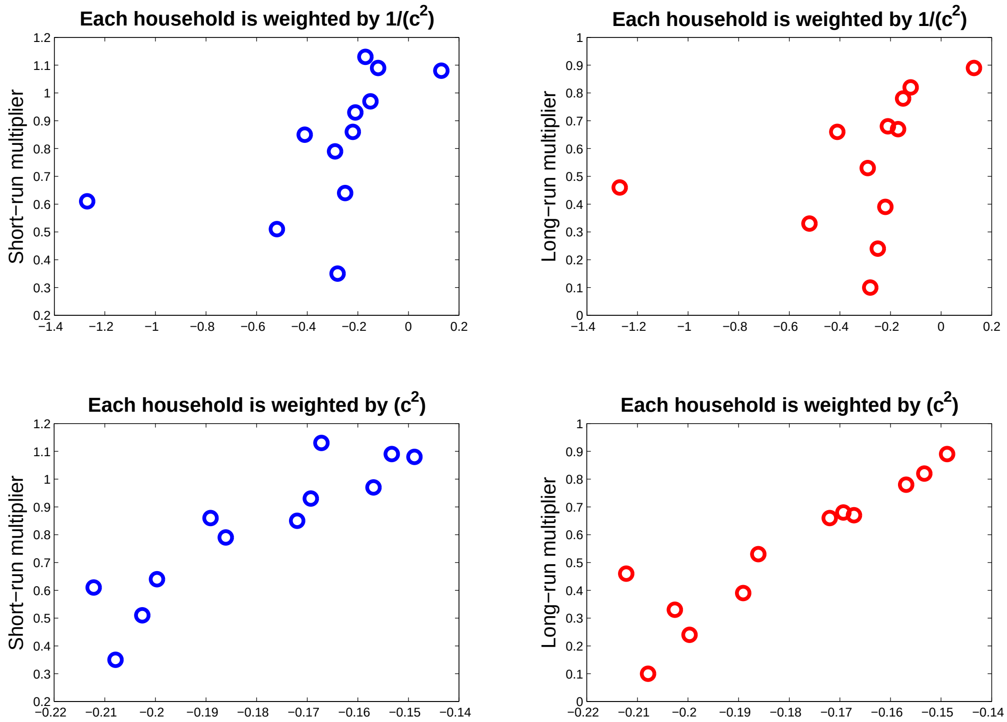

Figure 2.5.9: Multipliers and expected average welfare gain

There exist plausible combinations of values for Frisch elasticity of labor supply and intertemporal elasticity of substitution, for which a high multiplier might be associated with a lower welfare at the bottom of the wealth distribution (for a given policy). This can result in the average welfare gain being low when the multiplier is high if the welfare of the poor is given enough weight.

The mechanism which accounts for these findings relies on intertemporal response of output, government debt dynamics and precautionary saving behavior of the agents, which together affect the transition dynamics of the real interest rate. A more expansive path for the real rate redistributes wealth from asset poor to asset rich. This can lead to a wider dispersion of expected welfare gains across agents despite higher cumulative multiplier, with the agents at the bottom losing the most.

The main implication of this analysis is that when evaluating fiscal policy, one cannot fully rely on the multiplier statistic. First, if one wants to pick the most welfare-relevant multiplier they should look at the long-horizon present discounted value multiplier, which takes into account the whole transition path of output. Second, even the size of the cumulative multiplier can fail to reflect how welfare gains are distributed across different agents, because the relationship between the two depends on (among other factors) the size of Frisch elasticity of labor supply and intertemporal elasticity of substitution. Given that there is still a large disagreement in the literature on the the values of these structural parameters, there is a concern that even within a structural model one cannot precisely evaluate the relative size of redistributive and aggregate effects of government spending.

Appendix

2.A Definition of Equilibrium

An equilibrium constitutes sequences of government purchases $\{g_t\}_{t=0}^{\infty}$ and labor income taxes $\left\{\tau_t^l\right\}_{t=0}^{\infty}$, sequences of optimal consumption and labor supply $\{c_t(x_0, s^t), l_t(x_0, s^t)\}_{t=0}^{\infty}$, sequences of prices $\{w_t, r_t\}_{t=0}^{\infty}$ and dividends (profits) $\{\Gamma_t\}_{t=0}^{\infty}$, and a sequence of distributions for asset holdings and productivity levels $\{\lambda_t(x)\}_{t=0}^{\infty}$, such that given the initial distribution λ_0 for each time $t = 0, 1, 2, ...$ and each history s^t:

1. $\forall x_0$ $c_t(x_0, s^t)$ and $l_t(x_0, s^t)$ solve household maximization problem, given the sequences $\left\{\tau_t^l\right\}_{t=0}^{\infty}$, $\{w_t\}_{t=0}^{\infty}$, $\{r_t\}_{t=0}^{\infty}$ and $\{\Gamma_t\}_{t=0}^{\infty}$;

2. $\{\lambda_t(x)\}_{t=0}^{\infty}$ is induced by $c_t(x_0, s^t)$ and $l_t(x_0, s^t)$[27], and Π;

3. the tax rate is determined according to $\tau_{lt} = \phi_b B_t$ and the government budget constraint is satisfied

$$\tau_t^l w_t L_t + B_{t+1} = (1 + r_t)B_t + g_t;$$

4. the real wage is the inverse of product mark-up: $w_t = \frac{1}{\mu_t}$;

5. the markets for assets and labor clear

$$A_{t+1} = \sum_x \sum_{s^t} P(s^t) a_{t+1}(x_0, s^t)\lambda_t(x) = B_{t+1},$$
$$L_t^s = \sum_x \sum_{s^t} P(s^t) s_t l_t(x_0, s^t)\lambda_t(x) = \int_0^1 l_i di = L_t^d.$$

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[27] Consumption and labor supply optimal decisions together with the budget constraint fully determine asset holdings optimal decision.

2.B Multiplier computation in a dynamic model with distortionary taxation

The model is solved in deviations from the steady state under the assumption of perfect foresight. Together with the initial conditions $\frac{dY_{-1}}{d\epsilon_0} = 0$, and $\frac{dB_0}{d\epsilon_0} = 0$, equations (2.28), (2.29) (or (2.30) in case of debt), (2.31) and (2.32) below characterize solution for the change in output in each period after the shock

$$\frac{dY_t}{d\epsilon_0} = \frac{\sigma}{\sigma + \psi(1-s_g)}\frac{dg_t}{d\epsilon_0} + \frac{s_g y}{w(\sigma + \psi(1-s_g))}\frac{dw_t}{d\epsilon_0} - \frac{s_g y}{(1-\tau^l)(\sigma + \psi(1-s_g))}\frac{d\tau_t^l}{d\epsilon_0} \tag{2.28}$$

$$\frac{d\tau_t^l}{d\epsilon_0} = \frac{1}{wy}\frac{dg_t}{d\epsilon_0} + \frac{B}{wy}\frac{dr_t}{d\epsilon_0} - \frac{\tau^l(1+\omega)}{y}\frac{dY_t}{d\epsilon_0} \quad \text{if balanced budget} \tag{2.29}$$

$$\frac{d\tau_t^l}{d\epsilon_0} = \phi_b \sum_{s=0}^{t-1}\left[B\frac{dr_s}{d\epsilon_0} + \frac{dg_s}{d\epsilon_0} - \frac{\tau^l(1+\omega)}{\mu}\frac{dY_t}{d\epsilon_0}\right] \quad \text{if debt} \tag{2.30}$$

$$\frac{dr_t}{d\epsilon_0} = \frac{\sigma}{\beta c}\left[\left(\frac{dY_t}{d\epsilon_0} - \frac{dY_{t-1}}{d\epsilon_0}\right) - \left(\frac{dg_t}{d\epsilon_0} - \frac{dg_{t-1}}{d\epsilon_0}\right)\right] \tag{2.31}$$

$$\frac{dw_t}{d\epsilon_0} = \frac{\omega w}{y}\frac{dY_t}{d\epsilon_0}. \tag{2.32}$$

The multipliers can be computed according to (2.16). Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

2.C Welfare decomposition for model with heterogeneous agents

To simplify notation, in what follows I denote

$$u_t(x_0, s^t, \epsilon_0) \equiv u(c_t(x_0, s^t, \epsilon_0), l_t(x_0, s^t, \epsilon_0), g_t(\epsilon_0)),$$
$$u_{c_t}(x_0, s^t, \epsilon_0) \equiv \frac{\partial u_t(x_0, s^t, \epsilon_0)}{\partial c_t(x_0, s^t, \epsilon_0)}.$$

The optimality conditions are

$$u_{c_t}(x_0, s^t, \epsilon_0)\frac{\partial Y_t}{\partial l_t(x_0, s^t, \epsilon_0)} + u_{l_t}(x_0, s^t, \epsilon_0) = 0$$

$$u_{c_t}(x_0, s^t, \epsilon_0) \geq \beta \sum_{s_{t+1}} P(s_{t+1}|s_t)\frac{\partial Y_{t+1}}{\partial a_{t+1}(x_0, s^t, \epsilon_0)} u_{c_{t+1}}(x_0, s^{t+1}, \epsilon_0)$$

Slackness

$$\left[u_{c_t}(x_0, s^t, \epsilon_0) - \beta \sum_{s_{t+1}} P(s_{t+1}|s_t)\frac{\partial Y_{t+1}}{\partial a_{t+1}(x_0, s^t, \epsilon_0)} u_{c_{t+1}}(x_0, s^{t+1}, \epsilon_0)\right]\left[\bar{a} + a_{t+1}(x_0, s^t, \epsilon_0)\right] = 0$$

Transversality

$$\lim_{T\to\infty} \beta^{T+1} \sum_{s_{T+1}} P(s_{T+1}) u_{c_{T+1}}(x_0, s^{T+1}, \epsilon_0) a_{T+1} \leq 0$$

The solution to the problem of an agent is the optimal sequences for consumption, hours and assets $\left\{c_t^*(x_0, s^t, \epsilon_0), l_t^*(x_0, s^t, \epsilon_0), a_{t+1}^*(x_0, s^t, \epsilon_0)\right\}_{t=0}^{\infty}$, such that the conditions above hold. The maximum value of the agent's problem is

$$V_0^*(x_0, s_0, \epsilon_0) = \sum_{t=0}^{\infty} \beta^t \sum_{s^t} P(s^t) u(c_t^*(x_0, s^t, \epsilon_0), l_t^*(x_0, s^t, \epsilon_0), g_t(\epsilon_0)).$$

For simplification, again I denote

$$u_t^*(x_0, s^t, \epsilon_0) \equiv u(c_t^*(x_0, s^t, \epsilon_0), l_t^*(x_0, s^t, \epsilon_0), g_t(\epsilon_0)),$$
$$u_{c_t}^*(x_0, s^t, \epsilon_0) \equiv \frac{\partial u_t^*(x_0, s^t, \epsilon_0)}{\partial c_t^*(x_0, s^t, \epsilon_0)}.$$

Because the budget constraint in each period holds as equality[28], I can plug it (evaluated at optimum) into the problem. Then the change of the maximum value of the problem when ϵ_0 changes is (assuming differentiability wrt ϵ_0)

$$\frac{\partial V_0^*(x_0, s_0, \epsilon_0)}{\partial \epsilon_0} = \sum_{t=0}^{\infty} \beta^t \sum_{s^t} P(s^t) u_{c_t}^*(x_0, s^t, \epsilon_0)\left[\frac{\partial \tilde{Y}_t}{\partial \epsilon_0} + \frac{\partial Y_t}{\partial l_t^*(x_0, s^t, \epsilon_0)}\frac{\partial l_t^*(x_0, s^t, \epsilon_0)}{\partial \epsilon_0}\right.$$
$$\left. + \frac{\partial Y_t}{\partial a_t^*(x_0, s^{t-1}, \epsilon_0)}\frac{\partial a_t^*(x_0, s^{t-1}, \epsilon_0)}{\partial \epsilon_0} - \frac{\partial a_{t+1}^*(x_0, s^t, \epsilon_0)}{\partial \epsilon_0}\right]$$
$$+ \sum_{t=0}^{\infty} \beta^t \sum_{s^t} P(s^t) u_{l_t}^*(x_0, s^t, \epsilon_0)\frac{\partial l_t^*(x_0, s^t, \epsilon_0)}{\partial \epsilon_0} + \sum_{t=0}^{\infty} \beta^t \sum_{s^t} P(s^t) u_{g_t}^*(x_0, s^t, \epsilon_0)\frac{\partial g_t(\epsilon_0)}{\partial \epsilon_0}$$

where $\frac{\partial \tilde{Y}_t}{\partial \epsilon_0}$ is the change in Y_t due to change in variables which the agent takes as given (prices, taxes, dividends).

[28] Otherwise it is possible to increase consumption, and hence utility, staying within the constraint. Therefore sequences $\left\{c_t^*(x_0, s^t, \epsilon_0), l_t^*(x_0, s^t, \epsilon_0), a_{t+1}^*(x_0, s^t, \epsilon_0)\right\}_{t=0}^{\infty}$ satisfying optimality conditions and the budget constraint as inequality cannot be maximizing the value of the consumer problem.

Rearranging the terms, I get

$$\frac{\partial V_0^*(x_0,s_0,\epsilon_0)}{\partial \epsilon_0} = \sum_{t=0}^{\infty}\beta^t \sum_{s^t} P(s^t)\frac{\partial l_t^*(x_0,s^t,\epsilon_0)}{\partial \epsilon_0}\left[u_{l_t}^*(x_0,s^t,\epsilon_0) + u_{c_t}^*(x_0,s^t,\epsilon_0)\frac{\partial Y_t}{\partial l_t^*(x_0,s^t,\epsilon_0)}\right]$$
$$+ \frac{\partial a_{t+1}^*(x_0,s^t,\epsilon_0)}{\partial \epsilon_0}\left[\beta\sum_{s_{t+1}} P(s_{t+1}|s_t)\frac{\partial Y_{t+1}}{\partial a_{t+1}^*(x_0,s^t,\epsilon_0)}u_{c_{t+1}}^*(x_0,s^{t+1},\epsilon_0) - u_{c_t}^*(x_0,s^t,\epsilon_0)\right]$$
$$+ \sum_{t=0}^{\infty}\beta^t \sum_{s^t} P(s^t)u_{g_t}^*(x_0,s^t,\epsilon_0)\frac{\partial g_t(\epsilon_0)}{\partial \epsilon_0} + \sum_{t=0}^{\infty}\beta^t \sum_{s^t} P(s^t)u_{c_t}^*(x_0,s^t,\epsilon_0)\frac{\partial \tilde{Y}_t}{\partial \epsilon_0}$$

We can use first order conditions and the budget constraint to eliminate term (1). Let's show that term (2) is equal to zero as well.

If the borrowing constraint is not binding, i.e. the Euler equation holds as equality, the term is zero. If the constraint is binding, i.e. $\beta\sum_{s_{t+1}} P(s_{t+1}|s_t)\frac{\partial Y_{t+1}}{\partial a_{t+1}^*(x_0,s^t,\epsilon_0)}u_{c_{t+1}}^*(x_0,s^{t+1},\epsilon_0) - u_{c_t}^*(x_0,s^t,\epsilon_0) > 0$, we want to show that $\frac{\partial a_{t+1}^*(x_0,s^t,\epsilon_0)}{\partial \epsilon_0} = 0$.

The slackness condition at the optimum is

$$\underbrace{\left[u_{c_t}^*(x_0,s^t,\epsilon_0) - \beta\sum_{s_{t+1}} P(s_{t+1}|s_t)\frac{\partial Y_{t+1}}{\partial a_{t+1}^*(x_0,s^t,\epsilon_0)}u_{c_{t+1}}^*(x_0,s^{t+1},\epsilon_0)\right]}_{\text{A}} \underbrace{\left[\bar{a} + a_{t+1}^*(x_0,s^t,\epsilon_0)\right]}_{\text{B}} = 0$$

Differentiating this condition with respect to ϵ_0 yields

$$\left[\frac{\partial (A)}{\partial \epsilon_0}\right][B] + [A]\,\frac{\partial a_{t+1}^*(x_0,s^t,\epsilon_0)}{\partial \epsilon_0} = 0.$$

Since the borrowing constraint is binding, $I > 0$ and $B = 0$. From the equation above it follows that in this case it must be that $\frac{\partial a_{t+1}^*(x_0,s^t,\epsilon_0)}{\partial \epsilon_0} = 0$.

Dropping the zero terms, and evaluating derivatives at $\epsilon_0 = 0$, we obtain the decomposition of expected marginal welfare change.

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2.D Computation of the steady state and transition

A. Steady state

1. Set calibration targets, guess values for parameters which are calibrated

(a) Guess the real interest rate r_0 which clears the bond market

(b) Iterate on the Euler equation and first order condition for labor supply to get policy functions for consumption and hours, using Endogenous Grid Point Method (EGM) (see Carroll (2006))

(c) Derive the inverse of the bond accumulation policy from the consumption and labor optimal decisions and compute time invariant distribution

(d) Compute aggregate bond holdings, consumption and hours

(e) Update the guess for the interest rate

2. Update calibrated parameters

B. Transition

1. Choose T large enough so that at $t = T$ the economy is approximately in the steady state (I set $T = 200$)

2. Set consumption and labor supply optimal decisions are at their steady state in T

3. The initial bond distribution at $t = 0$ is the time invariant distribution

4. Guess a path of real interest rates $\{r_t\}_{t=0}^{T}$ with $r_T = r_{ss}$; guess a path for real wage, profit, tax rate

   (a) Solve for consumption and hours policies from $t = T - 1$ to $t = 0$ by iterating backward on the Euler equation and the first order condition for labor supply (using EGM)

   (b) Derive the asset accumulation policy from consumption and hours policies

   (c) Compute the sequence of distributions from $t = 0$ to $t = T$ starting from distribution at time $t = 0$ using optimal asset accumulation decision

   (d) Compute aggregate asset holdings, output, government debt paths

5. Update wage and profit path from output path, update tax rate path from government debt path

6. Update the guess for the interest rate path based on the difference between aggregate asset holdings and governemnt debt

Chapter 3

Output and Employment Fiscal Multipliers over the Medium Term

This paper is co-authored with Marcos Poplawski-Ribeiro and Salvatore Dell'Erba, IMF, and was written during my visit as a summer intern at the Fiscal Affairs Department of the IMF.

3.1 Introduction

Five years since the beginning of the financial crisis, the discussion on recovery and prospects for long-term growth remains at the top of the agenda in advanced economies. At the same time, most of these countries are (still) implementing fiscal consolidations to ensure debt sustainability. How do these fiscal consolidations affect the prospects of economic growth at longer horizons? Are they contributing to a more permanent reduction in economic growth, potential output, and employment in advanced economies?

A large literature has tried to estimate the effect of discretionary fiscal policy on output. However, only a few empirical studies have attempted to answer the questions above and analyzed the links between fiscal consolidations and employment at longer-horizons. Such studies highlight theoretically the possibility that, in a depressed economy, fiscal consolidations can lead to sustained reduction in potential output under the presence of hysteresis effects (DeLong and Summers (2012)).

This paper, therefore, attempts to shed light on those issues by studying the impact of fiscal consolidations on output growth and labor markets variables over the medium-term in a panel of 17 OECD countries. Our two main novelties with respect to the previous literature are that we estimate the medium-term responses of various macroeconomic variables by: (i) distinguishing between expenditure- and tax-based consolidations; and

(ii) testing for asymmetric responses of these variables on two different states of the economy, that is in periods of non-protracted versus protracted recessions (i.e., periods of economic contraction for at least two consecutive years).

Fiscal consolidations are identified via the narrative approach, using the dataset constructed by Devries et al. (2011). We then use the local projection estimator (Jorda' (2005)) to test for the non-linearity of impulse responses during periods of periods of protracted recession. Finally, we calculate cumulative multipliers over a five-year horizon for output, employment, and unemployment as in Monacelli et al. (2010) and Ramey and Zubairy (2013).

The results show that fiscal consolidation have negative impact on output, fiscal multipliers are above unity during periods of protracted economic contractions. While tax-based multipliers are not asymmetric over the state of the economy, this is not true for expenditure-based consolidations. The results for output hold also for labor market variables, e.g. employment ratio and the unemployment rate, indicating that the main transmission mechanisms for these medium-term output multipliers are related to hysteresis effects in the labor markets. Expenditure-based consolidations implemented during protracted contractions are accompanied by a persistent decline in employment and an increase in the actual and in the non-accelerating inflation rate of unemployment. Those results are robust to several alternative specifications, including different definitions of the cycle, anticipation of policy effects, and exclusion of countries with financial crises or with constrained monetary policy.

The rest of the paper is structured as follows. Section 3.2 provides a literature review. Section 3.3 presents the transmission mechanisms through which fiscal consolidations during protracted recessions could lead to longer term effects on growth and unemployment. Section 3.4 describes the dataset and empirical strategy, including the baseline model used. Section 3.5 discusses the main results, whereas several robustness checks are analyzed in Section 3.6. Conclusions and policy implications follow in Section 3.7.

3.2 Literature review

This paper relates to the literature which analyzes the macroeconomic consequences of fiscal consolidations. Earlier work on the topic (Alesina and Perotti (1995), Alesina and Perotti (1996), Alesina and Ardagna (1998), Alesina and Ardagna (2010)) identifies episodes of fiscal adjustments on the basis of changes in the cyclically adjusted primary balance (CAPB). The results from this identification approach are that fiscal adjustments can have expansionary effects, particularly if based on spending cuts rather than tax increases.

Recent work by IMF (2010a) and Leigh et al. (2011) argue that the episodes of consolidations identified with the CAPB are biased toward overstating expansionary effects of austerity measures. They therefore study episodes of fiscal consolidations identified with the narrative approach. Pioneered by Romer and Romer (2010), the approach is based on the examination of policy documents and news sources to identify tax changes in the US exogenous to the business cycle. Devries et al. (2011) have extended the database for a panel of 17 OECD countries by identifying changes in fiscal stance motivated by the decision to reduce the public deficit and exogenous to the business cycle, thus, allowing correct inference in the estimation of fiscal multipliers[1]. IMF (2010a) and Leigh et al. (2011) show that, by using the Devries et al. (2011) dataset, fiscal consolidations are contractionary, although spending based consolidations are less so than tax-based ones.

In this paper we follow the same methodology and focus on episodes of fiscal consolidations identified through the narrative approach by Devries et al. (2011). We are interested in the estimation of state-dependent, medium-term fiscal multipliers on output and labor markets variables. We pay particular attention to the estimation of multipliers during episodes of protracted recessions-a concept more aligned with the behavior of output in the current crisis-and test whether consolidations in those protracted contractions can lead to hysteretic effects, e.g., persistent decline in output and employment.

Rather than relying on regime-switching models to estimate state-dependent multipliers (Auerbach and Gorodnichenko (2012), Baum et al. (2012)), we use the local projection method (Jorda‘ (2005)) as in Jorda‘ and Taylor (2013) and Ramey and Zubairy (2013). As in Alesina et al. (2012), we emphasize the distinction between tax-based and expenditure-based consolidations. However, contrary to them, we are interested in testing whether the effects of tax-based vs. expenditure-based consolidations are different in protracted economic recessions compared to other states of the business cycle.

The papers most closely related to ours are Jorda‘ and Taylor (2013), Ramey and Zubairy (2013) and Alesina et al. (2012). Jorda‘ and Taylor (2013) analyze the impact of fiscal consolidations in a panel of 17 OECD countries. They are interested in comparing the results obtained from the episodes of consolidations identified with the CAPB (Alesina

[1]The fiscal multipliers literature originally adopted Structural Vector Auto Regressive (SVAR) models to obtain structural shocks to spending and taxes (for example, Blanchard and Perotti (2002), Perotti (2008), Mountford and Uhlig (2009)). The SVAR approach consists in applying a set of identifying restrictions on the dynamic system of macroeconomic variables, based on either institutional knowledge (Blanchard and Perotti (2002)) or the expected response of the macroeconomic variable to fiscal policy changes (Mountford and Uhlig (2009)). The responses of macroeconomic variables to fiscal shocks identified through SVAR estimates are typically short-lived and the estimated multipliers tend to be below unity.

and Ardagna (1998) and Alesina and Ardagna (2010)) and the narrative approach of Devries et al. (2011). They find that the expansionary effects of consolidations identified using the CAPB are mainly due to the effects of consolidations in the expansionary phase of the business cycle. On the contrary, using the narrative approach, the negative effect of fiscal consolidations appears to be more acute during downturns. As in Jorda‘ and Taylor (2013), we use of the narrative approach, the estimation strategy via local projection method (Jorda‘ (2005)), and allow the effects of fiscal policy to differ in periods of protracted economic recessions.

We differ from Jorda‘ and Taylor (2013) in two main respects. First, we focus on the distinction between expenditure-based and tax-based consolidations. Second, we look at a broader set of macroeconomic variables, particularly at labor market variables to test hysteretic effects. Third, we concentrate in medium-term multipliers as in Ramey and Zubairy (2013).

Alesina et al. (2012), in turn, estimate the output effects of fiscal consolidations based on the narrative approach, analyzing the difference between expenditure-based and tax-based consolidations. They extend the narrative dataset of Devries et al. (2011) by introducing the distinction between anticipated and unanticipated consolidations shocks. They find that fiscal adjustments based on spending cuts are much less costly in terms of output. Contrary to us, however, they do not analyze medium-term fiscal multipliers specifically in protracted recessions.

Ramey and Zubairy (2013) estimate state-dependent multipliers for the US using military spending news as exogenous fiscal shocks. They test whether the results of Auerbach and Gorodnichenko (2012) are robust to a longer time sample and a different computation of multipliers. They show that the larger multipliers in recession found in Auerbach and Gorodnichenko (2012) are due to their assumption about the duration of the economic downturn, which is assumed exogenous to fiscal policy. Moreover, the conversion factor used to transform impulse response in VAR into multipliers in Auerbach and Gorodnichenko (2012) affects the size of the multiplier. Ramey and Zubairy (2013), therefore, suggest defining the variables as in Hall (2009) and Barro and Redlick (2011). Also, taking into account the response of taxes and spending in different states of the business cycle is crucial for the computation of the size of the medium-term multiplier.

3.3 Transmission mechanisms

In this section we discuss possible transmission mechanisms through which fiscal consolidations can have medium-run impact on the economy. The main channel analyzed is related to the presence of hysteresis effects in the labor markets. According to the standard Phillips curve, demand-side shocks can affect the level of unemployment only in the short-run, while in the long-run unemployment always bounces back to its constant natural level. Hysteresis hypothesis, on the contrary, implies that the natural level of unemployment is itself determined by its previous actual path (Blanchard and Summers (1987), Jaeger and Parkinson (1994)). Ball (1999) argues that in these circumstances monetary policy can affect the long run potential of the economy. In a series of papers, Ball (1997), Ball (1999) and Ball (2009) shows that large decreases in the natural rate are associated with run ups in inflation and expansionary monetary policy.

DeLong and Summers (2012) and Romer (2012) provide reasons for why hysteresis effects can be strong in a situation like the current crisis. First, in a depressed economy, workers remain without jobs for an extended period. This negatively affects their future employment prospects and, therefore, the overall level of employment in the long run. Hysteretic effects in the labor market can arise because workers in a depressed economy may be discouraged or even forced to temporarily drop out of the labor force. This, in turn, may reduce the potential labor force participation rate, making it harder for them to find jobs later on due to the erosion of skills caused by the separation from jobs in the meantime. Second, in a depressed economy, investment is low, resulting in lower capital stock accumulation in subsequent periods. This decline in capital stock can have an impact on the aggregate level of potential output.

Farmer (2009) demonstrates that there is scope for active fiscal policy during downturns in a framework with multiple equilibria, in which the natural rate hypothesis does not hold. Fiscal expansion can then be seen as a transfer to the current generation. It stimulates consumption and aggregate demand in the short run, moving the economy to a new equilibrium with lower unemployment level. DeLong and Summers (2012) also suggest an explanation for why expansionary fiscal policy can be extremely potent during a major economic downturn. If fiscal stimulus can increase short-run employment and output and hysteretic effects are present, it can also increase the long run employment and output. The size of the impact depends positively on the degree of hysteresis and on the size of the short-run multiplier.

The literature above suggests a hypothesis that will be empirically tested in the next sections. During recessionary episodes, when hysteretic effects in the labor market are strong, upfront consolidation of public finances can aggravate the slack in the economy, leading to a persistent decline in employment and output. This decline should not be observed if a country consolidates during non-prolonged recessions, because hysteresis effects are likely to be weak in such circumstances.

The intuition for that is as follows. Governments spending cuts or tax hikes depress aggregate demand and demand for factors of production if there are nominal rigidities. This creates a potentially large decline in employment. Consumption decline leads to lower GDP, and investment can fall as well. This leads to a lower capital stock in the medium run. Import decreases as demand for foreign goods becomes lower because national income is low. Export response depends on the ability of a country to adjust the exchange rate and on whether other countries are consolidating at the same time. If consolidation is accompanied by a real depreciation of the currency, export goes up and cushions the negative impact of fiscal policy on private demand. On the contrary, if a country has a fixed exchange rate arrangement, the drop in demand is even more severe[2].

3.4 Data and empirical strategy

3.4.1 Data

The analysis is performed for a sample of 17 OECD countries with annual data spanning period from 1978 to 2007[3]. The series for all the macroeconomic variables used in the analysis are taken from OECD Economic Outlook (EO, 2013). Table 3.4.1 displays the descriptive statistics of all variables in the empirical analysis, whereas the Table 3.A.1 in the Appendix provides the description and sources of these variables.

The episodes of fiscal consolidations are identified with the narrative approach database from Devries et al. (2011). The amount of fiscal consolidation corresponds to the sum of tax increases and spending cuts calculated as percentage of GDP. Devries et al. (2011) also distinguish in their database expenditure-based- and tax-based-consolidations. Accordingly, consolidations are classified as expenditure-based (EB) if the expenditure component on the deficit reduction is larger than revenue increases. Tax-based consolidations (TB) have a larger tax hike component than expenditure reduction.

To identify periods of protracted recession, we use the Recession Indicators Series constructed by the Federal Reserve of St. Louis. These series are based on the identifications of turning points (as in the NBER recession definitions) in the Composite Leading Indicators (CLI) series constructed by the OECD. Protracted recessions are defined by an annual dummy variable equal to 1 for periods of at least 24 consecutive months of economic contraction and 0 otherwise.

[2]For an analysis of different transmission mechanisms for fiscal multipliers see also Leeper et al. (2011).

[3]The 17 OECD countries are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, Portugal, Spain, Sweden, UK, and USA.

Table 3.4.1: Summary Statistics

	Mean	Standard Dev.	Minimum	Maximum	Observations
Contractionary Episodes	0.28	0.45	0.00	1.00	510
Output Gap	-0.03	2.41	-6.60	17.50	506
Unemployment Gap	0.00	2.20	-9.63	8.38	508
Consolidation	0.33	0.69	-0.75	4.49	510
Tax Consolidation	0.12	0.37	-0.75	2.54	510
Spending Consolidation	0.20	0.48	-0.29	3.71	510
Real GDP	2.65	1.96	-6.19	11.00	468
Real Consumption	2.47	1.99	-3.86	10.18	468
Real Investment	2.99	5.68	-20.10	17.61	468
Real Export	5.58	4.59	-9.03	28.49	468
Real Import	5.62	5.38	-17.40	24.32	468
Potential Output	2.57	1.08	0.42	8.38	476
Capital Stock	3.64	1.45	0.10	9.72	481
Consumer confidence	0.07	2.29	-8.93	9.13	440
Business confidence	0.13	3.06	-12.09	9.24	364
Private employment	0.45	1.94	-9.47	7.97	493
Employment ratio	0.37	1.94	-21.74	8.87	491
Unemployment Rate	7.63	3.84	1.56	24.12	508
NAIRU	7.06	2.68	1.44	15.42	493
Term Structure	0.78	1.63	-5.65	6.87	510
Inflation	4.42	4.23	-1.00	29.30	507
Short rate	7.72	4.68	0.03	24.90	510

3.4.2 Stylized facts

Table 3.4.2 displays some stylized facts about our data sample. We identify 127 years of protracted recessions (PR) and 162 years of fiscal consolidations in the sample. The average GDP growth rate in PR episodes is lower (1.46 percent) compared to the rest of the periods (2.32 percent). From these consolidation episodes, the majority (122) happened in periods of non-PR, whereas 40 occurred in the PR periods.

Fiscal consolidations in PR periods tend to be equally split between EB and TB consolidations. For years of fiscal consolidation outside the PR periods, most of these consolidations are based on expenditure. Moreover, the average size of the consolidation is larger for EB compared to TB consolidations during protracted recessions. We also

Table 3.4.2: Stylized Facts

height	Total	TB	EB
Number of observations	457	457	457
Number of years of consolidation	162	62	100
Number of years of PR	127	127	127
GDP growth 1 year during PR	1.46 %	1.46 %	1.46%
GDP growth 1 year outside PR	2.32 %	2.32 %	2.32 %
Number of years of consolidation during PR	40	23	17
Average size, % of GDP	0.97 %	0.66 %	1.40 %
Average duration, years	1.42	1.41	1.44
GDP growth 1 year	0.72 %	0.57 %	0.93 %
Number of of years of consolidation outside PR	122	39	83
Average size, % of GDP	0.99 %	0.86 %	1.06 %
Average duration, years	0.75	0.8	0.7
GDP growth 1 year	2.03 %	1.61 %	2.19 %

Note: PR=protracted recession

compute the average duration of TB and EB consolidations based on the identification of the start of fiscal plans. Table 2 shows that EB and TB consolidations have similar duration. However, consolidations (of both types) implemented during protracted recessions are shorter.

3.4.3 Methodology

We estimate impulse responses to the fiscal consolidation shocks using the Local Projection (LP) methodology proposed by Jorda‘ (2005). According to the LP framework, the average effect of policy intervention d_j relative to a baseline d_0 on the outcome variable Y at $t+h$, is given by $E\left[(Y_{t,h}(d_j) - Y_t) - (Y_{t,h}(d_0) - Y_t)\right]$, and, under selection-on-observable assumption can be calculated by the following local projection:

$$Y_{t+h} - Y_t = \alpha^h + \theta^h D_t + \gamma^h \omega_t + \epsilon_{t+h},$$

where D_t is the fiscal policy variable, and ω_t is the rich conditioning set. The expected impact of the policy intervention is then:

$$E\left[\left(Y_{t,h}(d_j)-Y_t\right)-\left(Y_{t,h}(d_0)-Y_t\right)\right]=\theta^h\left(d_j-d_0\right), \quad \text{for} h=1,...,H$$

which is equivalent to an impulse response calculated from a VAR. The method was chosen because of its numerous advantages, some of which are particularly relevant for our study. First, this method can easily accommodate non-linearity which is crucial given that we study state-dependent multipliers. Second, the method is useful since it allows to have left-hand side and right-hand side variables measured in different units, which becomes particularly useful when calculating multipliers. As shown by RZ (2013), the multipliers calculated from VAR are subject to mismeasurement due to the assumptions used in converting elasticities into multipliers. Instead, by having both the left-hand side and the right-hand side specified in the same units (e.g., percent of *year 0* GDP), these pitfalls are avoided.

The narrative approach dataset from Devries et al. (2011) is constructed so that fiscal shocks are exogenous to output. One potential source of concern as Jorda‘ and Taylor (2013) argue, is that the fiscal shocks are not exogenous and can be predicted. We have run country by country regressions of the consolidations variable on two lags of GDP growth and lagged public debt. We find that, similar to Alesina et al. (2012) results are not significant except in the case of Netherlands[4]. However, Jorda‘ and Taylor (2013) show that estimating the model by Inverse-Probability Weighting (IPW) to correct for endogeneity of fiscal shocks, the contractionary effect of fiscal consolidations is confirmed for both expansions and recessions, and the estimates are more precise and larger for recessions[5].

Using the LP framework, we first estimate the following regression model with time and country fixed effects using panel OLS estimator:

$$\begin{aligned} Y_{i,t+h}-Y_{i,t} &= \alpha_i^h+\chi_t^h+\delta t+\theta^h D_{i,t} \\ &\quad +\beta_1^h\left(Y_{i,t-1}-Y_{i,t-2}\right)+\beta_2^h\left(Y_{i,t-2}-Y_{i,t-3}\right)+\beta_3^h Y_{i,t-1}^{GAP}+\epsilon_{i,t+h}, \end{aligned} \tag{3.1}$$

where α_i^h is the country fixed effect; χ_t^h is the time fixed effect; δt is the time trend; $D_{i,t}$ is the fiscal shock from Devries et al. (2011) dataset[6]; $\epsilon_{i,t+h}$ is an i.i.d. error term.

[4]In a robustness check we exclude Netherlands from the sample. Estimation results are not affected.

[5]Since our focus is estimating multipliers during protracted recession, we believe then that our results are probably are an upper bound of the true effects of fiscal consolidations.

[6]We have also tried specifications with further set of potential control variables and These additional control variables include the change in the short-term interest rate, lagged debt-to-GDP ratio, and either CA or REER gap. The results are robust to the inclusions of these variables.

The expected effect of fiscal consolidation is given by the coefficient θ^h. Equation (3.1) is estimated for each horizon $h = 0, 1, 2, 3, 4, 5$.

To accommodate the possibility of multiplier varying across the business cycle (Baum et al. (2012)), we allow regression coefficients to differ in periods of protracted recessions (PR) and non-PR periods (see also RZ (2013)):

$$\begin{aligned} Y_{i,t+h} - Y_{i,t} = I_t^{PR} &\left(\alpha_i^{h,PR} + \theta^{h,PR} D_{i,t} + \gamma^{h,PR} \omega_{i,t-1}\right) \\ &+ \left(1 - I_t^{PR}\right) \left(\alpha_i^{h,non-PR} + \theta^{h,non-PR} D_{i,t} + \gamma^{h,non-PR} \omega_{i,t-1}\right) \\ &+ \chi_t^h + \delta t + \epsilon_{i,t+h} \end{aligned} \tag{3.2}$$

where the indicator function I_t^{PR} is equal to 1 in periods of protracted recession and 0 otherwise; and the matrix $\omega_{i,t-1}$ includes the vectors $(Y_{i,t} - Y_{i,t-1})$, $(Y_{i,t-1} - Y_{i,t-2})$, and $Y_{i,t}^{GAP}$ as in the baseline specification (3.1). We allow all coefficients in the regression equation, except those for the time trend and time fixed effects, to be state-dependent.

3.4.4 Medium-term multipliers

The medium-term multipliers are calculated as in Monacelli et al. (2010) and Ramey and Zubairy (2013). Using the LP method, we estimate the impulse response of the variable of interest (e.g., GDP or employment) and the impulse response of the fiscal variable in analysis, which in our baseline estimation corresponds to the primary balance. Since from the estimation of (3.1) we obtain an elasticity estimate, one has to convert this estimate into a multiplier by dividing that elasticity by the average ratio of the fiscal variable to GDP. Alternatively, one can rescale the variables appropriately to a same scale before running the regression, so that the regression estimate provides the multiplier directly.

To facilitate the computation of multipliers, we choose the second option and define the fiscal variable as percentage of real GDP in the initial period, $Y_{i,t-1}$. As in Monacelli et al. (2010), real GDP and employment ratio growth are denoted in percentages, and unemployment change in percentage points. The medium-term multiplier is hence computed as the ratio between the sum of each of the impulse responses (IR) - for the variable of interest (e.g., GDP growth) in the numerator and the fiscal variable (primary balance) in the denominator - over the horizon of 5 years:

$$\text{LR Multiplier} = \frac{\sum_{s=0}^{5} IR_s^j}{\sum_{s=0}^{5} IR_s^{PB}},$$

where j corresponds to either GDP, employment, or unemployment; and corresponds to the primary balance.

3.5 Results

This section presents the results of estimations using specifications (3.1) and (3.2). We first compare the results using our methodology with the previous literature. Next, we present the results of our baseline regressions for GDP, employment and unemployment distinguishing between PR and non-PR periods, and between TB and EB consolidations. We then discuss how these estimations translate into medium-term multipliers and how they differ from the literature.

3.5.1 Effects of a fiscal consolidation: replication of the literature

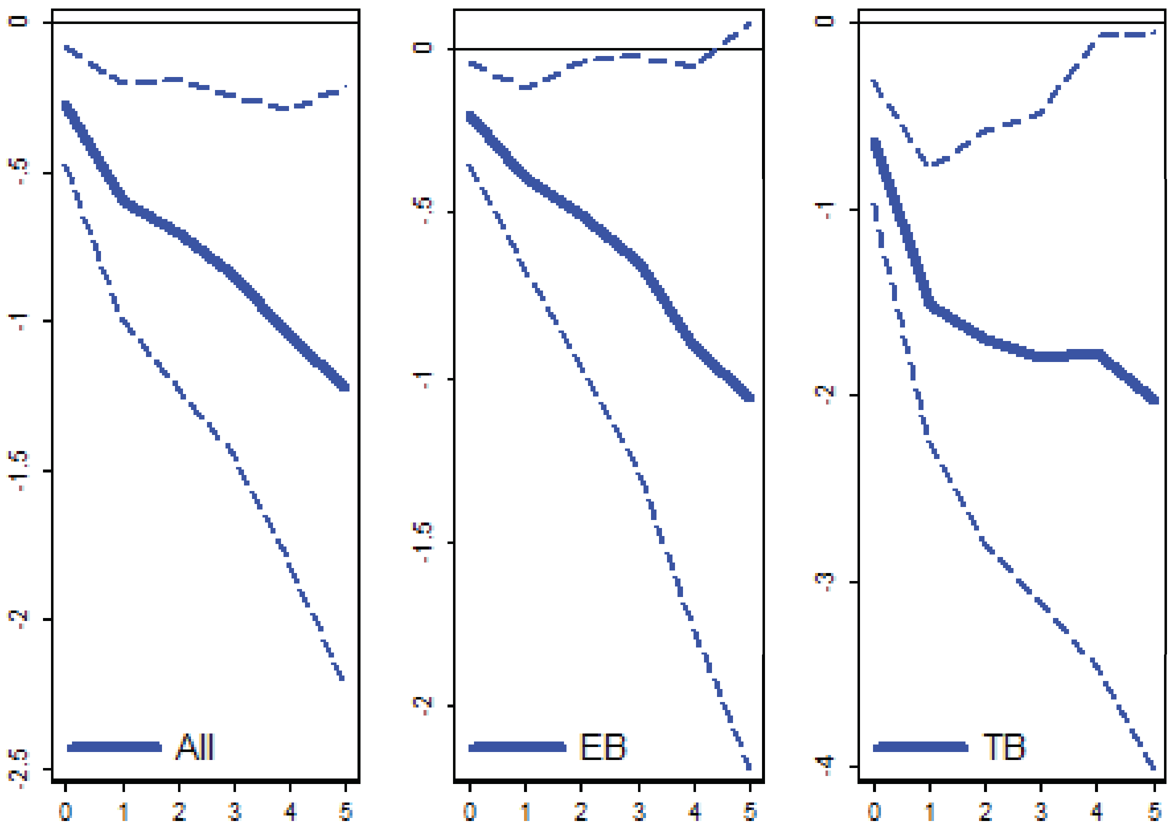
Figure 3.5.1 summarizes the comparison between our results and the previous literature. The first panel on the left presents the effects of the all types of fiscal consolidation on real GDP growth, while the second and third panels present the results focusing only on EB or TB consolidations. In line with the previous literature, we find that fiscal consolidations are indeed contractionary. Moreover, the negative effects of consolidations are persistent: the negative elasticity for real GDP growth of a consolidation in the primary balance is significant even after 5 years from the beginning of consolidation. We also find that multipliers in TB consolidations are larger than EB consolidations. The value of the impact multipliers are also similar to the literature (particularly to Romer and Romer (2010)), with TB consolidations having multipliers up to 2.

3.5.2 Estimation during protracted vs. non-protracted recessions

Figure 3.5.2 shows the impulse responses resulting from the estimation of equation (3.1) distinguishing between TB and EB consolidations (upper and lower panels on the left, respectively). Different IRs are also presented resulting from the estimation of Equation (3.2), which distinguishes between PR and non-PR periods (middle and left panels). For non-PR periods (including both expansions and non-prolonged recessions) the effects of the fiscal consolidation in on real GDP becomes insignificant after 3 years independently if the consolidation is TB or EB. During PR periods, however, fiscal consolidations tend to have larger and more persistent effects on output, particularly in EB consolidations.

To assess the validity of hysteresis hypothesis, we estimate the impact of fiscal consolidations on labor market variables. We replace real GDP by different labor market variables-employment and unemployment rates, and the estimated non-accelerating infla-

Figure 3.5.1: Effects of Consolidation on Real GDP: Replication of the Literature

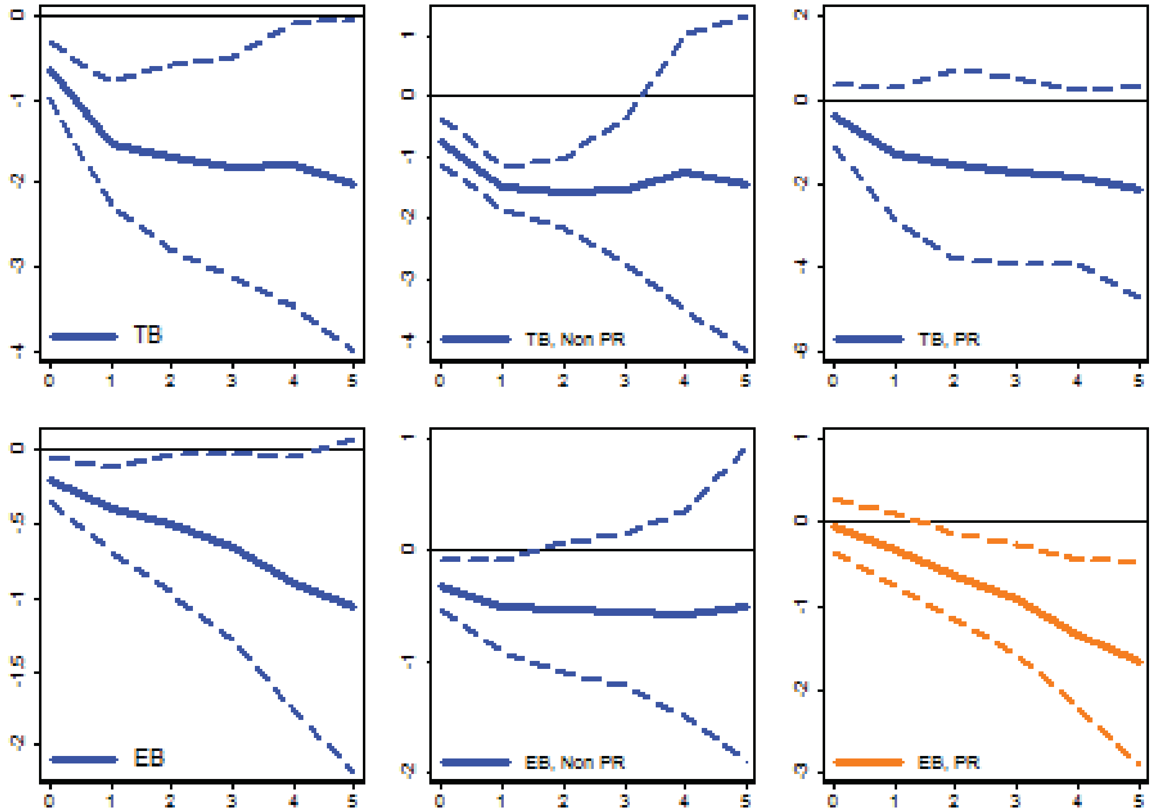


Note: $t = 0$ denotes the initial year of the fiscal consolidation. 95 percent confidence intervals are displayed. All denotes all episodes of fiscal consolidations; EB denotes expenditure-based consolidations; TB denotes tax-based consolidations.

tion rate of unemployment (NAIRU)-in the left-hand side of Equation (3.2). Figure 3.5.3 displays the results using the overall employment ratio as a dependent variable. It shows that that EB consolidations during PR lead to a persistent reduction in the employment rate in our country sample. This effect remains significant over time. TB consolidations have a large and more persistent negative impact on employment on average, even though the uncertainty is wider around TB consolidations during PR episodes. A similar pattern is observed when looking at the unemployment rate (Figure 3.5.4). Consolidations based on spending cuts persistently increase unemployment if implemented during PR episodes, while their impact non-PR periods is short-lived. These results are confirmed by the pattern of the NAIRU (Figure 3.5.5). While EB consolidations in non-PR periods leave the NAIRU virtually unaffected, during PR episodes those tend to have a significantly persistent impact.

Next, we test some restrictions regarding the shape and statistical significance of the IRs. First, we test whether the cumulative impulse responses in non-PR and PR periods

Figure 3.5.2: Asymmetric Effects of Fiscal Consolidations on Real GDP



Note: denotes the initial year of the fiscal consolidation. 95 percent confidence intervals are displayed. EB denotes expenditure-based consolidations; TB denotes tax-based consolidations. PR denotes episodes of protracted recession and non-PR all other episodes. See text for explanation on identification of PR episodes.

statistically differ from zero:

$$H_0 : \sum_{h=0}^{5} \theta^{h,i} = 0, \quad i = PR, non - PR. \tag{3.3}$$

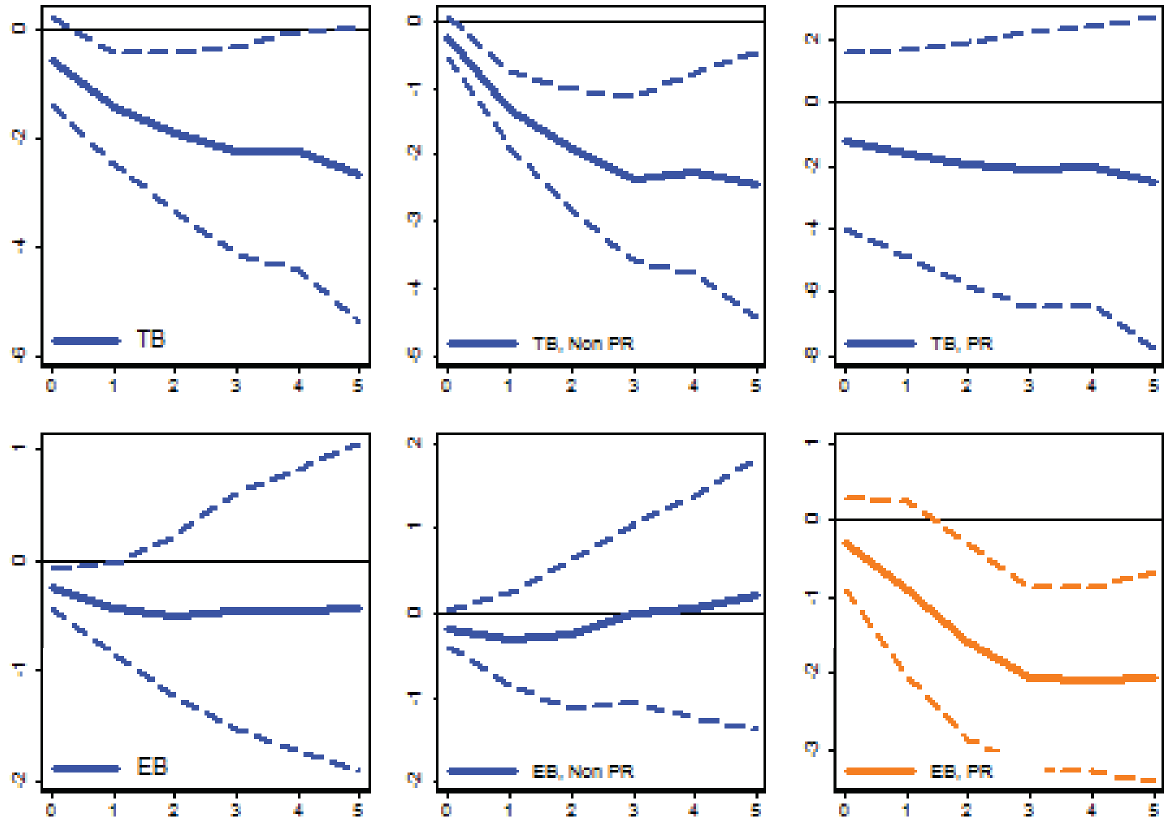
Second, we test whether the cumulated impulse responses in non-PR and PR episodes are different from each other:

$$H_0 : \sum_{h=0}^{5} \theta^{h,non-PR} = \sum_{h=0}^{5} \theta^{h,PR}. \tag{3.4}$$

These tests are applied for the sample with all types of consolidation combined as well as for the subsamples of either EB- or TB consolidations, separately.

Table 3.5.1 reports the results of these tests, for GDP, Employment, Unemployment, and Primary Surplus. We also include on it the calculation of fiscal multipliers according to Equation (3.4.4). Our results show that in general, there is no statistical difference between IRs of TB consolidations across different states of the economy, including for the

Figure 3.5.3: Asymmetric Effects of Fiscal Consolidations on Employment

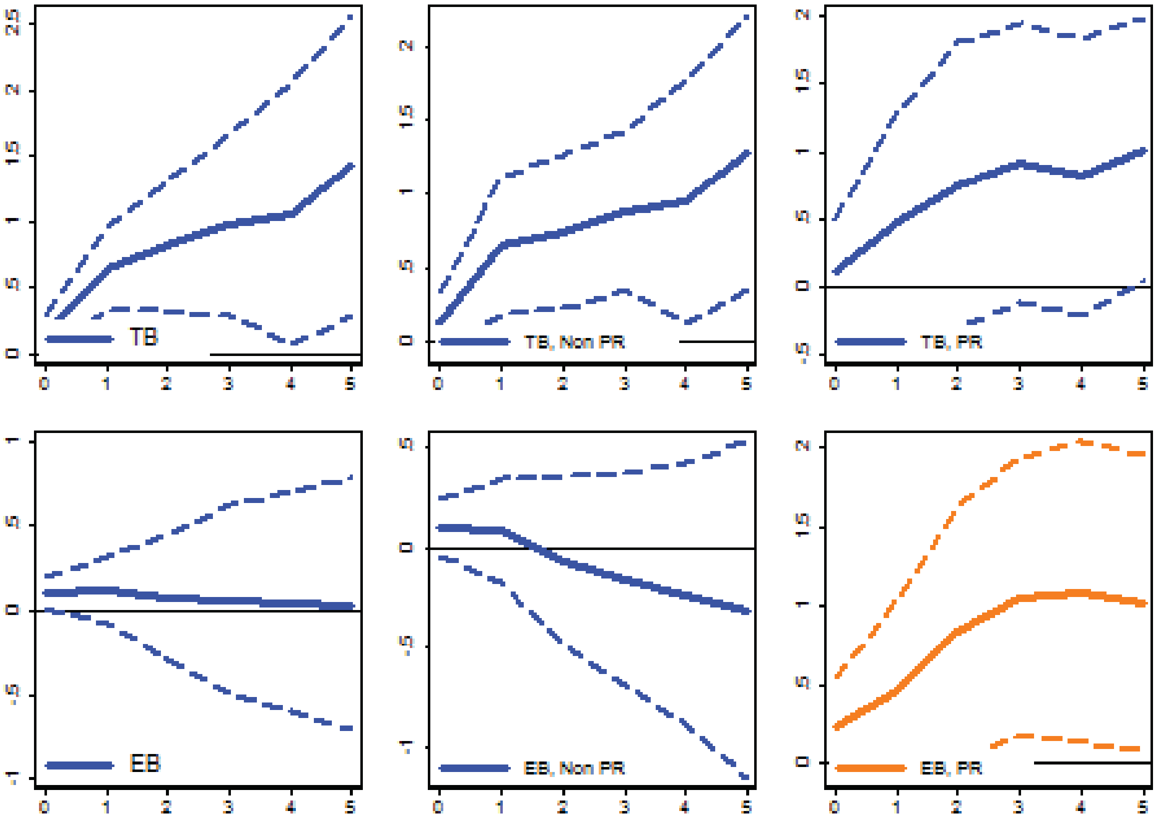


Note: denotes the initial year of the fiscal consolidation. 95 percent confidence intervals are displayed. EB denotes expenditure-based consolidations; TB denotes tax-based consolidations. PR denotes episodes of protracted recession and non-PR all other episodes. See text for explanation on identification of PR episodes.

changes in primary surplus. On contrary, EB consolidations during PR periods have a larger, more persistent, and significantly different cumulative effect on output, employment and unemployment than in non-PR periods. Moreover, the improvement in primary surplus during non-PR periods is much larger than in PR periods in EB consolidations.

Fiscal consolidations lead to large (above unity) medium-term output, employment and unemployment multipliers. While multipliers associated with TB consolidations do not differ across the state of the economy, we find that EB consolidations multipliers are larger if undertaken during PR than in non-PR episodes. The findings provide support in favor of the presence of hysteretic effects in the labor market following fiscal consolidations, particularly in PR periods. To the best of our knowledge, this is the first paper to provide such evidence. In non-PR periods, the effect of EB consolidations is moderate and short lived. During PR episodes, the decline in aggregate demand depresses employment and increases unemployment rate persistently.

Figure 3.5.4: Asymmetric Effects of Fiscal Consolidations on Unemployment



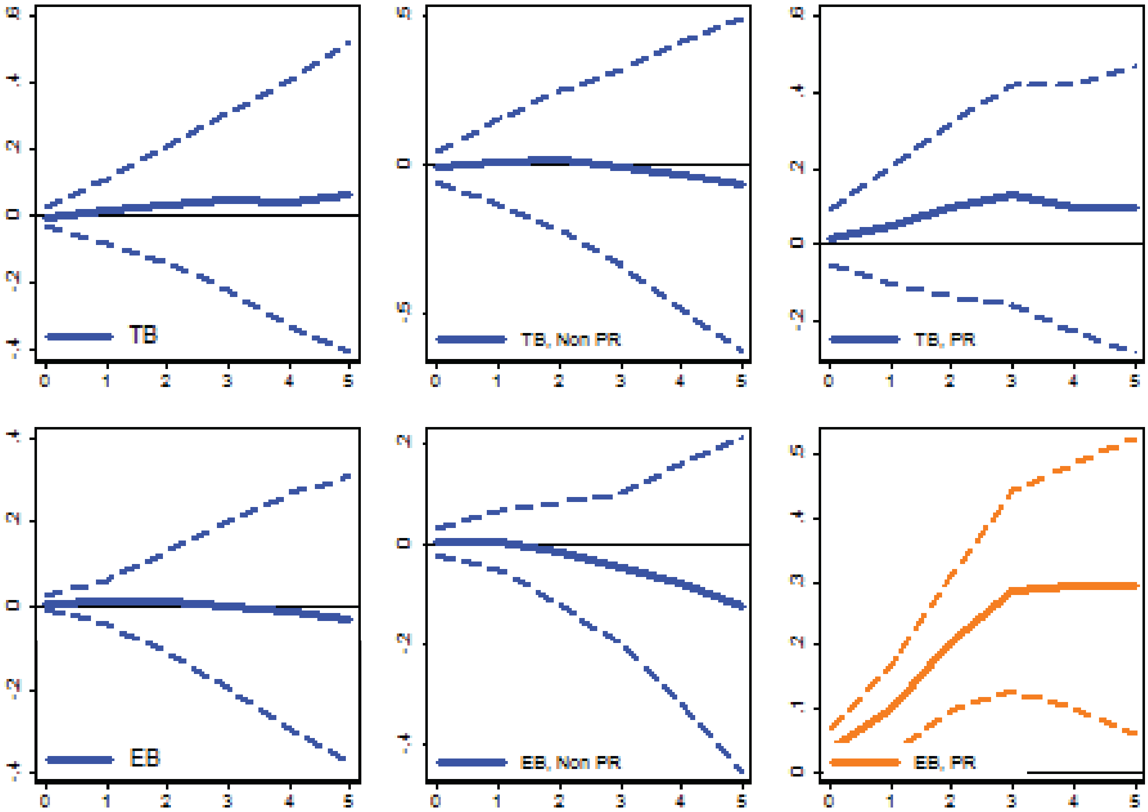
Note: denotes the initial year of the fiscal consolidation. 95 percent confidence intervals are displayed. EB denotes expenditure-based consolidations; TB denotes tax-based consolidations. PR denotes episodes of protracted recession and non-PR all other episodes. See text for explanation on identification of PR episodes.

3.5.3 Evidence on transmission mechanisms

Figure 3.5.6 present a comparison of the response of various components of aggregate demand and supply to fiscal consolidations contingent on the state of the economy. In the first panel we look at total consumption and investment. In the second panel we look at import and export. In the third panel we look at the capital stock and a measure of potential output estimated by the OECD[7]. Finally, the fourth panel looks at a comparison between a measure of private sector employment and overall employment. Within each panel, the top two charts provide a comparison of EB consolidations across PR and non-PR episodes. The bottom two charts display the same comparison for TB consolidations. The results are reported without confidence bands for the sake of exposition. However, in Table 3.5.2 we present the hypothesis tests (3.3) and (3.4) for the IRs.

[7]This is based on the methodology using the production function approach Giorno et al. (1995).

Figure 3.5.5: Asymmetric Effects of Fiscal Consolidations on NAIRU

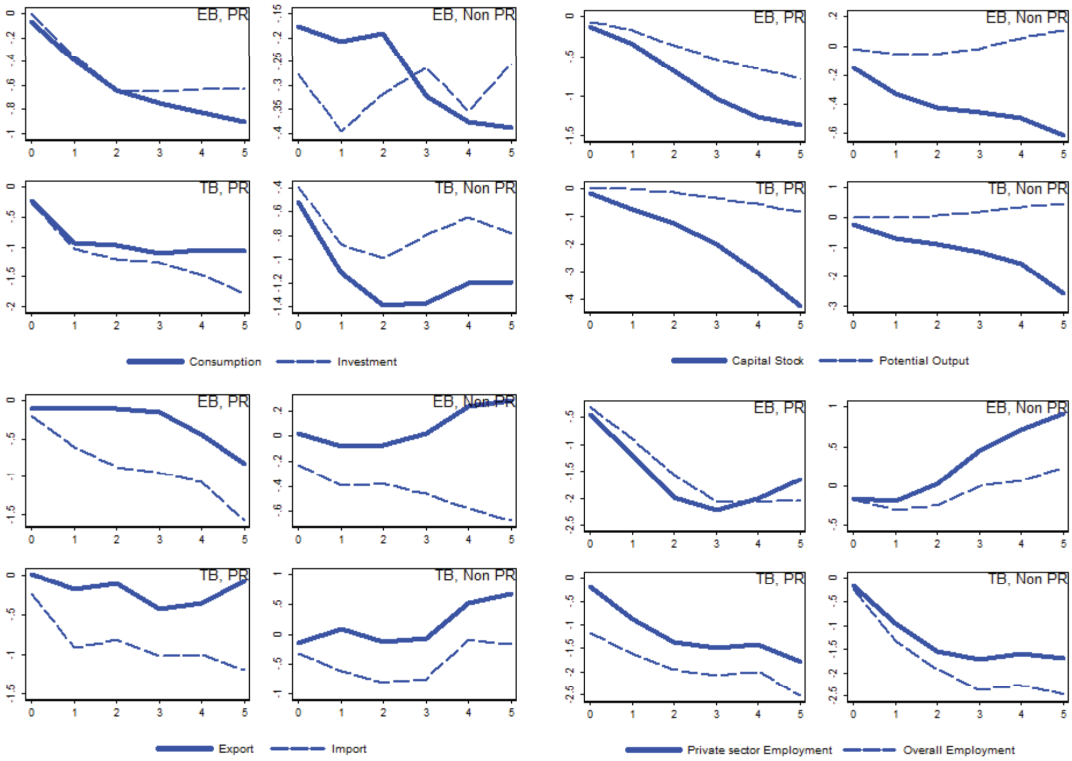


Note: denotes the initial year of the fiscal consolidation. 95 percent confidence intervals are displayed. EB denotes expenditure-based consolidations; TB denotes tax-based consolidations. PR denotes episodes of protracted recession and non-PR all other episodes. See text for explanation on identification of PR episodes.

The results show that consumption and investment are both negatively affected by consolidations. TB consolidations affect more strongly these two aggregate demand components, but EB consolidations enacted during PR episodes affect consumption more strongly. When looking at export and import, export does not seem to react to consolidations. This could be due to the heterogeneous response of exchange rate policy during fiscal consolidations. However, we do find a larger drop in imports in consolidations during PR periods. This effect is consistent with the evidence from consumption.

When we look at the supply side components, interestingly, estimated potential output does not react to consolidations enacted during non-PR episodes. However, there is a significant decline in potential output over the medium term during consolidations in PR periods. This effect is statistically different for both, TB and EB consolidations. The decline in investment observed during consolidations leads to lower capital stock over the medium term, notably in TB consolidations. Such decline is again significantly more

Figure 3.5.6: Transmission Channels of Fiscal Consolidations



Note: denotes the initial year of the fiscal consolidation. 95 percent confidence intervals are displayed. EB denotes expenditure-based consolidations; TB denotes tax-based consolidations. PR denotes episodes of protracted recession and non-PR all other episodes. See text for explanation on identification of PR episodes.

Table 3.5.1: Baseline Results
Cumulative Multipliers During Episodes of Non-Protracted and Protracted Recession

Variable	Type	Cumulative IR		Difference	Multipliers	
		Non PR	PR	Chi-sq.	Non PR	PR
GDP	All	-3.76***	-5.76***	2.19	0.6	2.0
	EB	-2.93***	-4.94***	2.73*	0.4	2.0
	TB	-8.02***	-8.90***	0.11	1.9	2.0
Employment	All	-2.59**	-9.65***	10.07***	0.4	3.4
	EB	-0.44	-8.95***	16.01***	0.1	3.6
	TB	-10.58***	-11.36**	0.03	2.5	2.6
Unemployment	All	0.50	4.62***	19.43***	0.1	1.6
	EB	-0.59	4.71***	21.10***	0.1	1.9
	TB	4.64***	4.06***	0.27	1.1	0.9
Primary Surplus	All	6.34***	2.85***	10.83***		
	EB	6.77***	2.49***	13.81***		
	TB	4.22***	4.44***	0.01		

Note : The column "Cumulative IR" reports the cumulative impulse response of the variable in row under protracted recession (PR) and non-protracted recession (Non PR) when considering: 1) All type of consolidation episodes (All); 2) Expenditure-Based (EB); 3) Tax-based (TB). The asterisks denote the significance of the rejection of the hypothesis that the cumulative IR is equal to zero at the 10 % (*), 5 % (**) and 1 %(***) level. The column "Difference" reports the Chi-squared statistics of the test of the difference between the cumulative IR. Asterisks denotes rejection of the hypotheses at the 10 % (*), 5 % (**) and 1 %(***) level. The columns "Multipliers" show the ratio between the cumulative IR of GDP, Employment and Unemplyoment divided by the cumulative IP of the Primary Surplus under respective type of consolidation and state of the economy.

pronounced during PR episodes.

Importantly, the decline in total employment observed during PR episodes is not only driven by the reduction in public sector employment. In fact, both (EB and TB) consolidations are associated to an equally strong decrease in private sector employment during PR episodes. For TB consolidations, this fall in private sector employment also happens in non-PR periods, evincing the negative effects of tax measures over employment even in less recessionary periods.

Finally, we look at the response of monetary policy to understand whether different degrees of monetary accommodation are responsible for different sizes of the consolidation multiplier in PR and non-PR periods. This is done via the analysis of the short-term interest rate (Table 3.5.2). As the non-significant Chi-squared test for the short-term rate in Table 4 conveys, monetary policy does not appear to respond significantly differently between the two states of the economy investigated. During EB consolidations,

Table 3.5.2: Transmission Channels of Fiscal Consolidations

Variable	Type	Cumulative IR Non PR	Cumulative IR PR	Difference Chi-sq.
Consumption	EB	-1.66**	-3.56**	3.28*
	TB	-6.79***	-5.30***	0.91
Investment	EB	-1.86***	-2.91***	2.6
	TB	-4.48***	-6.99***	1.29
Export	EB	0.4	-1.71	4.80**
	TB	0.97	-1.09	1.3
Import	EB	-2.72***	-5.26***	5.85**
	TB	-2.71***	-5.14***	1.81
Potential Output	EB	0.01	-2.56***	15.72***
	TB	1.06	-1.78*	2.96*
Capital Stock	EB	-2.46**	-4.81***	5.59**
	TB	-7.06***	-11.37***	1.43
Private Sector Employment	EB	1.75	-9.53***	40.71***
	TB	-7.67***	-7.10**	0.03
NAIRU	EB	-0.25	1.21***	43.66***
	TB	-0.08	0.49*	1.46
Inflation	EB	0.19	2.18***	6.56**
	TB	-4.68**	4.32***	17.92***
Short-Term Rate	EB	-2.28***	-1.97*	0.08
	TB	0.21	4.42***	6.03**

Note : The column "Cumulative IR" reports the cumulative impulse response of the variable in row under protracted recession (PR) and non-protracted recession (Non PR) when considering: 1) All type of consolidation episodes (All); 2) Expenditure-Based (EB); 3) Tax-based (TB). The asterisks denote the significance of the rejection of the hypothesis that the cumulative IR is equal to zero at the 10 % (*), 5 % (**) and 1 %(***) level. The column "Difference" reports the Chi-squared statistics of the test of the difference between the cumulative IR. Asterisks denotes rejection of the hypotheses at the 10 % (*), 5 % (**) and 1 %(***) level.

the short-term interest rate significantly falls in both PR and non-PR periods. To the contrary, during TB consolidations, the results are not statistically significant, indicating insignificant changes in monetary policy for that type of consolidation in any state of the economy.

Overall, this section indicates that fiscal consolidation during PR episodes can lead to hysteresis in the labor market. Our findings suggest that, TB consolidations affect output mainly through capital stock and investment. In turn, EB consolidations contract aggregate demand and, therefore, aggregate employment. During non-PR periods, this effect is moderate and short lived. However, during episodes of protracted slowdown, a freezing in aggregate demand depresses employment and increases the unemployment rate persistently. This leads to workers staying out of job for prolonged periods of time and having difficulties in rejoining the labor market, which finally results in lower employment levels over the medium term.

3.6 Robustness checks

The baseline results have shown that medium-run spending multipliers are above unity during periods of prolonged economic contractions. The latter result differs from evidence in Ramey and Zubairy (2013) who find no difference between multipliers across expansions and contractions of the economy in a sample of historical US data. The differences may be due to different factors, e.g. different sample or different measure of fiscal shocks. Another issue could be the different identification of slack states that we adopted in the baseline result. Our analysis uses episodes of protracted economic contraction based on the identifications of turning points in the OECD composite leading indicator.

This section, therefore, first checks if our results are affected by the way periods of economic contraction are identified. For that, we follow Ramey and Zubairy (2013) and use the unemployment rate as indicator of slack states. We then identify episodes of contraction as periods when the economy is at least one percent above its long-run level of unemployment. The latter is calculated using a Hodrick-Prescott filter on the actual unemployment series with a smoothing parameter of 100000[8]. With such rule at least 20 percent of observations are identified as being in slack states, which is quantitatively similar to the identification using the recession indicator.

Figure 3.6.1 compares the IRs from the two different specifications. With respect to GDP, the shape of the IR is similar to what we obtained when using the recession indicator as index of economic activity. For the employment ratio and the unemployment rate, the cumulative multipliers associated with the unemployment gap (Table 3.6.1) do not differ quantitatively from those calculated in Section 3.5. The main difference is the size of the unemployment multiplier of EB consolidation in PR episodes, which is below unity under this approach. The multiplier for TB consolidations during that PR periods is also larger than the ones obtained with the baseline approach.

The second robustness check tests whether the baseline results are driven by country specific episodes. In our sample of 17 OECD countries, Finland and Sweden have experi-

[8]Results are unaffected by the choice of the smoothing parameters.

Table 3.6.1: Cumulative Multipliers Using Unemployment Gap as Measure of Slack

Variable	Type	Cumulative IR		Difference	Multipliers	
		U-Gap< 1%	U-Gap> 1%	Chi-sq.	U-Gap< 1%	U-Gap> 1%
GDP	All	-4.25***	-4.20***	0.00	0.6	2.2
	EB	-2.95***	-3.76***	0.68	0.4	1.9
	TB	-8.01***	-8.35***	0.02	2.1	4.0
Emp.	All	-4.03***	-5.10***	0.68	0.6	2.7
	EB	-1.10	-4.76***	4.40**	0.1	2.5
	TB	-9.80***	-10.12***	0.01	2.5	4.9
Unemp.	All	0.93*	1.46***	0.80	0.1	0.8
	EB	0.05	1.09*	2.07	0.0	0.6
	TB	2.69***	6.29***	4.29**	0.7	3.0
Primary Surplus	All	6.64***	1.91**	16.35***		
	EB	7.62***	1.93**	17.83***		
	TB	3.90***	2.07	0.73		

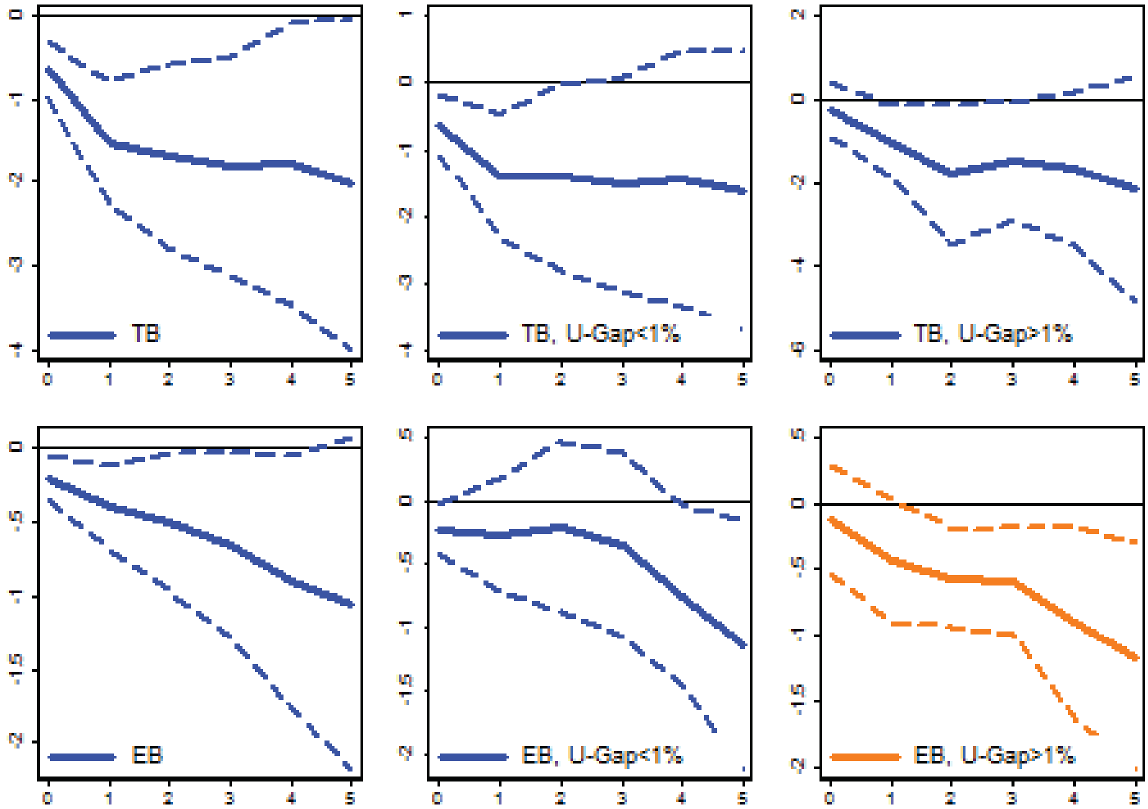
Note : The column "Cumulative IR" reports the cumulative impulse response of the variable in row under unemployment gap above 1 % (U-Gap¿1%) and below (U-Gap¡1%) when considering: 1) All type of consolidation episodes (All); 2) Expenditure-Based (EB); 3) Tax-based (TB). See text for detailes for the calculations of the unemployment gap. The asterisks denote the significance of the rejection of the hypothesis that the cumulative IR is equal to zero at the 10% (*), 5% (**) and 1%(***) level. The column "Difference" reports the Chi-squared statistics of the test of the difference between the cumulative IR. Asterisks denotes rejection of the hypotheses at the 10% (*), 5% (**) and 1%(***) level. The columns "Multipliers" show the ratio between the cumulative IR of GDP, Employment and Unemplyoment divided by the cumulative IP of the Primary Surplus under respective type of consolidation and state of the economy.

Table 3.6.2: Robustness to Exclusion of Single Countries

Excluded Country	Variable	Type	Cumulative IR		Difference	Multipliers	
			Non PR	PR	Chi-sq.	Non PR	PR
FIN	Output	All	-4.12***	-5.05***	0.53	0.6	1.4
	Output	EB	-3.17***	-4.18***	0.71	0.4	1.3
	Output	TB	-8.36***	-8.37***	0	2.1	1.6
	Employment	All	-3.23***	-8.97***	7.97***	0.5	2.5
	Employment	EB	-0.95	-8.03***	14.16***	0.1	2.4
	Employment	TB	-10.94***	-11.53**	0.02	2.7	2.3
	Unemployment	All	0.69	3.84***	17.03***	0.1	1.1
	Unemployment	EB	-0.46	3.81***	18.28***	0.1	1.1
	Unemployment	TB	4.66***	3.72***	0.82	1.2	0.7
	Primary Surplus	All	6.73***	3.64***	6.65***		
	Primary Surplus	EB	7.35***	3.32***	9.00***		
	Primary Surplus	TB	4.02***	5.09***	0.33		
JPN	Output	All	-4.05***	-5.21***	1.05	0.7	1.9
	Output	EB	-3.35***	-5.18***	2.43	0.5	2.3
	Output	TB	-7.59***	-5.19**	0.79	2.1	0.9
	Employment	All	-2.75***	-8.37***	9.15***	0.5	3.0
	Employment	EB	-0.69	-8.69***	14.83***	0.1	3.9
	Employment	TB	-10.57***	-6.31	1.27	2.9	1.1
	Unemployment	All	0.52	4.22***	17.69***	0.1	1.5
	Unemployment	EB	-0.52	4.66***	20.49***	0.1	2.1
	Unemployment	TB	4.58***	2.24**	5.17**	1.3	0.4
	Primary Surplus	All	5.79***	2.79***	10.44***		
	Primary Surplus	EB	6.22***	2.23***	13.10***		
	Primary Surplus	TB	3.63***	5.76***	1.28		
NLD	Output	All	-3.93***	-5.92***	1.5	0.5	1.9
	Output	EB	-2.90***	-4.76***	1.67	0.3	1.6
	Output	TB	-8.71***	-10.00***	0.2	2.0	2.5
	Employment	All	-3.06**	-10.36***	8.58***	0.4	3.3
	Employment	EB	-0.75	-9.04***	12.88***	0.1	3.0
	Employment	TB	-10.83***	-14.18***	0.54	2.5	3.6
	Unemployment	All	0.69	4.80***	18.02***	0.1	1.5
	Unemployment	EB	-0.55	4.70***	20.13***	0.1	1.6
	Unemployment	TB	4.89***	4.79***	0.01	1.1	1.2
	Primary Surplus	All	7.60***	3.15***	16.04***		
	Primary Surplus	EB	8.32***	3.02***	21.03***		
	Primary Surplus	TB	4.29***	3.96***	0.03		
SWE	Output	All	-4.08***	-5.96***	1.65	0.6	1.9
	Output	EB	-3.11***	-5.21***	2.23	0.5	1.8
	Output	TB	-8.43***	-8.86***	0.03	2.0	1.9
	Employment	All	-2.41**	-9.96***	10.03***	0.4	3.1
	Employment	EB	0.01	-9.22***	15.42***	0.0	3.2
	Employment	TB	-10.53***	-11.88**	0.1	2.5	2.6
	Unemployment	All	0.39	4.66***	18.04***	0.1	1.4
	Unemployment	EB	-0.81	4.76***	19.35***	0.1	1.6
	Unemployment	TB	4.51***	4.11***	0.13	1.1	0.9
	Primary Surplus	All	6.37***	3.22***	7.34***		
	Primary Surplus	EB	6.84***	2.90***	9.38***		
	Primary Surplus	TB	4.29***	4.65***	0.03		

Note : The rows FIN, JPN, NLD, SWE, refer to the results obtained when excluding either Finland, Japan, Netherlands or Sweden from the sample.

Figure 3.6.1: Effects of Fiscal Consolidations on Real GDP

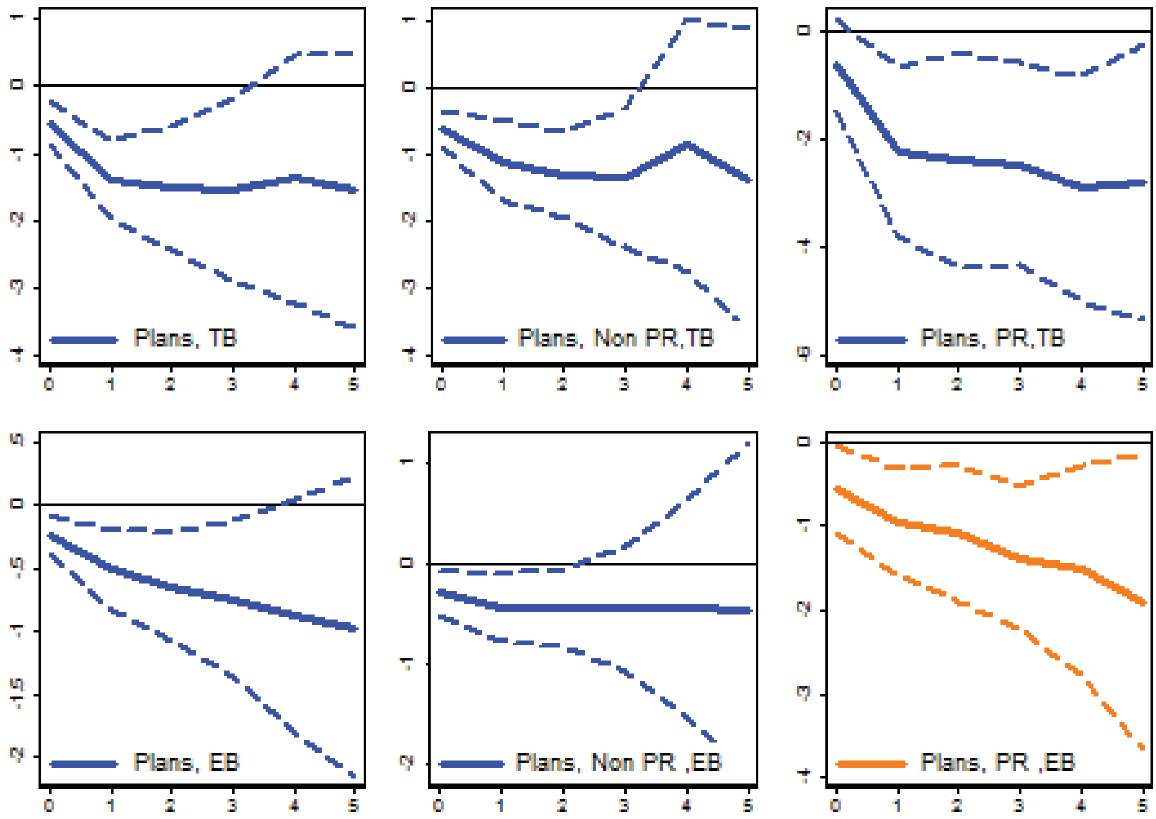


Note: denotes the initial year of the fiscal consolidation. 95 percent confidence intervals are displayed. All denotes all episodes of fiscal consolidations; EB denotes expenditure-based consolidations; TB denotes tax-based consolidations. U-Gap> 1% denotes episodes of unemployment gap above 1 % and U-Gap< 1% all other episodes. See text for explanation on identification of unemployment gap.

enced financial crises, which might act as an omitted variable biasing the results toward large contraction of output and employment in recessions. Japan has also experienced a protracted slowdown followed by a period of interest rates against the Zero Lower Bound (ZLB), which might have increased the value of the multipliers during this period. Therefore, we re-run the baseline model excluding at each estimation round one country. Table 3.6.2 shows that the multipliers are in general quite stable across the sample. In particular the EB multiplier in PR episodes is on average 1.5, with the lowest value level being 1.3 and the highest value being 2.3. For the employment and unemployment spending multipliers results are similar. Thus, we conclude that the results are not driven by specific episodes of financial crises or the ZLB.

The third robustness check tests whether the results change if fiscal plans are added to the estimation. As argued by Alesina et al. (2012), the episodes identified by Devries

Figure 3.6.2: Accounting for Fiscal Plans



Note: denotes the initial year of the fiscal consolidation. 95 percent confidence intervals are displayed. Plans denotes estimations of fiscal consolidations taking into account anticipation effects of expected fiscal policy changes; EB denotes expenditure-based consolidations; TB denotes tax-based consolidations. PR denotes episodes of protracted recession and non-PR all other episodes. See text for explanation on identification of PR episodes.

et al. (2011) are not isolated shocks, but part of multi-year fiscal adjustment plans. The possibility that planned fiscal adjustment might be anticipated, could lead to inconsistent estimation. Alesina et al. (2012) results show that, accounting for fiscal plans and the style of fiscal adjustment (whether it is a "stop and go" adjustment or executed according to plan), spending multipliers are lower than tax multipliers. Their results do not consider asymmetric effects over the state of the economy. Therefore, we check if the baseline result still holds in the specification augmented for fiscal plans.

When accounting for fiscal plans, the impact of EB consolidations on GDP during PR episodes is more pronounced, but still very similar to the specification without fiscal plans (Figure 3.6.2)[9]. The multipliers resulting from this exercise (Table 3.6.3) are indeed well

[9]The specification in Alesina et al. (2012) helps to correct for the impulse responses bias identified by Teulings and Zubanov (2013) in local projections estimation using panel data. At some forecasting

Table 3.6.3: Robustness to Fiscal Plans

Variable	Type	Cumulative IR		Difference	Multipliers	
		Non PR	PR	Chi-sq.	Non PR	PR
GDP	All	-3.69***	-8.18***	7.95***	0.7	2.6
	EB	-2.93***	-8.48***	11.19***	0.5	2.4
	TB	-3.48***	-8.92***	5.90**	1.5	1.7
Employment	All	-2.98***	-8.23***	4.90**	0.6	2.7
	EB	-0.62	-9.82***	11.02***	0.1	2.8
	TB	-9.47***	-7.96**	0.24	4.0	1.5
Unemployment	All	0.52	5.65***	17.47***	0.1	1.8
	EB	-0.70	6.17***	12.16***	0.1	1.8
	TB	2.74***	2.47***	0.06	1.2	0.5
Primary Surplus	All	5.32***	3.09***	5.75**		
	EB	5.65***	3.52**	2.40		
	TB	2.36*	5.17***	2.06		

Note : The column "Cumulative IR" reports the cumulative impulse response of the variable in row under protracted recession (PR) and non-protracted recession (Non PR) when considering: 1) All type of consolidation episodes (All); 2) Expenditure-Based (EB); 3) Tax-based (TB). The asterisks denote the significance of the rejection of the hypothesis that the cumulative IR is equal to zero at the 10% (*), 5% (**) and 1%(***) level. The column "Difference" reports the Chi-squared statistics of the test of the difference between the cumulative IR. Asterisks denotes rejection of the hypotheses at the 10% (*), 5% (**) and 1%(***) level. The columns "Multipliers" show the ratio between the cumulative IR of GDP, Employment and Unemplyoment divided by the cumulative IP of the Primary Surplus under respective type of consolidation and state of the economy.

aligned with those estimated in Table 3.6.2.

Our final robustness check investigates the role played by the exchange rate regimes (fixed vs. flexible). We check whether the option of exchange rate accommodation can explain the different impact of consolidations on output. We perform this test by estimating two separate baseline regressions for flexible regimes countries vs. non-flexible regimes countries based on the de-facto exchange rate regime classification of **?**, during

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horizon, the dependent variable may already be affected by the implementation of the consolidation, even though the variable measuring consolidation is set equal to zero. Under these circumstances, the effect of the consolidation on the dependent variable will be soaked up by the fixed effects rather than being reflected by the consolidation variables, thus resulting in a downward bias of the estimation of the fiscal consolidation. Figure 3.6.2 reveals in fact that the IRs under the specification with fiscal plans are in general below the specification not augmented for fiscal plans. Teulings and Zubanov (2013) suggest augmenting the specification to include the consolidation variable forwarded between period zero and the forecasting horizon. We conduct a test using the correction proposed by Teulings and Zubanov (2013) and found results very similar to the specification augmented for fiscal plans.

Table 3.6.4: Effects of Consolidations on Output, Fixed vs. Flexible Exchange Rate Regime

Variable	Type	Cumulative IR		Difference	Multipliers	
		Fixed	Flexible	Chi-sq.	Fixed	Flexible
GDP	EB	-2.39***	-5.71**	6.88***	0.6	0.7
	TB	-6.61***	-3.35	1.22	2.0	0.7
Primary Surplus	EB	3.71***	8.13**	0.02		
	TB	3.31***	5.12***	6.28**		

Note : The column "Cumulative IR" reports the cumulative impulse response of the variable in row under protracted recession (PR) and non-protracted recession (Non PR) when considering: 1) All type of consolidation episodes (All); 2) Expenditure-Based (EB); 3) Tax-based (TB). The asterisks denote the significance of the rejection of the hypothesis that the cumulative IR is equal to zero at the 10% (*), 5% (**) and 1%(***) level. The column "Difference" reports the Chi-squared statistics of the test of the difference between the cumulative IR. Asterisks denotes rejection of the hypotheses at the 10% (*), 5% (**) and 1%(***) level. The columns "Multipliers" show the ratio between the cumulative IR of GDP divided by the cumulative IP of the Primary Surplus under respective type of consolidation and state of the economy.

the entire estimation period. In particular, we define flexible regime if the country has a flexible regime or a crawling band according to the dataset. Fixed regimes are instead de-facto or crawling pegs. Given lacks of degrees of freedom, we restrict the attention to the sample with all types of consolidations (EB and TB), without analyzing further non-linearity with respect to the business cycle[10].

The results displayed in Table 8 indicate that, while the cumulative responses of output to EB consolidations in flexible regimes seem larger, this is due to an equally larger increase in primary surplus. Cumulative multipliers are below unity for EB consolidations across exchange rate regimes and above unity for TB consolidations, although they are close to 2 under fixed exchange rate regime, a results which is in line with the literature (Ilzetzki et al. (2013), Mineshima et al. (2014)). The distinction between fixed and flexible regimes does not seem to be driver of the differential impact of fiscal policy on output.

3.7 Conclusion

Since the inception of the global financial crisis, the deterioration of the fiscal positions in advanced countries has spurred a debate on the macroeconomic effects of fiscal consolidations. This paper provides a contribution to this literature by estimating fiscal multipliers on output, employment, and other macroeconomic variables during periods of protracted recession, i.e. periods of economic contraction of at least two years.

[10]We also correct for the impact of influential observations by excluding top and bottom 5 percent of observations of the dependent variable over each estimating horizon.

Two main novelties distinguish this paper from the previous literature. First, consolidations are identified through the narrative approach (Devries et al. (2011)). Second, we estimate impulse responses to expenditure and tax-based fiscal consolidations for two distinct states of the economy using the Jorda‘ (2005) local projection methodology. These effects are finally quantified by calculating the medium-term (five-year) multipliers following the approach suggested by Monacelli et al. (2010) and Ramey and Zubairy (2013).

The results show that fiscal consolidations tend to produce a negative effect on output and labor market variables, with larger multipliers being observed in periods of protracted recessions. Tax-based consolidations do not seem to have asymmetric effects across the two states of the economy. Contrarily, expenditure-based consolidations tend to have larger multipliers if enacted during prolonged recessions. This new expenditure-based multiplier is very close to the tax-based one during protracted recession. Such finding is new compared to the previous literature, which did not look at periods of protracted recession and found that cutting expenditures hurts less than increasing taxes during fiscal consolidations.

Regarding the main mechanisms, while tax-based consolidations act mainly through their negative impact on investment and capital accumulation, expenditure-based consolidations tend to have a negative effect on output largely through their impact on the labor market: employment rates significantly go down, whereas unemployment goes up leading to an increase in the estimated non-accelerating inflation rate of unemployment (NAIRU) over the medium term. These results are consistent with the presence of hysteresis effects in the labor markets: recessions lead workers to drop out of the labor force, having a persistent effect in the medium term unemployment rate.

Our paper has some policy implications. First, the large multipliers during protracted recessions suggest the need of a back-loaded adjustment under those circumstances. Fiscal adjustments should be gradually implemented. Rapid fiscal consolidation can further depress demand and reinforce hysteresis effects in the labor market. However, the pace of the adjustment should be balanced so that debt remains solvent at the same time that the potential output and growth is guaranteed in the medium-term. Furthermore, expenditure contractions could be guided by Public Expenditure Reviews providing and assessing ways of reforming public spending IMF (2010b)[11]. The latter will be even more important in period of recovery, in which expenditure multipliers are lower than unity. Moreover, social dialogue and consensus should further steer their design in order to minimize negative effects as well as their reversal in the medium-term (IMF (2014)).

The current analysis offers various possibilities for further research. For example, the

[11]For an example of such public expenditure review, see IMF (2013).

transmission mechanisms between the fiscal adjustment and medium-term growth could be further investigated. Moreover, rather than looking at expenditure- vs. tax-based consolidation, it could be interesting to calculate fiscal multipliers for each of the tax and expenditure instruments in separate. This could help one understanding how the fiscal measures propagates into the medium-term growth, and how to better targeting the design of the fiscal consolidation.

Appendix

3.A Data Sources

Table 3.A.1: Data Sources

Variable	Description	Source
Contractionary Episodes	Turning points in the Composite Leading Indicators (CLI) series constructed by the OECD	FRED
Output Gap	(GDP - Potential GDP) / Potential GDP	OECD
Unemployment Gap	(Unemployment - Trend Unemployment)	Authors' Calculation
Consolidation	Fiscal Consolidations from the Narrative Approach	Devries et al. (2011)
Real GDP		OECD
Real Consumption		OECD
Real Investment		OECD
Real Export		OECD
Real Import		OECD
Potential GDP		OECD
Capital Stock		OECD
Private Employment	Employment in the Private Sector	Haver
Employment ratio		OECD
Unemployment Rate		OECD
NAIRU	Non-Accelerating Inflation rate of Unemployment	OECD
Inflation	Annual Rate of Inflation	OECD
Short-term Rate	3-month Money Market Rate	OECD

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