Non-Keynesian Effects of Fiscal Policy in a New-Keynesian General Equilibrium Model for the Euro Area

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DOCTORAL THESIS

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Vita

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Abstract

After the fiscal profligacy of the 1970s and early 1980s, in the last 25 years several OECD governments undertook large fiscal consolidations, aimed at sustainably reducing public deficits and debt. Surprisingly, or not, some of these consolidations were characterized by large increases in private demand and output. Subsequently, a large body of theoretical and empirical literature on expansionary fiscal contractions, *i.e.* non-Keynesian effects of fiscal policy, has developed.

This literature has been far from consensual, not only because theoretical predictions are somehow fragile, but also because empirical evidence is, at best, contradictory. However, it seems that investment plays a crucial role in the existence of a possible negative fiscal multiplier. Against this background, this thesis studies the investment-related channel for non-Keynesian effects of fiscal policy, with the aim of identifying the conditions under which a fiscal consolidation may have expansionary effects on short-term output.

In this context, we develop a new-Keynesian DSGE model, which is calibrated for the Euro Area, with an expanded fiscal block that is gradually enhanced in order to simulate three alternative demand- and supply-driven transmission mechanisms of the investment channel: (i) the change in the composition of public expenditure; (ii) the relation between the level of the fiscal deficit, or debt, and the long-run interest rates; and (iii) the insertion of the fiscal consolidation in a broader economic reform, designed to increase markets' competition.

Among other conclusions, our simulations predict that a fiscal consolidation may give arise to non-Keynesian effects when: (i) the consolidation is conducted simultaneously with a structural change in the fiscal budget in favor of more productive spending; (ii) the initial state of the public finances is such that the long-run interest rate is sensitive to changes in the level of the public debt, so long as the consolidation is credible and based in cuts either on unproductive spending or weakly-productive public employment; and (iii) the consolidation is adequately combined with structural reforms increasing the competition in the markets.

Some particular fiscal consolidations in European countries are rather supportive of our thesis main findings.

Table of Contents

List of Tables

List of Figures

1 Introduction

"(...) while episodes of contractionary fiscal expansions, and expansionary contractions, are a rather common finding, there is still disagreement on the conditions under which a fiscal consolidation can raise output growth - or a fiscal expansion reduce it - and on the channels through which such effects might occur. Understanding these issues is obviously essential if one wishes to know which policies might improve the likelihood of non-Keynesian outcomes" (Giavazzi *et al.* (2005), p.5)

After the fiscal profligacy of the 1970s and early 1980s, in the last 25 years several OECD governments undertook large fiscal consolidations, aimed at sustainably reducing public deficits and debt. Surprisingly, or not, some of these consolidations, although not all of them, were characterized by large increases in private demand and output. Subsequently, a large body of theoretical and empirical literature on expansionary fiscal contractions, *i.e.* non-Keynesian effects of fiscal policy, has developed. This literature has been far from consensual, apart from the evident acknowledgement that such effects actually existed in some episodes. Different types of fiscal consolidations, characterized by different sizes of the fiscal adjustment, different compositions or distinct pre-consolidation states of public finances, seem to be linked with different macroeconomic performances. The literature, then, suggests that the traditional Keynesian short-run positive correlation between fiscal policy and aggregate demand and output may be reversed if some conditions are in place.

The controversies in the literature on the impact of fiscal contractions and consolidations on the aggregate economic activity arise, not only because theoretical predictions are somehow fragile, but also because empirical evidence is, at best, contradictory. Against this background, this thesis aims at identifying the conditions under which a fiscal contraction may be effective both in reducing public debt and in stimulating output growth in the short-term. The thesis thus attempts to tackle the issue raised in the above quotation from Giavazzi *et al.* (2005): searching for the circumstances and

possible channels under which non-Keynesian effects might prevail over the conventional Keynesian effects. The analysis will be focused especially in the Euro Area.

In this thesis we will claim that the currently prevailing theoretical explanations for non-Keynesians effects of fiscal policy − which, with very few exceptions emphasize the consumption channel (*via* the expectational effect, the wealth effect or the substitution effect) −, are necessary but not sufficient. Both the most relevant historical episodes of fiscal consolidations and the recent results of the empirical literature show that, although private consumption may rise after a fiscal contraction, the rise in private investment must play a crucial role in the existence of a possible negative fiscal multiplier, and particularly in the length and persistence of the effects.[1] In this context, the main objective of this thesis is to explore the investment-related channel for the existence of non-Keynesian effects of fiscal policy.

Assuming that investment decisions are driven directly by real interest rates and by expectations about future profits, the investment channel can be explored either by looking at demand factors or at supply factors. On the one hand, reductions in real interest rates associated with fiscal contractions can generate a direct positive impact on investment. This can be thought of as the traditional *crowding-in* effect presented in standard economic textbooks. However, this effect tends to be negligible unless when accompanied by a second effect on real interest rates derived from a reduction in the risk premium associated with high levels of public debt. On the other hand, when fiscal policy affects private factors' productivity (either directly or indirectly *via* labor or product market reforms), an indirect supply-driven effect can affect private investment. This channel essentially works through a pressure on real wages and the expected present value of the net marginal product of capital. While the demand-driven effect depends crucially on the initial state of public finances, the supply-driven effect is essentially dependent upon the composition of the fiscal adjustment and some institutional factors, like those

[1] Alesina and Perotti (1995, 1997a, 1997b), Alesina *et al.* (2002) and Ardagna (2007) explore the investment channel by investigating the impact of fiscal policy on the labor market.

related with the working and competitiveness of the labor market.

The thesis explores this range of possible transmission mechanisms of the investment channel through model simulations, developed within a new-Keynesian dynamic stochastic general equilibrium (DSGE) model. Hence, the thesis tries to reconcile the new-Keynesian framework with the main results of the empirical literature on non-Keynesian effects. Unlike most of the literature, where models of this class have been used for the analysis of monetary policy, this thesis develops a new-Keynesian DSGE model for the analysis of fiscal policy, which is then calibrated for the Euro Area.[2] In so doing, the thesis is closely related to a very recent new generation of new-Keynesian general equilibrium models that include a more developed fiscal policy block.[3].

Modern new Keynesian DSGE models, firstly suggested by Smets and Wouters (2003) and Christiano *et al.* (2005), extends the standard cashless DSGE model with various types of nominal and real frictions considered relevant for capturing the high degree of persistence present in macroeconomic data. This thesis develops a medium-scale general equilibrium model of this type, with a thorough set of fiscal budget components, devised for a possible account of the evidence of non-Keynesian effects of fiscal policy. A DSGE model like the one we develop allows for complex relations between the variables as well as for different transmission mechanisms, either demand-driven or supply-driven. Within this model, we simulate several policy experiments of fiscal consolidations in which a fiscal policy shock occurs in isolation from other types of shocks to macroeconomic variables. Studying the problem in the context of such experiments, should allow for a clear distinction and understanding of the dynamic processes involved in the transmission of the fiscal consolidation, thus solving possible limitations of the empirical and historical studies.

In summary, there are three types of motivations for this thesis: histori-

[2]In models designed for monetary policy analysis, fiscal policy was represented, both in new-Keynesian and neoclassical literature, by the very simple conventional lump-sum taxes financing or the balanced budget policy rule.

[3]Bilbiie and Straub (2004), Coenen and Straub (2005), Galí *et al.* (2007) and Coenen *et al.* (2008).

cal/empirical; theoretical/methodological; and economic policy motivations.

The thesis is first motivated by the empirical and annedoctal evidence on the existence of non-Keynesian effects of fiscal consolidations, and the fact that they still lack convincing explanations.

Secondly, it is motivated by the fact that the underdevelopment of the theoretical studies on this subject leaves the way open for an inquiry on the possible role of several yet unexplored theoretical channels through which fiscal consolidations may be expansionary. More specifically, there seems to exist an avenue for research on investment channels in the context of a new-Keynesian DSGE model with a thorough treatment of fiscal policy. The combination of a fiscal policy demand side intervention and a structural supply side reform, prompted by the fiscal consolidation and/or by other reforms associated to that consolidation (labor market or product market reforms, say) is a novel path of research that we intend to explore.

Finally, the relevance of this investigation for the current European (and particularly Portuguese) policy agenda is another source of motivation. The high levels of budget deficits and/or public debts in some European countries[4] (and also in the US and other OECD countries), combined with the requirements of the Stability and Growth Pact (SGP), are currently driving a consolidation of the public finances in some European countries.[5] Analyzing the conditions under which these consolidations can be reconciled with the existence of negative fiscal multipliers may be useful for policy recommendations aimed at helping fiscal authorities to manage the consolidation process. In sum, a good understanding of the short-term impact of fiscal consolidations is crucial for a proper implementation of a fiscal policy framework.

Chapter 2 lays the foundations and motivation for the thesis. There we briefly review the literature on the macroeconomic effects of fiscal pol-

[4] Taking as reference values for public debt-to-GDP ratio the ones adopted by the Maastricht Treaty and the Stability and Growth Pact, several EU-15 countries have recently exceeded that value: in 2005, seven countries presented debt ratios above 60% (Austria, Belgium, France, Germany, Greece, Italy and Portugal), with four of them showing an increasing path (France, Germany, Greece and Portugal).

[5] The thesis has been written before the 2008 financial crisis and the ongoing depression, in which fiscal stimulus programmes have widespread as a mean for contra-cyclical policy and the sustainability of fiscal positions has transitory lost importance.

icy, with a special focus on the references to non-Keynesian effects of fiscal consolidations. The main conclusion is that, despite all the theoretical developments as well as improvements in data and in econometric techniques, the magnitude and even the sign of the fiscal multiplier remains unclear.

In chapter 3 we begin the modelling work, developing a baseline new-Keynesian DSGE model that, in view of our purposes, includes a further detailed fiscal policy block than is usual in the literature. Our baseline model is then calibrated for the Euro Area and used to perform some simulations in order to understand the model's dynamic reaction to a fiscal shock. These simulations – systematically developed with two alternative scenarios for the labor market (monopolistic and perfect competition) – show that it does not predict non-Keynesian effects from a fiscal policy contraction. This result, which is consistent with the standard new-Keynesian DSGE models literature, motivates our work throughout chapters 4, 5 and 6 of the thesis: to enhance the model with further transmission mechanisms that refine the relation of fiscal policy to the macroeconomy. Specifically, we chose to explore mechanisms within the investment-channel for possible non-Keynesian effects, previously identified in chapter 2, and to do it sequentially in order to assess their individual role.

Chapter 4 explores a first possible transmission mechanism for the investment channel of non-Keynesian effects of fiscal consolidations – the change in the budget composition during the fiscal adjustment. For that purpose, and based on literature therein reviewed, we augment the baseline model introducing government spending and public employment expenditures as variables with a direct relation with total private factor productivity in the intermediate goods sector. Such relation is then allowed to be more or less important, with public spending split into highly-productive, weakly and non-productive spending – each calibrated with a realistic elasticity, according to the literature – whereas public employment is alternatively calibrated with a strong and a weak productivity effect (again, with elasticities in accordance with the literature). We then simulate a wide variety of single and composite fiscal shocks, with the latter changing the composition of the budget in favour of "quality", *i.e.* more productive expenditure. Among the set of conclusions

obtained, three stand out. First, the success of fiscal consolidations, either via public spending reductions or employment costs reduction, decreases with the degree of their productivity. Second, consolidations through pure contractions of weakly-productive or non-productive public spending generate short-run contractions of output. Third, for consolidations that include a change of the fiscal budget in favor of more productive spending, or a reduction in weakly-productive public employment (under perfect competition in the labor market) the model predicts non-Keynesian effects.

In chapters 5 and 6 we alternatively explore two further transmission mechanisms for the investment-channel of non-Keynesian effects, using the model with productive public inputs developed in chapter 4 that from that chapter onward constitutes our new-Keynesian DSGE model.

Chapter 5 is motivated by an extensive literature, both academic and from policy makers, on the correlation between highly unfavorable initial states of public finances, the success of fiscal consolidations and the appearance of non-Keynesian effects. The causal chain is, in such initial states, as follows: a successful fiscal consolidation permanently reduces the stock of public debt and the probability of default on government bonds, inducing a reduction in the sovereign long-term interest rate and in the whole range of long rates, which leads to an increase in private demand, especially private investment.

We firstly develop our model by considering a direct relation between the level of the public debt and the steady-state interest rate, with an elasticity in accordance with the empirical estimates in the literature. Then, the enhanced model is used to simulate a set of alternative fiscal consolidations. Differently from the analysis until then, this channel involves the transition to a new steady-state of the economy. In short, the simulations suggest that when the long-term interest rate is sensitive to changes in the level of the public debt, so long as the consolidation is credible and based in cuts on unproductive spending or weakly-productive public employment, non-Keynesian effects do arise.

Chapter 6 is motivated by literature, episodes and statements by policy makers suggesting that fiscal consolidations conducted within a broad economic reform program, aiming at increasing the competition and overall

efficiency of markets, are more prone to success and to be expansionary. In the literature, this transmission mechanism is seen as possibly operating via a more competitive environment in the labor market, in the product market, or in both, as a result of more or less comprehensive reforms. Given the structure of our model, such reforms could appear in the (intermediate) products market as well as in the labor market; and an increase in competition would imply a reduction of (price and wage) markups.

We have circumvented the problems with the calibration of changes in the markups following the reforms, assuming that a reform would reduce the markups from their original (Euro Area) levels to the levels that have been estimated in recent literature for the US. Then, a set of alternative fiscal consolidations are simulated in three alternative scenarios of market reforms: a pure product market reform (reduction of price markup); a pure labor market reform (decline of wage markup); and an overall markets reform (decline in both price and wage markup). As in chapter 5, the analysis now involves the transitional dynamics to a higher steady-state output. Overall, we conclude that fiscal consolidations based on spending contraction need not depress output, if adequately combined with structural reforms that increase the degree of competition in the markets to a realistic level. Our results further suggest that product market reforms seem to have a higher potential of generating non-Keynesian effects for fiscal consolidations in the Euro Area. Finally, one major economic policy conclusion from these simulations is that the more comprehensive the market reforms, the higher the probability of success of the consolidation and the lower the sacrifice demanded to economic agents.

In chapter 7, we review some particular fiscal consolidations in European countries, highlighting their basic features and establishing regularities as regards conditions for their degree of success, on the one hand, and of expansionary effects, on the other hand. We then compare the results obtained in the previous chapters on the studied transmission mechanisms, with the uncovered regularities. We conclude that the selected consolidation episodes are rather supportive of our thesis main findings.

Chapter 8 concludes the thesis. First, we present a brief summary of what

we have learned about the conditions under which a fiscal consolidation may simultaneously be successful and generate non-Keynesian effects. Then we discuss some of the caveats of our study. Finally, we present avenues for further research.

2 Fiscal Policy and the Macroeconomy: A Brief Review

Despite the efforts recently made in some countries, large fiscal adjustments cannot be avoided in most OECD countries in coming decades. High current levels of deficit-to-GDP and debt-to-GDP ratios combined with medium- and long-term spending pressures on public finances, related, *inter alia*, to population ageing, and the consequent increase in the demand for public spending on health and long-term care, urge the need for fiscal consolidations in most of the world.[6] Table 2.1, below, shows the structural primary surpluses required in 2006 to bring debt-to-GDP ratio to 60% in 2050, which are dependent upon the impact of those long-term spending pressures on public budget.

Table 2.1 – Structural primary surpluses required to bring debt to 60% of GDP by 2050

	Period average		*Memorandum item:*
	2006-15	2016-25	*2006 estimate*
	Ratio to potential GDP, per cent		
Euro area	**4.3**	**2.6**	***1.0***
Austria	2.7	1.6	*1.7*
Belgium	5.3	2.9	*4.5*
Finland	3.7	1.0	*2.1*
France	3.8	2.3	*0.6*
Germany	3.8	2.5	*0.6*
Greece	7.7	3.9	*0.7*
Ireland	4.9	2.1	*0.4*
Italy	5.2	3.7	*-0.1*
Luxembourg	4.6	1.5	*-1.1*
Netherlands	3.9	1.7	*2.6*
Portugal	6.2	3.2	*0.3*
Spain	4.6	2.4	*2.9*
Comparator countries			
Australia	2.1	0.4	*3.9*
Canada	3.5	1.9	*1.9*
Denmark	3.2	1.1	*4.2*
Japan	6.0	4.3	*-3.2*
New Zealand	4.0	1.2	*2.7*
Sweden	2.5	1.6	*2.0*
United Kingdom	2.5	1.2	*-0.8*
United States	2.9	1.4	*-0.3*

OECD (2007)

[6] Another source of spending pressures may come from the implications of climate change, which may lead governments to implement some measures that increase public spending like, for example, capital grants, tax credits or direct transfers for the development of renewable energies.

Against this background, there is little doubt that strong fiscal adjustments are required: "*Unless current policy settings change, the fiscal pressures from health and pension costs mean that public debt is on an explosive path*" (Cournède and Gonand (2006), p.5).

Fiscal consolidations are usually seen as having high short-term contractionary effects on output, given the traditional Keynesian positive fiscal spending multiplier. Is this really true or is it possible to conduct fiscal consolidations without relatively high short-term output losses? Or even, as some empirical evidence suggest, is it possible to reconcile fiscal consolidations with a short-term output expansion, *i.e.* is the fiscal spending multiplier negative?

2.1 The Fiscal Multiplier: Traditional Keynesian, Weak Keynesian, Ricardian Equivalence and Non-Keynesian Multipliers

There is a long standing debate about the macroeconomic effects of fiscal policy, and currently there is yet no consensus on the interaction between fiscal policy and short-term output growth.[7] Every turning point in macroeconomic thinking has led to a change in economists' view about these effects and the behavior of fiscal authorities (Buti *et al.* (2002)).

Until the early 1970s, macroeconomic thinking was dominated by the traditional Keynesian view of a positive and larger than one fiscal multiplier, which was the conventional wisdom both in academic and in policy-making circles. Based on the well-known Keynesian demand-side transmission mechanisms, this view states that a fiscal policy contraction reduces current income, thus reducing private consumption and output, and thus slowing down aggregate demand and economic activity with an amplified impact. In other words, fiscal policy was seen as an effective tool for cyclical stabilization.

The traditional view on the effects of fiscal policy is typical of the simple Keynesian driven, short-term horizon models, like the IS/LM or Mundell-

[7] For more detailed surveys of the literature see, for example, Hemming *et al.* (2002a), European Commission (2003), Capet (2004) and Briotti (2005).

Fleming, presented in standard macroeconomic textbooks. However, even in these simple models the size of fiscal multipliers may be narrowed by some factors like, (i) the presence of a productive capacity close to full employment, (ii) a possible *crowding-out* effect over private investment, depending on its sensitivity to possible changes in interest rates, and (iii) a possible external offsetting effect, depending on the exchange rate regime and on the degree of international capital mobility. Hence, even in the traditional Keynesian framework, the fiscal multiplier, although positive, can be relatively small – the so-called weak Keynesian multiplier.

In the second half of the 1970s, the consensus on the usefulness of fiscal policy for stabilization purposes has been challenged. In an environment of high inflation and unemployment (stagflation), following the expansion of the modern welfare state (unemployment benefits, insurance against old-age risks and sickness) during the 30 golden years, budget deficits rose and there was a rapid accumulation of public debt. For the first time in decades there was a conflict between cyclical stabilization and the long-term sustainability of public finances.

Within this context, Barro (1974) revived the concept of Ricardian Equivalence. He suggested that, under certain intertemporal optimizing assumptions, the fiscal multiplier could be null. According to this hypothesis, a tax cut financed by public debt may fail to stimulate private demand because households do not consider bonds as net wealth, as they discount the future expected tax burden required to repay the debt, and hence fully offset the decrease in public saving with higher precautionary private saving. In other words, economic agents anticipate the future increase in taxes to pay back the public debt and cut back their current consumption accordingly. However, this hypothesis has been questioned for its rather strong assumptions, namely those of: (i) perfect capital markets with no liquidity constrained agents; (ii) perfect foresight, altruistic and forward looking agents; (iii) inexistence of distortionary taxation. Ricardian Equivalence implicitly assumes the existence of fully rational economic agents that are "*(...) fully aware of the government policy measure, that they appreciate its consequences and are possessed of a correct model of the manner in which the macroeconomy*

operates." (Shaw (1997), p.63). In fact, a positive fiscal multiplier holds in a economy with myopic private agents with finite lives, liquidity constrained and subjected to distortionary taxes. Thus, although a useful starting point for the theoretical analysis of the effects of fiscal policy, very few economists would endorse it as a realistic description.

In the late 1970s and in the 1980s, two major research programs have emerged in macroeconomics with opposite ideas about the short-term effectiveness and usefulness of fiscal policy. On the one hand, new classical real business cycle researchers, based on wage and price flexibility in an environment of continuous market clearing, defend that fiscal policy can affect output only temporarily and only if economic agents do not anticipate it. Moreover, they state that fiscal policy should not be used to stabilization purposes because it would only "*(...) distorted output and employment away from the optimal amounts chosen by firms and workers.*" (Snowdon and Vane (1997), p.6). On the other hand, the new Keynesian researchers renewed the traditional Keynesian framework by introducing neoclassical elements, such as intertemporal optimization by forward looking agents forming rational expectations (*i.e.*, Ricardian agents), into models with market imperfections and wage and price stickiness. In the resulting new kind of dynamic models arised the possibility of smaller or even negative fiscal multipliers: "*(...) a policy innovation that would be contractionary in a static model may be expansionary if it induces significantly expectations of future policy changes in the opposite direction.*" (Bertola and Drazen (1993), p.12)

The possibility of a negative fiscal multiplier − non-Keynesian effects of fiscal policy on aggregate demand and output − has been firstly put forward, in modern macroeconomics, by Feldstein (1980, 1982). Exploring the link between current fiscal policy changes and their effects on private sector expectations of permanent income changes, Feldstein argued that permanent fiscal contractions can be expansionary provided that they create expectations of future tax cuts, and hence an increase in permanent income and thus in private sector current expenditures. Clearly, Feldstein's hypothesis only holds if the change in current fiscal policy is seen by households as a signal of possible future changes. A similar view, emphasizing the "*benign impact on*

expectations" (Fels and Froehlich (1986), p.184), has been expressed in 1981 by the German Council of Economic Experts, giving rise to what is currently known as the German View[8]. Further refinements to this view were proposed by Blanchard (1990) and Bertola and Drazen (1993), by emphasizing the role of debt stabilization in expectations, and Alesina and Perotti (1995, 1997b), by focusing on fiscal consolidation via cutting public spending as opposed to raising taxation.

The outcomes from some European episodes of fiscal consolidations, particularly Denmark (1983-86) and Ireland (1987-89), firstly documented by Giavazzi and Pagano (1990), strongly suggested that non-Keynesian effects of fiscal policy could actually exist.[9] The ratio of the cyclically adjusted primary deficit-to-GDP of Denmark and Ireland have fallen, in two years, by 10 percentage points and by 8 percentage points, respectively, while GDP average growth has been, respectively, 3.6% and 3.7%. Following this annedoctal evidence, and aware that "*the questions are that of when and how*" (Blanchard (1990), p.111), since the 1990s a growing body of theoretical and (mostly) empirical literature has been developed on the search for possible channels and conditions under which fiscal consolidations may be expansionary.

In sum, although macroeconomic thinking is still largely dominated by the Keynesian view, different theoretical models can predict different results on the economic effects of a fiscal policy; differences not only in the magnitude or persistence of those effects, but also in their sign.

2.2 Non-Keynesian Effects of Fiscal Policy: A Theoretical Review

The likelihood of expansionary effects of fiscal consolidations depends on whether the private consumption's and/or private investment's responses to the consolidation are able to offset its direct negative effect over aggregate demand and, hence, output. The costs of the fiscal contraction can be reduced

[8] For details see Hellwig and Neumann (1987).

[9] But also, for example, Belgium (1984-85), Portugal (1986), Italy (1994-95) and Greece (1996).

or even eliminated due to favorable expectational effects driving intertemporal saving choices. Thus, the literature searching for non-Keynesian effects may be effectively typified around two non-mutually exclusive consumption and investment channels.[10]

2.2.1 Consumption channel

The consumption channel consists of the hypothesis that a fiscal policy consolidation may, under certain conditions, raise private consumption, potentially because of three effects: a pure expectational effect, a wealth effect and a substitution effect.

The pure expectational effect arises from an improvement in consumers' expectations brought about by a fiscal consolidation that effectively reduces uncertainty about future tax liabilities and therefore allows consumers to decrease their precautionary saving (Feldstein (1982)).[11] By eliminating the need, or at least reducing the probability, for a stronger and disruptive consolidation in the future, the fiscal contraction raises the present discounted value of disposable income, thus leading to an increase in private consumption.[12] These expectational effects are dependent on the size and persistence of the fiscal contraction and are directly linked with its credibility. They also apply best to situations of fiscal stress, where the budget deficit and/or debt-to-GDP ratio is high or growing fast, cases in which a strong and persistent fiscal adjustment signals a change in regime and a solution to the country's fiscal imbalance.

The wealth effect arises from the increase in wealth, generated by a fall in interest rates which increases the market value of assets held by consumers

[10] Non-mutually exclusive because fiscal policy affects simultaneously private consumption and investment. We argue, yet, that different authors and literature strands tend to attach a different relevance to one of the two possible channels.

[11] For models incorporating this effect see, for example, Blanchard (1990), Bertola and Drazen (1993), Sutherland (1997) and Barry and Devereux (1995, 2003).

[12] It should be noted that this expectational effect is also very important to the investment channel. By reducing uncertainty about the future, a fiscal consolidation leads to a decrease in the option value of waiting by firms to take investment decisions (Blanchard (1990)). However, the literature tends to emphasize this expectational effect on private consumption.

and also increases the opportunity cost of saving, leading households to increase current consumption.[13] This effect depends on the relation between the fiscal contraction and interest rates, and can be seen as the consumption counterpart to an analogous interest rate effect that we will discuss within the investment channel.

It should be noted that, along with these two effects there is a negative direct effect of the fiscal consolidation over consumption, associated to the reduction in current disposable income. Thus, the consolidation only leads to an overall increase in private consumption if the positive expectational and wealth effects, over permanent income, are large enough to outweigh the negative direct effect over current income. Given the negative correlation between an higher permanent income and a lower current income, then the final result clearly depends on the fraction of households that cannot bring forward future incomes by borrowing, *i.e.*, liquidity constrained consumers.[14] Thus, the efficiency of the financial markets can be an important condition for an expansionary fiscal consolidation.

The third effect, the substitution effect, relates to the replacement of public consumption by private consumption. If consumers value social services supplied by the public sector − such as educational, health care, cultural or entertainment services − they will most likely increase private spending on these items once they are no longer provided by the public sector (Giavazzi and Pagano (1990)). In other words, if government spending is a resource drain for households, the absorption of a smaller share of GDP by the public sector creates room for the private sector to expand.

2.2.2 Investment channel

The investment channel consists of the hypothesis that a successful fiscal consolidation induces a strong and permanent increase in private investment. Alesina *et al.* (1998) argue that the major difference between an expansionary and a contractionary fiscal consolidation is the stronger response of private

[13] See, for example, McDermott and Wescott (1996).

[14] For a more detailed discussion see, for example, Coenen and Straub (2005) and Galí *et al.* (2007).

investment in the former, that "*is too robust to be attributed to the crowding-in effect only*" (Zaghini (2001), p.26). This stronger response is usually explained either by a demand-side interest rate effect or by a supply-side labor market effect.

The interest rate effect – which Alesina *et al.* (1998) and Alesina and Ardagna (1998) refer to as the "credibility effect" – operates via the decrease in real interest rates brought about by the reduction of the risk default premium prompted by the reduction of government borrowing requirements associated with the fiscal consolidation.[15] The decline in interest rates would, then, spur aggregate demand through private investment. This effect, which reinforces potential *crowding-in* effects, clearly depends on the initial state of public finances, being more probable when the level of the debt-to-GDP ratio before the consolidation surpasses some relatively high threshold.

The labor market effect emphasizes the increase in private investment resulting from an enhancement of the labor market efficiency and the overall competitiveness of the economy. Under certain conditions, a fiscal consolidation induces a moderation in the wage claims by unions (either by increasing the probability of unemployment or by increasing the costs of being unemployed), therefore reducing real wages pressure, stimulating employment, investment and output growth.[16] This effect stresses the role of the composition of current fiscal policy, as it is assumed that consolidations resulting from public spending cuts – especially government wage bills and welfare payments – rather than from increasing taxes, lead to higher increases in private investment.[17] As they directly affect the labor market, spending cuts induce market adjustments that reduce unit labor costs, increase profits and increase investment growth. Clearly, the structure and institutions of the labor market may play an important role in the development of this effect.

[15] Using a simple two period model, Afonso (2001) concludes that the reduction in the risk premium is essential to the existence of non-Keynesian effects of fiscal policy.

[16] See Alesina and Perotti (1995, 1997a, 1997b) , Alesina *et al.* (2002) and Ardagna (2007).

[17] Cournède and Gonand (2006) suggest that a fiscal consolidation based on raising taxes would reduce the incentive of the private sector to save and invest, thus reducing private investment and output.

2.3 Non-Keynesian Effects of Fiscal Policy: An Empirical Review

In the last quarter of a century, an extensive empirical work has been done in order to test for the existence and to identify the circumstances under which fiscal consolidations may have expansionary effects on global economic activity. However, until now the empirical literature has failed to provide robust stylized facts on the short-run effects of a fiscal policy shock and particularly of a fiscal consolidation. This empirical literature may be effectively divided into two main approaches: (i) cross-section or panel studies looking at large fiscal adjustment episodes; and (ii) time series studies, based on the specification and estimation of VARs.

2.3.1 Large fiscal adjustment episodes - analysis of events

In this branch of the empirical literature, panel data models are estimated for specific fiscal adjustment episodes. A crucial first step of these studies is the definition itself of "fiscal adjustment episode". This involves both measurement and conceptual issues.

The measurement is generally based on the size of the structural budget balance, *i.e.*, the balance that would occur at potential rather than actual output. This kind of studies use the notion of cyclically adjusted budget balance, by correcting the actual budget balances for the cyclical behavior of economic activity, which influences public budgets but are beyond the control of the authorities. In practice, however, there is no generally accepted methodology for measuring the structural budget balance. Among them the more frequently used, as we can see in table 2.2 below, are the measures presented by some European and/or international organizations like the IMF - International Monetary Fund (IMF (1993)), the OECD - Organization for Economic Cooperation and Development (OECD (1993), Giorno *et al.* (1995)), the European Commission (European Commission (1995)) or the ECB - European Central Bank (Bouthevillain *et al.* (2001)) and by some leading economists (see, for example, Blanchard (1993)).[18]

[18] Recently Afonso and Claeys (2008) derived a model-based indicator of structural bal-

The conceptual definition and the identification of the specific fiscal adjustment episodes is another challenge to this literature, as several approaches have been followed, leading to different turning points of fiscal policy. Another pitfall in this literature is that different studies are based in a different number of fiscal episodes (Afonso (2006)). As expected, different measures and definitions often provide different results, and so this literature is highly heterogeneous.

Table 2.2, below, summarizes this strand of the empirical literature. The results on the relation between fiscal policy and private consumption are overall rather inconclusive. While, for example, Giavazzi and Pagano (1996), Perotti (1999), Giavazzi *et al.* (2000), Giavazzi *et al.* (2005), Afonso (2006) and Carmignani (2008) found some evidence of non-Keynesian effects on private consumption, Heylen and Everaert (2000), von Hagen *et al.* (2001), Hjelm (2002), van Aarle and Garretsen (2003) and Hogan (2004) are inconclusive or even support the Keynesian view. However, when looking more specifically at the relation between fiscal policy and investment, the generic findings point to a large and persistent positive reaction of private investment to successful fiscal consolidations, which does not seem possible to justify only by simple textbook *crowding-in* effects. There is evidence of non-Keynesian effects on investment both through demand-driven effects (McDermott and Wescott (1996), Giudice *et al.* (2007)) and supply-driven effects (Alesina and Perotti (1995), Alesina and Ardagna (1998), Alesina *et al.* (2002), Ardagna (2004)).

Another set of conclusions refers to the analysis of the critical conditions for an expansionary fiscal consolidation. Here, it is generally found that the composition of the fiscal adjustment is crucial, with consolidations based on spending cuts − especially government wage bills and welfare payments − leading to larger non-Keynesian effects (Alesina and Perotti (1995), Alesina and Ardagna (1998), Alesina *et al.* (2002), Ardagna (2004)). Another important condition is the initial state of public finances, which is related with

ance, which may be seen as a first step towards a " *(...) economic indicator of discretionary fiscal stance that takes into account both the cyclical short-run and the long-term supply side aspects of fiscal policy.*" (Afonso and Claeys (2008), p. 114).

the initial values of deficit-to-GDP and debt-to-GDP ratios (McDermott and Wescott (1996), Perotti (1999), Zaghini (2001), Afonso (2006)). Size and persistence of the consolidation also seem to matter, but here the results are less conclusive.

Our brief review of the literature, when jointly considering the channel and the conditions for existence of non-Keynesian effects, suggests three main conclusions: (i) non-Keynesian effects on private consumption, when present, are essentially dependent on the size, persistence and composition of the fiscal policy − which is clearly in agreement with the expectational effect discussed in the last section; (ii) demand-driven effects on investment, related with the expectational effect and with the interest rate effect, which are prompted by confidence effects, are critically dependent on the initial state of public finances; (iii) composition seems crucial for the existence of supply-driven effects on investment.[19]

2.3.2 Structural VAR analysis - the spending fiscal multiplier

Paralleling a strand of empirical literature on monetary policy analysis, a number of studies have recently used VAR models for the analysis of fiscal policy, specifying and estimating VARs in order to identify the dynamic responses of the main macroeconomic variables to fiscal policy shocks. Even though not strictly directed to studying non-Keynesian effects of fiscal policy − but rather to analyze the sign and size of different fiscal multipliers − these studies allow for some conclusions on non-Keynesian effects of fiscal policy.

[19] Some studies also analyze possible asymmetric/non-linear effects of fiscal policy. Giavazzi *et al.* (2000) stresses that non-Keynesian effects are stronger for fiscal contractions than for fiscal expansions. Besides several episodes of expansionary fiscal contractions, only one contractionary fiscal expansion episode is generally emphasized in the literature (Sweden, 1991-93). However, empirical results are still rather inconclusive.

Table 2.2 - Empirical evidence on episodes of fiscal adjustment

Reference	Sample	Measure of the structural budget	Definition of the fiscal adjustment episode	Evidence	Conditions for nk effects
Alesina and Perotti (1995)	OECD-20; 1960-1992	Blanchard fiscal impulse	Def.1: change in the CAPB exceeds 1.5 percentage points (pp) of GDP; Def.2: change in the CAPB deviates from the country average change by +/- 1 standard deviation	nk effects on investment; important labor market effect	Composition is crucial; expenditure cuts on government wage bills and welfare payments more likely to be successful; size not relevant
Giavazzi and Pagano (1996)	OECD-19; 1976-1992	OECD	Accumulated change in the CAPB is above 5, 4 and 3 pp of GDP respectively in four, three and two consecutive years or the change is of 3 pp of potential GDP in one single year	nk effects on consumption	Size and persistence more important; composition not relevant
McDermott and Westcott (1996)	OECD-20; 1970-1995	OECD and IMF	CAPB must change by at least 1.5 pp of potential GDP over two years and not decrease in either of the two years	nk effects on consumption, *via* wealth effect and, especially on investment, *via* interest rate effect	Initial public debt value is crucial; size, persistence and composition are also important
Alesina and Ardagna (1998)	most OECD countries; 1960-1994	Blanchard fiscal impulse	CAPB changes at least 2 pp of GDP in one year, or changes 1.5 pp of GDP on average in two consecutive years	nk effects on consumption and investment; both demand-driven and supply-driven effects	Composition is crucial; expenditure cuts on government wage bills and welfare payments more important; size and initial conditions not relevant
Caselli and Rinaldi (1999)	EU-15; 1980-1997	European Commission		nk effects on consumption	Composition matters; expenditure cuts rather than increasing taxes
Miller and Russek (1999)	OECD-19; 1970-1996	OECD	CAPB exceeds its mean plus one standard deviation	Some evidence of nk effects on consumption	
Perotti (1999)	OECD-19; 1965-1994	Blanchard fiscal impulse	Definition of "bad times": CAPB exceeds 4 pp of GDP (benchmark case) in the two previous years	nk effects on consumption	Critical initial fiscal conditions; composition also matters; expenditure cuts rather than increasing taxes
Zaghini (2001)	EU-14; 1970-1998	European Commission	CAPB changes above a given threshold	nk effects on consumption and on investment	Composition, persistance and initial fiscal conditions are important; size not relevant
Giavazzi *et al.* (2000)	OECD-18; 1973-1996; and developing coutries 1960-1995	OECD	CAPB changes by more than 1.5 pp of potential GDP per year over a two-year period	nk effects on consumption	Size and persistence crucial; composition also important; increasing taxes rather than expenditure cuts; initial conditions not relevant
Heylen and Everaert (2000)	OECD-19; 1975-1995	OECD	CAPB changes by at least 2 pp of GDP in two consecutive years and at least by 0.25 pp in the first year	Inconclusive	
Afonso (2001)	EU-15; 1970-1999	European Commission	CAPB changes more than one standard deviation in a single year, or annual average change is at least one half of one standard deviation in the last two years	Little evidence of nk effects on consumption	Composition is important
von Hagen *et al.* (2001)	OECD-20; 1960-1998	Cyclical adjustment based on country--specif linear-quadratic trends	CAPB changes at least 2 pp of GDP in one year, or changes 1.25 pp of GDP on average in two consecutive years	Inconclusive, although pure Keynesian until 1990	

Table 2.2 - Empirical evidence on episodes of fiscal adjustment (conclusion)

Reference	Sample	Measure of the structural budget	Definition of the fiscal adjustment episode	Evidence	Conditions for nk effects
Hjelm (2002)	OECD-19; 1970-1997	OECD	Accumulated change in the CAPB is above 5, 4 and 3 pp of GDP respectively in four, three and two consecutive years or the change is of 3 pp of potential GDP in one single year	Pure Keynesian effects	
Alesina *et al.* (2002)	OECD-18; 1960-1996	Blanchard fiscal impulse	CAPB changes at least 2 pp of GDP in one year, or changes 1.25 pp of GDP on average in two consecutive years	nk effects on investment; important labor market effect	Composition is crucial; expenditure cuts on government wage bills and welfare payments more likely to be successful
Hemming *et al.* (2002)	29 advanced economies; 1970-1999	IMF	Focus on economic recession episodes instead of episodes of fiscal adjustment	Pure Keynesian effects, although small, during recessions	
van Aarle and Garretsen (2003)	EU countries; 1990-1998	Blanchard fiscal impulse and European Commission	Eight different definitions	Inconclusive	
Ardagna (2004)	OECD-17; 1975-2002	Blanchard fiscal impulse	Benchmark model: CAPB improves and two years after is at least 3 pp of GDP higher than in the year of fiscal tightening, and at least 1.5 pp of GDP higher than in the previous year	nk effects on investment; important labor market effect	Composition is crucial; expenditure cuts on government wage bills and welfare payments more likely to be successful
Hogan (2004)	OECD-18; 1970-1999	OECD		Weak nk effects on consumption; pure Keynesian effects on output	Initial public debt is important; size not relevant
Giavazzi *et al.* (2005)	OECD-19; 1970-2004	OECD	CAPB changes by more than 1.5 pp of potential GDP per year over a two-year period	nk effects on consumption	Size and persistence are crucial; composition not relevant
Afonso (2006)	EU-15; 1970-2005	European Commission	Def.1: Alesina and Ardagna (1998); Def.2: Giavazzi and Pagano (1996); Def.3: CAPB change is at least 1.5 times the standard deviation of the overall sample in one year, or is at least one standard deviation on average in the last two years	nk effects on consumption	Initial fiscal conditions are important
Weyerstrass *et al.* (2006)	EU-14; 1970-2005			Limited evidence of nk effects on consumption	
Giudice et al. (2007)	EU-14; 1970-2002	Based on AMECO database (EC)	Def.1: Alesina and Ardagna (1998); Def.2: CAPB changes at least 3 pp of GDP over three consecutive years, and in each year the change cannot be lower than -0.5 pp of GDP	nk effects on consumption and on investment	Composition and initial public debt are important
Carmignani (2008)	22 high-income; 20 transition central and eastern european economies	OECD	Change in primary balance in one year is at least ± 1.5% of GDP	Keynesian effects on consumption in transition economies; nk effects in high--income countries but only outside normal times	Outside normal times means large fiscal contractions; size is important

NOTES: CAPB - Cyclically Adjusted Primary Balance
nk - non-Keynesian

The use of VAR for fiscal policy analysis is somehow limited by the low frequency of fiscal data and by difficulties in identifying the policy shocks, mainly for two reasons. On the one hand, private agents may anticipate the fiscal policy, due to the long time lags between its announcement and its implementation, comprising lenghty and visible budget negotiations. On the other hand, there is an automatic reaction of fiscal variables to economic activity. Hence the existence of several alternative approaches to this identification in the literature. Four main identification approaches are usually used: i) the recursive approach (Sims (1980)); ii) the event-study approach (Ramey and Shapiro (1998)); iii) the Blanchard-Quah structural VAR approach (Blanchard and Perotti (2002)); and iv) the sign-restrictions structural VAR approach (Uhlig (2005)).[20]

For the purposes of this thesis, this literature has yet two additional limitations. First, most studies − as we can see in table 2.3 − look at United States (US) data and "*the United States is an outlier in many dimensions and (...) US responses to fiscal policy are often not representative of the average OECD country (...)*" (Briotti (2005), p.17). Second, VAR studies have typically ignored the responses of different fiscal instruments to the level of public debt (Favero and Giavazzi (2007), Claeys (2008)).

The VAR-based literature has typically found that tax cuts have a much greater effect on output than government spending. In fact, it typically estimates spending positive but small fiscal multipliers (lower than one on impact and decreasing thereafter), and tax revenue multipliers relatively large and persistent (always higher than one).[21] As in the former strand of empirical literature, while the results on the relation between fiscal policy and private consumption seems uncertain (although predominantly Keynesian), a strong negative effect of public expenditures on private investment has been typically detected.[22]

Two somehow new conclusions have been brought by the most recent

[20] For more details see, for example, Perotti (2005), and for a comparative analysis see Caldara and Kamps (2008).

[21] See, for example, Blanchard and Perotti (2002) and Mountford and Uhlig (2008).

[22] See, for example, Blanchard and Perotti (2002), Burnside *et al.* (2004), Perotti (2005) and Mountford and Uhlig (2008).

studies within this literature: first, Perotti (2005), Bilbiie *et al.* (2008) and Favero and Giavazzi (2007) have found that the size of fiscal multipliers has fallen gradually after the 1980s, which indicates a " *(...) reduced cost of fiscal consolidations in the 1990s.*" (von Hagen *et al.* (2002), p.35); second, Perotti (2005) has detected that the spending fiscal multiplier may presently be negative, especially in some European countries, which corresponds to the presence of non-Keynesian effects on output.[23]

On the one hand, these findings may be explained by the relaxation of credit constraints and the increased efficiency and sophistication of financial markets, which have widened private access to asset markets, thus reducing the number of liquidity constrained households and the dependence of consumption on current disposable income. Moreover, the deregulation of financial markets and changes in the conduct of monetary policy, with more active anti-inflationary policies, seem to be responsible for a stronger response of real interest rates, which can also explain those findings. On the other hand, the need for a fiscal consolidation is, since the 1990s, clearly more visible in Europe than in the US, due to the political emphasis on consolidation materialized in the Maastricht Treaty and the Stability and Growth Pact, as well as the public debate surrounding it (von Hagen *et al.* (2002), Brunila (2002)). These public discussions have increased the awareness of the private sector in Europe of how past fiscal measures affect present and future fiscal policy, which may justify a different behavior of European agents as regards fiscal stimulus relatively to that of the US private sector, leading to lower or even negative fiscal multipliers.

Table 2.3, below, summarizes this strand of the empirical literature.

[23] In recent studies Pereira and Sagalés (2006), Ramos and Roca-Sagales (2007), Afonso and Claeys (2008) and de Castro and de Cos (2008) also found some evidence of non-Keynesian effects on output in some European countries.

Table 2.3 - Empirical evidence on the spending fiscal multipler

Reference	Sample	Results
Edelberg *et al.* (1999)	US; 1948-1996	Evidence of positive although small fiscal multiplier; Some evidence of nk effects on consumption and on residential investment
Fatás and Mihov (2001)	US; 1960-1996	Evidence of positive and larger than one fiscal multiplier
Blanchard and Perotti (2002)	US; post-WWII	Evidence of positive although small fiscal multiplier; Some evidence of nk effects on investment
Burnside *et al.* (2003)	US; post-WWII	Evidence of positive although small fiscal multiplier; Some evidence of nk effects on investment
Gali *et al*. (2005)	US; 1954-2003	Evidence of positive fiscal multiplier, that can be either close to one or larger then one
Perotti (2005)	US, UK, Australia, Germany and Canada; 1960-1980 and 1980-2000	Before 1980, evidence of positive and larger than one fiscal multiplier in US and positive but smaller fiscal multipliers in the remaining countries; After 1980, evidence of substantially weaker multipliers, being negative in Germany, UK and Canada; Some evidence of nk effects on consumption, after 1980, in Germany, UK and Canada; Some evidence of nk effects on investment in all sample, but in US only after 1980
Bilbiie *et al.* (2006)	US; 1957-1979 and 1983-2004	Evidence of positive although small fiscal multiplier; Evidence of a smaller multiplier after 1980
Pereira and Sagalés (2006)	Portugal; 1977-2004	Effects on output depends on the fiscal instrument; Evidence of Keynesian effects for both direct and indirect taxes and for public wages and public investment; Evidence of nk effects for public transfers and intermediate consumption
Favero and Giavazzi (2007)	US; 1960-2002	Evidence of positive although small fiscal multiplier; Evidence of a smaller multiplier after 1980
Ramos and Sagalés (2007)	UK; 1970-2005	Effects on output depends on the fiscal instrument; Evidence of Keynesian effects for taxes, specially direct taxation; Evidence of nk effects for public spending, specially current spending
Clayes (2008)	US; 1965-2004	Some evidence of nk effects on private consumption and output; Initial conditions are crucial (high public debt)
Afonso and Clayes (2008)	France, Germany, Portugal and Spain; 1970-2004	Some evidence of nk effects on output in France and Portugal; Keynesian effects in Germany and Spain
Caldara and Kamps (2008)	US; 1955-2006	Evidence of Keynesian effects on consumption and output
De Castro and De Cos (2008)	Spain; 1980-2004	Evidence of a short-run positive and greater than one fiscal multiplier; Evidence of a negative multiplier about four years after the fiscal shock; However, a public wage bill shocks declines output, consumption and investment after only 2 or 3 quarters
Mountford and Uhlig (2008)	US; 1955-2000	Evidence of positive, although small, government spending multiplier, on impact; Evidence of a negative multiplier about two years after the spending shock; Some evidence of nk effects on investment; Consumption response is small and only significantly different from zero on impact

Note: nk - non-Keynesian

2.3.3 Final remarks

In sum, although we have found some inconclusive and even contradictory results, four conclusions can be derived from the literature. First, the empirical relation between the fiscal policy and private consumption is ambiguous and, hence, theories of non-Keynesian effects of fiscal policy based on a consumption channel seem hard to motivate. Second, the relation of fiscal policy with private investment seems much more clear and thus the investment channel seems to be a more fruitful avenue of theoretical research. Third, the empirical evidence clearly supports the theoretical view that there are some detectable critical conditions for a fiscal consolidation to generate expansionary effects: the size and persistence of the fiscal consolidation, the initial state of public finances (high value of budget deficit-to-GDP ratio and/or debt-to-GDP ratio) and, especially, its composition in terms of fiscal instruments, with consolidations based in spending cuts leading to a higher probability of non-Keynesian effects. Finally, it seems that the probability of non-Keynesian effects of fiscal policy is larger in European countries than in the US, and that it has increased in the last two decades.

Given these conclusions, and the aim of this thesis of identifying circumstances under which non-Keynesian effects of fiscal policy might prevail over conventional effects, we have decided to explore the investment channel, looking at demand-side and at supply-side effects. Our analysis will be based on model simulations, developed within a new-Keynesian DSGE model calibrated for the Euro Area, in which we intend to mimic a spending cut fiscal consolidation. In the next chapter we provide the baseline macroeconomic model to be developed in our subsequent analysis.

3 The Baseline Macroeconomic Model

"*Recent years have witnessed the development of a new generation of New-Keynesian dynamic stochastic general equilibrium (DSGE) models (...) that appears particularly suited for evaluating the consequences of alternative macroeconomic policies*" (Coenen and Straub (2005), p.436)

Since the early 1980s, several studies have used dynamic general equilibrium (DSGE) models in order to analyze the macroeconomic effects of fiscal policy. Most of these models were variants of the neoclassical growth model with no market imperfections and have been used to analyze steady-state (or long run) impacts of different fiscal shocks.[24] The last decade has witnessed the development of new-Keynesian DSGE models, built up from explicit microeconomic foundations with inter-temporally optimizing agents but in an environment of nominal rigidities (typically sticky prices). This class of models, which is presently the most-favoured framework for policy analysis, has been extensively used for monetary policy analysis.[25] Yet, the use of new-Keynesian DSGE models for fiscal policy analysis has been far less usual, which explains the typical extreme simplicity of these models in their fiscal policy block. Recently, Smets and Wouters (2003) and Christiano *et al.* (2005) have developed a new generation of new-Keynesian DSGE models, by incorporating into the standard model various types of nominal and real frictions in an attempt to capture the high degree of persistence characterizing macroeconomic data. Following those works, and given our purposes, we will develop a version of these models that incorporates a further detailed fiscal policy block.

Our baseline model represents a closed economy with identical infinitely lived households, firms, a government and a monetary policy authority. Households form rational expectations and derive their lifetime utility from the

[24] See, for example, Barro (1980, 1989), Aiyagari *et al.* (1992) and Baxter and King (1993).

[25] For details on the standard new-Keynesian DSGE model see, for example, Clarida *et al.* (1999), McCallum and Nelson (1999) and Rotemberg and Woodford (1999).

consumption of privately produced goods as well as from leisure. In an initial stage the wage dynamics is driven by a monopolistic competitive market, on the assumption that each household provides differentiated labor inputs, thus having some monopoly power over wages, which results in an explicit wage equation and allows for the introduction of sticky nominal wages as in the Calvo model.[26] Households use their disposable income to consume, to finance new investments and to purchase government bonds.

This economy produces a single final good and a continuum of intermediate goods. The final-good sector is perfectly competitive and the final good is used for consumption and investment. There is monopolistic competition in the market for intermediate goods, with firms producing differentiated goods and thus having some monopoly power over prices, with their price-setting following a dynamics *a la* Calvo. The model assumes that the monetary authority follows a generalized Taylor rule which includes inertia in the form of interest rate smoothing. Further sources of inertia include habit formation in consumption and capital adjustment costs.

As for the government, it purchases final goods from the private sector and finances its spending requirements with lump-sum taxes and with three different types of distortionary taxes, namely over consumption, over labor income and over capital income. The model also incorporates a fiscal rule that guarantees that the debt dynamics is non-explosive.

3.1 Behavior of Decentralized Agents - Households

Households maximize an intertemporal utility function, separable in consumption (C) and labor (l), over an infinite life horizon. The function is given by:

$$\mathrm{E}_t \sum_{t=0}^{\infty} \beta^t U_t^{\theta} \left(C_t^{\theta}, l_t^{\theta} \right) \tag{1}$$

where the index θ represents a continuum of households that differ in that they supply a differentiated type of labor, β is the discount factor and U_t^{θ} is

[26] See Calvo (1983).

the following instantaneous utility function:

$$U_t^\theta = e^{\varepsilon_t^b}\left[\frac{1}{1-\sigma_c}(C_t^\theta - H_t)^{1-\sigma_c} - \frac{e^{\varepsilon_t^N}}{1+\sigma_N}(l_t^\theta)^{1+\sigma_N}\right]. \tag{2}$$

Utility depends negatively on labor supply, l_t^θ, and positively on consumption, C_t^θ, relative to a time-varying external habit variable, H_t, that is assumed to be proportional to aggregate past consumption (habit formation in consumption):

$$H_t = hC_{t-1}. \tag{3}$$

In equation (2) the parameters σ_c and σ_N represent, respectively, the coefficient of relative risk aversion of households or the inverse of the intertemporal elasticity of substitution and the inverse of the elasticity of work effort with respect to the real wage. ε_t^b and ε_t^N are two preference shocks that affect the intertemporal substitution of households and the labor supply, and that are assumed to follow a first-order autoregressive process with i.i.d.-normal error terms:

$$\varepsilon_t^b = \rho_b \varepsilon_{t-1}^b + \eta_t^b; \tag{4}$$

$$\varepsilon_t^N = \rho_N \varepsilon_{t-1}^N + \eta_t^N. \tag{5}$$

Households face an intertemporal budget constraint given by:

$$Y_t^\theta + \frac{B_t^\theta - b_t B_{t+1}^\theta}{P_t} = (1+\tau_t^c)C_t^\theta + I_t^\theta. \tag{6}$$

This constraint means that current real disposable income, Y_t^θ, and real financial wealth[27], which is hold in the form of government bonds B_t^θ, can be used for consumption, C_t^θ, (including consumption taxes τ_t^c), and investment in physical capital, I_t^θ. Government bonds are one-period securities with price

[27] P is the price level.

b_t, being $b_t B_{t+1}^{\theta}$ the current value of future holdings of government bonds[28].

Current disposable income, Y_t^{θ}, consists of the sum of labor income with the return on the real capital stock and the dividends derived from the imperfect competitive intermediate firms, Div_t^{θ}, deducted from the lump-sum taxes, T_t^{θ} and distortionary labor and capital income taxes, τ_t^n and τ_t^k:

$$Y_t^{\theta} = (1-\tau_t^n) w_t^{\theta} l_t^{\theta} + (1-\tau_t^k) r_t^k K_t^{\theta} + \delta \tau_t^k K_t^{\theta} + Div_t^{\theta} - T_t^{\theta} \tag{7}$$

where w_t^{θ} is the real wage, r_t^k the real rental price of capital services and δ is the depreciation rate. It should be noted that capital income is not fully taxed because allowance is made for depreciation (δ).

3.1.1 Consumption and savings behavior

Households maximize their objective function, given by equations (1) and (2), subject to the intertemporal budget constraint, given by equations (6) and (7):

$$\text{MAX } \mathrm{E}_t \sum_{t=0}^{\infty} \beta^t \left\{ e^{\varepsilon_t^b} \left[\frac{1}{1-\sigma_c} (C_t^{\theta} - H_t)^{1-\sigma_c} - \frac{e^{\varepsilon_t^N}}{1+\sigma_N} (l_t^{\theta})^{1+\sigma_N} \right] \right\} \tag{8}$$

subject to,

$$(1-\tau_t^n) w_t^{\theta} l_t^{\theta} + (1-\tau_t^k) r_t^k K_t^{\theta} + \delta \tau_t^k K_t^{\theta} + Div_t^{\theta} - T_t^{\theta} + \frac{B_t^{\theta} - b_t B_{t+1}^{\theta}}{P_t} = (1+\tau_t^c) C_t^{\theta} + I_t^{\theta}. \tag{9}$$

The Lagrangian of this optimization problem is,

$$L = \mathrm{E}_t \sum_{t=0}^{\infty} \beta^t \left\{ e^{\varepsilon_t^b} \left[\frac{1}{1-\sigma_c} (C_t^{\theta} - H_t)^{1-\sigma_c} - \frac{e^{\varepsilon_t^N}}{1+\sigma_N} (l_t^{\theta})^{1+\sigma_N} \right] - \right.$$

[28] As $b_t = \frac{1}{R_t}$, where R_t is the nominal interest rate on bonds, $b_t B_{t+1}^{\theta} = \frac{B_{t+1}^{\theta}}{R_t}$.

$$-\lambda_t \Bigg[(1-\tau_t^n)w_t^\theta l_t^\theta + (1-\tau_t^k)r_t^k K_t^\theta + \delta\tau_t^k K_t^\theta + Div_t^\theta - T_t^\theta + \frac{B_t^\theta - b_t B_{t+1}^\theta}{P_t} -$$

$$-(1+\tau_t^c)C_t^\theta - I_t^\theta\Big]\Big\}. \tag{10}$$

Maximization with respect to consumption and bonds holdings yields the following first-order conditions:

$$\frac{\partial L}{\partial C_t} = 0 \Longrightarrow \lambda_t = \frac{e^{\varepsilon_t^b}(C_t - H_t)^{-\sigma_c}}{1+\tau_t^c}; \tag{11}$$

$$\frac{\partial L}{\partial B_{t+1}} = 0 \Longrightarrow \mathrm{E}_t\left[-\lambda_t \frac{b_t}{P_t} + \beta\lambda_{t+1}\frac{1}{P_{t+1}}\right] = 0 \Longrightarrow \mathrm{E}_t\left[\beta\frac{\lambda_{t+1}}{\lambda_t}\frac{R_t P_t}{P_{t+1}}\right] = 1 \tag{12}$$

where $R_t = 1/b_t$ is the gross nominal rate of return on bonds and λ_t is the marginal utility of consumption.

Aggregating equations (11) and (12), and using equation (3) we have:

$$\mathrm{E}_t\left[\beta\frac{e^{\varepsilon_{t+1}^b}\frac{(C_{t+1}-hC_t)^{-\sigma_c}}{1+\tau_{t+1}^c}}{e^{\varepsilon_t^b}\frac{(C_t-hC_{t-1})^{-\sigma_c}}{1+\tau_t^c}}\frac{R_t P_t}{P_{t+1}}\right] = 1. \tag{13}$$

3.1.2 Investment and capital accumulation

Households own the capital stock which they rent out to firms at a given rental rate of r_t^k. They decide how much capital to accumulate in each period given the depreciation rate (δ) and the costs ($S(\cdot)$) of adjusting the capital stock − which, following Smets and Wouters (2003), we model as a positive function of changes in investment,[29]

$$K_t = K_{t-1}(1-\delta) + \left[1 - S\left(\frac{e^{\varepsilon_{t-1}^I} I_{t-1}}{I_{t-2}}\right)\right] I_{t-1} \tag{14}$$

[29] It is assumed that, in the steady-state, $S(\cdot)$ equals zero, and the first derivative, $S'(\cdot)$, also equals zero around the equilibrium.

where ε_t^I represents a shock to the investment cost function, which is assumed to follow a first-order autoregressive process with an i.i.d.-normal error term:

$$\varepsilon_t^I = \rho_I \varepsilon_{t-1}^I + \eta_t^I. \tag{15}$$

Households choose the capital stock and investment in order to maximize their intertemporal objective function subject to the intertemporal budget constraint, as described by (8) and (9), as well as subject to the capital accumulation equation (14).

Building the Lagrangian,

$$L = \mathrm{E}_t \sum_{t=0}^{\infty} \beta^t \left\{ e^{\varepsilon_t^b} \left[\frac{1}{1-\sigma_c} (C_t^\theta - H_t)^{1-\sigma_c} - \frac{e^{\varepsilon_t^N}}{1+\sigma_N} (l_t^\theta)^{1+\sigma_N} \right] - \right.$$

$$-\lambda_t \left[(1-\tau_t^n) w_t^\theta l_t^\theta + (1-\tau_t^k) r_t^k K_t^\theta + \delta \tau_t^k K_t^\theta + Div_t^\theta - T_t^\theta + \frac{B_t^\theta - b_t B_{t+1}^\theta}{P_t} - \right.$$

$$\left. \left. -(1+\tau_t^c) C_t^\theta - I_t^\theta - q_t \left[K_{t+1}^\theta - K_t^\theta (1-\delta) - \left[1 - S\left(\frac{e^{\varepsilon_t^I} I_t^\theta}{I_{t-1}^\theta} \right) \right] I_t^\theta \right] \right] \right\}. \tag{16}$$

The first-order conditions are the following equations for the real current value of capital stock (q_t) and investment:

$$\frac{\partial L}{\partial K_{t+1}} = 0 \Longrightarrow q_t = \mathrm{E}_t \left[\beta \frac{\lambda_{t+1}}{\lambda_t} \left[q_{t+1}(1-\delta) + (1-\tau_{t+1}^k) r_{t+1}^k + \delta \tau_{t+1}^k \right] \right]; \tag{17}$$

$$\frac{\partial L}{\partial I_t} = 0 \Longrightarrow q_t \left[1 - S\left(\frac{e^{\varepsilon_t^I} I_t}{I_{t-1}}\right)\right] = \tag{18}$$

$$= q_t S'\left(\frac{e^{\varepsilon_t^I} I_t}{I_{t-1}}\right) \frac{e^{\varepsilon_t^I} I_t}{I_{t-1}} - \mathrm{E}_t\left[\beta \frac{\lambda_{t+1}}{\lambda_t} q_{t+1} S'\left(\frac{e^{\varepsilon_{t+1}^I} I_{t+1}}{I_t}\right) \frac{e^{\varepsilon_{t+1}^I} I_{t+1}}{I_t} \frac{I_{t+1}}{I_t}\right] + 1.$$

3.1.3 Labor supply decisions and wage setting

Each household provides differentiated labor inputs, so that there is some monopoly power over wages that results in an explicit wage equation. Nominal wages are assumed to be sticky as in the Calvo model: households are allowed to optimally adjust their wage each period with a constant probability equal to $1 - \xi_w$. Each household reoptimizing his wage at a given period, will set a new wage $\widetilde{w}_t^\theta$, taking into account the probability that he will not be reoptimizing the wage in the near future. Following Smets and Wouters (2003), we augment the Calvo model with the assumption that the fraction of wages not reoptimized in a given period is partially indexed to past inflation:

$$W_t^\theta = \left(\frac{P_{t-1}}{P_{t-2}}\right)^{\gamma_w} W_{t-1}^\theta \tag{19}$$

where γ_w is the degree of wage indexation. When $\gamma_w = 0$ there is no indexation, and the wages that cannot be reoptimized remain constant; when $\gamma_w = 1$ there is perfect indexation to past inflation.

Households set their nominal wages in order to maximize their intertemporal objective function subject to the intertemporal budget constraint, as described by (8) and (9), as well as subject to the demand for labor, which is:

$$l_t^\theta = \left(\frac{W_t^\theta}{W_t}\right)^{-(1+\lambda_{w,t})/\lambda_{w,t}} N_t \tag{20}$$

where $\lambda_{w,t}$ is a stochastic parameter that determines the time-varying wage markup. It is assumed that $\lambda_{w,t} = \lambda_w + \eta_t^w$, with η_t^w i.i.d.-normal. The aggregate labor demand, N_t, and the aggregate nominal wage, W_t, are given

by the following Dixit-Stiglitz-type aggregator functions:

$$N_t = \left[\int_0^1 (l_t^\theta)^{1/(1+\lambda_{w,t})} d\theta\right]^{(1+\lambda_{w,t})}; \tag{21}$$

$$W_t = \left[\int_0^1 (W_t^\theta)^{-1/\lambda_{w,t}} d\theta\right]^{-\lambda_{w,t}}. \tag{22}$$

This maximization problem results in the following markup equation for the reoptimized wage:

$$\mathrm{E}_t \sum_{i=0}^{\infty} \beta^i \xi_w^i N_{t+i}^\theta \left[\frac{\widetilde{w}_t}{P_t}\left(\frac{\left(\frac{P_{t-1+i}}{P_{t-1}}\right)^{\gamma_w}}{\frac{P_{t+i}}{P_t}} \frac{U_{t+i}^C}{(1+\tau_{t+i}^c)}\right) - (1+\lambda_{w,t+i})\frac{U_{t+i}^l}{(1-\tau_{t+i}^n)}\right] = 0 \tag{23}$$

where U_{t+i}^C and U_{t+i}^l are, respectively, the marginal utility of consumption and the marginal disutility of labor.

Following the Calvo model, and given equations (19) and (22), the law of motion of the aggregate wage index is given by:

$$(W_t)^{-1/\lambda_{w,t}} = \xi_w \left[W_{t-1}\left(\frac{P_{t-1}}{P_{t-2}}\right)^{\gamma_w}\right]^{-1/\lambda_{w,t}} + (1-\xi_w)(\widetilde{w}_t)^{-1/\lambda_{w,t}}. \tag{24}$$

3.2 Behavior of Decentralized Agents - Firms

The model presents a closed economy that produces a single final good and a continuum of intermediate goods indexed by j, with j distributed over the unit interval $[0, 1]$. The final-good sector is perfectly competitive, and the final good is used for consumption and investment, while there is monopolistic competition in the markets for intermediate goods.

3.2.1 Final-good sector

Following Galí *et al.* (2007), the final good is assumed to be produced using the intermediate goods with the following constant returns technology:

$$Y_t = \left[\int_0^1 (y_t^j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{25}$$

where y_t^j denotes quantity of intermediate good of type j at date t and ε is the constant elasticity of substitution.

At each period, the competitive final good producer maximizes its profit:

$$\text{MAX} \left[P_t Y_t - \int_0^1 p_t^j y_t^j dj \right] \tag{26}$$

where P_t is the overall price index of the final good and p_t^j are the prices of the intermediate inputs. From (25) and (26), the demand for each intermediate input and the price index can be shown to be:

$$y_t^j = \left(\frac{p_t^j}{P_t} \right)^{-\varepsilon} Y_t; \tag{27}$$

$$P_t = \left[\int_0^1 (p_t^j)^{1-\varepsilon} dj \right]^{\frac{1}{1-\varepsilon}}. \tag{28}$$

3.2.2 Intermediate goods sector

In the intermediate goods sector each good j is produced by a firm j with the following technology:

$$y_t^j = e^{\varepsilon_t^a} K_{j,t}^{\alpha} N_{j,t}^{(1-\alpha)} \tag{29}$$

where α is a constant parameter, which can take values between 0 and 1, and can be interpreted as the percentage change in output resulting from a 1% increase in the capital output. ε_t^a is a productivity shock, assumed to follow a first-order autoregressive process with an i.i.d.-normal error term,

$$\varepsilon_t^a = \rho_a \varepsilon_{t-1}^a + \eta_t^a. \tag{30}$$

Cost minimization implies that the marginal productivities ratio equals the price of production factors ratio, thus,

$$\frac{(1-\alpha)e^{\varepsilon_t^a}K_{j,t}^{\alpha}N_{j,t}^{-\alpha}}{\alpha e^{\varepsilon_t^a}K_{j,t}^{\alpha-1}N_{j,t}^{(1-\alpha)}} = \frac{w_t}{r_t^k} \Longrightarrow \frac{w_t N_{j,t}}{r_t^k K_{j,t}} = \frac{1-\alpha}{\alpha} \tag{31}$$

which implies that the capital-labor ratio will be identical across all intermediate good producers and equal to the aggregate capital-labor ratio.

With the total costs given by,

$$TC_t = w_t N_t + r_t^k K_t \tag{32}$$

and given that, from equation (29),

$$N_t = \left(\frac{Y_t}{e^{\varepsilon_t^a}K_t^{\alpha}}\right)^{\frac{1}{(1-\alpha)}} \tag{33}$$

the firms' marginal costs (MC_t) are given by,

$$MC_t = \left.\frac{\partial TC_t}{\partial Y_t}\right|_{K_t \text{ fixed}} = \frac{\partial TC_t}{\partial N_t}\frac{\partial N_t}{\partial Y_t} = \frac{1}{e^{\varepsilon_t^a}} w_t^{(1-\alpha)} r_t^{k^{\alpha}} \alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)} \tag{34}$$

which implies that the marginal costs are also independent of the intermediate good produced. Real profits of firm j are then given by:

$$profit_t^j = \left(\frac{p_t^j}{P_t} - MC_t\right) y_t^j = \left(\frac{p_t^j}{P_t} - MC_t\right)\left(\frac{p_t^j}{P_t}\right)^{-\varepsilon} Y_t. \tag{35}$$

3.2.3 Price setting

Each firm produces a differentiated intermediate good and thus has some monopoly power over prices. Nominal prices are sticky, by assumption, and their dynamics is modelled as in the Calvo model, *i.e.*, firms are allowed to optimally adjust their prices each period with a constant probability equal to $1-\xi_p$. In setting the new price, $\widetilde{p}_t^j$, the reoptimizing firms take into account the probability that it will not reoptimize in the near future. Following Smets and Wouters (2003), the Calvo model is augmented with the assumption that prices that are not reoptimized in a given period are partially indexed to past inflation:

$$p_t^j = \left(\frac{P_{t-1}}{P_{t-2}}\right)^{\gamma_p} p_{t-1}^j \tag{36}$$

where γ_p is the degree of price indexation. When $\gamma_p = 0$ there is no indexation, and the prices that cannot be reoptimized remain constant. When $\gamma_p = 1$ there is perfect indexation to past inflation.

A firm resetting its price in period t will seek to maximize the discounted sum of future profits (given by equation (35)), using the relevant stochastic discount factor $\Lambda_{t,t+i}$,

$$\text{MAX}_{\widetilde{p}_t^j} \; \text{E}_t \sum_{i=0}^{\infty} \left\{ \xi_p^i \Lambda_{t,t+i} \left[\left(\frac{\widetilde{p}_t^j}{P_{t+i}} - MC_{t+i} \right) y_{t+i}^j \right] \right\}. \tag{37}$$

Given equation (36), profit maximization by the producers that reoptimize their prices at time t results in the following first-order condition:

$$\text{E}_t \sum_{i=0}^{\infty} \left\{ \xi_p^i \Lambda_{t,t+i} y_{t+i}^j \left[\frac{\widetilde{p}_t^j}{P_t} \left(\frac{\left(\frac{P_{t-1+i}}{P_{t-1}}\right)^{\gamma_p}}{\frac{P_{t+i}}{P_t}} \right) - \mu \; MC_{t+i} \right] \right\} = 0 \tag{38}$$

which shows that prices are set as a function of current and expected real marginal costs, with a markup μ over these weighted marginal costs. The gross "frictionless" price markup is,

$$\mu = \frac{\varepsilon}{\varepsilon - 1}. \tag{39}$$

Following the Calvo model, and given equations (28) and (36), the law of motion of the aggregate price index is given by:

$$P_t^{(1-\varepsilon)} = \xi_p \left[P_{t-1} \left(\frac{P_{t-1}}{P_{t-2}} \right)^{\gamma_p} \right]^{(1-\varepsilon)} + (1 - \xi_p)(\widetilde{p}_t^j)^{(1-\varepsilon)}. \tag{40}$$

3.3 Centralized Behavior - The Monetary Authority and the Government

3.3.1 Monetary policy

The monetary authority sets the nominal interest rate according to a simple rule which includes inertia in the form of interest rate smoothing:

$$R_t = R_{t-1}^{\rho} \left[\left(\frac{P_t}{P_{t-1}} \right)^{\Phi_\pi} \right]^{1-\rho} \tag{41}$$

with $\Phi_\pi > 1$.

Following Bilbiie and Straub (2004), Bilbiie *et al.* (2008), Galí *et al.* (2007) and Pappa (2009), among others, our monetary policy-maker follows a simple interest rate rule corresponding to a strict inflation targeting regime – a particular case of the well-known Taylor rule[30], placing a zero coefficient on the output gap. It should be noted that this kind of rule is said to satisfy the Taylor principle if and only if $\Phi_\pi > 1$, which is, in the absence of non-Ricardian consumers, a necessary and sufficient condition to guarantee the uniqueness of equilibrium in this class of models.

We model the monetary policy-maker reacting purely to deviations of inflation from the target, and not to fluctuations in the output gap, for two main reasons. First, as we intend to isolate possible "purely fiscal" non-Keynesian effects of a fiscal consolidation, we purposely assume the simplest possible monetary framework; in fact, alternative frameworks including output or the output gap in the interest rate rule may suggest lower (higher) Keynesian (non-Keynesian) effects because of the immediate interest rate response to the initial decrease in output. Second, as we are calibrating the model to the Euro Area case, our policy rule seems more in line with the legal mandate of the European Central Bank (ECB) – maintaining price stability in the medium-to-long-run – and is further justified by the apparent lack of consensus on the relevance of the output gap in the actual preferences and reactions of the ECB.[31]

[30] Taylor (1993).

[31] See, for example, Aguiar and Martins (2005).

3.3.2 Fiscal policy

The fiscal authority purchases consumption goods (G_t), collects four types of taxes − lump-sum taxes (T_t) and distortionary taxes, over consumption (τ_t^c), labor income (τ_t^n) and capital income (τ_t^k) − and issues debt (B_{t+1}), which consists of one-period nominal discounted bonds, paying 1 unit at the beginning of next period. The government budget constraint is,

$$G_t + \frac{B_t}{P_t} = T_t + \frac{B_{t+1}}{P_t} b_t + \tau_t^n w_t N_t + \tau_t^k r_t^k K_t - \delta \tau_t^k K_t + \tau_t^c C_t. \tag{42}$$

It should be noted that we will assume that all tax rates evolve exogenously according to a first order autoregressive process with an i.i.d.-normal error term,

$$\widehat{\tau}_t^c = \rho_{\tau^c} \widehat{\tau}_{t-1}^c + \eta_t^{\tau^c}, \tag{43}$$

$$\widehat{\tau}_t^n = \rho_{\tau^n} \widehat{\tau}_{t-1}^n + \eta_t^{\tau^n}, \tag{44}$$

$$\widehat{\tau}_t^k = \rho_{\tau^k} \widehat{\tau}_{t-1}^k + \eta_t^{\tau^k}, \tag{45}$$

with,[32]

$$\widehat{\tau}_t^c = \frac{\tau_t^c - \overline{\tau}_t^c}{\overline{\tau}_t^c} \ , \ \widehat{\tau}_t^n = \frac{\tau_t^n - \overline{\tau}_t^n}{\overline{\tau}_t^n} \text{ and } \widehat{\tau}_t^k = \frac{\tau_t^k - \overline{\tau}_t^k}{\overline{\tau}_t^k}.$$

Letting $\widehat{G}_t$, $\widehat{T}_t$ and $\widehat{B}_t$ be the log-linear counterparts of the fiscal variables, that is,

$$\widehat{G}_t = \frac{G_t - \overline{G}}{\overline{G}}, \ \widehat{T}_t = \frac{T_t - \overline{T}}{\overline{T}} \ \text{ and } \ \widehat{B}_t = \frac{\frac{B_t}{P_t} - \frac{\overline{B}}{\overline{P}}}{\frac{\overline{B}}{\overline{P}}}$$

and following Bilbiie and Straub (2004) and Galí *et al.* (2007), we assume a fiscal policy rule of the form,

[32] In what follows, the − above a variable denotes its steady-state value.

$$\widehat{T}_t = \phi_b \widehat{B}_t + \phi_g \widehat{G}_t \tag{46}$$

where ϕ_b and ϕ_g are positive constants representing the elasticities of lump-sum taxes with respect to government debt and government spending, respectively. Under this fiscal rule, a necessary and sufficient condition for non-explosive debt dynamics is given by,

$$\beta^{-1}(1 - \phi_b) < 1.^{33} \tag{47}$$

Finally, government spending is assumed to evolve exogenously according to a first order autoregressive process with an i.i.d.-normal error term,

$$\widehat{G}_t = \varepsilon_t^g = \rho_g \varepsilon_{t-1}^g + \eta_t^g. \tag{48}$$

3.4 Market Clearing and the Final Model

3.4.1 Market clearing

The final good market is in equilibrium if production equals demand by households, for consumption and investment, and by government:

$$Y_t = C_t + I_t + G_t. \tag{49}$$

The capital rental market is in equilibrium when the demand for capital by the intermediate goods producers equals the supply by the households, and the labor market is in equilibrium if firms' demand for labor equals labor supply at the wage level set by households. Finally, the capital market equilibrium means that the government debt is held by domestic investors at the market interest rate R_t.

3.4.2 The Final Model

In summary, the baseline model has fourteen equations: six for the households' behavior − (13), (14), (17), (18), (23) and (24) −, four for the firms'

[33] For more details see Galí *et al.* (2007).

behavior − (29), (31), (38) and (40) −, one for the monetary authority's behavior − (41) −, two for the government's behavior − (42) and (46) − and one market clearing equation − (49).

3.5 Linearization of the Baseline Model

In order to solve the model with the method of undetermined coefficients suggested by McCallum (1998) and the generalized Schur decomposition suggested by Klein (2000), both based on the seminal work by Blanchard and Kahn (1980) for linear rational expectations models, it is necessary to linearize the model's equations around the nonstochastic steady state. In this section we present the main steps of the linearization process leading to the full set of linear rational expectations equations. In what follows, and as previously used, a variable with a hat denotes its log deviation from steady-state. The full linearization process is available upon request.

Consumption equation The consumption equation results from the linearization of equation (13). By this equation we can conclude that in the steady state,

$$\overline{R} = \frac{1}{\beta}. \tag{50}$$

Using a first order Taylor approximation, equation (13) is transformed into,

$$\mathrm{E}_t \left[\varepsilon^b_{t+1} - \varepsilon^b_t - \frac{\sigma_c}{1-h}\widehat{C}_{t+1} + \frac{\sigma_c(1+h)}{1-h}\widehat{C}_t - \frac{h\sigma_c}{1-h}\widehat{C}_{t-1} + \widehat{R}_t + \widehat{P}_t - \widehat{P}_{t+1} \right.$$

$$\left. + \frac{\overline{\tau}^c}{1+\overline{\tau}^c}\widehat{\tau}^c_t - \frac{\overline{\tau}^c}{1+\overline{\tau}^c}\widehat{\tau}^c_{t+1} \right] = 0. \tag{51}$$

Denoting by $\widehat{\pi}_{t+1} = \left(\widehat{P}_{t+1} - \widehat{P}_t\right)$ the inflation at time $t+1$, equation (51) can be written as,[34]

[34]Note that with ε^b_t an exogenous shock defined by equation (4), $\mathrm{E}_t\varepsilon^b_{t+1} = \rho_b\varepsilon^b_t$ (because

$$\begin{aligned}\widehat{C}_t &= \frac{1}{1+h}\mathrm{E}_t\widehat{C}_{t+1} + \frac{h}{1+h}\widehat{C}_{t-1} - \frac{1-h}{\sigma_c(1+h)}\left(\widehat{R}_t - \mathrm{E}_t\widehat{\pi}_{t+1}\right) \\ &\quad -\frac{(1-h)\overline{\tau}^c(1-\rho_{\tau^c})}{\sigma_c(1+h)(1+\overline{\tau}^c)}\widehat{\tau}^c_t + \frac{(1-h)(1-\rho_b)}{\sigma_c(1+h)}\varepsilon^b_t. \qquad (52)\end{aligned}$$

Thus, current consumption depends (i) positively on a weighted average of past and expected future consumption, with the corresponding elasticity depending on the habit persistence parameter (h); and (ii) negatively on the ex-ante real interest rate, with the interest rate elasticity of consumption depending on the habit persistence parameter and on the inverse of the intertemporal elasticity of substitution (σ_c). Preferences shocks have also a positive impact on current consumption and, as expected, the consumption tax shock has a negative impact.

Investment equation The investment equation results from the linearization of equation (18). Knowing that in the steady state $S(\cdot) = S'(\cdot) = 0$ (see footnote 29, above), then,

$$\overline{q} = 1. \qquad (53)$$

Using the first order Taylor approximation, equation (18) is transformed into,

$$\begin{aligned}&\mathrm{E}_t\Big\{S'(\cdot)\,\widehat{q}_t + \beta S'(\cdot)\,\widehat{q}_{t+1} + [(1+\beta)S''(\cdot) + (1+\beta)S'(\cdot)]\,\widehat{I}_t \\ &+ [S'(\cdot) - S''(\cdot)]\,\widehat{I}_{t-1} - \beta\,[S'(\cdot) + S''(\cdot)]\,\widehat{I}_{t+1} + [S'(\cdot) + S''(\cdot)]\,\varepsilon^I_t \\ &-\beta\,[S'(\cdot) + S''(\cdot)]\,\varepsilon^I_{t+1}\Big\} = [1 - S(\cdot)]\,\widehat{q}_t \qquad (54)\end{aligned}$$

which is equivalent to,

$\mathrm{E}_t\eta^b_{t+1} = 0$). Then $\varepsilon^b_t - \mathrm{E}_t\varepsilon^b_{t+1} = (1-\rho_b)\varepsilon^b_t > 0$. The same applies to the consumption tax shock, thus $\mathrm{E}_t\widehat{\tau}^c_{t+1} - \widehat{\tau}^c_t = (\rho_{\tau^c} - 1)\widehat{\tau}^c_t < 0$.

$$(1+\beta)S''(\cdot)\widehat{I}_t+S''(\cdot)\widehat{I}_{t-1}-\beta S''(\cdot)\,\mathrm{E}_t\widehat{I}_{t+1}+S''(\cdot)\,\varepsilon_t^I-\beta S''(\cdot)\,\mathrm{E}_t\varepsilon_{t+1}^I=\widehat{q}_t \quad (55)$$

and rearranging,

$$\widehat{I}_t=\frac{1}{1+\beta}\widehat{I}_{t-1}+\frac{\beta}{1+\beta}\mathrm{E}_t\widehat{I}_{t+1}+\frac{\varphi}{(1+\beta)}\widehat{q}_t-\frac{(1-\beta\rho_I)}{1+\beta}\varepsilon_t^I \qquad (56)$$

where $\varphi=1/S''(\cdot)$.

Thus, current investment depends positively (i) on past and expected future investment, with elasticities that depend on the rate of time preference β, and (ii) on the value of installed capital, with an elasticity that is a function of β and φ, a parameter summarizing the investment adjustment costs. A positive shock to the adjustment cost function temporarily reduces investment.

Value of capital stock equation The value of capital stock equation results from the linearization of equation (17). Rearranging equation (12) we have,

$$\mathrm{E}_t\left(\beta\frac{\lambda_{t+1}}{\lambda_t}\right)=\mathrm{E}_t\left(\frac{P_{t+1}}{R_tP_t}\right). \qquad (57)$$

Substituting into equation (17),

$$q_t=\mathrm{E}_t\left[\frac{P_{t+1}}{R_tP_t}\left[q_{t+1}(1-\delta)+(1-\tau_{t+1}^k)r_{t+1}^k+\delta\tau_{t+1}^k\right]\right]. \qquad (58)$$

Using the first order Taylor approximation, and rearranging,

$$\begin{aligned}\widehat{q}_t &= \beta(1-\delta)\mathrm{E}_t\widehat{q}_{t+1}-\left(\widehat{R}_t-\mathrm{E}_t\widehat{\pi}_{t+1}\right)+\beta(1-\overline{\tau}^k)\overline{r}^k\mathrm{E}_t\widehat{r}_{t+1}^k\\ &\quad+\rho_{\tau^k}(\delta-\beta\overline{r}^k)\overline{\tau}^k\widehat{\tau}_t^k+\eta_t^q. \qquad (59)\end{aligned}$$

It is easy to conclude that, around the steady-state,

$$\overline{r}^k = \frac{\frac{1}{\beta} - \delta\overline{\tau}^k + \delta - 1}{1 - \overline{\tau}^k}. \tag{60}$$

Thus, the current value of the capital stock depends positively on its expected future value and on the expected rental rate, and negatively on the ex-ante real interest rate. As expected, it depends negatively on the capital income tax rate as $(\delta - \beta\overline{r}^k)$ is always negative.[35] In equation (59) we have considered an equity premium shock (η_t^q) that affects positively the value of installed capital, which is meant to capture changes in the cost of capital that may be due to stochastic variations in the external finance premium, and is assumed to follow an i.i.d.-normal process.

Capital accumulation equation The capital accumulation equation results from the linearization of equation (14). Around the steady state,

$$\overline{K} = (1-\delta)\overline{K} + [1 - S(\cdot)]\,\overline{I} \Leftrightarrow \overline{I} = \delta\overline{K}. \tag{61}$$

Using the first order Taylor approximation in order to linearize equation (14),

$$\widehat{K}_t = (1-\tau)\widehat{K}_{t-1} + [1 - S(\cdot) - S'(\cdot)]\frac{\overline{I}}{\overline{K}}\widehat{I}_t + S'(\cdot)\frac{\overline{I}}{\overline{K}}\widehat{I}_{t-1} - \frac{S'(\cdot)}{\overline{K}}\varepsilon_t^I. \tag{62}$$

Rearranging and using equation (61), we obtain:

$$\widehat{K}_t = (1-\delta)\widehat{K}_{t-1} + \frac{\overline{I}}{\overline{K}}\widehat{I}_{t-1} \Leftrightarrow \widehat{K}_t = (1-\delta)\widehat{K}_{t-1} + \delta\widehat{I}_{t-1}. \tag{63}$$

Inflation equation The inflation equation derives from the linearization and aggregation of equations (38) and (40). Since this linearization involves some burdensome mathematical work, we have decided to present the main steps in appendix (appendix A.1). The final linearized equation can be ex-

[35] It can be easily be proven that, $(\delta - \beta\overline{r}^k) = \frac{(1-\beta)\left[\delta\left(1-\overline{\tau}^k\right)-1\right]}{1-\overline{\tau}^k} < 0$.

pressed as:

$$\begin{aligned}\widehat{\pi}_t &= \frac{\gamma_p}{1+\beta\gamma_p}\widehat{\pi}_{t-1} + \frac{\beta}{1+\beta\gamma_p}\mathrm{E}_t\widehat{\pi}_{t+1} + \\ &+ \frac{(1-\beta\xi_p)(1-\xi_p)}{\left(1+\beta\gamma_p\right)\xi_p}\left[(1-\alpha)\widehat{w}_t + \alpha\widehat{r}_t^k - \varepsilon_t^a\right] + \eta_t^p. \end{aligned} \tag{64}$$

Current inflation depends positively on past and expected future inflation and on current real marginal costs, which are a positive function of real wages and the rental cost of capital. The elasticity with respect to changes in past inflation is essentially dependent on the degree of price indexation (γ_p) while the elasticity with respect to changes in marginal costs depends crucially on the degree of price stickiness (ξ_p). The productivity process (ε_t^a) impacts negatively on inflation. Following Smets and Wouters (2003), we have introduced a "cost push" shock (η_t^p) into the inflation equation (64), which affects positively the price markup, and thus inflation. This shock is assumed to follow an i.i.d.-normal process.

Real wage equation The real wage equation derives from the linearization and aggregation of equations (23) and (24). Once more the main steps of the linearization process are presented in appendix (appendix A.2). The final linearized equation can be expressed as:

$$\begin{aligned}\widehat{w}_t &= \frac{\beta}{1+\beta}\mathrm{E}_t\widehat{w}_{t+1} + \frac{1}{1+\beta}\widehat{w}_{t-1} + \frac{\beta}{1+\beta}\mathrm{E}_t\widehat{\pi}_{t+1} - \frac{1+\beta\gamma_w}{1+\beta}\widehat{\pi}_t \\ &+ \frac{\gamma_w}{1+\beta}\widehat{\pi}_{t-1} - \frac{(1-\beta\xi_w)(1-\xi_w)}{(1+\beta)\,\xi_w\left(1+\frac{(1+\lambda_w)\sigma_N}{\lambda_w}\right)} \times \\ &\times \left[\widehat{w}_t - \sigma_N\widehat{N}_t - \frac{\sigma_c}{1-h}(\widehat{C}_t - h\widehat{C}_{t-1}) - \frac{\overline{\tau}^c}{1+\overline{\tau}^c}\widehat{\tau}_t^c - \frac{\overline{\tau}^n}{1-\overline{\tau}^n}\widehat{\tau}_t^n - \widehat{\varepsilon}_t^N\right] + \eta_t^w. \end{aligned} \tag{65}$$

The real wage is (i) positively related to past and future expected real wage, past and future expected inflation, labor demand, current consumption and tax rates (consumption and labor income); and (ii) negatively related to current inflation and past consumption. The elasticities of real wage with

respect to inflation are dependent on the degree of indexation of the non-optimized wages (γ_w). In turn, the elasticities with respect to labor demand and consumption are intrinsically related to the degree of wage stickiness (ξ_w). There is also a positive effect on the current real wage from a labor supply preference shock ($\widehat{\varepsilon}_t^N$). We have introduced a shock to the wage markup (η_t^w) that affects positively the real wage, which is assumed to follow an i.i.d.-normal process.

Labor demand function The labor demand function results from the linearization of equation (31), which has been derived from firms' cost minimization for a given installed capital stock. Rearranging equation (31),

$$\frac{w_t N_t}{r_t^k K_t} = \frac{1-\alpha}{\alpha} \Longleftrightarrow N_t = \frac{(1-\alpha)\, r_t^k K_t}{\alpha w_t}. \tag{66}$$

Linearizing around the steady state,

$$\widehat{N}_t = -\widehat{w}_t + \widehat{r}_t^k + \widehat{K}_t. \tag{67}$$

Labor demand depends negatively on the real wage, with a unit elasticity, and positively on the real rental price of capital and on the capital stock.

Production function The production function is deduced from the linearization of equation (29), from which we get:

$$\widehat{Y}_t = \varepsilon_t^a + \alpha \widehat{K}_t + (1-\alpha)\widehat{N}_t. \tag{68}$$

Monetary policy rule The model assumes that the monetary authority follows a simple interest rate rule as expressed by equation (41). If we linearize that equation around the steady-state we get,

$$\widehat{R}_t = \rho \widehat{R}_{t-1} + (1-\rho)\phi_\pi \widehat{\pi}_t + \eta_t^R. \tag{69}$$

The interest rate reacts to current inflation but exhibits persistence, with a degree of smoothing ρ. It is also assumed that there is a monetary policy shock which is a temporary i.i.d. normal interest rate shock (η_t^R).

Government budget constraint and fiscal policy rule Linearization of the government budget constraint (equation (42)) around a steady-state yields,

$$\begin{aligned}\widehat{B}_t &= \frac{1}{\beta}\widehat{B}_{t-1} + \frac{1}{\beta}\frac{\gamma_g}{\gamma_b}\widehat{G}_t - \frac{1}{\beta}\frac{\gamma_t}{\gamma_b}\widehat{T}_t + \widehat{R}_t - \frac{1}{\beta}\frac{\gamma_{wn}\overline{\tau}^n}{\gamma_b}(\widehat{\tau}_t^n + \widehat{w}_t + \widehat{N}_t) \\ &\quad -\frac{1}{\beta}\frac{\gamma_k\overline{\tau}^k\overline{r}^k}{\gamma_b}\widehat{r}_t^k - \frac{1}{\beta}\frac{\gamma_k\overline{\tau}^k(\overline{r}^k-\delta)}{\gamma_b}(\widehat{\tau}_t^k + \widehat{K}_t) - \frac{1}{\beta}\frac{\gamma_c\overline{\tau}^c}{\gamma_b}(\widehat{\tau}_t^c + \widehat{C}_t) \quad (70)\end{aligned}$$

where, $\gamma_g = \frac{\overline{G}}{\overline{Y}}$, $\gamma_t = \frac{\overline{T}}{\overline{Y}}$, $\gamma_b = \frac{\frac{\overline{B}}{\overline{P}}}{\overline{Y}}$, $\gamma_{wn} = \frac{\overline{wN}}{\overline{Y}}$, $\gamma_k = \frac{\overline{K}}{\overline{Y}}$ and $\gamma_c = \frac{\overline{C}}{\overline{Y}}$.

As expected, debt depends positively on government spending and on the debt service (past debt and real interest rate), and negatively on taxes.

As regards fiscal policy, recall that we have allowed a fiscal policy rule of the form,

$$\widehat{T}_t = \phi_b\widehat{B}_t + \phi_g\widehat{G}_t. \quad (71)$$

Goods market equilibrium condition The goods market equilibrium condition results from the linearization of equation (49). Knowing that in the steady state,

$$\overline{Y} = \overline{C} + \overline{I} + \overline{G} \Longrightarrow \frac{\overline{C}}{\overline{Y}} = 1 - \frac{\overline{I}}{\overline{Y}} - \frac{\overline{G}}{\overline{Y}} \Longrightarrow \gamma_c = 1 - \gamma_i - \gamma_g \quad (72)$$

since, from equation (61), $\gamma_i = \delta\gamma_k$, then,

$$\gamma_c = 1 - \delta\gamma_k - \gamma_g. \quad (73)$$

Applying the first order Taylor approximation to equation (49) and using the result in (72), we obtain:

$$\widehat{Y}_t = \left(1 - \delta\gamma_k - \gamma_g\right)\widehat{C}_t + \delta\gamma_k\widehat{I}_t + \gamma_g\widehat{G}_t. \quad (74)$$

3.6 Calibrating and Solving the Model

3.6.1 Solving the model

In summary, after the linearization process the model has twelve equations and twelve endogenous variables: consumption, interest rate, inflation, investment, real current value of capital stock, rental rate of capital, capital stock, real wage, labor demand, output, government bonds and lump-sum taxes. The equations are (52), (56), (59), (63), (64), (65), (67), (68), (69), (70), (71) and (74). The stochastic behavior of the model is driven by twelve exogenous shock variables: four shocks arising from technology and preferences (ε^b, ε^I, $\varepsilon^a$and ε^N), three "cost-push" shocks (η^Q, η^p and η^w), a monetary policy shock (η^R) and four fiscal policy shocks ($\widehat{G}_t$, $\widehat{\tau}_t^c$, $\widehat{\tau}_t^n$ and $\widehat{\tau}_t^k$).

Hence, our baseline model is now ready to be solved. In order to apply Blanchard and Kahn (1980) method, the model must be written in the state-space form:

$$A\mathrm{E}_t(X_{t+1}) = BX_t + CZ_t; \tag{75}$$

$$Z_t = \rho_Z Z_{t-1} + \eta_t^Z \quad , \quad \mathrm{E}_t\eta_{t+1}^Z = 0 \tag{76}$$

where X_t is a $[(n+k)\times 1]$ vector of endogenous variables, consisting of a $(n\times 1)$ vector of non-predetermined variables in time t and a $(k\times 1)$ vector of predetermined variables in t, Z_t is a $(z\times 1)$ vector of exogenous variables, and A, B and C are coefficient matrixes.

Compliance of our model with this structure implied rewriting its equations as follows:

Consumption equation:

$$\frac{1}{1+h}\mathrm{E}_t\widehat{C}_{t+1}+\frac{1-h}{\sigma_c(1+h)}\mathrm{E}_t\widehat{\pi}_{t+1}=\widehat{C}_t-\frac{h}{1+h}\widehat{C}_{t-1}+\frac{1-h}{\sigma_c(1+h)}\widehat{R}_t+$$
$$+\frac{(1-h)\overline{\tau}^c(1-\rho_{\tau^c})}{\sigma_c(1+h)(1+\overline{\tau}^c)}\widehat{\tau}^c_t-\frac{(1-h)(1-\rho_b)}{\sigma_c(1+h)}\varepsilon^b_t$$

Investment equation:

$$\frac{\beta}{1+\beta}\mathrm{E}_t\widehat{I}_{t+1}=\widehat{I}_t-\frac{1}{1+\beta}\widehat{I}_{t-1}-\frac{\varphi}{(1+\beta)}\widehat{q}_t+\frac{(1-\beta\rho_I)}{1+\beta}\varepsilon^I_t$$

Value of capital stock equation:

$$\beta(1-\delta)\mathrm{E}_t\widehat{q}_{t+1}+\mathrm{E}_t\widehat{\pi}_{t+1}+\beta(1-\overline{\tau}^k)\overline{r}^k\mathrm{E}_t\widehat{r}^k_{t+1}=\widehat{q}_t+\widehat{R}_t-$$
$$-\rho_{\tau^k}(\delta-\beta\overline{r}^k)\overline{\tau}^k\widehat{\tau}^k_t-\eta^q_t$$

Capital accumulation equation:

$$0=\widehat{K}_t-(1-\delta)\widehat{K}_{t-1}-\delta\widehat{I}_t$$

Inflation equation:

$$\frac{\beta}{1+\beta\gamma_p}\mathrm{E}_t\widehat{\pi}_{t+1}=\widehat{\pi}_t-\frac{\gamma_p}{1+\beta\gamma_p}\widehat{\pi}_{t-1}-\alpha\mu_p\widehat{r}^k_t-(1-\alpha)\mu_p\widehat{w}_t+\mu_p\varepsilon^a_t-\eta^p_t$$
$$\text{where,}\quad \mu_p=\frac{(1-\beta\xi_p)(1-\xi_p)}{\left(1+\beta\gamma_p\right)\xi_p}$$

Real wage equation (monopolistic competition in labor market):

$$\frac{\beta}{1+\beta}\mathrm{E}_t\widehat{w}_{t+1}+\frac{\beta}{1+\beta}\mathrm{E}_t\widehat{\pi}_{t+1}=\left[1+\frac{\mu_w}{1+mk_w\sigma_N}\right]\widehat{w}_t-\frac{1}{1+\beta}\widehat{w}_{t-1}+\frac{1+\beta\gamma_w}{1+\beta}\widehat{\pi}_t$$
$$-\frac{\gamma_w}{1+\beta}\widehat{\pi}_{t-1}-\frac{\mu_w\sigma_N}{1+mk_w\sigma_N}\widehat{N}_t-\frac{\mu_w\sigma_c}{(1+mk_w\sigma_N)(1-h)}\widehat{C}_t+$$
$$+\frac{\mu_w\sigma_c h}{(1+mk_w\sigma_N)(1-h)}\widehat{C}_{t-1}-\frac{\mu_w}{1+mk_w\sigma_N}\varepsilon^N_t-$$
$$-\frac{\mu_w}{1+mk_w\sigma_N}\frac{\overline{\tau}^c}{1+\overline{\tau}^c}\widehat{\tau}^c_t-\frac{\mu_w}{1+mk_w\sigma_N}\frac{\overline{\tau}^n}{1-\overline{\tau}^n}\widehat{\tau}^n_t-\eta^w_t$$
$$\text{where,}\quad \mu_w=\frac{(1-\beta\xi_w)(1-\xi_w)}{(1+\beta)\xi_w}\quad\text{and}\quad mk_w=\frac{1+\lambda_w}{\lambda_w}$$

Labor demand function:

$$0=\widehat{N}_t+\widehat{w}_t-\widehat{r}^k_t-\widehat{K}_t$$

Production function:

$$0=\widehat{Y}_t-\alpha\widehat{K}_t-(1-\alpha)\widehat{N}_t-\varepsilon^a_t$$

Monetary policy reaction function:

$$0=\widehat{R}_t-\rho\widehat{R}_{t-1}-(1-\rho)\phi_\pi\widehat{\pi}_t-\eta^R_t$$

Government budget constraint:

$$0=\widehat{B}_t-\frac{1}{\beta}\widehat{B}_{t-1}+\frac{1}{\beta}\frac{\gamma_t}{\gamma_b}\widehat{T}_t-\widehat{R}_t+\frac{1}{\beta}\frac{\gamma_{wn}\overline{\tau}^n}{\gamma_b}\widehat{N}_t+\frac{1}{\beta}\frac{\gamma_{wn}\overline{\tau}^n}{\gamma_b}\widehat{w}_t+$$
$$+\frac{1}{\beta}\frac{\gamma_k\overline{\tau}^k\overline{r}^k}{\gamma_b}\widehat{r}^k_t-\frac{1}{\beta}\frac{\gamma_k\overline{\tau}^k(\delta-\overline{r}^k)}{\gamma_b}\widehat{K}_t+\frac{1}{\beta}\frac{\gamma_c\overline{\tau}^c}{\gamma_b}\widehat{C}_t-$$
$$-\frac{1}{\beta}\frac{\gamma_k\overline{\tau}^k(\delta-\overline{r}^k)}{\gamma_b}\widehat{\tau}^k_t+\frac{1}{\beta}\frac{\gamma_c\overline{\tau}^c}{\gamma_b}\widehat{\tau}^c_t+\frac{1}{\beta}\frac{\gamma_{wn}\overline{\tau}^n}{\gamma_b}\widehat{\tau}^n_t-\frac{1}{\beta}\frac{\gamma_g}{\gamma_b}\widehat{G}_t$$

`Fiscal policy rule:` $$0 = \widehat{T}_t - \phi_b \widehat{B}_t - \phi_g \widehat{G}_t$$
`Goods market equilibrium condition:` $$0 = \widehat{Y}_t - \left(1 - \delta\gamma_k - \gamma_g\right) \widehat{C}_t - \delta\gamma_k \widehat{I}_t - \gamma_g \widehat{G}_t$$

3.6.2 Calibrating the Model

This section presents the numerical values assigned to the parameters of the linearized baseline model. Each period is assumed to correspond to a quarter. Since our baseline model has been built upon Smets and Wouters (2003), with parameter values estimated for the Euro Area, we closely follow, when possible, their values.

We use Smets and Wouters (2003) values throughout concerning (i) the preferences and technology parameters and (ii) the inertia and price and wage setting parameters:

(i) regarding the preferences and technology parameters, the discount factor (β) is calibrated to 0.99 implying a annual steady-state real interest rate of 4%; the depreciation rate (δ) is set to 0.025 (10% annual); the capital share (α) is equal to 0.3 (which implies a labor share of 0.7); and the inverse elasticity of substitution (σ_c) and of work effort (σ_N) are 1 and 2, respectively;

(ii) as for the inertia and price and wage setting parameters we have calibrated both the degree of price indexation (γ_p) and the degree of real wage indexation (γ_w) as 0.75; also the Calvo parameter on prices (ξ_p) and the Calvo parameter on wages (ξ_w) are both set to 0.75 in the baseline calibration; and the inertia parameters related with investment adjustment costs (φ) and consumption habit (h) are set to 4 and 0.7, respectively.

A difference between our parameter values and those used by Smets and Wouters (2003) concerns the steady-state values of the wage markup (λ_w) and of the price markup (μ). Smets and Wouters (2003) set those values equal to 1.5, by increasing the values estimated by Griffin (1996) for the United States. Our values are set at, respectively, 1.3 and 1.35, following the values used by Bayoumi *et al.* (2004) and Jonsson (2007), which have been

estimated for the Euro Area.[36]

Another difference regards the baseline policy parameters since, in view of the purposes of the thesis, our monetary policy framework has been simplified, while the fiscal policy block is much more detailed. The parameter values are as follows: we set the degree of interest rate smoothing (ρ) and the size of the response of the monetary authority to inflation (ϕ_π) equal to, respectively, 0.8 and 1.5, values commonly used in empirical Taylor rules; as regards the parameters describing the fiscal policy rule (ϕ_g and ϕ_b), following Coenen and Straub (2005), we have calibrated both to 0.1, which satisfies the necessary and sufficient condition for non-explosive debt dynamics given by equation (47); the autoregressive parameters of the fiscal policy shocks are set to 0.9, while the autoregressive parameters of all other shocks are set to 0.85.

In what regards the steady-state values, we set the ratios of government spending and private investment relative to GDP both equal to 0.2, which corresponds more or less to their average value in the Euro Area over the period 1981Q1:2005Q4[37]. Given those values, the steady-state ratio of the private consumption to GDP becomes equal to 0.6. The quarterly value of the ratio of real government debt relative to GDP is set to 2.4, which is in accordance to the Stability and Growth Pact reference value of a government debt ratio parameter of 60% at the annual steady-state. Finally, as regards distortionary taxation, following the average values for Euro Area calculated by Coenen *et al.* (2007), we set the steady-state values of the consumption tax rate (τ^c) and the labor income tax rate (τ^n) equal to a reasonable value of 0.2.[38] As for capital income tax rate (τ^k), we found a widely range of values in the literature, going from 0 (Coenen *et al.* (2007)) to 40% (Cavallo (2005)). Hence, we set the steady-state value of capital tax rate in an average

[36] Christopoulos and Vermeulen (2008) estimated an identical value for the Euro Area's price markup: 1.37.

[37] European Central Bank's Area-wide Model database, update 6 (September 2006), which has been originally published in Fagan *et al.* (2005).

[38] Coenen *et al.* (2007) found, for Euro Area, average values for consumption and labor income tax rates of, respectively, 18.3% and 24%. The labor income tax rate includes social security contributions by employees.

value of 20%.[39]

Table 3.1 below presents the calibrated values of the parameters of the baseline model.

Table 3.1 - Parameters values

Parameter	Value	Parameter	Value
Discount factor - β	0.99	Consumption habit - h	0.7
Inverse elasticity of substitution - σ_c	1.0	Inverse elasticity of work effort - σ_N	2.0
Investment adjustment costs - φ	4.0	Depreciation rate - δ	0.025
Degre of price indexation - γ_p	0.75	Calvo's parameter on prices - ξ_p	0.75
Degre of real wage indexation - γ_w	0.75	Calvo's parameter on wages - ξ_w	0.75
Share of capital input - α	0.3	Wages markup - λ_w	0.3
Steady-state I/Y - γ_i	0.2	Steady-state G/Y - γ_g	0.2
Steady-state C/Y - γ_c	0.6	Steady-state (B/P)/Y - γ_b	2.4
Prices markup - μ	1.35	Degree of interest rate smoothing - ρ	0.8
Taylor rule inflation - ϕ_π	1.5	Elasticity of taxes to debt - ϕ_b	0.1
Elasticity of taxes to spending - ϕ_g	0.1	Consumption tax rate - τ^c	0.2
Labor income tax rate - τ^n	0.2	Capital income tax rate - τ^k	0.2
AR parameter of fiscal policy shocks	0.9	AR parameter of other shocks	0.85

3.7 The Effects of (negative) Government Spending Shocks

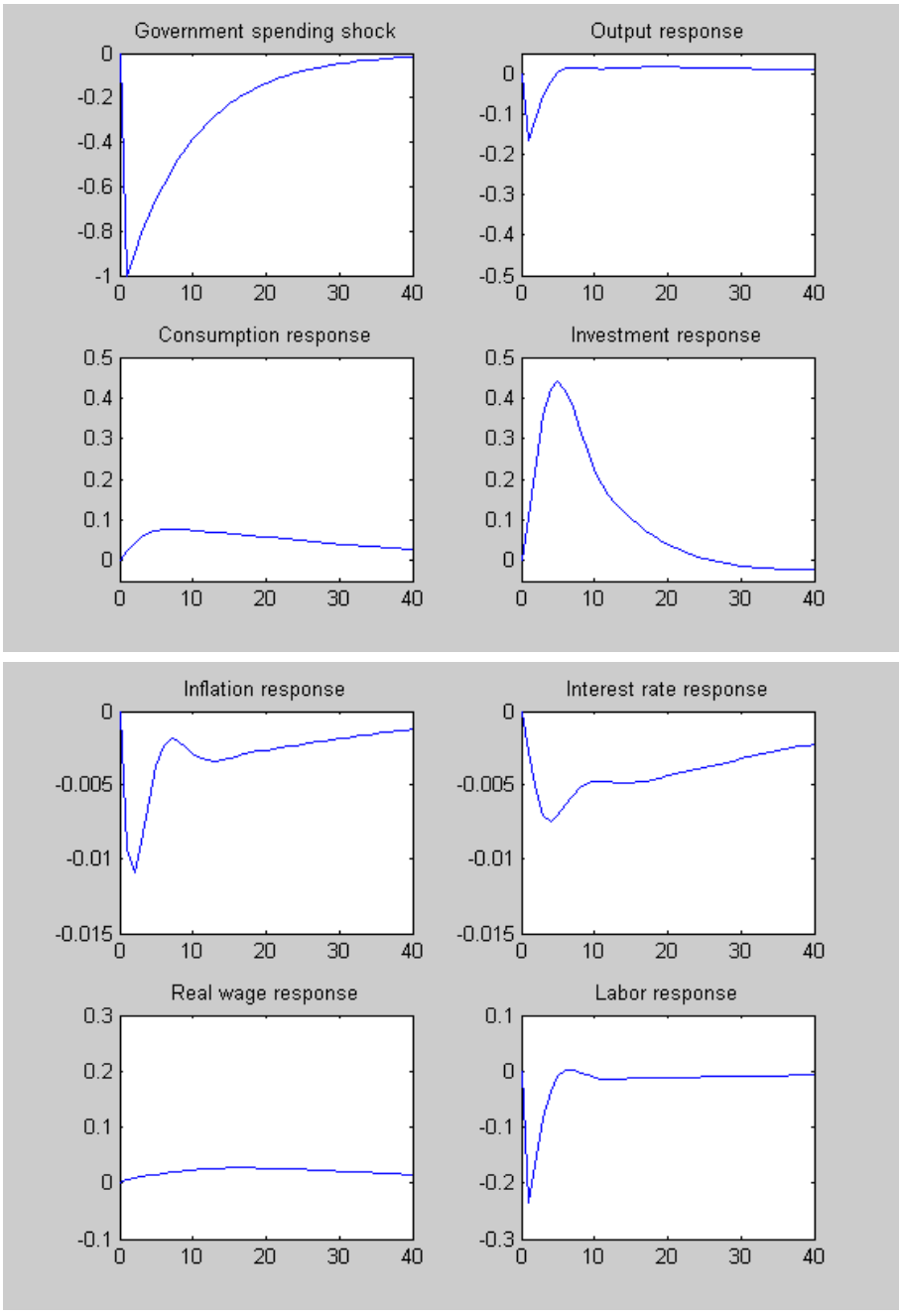
Once our baseline model has been set out, we are ready to simulate a government spending negative shock and analyze the reaction of the different variables, in order to have an initial understanding of the model's dynamic effects of fiscal policy.[40] As we will see in detail in the next chapter, these shocks mimic a fiscal consolidation in the sense that they are modelled with a very high persistence, specifically as AR processes with a root close to 1 (0.9), so that they have a gradual, strong and persistent impact on public

[39] We have done some sensitivity tests, and we have found that the results are robust to a reasonable variation in the tax rate values. Hence, the choice of these values does not seem to be relevant, since we obtain very similar results with different calibrations.

[40] It should be noted that the techniques we use to solve the model ensure symmetry of the responses to shocks with equal absolute value but different signs. Thus, it is straightforward to extrapolate the effects of a positive government spending shock.

debt. As usual we base the analysis on the inspection of the impulse response functions to the shock (figure 3.1).

FIGURE 3.1 - Government spending shock (negative)



The decrease in government spending generates a wealth effect which is caused by the decrease in the present value of future taxes. By anticipating the lower tax burden, households increase consumption and leisure, thus reducing labor supply. In an environment of monopolistic competition and sticky prices, there is also a labor demand effect: in response to the decline of aggregate demand, only a few firms are able to lower prices; all other firms necessarily react by lowering production, which leads to a decrease in labor demand. Hence, these two opposite forces that drive a decrease in labor generate a undefined effect on the real wage. Given the real wage stickiness, real wages are not much affected. Our results show that there is a real wage increase, although of a very small magnitude. As we will see below, this result is highly dependent on the level of labor market competition.

Paralleling the wealth effect, there is an intertemporal substitution effect. Given the monetary policy framework, the decrease in prices and inflation leads to a fall in the real interest rate, leading households to anticipate consumption. At the same time, the real interest rate reduction induces an increase in private investment, which is also triggered by the decrease in the marginal productivity of capital (due to the decrease in labor), and consequently on the rental price of capital.

In sum, a cut in government spending is followed by a rather small increase in private consumption and a relatively strong increase in private investment: the impact on investment is about 5 to 6 times higher than the impact on consumption. Combined with the direct negative effect of the cut in government spending, these impacts on private demand do not hinder a relatively small decrease of output.

These results are generally in line with those obtained by Smets and Wouters (2003), with one major difference: Smets and Wouters (2003) found a strong crowding-out effect on investment (just like us) and also on consumption (the effects on consumption and investment are of similar magnitude). These difference may be explained by two main reasons, related with both our fiscal and monetary policy framework: (i) in order to avoid an explosive path for the public debt, our model includes a fiscal policy rule that generates a decrease in current lump-sum taxes in response to a lower gov-

ernment spending and debt; this decrease in current taxes, induces a lower decrease in future tax burden, and thus reduces the wealth effect; since it is the present value of future taxes that matters for inter-temporally optimizing households (Bilbiie and Straub (2004)), than there is a lower increase in private consumption; (ii) our interest rate rule attaches a zero coefficient to the output gap; therefore there is not an interest rate reaction to the output decrease, which reduces the intertemporal substitution effect.

Hence, the model indicates that there is a positive, although small effect of government spending on economic activity, because the effects over consumption and investment are insufficient to compensate the direct negative effect of the cut in public spending.

3.8 Extensions to the Baseline Model

By exploring the literature on new-Keynesian models specifically designed to analyze the effects of fiscal policy, we found two major possible extensions to the baseline model: (i) the introduction of a share of non-Ricardian households and (ii) the presence of a perfectly competitive labor market. We end this chapter discussing these variants of the baseline model and explaining why only the latter will be explored, later on in the thesis.

3.8.1 Non-Ricardian households

Some empirical studies have detected a strong positive correlation between private consumption and public spending.[41] Motivated by this some-how puzzling evidence, some authors, like Coenen and Straub (2005), Bilbiie *et al.* (2008) and Galí *et al.* (2007), based on the idea proposed by Mankiw (2000), have recently inserted into their new-Keynesian dynamic models a sub-set of households with non-Ricardian behavior. These households decide consumption on the basis of a rule of thumb, according to which all current disposable income is consumed. Hence, they do not participate in financial markets and are immune to the wealth effect.

[41] See *inter alia* Fatás and Mihov (2001), Blanchard and Perotti (2002) and Monacelli and Perotti (2008).

In spite of a mounting interest in this topic by a recent specific literature, we have decided not to include non-Ricardians consumers in our model on the basis of three main arguments. First, the empirical relation between fiscal policy and private consumption seems far from clear cut, as alternative studies have found inconclusive and even opposite results.[42] Second, since the focus of this thesis is to explore the investment-related channel of non-Keynesian effects of fiscal policy, we deliberately chose not to exhaustively develop the possible consumption-related channel. Third, some authors have recently questioned the introduction of these consumers in new-Keynesian models due to the extreme dependence of the results on parameterization, specifically on the share of non-Ricardian consumers.[43] In the words of Monacelli and Perotti (2008, p.32), the results of this literature "*rely on an extreme form of market incompleteness to generate the increase in private consumption*". This criticism seems to be even more important regarding the Euro Area, because "*the estimated share of non-Ricardian households in the euro area is relatively small, suggesting that financial deregulation over the last two decades has lowered financial-market participation costs (...)*" and so "*there is only a fairly small chance that a government spending shock crowds in consumption (...)*" (Coenen and Straub (2005), p.439).

A fourth reason that may also be invoked concerns possible technical problems associated to the inclusion of non-Ricardian consumers in new-Keynesian dynamic general equilibrium models. As some authors have noted, under certain parameter calibrations the equilibrium may not be unique.[44] These technical problems are very likely to be more severe in our model, which extends the usual new-Keynesian framework with a much more detailed fiscal policy block.[45]

[42] For empirical works that found a negative correlation between private consumption and public spending see, *inter alia*, Perotti (1999, 2005), Giudice et al (2004), Giavazzi et al (2000, 2005) and Afonso (2006).

[43] Monacelli and Perotti (2008) and Kühn *et al.* (2009).

[44] See Gali *et al* (2004, 2007) and Bilbiie (2008).

[45] We have performed some model simulations that confirmed this presumption.

3.8.2 Perfectly competitive labor market

Galí *et al.* (2007) introduce, as an alternative specification of the labor market, a perfectly competitive market, with the main objective of comparing the results of the effects of a fiscal policy shock. This variation to the baseline model could indeed prove to be interesting for the purposes of this thesis. In fact, as the review in chapter 2 has shown, the theoretical literature on the investment-related channel for non-Keynesian effects suggests that an increase in the labor market efficiency and competitiveness may be crucial for the occurrence of non-Keynesian effects of a fiscal consolidation. Actually, in the throughout sensitivity checks to which we have submitted the baseline model (mostly not reported) have shown that the introduction of perfect competition in the labor market is the main feature than can qualitatively change the results. Hence, we now explain the changes to the model caused by this alternative assumption, as well as describe its dynamics in response to a government spending shock.

Alternative labor supply - perfectly competitive labor market Assuming a perfectly competitive labor market, each household chooses the quantity of hours supplied given the market wage. This is done by maximizing the intertemporal objective function (8) subject to the intertemporal budget constraint (9). With the Lagrangian given by (10), the first-order condition yields the following equation for the real wage:

$$\frac{\partial L}{\partial l_t} = 0 \Rightarrow \lambda_t(1-\tau_t^n)w_t = e^{\varepsilon_t^N} e^{\varepsilon_t^b} N_t^{\sigma_N}. \tag{77}$$

Using (11) and rearranging, we obtain

$$(C_t - hC_{t-1})^{-\sigma_c}(1-\tau_t^n)w_t = e^{\varepsilon_t^N} N_t^{\sigma_N}\left(1+\tau_t^c\right). \tag{78}$$

Alternative real wage equation - perfectly competitive labor market An alternative real wage equation is derived from the linearization of equation (78),

$$\widehat{w}_t = \sigma_N \widehat{N}_t + \frac{\sigma_c}{1-h}(\widehat{C}_t - h\widehat{C}_{t-1}) + \frac{\overline{\tau}^c}{1+\overline{\tau}^c}\widehat{\tau}_t^c + \frac{\overline{\tau}^n}{1-\overline{\tau}^n}\widehat{\tau}_t^n + \varepsilon_t^N. \qquad (79)$$

The real wage is (i) positively related to the quantity of labor, current consumption and tax rates (consumption and labor income); and (ii) negatively related to past consumption. There is also a positive effect on the current real wage from a labor supply preference shock ($\widehat{\varepsilon}_t^N$).

The effects of a negative government spending shock The main effects of a negative government spending shock of the same magnitude of the shocks considered above, in an environment of a perfectly competitive labor market, are shown in figure 3.2.

A comparison of these results with the effects of a fiscal spending cut in an environment of monopolistic competition in the labor market (figure 3.1) shows that the main difference occurs in the response of real wages: within a perfectly competitive labor market, real wages clearly decline upon the impact of the shock, in contrast to what happens in figure 3.1. Hence, as competition increases in labor market, real wages tend to decrease in response to a government spending reduction. This is a result already documented in the theoretical literature on non-Keynesian effects based on the investment-related channel.[46] Its main origin is the moderation of wage claims by households (unions) induced by the government spending cut, resulting from the fact that these cuts generate a labor demand reduction and thus increase the probability of unemployment.

[46] See, for example, Alesina and Perotti (1995, 1997a, 1997b), Alesina *et al.* (2002) and Ardagna (2007).

FIGURE 3.2 - Government spending shock (negative)

(perfectly competitive labor market)

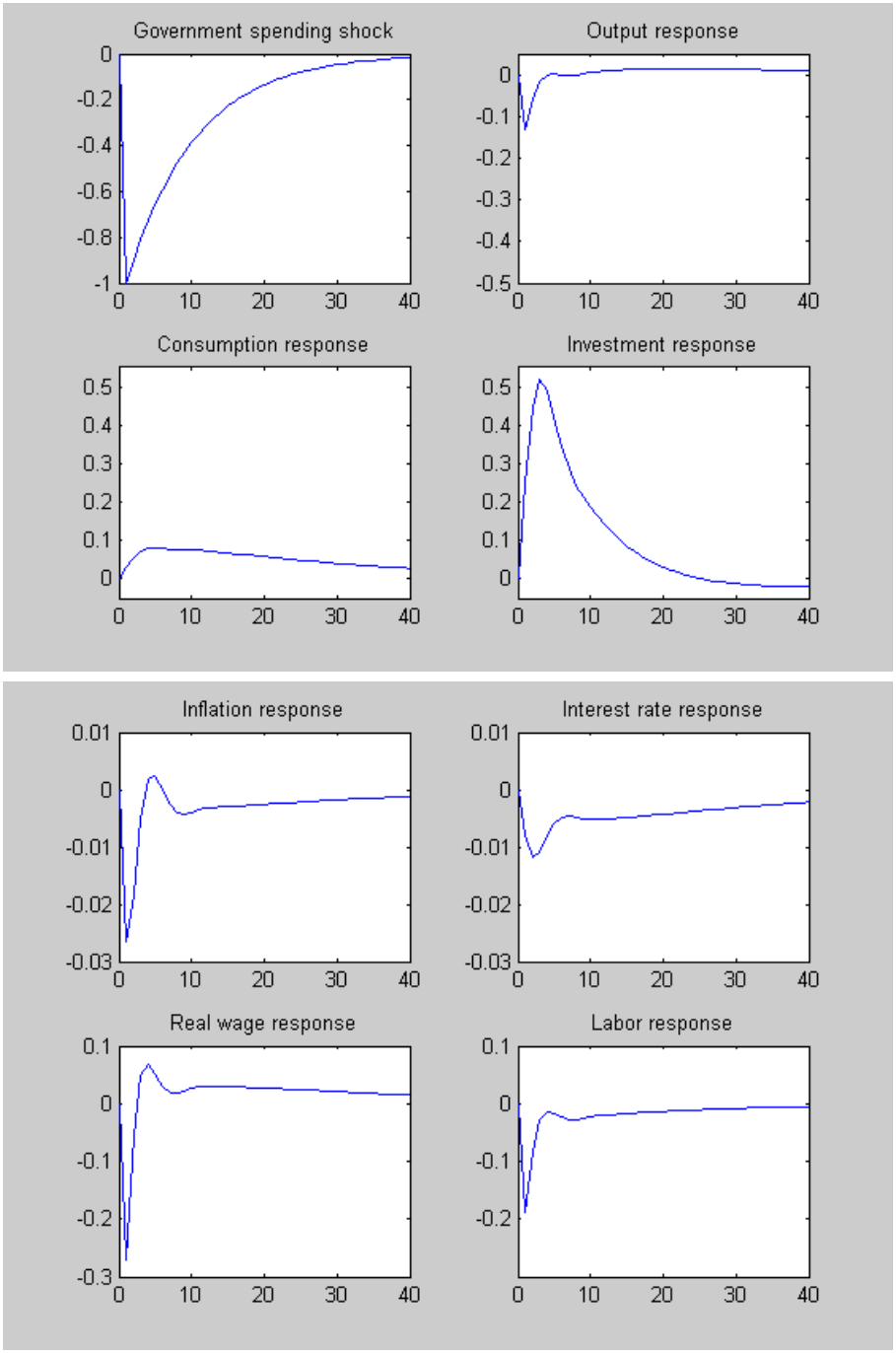


Figure 3.2. further shows that while the response of private consumption is similar to the monopolistic competition scenario, the crowding-in effect on investment is higher on impact and, thus, the overall impact on output is lower. The main reason is that a lower real wage induces a reduction in firms' marginal costs and, hence, an increase in profits, generating an upward pressure on investment and private consumption. Note, however, that this does not necessarily leads to a further rise in private consumption, because the offsetting effect of the lower real wage, via the well known intratemporal substitution effect, tends to depress private consumption.

3.9 Final Remarks

The simulations performed so far show that the baseline model does not predict non-Keynesian effects of a fiscal policy contraction, in spite of the strong crowding-in effect over investment.

In this chapter we have shown the most relevant fiscal policy simulations and deliberately omitted some additional simulations that we have performed in order to inspect for possible non-Keynesian effects in alternative policy instruments. Although there is some agreement in the literature that achieving fiscal consolidation by increasing the tax burden is likely not to succeed, and that a strong and persistent fiscal consolidation must be based on expenditure cuts (von Hagen *et al.* (2002)), we have simulated some (positive) government revenue shocks, by increasing tax rates. The results, which are documented and very briefly commented in appendix A.3, show that the baseline model predicts that shocks in different tax rates do not lead to non-Keynesian effects over output.

This chapter has laid down the foundations for the purpose in this thesis – to explore the investment-related channel for the existence of non-Keynesian effects of fiscal consolidations on short-run output in a new-Keynesian DSGE model. We now have a baseline model fully specified, calibrated, solved, and with a understood dynamic reaction to a fiscal shock. The simulations performed so far suggest that the model must be enhanced with further channels refining the relation of fiscal policy to the macroeconomy.

In view of the literature assessed in chapter 2, and given our choice to explore the investment-related channels for possible non-Keynesian effects, three transmission mechanisms may be added to the model. In the following chapters we sequentially introduce such mechanisms: in chapter 4, the productive effect of government spending; in chapter 5, the demand-driven effect of the impact of public deficits/debt on interest rates risk premium; and in chapter 6, the supply-side effect of an enhancement of the labor market efficiency and the product market competition, linked with possible structural reforms on these two markets. It should be noted that these three transmission mechanisms are closely linked with the critical conditions found, both, in the theoretical and the empirical literature on the non-Keynesian effects of fiscal policy: the composition of the fiscal adjustment, the initial state of public finances and the supply-side transmission mechanism of fiscal policy.

4 The Composition: Productive Government Spending and Employment

"*In a follow-up to the process initiated in Lisbon, the Commission and EcoFin Council underscored that the "quality" of public finances plays a crucial role for growth and employment. More specifically, they outlined the necessity to (...) shift resources towards productive expenditures in health, education and physical infrastructures, and to ensure the sustainability of public finances.*" (Romero-Ávila and Strauch (2008), p.172)

A consensual conclusion in the literature on the effects of fiscal policy on growth is that "*not all kinds of government spending should be treated alike when it comes to reforming public finances.*" (Afonso *et al.* (2005), p.31). Changes to different types of public spending, not only have a different direct impact on debt, and so on public finances consolidation, but also induce a different dynamic behavior on other macroeconomic variables. In this chapter we inspect the impact of fiscal consolidations, achieved through changes in qualitatively different items of fiscal expenditure, on output. In order to do so, we disaggregate the composition of public spending into three types of productive public expenditures: (i) highly productive spending; (ii) weakly productive spending; and (iii) public employment.

This chapter considers a structural change to the baseline model, including public spending in the production function of intermediate goods.

The introduction of government spending in the production function of the private sector follows the seminal work by Aschauer (1989a) admitting a direct relationship between government spending and the productivity of the private factors. This productivity effect, outlined, for example, by Finn (1998), is one channel through which the government can influence the economic activity.

4.1 Theoretical and Empirical Motivation

Much of the literature focusing on the effects of fiscal policy treats government spending as consisting entirely of unproductive expenditure on goods, overlooking the productive and the employment components of public spending. However, "*In practice, government expenditure is on a variety of goods, some of which are intended to enhance the productive capacity in the economy*" (Turnovsky (2000), p.255)

Macroeconomists have known for a long time that public spending is an important input in the production of total output, but only recently did the mainstream literature begin paying attention to this feature of public spending.[47] Using aggregate annual data for US (1949-1973) Ratner (1983) has been the first to suggest an empirical model explicitly adding public spending to the neoclassical production function and to present econometric evidence consistent with that hypothesis. Costa *et al.* (1987), also within this production function framework, have used regional data (from the 48 US contiguous states, 1972) to perform a cross-section estimation in order to study the role of public capital in regional development, finding significant evidence of its relevance. Barro (1990) has introduced government expenditure as an argument in the production function of a theoretical endogenous growth model.

This strand of literature received an important impulse with Aschauer's (1989a, 1989b, 1990) study of the effects of public inputs on output and productivity. Testing the hypothesis that the decrease in productive government services in the United States had been crucial for the productivity slowdown of the early 1970s, Aschauer (1989a) found a strong positive relationship between the stock of non-military public structures and equipment and total output. In that study, he has estimated an elasticity of 0.39 for the sample period 1949-1985, a figure considered surprisingly high by several authors.

Aschauer's controversial results stimulated a large body of empirical research testing their robustness, which has yielded mixed results: on the one hand, Munnell (1990, 1992), Garcia-Milà and McGuire (1992), Bajo-Rubio

[47] See, for example, Arrow and Kurz (1970).

and Sosvilla-Rivero (1993), Finn (1993) and Eisner (1994), among others, obtained results consistent with Aschauer's; on the other hand, Tatom (1991, 1993), Holtz-Eakin (1994), Pinnoi (1994) and Evans and Karras (1994), among others, did not find significant productive impacts of public inputs.[48]

Aschauer's results have been criticized especially because they imply that public inputs seem more productive than private capital. Most of the criticism has focused on possible econometric problems such as non-stationarities, omitted exogenous variables and reverse causation.[49] However, even when these econometric problems have been accounted for, the ambiguity remained, with several studies concluding in favor of Aschauer's hypothesis, and others concluding against it.

Subsequently, an alternative approach based on cost and profit functions and using co-integration techniques has been developed (see, for example, Berndt and Hansson (1992), Shah (1992), Lynde and Richmond (1993), Nadiri and Mamuneas (1994), Morrison and Schwartz (1996), Demetriades and Mamuneas (2000) and Abdih and Joutz (2008)), with results quite in agreement with Aschauer's.

Considering the whole literature, it can be argued that public inputs are clearly relevant in the production process − either by directly providing intermediate services to private sector firms, or by complementing private inputs in production − and thus raise marginal productivity of private capital and labor. Yet, there is controversy on the magnitude of the contribution: "*Government capital serves as an input into private-sector production, augmenting output and productivity. Here, there is conceptual agreement, but researchers disagree about the magnitudes involved.*" (Holtz-Eakin, 1993, p. 231).

Moreover, the literature suggests that different types of public expenditure yield different magnitudes for the respective elasticity of private factor productivity. Public capital stock, and especially non-military "core" infrastructures (highways, airports, electric and gas facilities, water systems,

[48] For a comprehensive survey on this empirical literature see Gramlich (1994).

[49] When output growth is high, incomes are rising rapidly and then the government can provide more public goods and services; *i.e.*, the correlation can reflect a demand-side rather then a supply-side causal relationship.

sewers, mass transit), directly raise the productive capacity of private firms, and are the most productive government expenditures. The output elasticity of this type of public capital stock may be higher than 0.3.[50] Other types of government spending, generally considered as a whole set of non capital expenditures (including, among others, education, health care, entertainment, culture, national defense and environment) provide a lower contribution to private production.[51] The productive role of this kind of public inputs may be generally neglected, as the positive effects from their services may be offset by the negative impact of the allocation of resources to other unproductive government spending, like the regulatory and bureaucratic processes and other current wasteful expenses.

The corollary of the results and arguments reviewed above is that governments should be able to achieve productivity gains by altering the composition of government spending from weakly to highly productive expenses. Then, a criterious selection of the type of public expenditure cut in fiscal consolidations may minimize the possible negative impact of these cuts on the performance of the economy and may even generate a positive impact (*i.e.*, a non-Keynesian effect). Thus, we conjecture that a possible channel for non-Keynesian effects is centered on the switching from weakly productive government spending to highly productive spending, as this might reconcile the fiscal consolidation with an increase in global productivity. In the next sections we assess this conjecture.

4.2 Changes to the Baseline Model

In this section we contribute to the literature by extending the baseline new-Keynesian DSGE model with a break up of public spending into three types of

[50] In fact, several studies have found elasticities in the range $0.3 - 0.4$. For example, Aschauer (1989a), 0.39; Munnell (1990), between 0.31 and 0.39; Garcia-Milà *et al.* (1996), 0.37; Fernald (1999), 0.35; Abdih and Joutz (2008), 0.39.

[51] While Aschauers' estimated elasticities are insignificant, Garcia-Milà and McGuire (1992) found a positive correlation between these other types of government spending, especially education, and total output, estimating an elasticity in the range of 0.07 to 0.16 for the US (1969-1983). Romero-Ávila and Strauch (2008) also emphasized the role of wage payments going to teachers and professors.

productive public expenditures: (i) highly productive spending; (ii) weakly productive spending; and (iii) public employment. When thinking of (i), highly productive spending, our first association is with expenditures with public capital; yet, there are items of current public spending that may also increase private factors productivity, like basic education, security and justice, and basic health care.

The literature is very scarce as regards inclusion of government expenditures in the production function within DSGE models.[52] More recently, Pappa (2009) has incorporated both productive government spending and public employment in a new-Keynesian DSGE model. Our exercise differs from hers' in several respects: first, her model features less sources of nominal and real frictions and is thus less likely to be data-consistent; second, she explicitly identifies productive public spending with public investment; finally, her aim is to study the transmission of fiscal shocks to labor markets and not any fiscal consolidation.

We now develop our model in order to account for productive public expenditures.

The production function given by equation (29) is now replaced by:

$$y_t^j = e^{\varepsilon_t^a} K_{j,t}^{\alpha} \left(N_{j,t}^p\right)^{(1-\alpha)} \left(G_t^{lp}\right)^{\gamma} \left(G_t^{hp}\right)^{\eta} \left(N_t^g\right)^{\nu}. \tag{80}$$

The production function (80) features constant returns to scale with respect to private inputs;[53] and differs from the standard production function in that public spending has three components, G^{lp}, G^{hp} and N^g, respectively, low productivity (or unproductive) spending, high productivity spending and public employment. The three types of public expenditures are incorporated

[52] Finn (1998) and Cavallo (2005) explicitly incorporate productive public spending and public employment but in a purely neoclassical DSGE model.

[53] In the empirical literature there is no clear preference between constant returns to scale in all inputs or only in the two private inputs. Turnovsky and Fisher (1995, p.753) argue that "*(...) our assumption of linear homogeneity in the two private factors views infrastructure as providing economies of scale in production. An alternative assumption discussed by Aschauer (1989) is to assume that the production function is linearly homogeneous in all three factors of production. It turns out that the choice between these two alternative formulations makes little difference, as long as one assumes* $F_{KL}>0$ *in this alternative specification.*"

in the production function as separate inputs enhancing the productivity of private factors. We assume that these public inputs are freely made available by the government at the beginning of each period.

The parameters γ, η and ν, the output elasticities of each of the components of public spending, determine the interaction between public and private inputs in production. Depending on their value, an increase in government spending or employment has large, small or null effects on output (a value of zero means that the public input is unproductive). From the literature reviewed in the last subsection, we conjecture that a value between 0.15 and 0.2 for the highly productive components of government spending would not risk any overvaluation of the possible productive role of public spending; we have furthermore chosen to be conservative and so we have calibrated parameter η with the value 0.15. As regards the low productivity spending we have calibrated parameter γ with two alternative values (0.05 and 0) and have assessed both parameterizations subsequently. Regarding the public employment parameter (ν), we have considered it as productive as the high productive government spending (0.15) and as the weakly productive government spending (0.05), in alternative calibrations.[54]

All government spending variables are assumed to evolve exogenously according to a first order autoregressive process with i.i.d.-normal errors,

$$\widehat{G}_t^{lp} = \varepsilon_t^{g^{lp}} = \rho_{g^{lp}} \varepsilon_{t-1}^{g^{lp}} + \eta_t^{g^{lp}}, \tag{81}$$

$$\widehat{G}_t^{hp} = \varepsilon_t^{g^{hp}} = \rho_{g^{hp}} \varepsilon_{t-1}^{g^{hp}} + \eta_t^{g^{hp}}, \tag{82}$$

$$\widehat{N}_t^{g} = \varepsilon_t^{N^g} = \rho_{N^g} \varepsilon_{t-1}^{N^g} + \eta_t^{N^g}. \tag{83}$$

Labor demand by private firms is derived from the firms' cost minimization for a given installed capital stock and a given stock of public inputs. Thus, equation (31) and equation (66) are replaced by,

[54] These alternative calibrations are also important to test the model's sensitivity to these central parameters.

$$\frac{w_t N_t^p}{r_t^k K_t} = \frac{1-\alpha}{\alpha} \Longleftrightarrow N_t^p = \frac{(1-\alpha)\, r_t^k K_t}{\alpha w_t}. \tag{84}$$

The new production function implies that the firms' marginal costs (MC_t) are now given by,

$$MC_t = \frac{1}{e^{\varepsilon_t^a}} w_t^{(1-\alpha)} r_t^{k^\alpha} \left(G_t^{lp}\right)^{-\gamma} \left(G_t^{hp}\right)^{-\eta} (N_t^g)^{-\nu} \left[\alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}\right]. \tag{85}$$

The fiscal authority now purchases two types of final goods from the private sector (G_t^{lp} and G_t^{hp}), hires labor (N_t^g), finances its spending requirements with lump-sum taxes (T_t) and distortionary taxes − over consumption (τ_t^c), labor income (τ_t^n) and capital income (τ_t^k) − and issues debt (B_{t+1}). Wages are equal in the public and private sector, as we assume that (i) working hours can be moved costlessly across the two sectors, and (ii) the private and public labor supply are perfect substitutes, as working for private firms or for the government brings households exactly the same marginal disutility.[55] Thus, the new government budget constraint, which replaces equation (42), is given by,

$$G_t^{lp} + G_t^{hp} + w_t N_t^g + \frac{B_t}{P_t} = T_t + \frac{B_{t+1}}{P_t} b_t + \tau_t^n w_t N_t + \tau_t^k r_t^k K_t - \delta \tau_t^k K_t + \tau_t^c C_t. \tag{86}$$

Finally, the model is closed with two types of aggregate constraints. First, labor supply must equate labor employed by the private firms and by the public sector,

$$N_t = N_t^p + N_t^g. \tag{87}$$

Second, aggregate production must equal the demand for goods by the private and public sector, and hence equation (49) must be replaced by,

[55] Some recent literature shows that there is indeed a significative positive correlation between private and public sector wages, even though their average levels differs (Afonso and Gomes (2008), Lamo *et al.* (2008)).

$$Y_t = C_t + I_t + G_t^{lp} + G_t^{hp}. \tag{88}$$

After the linearization process, equations (64), (67), (68), (70) and (74) are replaced by,[56]

$$\begin{aligned}\widehat{\pi}_t &= \frac{\gamma_p}{1+\beta\gamma_p}\widehat{\pi}_{t-1} + \frac{\beta}{1+\beta\gamma_p}\mathrm{E}_t\widehat{\pi}_{t+1} + \frac{(1-\beta\xi_p)(1-\xi_p)}{\left(1+\beta\gamma_p\right)\xi_p} \quad x \\ &\quad x \left[(1-\alpha)\widehat{w}_t + \alpha\widehat{r}_t^k - \gamma\widehat{G}_t^{lp} - \eta\widehat{G}_t^{hp} - \nu\widehat{N}_t^g - \varepsilon_t^a\right] + \eta_t^p, \end{aligned} \tag{89}$$

$$\widehat{N}_t^p = -\widehat{w}_t + \widehat{r}_t^k + \widehat{K}_t, \tag{90}$$

$$\widehat{Y}_t = \varepsilon_t^a + \alpha\widehat{K}_t + (1-\alpha)\widehat{N}_t^p + \gamma\widehat{G}_t^{lp} + \eta\widehat{G}_t^{hp} + \nu\widehat{N}_t^g, \tag{91}$$

$$\begin{aligned}\widehat{B}_t &= \frac{1}{\beta}\widehat{B}_{t-1} + \frac{1}{\beta}\frac{\gamma_{g^{lp}}}{\gamma_b}\widehat{G}_t^{lp} + \frac{1}{\beta}\frac{\gamma_{g^{mp}}}{\gamma_b}\widehat{G}_t^{hp} - \frac{1}{\beta}\frac{\gamma_t}{\gamma_b}\widehat{T}_t + \widehat{R}_t - \frac{1}{\beta}\frac{\gamma_{wn}\overline{\tau}^n}{\gamma_b}(\widehat{\tau}_t^n + \widehat{N}_t) - \\ &\quad -\frac{1}{\beta}\frac{\gamma_k\overline{\tau}^k\overline{r}^k}{\gamma_b}\widehat{r}_t^k + \frac{1}{\beta}\frac{\gamma_k\overline{\tau}^k(\delta-\overline{r}^k)}{\gamma_b}(\widehat{\tau}_t^k + \widehat{K}_t) - \frac{1}{\beta}\frac{\gamma_c\overline{\tau}^c}{\gamma_b}(\widehat{\tau}_t^c + \widehat{C}_t) + \\ &\quad +\frac{1}{\beta}\frac{\gamma_{wn^g}}{\gamma_b}\widehat{N}_t^g + \frac{1}{\beta}\frac{(\gamma_{wn^g} - \gamma_{wn}\overline{\tau}^n)}{\gamma_b}\widehat{w}_t, \end{aligned} \tag{92}$$

where $\gamma_{wn^g} = \frac{\overline{wN^g}}{\overline{Y}}$,

$$\widehat{Y}_t = \gamma_c\widehat{C}_t + \delta\gamma_k\widehat{I}_t + \gamma_{g^{lp}}\widehat{G}_t^{lp} + \gamma_{g^{hp}}\widehat{G}_t^{hp}, \tag{93}$$

and a new equation is introduced,

$$\widehat{N}_t = \vartheta_{n^p}\widehat{N}_t^p + \vartheta_{n^g}\widehat{N}_t^g \tag{94}$$

where, $\vartheta_{n^p} = \frac{\overline{N}^p}{\overline{N}}$ and $\vartheta_{n^g} = \frac{\overline{N}^g}{\overline{N}}$, are the steady-state ratios of private and public employment to total employment. Following Cavallo (2005), Ardagna

[56] Full linearizations are available upon request.

(2007) and Afonso and Gomes (2008), we calibrate these parameters as, respectively, 0.84 and 0.16. Following Finn (1998) and Pappa (2009), the steady-state ratios of the low productivity government spending, high productivity government spending and public wage bill to output ($\gamma_{g^{lp}}$, $\gamma_{g^{hp}}$ and γ_{wn^g}) are calibrated as, respectively, 0.07, 0.03 and 0.1.[57]

4.3 Fiscal Consolidations in the Developed Model

There is a growing consensus in the literature that the success of a fiscal consolidation, *i.e.* the size and the sustainability (persistence) of debt reduction, clearly depends on the "quality" of fiscal adjustments.[58] "Quality" concerns to the relative contribution of different public budget components, *i.e.*, to the composition of the fiscal adjustment. In the literature, "good quality" fiscal adjustments are defined as those with a strong emphasis on government spending cuts rather than on raising taxes, and particularly on the reduction of current expenditures (public consumption and social transfers) and some politically sensitive items of the budget, such as public employment and public sector wages.

Typically, the association between cuts in politically sensitive expenditures and a higher probability of success of fiscal consolidations is seen as the result of the fact that such cuts signal a stronger commitment to public finances sustainability. In our model there are no comparable credibility effects but rather the general equilibrium effects of fiscal shocks (leading to fiscal consolidation) that have different roles in the production of intermediate goods and income.

We now analyze the impact of shocks to each of the different fiscal components on debt, in order to verify which may lead to a sizable and persistent fiscal consolidation. As we have referred in chapter 3, our fiscal policy shocks mimic a fiscal consolidation in the sense that they are modelled with high persistence, as AR processes with a root close to 1, and are thus expected to

[57] This last value is roughly in accordance with the value presented by the European Commission for the European Union for 2007, which was around 11% (see Afonso and Gomes (2008)).

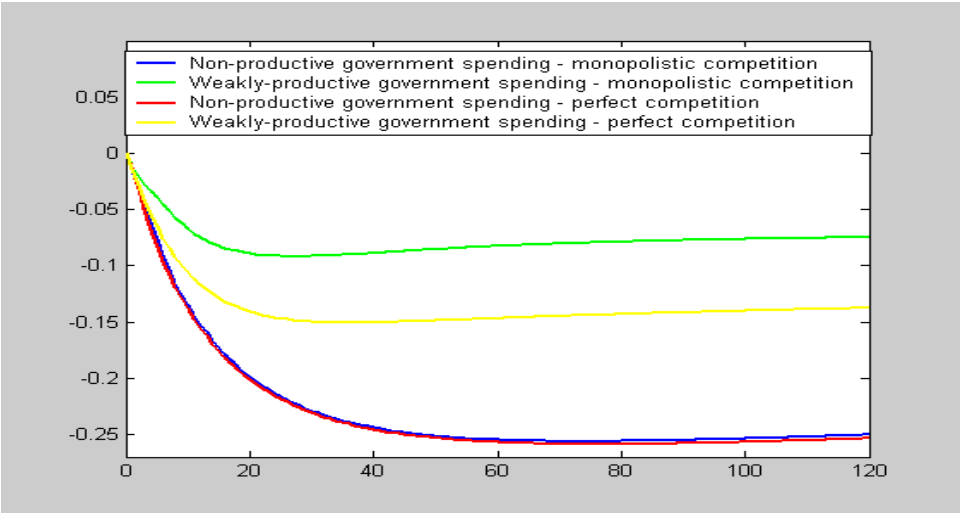
[58] See, for example, von Hagen *et al.* (2002) and Guichard *et al.* (2007).

have a gradual and persistent impact on public debt.

In figure 4.1 we show the dynamic path of the deviation of the public debt ($\widehat{B}_t$) as a result of a unitary shock to government spending, both non-productive and weakly productive. In figure 4.2 we show the path of $\widehat{B}_t$ as a response to a unitary shock to both highly and weakly productive public employment. In both figures we show the results of simulations under the baseline labor market and the alternative perfectly competitive market.

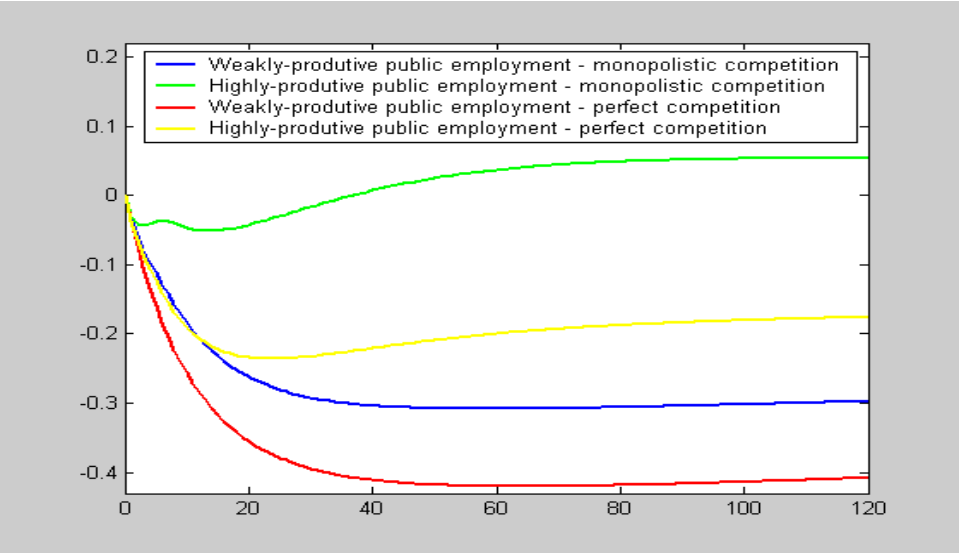
Figures 4.1 and 4.2 show results that are in the line with the literature: (i) cuts in the less productive government spending and public employment (*i.e.* unproductive spending and weakly productive employment) are more likely to generate strong and persistent fiscal consolidations; (ii) cuts in productive public spending, even if weakly productive, generate a rather limited and not sustained response of debt;[59] (iii) cuts in highly productive public employment also generate a rather timid and less persistent response of debt and may even induce a medium- to long- term increasing path for debt.

FIGURE 4.1 - Impact of government spending cut on debt



[59] We did not consider a fiscal consolidation entirely based on cuts in the highly-productive government spending because, on the one hand, it seems economically unsustainable, from a long-term output growth view, to reduce the most productive expenditures, and, on the other hand, our preliminary results show an rather insignificant short-run impact on debt, followed by an clear medium- to long-run increase in debt path.

FIGURE 4.2 - Impact of public employment reduction on debt



There are two additional results that worth to be mentioned. First, as a rule, shocks to all budget spending components generate a larger fiscal consolidation the more competitive is the labor market. This rule knows only one exception: when the fiscal consolidation is achieved through a persistent shock in non-productive government spending, the debt dynamics is independent of the degree of competition in the labor market. Second, fiscal consolidations appear gradually and, in the case of the most effective shocks, takes between 40 and 60 quarters to fully develop.

4.4 Dynamic Effects of the Fiscal Consolidations - Government Spending Shocks

In this section we present and discuss the general equilibrium effects of the fiscal shocks on types of spending and employment that have been identified as achieving a fiscal consolidation, in the previous section.

4.4.1 Non-productive government spending (negative) shock ($\gamma = 0$)

Figure 4.3 shows the results from a non-productive government spending negative shock. These turn out to be qualitatively very similar to the results presented in section 3.7 (public spending shock in the baseline model).[60] While there is a small increase in private consumption, a marked crowding-in effect on private investment occurs, but is insufficient to offset the direct negative impact of the spending cut on output. As argued in section 3.7, these results derive, essentially, from a combination of (i) a wealth effect, which raises consumption and reduces labor supply, (ii) a demand effect, which leads to a reduction in labor demand; and (iii) a intertemporal substitution effect. The strong increase in investment can be explained, besides the wealth effect, by a lower interest rate in response to a lower inflation, and by a decline in the rental price of capital.

It should be noted that, results are within the alternative scenario of a perfectly competitive labor market, which we have already documented in section 3.8.2 above. While the response of private consumption is identical, the crowding-in effect on investment is slightly higher on impact and, thus, the overall impact on output is slightly lower. As we have seen, the main reason for this difference is the decline of the now flexible real wage.[61]

4.4.2 Weakly-productive government spending (negative) shock ($\gamma = 0.05$)

The reaction of the relevant macroeconomic variables to a weakly-productive government spending shock is quite different (figure 4.4). Although the effect on private consumption remains small (albeit with a different sign), the

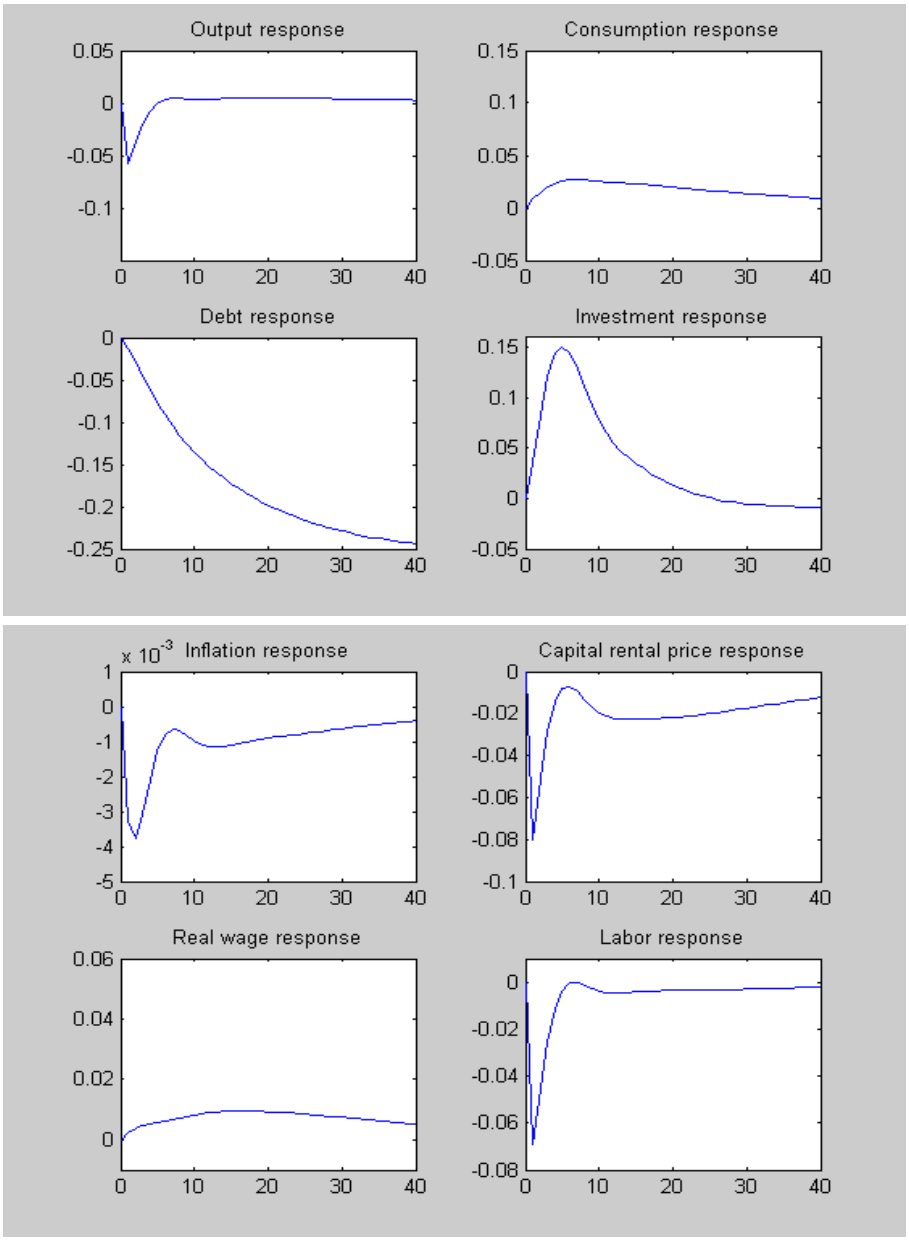
[60] In the following figures we have replaced the IRFs of the interest rate, which closely follow the (reported) inflation rate dynamics, by the IRFs of the capital rental price, which will be useful in some of the discussions. We also replace the figure depicting the fiscal shock by the figure with the debt dynamics, as we now finally focus on the issue of fiscal consolidation.

[61] Due to this similarity, we have decided not to present the figures concerning the perfectly competitive labor market. This will also occur in the case of the weakly-productive government spending cut. All these impulse response functions are available on request.

reduction of public spending crowds-out investment. This leads to a stronger negative impact on output when compared to the shock analyzed in the previous sub-section.

FIGURE 4.3 - Non-productive government spending

(monopolistic competition in labor market)



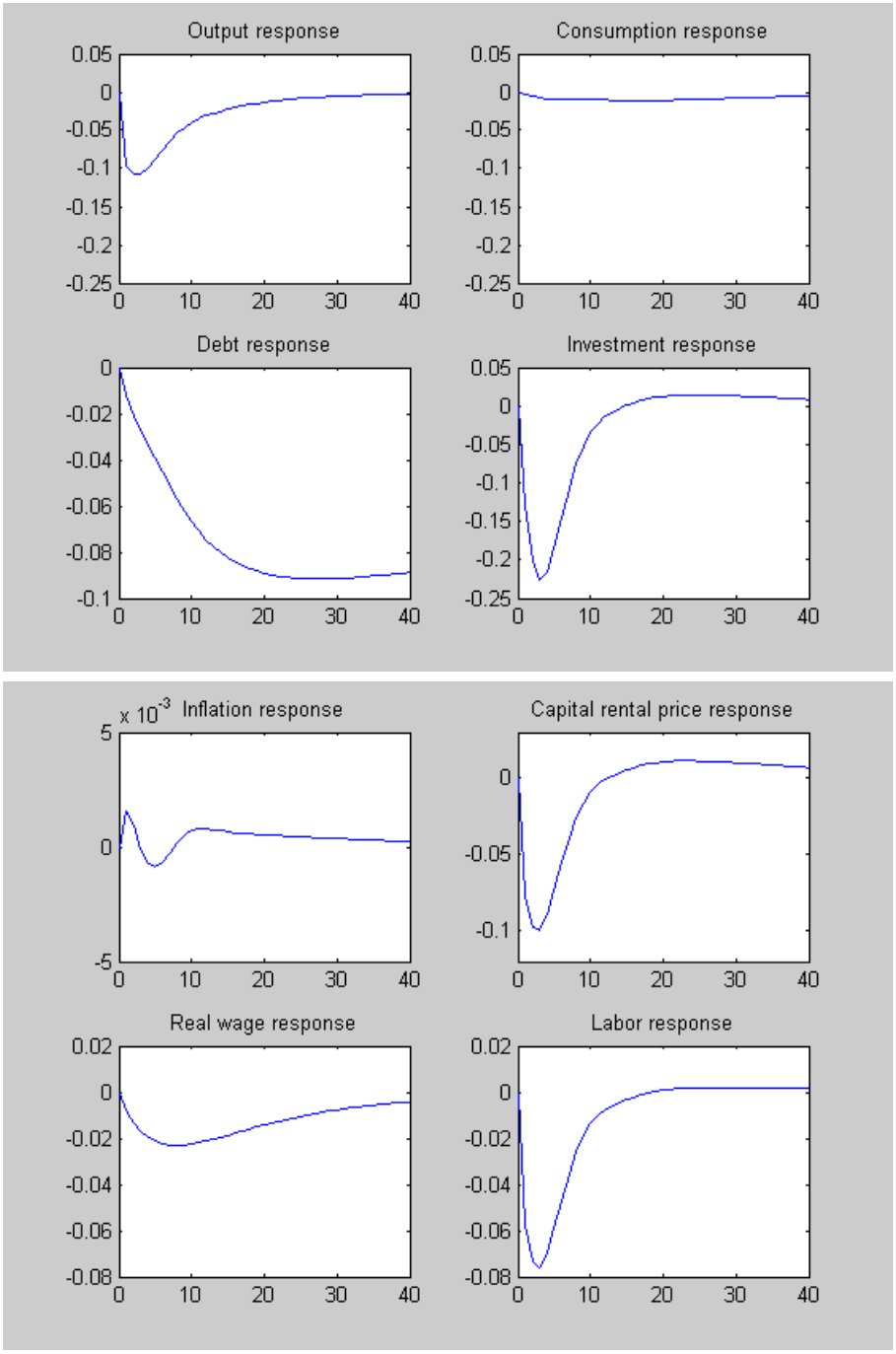
The differences to the case of a shock to non-productive public spending are caused by a direct negative impact of the government spending cut on the productivity of private factors, which generates a negative effect on wealth, that offsets the positive wealth effect that derives from a lower present value of taxes. Hence the strong negative direct impact on capital demand (and so on investment) and on labor demand, and the corresponding fall in wages (relatively small due to the stickiness in wages) and in the rental price of capital.

In the alternative labor market scenario (perfect competition, figures not reported), the main difference concerns a smaller negative impact on investment and, hence, a lower contraction of output. Again, the explanation lies on the higher decline of the flexible real wage, which induces a reduction in firms' marginal costs and, hence, an increase in profits, generating an upward pressure on investment.

In sum, comparing the dynamic effects of the non-productive and weakly-productive government spending cuts, follows for three main conclusions: (i) the decrease in output is almost twice as large when government cuts the weakly-productive spending; (ii) the final effect on private consumption is small in both cases, although with a different sign; (iii) the reaction of investment is opposite, as it increases when unproductive government spending is reduced and decreases when the cut is on weakly-productive public spending. Overall, we conclude, on the one hand, that the direct effect of the weakly productive spending shock on the productivity of the private inputs clearly prevails over the indirect effects, pushing down private consumption and, mostly, investment. One the other hand, we conclude that the smaller size and persistence of the fiscal consolidation generated by the weakly-productive government spending cut, induces a lower positive wealth effect and, hence, a smaller crowding-in effect on private consumption and investment.

FIGURE 4.4 - Weakly-productive government spending

(monopolistic competition in labor market)



4.4.3 Switching from less to higher productive government spending

The simulations performed so far with the developed model have focused on the reduction of a single component of government spending. The reductions have, irrespectively of the class of spending cut, generated contractionary fiscal consolidations, *i.e.*, consolidation with no evidence of non-Keynesian effects. However, it is well known that, in an environment of limited public resources and binding fiscal constraints, fiscal policy makers may redirect spending towards more productive activities (Afonso and Furceri (2008)). Although this kind of switching can induce, in the short-run, a smaller and less intensive fiscal consolidation, in the medium- to long-run they may generate a stronger and, possibly, more persistent consolidation, due to a positive impact on growth.

We now use our developed model in simulations in which there is a switching from non- or weakly- to highly-productive public spending. Such simulations are, on the one hand, devised to account for realistic features of fiscal consolidations in the real world, when policy makers try to minimize the social costs of consolidations; on the other hand, our simulations will aim at uncovering thresholds for combinations of shocks that may, in our model, generate non-Keynesian effects driven by a strong increase in private investment. Actually, it seems that a fiscal consolidation may be successful and yet generate non-Keynesian effects if the government reduces their non- or weakly-productive expenses while it increases the highly-productive.

We have performed four different experiments of a switching from low productivity spending to high productivity spending, always with the decrease in the low productivity spending fully compensating the increase in the high productivity spending ($\widehat{G}_t^{lp} = -\widehat{G}_t^{hp}$): (i) $\gamma = 0$ within a perfectly competitive labor market (figure 4.5); (ii) $\gamma = 0$ with monopolistic competition in labor market (figure 4.6); (iii) $\gamma = 0.05$ within a perfectly competitive labor market (figure 4.7); and, (iv) $\gamma = 0.05$ with monopolistic competition in labor market (figure 4.8).

FIGURE 4.5 - Switching from non-productive to highly productive spending (perfectly competitive labor market)

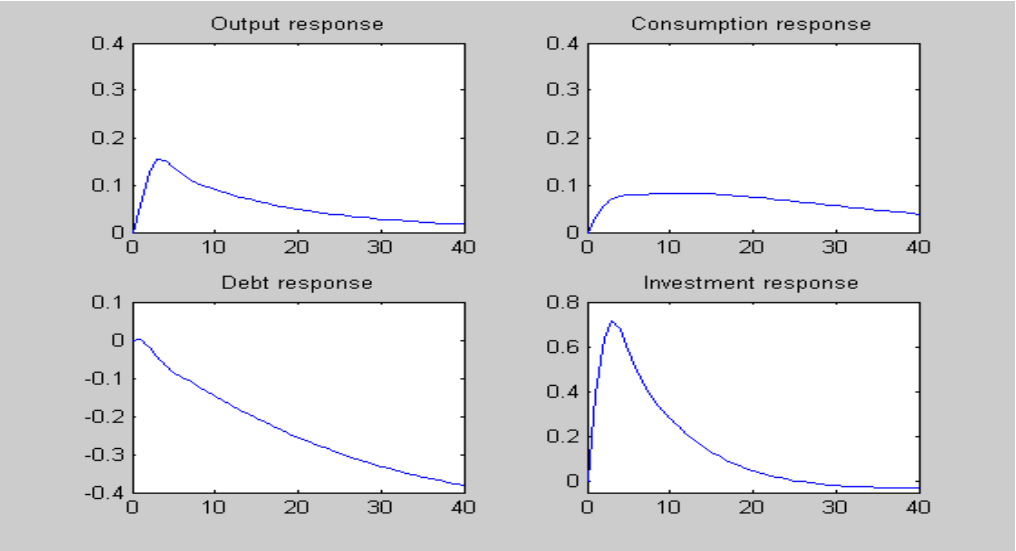


FIGURE 4.6 - Switching from non-productive to highly productive spending (monopolistic competition in labor market)

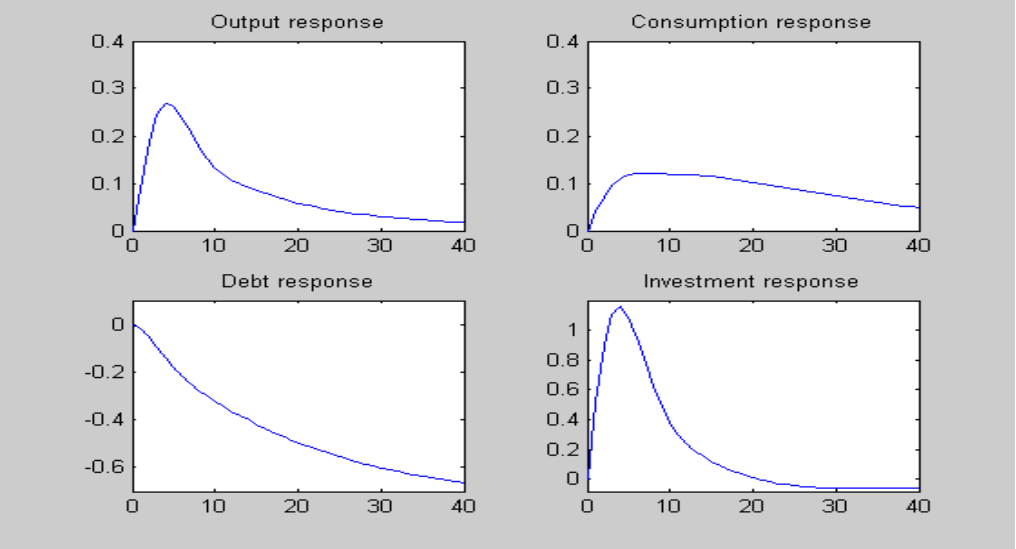


FIGURE 4.7 - Switching from weakly-productive to highly productive spending (perfectly competitive labor market)

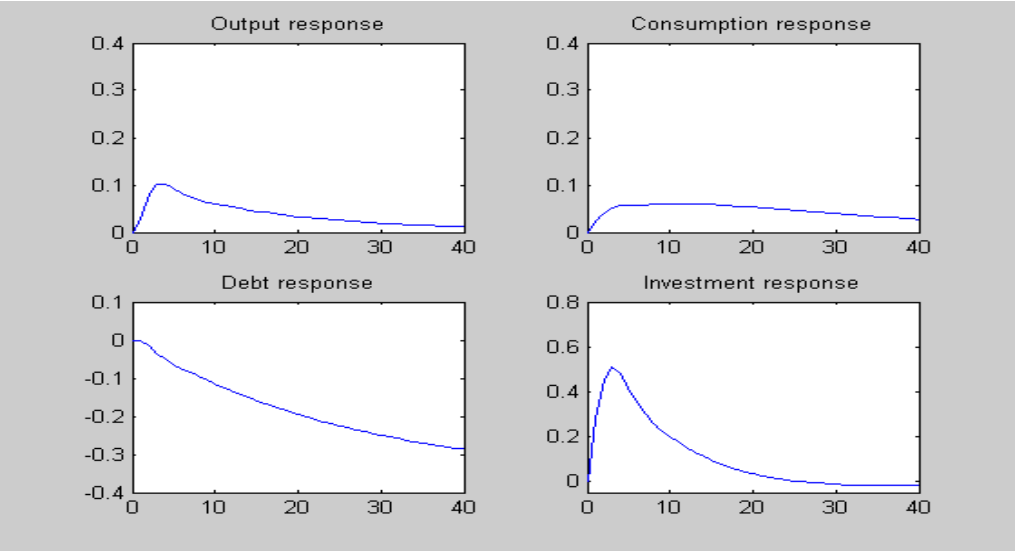
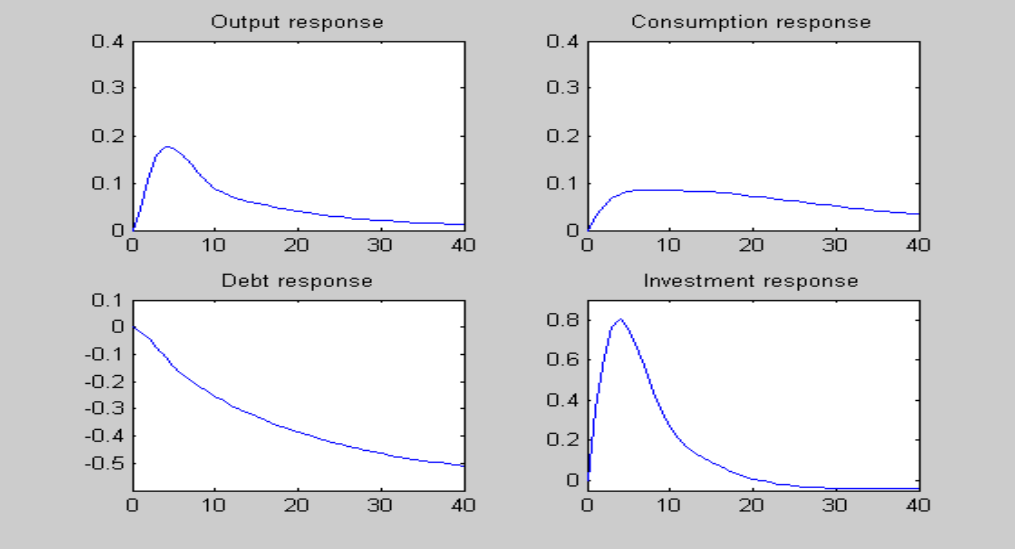


FIGURE 4.8 - Switching from weakly-productive to highly productive spending (monopolistic competition in labor market)



Overall, the main conclusion is that replacing less productive public spending with highly productive spending can generate a decrease in public debt and positive effects on output (*i.e.*, non-Keynesian effects), driven by a strong increase in private investment. Two notes are in order regarding these results. First, although there is no overall reduction of public expenditures, in all cases the fiscal deficit improves because of the increase in taxes generated by higher output. Second, as before, the main transmission mechanism leading to the non-Keynesian effects is the wealth effect over investment, crucially associated with the credibility of the consolidation process.

We have further analyzed whether non-Keynesian effects arise in cases in which the increase in the highly productive government spending is smaller than the decrease in the weakly productive spending. Such combinations would improve the budget balance more rapidly and thus enhance the fiscal consolidation credibility. In particular, we aim at finding the threshold for the percentage of the low productivity spending cut that needs to be compensated by an high productivity spending increase in order to generate non-Keynesian effects. Four experiments have been made, and results are summarized in table 4.1.

Table 4.1 - Thresholds for spending switching

		Switching from:	
		non-productive spending	**weakly-productive spending**
highly-productive spending threshold	**perfect competition**	0.40	0.70
	monopolistic competition	0.35	0.65

Quantitatively, the results show that, with our developed model and our calibration, non-Keynesian effects appear when the highly productive spending is increased by about 40% of the reduction in the non-productive spending and 70% of the reduction in the weakly-productive spending. Hence, if the government reduces the non-productive (weakly-productive) spending

by 10% of its steady-state level, he should increase the highly productive spending by about 4% (7%) of its steady-state level. These values are rather similar in the two analyzed scenarios (perfectly competitive and monopolistic competitive labor market).[62]

4.5 Dynamic Effects of the Fiscal Consolidations - Public Employment Shocks

In this section, we report the main results of simulating a negative shock to public employment, which can be thought of as a reduction in the number of public employees and/or in public wages. As we have seen in section 4.3, a cut in the highly productive public employment only generates a fiscal consolidation in the monopolistic competition labor market scenario (figure 4.2). That consolidation is, yet, rather small and unsustained. Hence, we will only analyze the case of a consolidation via a reduction of the weakly-productive government employment.[63]

The results concerning the monopolistic competition scenario are qualitatively similar to the results obtained with the weakly-productive government spending cut (figure 4.9). The reduction in public employment generates two contradictory wealth effects: on the one hand, the decrease in public spending increases wealth by decreasing the present expected value of the tax burden, generating an upward pressure on both private consumption and investment; on the other hand, the direct negative impact on private factors productivity induces a negative effect on wealth, leading to a decrease in investment and, though to a lesser extent, in consumption. Since the direct effect is stronger, the final result is a small decline in private consumption and a

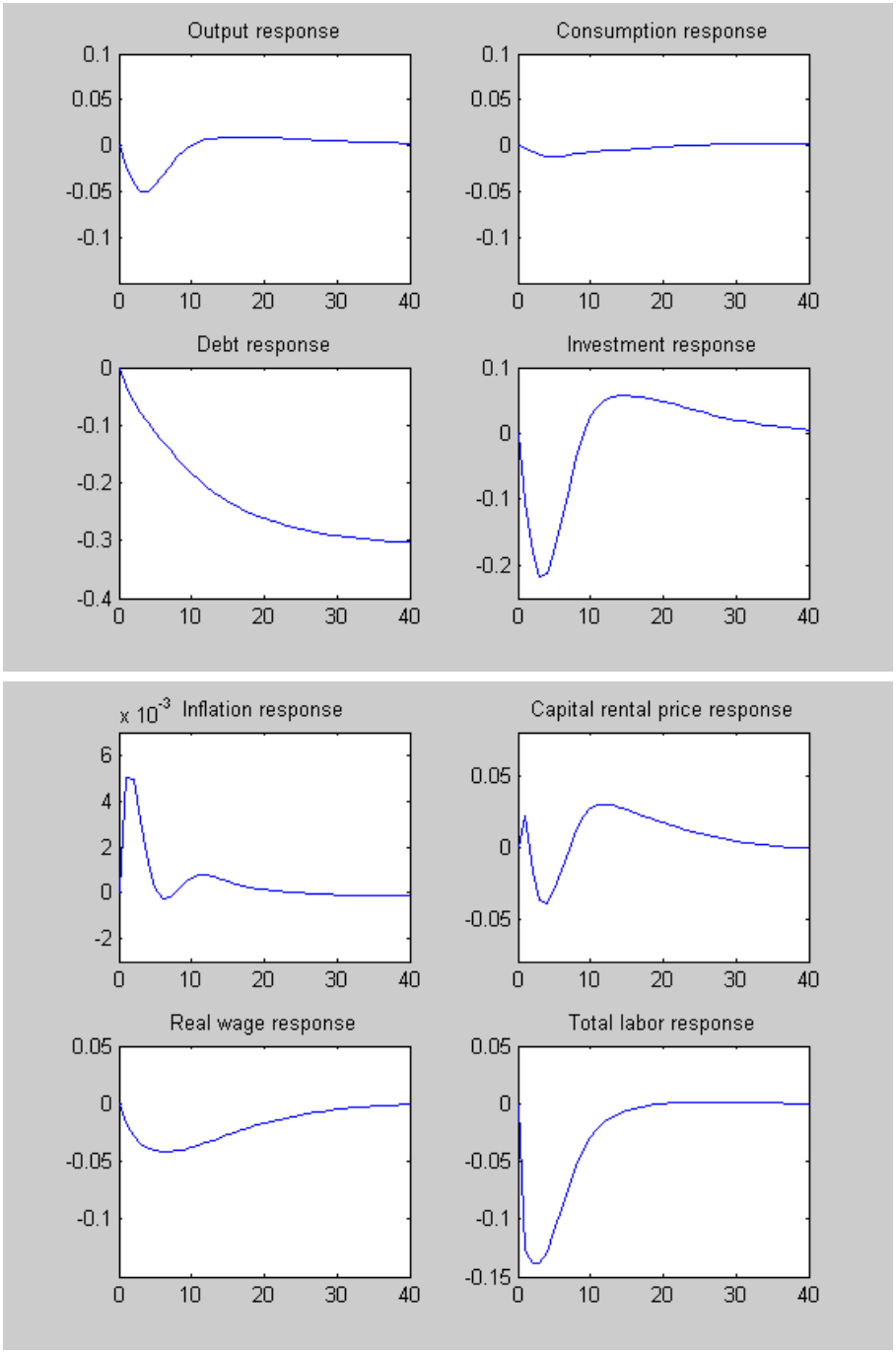
[62] The thresholds presented allow for visible non-Keynesian effects. Some inferior values may also allow for medium-term non-Keynesian effects, but with a negative impact and short-run effect on output. We have disregarded such cases as they do not correspond to the concept of non-Keynesian effects.

[63] We have done some simulations for shocks with highly-productive public employment that confirmed its failure in achieving non-Keynesian effects. These simulations are available upon request.

strong contraction of investment, inducing a contractionary effect on output.

FIGURE 4.9 - Weakly-productive public employment

(monopolistic competition in labor market)



In contrast, in a version of our model with perfect competition in the labor market, results differ substantially (figure 4.10). There is now clear evidence of non-Keynesian effects, driven by an increase in private investment. The strong crowding-out effect on investment in the monopolistic competition scenario, becomes a strong crowding-in effect in the perfect competition scenario.

This can be explained essentially by two reasons.

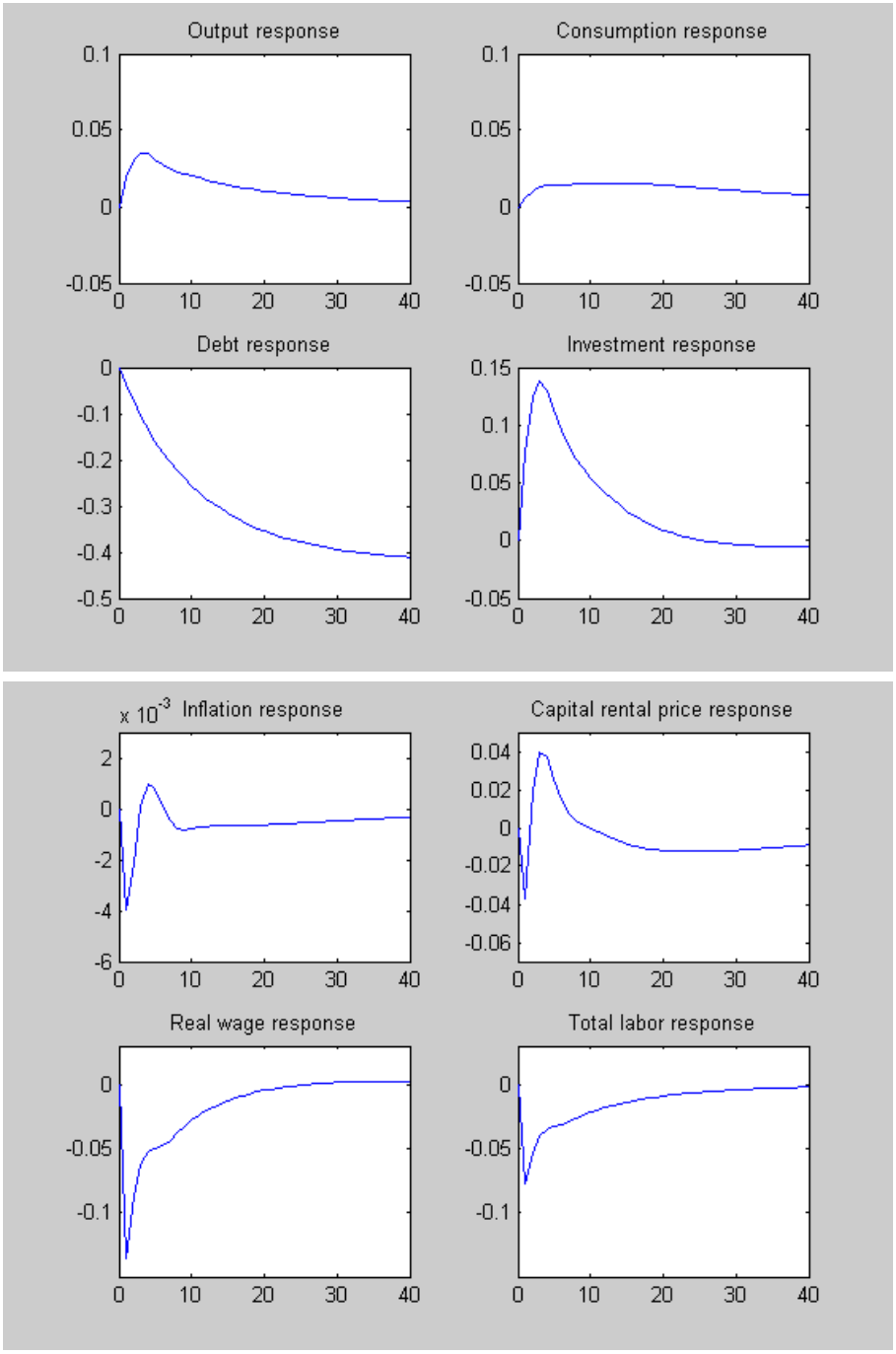
First, the reduction in public employment tends to put a marked downward pressure on real wages via two mechanisms: (i) the negative impact on private factors productivity tends to generate a decrease in labor demand and, hence, in wages; (ii) lower public employment decreases the probability of being employed in the public sector, inducing a lower reservation utility for private sector workers and, hence, lower pressure on wage bargaining. Following these dynamics, the decline in real wages is now visibly larger in a flexible labor market: the impact decrease in real wages is more than three times that of the monopolistic competition. Lower real wage means lower marginal costs, higher profits and, hence, higher investment.

Second, the fiscal consolidation tends to be stronger and more persistent in the perfect competition scenario (figure 4.2), which tends to generate a larger positive effect on wealth, and thus an upward pressure on private investment.

In sum, these results suggest that a contraction of (weakly-productive) public employment may induce a fiscal consolidation and promote non-Keynesian effects, provided that the labor market features a high degree of competition. Hence, the advantages of combining fiscal policy consolidations with some structural reforms in the labor market − an interesting result that will be further explored in chapter 6.

FIGURE 4.10 - Weakly-productive public employment

(perfectly competitive labor market)



4.6 Summary and Final Remarks

This chapter has explored one of the possible transmission mechanisms, identified in chapter 2, for the investment channel of non-Keynesian effects of fiscal consolidations – the change in the composition of public expenditure.

In order to motivate the chapter, we firstly reviewed the theoretical and empirical literature that considers how and which items of government expenditure may be directly related to total factor productivity; and secondly tried to ascertain literature studying how cuts in those items of expenditure could generate different patterns of fiscal consolidation and of the dynamic response of the main macroeconomic variables.

This chapter then contributes to the literature by incorporating into the new-Keynesian DSGE model developed in chapter 3 some classes of public expenditure possibly involved in the investment channel for non-Keynesian effects of fiscal consolidations. Specifically, the baseline model has been enhanced with the introduction of government spending and public employment expenditures as variables with a direct relation with total private factor productivity in the intermediate goods sector. Such relation has been allowed to be important or unimportant, as public spending has been split into highly-productive and weakly or non-productive spending, and public employment has been alternatively calibrated with a strong and a weak productivity effect. The production elasticity of each class of public spending and employment have been calibrated according to evidence in the literature.

Our analysis has been laid down in successive steps, all replicated, as a rule, for models with monopolistic and, alternatively, perfect competition in the labor market.

First, we have assessed the ability of cuts in public spending and employment, for a realistic range of their impact on productivity, to generate fiscal consolidations – *i.e.* sizeable and sustained deviations from the debt-ratio from its starting level.

Second, we have studied the general equilibrium effects of fiscal consolidations based on the reduction of weakly-productive and non-productive spending; and further studied consolidations based on the switching from

less to more productive public spending.

Third, we have studied the general equilibrium effects of fiscal consolidations based on the reduction of weakly-productive public employment.

The main conclusions are the following.

The success – dimension and sustainability – of fiscal consolidations, either via public spending reductions or employment costs reduction, decreases with the degree of their productivity.

So long as consolidation involves the contraction of expenditures with some productivity, its success increases with the degree of competition in the labor market.

Consolidations through pure contractions of weakly-productive or, alternatively, non-productive public spending, generate short-run contractions of output and as such do not generate non-Keynesian effects. However, the effects on investment are opposite in these alternative routes for consolidation. Cuts in unproductive spending generate the wealth effect associated to the fall in the discounted value of future taxes and a fall in the price of capital that visibly stimulate investment in the short-run, albeit by less than would be necessary to compensate the negative impact of the reduction in public demand. Cuts in weakly-productive spending generate a negative wealth effect due to the reduction of overall productivity that surpass the standard wealth effect associated to the fall in future taxes (which is, by itself, smaller as the consolidation is weaker); as a result, investment crowds-out and output falls twice as much as does in the case of unproductive spending consolidations.

If the consolidation is conducted simultaneously with a structural change in the fiscal budget in favor of more productive spending – a cut in weakly (or non) productive spending together with a symmetric increase in highly-productive spending – then our model predicts the existence of non-Keynesian effects. The spending switch generates the standard wealth effect associated to expected future taxes as well as a direct increase in productivity, which both stimulate investment (and, although to a lesser extent, consumption) and create a net short-run increase of output. This increase expands taxes and triggers an improvement in the fiscal deficit and a sustained decrease in public debt. The non-Keynesian effects are larger when the labor market

features monopolistic competition, because the increase in labor demand due to the rise in productivity leads to a smaller rise in the real wage than in a perfectly competitive market, and thus to a larger net increase in profits and investment. A thorough sensitivity analysis has allowed the detection of thresholds for the spending switch: fiscal consolidation and non-Keynesian effects exist as long as highly-productive spending increases by 70 percent of the reduction in the weakly-productive spending (or 40 percent of the cut in non-productive spending).

Consolidation through a reduction in weakly-productive public employment (cuts in highly-productive employment have been disregarded, as the model does not predict a proper consolidation in such case) yields results similar to those of a reduction in weakly-productive public spending in our baseline model. Actually, output falls more markedly in this case because the increase in inflation triggers an increase in the interest rate that further depresses investment. However, in a version of the model with perfect competition in the labor market, such a route for consolidation does generate some short-run increase in output, as a large positive reaction of investment arises. The change in the behavior of investment and in the overall dynamics is associated to a larger fall in real wages: in a perfect competition labor market, the fall in the demand for labor by the government decreases real wages throughout the market, reducing marginal costs, increasing profits and consequently private investment. Additionally, the consolidation develops quicker and the wealth effect further stimulates investment.

We have argued, in this chapter, that the literature supports an enhancement of our new-Keynesian DSGE model to account for some productive role of public spending and/or public employment. With such an enriched model, we have detected conditions for the existence of non-Keynesian effects within a first transmission mechanism of the investment channel. In the subsequent chapters we retain the model developed in this chapter and use it to explore two other transmission mechanisms that, as will be shown, have their own role in the literature of non-Keynesian effects of fiscal policy. They are: the demand-side transmission via the reduction of expected interest rates (chapter 5); and the interaction between the fiscal adjustment

and structural reforms increasing the degree of competition in the markets (chapter 6).

5 The Initial State: Public Deficits/Debt and Interest Rates

"Empirical research indicated that the Keynesian multiplier was much smaller than earlier analyses had assumed, reduced by a crowding out of interest sensitive spending caused by an induced increase in the demand for money and by the effect of the larger national debt on long-term interest rates." (Feldstein (2009), p.2)

The investment-related channel of non-Keynesian effects of fiscal policy may operate *via* the link between the levels of budget deficits and government debt, and interest rates, especially long-term interest rates. Some authors have already highlighted this channel (See Alesina and Perotti (1997a), Afonso (2001) and Ardagna (2009)). Yet, in the literature, as far as we know, only Coenen *et al.* (2008) have explicitly incorporated this channel in a new-Keynesian DSGE model. Our analysis differs from theirs in three regards: (i) while they aim to study possible long run benefits of a fiscal consolidation, we properly focus on the possible non-Keynesian short-run effects; (ii) while we use the version of our model developed in chapter 4, they do not consider productive government spending and public employment and, hence, do not consider the "quality" of the composition of the fiscal adjustment; and (iii) we explicitly consider the structural supply-side effect of the demand-side policy of fiscal consolidation.[64]

In short, this investment channel works when and if market participants believe that a successful fiscal consolidation will permanently reduce the stock of public debt and, thus, the probability of a default on government bonds. As a result, the market participants ask for a lower risk premium, with the consequent reduction in the interest rate.[65] This leads to an increase in private

[64] Coenen *et al.* (2008) compare a general expenditure-based consolidation with a revenue-based consolidation.

[65] This argument follows the usually called portfolio effect (see Caporale and Williams (2002)): when investors consider government bonds of higher quality (less risky and more liquid), they switch from low quality debt into government bonds, which leads to an increase of its price and to a decrease of its yield/interest rate.

demand, especially private investment, therefore providing an expansionary effect of the fiscal contraction. Moreover, the literature has suggested that a non-linearity could exist in the relation between interest rates and budget deficits. Specifically, the change in the risk premium and interest rates may depend on the level of public debt, as it determines the risk of default on government bonds. Some recent empirical evidence also seems to support this non-linear relation.

We begin this chapter presenting a review of the literature on this subject. We conclude that, at a theoretical level the debate remains open. Yet, econometric and annedoctal evidence, as well as remarks by leading economists and policy makers, almost all indicate that increases in expected future deficits and government debt tend to raise long-term interest rates.[66]

We then enhance our model to allow for an explicit relation between the level of public debt and long-term interest rates; and then use the developed model to simulate the effects of fiscal consolidations that lead to a fall of long-term interest rates according to a set of calibrations suggested by the reviewed literature.

5.1 Interest Rates and Budget Deficits/Debt: A Theoretical View

Economic Theory yields ambiguous predictions as regards the effects of public deficits on interest rates. The simplest theoretical approach to this question is the standard textbook IS/LM framework: an higher budget deficit, caused by an increase in government spending and/or a decrease in revenue, raises the interest rate, generating a *crowding-out* effect. However, even in the basic IS/LM framework, fiscal policy can have no effect on interest rates in a small open economy within an environment of high international mobility of capital.

An alternative simple approach to the issue may be based in the national account identity (Elmendorf and Mankiw (1999), Gale and Orzag (2002)):

[66] For a review of literature see Barth *et al.* (1991), Gale and Orzag (2002), Laubach (2004) and European Commission (2004).

$$S + (T - G) = I + NFI \tag{95}$$

where, S is private saving, T is government revenue, G is government spending (and so $(T - G)$ is public saving), I is domestic investment and NFI is net foreign investment. This identity may be interpreted as describing the two sides of the market for loanable funds. An increase in the budget deficit corresponds to a decrease in public saving and implies, at least, one of three effects: (i) an increase in private saving; (ii) a decrease in domestic investment; and/or (iii) a decrease in net foreign investment.

We detected, at least, four approaches in the literature concerning the relation between public deficits/debt and interest rates, which overall create a rather mixed scenario, with some views predicting a positive relation between the level of public debt and long-run interest rates, but others generating ambiguous predictions.

First, the conventional approach predicts a combination of the three effects referred to above, suggesting that the most important is likely to be the one over investment (Elmendorf and Mankiw (1999)). Since households smooth their consumption over time, the increase in private saving is smaller than the fall in public saving. The consequent reduction in national saving relative to current investment generates: (i) a shortage of funds that puts upward pressure on interest rates as firms compete for a limited pool of funds to finance their investment projects; and (ii) an increase in the government debt held by the public, given that the government persuades investors to hold the additional bonds offering an higher interest rate − hence a positive correlation between public deficits/debt and interest rates.

Second, the Ricardian Equivalence hypothesis, predicts that, under certain assumptions, the decrease in public saving is entirely offset by an increase in private saving, so that the interest rate remains constant.[67] In particular, a tax cut does not affect interest rates if, for a given amount of government spending, consumers fully anticipate the future tax burden needed to repay

[67]For more details on the Ricardian Equivalence theorem see, for example, Elmendorf and Mankiw (1999), pp.1640-1659, and Seater (1993).

the resulting debt and save all their additional current disposable income. However, it is widely accepted that the assumptions of the Ricardian Equivalence hypothesis do not hold in practice, as agents face liquidity constraints, have limited horizons and/or taxes are distortionary. Moreover, observed changes in current and future deficits do not seem to correspond to a pure shift in the timing of taxes and so, even in an otherwise Ricardian world a temporary increase in government spending leads to a fall in domestic saving and to an increase in interest rates (Laubach (2004), Faini (2004)) − hence the results are ambiguous.

A third and more recent approach, is based on the idea that the "new economy" era of global capital mobility implies a different relationship between fiscal imbalances and interest rates. In short, the growing integration of emerging markets into the world economy depresses interest rates, because these fast-growing developing countries have a high propensity to save but are unable to employ their savings domestically, to a large extent because of capital market insufficiencies, and thus channel their savings to global financial markets and industrial countries (Caballero *et al.* (2008)). Under this hypothesis, fiscal imbalances do not necessarily transmit to higher interest rates. Hauner and Kumar (2006), however, did not find evidence of this hypothesis, and have argued that these capital flows are transitory and "old economy" forces explaining interest rates are likely to prevail − hence the ambiguous results.

Finally, a fourth approach is based on the market-discipline hypothesis (Schuknecht *et al.* (2008)). Its main argument is that long-run interest rate spreads on government bonds signal the financial markets' assessment of the sustainability of a governments' fiscal position. A weaker fiscal position (higher deficit or debt ratios) implies an higher credit risk, and so financial markets impose some fiscal discipline on governments demanding higher interest rates − hence a positive correlation between public deficits/debt and interest rates.

The positive relationship between budget deficits and interest rates under the conventional approach features a time dimension in the sense that interest rates are affected not only by current or past deficits/surpluses, but

also by expectations of future deficits/surpluses; this means that anticipated future deficits/surpluses may affect long-term interest rates today, as these are determined by a weighted average of expected short-term interest rates in the future: "*In other words, dissipating future surpluses imposes economic costs not only in the long-term, but may also drive up long-term interest rates today and thereby hamper economic activity in the short-term*" (Gale and Orzag (2002), p.11).

Focusing on our research purposes, we may infer the corollary of the reviewed theory regarding fiscal consolidations: a credible decline in present and future budget deficits, and thus in debt, tends to lower expected future short-term interest rates, and therefore tends to lower present long-term interest rates immediately. This theoretical view seems highly confirmed by statement of leading economists. We report two different historical episodes. In the first, Feldstein (1986) refers to the rise of deficits and debt as pressing up interest rates in the 70s:

"*An anticipated future budget deficit means a smaller amount of funds at that future date to finance investment in plant and equipment. Restricting that investment will require a higher real rate of interest. Similarly, the anticipated budget deficit means that individuals will have to be offered a higher yield in the future to induce them to hold the larger amount of government debt in their portfolios. Both of these effects raise the expected future interest rate and therefore (...) they raise the current long-term rate as well*" (Feldstein (1986), p.13).

In the second, Taylor (1995) addresses the relation debt−interest rates in the 80s−90s' context of fiscal consolidations:

"*Economic research - both theory and econometric models - provides evidence that lower budget deficits will lower real interest rates, increase investment, and thereby increase productivity growth and real incomes*" (Taylor (1995), p.151).

5.2 Interest Rates and Budget Deficits/Debt: Empirical Evidence

In spite of the mixed theoretical scenario pictured in the previous section, the conventional view suggests a positive correlation between budget deficits, public debt and interest rates. This correlation is not apparent in the recent history, as the deterioration of public budgets across industrialized countries (Japan, US, EU) has coexisted with interest rates at very low levels. Yet, this could be the result of the specific historical circumstances of the recent years. We now look at the literature on the empirical evidence on this correlation. We will find a rather mixed picture, as coefficients of fiscal policy variables in interest rate regressions span from positive and significant to insignificant, and as significant estimates vary widely.

The most widely known structural macro-econometric models (developed by the Congressional Budget Office or the Federal Reserve Bank in the US, the IMF or the OECD) feature economically significant effects of budget deficits on interest rates. An unweighted average of the coefficients in these models indicates that an increase of one percentage point (pp) in the primary deficit-to-GDP ratio induces an increase in the interest rates of 10-year government bonds by about 50 basis points (bp) after one year. This sensitivity increases to 60 bp in the case of deficits caused by spending (Gale and Orzag (2002)).

In the last three decades an extensive empirical literature has attempted to estimate the relationship between interest rates and deficits/debt, with a special focus on the US economy. In a comprehensive review of this literature (until 1989), Barth *et al.* (1991) find that out of the existing 42 studies, 17 found significant positive effects of deficits on interest rates,[68] 19 did not found significant positive effects,[69] and 6 found mixed results.

More recently, Laubach (2004) has pointed out that this literature lacks controlling for factors such as the response of monetary policy and automatic

[68] See, for example, Feldstein (1986), Wachtel and Young (1987), Cebula (1988) and Barth and Bradley (1989).

[69] See, for example, Evans (1985, 1987), Bradley (1986), Plosser (1987) and Kolluri and Giannaros (1987).

stabilizers to the business cycle, which may mask the effect of current deficits on interest rates.[70]

Given this empirical problem, the most recent literature has focused on the relation between long horizon forecasts of budget deficits/debt and interest rates, along two alternative approaches. First, event analysis have looked at changes in interest rates (and other asset prices) on the day of the release of new information about the future budget outlook. Second, the announcement effect methodology (Knot and de Haan (1999)) has used current projections/expectations of future deficits obtained from macroeconometric methods such as VARs, or using official budget projections based on the analysis of current and announced future fiscal policies.[71]

In a closer examination of the 42 papers analyzed in Barth *et al.* (1991), Gale and Orzag (2002) found that studies incorporating deficit expectations in addition to current and past deficits tend to find economically and statistically significant positive correlations. Of the 19 papers finding no significant positive effect, only one did take deficit expectations directly into account, twelve did not take expectations into account (and the same happened with 4 out of the 6 papers that have found mixed results), and the remaining six only considered expectations indirectly. Moreover, they found that VAR expectations may probably be poor measures of agents' expectations of budget deficits, as these are dependent on a political process and, hence, can change dramatically: a VAR approach "*often produces poor forecasts because it assumes that expectations are based on a mechanical projection of past variables and because it typically incorporates only a very limited number of variables (...) A VAR projection is thus fundamentally backward-looking, and fails to incorporate information that may be widely available to market participants about future events*" (Gale and Orzag (2002), p.21-22).[72]

[70] A cyclical downturn may result in a deterioration of the government budget due to the automatic fiscal stabilizers, while the monetary policy response is inducing a fall in interest rates, which produces a negative correlation between the budget deficits and interest rates (Laubach (2004)).

[71] Budget projections produced by several institutions like, in the US, the Congressional Budget Office and the Office of Management and Budget, or the European Central Bank, in EU.

[72] Elmendorf (1993) compared the performance of VAR forecasts relative to some pub-

Extending the literature review from 1989 onwards until 2002, Gale and Orzag (2002) examined 16 additional studies, from which 11 found positive significant effects[73] and 5 found mixed effects.[74] Overall, from the 58 papers in this literature only one did take deficit expectations explicitly into account and still produced insignificant results, which strongly indicates that there is a positive correlation between expected deficit/debt and long-term interest rates.

As regards the magnitude of the elasticity, although the estimates vary, its average is consistent with the parameters of the structural macroeconometric models: an increase of one pp in the primary deficit-to-GDP ratio is associated with an increase in long-term government bonds interest rates of about 40 to 50 bp.

European Union evidence Almost all the studies referred to above analyze the relation between budget deficits/debt and interest rates in the US, while evidence for the case of the European Union is much more scarce.

Studies of the EU have focused on micro analysis of the behavior of interest rate spreads (Codogno *et al.* (2003), Bernoth *et al.* (2004), Faini (2004), Paesani *et al.* (2006)) or on event studies (Afonso and Strauch (2007), Ardagna (2009)). Overall, Faini (2004, p.490) concludes that "*The main conclusion that emerges from such literature is that fiscal policy, however measured, matters but its effects are quite small, namely a one per cent increase in the deficit to GDP ratio would raise interest rates on government bonds by around 10 basis points. While not negligible, this effect is substantially smaller than that estimated in the US literature*". Some of these results are presented in table A.1, in appendix A.4.

licly available budget projections, and concluded that these projections were much better proxies of deficit expectations. He also concluded that when replacing the VAR forecasts by those projections the findings of some studies, like Evans (1987) and Plosser (1987), could be overturned. Miller and Russek (1996) used three different econometric methods in order to estimate the relation between expected budget deficits and long-term interest rates. They found evidence of a significant positive link, except with the VAR methodology, with which they found mixed results.

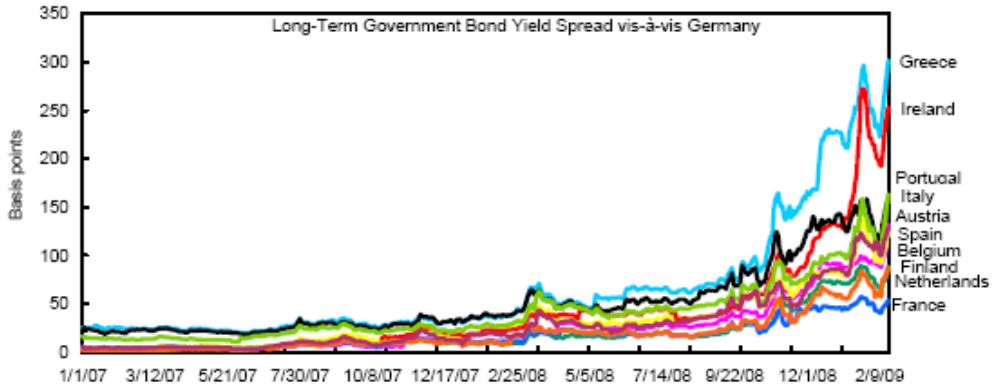
[73] See, for example, Miller and Russek (1991, 1996), Elmendorf (1996), Kitchen (1996), Tavares and Valkanov (2001) and Canzoneri *et al.* (2002).

[74] See, for example, Quigley and Porter-Hudak (1994).

The fact that, within the Euro Area, interest rates on euro-denominated bonds issued by different governments have been quite similar since the beginning of the monetary union, is itself informative about the small sensitivity of interest rates to public debt. As Codogno *et al.* (2003) and Bernoth *et al.* (2004) argue, existing spreads should reflect differences in liquidity (liquidity risk), and, mainly, differences in the creditworthiness of sovereign issuers (risk of default), which should increase with the debt, deficit and debt-service ratio.[75]

Actually, IMF (2009) have showed that, within the Euro Area, long-term government bond yield spreads vis-à-vis Germany began rising significantly only after the outset of the current 2007/09 financial crisis, but have done so especially for economies where the risk of default is high and rising (figure 5.1).[76] Thus, it is fair to conclude that currently the governments of Euro Area countries are paying significant risk premiums, related with their fiscal performance.

FIGURE 5.1 – Long-term government bond yield spread vis-à-vis Germany



IMF (2009), p.30

[75] Pagano and von Thadden (2004) concluded that, after the start of EMU, the liquidity premiums have vanished. Hence, the interest rates' yield spreads should essentially be affected by default risk premiums.

[76] Highly indebted economies (like Greece and Italy) and also Ireland, where government guarantees provided to the financial sector amount to more than 250% of GDP.

Non-linearities It has been argued in the literature that the positive relation between debt/deficit and interest rates is non-linear, in the sense that the correlation coefficient increases with the level of the debt. Higher stocks of public debt raise the public's concern about long run sustainability, which renders the adjustment required to stabilize the debt larger and, thus, raises the risk of default and leads market participants to ask for an higher risk premium. As argued by Faini (2004), there is a circularity between the debt stabilizing primary surplus and the interest rate: an higher interest rate leads to an higher debt service, an higher debt stabilizing primary surplus, and thus an higher interest rate, and so on and so forth.

At an empirical level, Faini (2004) found that in the high-debt countries within the EU, fiscal deficits tend to have a stronger impact on interest rates. This non-linear effect has also been stressed by Ardagna *et al.* (2007): in a cross-section analysis of 16 OECD countries, for the period between 1960 and 2002, they found evidence of significant effects of fiscal imbalances on long-term interest rates − on average a one pp increase in the primary deficit-to-GDP ratio is associated with a 10 bp rise in the interest rate on 10-year government bonds. However, this effect seems to be significant only when the public debt to GDP ratio is above a threshold that they estimated to be around 65%.

For a panel of 16 OECD countries, with data for the period between 1960 and 2002, and using an event analysis methodology, Ardagna (2009) found that the relation between budget deficits and interest rates depend on the countries' initial fiscal conditions − such as the level of public debt − and also on the type of fiscal consolidation. The fiscal adjustments typically associated with larger reductions in interest rates fulfilled three conditions: (i) occurred in countries with high levels of budget deficit and/or high stock of public debt; (ii) generated a permanent and significant reduction in the public debt; and (iii) were implemented by cutting government spending.[77] Specifically, nominal (real) long-term interest rates on government bonds

[77] Cutting expenses generates a credibility effect, as agents believe that the government is able to generate a persistent decrease in public debt. This effect is stronger if the changes affect some structural and politically sensitive components of government spending, like the government wage bills.

have decreased, on average, by 124 bp (97 bp) around such episodes of sharp fiscal consolidations.[78]

Public debt direct effect The empirical evidence surveyed thus far essentially refers to a relation between budget deficits and long-term interest rates. However, as already seen in the last subsection, the level of the public debt may have an important influence on that relation, namely when debt is above a certain threshold.

Actually, the strand of literature empirically studying the relation between public debt and long term interest rates has found some evidence of a positive, although small, direct correlation (see table A1 in appendix A.4). Generally, estimates of the effect of a one pp change in the expected deficit-to-GDP ratio on long term interest rates are 5 to 10 times larger than the estimates of the effects of such a change in the expected debt-to-GDP ratio.

For the US, Laubach (2003) and Engen and Hubbard (2004) have found that a one pp increase in the deficit-to-GDP ratio increases the expected real interest rate, on average, by 20 to 40 bp, while a one pp increase in the debt-to-GDP ratio increases the expected real interest rate by a merely 3 to 5 bp. Evidence for a wider range of industrial countries is quite similar: Kinoshita (2006), using panel data for 19 industrial countries, reports a deficit-to-GDP impact of 20 to 25 bp, and a debt-to-GDP impact of 1 to 3 bp;[79] Ardagna *et al.* (2007), with their panel of 16 OECD countries, have found an effect of about 10 bp of a change in deficit-to-GDP ratio, and of 0 to 4 bp in the case of a change in debt-to-GDP ratio. For the Euro Area, Chalk and Tanzi (2002) estimated a 1 to 6 bp change in the real interest rate for a one pp change in the public debt-to-GDP ratio, and Faini (2004) has found a debt-to-GDP effect of 5 to 7 bp.

Based on his estimates, for 19 OECD countries (1971-2004), Kinoshita

[78] Ardagna (2009) presents a wide set of alternative estimations for the effect of an increase in the expected budget deficit on the long-run interest rate: under "normal" conditions, 25 to 33 bp; under a decrease of 3 pp in public debt after two years, 54 to 62 bp; under a decrease of 5 pp in public debt after two years, 76 to 85 bp; in situations of a high initial debt, 66 to 71 bp; after a larger government spending cut, 48 to 55 bp.

[79] These effects are raised, respectively, to 70−90 bp and 4−5 bp when fixed country effects are included in the regression.

(2006) has suggested that a simultaneous increase (or decrease) in the public debt and the budget deficit would generate considerably larger effects on the long-run interest rates than changes in the public debt alone. We thus argue that when studying fiscal consolidations the proper calibration should include the combined effects on long term interest rates of the reduction of public debt and of the budget deficit − as consolidations are, by definition, sustained (and, thus, deficit-based) debt-to-GDP ratio reductions.

Summary Overall, the empirical literature on the relation between deficits/debt and long-term interest rates allows for the following main conclusions. First, there is a positive relation; second, the sensitivity of interest rates to deficit/debt seems to be smaller in Europe than in the US; third, the estimated effects are stronger in studies that use long-term interest rates and/or budget deficits/debt projections, instead of short-run interest rates and/or current deficits/debt (which is clearly linked with the forward looking behavior of financial markets' participants); fourth, the level of the public debt stock has a strong influence on the relation, as the elasticity seems to be higher when the public debt-to-GDP ratio is above a given threshold, and maybe is an increasing function of the debt-to-GDP ratio; fifth, the direct effect of debt seems to be significantly smaller than the budget deficit effect.

5.3 The Model With a Public Debt−Interest Rate Channel

Based on the literature reviewed in the previous section, we now enhance our model of chapter 4 introducing a direct relation between the level of public debt and the equilibrium long-term interest rate. We will then use the developed model in order to assess whether fiscal consolidation policies may generate non-Keynesian effects in the context of such a model with dependence of the real equilibrium interest rate on the level of public debt.

As in the previous chapter, we will simulate a set of alternative fiscal shocks that mimic a fiscal consolidation in the sense that they have a persistent impact on public debt over several years (see figures 4.1 and 4.2).

Fiscal consolidation now affects the long-term real interest rate and long-run investment, so a persistent decrease in the debt-to-GDP ratio generates an higher steady-state capital stock and an higher potential output (European Commission (2004)). Therefore, the model now considers a structural effect of the fiscal consolidation. Hence, differently from the analysis so far, there is a structural supply-side effect of the demand-side fiscal policy action. As the model has been enhanced with the new debt−interest rate channel with everything else constant, and we will simulate the shocks considered in the previous chapter, this chapter should allow for the detection of changes in the results due to the new channel.

Technically, the analysis will develop in three steps: first, we extend our model in order to account for the link between government debt (B) and the long-term real interest rate ($\overline{R}$), which is equal to the inverse of the households' discount rate (β);[80] second, we describe the models' long-term relation between the parameter β and equilibrium output, in order to account for the changes in the steady-state variables affected by changes in the equilibrium interest rate; third, the transition path to a new steady-state after some fiscal shock is then derived by adding-up both the dynamics present in the previous chapter and the transition of the economy into a different steady-state.

As before, we will consider three different types of fiscal shock in the two usual scenarios (a perfectly competitive labor market and a labor market characterized by monopolistic competition): i) a non-productive government spending shock; ii) a weakly productive government spending shock; and iii) a weakly-productive public employment shock.

5.3.1 Government debt and long-term real interest rate

The extension of our model in order to account for the relation between government debt (B) and long-term real interest rate ($\overline{R}$) follows closely Coenen *et al.* (2008). They allow upward deviations of the debt ratio ($\frac{B_t}{\overline{Y}}$) from the steady-state level ($\frac{\overline{B}}{\overline{Y}}$) to have a direct and positive effect on the

[80] See equation (50).

real equilibrium interest rate, which is by definition equal to the inverse of the households' discount rate ($\overline{R} = \frac{1}{\beta}$). The relation is given by:

$$R_t = \frac{1}{\beta_t} = \frac{1}{\beta} + \theta \left(\frac{B_t}{\overline{Y}} - \frac{\overline{B}}{\overline{Y}} \right). \tag{96}$$

The parameter θ measures the sensitivity of the equilibrium real interest rate to changes in the expected debt-to-GDP ratio. Our baseline calibration of this parameter is 0.003125, implying that a one pp reduction in the annual public debt-to-GDP ratio (relative to its steady-state level) results in a decline of the annualized equilibrium real interest rate of 5 bp. This is in line with the range of estimates reported in the literature for the pure direct impact of public debt changes on long term interest rates. Hence, our starting point is a rather conservative calibration, as this elasticity seems to be larger when the fiscal consolidation is generated by a cut in government spending.

5.3.2 Steady-State Analysis

This section describes the steady-state (SS) of the model. Some SS relations have already been described in previous chapters, such as the SS real interest rate (equation (50)), the SS real current value of the capital stock (equation (53)), the SS real rental rate of capital (equation(60)) and the SS capital accumulation equation (equation(61)).

From the conditions for cost minimization (equation (84)) and profit maximization (equation(85)) by the producers we get to,

$$\frac{\overline{w}\overline{N^p}}{\overline{r^k}\overline{K}} = \frac{1-\alpha}{\alpha} \tag{97}$$

and

$$\frac{1}{\mu} = \overline{w}^{(1-\alpha)} \left(\overline{r^k}\right)^{\alpha} \left(\overline{G^{lp}}\right)^{-\gamma} \left(\overline{G^{hp}}\right)^{-\eta} \left(\overline{N^g}\right)^{-\nu} \alpha^{-\alpha} (1-\alpha)^{-(1-\alpha)}. \tag{98}$$

The SS optimal labor supply can be directly derived from equation (23),

for a monopolistic competitive labor market, or equation (78), for a perfectly competitive labor market, respectively:

$$\left[(1-h)\,\overline{C}\right]^{-\sigma_c}(1-\overline{\tau}^n)\overline{w} = (1+\lambda_w)\overline{N}^{\sigma_N}(1+\overline{\tau}^c) \tag{99}$$

and

$$\left[(1-h)\,\overline{C}\right]^{-\sigma_c}(1-\overline{\tau}^n)\overline{w} = \overline{N}^{\sigma_N}(1+\overline{\tau}^c). \tag{100}$$

Finally, the SS production function, the labor market clearing condition and the goods market equilibrium condition can be written as,

$$\overline{Y} = \overline{K}^{\alpha}\overline{N^p}^{(1-\alpha)}\left(\overline{G^{lp}}\right)^{\gamma}\left(\overline{G^{hp}}\right)^{\eta}\overline{N^g}^{\nu}, \tag{101}$$

$$\overline{N} = \overline{N^p} + \overline{N^g} \tag{102}$$

and

$$\overline{Y} = \overline{C} + \overline{G^{lp}} + \overline{G^{hp}} + \overline{I} \Leftrightarrow \frac{\overline{C}}{\overline{Y}} = \gamma_c = 1 - \frac{\overline{G^{lp}}}{\overline{Y}} - \frac{\overline{G^{hp}}}{\overline{Y}} - \frac{\overline{I}}{\overline{Y}}. \tag{103}$$

After combining and rearranging the previous steady-state equations (all the equations and derivations are presented in appendix A.5), we obtain the following analytical solution for steady-state output, under monopolistic competition in labor market,

$$\overline{Y}^{(\sigma_N+\sigma_c)} = \frac{(1-\overline{\tau}^n)\overline{w}^{(1+\alpha\sigma_N)}\alpha^{(\alpha\sigma_N)}\left(\overline{G^{lp}}\right)^{(\gamma\sigma_N)}\left(\overline{G^{hp}}\right)^{(\eta\sigma_N)}\overline{N^g}^{(\nu\sigma_N)}}{(1-\alpha)^{(\alpha\sigma_N)}\left(\overline{r^k}\right)^{(\alpha\sigma_N)}(1-h)^{\sigma_c}\gamma_c^{\sigma_c}(1+\overline{\tau}^c)\left(1+\frac{\overline{N^g}}{\overline{N^p}}\right)^{\sigma_N}(1+\lambda_w)} \tag{104}$$

and the following under a perfectly competitive labor market,

$$\overline{Y}^{(\sigma_N+\sigma_c)} = \frac{(1-\overline{\tau}^n)\overline{w}^{(1+\alpha\sigma_N)}\alpha^{(\alpha\sigma_N)}\left(\overline{G^{lp}}\right)^{(\gamma\sigma_N)}\left(\overline{G^{hp}}\right)^{(\eta\sigma_N)}\overline{Ng}^{(\nu\sigma_N)}}{(1-\alpha)^{(\alpha\sigma_N)}\left(\overline{r^k}\right)^{(\alpha\sigma_N)}(1-h)^{\sigma_c}\gamma_c^{\sigma_c}(1+\overline{\tau}^c)\left(1+\frac{\overline{Ng}}{\overline{Np}}\right)^{\sigma_N}}. \quad (105)$$

Two features of equations (104) and (105) are noteworthy:

First, an increase in the discount rate (β) increases the SS values of investment through the reduction in the SS real capital rental price;[81] as the lower cost of capital induces capital accumulation, then the steady-state output increases.

Second, the reduction in the cost of capital, which may be seen as an income effect, induces an increase in the demand for labor, which leads to an higher SS real wage and an higher SS output.

Thus, a decrease in the long-term real interest rate, clearly induces an increase in the steady-state values of private investment and output.

5.4 Dynamic Effects of Fiscal Consolidations

This section reports the effects on output, private consumption and investment of the three different types of fiscal consolidations mentioned in the previous section. We will be using the new-Keynesian DSGE model with productive public inputs and a channel between public debt and the long-term interest rates developed in that section.

Following the process of implementation described above, each model simulation will be conducted in three steps: (i) calculation of the new discount rate generated by the public debt decrease, using equation (96); (ii) computation of the new steady-state values for the relevant macroeconomic variables, solving the system of steady-state equations; (iii) derivation of the transition path to the new steady-state by adding-up both the dynamics present in the previous chapter and the new dynamics of the transition of the economy into the new steady-state.

[81] Equation (60): $\overline{r}^k = \frac{\frac{1}{\beta}-\delta\overline{\tau}^k+\delta-1}{1-\overline{\tau}^k}$.

5.4.1 Fiscal consolidations and the discount rate

We consider the three different types of fiscal consolidation analyzed in chapter 4, under the two usual labor market scenarios (perfectly competitive and monopolistic competitive): i) a non-productive government spending shock ($\gamma = 0$); ii) a weakly productive government spending shock ($\gamma = 0.05$); and iii) a weakly-productive public employment shock ($\nu = 0.05$). Having in mind the purposes of our study and given that we have found in chapter 4 that, even without the interest rate effect, a fiscal consolidation induced by weakly-productive public employment produces non-Keynesian effects in a perfectly competitive labor market, we will skip this case.

We first calculate the new discount rate (β). Given that

$$\frac{B_t}{\overline{Y}} - \frac{\overline{B}}{\overline{Y}} = \widehat{B}_t \frac{\overline{B}}{\overline{Y}} = 2.4\widehat{B}_t \tag{106}$$

we use equation (96).[82] Results are summarized in table 5.1 below.

Table 5.1 - New discount rate and steady-state interest rate for selected fiscal consolidations

	Monopolistic competition			Perfect competition	
	Government spending shock		Public employment shock	Government spending shock	
	γ=0	γ=0.05	ν=0.05	γ=0	γ=0.05
$\frac{B_t}{\overline{Y}} - \frac{\overline{B}}{\overline{Y}}$	-0.614	-0.2208	-0.7392	-0.622	-0.3624
R_t	1.00808	1.00931	1.00769	1.0075	1.00887
β_t	0.99198	0.99078	0.99237	0.99201	0.99121

Notes: 1) See equation (96) for relation between the parameters in the table.
2) Coefficient θ in equation (96) is calibrated as 0.003125.

Recall that, with our calibration, a reduction of 1 pp in the debt-to-GDP

[82] $\widehat{B}_t$ is the percentage deviation of real public debt from the steady-state value ($\frac{B_t - \overline{B}}{\overline{B}}$).

ratio induces a decrease of 5 bp in the long-term real interest rate. Hence, the positive relation between the discount rate and the success of the fiscal consolidation in the table. In accordance to the consolidation effects of each fiscal shock already detected in the previous chapter, β decreases with the degree of the public spending productivity and increases with the degree of competition in the labor market, everything else constant.

5.4.2 The new steady-state and the transitional path

Given the new discount rates, we now proceed to compute the new steady-state values of the main macroeconomic variables. Then, we derive the transition path to the new steady-state, adding-up both the dynamics present in the previous chapter and the transitional dynamics into the new steady-state (structural supply-side effect). Figures 5.2 to 5.6 show the new steady-state and the transition path for each of the fiscal shocks leading to the consolidation (and labor market environment).

The main conclusions that can be drawn from the results of the simulations may be summarized as follows.

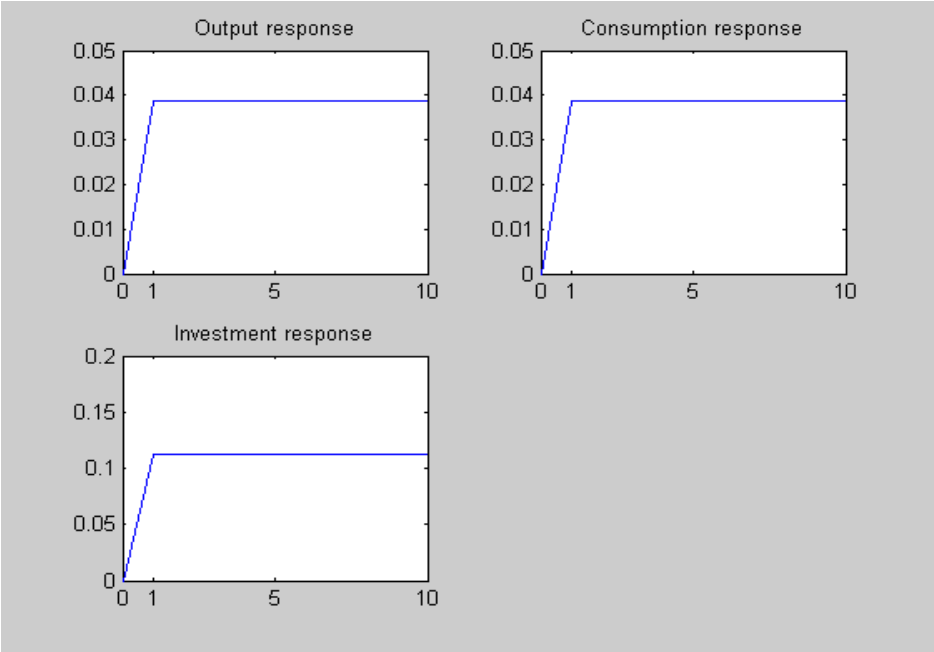
First, none of the five consolidation strategies generate non-Keynesian effects on impact (*i.e.* immediately after the fiscal shock).

Second, the larger non-Keynesian effects occur when the consolidation is based in the cut of non-productive government spending, in which output surpasses its original steady-state level since period 2 (both in monopolistic and perfect competitive labor markets). When the consolidation is based on the cut of the weakly-productive public employment, there is a positive effect on output on impact, but the rather strong negative impact on investment (see figure 4.10) induces a new decrease in output. Then, non-Keynesian effects appear from around the fifth quarter. In both consolidations, the steady-state effects induced by the decrease in the long-term interest rate generates a strong positive impact on private investment that, in two to five quarters, offsets the direct negative impact of the fiscal contraction on output.

FIGURE 5.2 - Non-productive government spending

(monopolistic competition)

Steady-state



IRFs - Transitional path

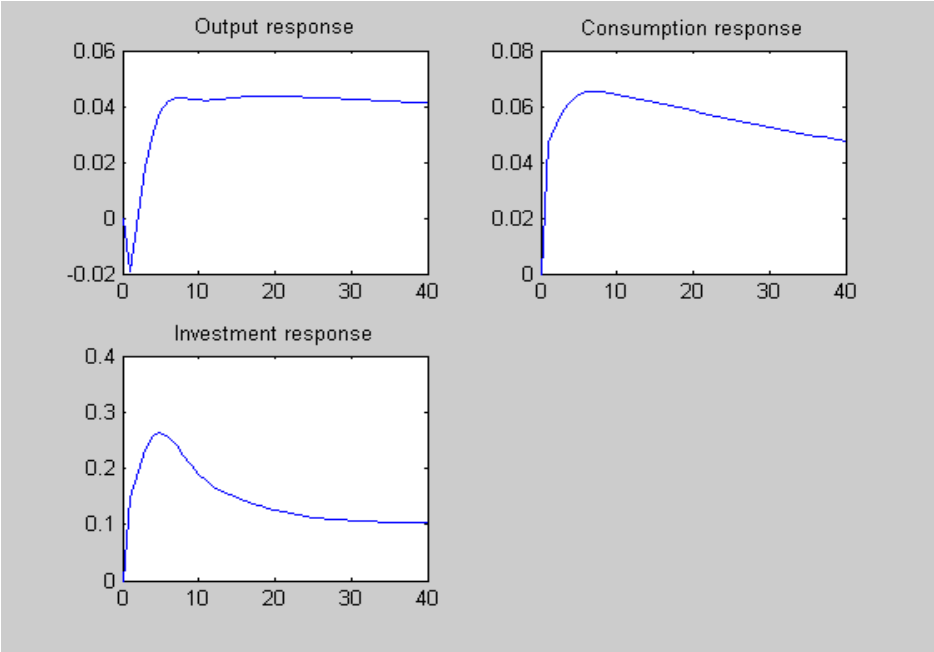
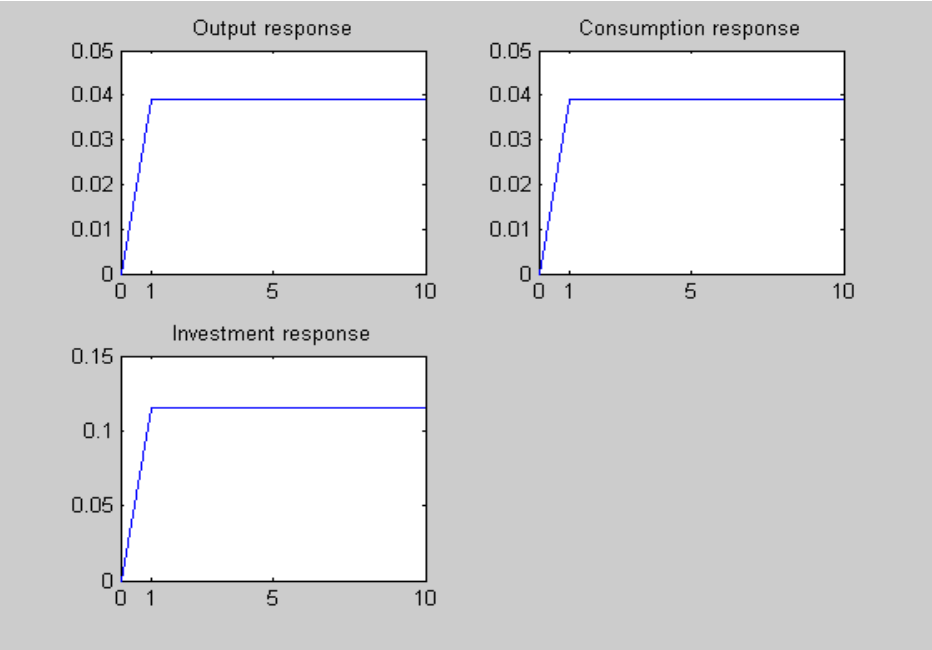


FIGURE 5.3 - Non-productive government spending

(perfect competition)

Steady-state



IRFs - Transitional path

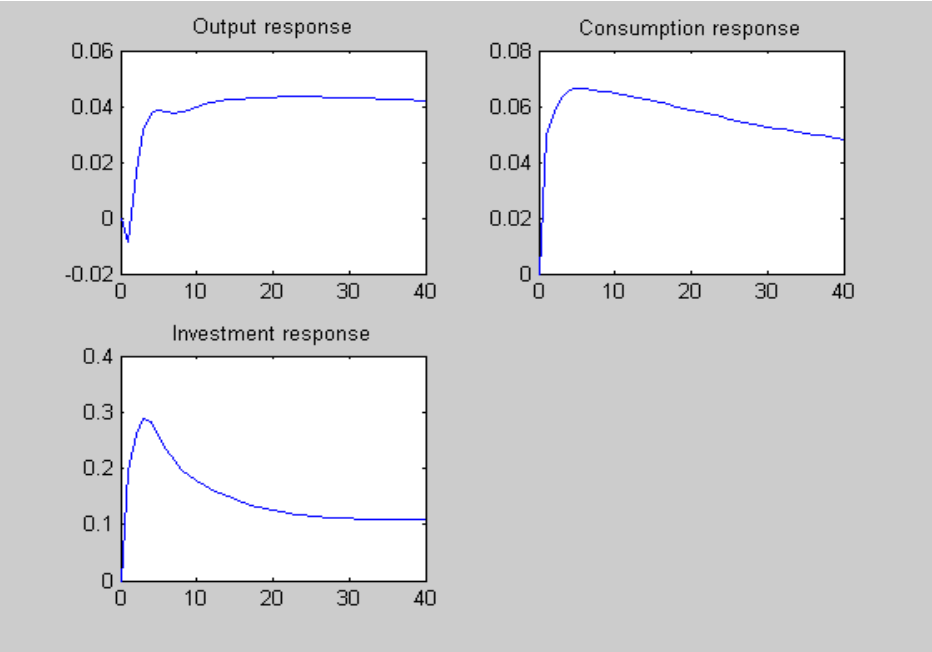
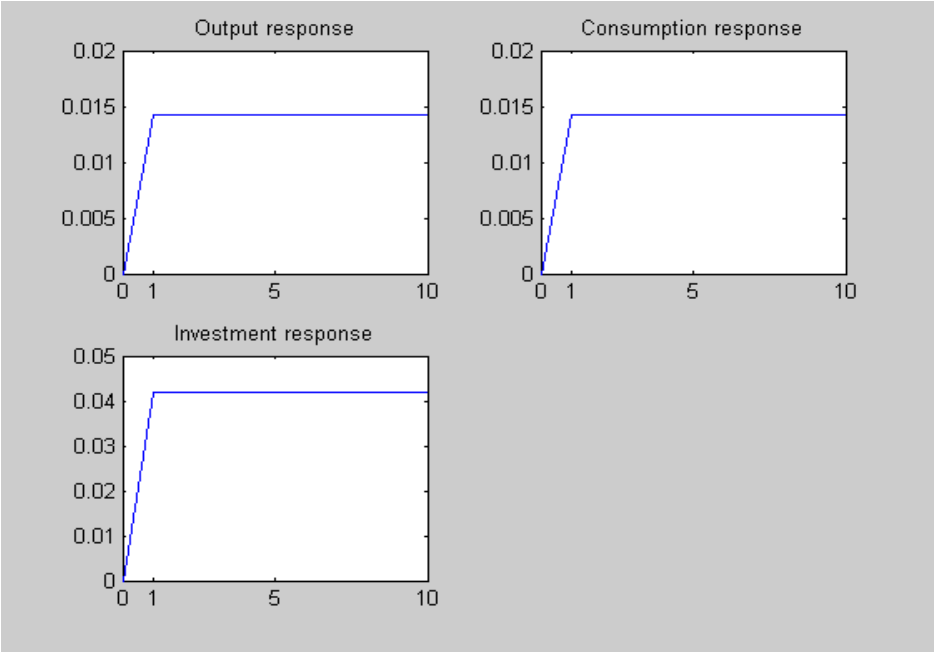


FIGURE 5.4 - Weakly-productive government spending

(monopolistic competition)

Steady-state



IRFs - Transitional path

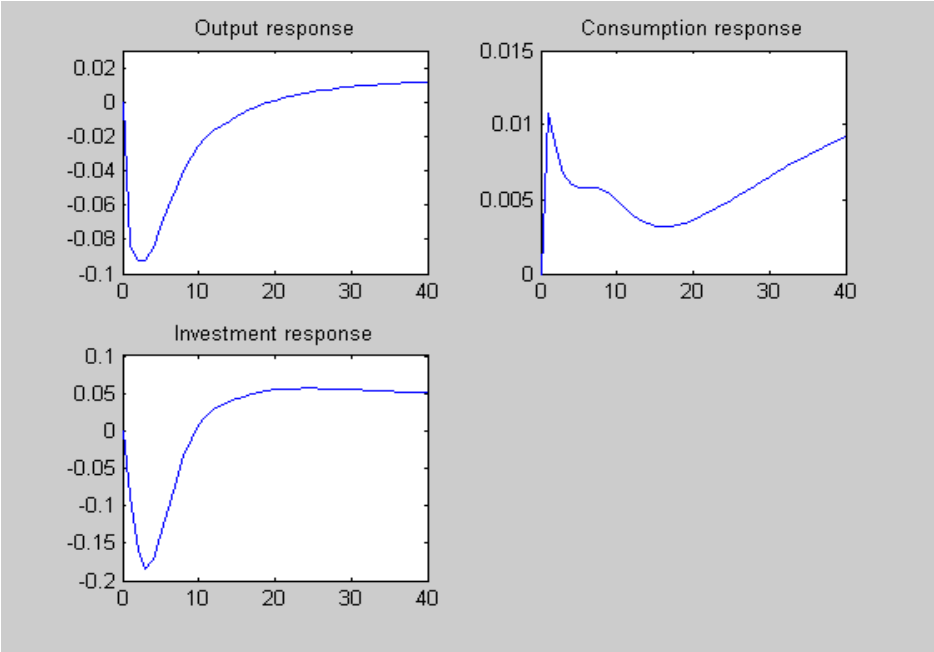
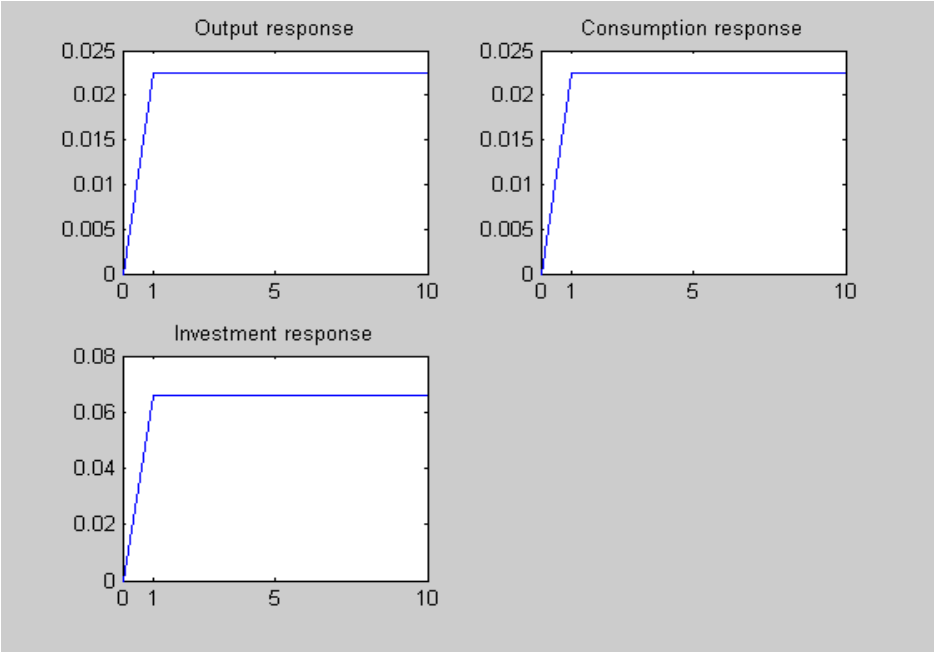


FIGURE 5.5 - Weakly-productive government spending

(perfect competition)

Steady-state



IRFs - Transitional path

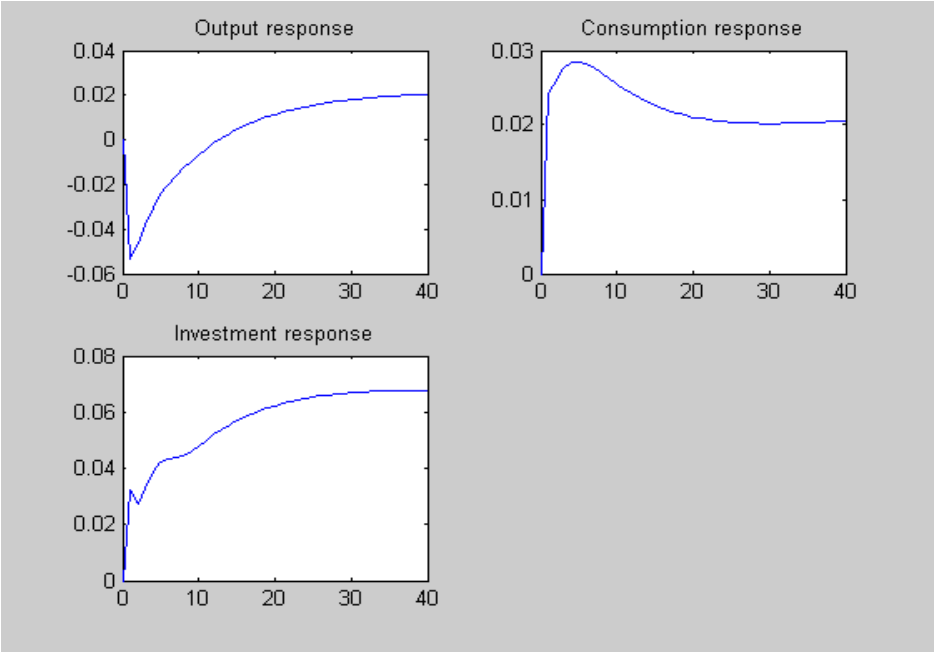
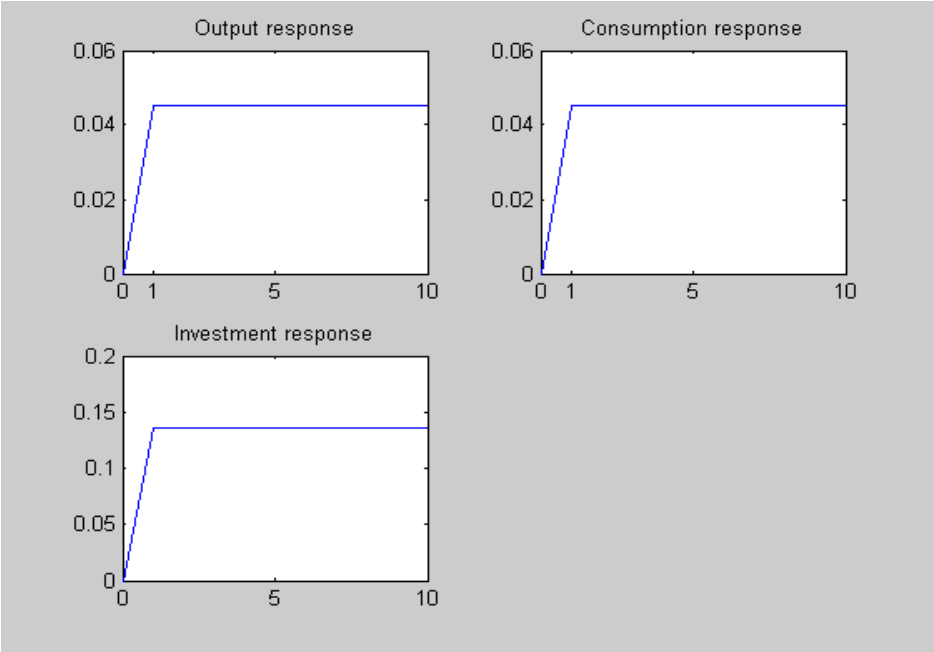


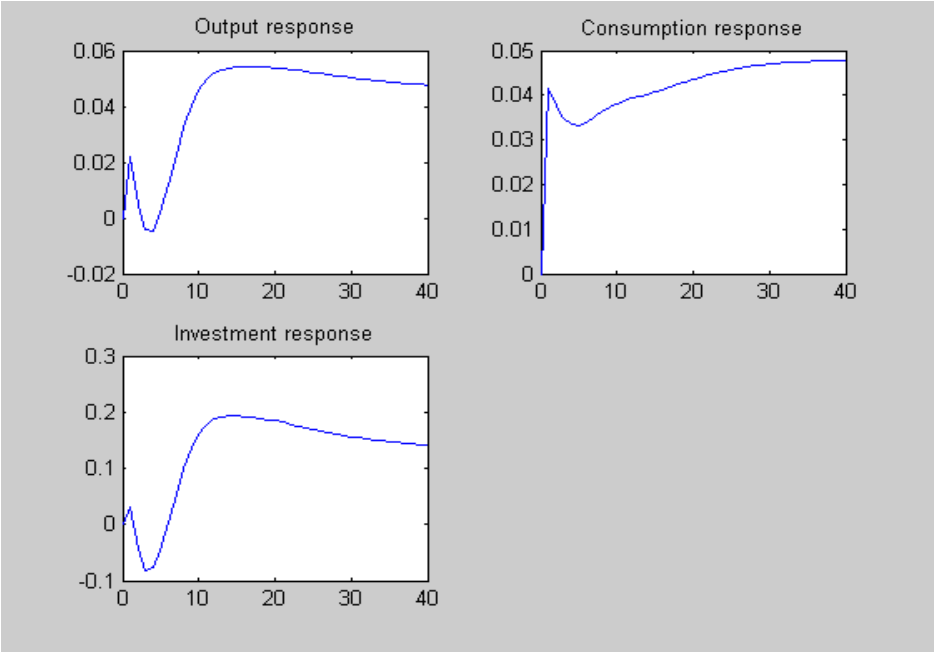
FIGURE 5.6 - Weakly-productive public employment

(monopolistic competition)

Steady-state



IRFs - Transitional path



Third, when the fiscal consolidation is based on the reduction of weakly-productive government spending, output exceeds its original steady-state level 3 years after the shock (under a perfectly competitive labor market). When the labor market has monopolistic competition, output crosses its previous steady-state 5 years after the shock. In these cases, it seems that is debatable to classify such delayed effects as non-Keynesian effects. This result may be explained by two reasons: (i) even without the long-term interest rate effect, a consolidation through weakly-productive government spending was associated with the higher contraction of short-run output (see figure 4.4); moreover, (ii) the steady-state effects are rather limited because, as we have seen in chapter 4 (figure 4.1), this type of consolidation induces a weak and not sustained response of debt and, thus, generates only a small decrease in the long-term interest rate.

5.4.3 Sensitivity analysis to the parameter θ

The parameter θ, which measures the sensitivity of the equilibrium real interest rate to changes in the expected debt-to-GDP ratio, has been calibrated so far in the presumption that a 1 pp reduction in the debt-to-GDP ratio induces a decrease of 5 bp in the long-term real interest rate. In the last subsection we have seen that with such calibration none of the five cases generate non-Keynesian effects on impact. Table 5.2 below shows the size of the long-term interest rate decrease that would be necessary to generate non-Keynesian effects on impact.

Table 5.2 - Sensitivity analysis

	Monopolistic competition	**Perfect competition**
γ=0	7.42 bp	6.08 bp
γ=0.05	37.91 bp	16.83 bp
ν=0.05	5.51 bp	---

As we have stressed before, in view of our literature review at the outset of this chapter, the value of 5 bp is a rather conservative value. As discussed in section 5.2, it could be argued that values between 5 and 10 bp may be

plausible. As Table 5.2 shows, values slightly higher than 5 would actually generate non-Keynesian effects on impact in all cases except when the fiscal consolidation is based on the reduction of the weakly-productive government spending. Here, the probability of the existence of non-Keynesian effects remains very low.

5.5 Dynamic Effects of a Fiscal Consolidation Under Imperfect Credibility

The adjustment of long-term interest rates to the public debt consolidation clearly depends on economic agents' expectations. Since agents participating in financial markets tend to take their decisions with a forward-looking perspective, the credibility of the fiscal consolidation is crucial to the possible impact on interest rates. Until now, we have analyzed a perfectly credible fiscal consolidation, that generated an immediate reduction in the long-term interest rate.

However, if economic agents have some doubts about the success of the fiscal consolidation, they may not anticipate the interest rate decrease. In order to account for such a possibility, we now consider two additional scenarios with respect to the fiscal consolidation credibility: (i) a medium-credibility consolidation and (ii) a low-credibility consolidation.

5.5.1 Medium-credibility consolidation

In this scenario, economic agents have some doubts about the success of the fiscal consolidation and, hence, they only anticipate immediately half of the expected decrease in long-term interest rate. We assume that the other half will be anticipated when the debt-to-GDP ratio reduction equals $\frac{1}{3}$ of the total expected reduction. Table 5.3 shows, for the five consolidating strategies, the period in which the $\frac{1}{3}$ reduction is reached, and the corresponding values for the discount rate.

Table 5.3 - Medium-credibility consolidation					
	Monopolistic competition			Perfect competition	
	Government spending shock		Public employment shock	Government spending shock	
	γ=0	γ=0.05	v=0.05	γ=0	γ=0.05
Period t: 1/3 debt reduction	6	4	5	6	4
β_1	0.99099	0.99039	0.99119	0.99100	0.99061
β_t	0.99198	0.99078	0.99237	0.99201	0.99121

Notes: 1) See equation (96) for relation between the parameters in the table.
2) Coefficient θ in equation (96) is calibrated as 0.003125.

Figures 5.7 to 5.11 show the new steady-states and the transition dynamics of the main macroeconomic variables, for each of the 5 cases of fiscal shocks/labor market competition. Differently from the previous pictures, the economy has now an intermediate steady-state, corresponding to the immediate reduction in the long-run interest rates and the final steady state, obtained after completion of 1/3 of the fiscal consolidation.

The main conclusions of these simulations may be summarized as follows.

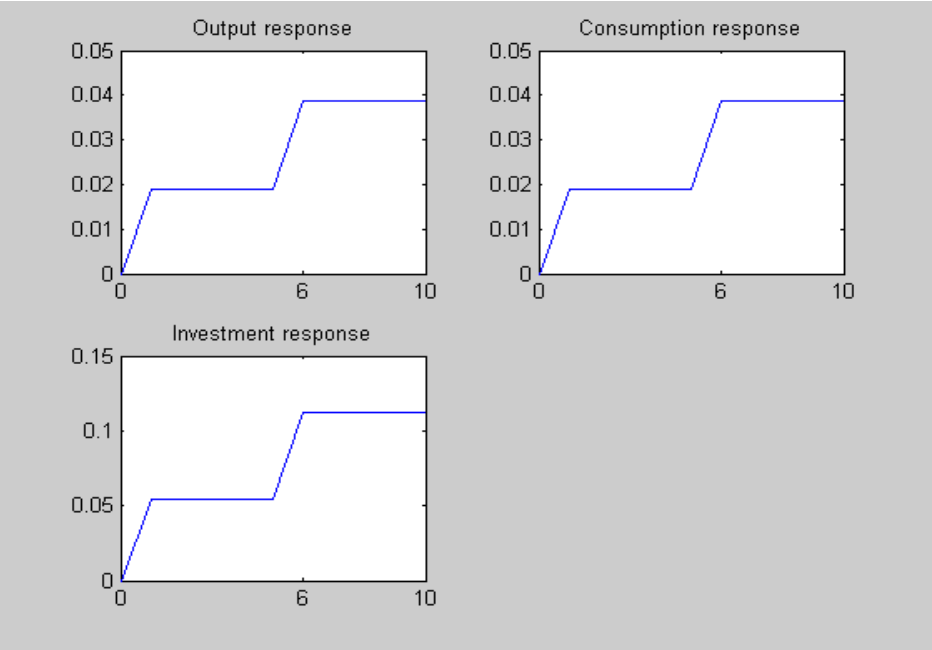
First, as expected, the occurrence of non-Keynesian effects has been reduced, in comparison to the baseline case of perfect credibility seen in the previous section.

Second, the larger non-Keynesian effects occur when the consolidation is based in the cut of non-productive government spending, in which output exceeds the level of the original steady-state in periods 3 and 4, respectively, with perfect competition and monopolistic competition in the labor market. When government cuts the weakly-productive public employment, non-Keynesian effects appear in the fifth quarter.

FIGURE 5.7 - Non-productive government spending

(monopolistic competition; medium credibility)

Steady-state



IRFs - Transitional path

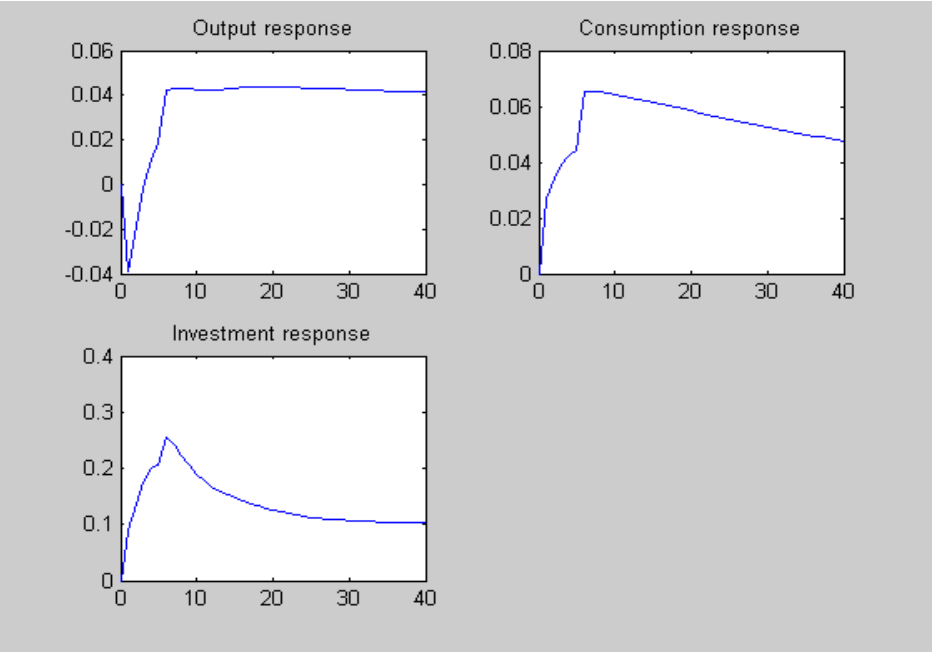
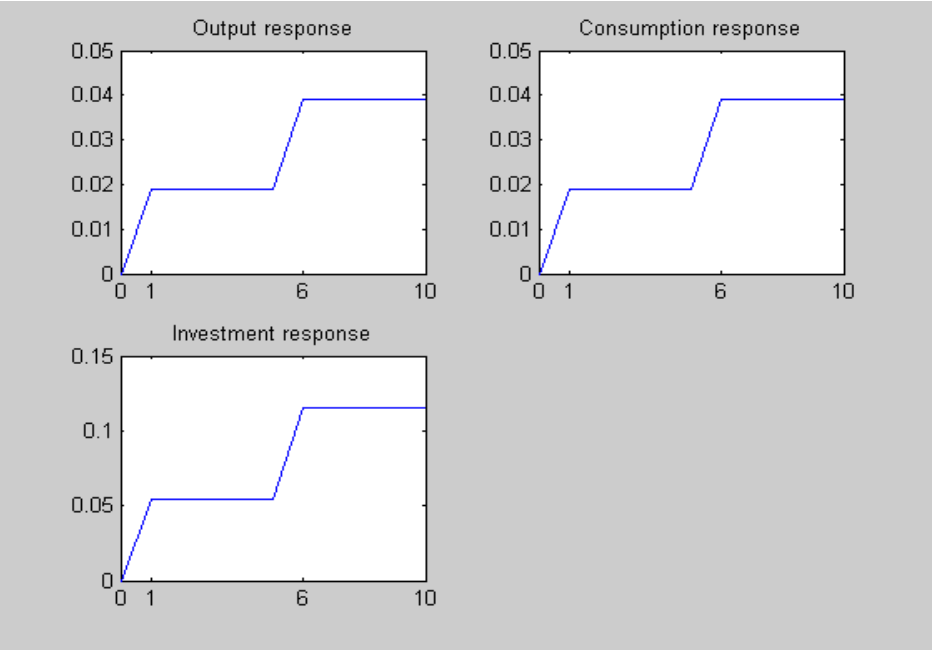


FIGURE 5.8 - Non-productive government spending

(perfect competition; medium credibility)

Steady-state



IRFs - Transitional path

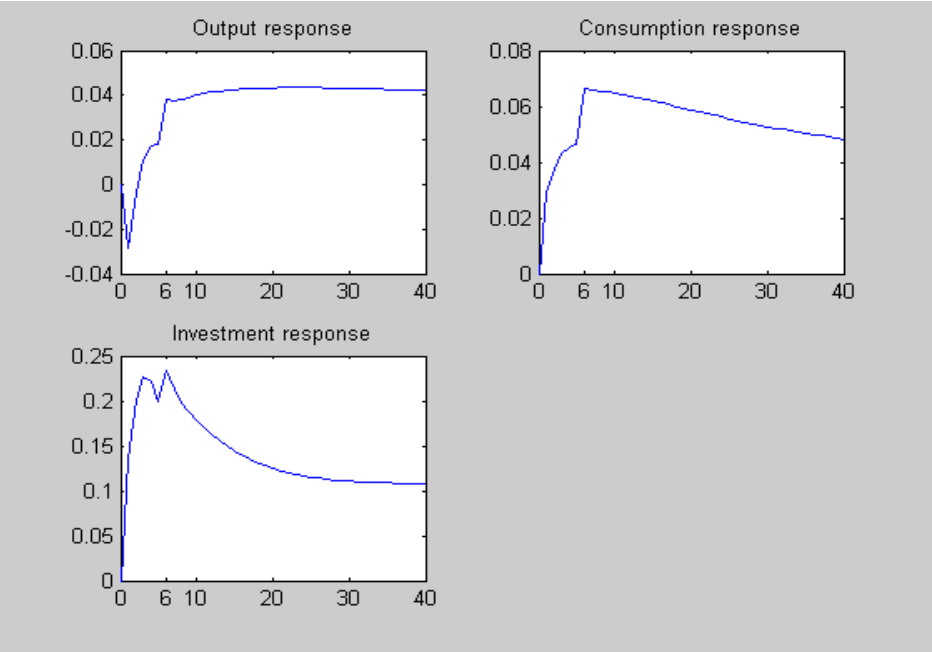
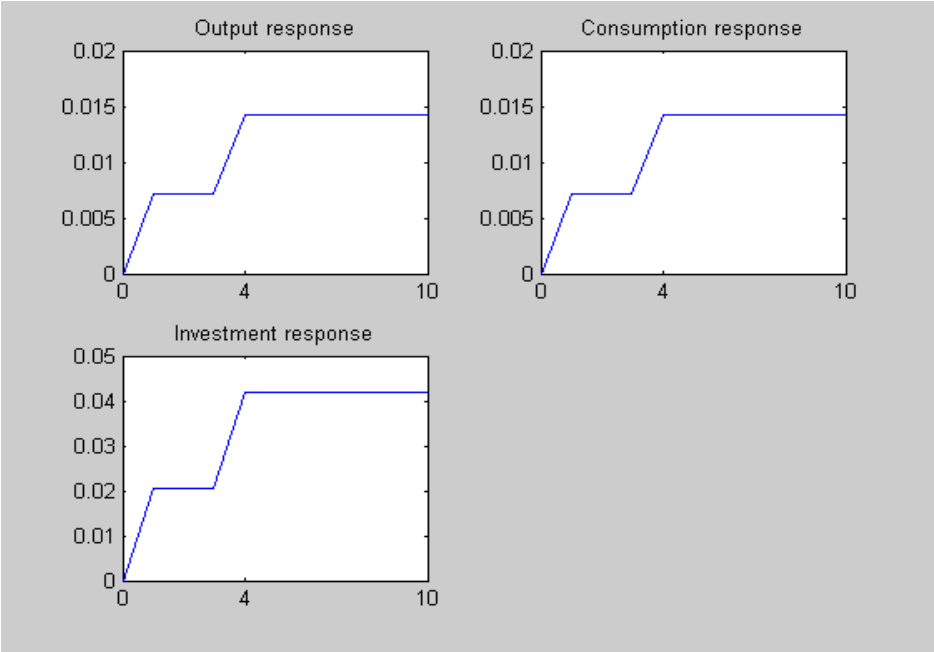


FIGURE 5.9 - Weakly-productive government spending

(monopolistic competition; medium credibility)

Steady-state



IRFs - Transitional path

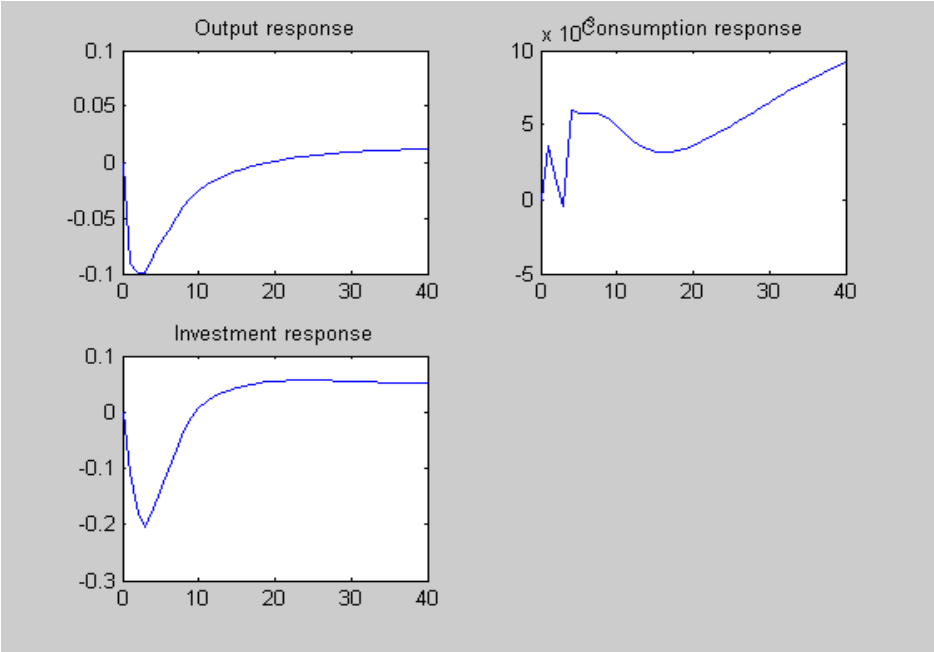
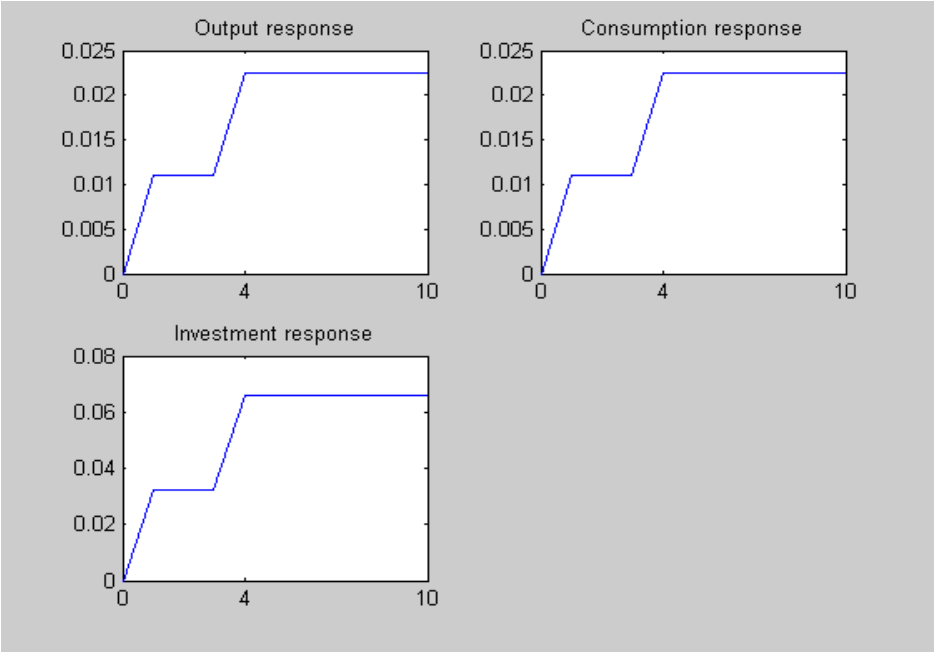


FIGURE 5.10 - Weakly-productive government spending

(perfect competition; medium credibility)

Steady-state



IRFs - Transitional path

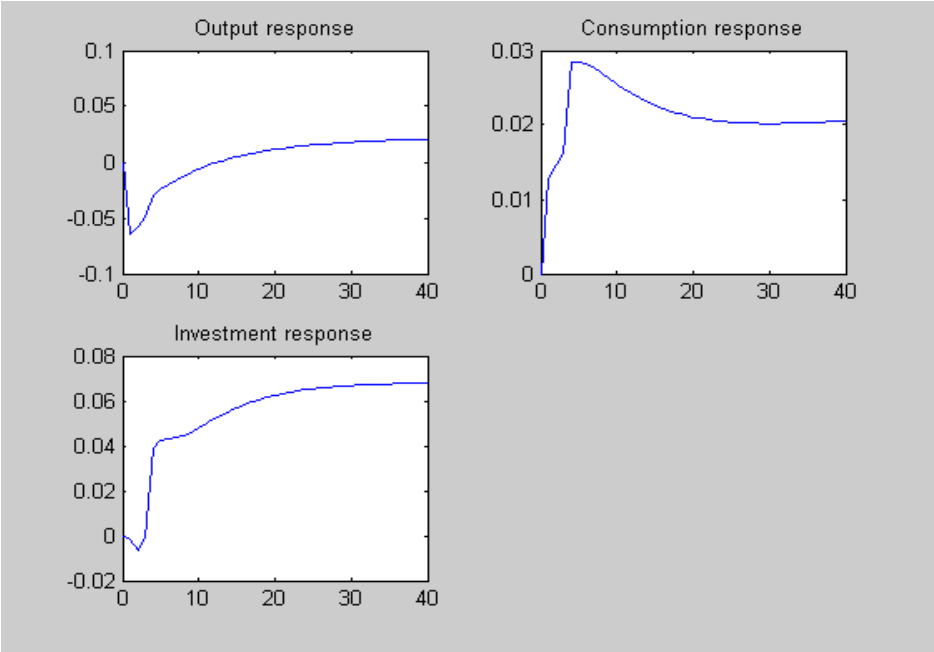
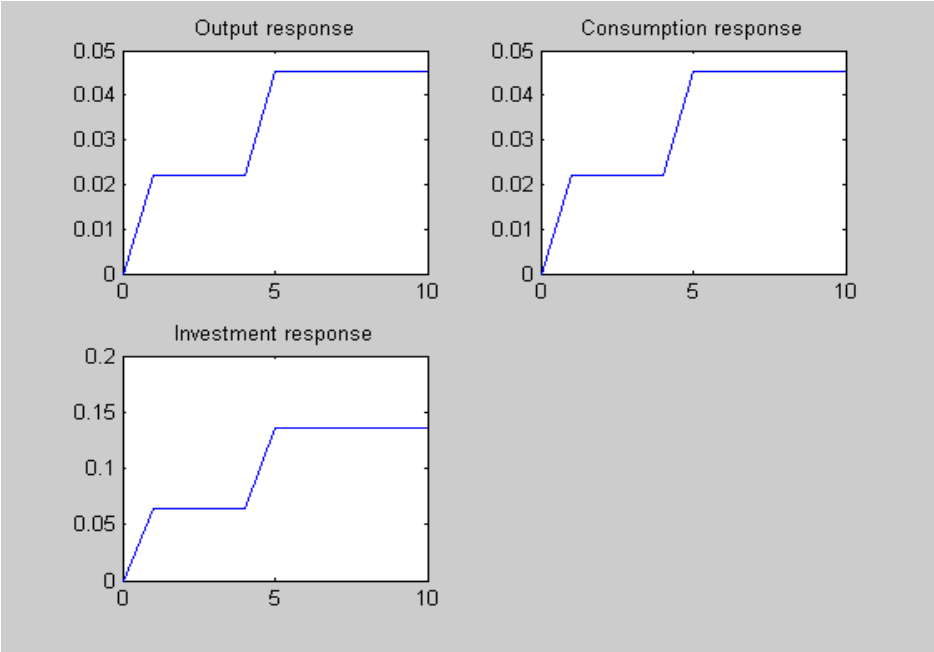


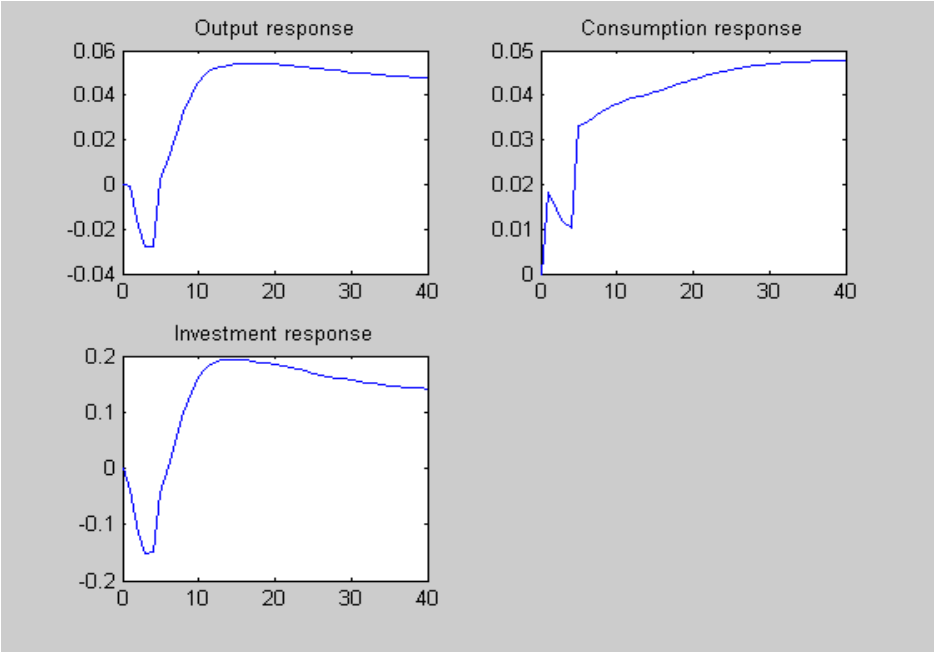
FIGURE 5.11 - Weakly-productive public employment

(monopolistic competition; medium credibility)

Steady-state



IRFs - Transitional path



Third, the results in the case of a fiscal consolidation based on the reduction of weakly-productive government spending in the perfect credibility scenario hold in the medium credibility scenario.

Fourth, non-Keynesian effects on impact would require a 1 pp reduction in the debt-to-GDP ratio induced a decrease of: (i) 12.38 bp and 15.07 bp, respectively in the perfect competition and monopolistic competition labor markets, when the consolidation is based on non-productive government spending cuts; (ii) 33.97 bp when the consolidation is based on weakly-productive government spending cuts in the scenario of a perfectly competitive labor market; (iii) 11.21 bp when the consolidation is based on weakly-productive public employment. Hence, immediate non-Keynesian effects are completely ruled out if the fiscal consolidation lacks credibility, even to a medium extent.

5.5.2 Low-credibility consolidation

In this scenario we assume that the fiscal consolidation completely lacks credibility at its outset. We assume that credibility arises when $\frac{1}{3}$ of the debt reduction is accomplished, but that from that moment onwards economic agents fully anticipate all the reduction of long-term interest rates. This implies that the discount rate only increases in period t but then it does go up to the value shown in table 5.3.

Figures 5.12 to 5.16 show in the upper panel the original and final steady-states – with the shift occurring at $\frac{1}{3}$ of the fiscal consolidation – and in the lower panel the transition path.

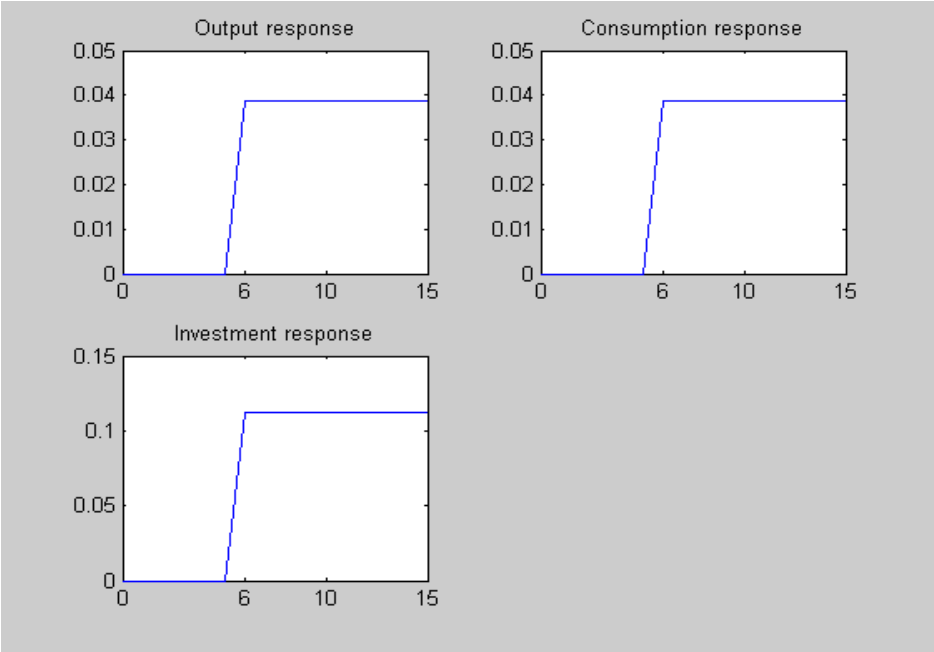
The main conclusions are the following.

First, as expected, the occurrence of non-Keynesian effects has been furthermore reduced, in comparison to the previous simulations.

FIGURE 5.12 - Non-productive government spending

(monopolistic competition; low credibility)

Steady-state



IRFs - Transitional path

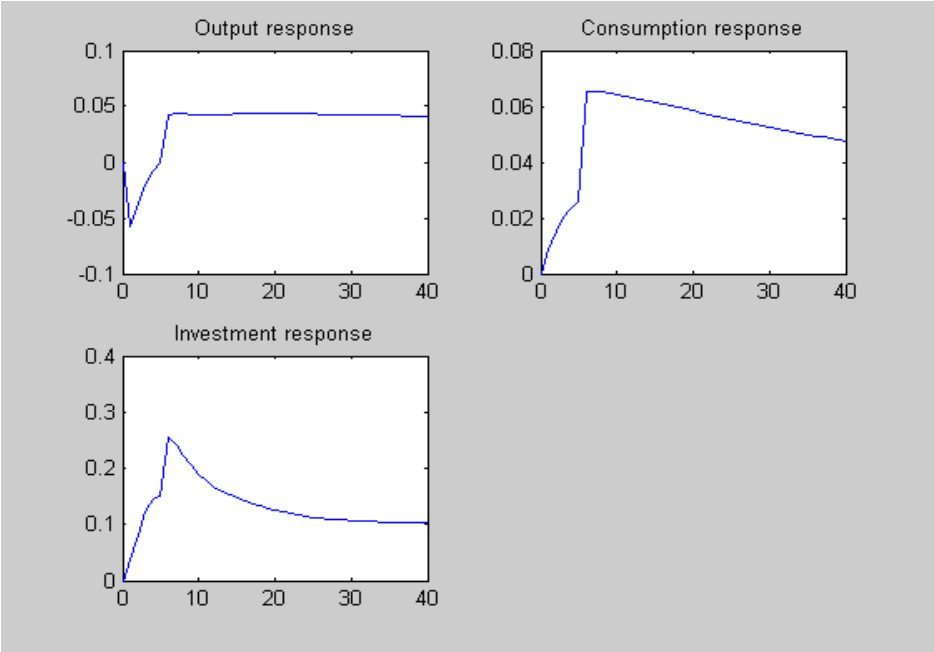
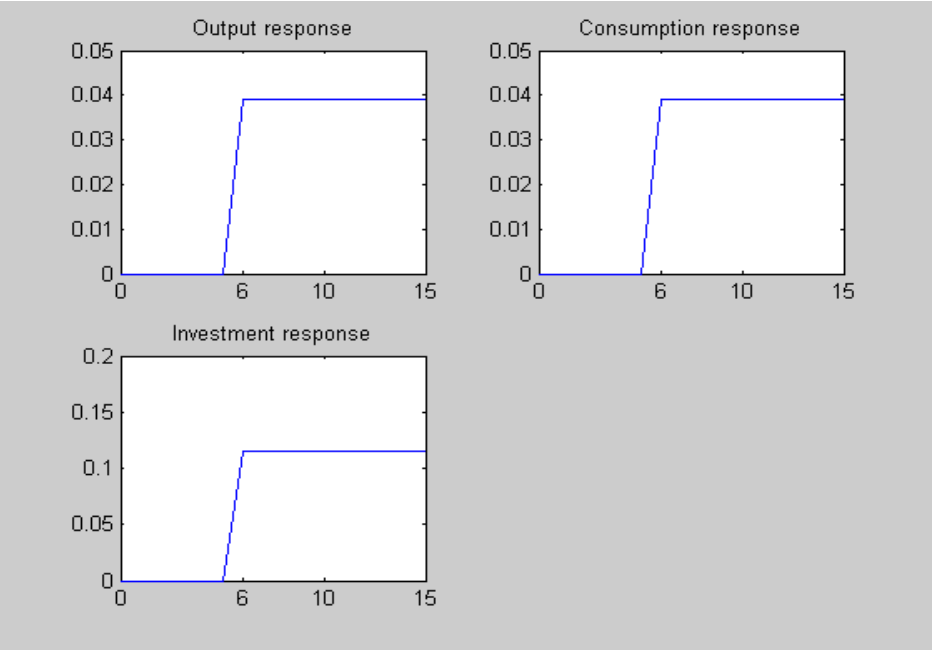


FIGURE 5.13 - Non-productive government spending

(perfect competition; low credibility)

Steady-state



IRFs - Transitional path

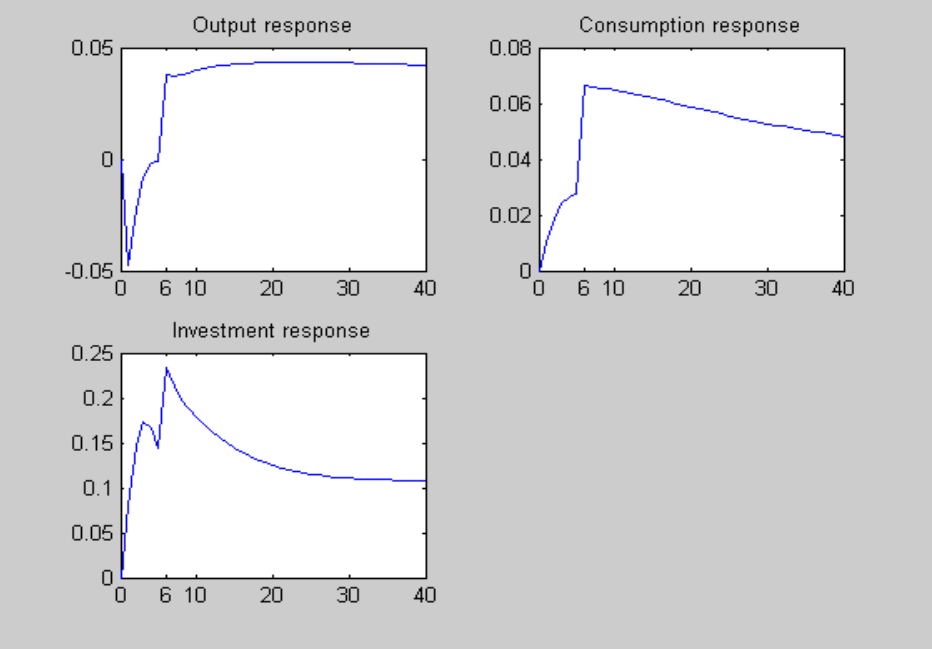
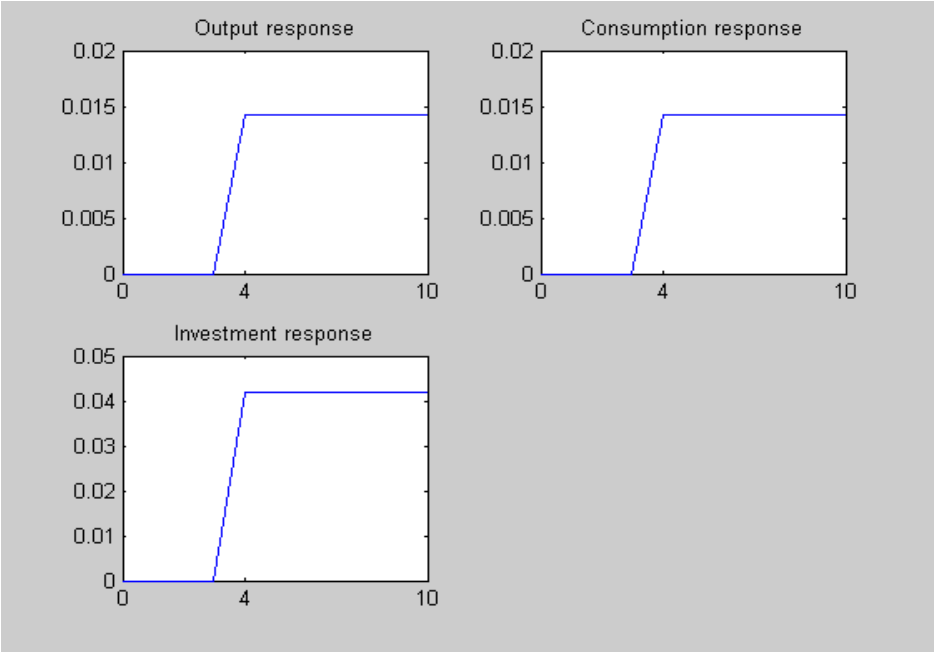


FIGURE 5.14 - Weakly-productive government spending

(monopolistic competition; low credibility)

Steady-state



IRFs - Transitional path

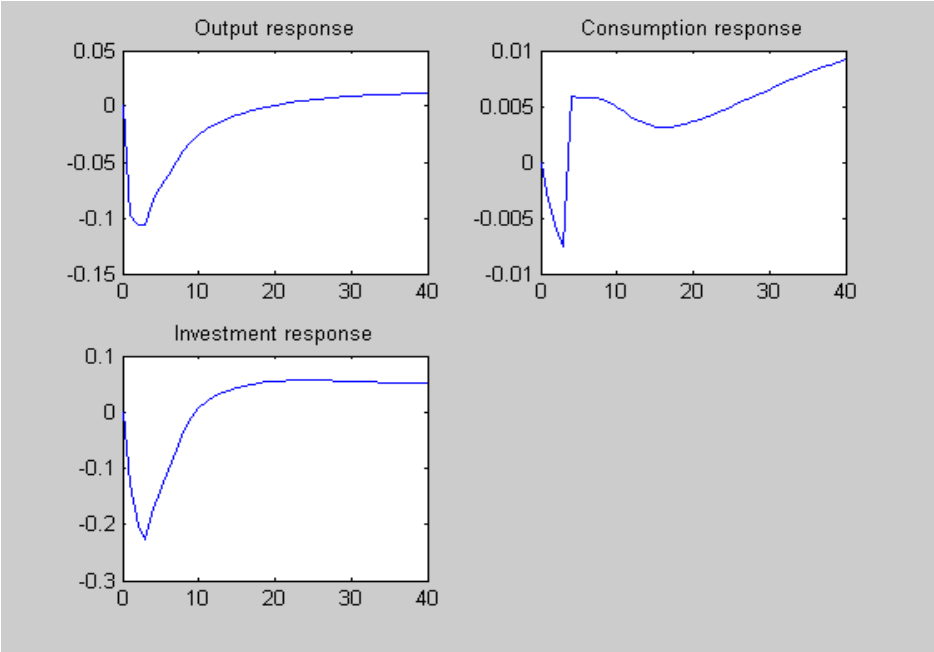
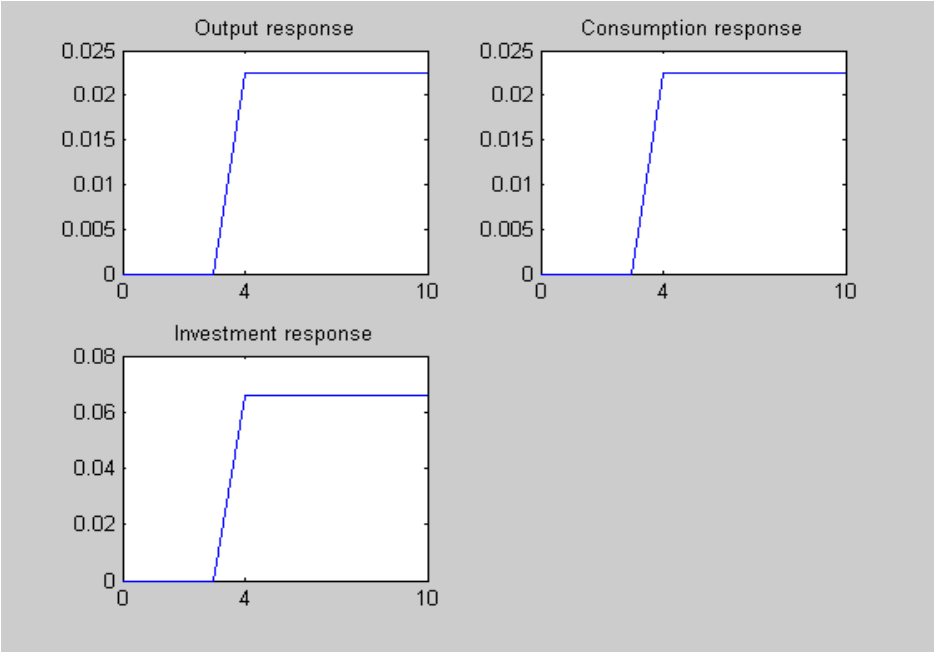


FIGURE 5.15 - Weakly-productive government spending

(perfect competition; low credibility)

Steady-state



IRFs - Transitional path

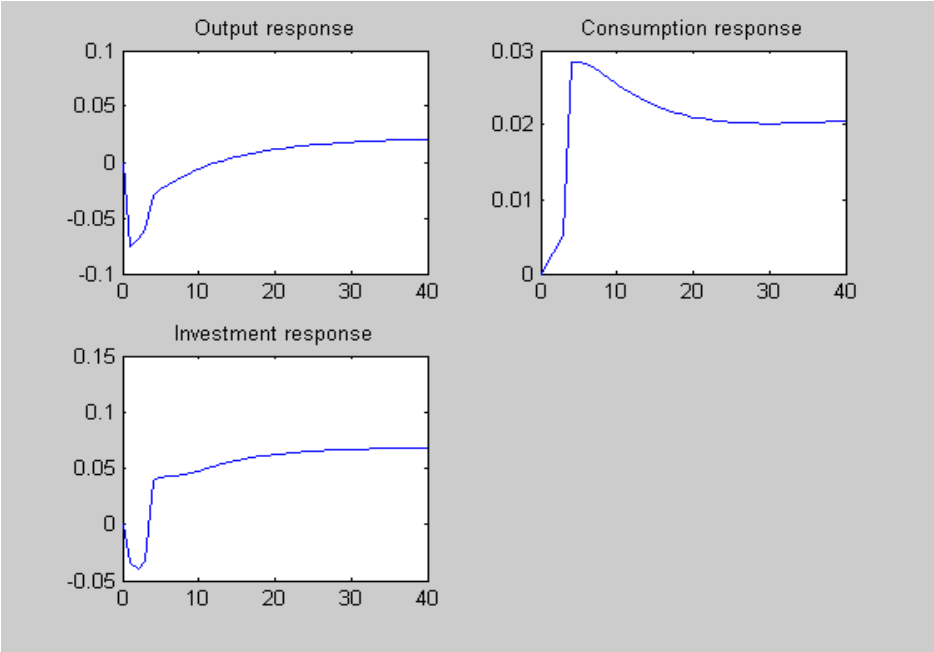
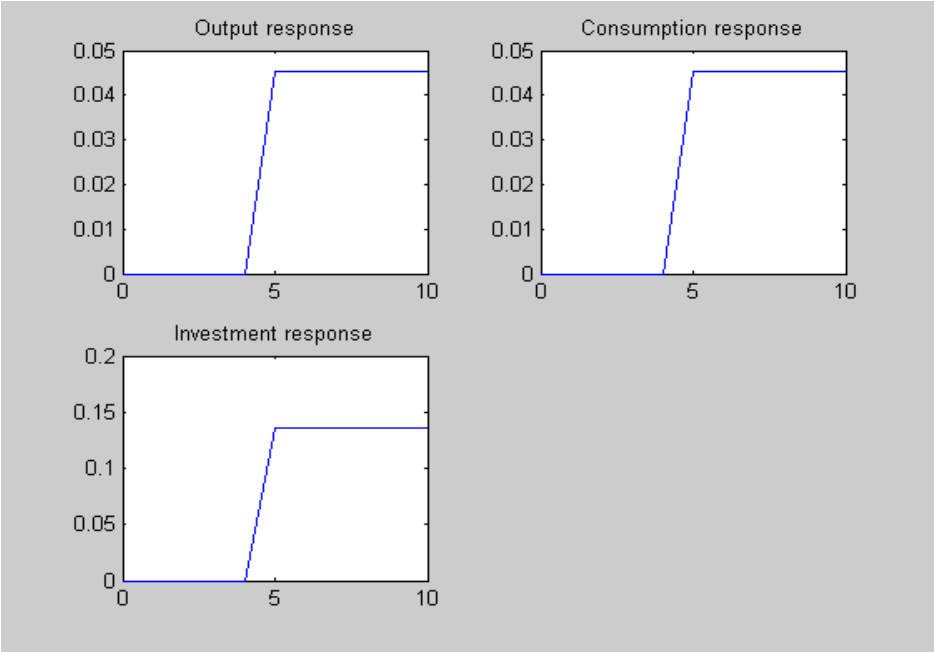


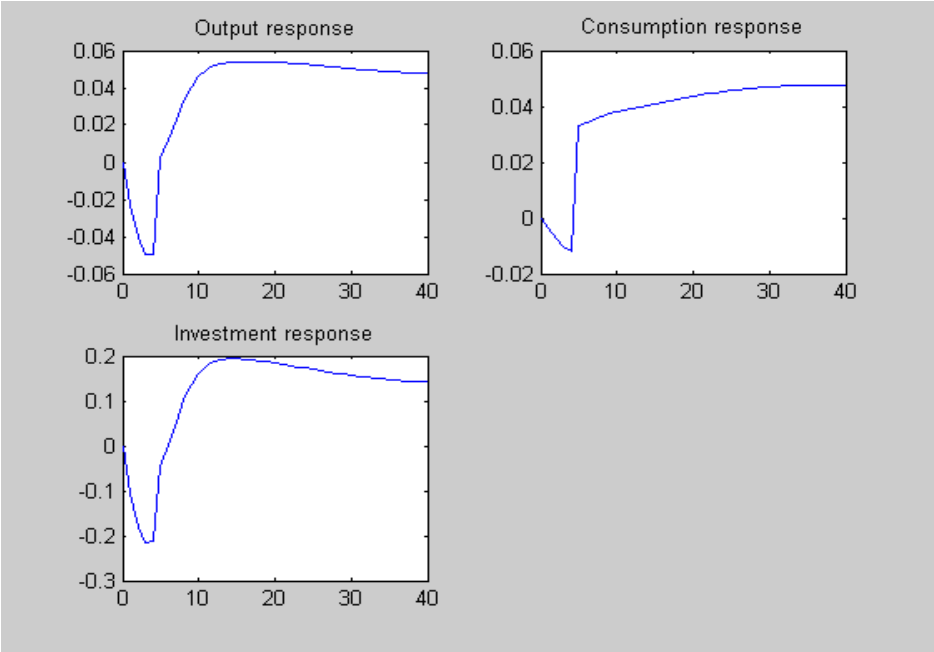
FIGURE 5.16 - Weakly-productive public employment

(monopolistic competition; low credibility)

Steady-state



IRFs - Transitional path



Second, the larger non-Keynesian effects occur when government cuts the weakly-productive public employment, where persistent non-Keynesian effects appear in the fifth quarter. When the consolidation is based on the cut of non-productive government spending, non-Keynesian effects arise slightly later, in both labor market scenarios, namely around a year and a half after the fiscal policy shock.

Third, the results in the case of a fiscal consolidation based on the reduction of weakly-productive government spending have remained identical to those of the other two credibility scenarios.

Fourth, irrespective of the value of the discount rate, there is never non-Keynesian effects on impact in all of the fiscal consolidation cases.

5.6 Summary and Final Remarks

This chapter has explored another possible transmission mechanism, among those identified in chapter 2, for the investment channel of non-Keynesian effects of fiscal consolidations – the relation between the level of the fiscal deficit, or debt, and the long-run interest rates.

In order to motivate the chapter, we firstly reviewed the theoretical and empirical literature that considers how long-run interest rates may be affected by the level of the fiscal deficit and debt. At a theoretical level we have found that although some approaches may lead to ambiguous predictions, there seems to have emerged a consensual hypothesis that fiscal profligacy is associated with higher long-run interest rates. We have presented quotes from well known academics involved in policy making pointing out that episodes of mounting fiscal indiscipline have been associated with increasing interest rates, while more recent episodes of fiscal adjustment have engendered declining interest rates. Our survey of the empirical literature has found some heterogeneity of results but, clearly, a positive correlation between fiscal deficits or debt and long-run interest rates is uncovered in studies that properly look at the structural and prospective state of public finances and its relation to interest rates that are actually long-term ones. On the basis of this finding we conclude that at the heart of the relation

deficit/debt-interest rates are the expectations about the fiscal stance and sustainability, which puts the relation at the center of the fiscal consolidation processes that we aim to study. Two additional results in the literature are relevant for our analysis. First, while the estimates for the relevant elasticity seem somewhat smaller in the European case (comparing to the US case), overall the literature offers useful benchmarks for a calibration of the relation. Second, the relation seems to depend upon the initial state of the public finances, and thus it may be argued that it should be larger in episodes of fiscal consolidations.

The chapter then contributes to the literature by incorporating into the new-Keynesian DSGE model developed in chapter 4 (the baseline model of chapter 3 enriched with productive public spending and employment) a direct relation between the level of the public debt and the steady-state interest rate. The transmission mechanisms in our model, in addition to the standard demand-side effects and the effects on total factor productivity considered since chapter 4, now include a structural supply-side effect consisting of the impact of fiscal consolidation on the steady-state of the economy.

Technically, we proceed in three steps. First, we model the relation between the fiscal debt and the discount factor – which determines the steady-state interest rate – and calibrate the relation in agreement with the estimates for the elasticity given by the reviewed empirical literature. Second, we derive the steady-state of the economy explicitly solving for the relation between the discount factor (steady-state interest rate) and the main macroeconomic variables. Third, we derive the transitional path from the initial steady-state to the final steady-state with a simultaneous response to the fiscal shock.

Following the basic approach of the previous chapter we have considered three alternative fiscal shocks leading to the fiscal consolidation, namely reductions in weakly-productive public spending, in unproductive public spending and in weakly-productive public employment. All shocks have been simulated in two different models regarding the labor market, one with monopolistic competition the other with perfect competition. We have skipped the case of the employment-led consolidation in a perfectly competitive labor market, as in chapter 4 was clear that non-Keynesian effects would arise even

without the new transmission mechanism.

We considered as benchmark the case of perfect credibility of the fiscal consolidation, in which the discount factor shifts immediately with the fiscal shock and, thus, the steady-state of the economy jumps instantaneously. The simulations have shown that in none of the fiscal consolidations output increases immediately after the tightening fiscal shock. It may be argued that there are non-Keynesian effects in the case of consolidations based on unproductive spending and weakly-productive employment, in which output surpasses the initial level as soon as in the second and fifth quarter, respectively. In contrast, fiscal consolidations entirely based on cuts in weakly-productive spending can not be considered to generate non-Keynesian effects, as output exceeds its initial level only after three or five years, respectively, for perfect competition and monopolistic competition labor markets. As a sensitivity analysis, we have computed the reduction of the steady-state interest rate per percentage point of debt reduction that would generate immediate non-Keynesian effects – *i.e.* increases in output since the first period of the fiscal adjustment. We have found magnitudes that are plausible in light of the literature in the first three cases – between 5.5 and 7.4 basis points – but not in the case of cuts in weakly-productive spending – between 16.8 and 37.9 basis points.

As a sensitivity check to our baseline results, we have assumed two alternative scenarios with more pessimistic assumptions regarding the credibility of the fiscal consolidation. In fact, the baseline results assume perfect credibility: it is assumed that the economic agents instantaneously believe in the consolidation and thus there is an immediate jump in the steady-state interest rate, and all the adjustments run under the new steady-state. Specifically, we assumed a scenario of medium-credibility in which only half of the reduction in the steady-state interest rate occurs on impact and the remaining fall in the long-run rate occurs when the public debt reaches one third of the total adjustment; and a low-credibility scenario, in which agents only believe in the consolidation once the public debt falls by one third of the total planed reduction, at which moment they adjust completely their expectations of the long-run interest rate (*i.e.* the steady-state interest rate switches to its new

value).

Table 5.4 summarizes the results under the baseline and these alternative credibility scenarios. As expected, the lower the credibility the less prevalent are the non-Keynesian effects. However, in the medium-credibility scenario, consolidations based on unproductive spending and weakly-productive employment, generate higher levels of output after three to five quarters, depending on the instrument and the labor market structure. Thus, such a decrease in credibility generates a very slight shift forward of the effects, in comparison to those obtained under perfect credibility. Overall, the possibility of increases in output on impact changes more substantially and the required fall in the interest rate per percentage point of debt reduction is above the 10 basis points threshold that has been identified in the literature. In the scenario of low credibility, the results change more markedly. In the case of a fiscal consolidation based on weakly-productive spending, output surpasses its initial steady-state level only after more than six quarters, which can hardly be classified as a non-Keynesian effect. The exception is the result of a consolidation based on cuts in weakly-productive employment, in which there is hardly a change in the horizon within which output surpasses its initial level. Overall, there is no realistic calibration that would generate non-Keynesian effects on impact.

TABLE 5.4 - Non-Keynesian effects in a NK-DSGE model with productive public spending and employment and a debt-interest rate channel

Fiscal shock	Productive elasticity	Monopolistic competition			Perfect competition		
		Perfect credibility	Medium credibility	Low credibility	Perfect credibility	Medium credibility	Low credibility
Spending	γ=0	(++)	(++)	(+)	(++)	(++)	(+)
	γ=0.05	(–)	(–)	(–)	(-)	(-)	(-)
Employment	ν=0.05	(+)	(+)	(+)	n.a.	n.a.	n.a.

Notes:
(++): output exceeds initial level within 4 quarters after the fiscal shock.
(+): output exceeds initial level within 4 to 8 quarters after the fiscal shock.
(-): output exceeds initial level within 8 to 16 quarters after the fiscal shock.
(--): output exceeds initial level more than 16 quarters after the fiscal shock.
n.a.: non available.

To sum-up, the simulations in this chapter suggest that when the initial state of the public finances is such that the long-run interest rate is sensitive

to changes in the level of the public debt, so long as the consolidation is credible and based in cuts either on unproductive spending or weakly-productive public employment, non-Keynesian effects do arise. Evidently, if such a consolidation is based on shifts from less to more productive expenditures of the sort examined in chapter 4 (simulations not presented), non-Keynesian effects would be even more marked.

The results in chapter 4 and in this chapter suggest that the structure of markets – at least of the labor market – often affect the output results of fiscal consolidations. In the next chapter we explore yet another channel for non-Keynesian effects of fiscal policy, considering scenarios in which the fiscal consolidation coincides with some degree of deregulation in the goods as well as the labor market.

6 The Supply-side Effects: Markets Reforms and Competition

"*The beneficial effects of* (public) *expenditure reforms can be reinforced if they are conducted as a part of a comprehensive reform programme where macroeconomic or structural bottlenecks elsewhere in the economy are eliminated at the same time.*" (Hauptmeier *et al.* (2007), p.294)

This chapter explores a third investment-related channel for possible non-Keynesian effects of fiscal consolidations. The channel is open when the fiscal consolidation is combined with deregulating reforms that create a more competitive environment, either in the products market or in the labor market. There are some references to this supply-side channel for non-Keynesian effects in the literature as, for example, Alesina and Perotti (1995, 1997a and 1997b), Alesina *et al.* (2002) and Ardagna (2007). However, as far as we know, there has been yet no explicit incorporation of this channel in a new-Keynesian DSGE model. Moreover, the literature is rather biased toward the study of the regulation and competition of the labor market, with that of the product market and price markup hardly seen in studies of the effects of fiscal policy.[83]

Although still lacking a strong theoretical foundation or a large corpus of hard empirical evidence at a macro level, there is anecdotal evidence of fiscal consolidations associated to increased competition leading to productivity gains and stimulating private investment and output, especially in an environment of monopolistic competition.[84] Hence our conjecture in this chapter: that a fiscal consolidation, either by a positive direct impact on competition levels, or by a combination with structural reforms improving competition

[83] In this kind of models, markups are usualy assumed as exogenous parameters. There is some literature of DSGE models with endogenous markups, but that are not especially concerned with fiscal policy (see, for example, Rotemberg and Woodford (1991) and Gali (1995)). An exception is Costa (2004) who uses a Cournotian monopolistic framework, with endogenous price markup, to analyse fiscal policy effectiveness.

[84] For surveys see, for example, Ahn (2002) and Schiantarelli (2005).

may generate non-Keynesian effects. We next review the literature motivating the simulations subsequently presented in this chapter, looking both at the direct effect and the junction of a demand side intervention and a supply side reform.

6.1 Theoretical and Empirical Motivation

A standard result in the literature is that the fiscal multiplier is higher under monopolist competition and is positively associated to the markups, due to a profit multiplier.[85] In short, an increase in government spending and aggregate demand and output generates an increase in profits and, hence, higher levels of consumption and investment; yet, the usual wealth effect that dampens the multiplier, tends to be less severe if firms and workers have more monopoly power.

Several results in the previous chapters have pointed to such an effect in our model's responses to a fiscal shock. In fact, overall we have found smaller contractionary impacts of the fiscal consolidations for perfectly competitive labor market than for a market of monopolistic competition. The fiscal multiplier is higher with a monopolistic competitive labor market because of the effects of profits on investment, while in a perfectly competitive labor market the stronger reaction of the real wage generates lower marginal costs, putting an upward pressure on profits and investment, that dampens the multiplier.

Thus, we conjecture that the higher the degree of competition in both product and labor markets, the smaller the fiscal multiplier and the larger the probability of non-Keynesian effects.

Competition and macroeconomic performance It is well known from microeconomic and industrial organization theory that perfect competition delivers a better resource allocation and, thus, higher efficiency than monopolistic competition. It is also well known that this result holds at a macroeconomic level (see, among many others, Blanchard and Kiyotaki (1987)).

[85] See, among others, Dixon (1987), Mankiw (1988) and Startz (1989).

There is ample evidence in the literature linking competition to efficiency and growth through several mechanisms; in fact, competition: (i) promotes a shift of market shares from lower to higher productivity firms and of wages from lower to higher productive workers and, hence, a more efficient allocation of productive factors (Griffith and Harisson (2004)); (ii) stimulates technical efficiency, at the firm level (Green and Mayes (1991)) and at the industry level (Baily and Gersbach (1995)); (iii) increases the incentives to reduce x-inefficiencies and to improve the efficiency of the organization of work both by managers and workers, leading to a direct and positive effect on productivity of the existing firms;[86] (iv) enhances the incentives to higher investment in research and development as well as human capital, as firms and workers try to differentiate their products and labor skills (Nickell (1996), Bassanini and Ernst (2002)).[87]

Fiscal policy and competition We firstly address a branch of the literature about possible direct effects of fiscal consolidation on the degree of competition. The results are heterogeneous and may be summarized as follows.

On the one hand, the *elasticity approach* has argued that a fiscal contraction may increase the elasticity of demand and reduce the price markup.[88] This approach is based on the assumption that "*it seems reasonable to argue that public spending is less price-elastic than private spending for the most economies*"(Dixon and Rankin (1994), p.189); the argument goes, then, that

[86] As explained by the agency costs literature – including the seminal paper by Nickell (1996) and, for example, Disney *et al.* (2003) and Djankov *et al.* (2002) – the reduction of inefficiencies in labor organization derives from the fact that, in a more competitive environment, (i) it is easier for owners to monitor managers because it is easier to compare across firms, and (ii) the increased probability of losing market shares and, thus, of bankruptcy, induces managers to make a higher effort in order to avoid that scenario.

[87] However, some authors have argued that the capacity and the determination of a firm to invest in innovative processes is intrinsically related with the existence of above-normal profits, because monopoly rents reward successful innovations. Hence, the final effect of product market reforms over innovation may be ambiguous. Some very recent studies suggest that the relation between competition and innovation is non-linear with an inverted-U shape: innovation is adversely affected by extreme environments such as a high competition and a monopoly (Griffith and Harisson (2004), Aghion *et al.* (2005)).

[88] See, for example, Dixon and Rankin (1994) and Jacobsen and Schultz (1994).

since the elasticity of demand for goods and services is a weighted average of private and public elasticities, a fiscal contraction and the resulting decrease of the share of public spending would increase the aggregate elasticity of demand.

On the other hand, it has been argued that a fiscal contraction and the fall in aggregate demand generates a fall in profit making opportunities, reducing new entries and, hence, increasing firms' market power and markups (Molana and Zhang (2001), Heijdra and van der Ploeg (1996)). However, Costa (2004) argues that if less spending decreases factors' productivity, increasing marginal costs, then the price markup should fall, in a sticky price environment.

Another line of literature has focused on the relation between public spending, regulation and competition. Some authors have argued that in order to increase competition and also minimize the squandering of public resources, governments should reduce the regulatory procedures that increase firms' costs and act as formal barriers to entry (Alesina *et al.* (2005)). Official organizations have also stressed this argument in recent times: "*restrictions on competition - such as limitations on entry, price, output, or production methods - are very costly ways to promote public interest; have often been ineffective; and therefore should be avoided*" (OECD (1997), p.6). However, we argue that the relation between regulation and competition is not straight forward, as in some sectors more competition requires a more sophisticated regulatory environment, involving higher public spending.

The literature appears more consensual regarding the labor market, as it seems more likely that a fiscal consolidation generates a lower wage markup. A fiscal consolidation based on the reduction of public employment and/or public wages increases the probability of unemployment or the costs of being unemployed, reduces workers' bargaining power and, hence, the wage markup (Alesina *et al.* (2002), Ardagna (2007)). Fiscal consolidations in general reduce the demand for labor and thus restraint workers' wage claims.

Overall, the direct link between a fiscal consolidation and market competition is rather ambiguous especially in the case of the goods market. Yet, there is room to argue that a consolidation based on productive public spend-

ing and/or public employment may reduce the wage markup, and, possibly, the price markup, via direct links.

Fiscal policy and product and labor market reforms We now briefly review the literature focusing on the effects of consolidations combined with structural reforms of labor or product markets that enhance competition.

The concept of product market reform is generally associated to the reduction of the costs of entry into the industry faced by firms and to the promotion of competition in particular industries or at the aggregate level. The concept of labor market reform is associated to the reduction of the bargaining power of workers/unions, either by deregulation or by imposing appropriate regulation.[89] An higher market power by firms and/or workers, *i.e.* an higher price and/or wage markup, tends be positively associated with the market's regulatory burdens. Both product and labor market reforms typically reduce market regulation and positively affect competition, lowering price and wage markups, and improving overall economic efficiency.[90]

At a microeconomic level, there is a large evidence that market deregulation tends to lower markups and, hence, to foster total factor productivity gains.[91] Most studies follow what Joskow and Rose (1989) call a "before-and-after" approach; this approach is an analysis of changes in regulatory environments over time, *i.e.*, the behavior and performance of firms or markets before and after the introduction or elimination of some regulation. Studies at a macroeconomic level are much more scarce. In the most important study at a macro level, Griffith and Harisson (2004) have concluded that a tight regulation has a significant positive effect on markups, especially when tightness applies to the ease of starting a new business, to administrative bureaucracy and to labor market rules.

Overall, it seems fair to argue that structural market reforms inducing

[89] Although regulatory reform formally means the improvement of regulatory quality (institutions or processes) and deregulation means complete or partial elimination of regulation, these terms are usually presented in the literature as synonyms (OECD (1997)).

[90] See Gersbach (2000), Blanchard and Giavazzi (2003), Blanchard (2004) and Schiantarelli (2005).

[91] See, for example, Martins *et al.* (1996), Blöndal and Pilat (1997), Joskow and Rose (1989), Gönenç *et al.* (2001) and Kumbhakar and Lozano-Vivas (2005).

higher competition/lower markups, generate lower prices, stimulate product demand, investment and output, pushing employment up: "*market deregulation and increased competition might help to reduce unemployment by improving employment prospects*" (Solow (2000), p.5).

In spite of the potential medium- to long-run benefits, political support for a structural market reform can not be taken for granted, as reforms typically entail short-term costs. First, productivity improvements may result in some job destruction in the short-run, as real wages fail to adjust downwards and less efficient firms are pushed out from the market. Second, as it reduces total rents, deregulation tends to decrease the part of rents accruing to workers. Third, product market reforms may be blocked by the influence of vested interests, some of them with strong political power, seeking protection from competition − the lobbying power of existing incumbents.

In order to promote the reforms' success and by obvious political reasons, the lack of political support requires the implementation of transfer schemes aimed at compensating reform losers, both firms and workers; hence, reforms call for higher levels of government spending.[92] Furthermore, the rise in unemployment that may follow the reforms also increases public spending.

This line of reasoning suggests that it may not be possible to carry on a successful fiscal consolidation simultaneously with extensive supply-side reforms. However there are, at least, three reasons that may reverse this reasoning. First, increasing factors' productivity may compensate the transitional costs of structural reforms (Duval (2008)). Our model specification and the results of some simulations in chapter 4 may be seen in the light of this argument. If government compensations take the form of highly-productive spending, it is possible to have a successful fiscal consolidation shifting from unproductive to productive spending and simultaneously higher productivity levels, mitigating the reforms' short-run costs. Second, a very weak initial state of public finances can also be determinant for the success of the fiscal consolidation as the inevitability of consolidation reduces the po-

[92] These transfer schemes are basically in agreement with the "two-hands approach", firstly put forward by Blanchard *et al.* (1986). This approach advocates that the success of structural supply-side policies is linked with some degree of complementarity with expansionary demand-side policies.

litical power of blockers (Alesina *et al.* (2008)). Third, some authors showed that there are substantial spillover effects between reforms (product market, labor market, fiscal and financial), and that these spillovers may effectively reduce, or even, eliminate the transitional costs (Blanchard and Giavazzi (2003), Nicoletti and Scarpetta (2005), Berger and Danninger (2007)).[93]

We thus put forth the hypothesis that a successful fiscal consolidation may take place simultaneously with structural supply-side reforms. Besides the literature reviewed, there seems to exist an important historical evidence suggesting that some of the most successful fiscal consolidations of the last decades involved extensive programs of labor market and product market reforms and, hence, of increased market competitiveness. Some authors have, indeed, closely linked fiscal reforms to market reforms: "*the key lesson for policymakers is that successful reform programs consist of internally consistent mixtures of labor market, fiscal, and product market reforms that complement and reinforce each other*" (Annett (2007), p.19).

6.2 Fiscal Consolidation and Markets' Competition

On the basis of the literature and arguments reviewed in the previous section, we now use our new-Keynesian DSGE model with productive public inputs to simulate a fiscal consolidation jointly with market reforms that enhance competition. Our purpose is, as before, to establish conditions under which fiscal consolidations may generate non-Keynesian effects, now in the context of increasing competition in labor or product markets.

As in the previous chapters, we will simulate a set of alternative fiscal shocks that, as seen in chapter 4 (figures 4.1 and 4.2), mimic a fiscal consolidation. The novelty in this chapter is that the fiscal consolidation is associated to a reduction of price and wage markups that induces higher steady-state levels of investment and output. Therefore, the model now con-

[93] Two examples often referred to are the following: (i) by reducing firing costs, a labor market reform may decrease the costs associated with the reallocation of labor across firms and sectors induced by a product market reform; (ii) by reducing labor demand and, hence, increasing the probability of unemployment, a fiscal consolidation may reduce the blocking power of workers with respect to a labor market reform.

siders a possible structural effect of the fiscal consolidation over price and wage markups, a junction of a demand side intervention and a supply side effect that is new in the literature. It should be noted, at this point, that with the aim of detecting the effects of each channel *per se*, we only consider this transmission mechanism in this chapter, and have purposely switched-off any transmission via the interest rate channel explored in chapter 5. This does not imply that in real world fiscal consolidations both channels can not be simultaneously active.

Technically, the analysis is similar to the one developed in chapter 5. First, we assume a link between the fiscal consolidation and the decrease in price and wage markups. Second, we describe the models' long-run relation between price and wage markups and equilibrium output, in order to account for the changes in the steady-state induced by the changes in the markups. Third, the transition path to a new steady-state after a fiscal consolidation is then derived by adding-up the dynamics presented in chapter 4 and the transition of the economy into the new steady-state.

In order to keep the analysis systematic, we consider, as before three alternative types of fiscal consolidations: i) a non-productive government spending shock; ii) a weakly productive government spending shock; and iii) a weakly-productive public employment shock. It should be noted that this is, again, a conservative approach regarding the possible arise of non-Keynesian effects; in fact, shifting from less to more productive public spending creates by itself, as seen in chapter 4, non-Keynesian effects; and such a shift could be a realistic scenario in the context of structural reforms, as reviewed above in the literature. Since the simulations now involve the improvement of competition in the product and labor market, differently from the previous chapters we will only consider the scenario of monopolistic competition in the labor market.

6.2.1 Fiscal consolidation and price and wage markups

Unlike the case of the relation between public debt and long-term interest rates, analyzed in chapter 5, it is not possible to find in the literature em-

pirical estimates of the link between fiscal policy and markups. Since our model has been calibrated for the Euro Area, in order to establish such a link, we conjecture that a reasonable effect of the simulated structural market reforms would be to reduce the markups to the US levels. Hence, we run our simulations assuming that the larger effect that the fiscal consolidation and structural reform program can induce is to change both the price and wage markups from their original calibrations (Euro Area based) to values that would correspond to calibrations for the US economy.

As shown in table 3.1, the price and wage markup values were set at, respectively, 1.35 and 1.3, following the values used by Bayoumi *et al.* (2004) and Jonsson (2007), which have been estimated for the Euro Area. The same authors also presented the corresponding values for the US, which are 1.23 and 1.16, respectively for the wage markup and the price markup. Hence a change from European to US levels implies reducing the price and wage markups by, respectively, 8.9% and 10.8%. These values are summarized in table 6.1. Later on this section, we will consider different values for this reduction, as a sensitivity check.

TABLE 6.1 - Benchmark levels for the price and wage markups

	Euro Area	United States	Percentual Deviation
Price Markup (λw)	1.35	1.23	-8.89%
Wage Markup (μ)	1.30	1.16	-10.77%

Source: Bayoumi *et al* (2004) and Jonsson (2007)

6.2.2 Steady-State Analysis

The steady-state of the model has already been described in chapter 5. The compilation of all equations and the analytical solution for the model's steady-state are shown in appendix A.5. The most relevant equations for inspecting the steady state impact of a change in the price and wage markups are:

$$\overline{w} = \frac{\alpha^{\frac{\alpha}{(1-\alpha)}}(1-\alpha)\left(\overline{G^{lp}}\right)^{\frac{\gamma}{(1-\alpha)}}\left(\overline{G^{hp}}\right)^{\frac{\eta}{(1-\alpha)}}\left(\overline{N^g}\right)^{\frac{\nu}{(1-\alpha)}}}{\mu^{\frac{1}{(1-\alpha)}}\overline{r}^{k\frac{\alpha}{(1-\alpha)}}}, \tag{107}$$

$$\overline{I} = \frac{\alpha^{(1-\alpha)}\delta\overline{w}^{(1-\alpha)}\overline{Y}}{(1-\alpha)^{(1-\alpha)}\left(\overline{r^k}\right)^{(1-\alpha)}\left(\overline{G^{lp}}\right)^{\gamma}\left(\overline{G^{hp}}\right)^{\eta}\overline{N^g}^{\nu}}, \tag{108}$$

and

$$\overline{Y}^{(\sigma_N+\sigma_c)} = \frac{(1-\overline{\tau}^n)\overline{w}^{(1+\alpha\sigma_N)}\alpha^{(\alpha\sigma_N)}\left(\overline{G^{lp}}\right)^{(\gamma\sigma_N)}\left(\overline{G^{hp}}\right)^{(\eta\sigma_N)}\overline{N^g}^{(\nu\sigma_N)}}{(1-\alpha)^{(\alpha\sigma_N)}\left(\overline{r^k}\right)^{(\alpha\sigma_N)}(1-h)^{\sigma_c}\gamma_c^{\sigma_c}(1+\overline{\tau}^c)\left(1+\frac{\overline{N^g}}{\overline{N^p}}\right)^{\sigma_N}(1+\lambda_w)}. \tag{109}$$

As equations (107), (108) and (109) show, a decrease in either the price markup (μ) or the wage markup (λ_w) induces an increase in the steady-state levels of investment and output.

A lower price markup generates a decrease in prices and, thus, an higher real wage and a lower interest rate, the latter due to the monetary policy reaction. This leads to an increase in the steady-state values of private consumption and investment. As a result, the steady-state output increases.

As regards the reduction in the wage markup, the first impact is over real wages. Given the initial level of labor productivity, a lower real wage generates lower marginal costs which induces an upward pressure on profits. This leads to higher steady-state levels of private consumption, investment and output.

6.3 Dynamic effects of fiscal consolidations

This section reports the effects on output, private consumption and investment of the three types of fiscal consolidation mentioned in the previous section.

Recall that these fiscal consolidation shocks are the following: i) a non-productive government spending shock ($\gamma = 0$); ii) a weakly-productive gov-

ernment spending shock ($\gamma = 0.05$); and iii) a weakly-productive public employment shock ($\nu = 0.05$). All simulations are run in a model with monopolistic competition both in the products and in the labor market.

In the following sub-sections, the analysis will be sequentially conducted for three scenarios, the first two more conservative and the third corresponding to a more throughout and ambitious program of structural reforms, including a fiscal consolidation, a product market reform and a labor market reform. In the first, we assume that the fiscal consolidation only reduces the price markup; in the second, the fiscal consolidation reduces the wage markup; in the third, both markups are reduced.

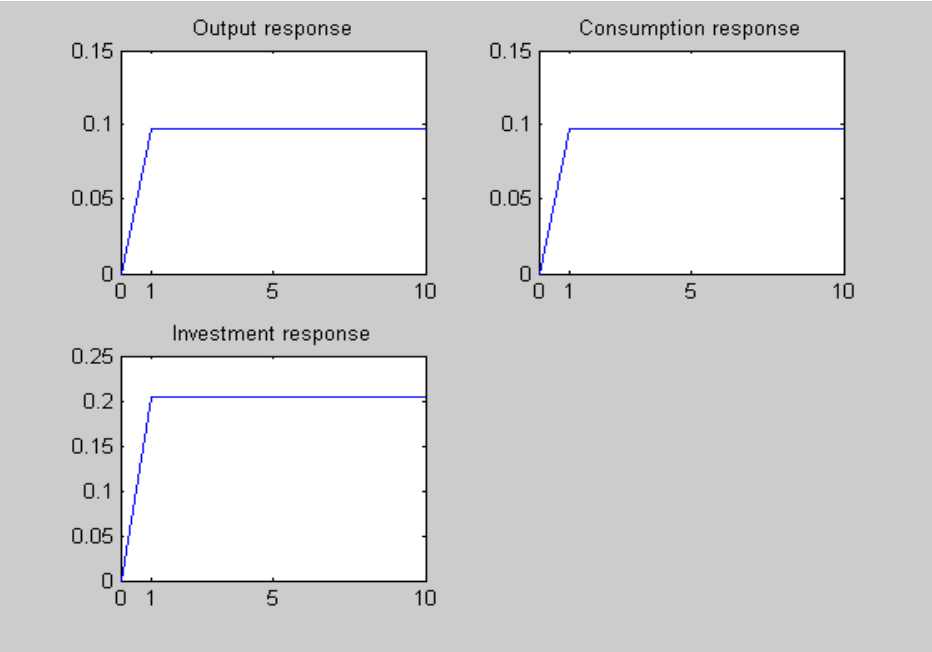
The dynamics of the transitional paths are essentially explained by the short-run dynamics presented in chapter 4, but the economy is now converging to a higher new steady state. The new steady-state values depend on the relative impact of each markups' reduction. As expected, a simultaneous decrease of both markups induces a larger effect on potential output. To anticipate a crucial result of the following simulations, it is noteworthy that, in our model, the impact on potential output of the 8.9% reduction of the price markup is almost twice as large as the impact of the 10.8% reduction of the wage markup.

6.3.1 Increasing product market competition

Figures 6.1 to 6.3 show the new steady-state and the transitional path for each of three fiscal consolidation shocks, in the context of a simultaneous reduction of the price markups from 1.35 (Euro Area level) to 1.23 (US level).

FIGURE 6.1 - Non-productive government spending

Steady-State



IRFs - Transitional path

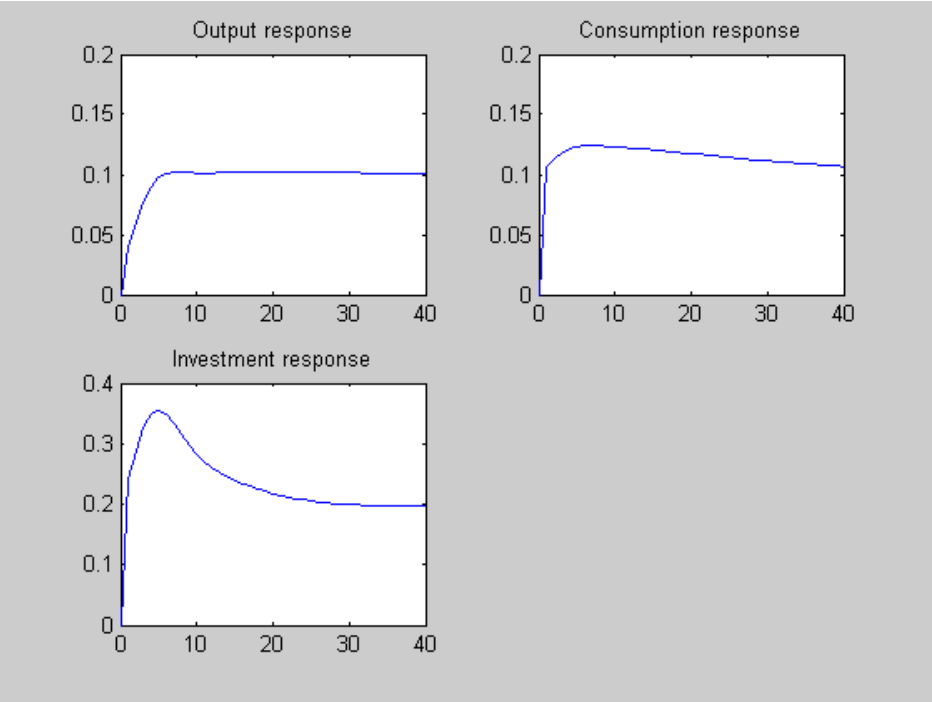
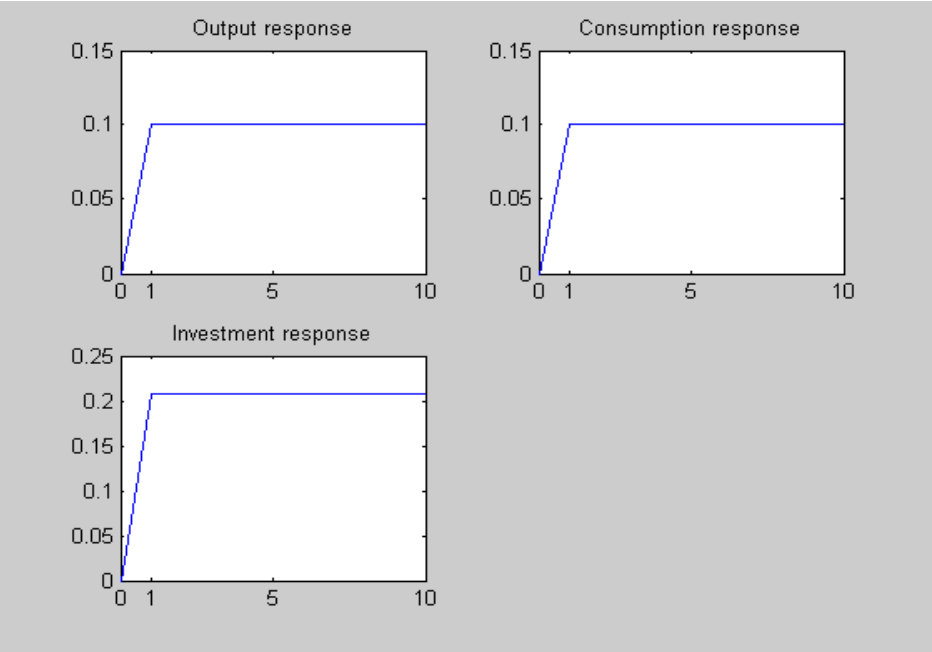


FIGURE 6.2 - Weakly-productive government spending

Steady-State



IRFs - Transitional path

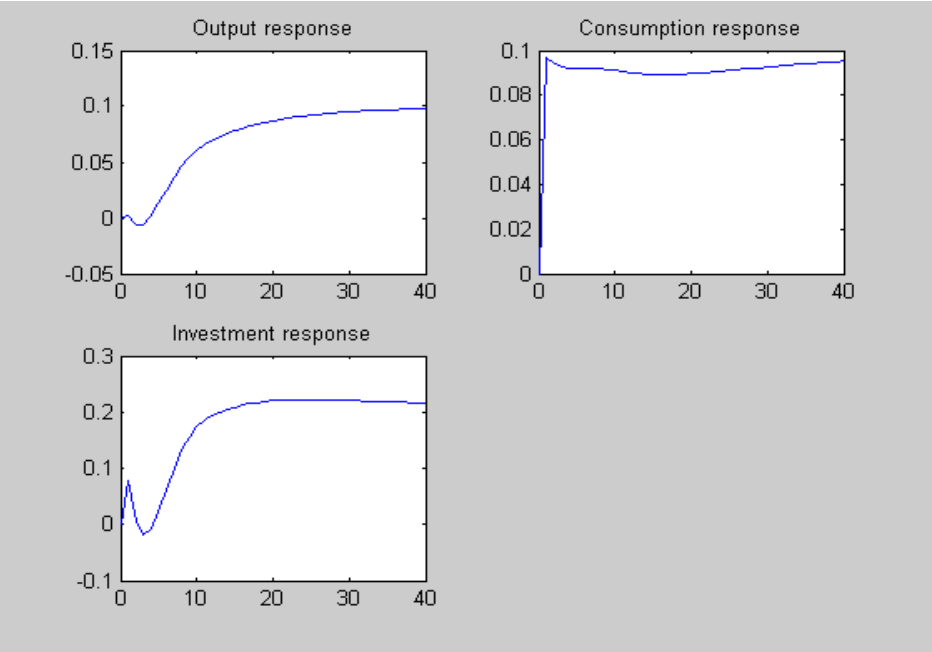
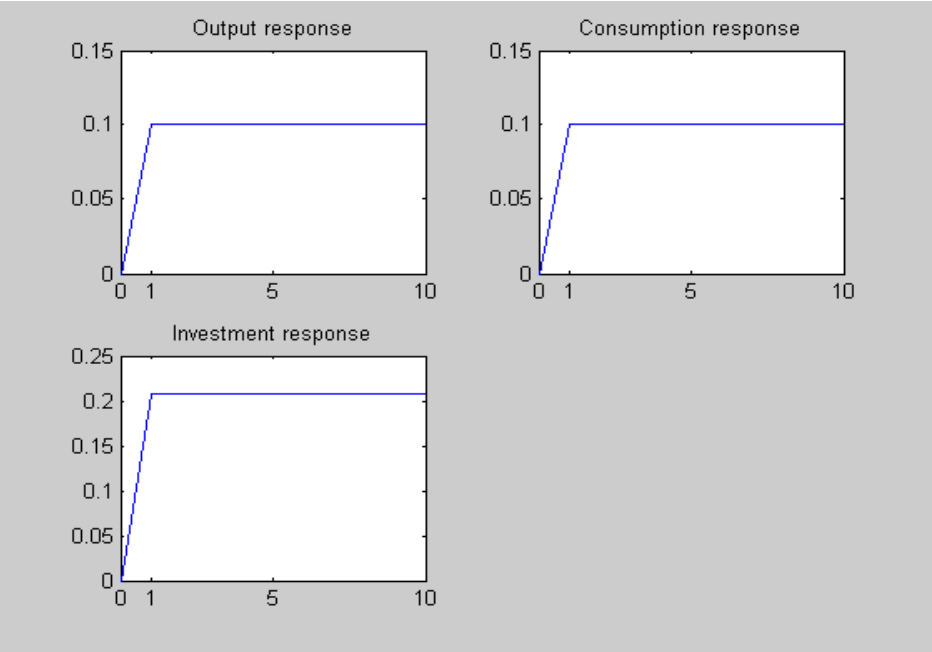
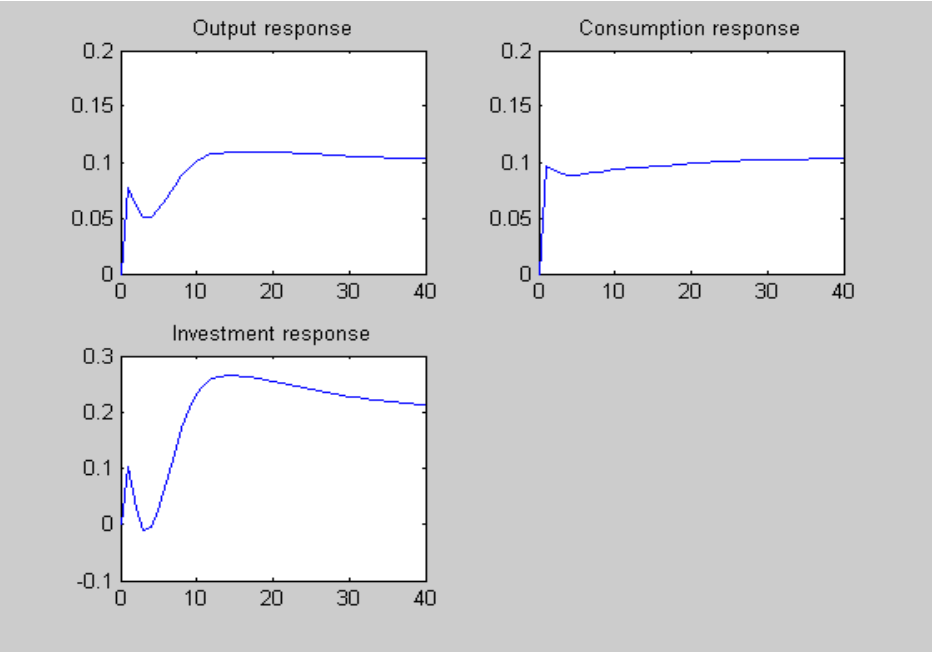


FIGURE 6.3 - Weakly-productive public employment

Steady-State



IRFs - Transitional path



The main conclusions from the simulations may be summarized as follows.

First, consolidation strategies based on the reduction of non-productive government spending or weakly-productive public employment when coupled with a product market reform, generate non-Keynesian effects on impact (*i.e.* an increase in output immediately after the fiscal shock). The effects of consolidation via public employment are especially noteworthy, as they are in sharp contrast to those obtained when no market reform occurs (see figure 4.9). In short, the impact on investment and output induced by the reduction in the price markup compensates the strong negative effect on investment induced by the public employment contraction.

As a sensitivity check, we have computed the threshold of price markup reduction that would assure non-Keynesian effects on impact. It turns out that a reduction of 5.5% and 4.6% when the consolidation is based, respectively, in non-productive government spending and weakly-productive public employment, would generate immediate non-Keynesian effects. On the one hand, this implies that milder reforms (involving about a half of the reduction in the markup) would be consistent with immediate expansions of output in spite of public spending/employment cuts. On the other hand, this means that market reforms are essential for the existence of instantaneous non-Keynesian effects.

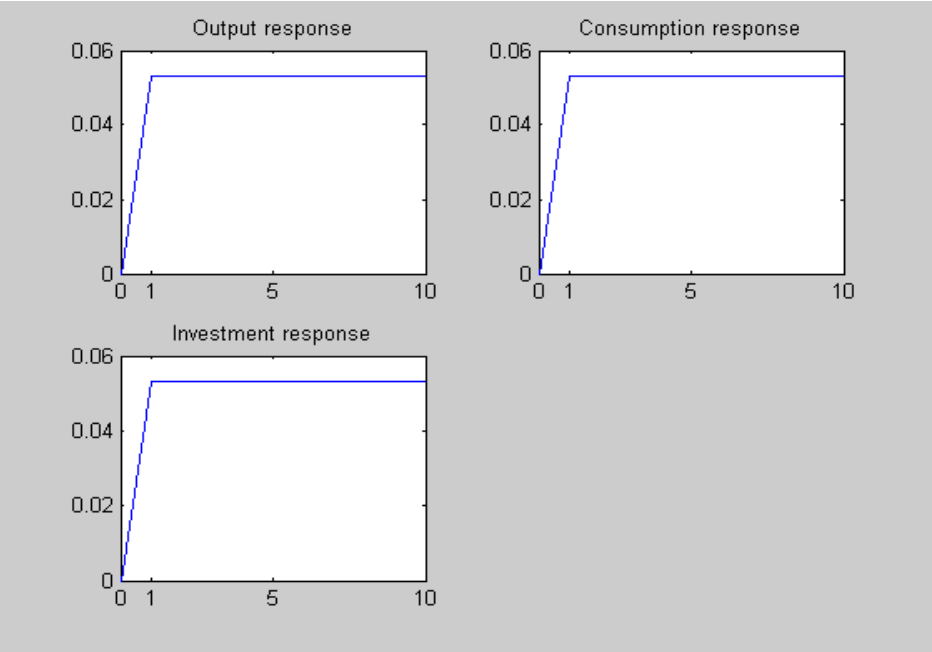
Second, when the consolidation is based on the weakly-productive government spending, output exceeds its original steady-state level 1 year after the shock. While one year is a reasonable period to classify these effects as non-Keynesian, it must be stressed that this would only happen if the price markup is effectively reduced to the US level.

6.3.2 Increasing labor market competition

Figures 6.4 to 6.6 show, for each of the fiscal shocks leading to consolidation, the new steady-state and the transitional path, according to our model, when a labor market reform changes the wage markup from 1.3 (Euro Area level) to 1.16 (US level).

FIGURE 6.4 - Non-productive government spending

Steady-State



IRFs - Transitional path

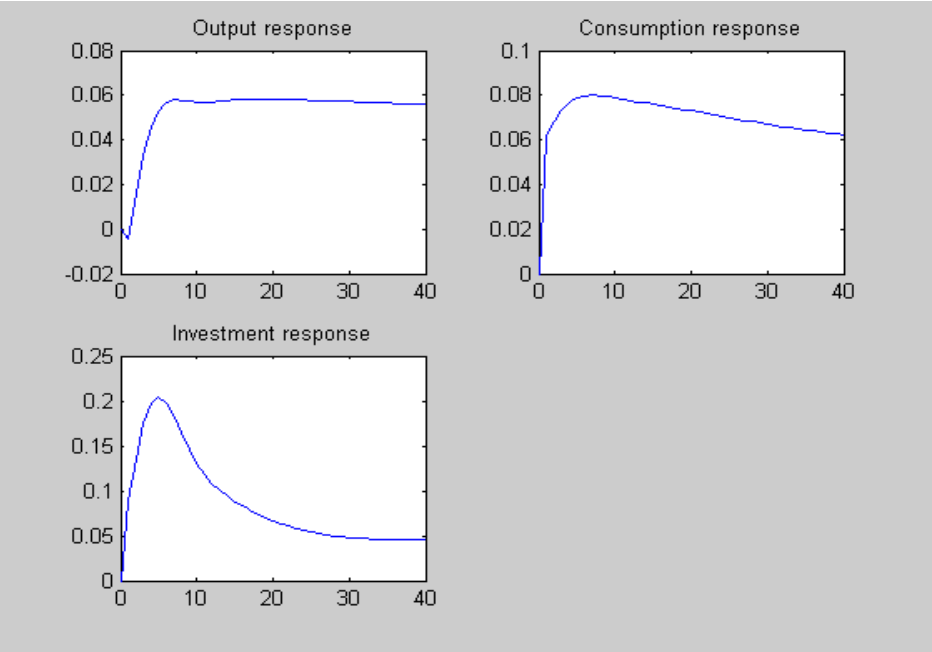
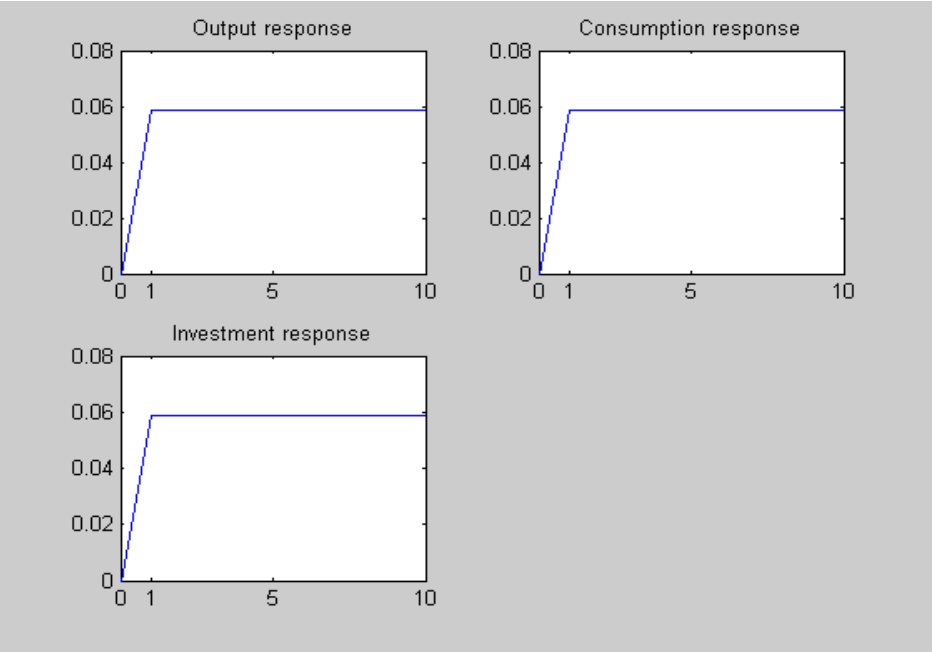


FIGURE 6.5 - Weakly-productive government spending

Steady-State



IRFs - Transitional path

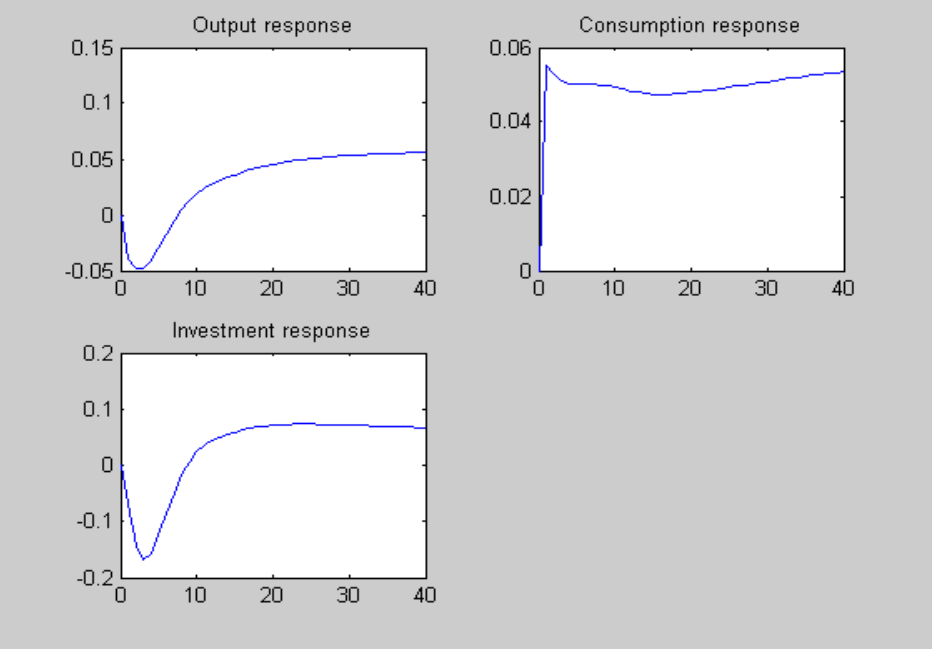
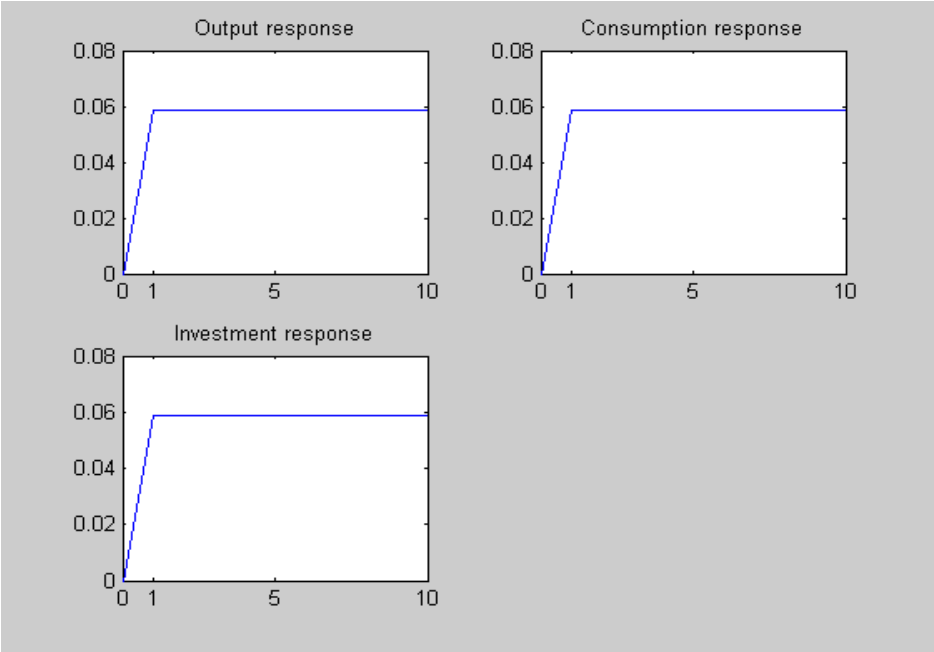
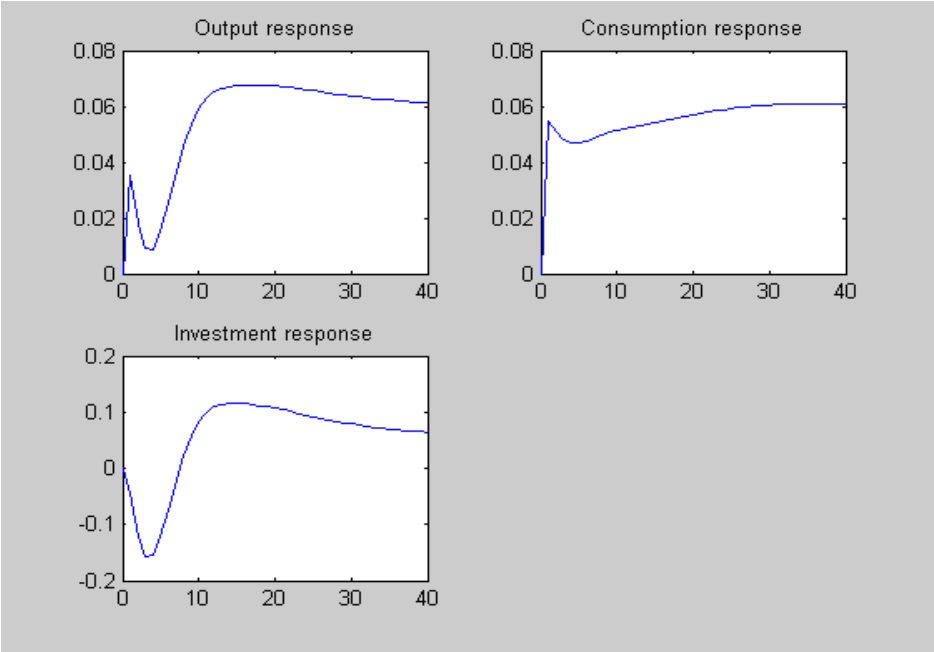


FIGURE 6.6 - Weakly-productive public employment

Steady-State



IRFs - Transitional path



The main conclusions from the simulations may be summarized as follows.

First, when fiscal reform is combined with a labor market reform, only consolidation strategies based on weakly-productive public employment generate non-Keynesian effects on impact (*i.e.* immediately after the fiscal shock). Truly, as when no increase in labor market competition occurred (see figure 4.9), the impact on investment is negative. However, the overall impacts are sufficient to generate an output level above the original steady-state level. Our sensitivity checks have shown that the baseline markup reduction is close to the minimum consistent with instantaneous expansions of output (9.3% *versus* 10.8%).

Second, a consolidation based on non-productive government spending generates non-Keynesian effects in the second quarter and a quite rapid transition to the new steady-state. Hence, this is a combination that clearly generates non-Keynesian effects.

Third, when the consolidation is based on the weakly-productive government spending, output exceeds its original steady-state level only 2 years after the shock. In the dynamics, the strong impact on investment, already documented in figure 4.10, turns out to prevail. The timing of the impact on output hardly allows classifying its expansion as a non-Keynesian effect.

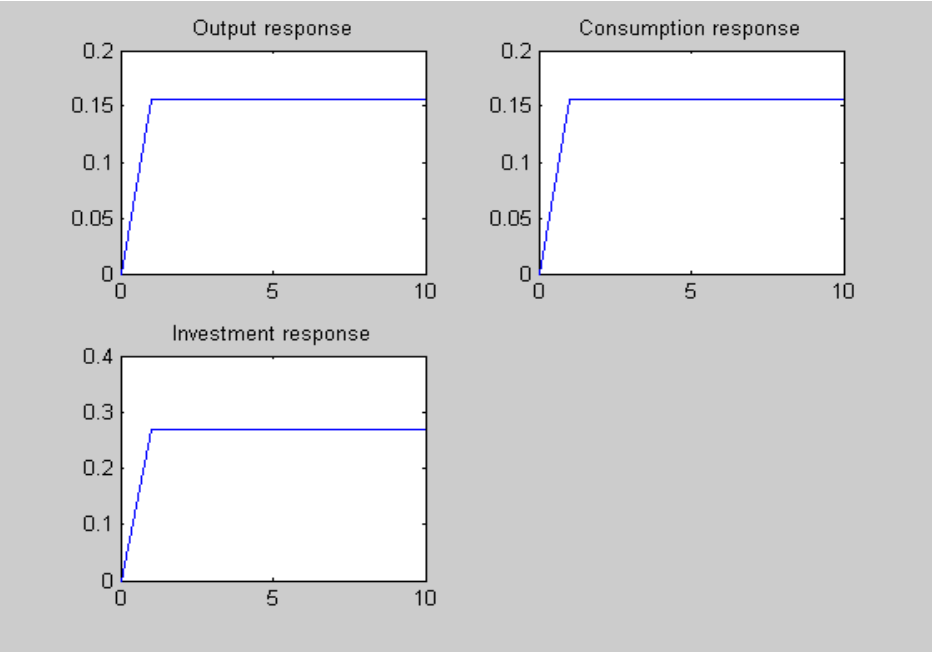
Overall, combining the fiscal consolidation with a labor market reform of a reasonable magnitude is by and large less likely to generate non-Keynesian effects than a combination of a fiscal consolidation and a product market reform of a realistic magnitude. The main explanation, within our model, seems to be that the latter entails a much larger increase in the steady-state output.

6.3.3 Increasing overall competition

Figures 6.7 to 6.9 show, for each of the fiscal shocks leading to consolidation, the new steady-state and the transitional path, when consolidation is combined with a broad structural reform that reduces markups both in the products and in the labor market.

FIGURE 6.7 - Non-productive government spending

Steady-State



IRFs - Transitional path

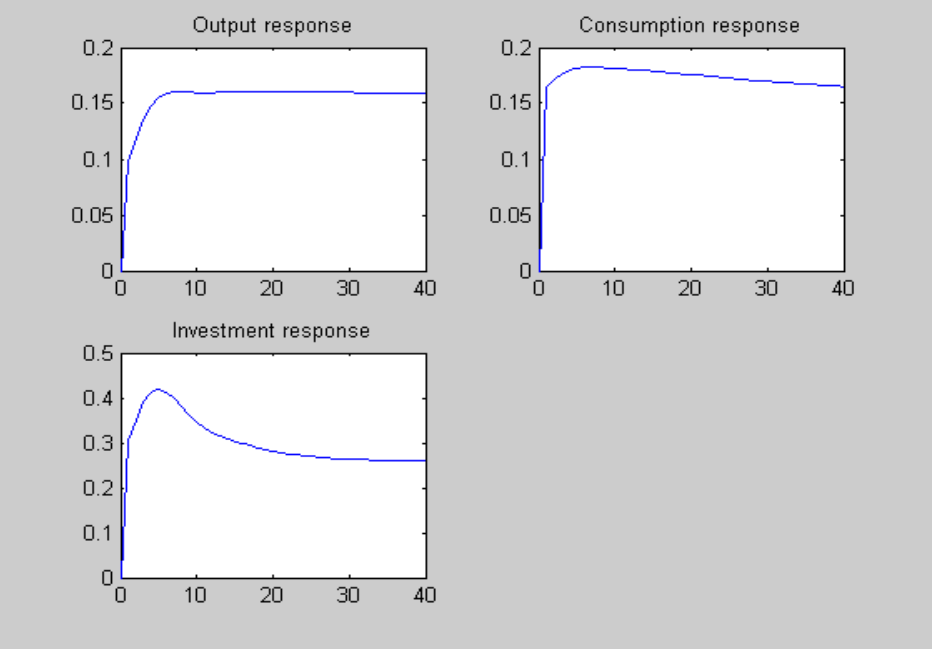
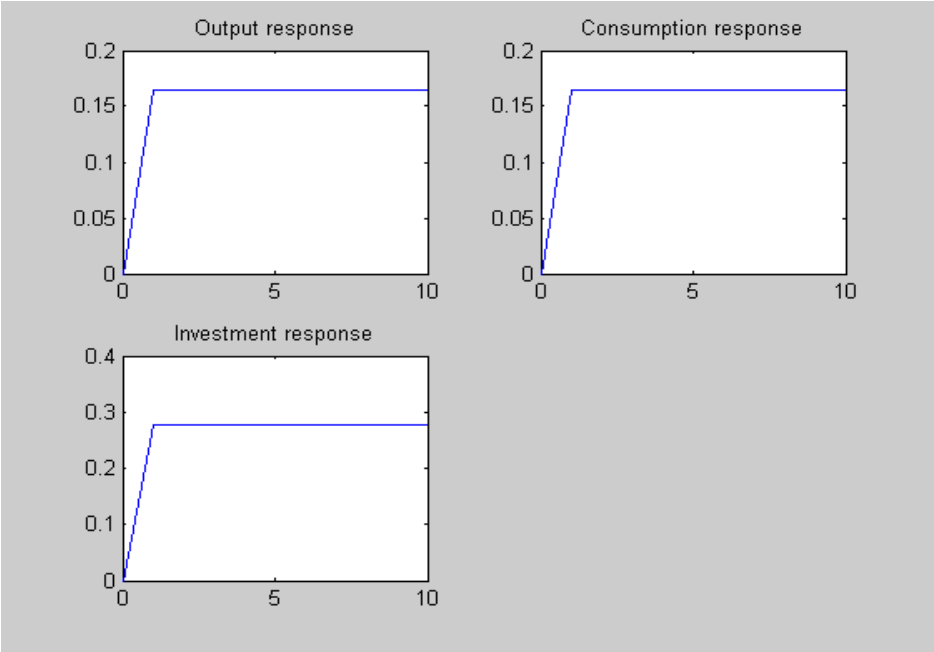


FIGURE 6.8 - Weakly-productive government spending

Steady-State



IRFs - Transitional path

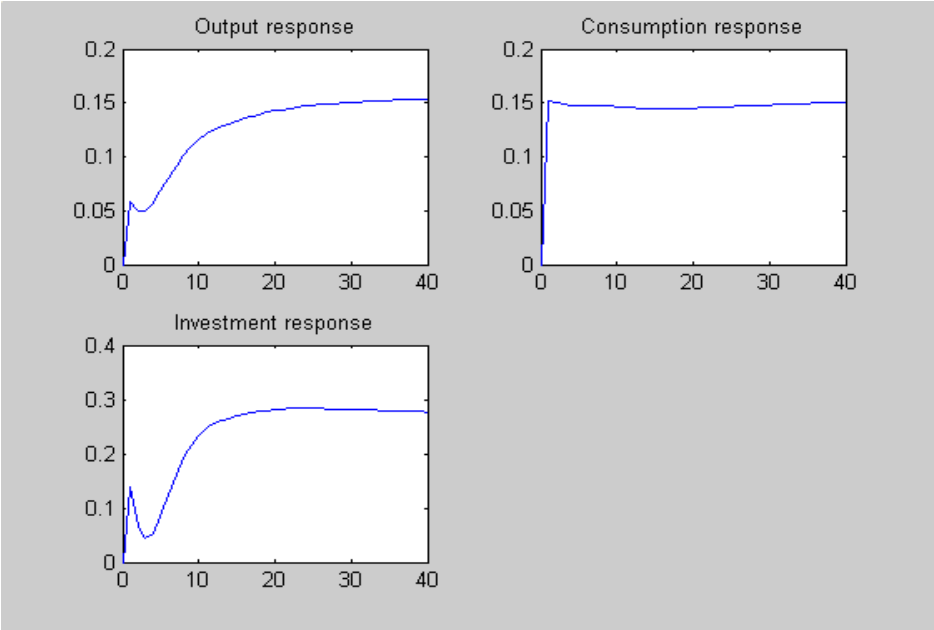
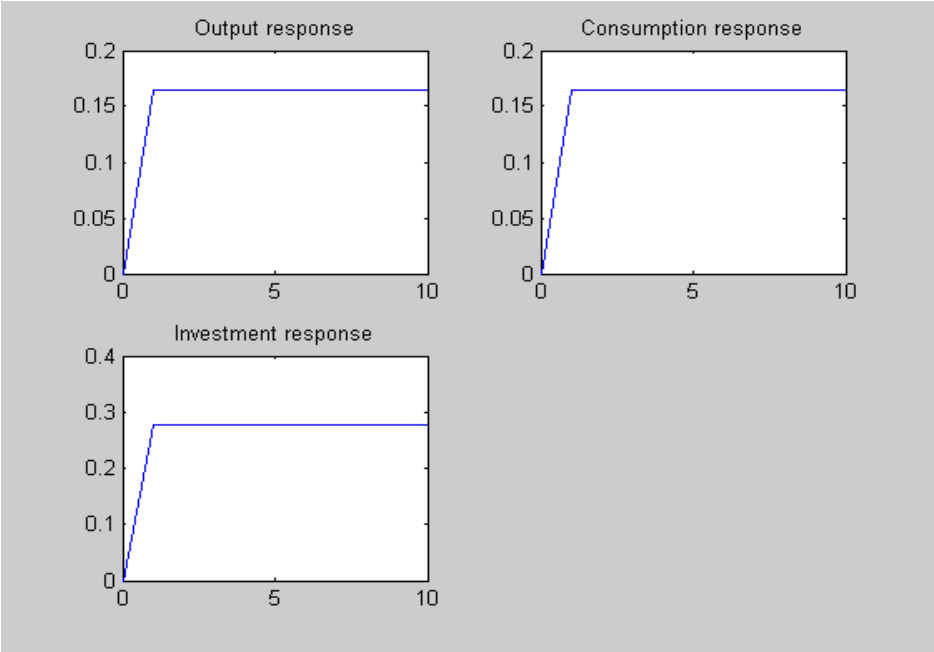
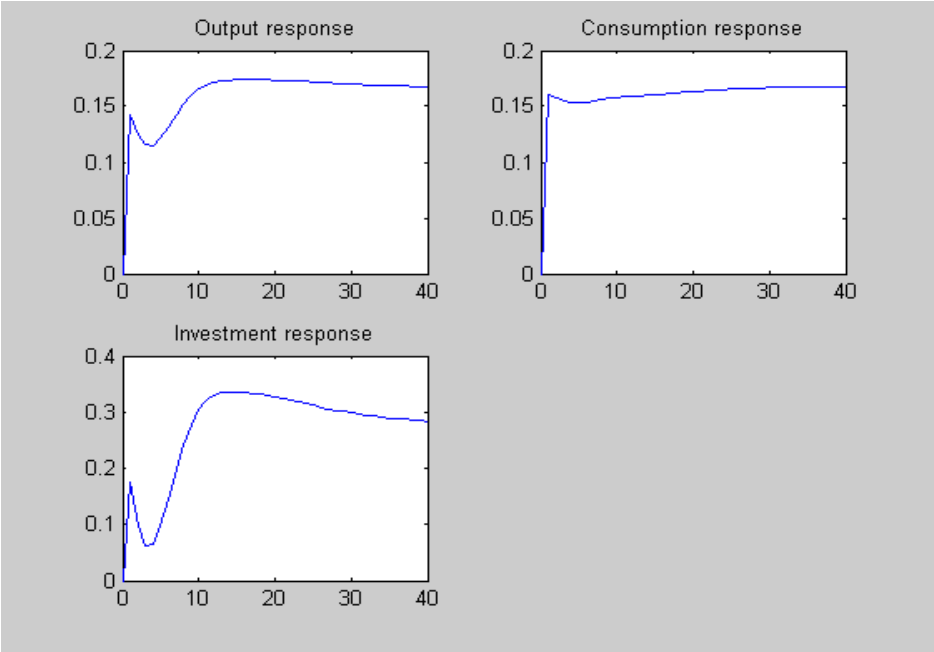


FIGURE 6.9 - Weakly-productive public employment

Steady-State



IRFs - Transitional path



The main conclusions from the simulations may be summarized as follows.

First, a comprehensive structural reform including fiscal consolidation and a deregulation of markets, leading to a reduction of both the price markup and the wage markup to the US levels, would generate non-Keynesian effects on impact in all analyzed consolidation strategies.

Our sensitivity analysis has further indicated that non-Keynesian effects on impact would require a substantially lower variation in the markups: 3.8%, 6.4% and 3.1%, respectively, for consolidations based on non-productive government spending, weakly-productive government spending and weakly-productive public employment.[94]. Moreover, if one accepts that an expansion of output above its initial level within a year is a time horizon that classifies as a non-Keynesian effect, the required reduction of the markups is of, respectively, 0%, 5.3% and 2.7%.

Second, the magnitude and timing of the expansion in output is substantially larger when the fiscal consolidation is based on reductions in non-productive spending or weakly-productive employment. In turn, cuts in productive spending, even if weakly productive as we consider, generate a smaller immediate reaction and a far more gradual convergence to the (15% superior) steady-state level of output.

6.4 Summary and Final Remarks

This chapter has explored yet another possible transmission mechanism, among those identified in chapter 2, for the investment channel of non-Keynesian effects of fiscal consolidations – the insertion of the fiscal consolidation in a broader economic reform. Such a reform program would involve not only the fiscal reform but also a deregulation of markets designed to increase their degree of competition. In a DSGE model such as ours, such reforms could appear in the (intermediate) products market as well as in the labor market, and would imply a reduction of (price and wage) markups.

In order to motivate the chapter, we reviewed the literature on the relation between fiscal and market reforms. We first looked at a line of literature

[94] We here assume that the relative (percentage) change in both markups is equal.

that posits some possible direct effects of fiscal reform on the degree of competition and efficiency. While this literature is ambiguous as regards the impact of fiscal consolidations on the product market competition, it more clearly argues in favor of a direct increase in the labor market competition resulting from the fiscal consolidation; in short, consolidations – especially when based in public employment cuts – causes an immediate fall in labor demand and a higher probability and cost of unemployment, which contracts workers' and unions' power. A second type of literature focuses on the likelihood that fiscal consolidations may be embedded in a wider program of reforms involving an overall quest for higher efficiency. We have highlighted reasons for a possible lack of political support for such reform programs, which would indicate that higher public spending would be needed in order to compensate for the short-run social impacts of markets reforms, thus invalidating the consolidation; yet, we have also uncovered arguments in favor of the hypothesis that a simultaneous fiscal consolidation would minimize or even eliminate the transitional costs of reforming markets. Moreover, we have identified important historical evidence of such comprehensive reform programs.

A problem with the literature on the topic explored in this chapter is the absence of estimates for the magnitude of reduction of markups possibly associated with fiscal consolidation and reforms. Given that we had initially calibrated the markups with estimates obtained with Euro Area data, and given that according to the empirical evidence the markups are lower for the US case, we have tackled this issue assuming that a reform would correspond to a reduction of the markup from Euro Area to US levels.

The chapter then contributes to the literature by simulating a fiscal consolidation shock in the new-Keynesian DSGE model developed in chapter 4 (the baseline model of chapter 3 enriched with productive public spending and employment) under a simultaneous reduction of the markup in at least one market (product, labor) from Euro Area to US levels. Thus, in addition to the standard demand-side effects and the effects on total factor productivity considered since chapter 4, we now include a structural supply-side effect that aims at mimicking a deregulation of markets and the consequent

increase in efficiency and in the steady-state level of output.

Technically, the procedures in this chapter are similar to those in the previous one, and develop in three steps. First, we calibrate the change of markups according to the referred evidence for the Euro Area and the US. Second, we derive the steady-state of the economy explicitly obtaining the relation between the markups and the main macroeconomic variables. Third, we derive the transitional path from the initial steady-state to the final steady-state when a fiscal shock occurs.

Following the approach of the previous chapter we have considered three alternative fiscal shocks leading to the fiscal consolidation, namely reductions in weakly-productive public spending, in unproductive public spending and in weakly-productive public employment. All shocks have been simulated in three alternative scenarios of market reforms: a pure product market reform (reduction of price markup); a pure labor market reform (decline of wage markup); and an overall markets reform (decline in both price and wage markups).

Differently from the previous chapters, the labor market has been assumed throughout to have a structure of monopolistic competition, as the focus here has been set precisely on reforms and changes to the degree of competition. Differently from chapter 4 and likewise chapter 5 we have not simulated any spending shift but merely cuts in one class of public expenditure, in order to offer a systematic assessment of the marginal effects of the market reforms.

Table 6.2 summarizes the results, with, for the sake of comparability, a notation as similar as possible to that of table 5.4.

TABLE 6.2 - Non-Keynesian effects in a NK-DSGE model with productive public spending and employment and a markup channel: price and/or wage markups reduced from Euro Area to US levels				
Fiscal shock	**Productive elasticity**	**Price markup**	**Wage markup**	**Price and wage markups**
Spending	**γ=0**	**(+++)**	**(++)**	**(+++)**
	γ=0.05	**(++)**	**(+)**	**(+++)**
Employment	**ν=0.05**	**(+++)**	**(+++)**	**(+++)**

Notes: (+++): output exceeds initial level on impact.

(++): output exceeds initial level within 2 to 4 quarters after the fiscal shock.

(+): output exceeds initial level within 4 to 8 quarters after the fiscal shock.

The simulations have shown that consolidations based on cuts in non-productive spending or weakly-productive public employment, when combined with an increase in competition in the products market, generate non-Keynesian effects immediately. In fact, immediate expansions of output would arise even if the price markup fell slightly more than half the way through the reduction from Euro Area levels to US levels. When the fiscal consolidation is based on cuts in weakly-productive spending, output firstly contracts and then surpasses its initial level, on the way to the higher steady-state, 4 quarters after the shock. While this timing still qualifies as a non-Keynesian effect, it is clear that the more productive is the reduced public sending the more ambitious must product markets reforms be in order to avoid the traditional contraction of output.

The impact of the labor market reform – according to our wage markup calibrations – on the economy's steady-state is smaller than the impact of the product market reform. As a result, and given the specific market under reform in these simulations, only when the fiscal consolidation is based on the reduction of public employment do non-Keynesian effects hold at impact. Fiscal consolidations based on reductions of public spending combined with a fall in the wage markup only generate non-Keynesian effects in the case of non-productive spending. In consolidations based on cuts to productive spending simultaneously with an increase in competition in the labor market,

output only exceeds its initial steady-state level two years after the beginning of the reforms, which can not be classified as a non-Keynesian effect.

As the last column in table 6.2 shows, when fiscal consolidation is conducted within a global reform program involving deregulation and higher competition in all markets, the model predicts immediate non-Keynesian effects irrespectively of the class of public expenditure reduced. Our sensitivity analysis has shown, moreover, that in the case of such a global program of reforms, the degree of markup reduction required for output not to contract is between thirty and seventy percent of the reduction from Euro Area to US levels.

To sum-up, the simulations in this chapter suggest that fiscal consolidations based on spending contraction need not depress output, if adequately combined with structural reforms increasing the competition in the markets. On the basis of our model and calibrations, it seems that product market reforms have a higher potential to generate non-Keynesian effects of fiscal consolidations in the Euro Area. Finally, one major economic policy conclusion from these simulations is that the more comprehensive the market reforms, the higher the probability of success of the consolidation and the lower the sacrifice demanded to economic agents.

7 Fiscal Consolidations: Lessons From Some European Cases

"*In particular, (...) the composition of the adjustment appears as the strongest predictor of the growth effect: all of the non-expansionary adjustments were tax based and all of the expansionary ones were expenditure based. (...) wage agreements seem also to be important, although a couple of cases show that, alone, they are not sufficient. (...) In all of the expansionary cases, governments and unions agreed on wage moderation policies.*" (Alesina and Ardagna (1998), p.516)

While until the early 1970s most developed countries exhibited balanced fiscal budgets overall - as the build-up of the welfare state coincided with a high and steady growth during the 30 glorious years - many went into increasing deficits afterwards. In fact, in the wake of the two oil shocks, both spending and taxes increased dramatically, but revenues were constantly lower than expenses. In parallel, there were significant changes in the composition of public budgets, with transfers (particularly social security contributions) increasing much more than any other component of spending, closely followed by the government wage bill. In contrast, public investment has fallen as a share of GDP. Governments have become "*more and more 'redistributive machines'*" (Alesina and Ardagna (1998), p.494).

In the early 80s, the resulting large stocks of public debt, combined with high real interest rates, created a potentially explosive debt problem. To tackle this problem, some governments implemented harsh fiscal adjustments aimed at reducing fiscal deficits and bringing the debt-to-GDP ratio downward and to a controlled path. This was a first wave of policies aiming at restoring sound public finances (European Commission (2007)).

In Europe, the consolidation efforts were reinforced in the first half of the 1990s, drove by the need to ensure compliance with the fiscal criteria set out in the Maastricht Treaty. Member states wanting to be a part of the EMU were required to have a deficit-to-GDP ratio no higher than 3%, and

a debt-to-GDP ratio below or approaching a reference level of 60%. This was a second wave of fiscal policies aiming at the control of public deficits and debt. Besides the EMU countries' effort, also the US, under President Clinton's administration, achieved an outstanding fiscal consolidation, in the mid-90s.

After the EMU has been established, in 1999, the consolidation efforts were initially relaxed. Yet, in order to meet the fiscal impositions of the Stability and Growth Pact, and given the implicit financial liabilities posed by ageing populations, many EMU members faced again the need to implement major consolidations. This was a third wave of policies aiming at the control of the weight of public debt. This new wave has been, yet, less widespread, less transparent and less sustained; this was the case for some countries in the early 2000s and is surely the case for all in the current financial crisis, in which fiscal stimulus are part of the fight against the crisis.

A fiscal consolidation is a hard decision for a government to make because standard Keynesian theory indicates that it will have a dampening effect on output and on employment. Moreover, if the consolidation induces an economic contraction it has a lower probability of success and thus of political support, as it complicates the stabilization of the deficit-to-GDP or debt-to-GDP ratios in two ways: (i) directly, by decreasing the denominator (or its growth rate); and (ii) indirectly, by triggering the automatic fiscal stabilizers that induce lower levels of receipts and higher levels of spending (higher unemployment benefits, for example).

However, as reviewed in chapter 2, there is no consensus on the size or even the sign of the effects of fiscal policy on economic activity. Indeed, as we have shown, in the context of our new-Keynesian DSGE model, in the previous chapters, under certain circumstances a fiscal consolidation can have expansionary effects on output, *i.e.* non-Keynesian effects. We have claimed, in fact, that a successful fiscal consolidation, *i.e.* a sizable and persistent fiscal contraction, can generate non-Keynesian effects, essentially through an investment channel. In chapters 4 through 6 we further identified conditions under which, in our model, such non-Keynesian effects may arise. Specifically, they are highly dependent on the composition of the fiscal adjustment, the

initial state of public finances and some supply-side structural effects, linked with markets' competition.

In this chapter, we present an overview of some particular fiscal consolidations in European countries. We first highlight their basic features and regularities, discriminating successful from unsuccessful, and expansionary from contractionary consolidations. Then we check if the conditions that we have identified in the previous chapters match the features of the different classes of consolidations in these specific European cases.

Since the third wave of European fiscal consolidations was interrupted due to the current financial crises and depression, we limit our discussion to some fiscal consolidations that happened in the 1980s and early to mid 1990s (the first and second waves). We closely follow the evidence presented in Alesina and Perotti (1997a) and Alesina and Ardagna (1998), and discuss eight fiscal consolidations: Belgium (1984-85), Denmark (1983-86), Greece (1986-87), Ireland (1983-84), Ireland (1987-89), Italy (1994-95), Netherlands (1991) and Sweden (1986-87).

7.1 Successful Versus Unsuccessful Consolidations

In chapter 4 we have assessed the ability of cuts in public spending and employment, for a realistic range of their impact on productivity, to generate fiscal consolidations, defined as a sizeable and sustained deviation of the debt-ratio from its starting level. We have concluded that cuts in the less productive government spending and employment (unproductive spending and weakly productive employment) are more likely to generate strong and persistent fiscal consolidations, while cuts in more productive public spending or employment generate a rather limited and not sustained response of debt, and may even induce a medium- to long- term increasing path for debt. We now look at the selected European fiscal consolidation episodes in order to access their success and cross-check it with the conditions detected in chapter 4.

Defining episodes of successful fiscal consolidations There is no commonly agreed definition of a successful consolidation in the literature. The usual definitions typically imply one of two conditions: (i) the cyclically adjusted primary balance (CAPB) as a percentage of GDP or the debt-to-GDP ratio is reduced by some specified amount during and, possibly after the tightening period (a definition that emphasizes the size of the consolidation); (ii) for some period after the consolidation the CAPB does not deteriorate by more than some specified amount (a definition that emphasizes the persistence of the consolidation). For example, Alesina and Ardagna (1998) define a consolidation as successful if in the three years after the tightening period the ratio of the CAPB-to-GDP is, on average, at least 2 pp above the initial level, or the debt-to-GDP ratio is at least 5 pp below the initial level; for European Commission (2007) a fiscal consolidation is successful if there is an improvement of the CAPB-to-GDP ratio of at least 1.5 pp, and in the three years after the end of the consolidation episode the CAPB-to-GDP ratio does not deteriorate by more than 0.75 pp.

In order to systematically determine how successful the eight episodes of consolidation have been, we have used a criterion based on three conditions that corresponds to a combination of the definitions in Alesina and Ardagna (1998) and European Commission (2007): (i) the tightening period is characterized by an improvement of, at least, 2 pp in the CAPB-to-GDP ratio; (ii) in the two years after the end of tightening period the CAPB-to-GDP ratio increases at least 1 pp; and (iii) in the two years after the tightening period, the debt-to-GDP ratio is at least 5 pp below the initial level. Our criterion is slightly more demanding than each of the individual definitions in which it is based.

On the basis of our criterion, we have furthermore established a classification of the consolidations according to their degree of success. A fiscal consolidation is classified as "very successful" if it satisfies all the three conditions, as "moderately successful" if it satisfies two conditions, or as "unsuccessful" when it does not satisfy more than one condition. According to this taxonomy, in the selected eight consolidation episodes we have identified three "very successful" consolidations (Denmark, 1983-86; Ireland, 1987-

89; and Sweden, 1986-87), two "moderately successful" consolidations (Belgium, 1984-85; and Italy, 1994-95), and three "unsuccessful" consolidations (Greece, 1986-87; Ireland, 1983-84; and Netherlands, 1991). A summary is shown in table 7.1.

Table 7.1 - Fiscal consolidations in some European countries: successful versus unsuccessful
Changes in the cyclically adjusted primary deficit-to-GDP and in the debt-to-GDP (percentage points)

Country and tight period	Cyclically adjusted primary deficit		Debt	Successful or Unsuccessful
	Tightening period	Two years after the tightening	Two years after the tightening	
Belgium, 1984-85	- 3.9	- 1.8	+ 9	(++)
Denmark, 1983-86	- 5.6	- 4.4	- 6	(+++)
Greece, 1986-87	- 2.0	+ 1.0	+ 17	(+)
Ireland, 1983-84	- 3.2	- 0.4	+ 12	(+)
Ireland, 1987-89	- 5.7	- 2.1	- 15	(+++)
Italy, 1994-95	- 1.5	- 2.0	- 6	(++)
Netherlands, 1991	- 2.0	- 0.3	+ 1	(+)
Sweden, 1986-87	- 4.0	- 1.6	- 13	(+++)

Notes: (+++) Very successfull consolidation: satisfied three conditions for a successful consolidation
(++) Moderately successful consolidation: satisfied two conditions for a successful fiscal consolidation
(+) Unsuccessful consolidation: satisfied one condition for a successful fiscal consolidation

Source: Alesina and Ardagna (1998)
and author's taxonomy and calculations

Determinants of fiscal consolidation success A wide variety of economic, political, and institutional factors have been identified as relevant for the success of a fiscal consolidation. These include the initial macroeconomic and fiscal conditions, the monetary stance, the adoption of structural reforms, and political factors.[95] However, as seen in chapter 4, there is a consensus in the literature that to begin with the success of a fiscal consolidation clearly and foremost depends on the "quality" of the fiscal adjustment, *i.e.* the composition of the fiscal adjustment. Hence our choice of a gradual approach, in this chapter, closely following the path that we have gone through in the previous chapters. In this section, we merely focus on the composition of the fiscal adjustment − which puts us in the framework of chapter 4 −

[95] For a review of the literature see, for example, European Commission (2007) and Kumar *et al.* (2007).

in order to present a first gauge of the consolidation's success; we leave for the next section a more detailed analysis of each consolidation, involving the initial conditions (chapter 5) and structural reforms (chapter 6), which in addition to the composition are needed for an identification of conditions for non-Keynesian effects.

In the literature, "good quality" fiscal adjustments are defined as those with a strong emphasis on government spending cuts rather than on raising taxes, and particularly on the reduction of less productive expenditures (current public consumption and transfers) and some politically sensitive items of the budget, such as the government wage bill. We have inspected the characteristics of the selected eight consolidation episodes regarding the composition of the fiscal adjustment, and present in table 7.2 a summary of our findings.

Table 7.2 - Fiscal consolidations in some European countries: composition of the fiscal adjustment

Country and tight period	Adjustment basis			Expenditure cuts			
	Expenditure based	Revenue based	Mixed	Transfers	Government wage bill	Public investment	Others
Belgium, 1984-85	✓			✓	✓	✓	
Denmark, 1983-86			✓	✓	✓		
Greece, 1986-87		✓				✓	
Ireland, 1983-84		✓				✓ a)	
Ireland, 1987-89	✓			✓	✓	✓	✓
Italy, 1994-95	✓			✓	✓		
Netherlands, 1991		✓ b)					
Sweden, 1986-87		✓			✓ c)		

a) Sharp reduction in public investment compensating an increase in transfers.

b) Large increase in transfers (especially unemployment benefits).

c) Slight decrease in the government wage bill that continued after the tightening.

Source: Author's calculations

The three most successful consolidations portray a scenario of somewhat mixed features: one has been based on expenditure cuts (Ireland, 1987-89), another has been revenue based (Sweden, 1986-87) and the third consolidation has been based on a mix of expenditure cuts and tax rises (Denmark, 1983-86). Yet, when very and moderately successful consolidations are considered, a common set of features arises: all have been, to some extent,

based on a reduction in transfers and/or of the government wage bill. In contrast, the unsuccessful consolidations, have been entirely based on tax rises (Netherlands, 1991), or have involved some important cuts in the more productive spending: public investment (Greece, 1986-87; Ireland, 1983-84).

Overall, the results of our simulations in chapter 4 are consistent with this overview of the selected consolidations: the most successful consolidations are associated to cuts in the less productive government spending and employment; differently, cuts in more productive public spending generate rather limited and not sustained consolidations.

7.2 Expansionary Versus Contractionary Consolidations

The simulations with our new-Keynesian DSGE model throughout chapters 4-6 have allowed for a number of conclusions, of which we highlight three: (i) if the consolidation is conducted simultaneously with a structural change in the fiscal budget in favor of more productive spending then the model predicts non-Keynesian effects; (ii) if the initial state of the public finances is such that the long-run interest rate is sensitive to changes in the level of the public debt, so long as the consolidation is credible and based in cuts either on unproductive spending or weakly-productive public employment, non-Keynesian effects are predicted; and (iii) fiscal consolidations based on spending contractions need not depress output, if adequately combined with structural reforms increasing the competition in the markets. We now look at the selected European cases of fiscal consolidation in order to assess their short-run impacts on output and cross-check their main characteristics with those identified in our model as susceptible of generating non-Keynesian effects.

Defining episodes of expansionary fiscal consolidations As happens in the definition of a successful consolidation, the definition of expansionary fiscal consolidations is somehow heterogeneous in the literature. The most simple definition identifies an expansionary consolidation as one that generates a positive output growth during and after the fiscal tightening (Eu-

ropean Commission (2003)). In turn, some authors call for a more refined measure and argue that the relevant GDP growth is the difference to some benchmark, such as to the G7 or OECD average growth rate. For example, Alesina and Ardagna (1998) define a fiscal consolidation as expansionary if the average growth rate of GDP in the period of tight and in the two years after, in difference from the G7 average, is larger than the average value before the tightening period.

In order to thoroughly determine whether a fiscal consolidation has been expansionary or contractionary, we use a criterion that analyzes both the GDP growth rate and its difference to the G7 average growth rate. We furthermore define a classification of the consolidations according to which an "expansionary consolidation" induces an increase in the GDP growth rate both in the tightening period and in the two subsequent years, as well as a positive differential with the G7 growth rate. If it only accomplishes one of the conditions, we define the consolidation as "moderately expansionary". A contractionary consolidation occurs in the cases where the GDP growth rate declines in all periods, during or after the tightening. Table 7.3 summarizes our assessment of the selected consolidations.

Table 7.3 - Fiscal consolidations in some European countries: expansionary versus contractionary
(changes from the period before the tightening in percentage points)

Country and tightening period	GDP growth		GDP growth (G7) a)		Investment growth	Consumption growth	Expansionary or Contractionary
	Tightening period	2 years after the tightening	Tightening period	2 years after the tightening	Tightening period	Tightening period	
Belgium, 1984-85	+ 0.5	+ 0.7	- 2.1	-1.1	+ 5.2	+ 1.7	(+)
Denmark, 1983-86	+ 2.7	- 0.3	- 0.2	- 3.5	+ 11.5	+ 4.6	(+)
Greece, 1986-87	- 2.4	+ 1.3	- 1.5	+ 1.5	- 15.8	- 1.9	(+)
Ireland, 1983-84	- 0.7	- 2.0	- 3.9	- 4.4	- 13.0	+ 4.1	(-)
Ireland, 1987-89	+ 5.0	+ 4.9	+ 4.4	+ 5.9	+ 16.0	+ 3.3	(++)
Italy, 1994-95	+ 3.7	+ 2.5	+ 2.5	+ 1.8	+ 25.5	+ 4.3	(++)
Netherlands, 1991	- 2.1	- 3.6	- 1.2	- 2.3	- 3.1	- 0.8	(-)
Sweden, 1986-87	- 0.3	- 0.7	+ 0.6	- 0.5	- 4.2	+ 2.4	(-)

NOTES: a) Difference between the country's GDP growth rate and the average G7 GDP growth rate
(++) Expansionary consolidation
(+) Moderately expansionary consolidation
(-) Contractionary consolidation

Source: Alesina and Ardagna (1998)
and author's taxonomy and calculations

In table 7.3 one can clearly identify two "expansionary consolidations" – Ireland, 1987-89 and Italy, 1994-95 – and two "contractionary" – Ireland, 1983-84 and Netherlands, 1991. These extreme cases suggest, moreover, *prima facie* evidence of the relevance of the investment channel in the transmission of non-Keynesian effects that we have chosen to explore in this thesis. In fact, the "expansionary consolidations" feature the higher increase in investment (and of the two "contractionary consolidations" the first features one of the largest fall in investment, even though with an increase in consumption, and the second features a larger fall in investment than in consumption).

The table suggests a positive link between unsuccessful and contractionary consolidations: all the unsuccessful consolidations were contractionary to the exception of Greece (1986-87); yet it should be noted that the Greek case is rather exceptional, as the expansion in the two years after the tightening was due to a sharply expansionary fiscal policy in 1988, reverting the failed attempt of consolidation. Hence, we conclude that a sizable and persistent consolidation seems to be a pre-requisite for the arise of non-Keynesian effects, just as argued in chapter 4.

Truly, success of the consolidation is not enough to generate non-Keynesian effects. Of the three successful consolidations detected in the previous section, only Ireland (1987-89) proved to be clearly "expansionary", while the Danish consolidation can not be considered "expansionary" and the Swedish can not even be considered "moderately expansionary". That a successful consolidation seems to be necessary but not sufficient for the arise of non-Keynesian effects is in accordance to conclusions obtained in chapter 4.

Conditions for expansionary fiscal consolidations We now provide, in table 7.4, a systematic assessment of the eight selected consolidations regarding their characteristics in the light of the simulations in chapters 4 through 6 of the thesis; the first column identifies the nature of each consolidation regarding the deficit composition, while the second column states whether long-run interest rate effects such as those simulated in chapter 5 existed; finally, the third column identifies the episodes that have coincided with labor

or products market reforms, at least in the form of agreed wage and/or price moderation. Table 7.4 summarizes the evidence allowing for a detection of features present in the selected consolidations.

Table 7.4 - Fiscal consolidations in some European countries: some more evidence

Country and tight period	Consolidation: decreasing transfers or government wage bill		Long-term real interest rates: decrease of spread to G7		Markets' competition: price or wage moderation	
	Yes	No	Yes	No	Yes	No
Belgium, 1984-85	✓a)		✓		✓	
Denmark, 1983-86	✓b)		✓		✓c)	
Greece, 1986-87		✓		✓		✓
Ireland, 1983-84		✓		✓		✓
Ireland, 1987-89	✓			✓	✓	
Italy, 1994-95	✓		✓		✓	
Netherlands, 1991		✓		✓		✓
Sweden, 1986-87	✓			✓		✓

a) Public investment was also decreased

b) About half of the adjustment has come from higher tax revenues

c) Wage agreement with unions abandoned immediatly after the tightening period

Source: Author's taxonomy and calculations

Focusing first in the identified "successful consolidations", a noteworthy feature of the Ireland 1987-89 episode is that, contrary to what had happened in 1983-84, the Irish government implemented an extensive reform program ("Programme for National Recovery") that included a fiscal reform, a labor market reform and a product market reform. Among its main measures were a sharp reduction of public employment, legislative changes that lastingly embedded significant cuts in public transfers, a centralized policy of wage moderation, a tightening of the eligibility for social security benefits, privatizations and public-private partnerships, as well as a reform of the tax system that allowed Ireland to have the lowest corporate tax scheme in the EU. The result was "*a prime example of how expenditure retrenchment as a part of a broad and deep structural and macroeconomic reform agenda can coincide with a swift and sustained economic recovery*" (Hauptmeier *et al.* (2007), p.307). In short, from the conditions detected in chapters 4 through to 6, only those studied in chapter 5 were not present in Ireland (1987-89).

In Denmark 1983-86, while during the tightening period GDP increased,

in the following years there was a downturn in GDP. During the tightening period, public wage indexation was suspended, public employment was frozen and a wage moderation policy was imposed. The combination of these policies with a strong fiscal consolidation and the decrease in the long-run real interest rate (about 4 pp) induced an higher output growth. However, the confrontational approach with unions leaded to industrial unrest and ultimately failed: in 1987 unions asked for and obtained larger wage increases (Annett (2007)). The end of wage moderation led to an increase in the relative labor costs, restrained investment and induced a lower output growth. In short, the consolidation had all the identified conditions for success, but turned out to fail in the subsequent years because of the lack of their sustainability.

The Swedish 1986-87 consolidation has been contractionary essentially because of the same problem of the Danish consolidation except that in the case of Sweden the timings were even worse: there was no agreement between unions and the government and, hence, there was no wage moderation. Increasing labor cost induced a loss of competitiveness and a strong decrease in private investment, which generated a recession.

Alongside, with these successful but not expansionary fiscal consolidations, we also find two "moderately successful" consolidation cases that can be considered expansionary: Belgium, 1984-85 ("moderately expansionary") and Italy, 1994-95 ("expansionary"). These cases have two common characteristics: (i) the long-term real interest rate have decreased after the tightening; and (ii) the fiscal consolidation was part of a broad structural reform with special emphasis in the labor market. In Belgium, there was a broad wage agreement with unions and a large restructuring of labor markets, which included the recourse to active labor market policies and a reform of the social benefits system (Hauptmeier *et al.* (2007)). In Italy, the labor market reform, which included the abolition of the system of automatic wage indexation, was accompanied by the liberalization of product and financial markets (European Commission (2007)). Hence, in table 7.4 all columns of relevant conditions for non-Keynesian effects are ticked. In relation to our study in this thesis, this means that all the transmission mechanisms of chapters 4

through 6 were somehow present.

Overall, the episodes here assessed strongly suggest that the probability that a successful consolidation is expansionary increases with the presence of the transmission mechanisms that we have identified in chapters 5 and 6, related with the impact of the fiscal consolidation on long-term interest rates and with the insertion of the fiscal consolidation in a broader economic reform.

7.3 Summary and Final Remarks

In this chapter we have studied the main features of eight selected episodes of fiscal consolidations belonging to the first (80s) and to the second (early-90s) wave of European recent fiscal consolidations. The purpose has been to check whether their success (unsuccess) and non-Keynesian (Keynesian) effects associate with the conditions detected with our model and the simulations of the several transmission mechanisms for the investment-channel of non-Keynesian effects throughout chapters 4-6. Hence, the chapter was meant to somehow suggest indirect evidence of the realism of our model, its calibrations and its dynamics following alternative types of fiscal consolidations.

We have studied eight heterogeneous episodes well documented in recent literature: Belgium (1984-85) Denmark (1983-86), Greece (1986-87), Ireland (1983-84 and 1987-89), Italy (1994-95), the Netherlands (1991) and Sweden (1986-87); these encompass cases of successful as well as unsuccessful consolidations and cases of expansionary as well as contractionary consolidations.

In order to systematically study the historical episodes in light of our theoretical framework, we have suggested a specific criterion and taxonomy for the degree of success of consolidations; and, similarly, for the degree of presence of non-Keynesian effects. The first classification allowed for classifying the episodes as ones of "very successful consolidation", "moderately successful consolidation" and "unsuccessful consolidation"; the second allowed for a distinction between "expansionary consolidations", "moderately expansionary consolidations" and "contractionary consolidations".

We detected three episodes of "very successful" consolidations (Denmark (1983-86), Ireland (1987-89) and Sweden (1986-87)), two "moderately successful" consolidations (Belgium (1984-85) and Italy (1994-95)), and three "unsuccessful" consolidations (Greece (1986-87), Ireland (1983-84) and the Netherlands (1991)). The inspection of the characteristics of these episodes allowed for a set of results that are overall in accordance with the conclusions of our modeling strategy and simulations in chapter 4. On the one hand, unsuccessful consolidations have typically been based on the increase of taxes and/or a reduction of public investment. On the other hand, regarding the very successful consolidations, just one case – Ireland (1987-89) – matches perfectly the pattern uncovered in chapter 4, as in Sweden (1986-87) a large increase in taxes has occurred and in Denmark (1983-86) a mixed spending-taxes strategy has been followed. However, successful consolidations are overall associated to cuts in less productive spending (e.g. social transfers) and in public employment (and the public wage bill) – a condition clearly uncovered in chapter 4.

We detected two episodes of "expansionary consolidations" (Ireland (1987-89) and Italy (1994-95)), three episodes of "moderately expansionary consolidation" (Belgium (1984-85), Denmark (1983-86) and Greece (1986-87)) and three episodes of "contractionary consolidations" (Ireland (1983-84), the Netherlands (1991) and Sweden (1986-87)). A first conclusion has been that success seems to be a necessary but not a sufficient condition for fiscal consolidations to create non-Keynesian effects; in fact, while all unsuccessful consolidations have generated the standard Keynesian effects, not all successful consolidations created persistent non-Keynesian effects (Denmark (1983-86) and Sweden (1986-87)); moreover, both "very successful" (Ireland (1987-89)) and merely "moderately successful" consolidations (Belgium (1984-85) and Italy (1994-95)) may bring in non-Keynesian effects.

The main features of each of these episodes are overall in accordance with our model and simulations in chapters 4 through 6. In fact, fiscal consolidations that led to non-Keynesian effects involved not only a shift of the budget composition toward "quality", but at least one (and generally two) of the other transmission mechanisms studied in chapters 5 and 6 – a de-

crease in long-run interest rate and a reform program increasing competition in labor and/or product markets. The establishment of wage moderations, especially when in the context of a broad reform program and an enduring socio-political pact has been particularly relevant for the existence of non-Keynesian effects (Ireland (1987-89), Italy (1994-95) and, although with a smaller impact, Belgium (1984-85)). The cases of Denmark (1983-86) and Sweden (1986-87) provide a counterfactual proof to this argument, as their failure to maintain a market reform and nominal restraint in the years immediately after the consolidation effort seem responsible for the subsequent reduction of output.

Finally, the path of private investment and consumption during the tightening period strongly supports the choice in this thesis to focus on the investment-channel for the transmission of non-Keynesian effects. On one hand, the two expansionary consolidations (Ireland (1987-89) and Italy (1994-95)) recorded the highest increases of investment and the moderately expansionary consolidations by Belgium (1984-85) and Denmark (1983-86) have also been associated with a larger expansion of investment than consumption. On the other hand, all consolidation episodes that failed the three or at least two of the three transmission mechanisms for the investment-channel studied in chapters 4-6 resulted in a reduction of private investment (Greece (1986-87), Ireland (1983-84), the Netherlands (1991) and Sweden (1986-87)).

8 Conclusion

This thesis has studied the investment-related channel for non-Keynesian effects of fiscal policy, with the aim of identifying the conditions under which a fiscal consolidation may have expansionary effects on short-term output. When this research started, this question was of extreme relevance for policy-making, since some European countries were (and others should be) conducting a consolidation of their public finances and naturally wanted to understand how to avoid its Keynesian effects. Presently, as the 2007/08 financial crisis developed into a global depression, fiscal sustainability has transitory lost importance. In fact, policy makers now hope that their widespread fiscal stimulus programs do have strong Keynesian effects on output and employment.

Yet, the contributions of this thesis for policy-making are intact. First, because it is now clear that large fiscal adjustments cannot be avoided, in most European countries, in the coming decades. High and growing current levels of deficit-to-GDP and debt-to-GDP ratios, combined with medium- and long-term spending pressure on public finances, related, *inter alia*, to population ageing, urge the need for fiscal consolidations, sooner or later. Second, because the identification of the circumstances under which a fiscal consolidation has expansionary effects, implicitly corresponds to a detection of conditions for a Keynesian behavior of the fiscal policy. For example, our finding that the highly-productive public spending generates strong Keynesian effects leads to the case for an important role of public investment in the current fiscal stimulus programs.

In parallel to the economic policy motivations, this research was also drived by empirical and theoretical reasons, namely the fact that an extensive empirical and annedoctal evidence of episodes of non-Keynesian effects of fiscal consolidations still lacks convincing explanations and modelling. The underdevelopment of the theoretical studies on non-Keynesian effects of consolidations seemed particularly clear as regards investment-related

channels; and, moreover, as regards their modelling in the context of new-Keynesian DSGE models allowing for a more thorough treatment of fiscal policy. Against this background, we have developed a new-Keynesian DSGE model with an expanded fiscal block, able to account for the interactions between a fiscal consolidation and the most relevant macroeconomic variables, qualitatively and quantitatively. The model developed in this thesis is, on the one hand, based on a well established state-of-the-art literature of new-Keynesian DSGE models, and, on the other hand, improves such a framework with the inclusion of new features based on the literature on non-Keynesian effects of fiscal policy.

For reasons made clear in chapter 2 – essentially the scarcity of studies of this channel, relative to the consumption one, in spite of its promising role, at least in our view – from its onset this thesis has studied possible investment-related transmission mechanisms for non-Keynesian effects. In the context of the developed model, in addition to the usual wealth effect, this channel involves transmission mechanisms operating through the inter-temporal relation between investment decisions, the real interest rate and expectations of future profits.

On the one hand, if a fiscal consolidation would induce a decrease in the real interest rate, a direct positive impact on investment would arise. Truly, this effect is usually small, unless a successful fiscal consolidation reduces the probability of default on government bonds, decreases the risk premium and induces a decrease in the long-term real interest rate. This is the hypothesis studied in chapter 5: in cases where the initial state of public finances is highly unfavorable, the long-term interest rates may react to a sustained change in the level of public debt, and thus a consolidation may trigger an upward pressure on private investment

On the other hand, if a fiscal consolidation were to directly affect the private factors' productivity, or were to indirectly improve productivity through an enhancement of the efficiency of markets, another sort of positive effect on private investment would arise. Such an effect would work either through a reduction in the marginal cost of labor – a pressure on real wages – or through an increase in the marginal productivity of labor, resulting either

way in an increase in the expected value of the net marginal product of capital. These are the hypothesis of chapters 4 and 6. In chapter 4 we model the direct contribution of public spending and employment to private inputs' productivity and study consolidations that shift the composition of the fiscal budget in favour of higher quality expenditure. In chapter 6, we consider fiscal adjustments embedded in a deregulating reform that improves the competition in markets – labor, products or both – and thus improve the overall competitiveness of the economy.

In order to analyze these alternative demand- and supply-driven transmission mechanisms of the investment channel, the thesis progresses in a mixture of cumulative and alternative developments of the model established in chapter 3. Specifically, the developments introduced in chapter 4 have been retained throughout the rest of the thesis, while the analysis of chapter 5 and 6 are conducted as alternative research paths. In each chapter, from 4 to 6, the model is used to simulate several policy experiments of fiscal consolidations and highlight conditions for non-Keynesian effects.

The first structural change to the baseline model, made in chapter 4 in order to study the direct productivity transmission mechanism, has consisted of the inclusion of government spending and public employment in the production function of intermediate goods. Although such a specification implies that both classes of public expenditure have a direct impact on total factor productivity, following the literature we have allowed such impact to have different degrees of relevance. More specifically, we have split public spending into highly-productive and weakly or non-productive spending, and public employment as strongly and weakly productive, calibrating each class with appropriate elasticities.

In chapter 4 we reviewed the literature and found a growing consensus that the success of a fiscal consolidation depends on the "quality" of fiscal adjustments, *i.e.* on shifts in the budget composition acting on the less productive forms of expenditure. Then, we have used the enhanced model to simulate fiscal consolidations through persistent cuts in public spending and employment of the various productivity impacts. In accordance with the literature, we found that fiscal adjustments with a strong emphasis on less

productive public expenditure cuts, including some politically sensitive items of the budget such as the government wage bill, do generate more successful fiscal consolidations. We have confirmed this result in the study of some European fiscal consolidations of the last decades, in chapter 7.

Chapter 4 has shown that consolidations based on reductions of a pure class of expenditure generate, as a rule, the Keynesian short-run contractions of output. However, it has illustrated that the less productive the public expenditure is, and the more competitive the labor market is, the more favorable is the reaction of private investment. We went a step further and simulated consolidations conducted simultaneously with a shift in the composition of the fiscal budget in favor of more productive spending, to find that in such cases the model does predict non-keynesian effects.

A second transmission mechanism for the investment channel operates via the interest rate effect of the consolidation. This is twofold: first, there is a cyclical effect, as the monetary policy reacts to the disinflationary impact of the aggregate demand contraction reducing the short-term interest rate; second, there may be a structural effect, as the consolidation reduces the risk premium on government bonds and thus lowers long-term interest rates, establishing a steady-state with a higher output level. While the former is typically small, in chapter 5 we have studied conditions for the latter to be of importance.

In order to do so, we have enhanced the model with a direct relation between the level of the public debt and the steady-state interest rate, which we have calibrated according to estimates in the literature. The simulations have suggested that, when the initial state of the public finances is such that the long-run interest rate is sensitive to changes in the level of the public debt, so long as the consolidation is based in cuts either on unproductive spending or weakly-productive public employment, non-Keynesian effects do arise. In contrast, fiscal consolidations entirely based on cuts in productive spending do not generate non-Keynesian effects. Our simulations have also considered alternative scenarios concerning the credibility of the fiscal consolidation; as expected, the lower the credibility the less prevalent are the non-Keynesian effects.

In chapter 6 we have deactivated the interest rate mechanism of chapter 5 and focused on a third transmission mechanism: the hypothesis that fiscal consolidations combined with structural reforms creating a more competitive environment, either in the product market or in the labor market, may be non-Keynesian. In the previous chapters we had some signs that in highly competitive labor markets the fall in the real wage induced by the fiscal contraction would stimulate private investment. This chapter has taken a step beyond and studied the effects of consolidations that are politically designed in combination with structural reforms that improve markets' efficiency - thus mixing a demand side intervention and a supply side reform, an analysis hardly seen in the literature.

After assuming, for the sake of calibration, that the simulated reform would change the degree of competition from European to US levels, we have simulated several consolidation strategies in different contexts of structural reforms involving the labor and/or the products market. Our results have suggested that fiscal consolidations based on the contraction of expenditure need not depress output, if adequately combined with structural reforms increasing the competition in the markets. Furthermore, we have reached a conclusion of the outmost economic policy relevance: the more comprehensive the market reforms, the higher the likelihood of an expansionary fiscal consolidation.

In sum, the analysis in this thesis suggests that for a fiscal consolidation to be non-Keynesian, a strong positive response of investment seems to be a basic ingredient; albeit one that can not be created exclusively through a single of the studied transmission mechanisms. The assessment of some recent episodes of fiscal consolidations in European countries, in chapter 7, has offered additional evidence of this conclusion. Successful consolidations with non-Keynesian effects are typically associated with the presence of the three transmission mechanisms of the investment-channel studied throughout chapters 4-6. In particular, while the choice of an adequate composition of the shifts in the fiscal budget is necessary, it is not sufficient; the consolidation must be credible and coupled with a comprehensive reform program.

Both the model that we have built and the analysis that we have con-

ducted with it provide a useful basis for future research. The most immediate extensions of this thesis are, probably, twofold: first, to further develop the modelling of the role of the government in the economy, for example by considering an explicit role for public investment; and second, to extend the analysis of historical episodes (conducted in chapter 7) so as to include the third wave of European fiscal consolidations, which began in the early 2000s.

A somehow less immediate extension would deal with the credibility of the fiscal consolidation, which seems to be crucial for the appearance of non-Keynesian effects. A recent body of literature has shown that fiscal sustainability is linked with strong and effective elements of fiscal governance, such as fiscal rules. Fiscal rules avoid temporal inconsistencies and enhance the transparency of fiscal policy, by providing a clear benchmark against which the results can be compared, thus providing a credible fiscal environment. As our model incorporates a very simple fiscal rule, there is room for a more detailed characterization of its fiscal rule, including the study of different rules – probably allowing for further conclusions on the conditions under which a fiscal consolidation may generate non-Keynesian effects.

Another path for future research would be to address the question of the political support for the fiscal consolidation, which may be crucial for its success. Addressing this question would require conducting an welfare analysis, identifying losers and winners of the consolidation. In fact, fiscal policy consolidations of a different nature can have distributional effects among different types of households. The diversity of impacts should be taken into account in the design of policies, because of its social relevance, as well as because it may be important for determining the political support of each particular fiscal action. Yet, such an analysis would require a model of heterogeneous agents, an avenue of research that, as far as we know, has not been pursued in analysis of fiscal policy in the framework of new-Keynesian DSGE models.

Appendix

A.1 Linearization of the inflation equation

The inflation equation derives from the linearization and aggregation of equations (38) and (40). The first-order condition for firms' profit maximization (38), can be expressed as:

$$\mathrm{E}_t \sum_{i=0}^{\infty} \left(\beta^i \xi_p^i \widetilde{p}_t X_{it}^p\right) = \mathrm{E}_t \sum_{i=0}^{\infty} \left[\beta^i \xi_p^i \mu MC_{t+i}\right] \tag{110}$$

with,

$$\widetilde{p}_t = \frac{\widetilde{p}_t^j}{P_t} \quad \text{and} \quad X_{it}^p = \frac{\left(\frac{P_{t-1+i}}{P_{t-1}}\right)^{\gamma_p}}{\frac{P_{t+i}}{P_t}}$$

with the second expression implying that $X_{0t}^p = 1$ and $\overline{X_i^p} = 1, i = 0, 1, 2, ...$

Expanding the left-hand side of the equation (110),

$$\mathrm{E}_t \left(\widetilde{p}_t + \beta \xi_p \widetilde{p}_t X_{1t}^p + \beta^2 \xi_p^2 \widetilde{p}_t X_{2t}^p + \beta^3 \xi_p^3 \widetilde{p}_t X_{3t}^p + ...\right) \tag{111}$$

and using the first order Taylor approximation,

$$\mathrm{E}_t \left(\widehat{\widetilde{p}}_t + \frac{\beta \xi_p}{1 + \beta \xi_p + \beta^2 \xi_p^2 + ...} \widehat{X^p}_{1t} + \frac{\beta^2 \xi_p^2}{1 + \beta \xi_p + \beta^2 \xi_p^2 + ...} \widehat{X^p}_{2t} + ...\right). \tag{112}$$

If we linearize the equations for X_{it} around the steady state we get,

$$\begin{aligned} &\widehat{X^p}_{1t} = \gamma_p \widehat{\pi}_t - \mathrm{E}_t \widehat{\pi}_{t+1}; \\ &\widehat{X^p}_{2t} = \gamma_p \mathrm{E}_t \widehat{\pi}_{t+1} + \gamma_p \widehat{\pi}_t - \mathrm{E}_t \widehat{\pi}_{t+2} - \mathrm{E}_t \widehat{\pi}_{t+1}; \\ &(...) \end{aligned} \tag{113}$$

Knowing that,

$$1 + \beta\xi_p + \beta^2\xi_p^2 + ... = \sum_{i=0}^{\infty} \beta^i \xi_p^i = \frac{1}{1 - \beta\xi_p} \tag{114}$$

then after inserting expressions (113) and (114) into (112), and rearranging, we obtain:

$$\widehat{\widehat{p}}_t + \mathrm{E}_t \sum_{i=1}^{\infty} \left[\beta^i \xi_p^i \left(\gamma_p \widehat{\pi}_{t+i-1} - \widehat{\pi}_{t+i} \right) \right]. \tag{115}$$

Expanding the right-hand side of equation (110),

$$\mathrm{E}_t \left[\mu MC_t + \beta\xi_p \mu MC_{t+1} + \beta^2 \xi_p^2 \mu MC_{t+2} + ... \right] \tag{116}$$

and applying the first order Taylor approximation,

$$\begin{aligned} \mathrm{E}_t \Bigg(& \frac{1}{1 + \beta\xi_p + \beta^2\xi_p^2 + ...} \widehat{MC}_t + \frac{\beta\xi_p}{1 + \beta\xi_p + \beta^2\xi_p^2 + ...} \widehat{MC}_{t+1} \\ & + \frac{\beta^2\xi_p^2}{1 + \beta\xi_p + \beta^2\xi_p^2 + ...} \widehat{MC}_{t+2} + ... \Bigg). \end{aligned} \tag{117}$$

Using (114) and rearranging we get,

$$\widehat{MC}_t + \mathrm{E}_t \sum_{i=1}^{\infty} \left[\beta^i \xi_p^i \left(\widehat{MC}_{t+i} - \widehat{MC}_{t+i-1} \right) \right]. \tag{118}$$

Aggregating the two linearized sides of equation (110), *i.e.*, equations (115) and (118), and rearranging, gives:

$$\widehat{\widehat{p}}_t = \widehat{MC}_t + \mathrm{E}_t \left\{ \sum_{i=1}^{\infty} \left[\beta^i \xi_p^i \left(\widehat{\pi}_{t+i} - \gamma_p \widehat{\pi}_{t+i-1} \right) \right] + \sum_{i=1}^{\infty} \left[\beta^i \xi_p^i \left(\widehat{MC}_{t+i} - \widehat{MC}_{t+i-1} \right) \right] \right\} \tag{119}$$

which is equivalent to:

$$\widehat{\widetilde{p}}_t = (1-\beta\xi_p)\widehat{MC}_t - \beta\xi_p\gamma_p\widehat{\pi}_t + \mathrm{E}_t\left[\beta\xi_p(1-\beta\xi_p)\widehat{MC}_{t+1} + \beta^2\xi_p^2(1-\beta\xi_p)\widehat{MC}_{t+2} + \right.$$
$$\left. + ... + \beta\xi_p(1-\beta\xi_p\gamma_p)\widehat{\pi}_{t+1} + \beta^2\xi_p^2(1-\beta\xi_p\gamma_p)\widehat{\pi}_{t+2} + ...\right]. \quad (120)$$

Dividing both sides of equation (39) by $P_t{}^{(1-\varepsilon)}$, and rearranging,

$$1 = \xi_p\left[\frac{(P_{t-1})^{\gamma_p+1}}{P_t\,(P_{t-2})^{\gamma_p}}\right]^{(1-\varepsilon)} + (1-\xi_p)(\widetilde{p}_t)^{(1-\varepsilon)}. \quad (121)$$

Knowing that around the steady state,

$$1 = \xi_p + (1-\xi_p)(\overline{\widetilde{p}})^{(1-\varepsilon)} \Longrightarrow (\overline{\widetilde{p}})^{(1-\varepsilon)} = 1 \quad (122)$$

using the first order Taylor approximation,

$$0 = \xi_p\left(\widehat{P}_t - \widehat{P}_{t-1}\right) - \gamma_p\xi_p\left(\widehat{P}_{t-1} - \widehat{P}_{t-2}\right) - (1-\xi_p)\widehat{\widetilde{p}}_t \quad (123)$$

and rearranging,

$$\widehat{\widetilde{p}}_t = \frac{\xi_p}{(1-\xi_p)}\left(\widehat{\pi}_t - \gamma_p\widehat{\pi}_{t-1}\right). \quad (124)$$

Finally, aggregating the linearized equations (120) and (124),

$$(1-\beta\xi_p)\widehat{MC}_t - \beta\xi_p\gamma_p\widehat{\pi}_t + \mathrm{E}_t\left[\beta\xi_p(1-\beta\xi_p)\widehat{MC}_{t+1} + \right.$$
$$+ \beta^2\xi_p^2(1-\beta\xi_p)\widehat{MC}_{t+2} + ... + \beta\xi_p(1-\beta\xi_p\gamma_p)\widehat{\pi}_{t+1}$$
$$\left. + \beta^2\xi_p^2(1-\beta\xi_p\gamma_p)\widehat{\pi}_{t+2} + ...\right] = \frac{\xi_p}{(1-\xi_p)}\left(\widehat{\pi}_t - \gamma_p\widehat{\pi}_{t-1}\right) \quad (125)$$

leading this equation by one period and multiplying both members by $\beta\xi_p$,

$$\begin{aligned}
&\mathrm{E}_t\Big[\beta\xi_p(1-\beta\xi_p)\widehat{MC}_{t+1}-\beta^2\xi_p^2\gamma_p\widehat{\pi}_{t+1}+\beta^2\xi_p^2(1-\beta\xi_p)\widehat{MC}_{t+2}+\\
&+\beta^3\xi_p^3(1-\beta\xi_p)\widehat{MC}_{t+3}+...+\beta^2\xi_p^2(1-\beta\xi_p\gamma_p)\widehat{\pi}_{t+2}+\\
&+\beta^3\xi_p^3(1-\beta\xi_p\gamma_p)\widehat{\pi}_{t+3}+...\Big]=\frac{\beta\xi_p^2}{(1-\xi_p)}\left(\mathrm{E}_t\widehat{\pi}_{t+1}-\gamma_p\widehat{\pi}_t\right) \qquad (126)
\end{aligned}$$

subtracting (126) from (125) and rearranging,

$$\frac{\xi_p(1+\beta\gamma_p)}{1-\xi_p}\widehat{\pi}_t=\frac{\xi_p\gamma_p}{1-\xi_p}\widehat{\pi}_{t-1}+\frac{\beta\xi_p}{1-\xi_p}\mathrm{E}_t\widehat{\pi}_{t+1}+(1-\beta\xi_p)\widehat{MC}_t. \qquad (127)$$

Knowing from equation (34) that,

$$MC_t=\frac{1}{e^{\varepsilon_t^a}}w_t^{(1-\alpha)}r_t^{k^\alpha}\alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}$$

the linearization around the steady state of this last equation can then be expressed as:

$$\widehat{MC}_t=(1-\alpha)\widehat{w}_t+\alpha\widehat{r}_t^k-\varepsilon_t^a. \qquad (128)$$

Replacing $\widehat{MC}_t$ in equation (127) by the corresponding expression (128), and rearranging, we finally obtain:

$$\begin{aligned}
\widehat{\pi}_t &= \frac{\gamma_p}{1+\beta\gamma_p}\widehat{\pi}_{t-1}+\frac{\beta}{1+\beta\gamma_p}\mathrm{E}_t\widehat{\pi}_{t+1}+\\
&\quad+\frac{(1-\beta\xi_p)(1-\xi_p)}{\left(1+\beta\gamma_p\right)\xi_p}\left[(1-\alpha)\widehat{w}_t+\alpha\widehat{r}_t^k-\varepsilon_t^a\right]+\eta_t^p. \qquad (129)
\end{aligned}$$

A.2 Linearization of the real wage equation (monopolistic competition in labor market)

The process of linearization of the real wage equation is similar to the one presented before for the inflation equation, and we have decided to skip some steps in what follows. Equation (23), can be expressed as:

$$\mathrm{E}_t \sum_{i=0}^{\infty} \beta^i \xi_w^i \left[\widetilde{\omega}_t w_t X_{it}^w \frac{U_{t+i}^C}{(1+\tau_{t+i}^c)} \right] = \mathrm{E}_t \sum_{i=0}^{\infty} \beta^i \xi_w^i \left[(1+\lambda_{w,t+i}) \frac{U_{t+i}^l}{\left(1-\tau_{t+i}^n\right)} \right] \tag{130}$$

where,

$$\widetilde{\omega}_t = \frac{\widetilde{w}_t}{W_t},\ w_t = \frac{W_t}{P_t}\ ,\ X_{it}^w = \frac{\left(\frac{P_{t-1+i}}{P_{t-1}}\right)^{\gamma_w}}{\frac{P_{t+i}}{P_t}}\ ,\ U_{t+i}^{*C} = \frac{U_{t+i}^C}{(1+\tau_{t+i}^c)} \text{ and } U_{t+i}^{*l} = \frac{U_{t+i}^l}{\left(1-\tau_{t+i}^n\right)}.$$

The last expression implies that $X_{0t}^w = 1$ and $\overline{X_i^w} = 1, i = 0, 1, 2, ...$

Linearizing the left-hand side of equation (130), using the first order Taylor approximation, and rearranging:

$$\widehat{\widetilde{\omega}}_t + \widehat{w}_t + \mathrm{E}_t \left[(1-\beta\xi_w) \sum_{i=0}^{\infty} \beta^i \xi_w^i \widehat{U_{t+i}^{*C}} \right] + \mathrm{E}_t \left[\sum_{i=1}^{\infty} \beta^i \xi_w^i \left(\gamma_w \widehat{\pi}_{t+i-1} - \widehat{\pi}_{t+i} \right) \right]. \tag{131}$$

Applying a similar procedure to the right-hand side of equation (130), we get:

$$\mathrm{E}_t \left[(1-\beta\xi_w) \sum_{i=0}^{\infty} \beta^i \xi_w^i \widehat{U_{t+i}^{*l}} \right]. \tag{132}$$

Aggregating the two linearized sides, i.e., equations (131) and (132), and rearranging,

$$\begin{aligned}\widehat{\widetilde{\omega}}_t &= -\widehat{w}_t + \mathrm{E}_t \left\{ \sum_{i=1}^{\infty} \left[\beta^i \xi_w^i \left(\widehat{\pi}_{t+i} - \gamma_w \widehat{\pi}_{t+i-1} \right) \right] \right. \\ &\left. + (1-\beta\xi_w) \sum_{i=0}^{\infty} \left[\beta^i \xi_w^i \left(\widehat{U_{t+i}^{*l}} - \widehat{U_{t+i}^{*C}} \right) \right] \right\}. \end{aligned} \tag{133}$$

Dividing both sides of equation (24) by $(W_t)^{-1/\lambda_{w,t}}$ and rearranging,

$$1 = \xi_w \left[\frac{w_{t-1}}{w_t} \frac{(P_{t-1})^{\gamma_w+1}}{P_t \left(P_{t-2}\right)^{\gamma_w}} \right]^{-1/\lambda_{w,t}} + (1-\xi_w)(\widetilde{\omega}_t)^{-1/\lambda_{w,t}}. \tag{134}$$

Knowing that around the steady state,

$$1 = \xi_w + (1-\xi_w)(\overline{\widetilde{\omega}})^{-1/\lambda_w} \Longrightarrow (\overline{\widetilde{\omega}})^{-1/\lambda_w} = 1 \tag{135}$$

using the first order Taylor approximation and rearranging,

$$\widehat{\widetilde{\omega}}_t = \frac{\xi_w}{(1-\xi_w)} \widehat{w}_t - \frac{\xi_w}{(1-\xi_w)} \widehat{w}_{t-1} + \frac{\xi_w}{(1-\xi_w)} \left(\widehat{\pi}_t - \gamma_w \widehat{\pi}_{t-1} \right). \tag{136}$$

Finally, aggregating the linearized equations (133) and (136), transforming and rearranging,

$$\begin{aligned}\widehat{w}_t &= \frac{1}{1+\beta} \widehat{w}_{t-1} + \frac{\beta}{1+\beta} \mathrm{E}_t \widehat{w}_{t+1} + \frac{\gamma_w}{1+\beta} \widehat{\pi}_{t-1} - \frac{1+\beta\gamma_w}{1+\beta} \widehat{\pi}_t + \frac{\beta}{1+\beta} \mathrm{E}_t \widehat{\pi}_{t+1} \\ &- \frac{(1-\xi_w)(1-\beta\xi_w)}{\xi_w(1+\beta)} \left(\widehat{w}_t + \widehat{U_t^{*C}} - \widehat{U_t^{*l}} \right). \end{aligned} \tag{137}$$

Knowing that,

$$U_t^C = \frac{\partial U}{\partial C_t} = e^{\varepsilon_t^b} \left(C_t - hC_{t-1} \right)^{-\sigma_c} \tag{138}$$

and

$$-U_t^l = -\frac{\partial U}{\partial l_t} = e^{\varepsilon_t^b} e^{\varepsilon_t^N} l_t^{\sigma N} \tag{139}$$

then,

$$\widehat{U_t^{*C}} = -\frac{\sigma_c}{1-h}\left(\widehat{C}_t - h\widehat{C}_{t-1}\right) - \frac{\overline{\tau}^c}{1+\overline{\tau}^c}\widehat{\tau}_t^c + \varepsilon_t^b \tag{140}$$

and,

$$\widehat{U_t^{*l}} = \sigma_N \widehat{l}_t + \frac{\overline{\tau}^n}{1-\overline{\tau}^n}\widehat{\tau}_t^n + \varepsilon_t^N + \varepsilon_t^b. \tag{141}$$

Inserting expressions (140) and (141) into equation (137) and using equation (21) in order to transform the labor supply l_t into the labor demand N_t, we obtain:

$$\begin{aligned}
\widehat{w}_t \;=\; & \frac{\beta}{1+\beta}\mathrm{E}_t\widehat{w}_{t+1} + \frac{1}{1+\beta}\widehat{w}_{t-1} + \frac{\beta}{1+\beta}\mathrm{E}_t\widehat{\pi}_{t+1} - \frac{1+\beta\gamma_w}{1+\beta}\widehat{\pi}_t \\
& + \frac{\gamma_w}{1+\beta}\widehat{\pi}_{t-1} - \frac{(1-\beta\xi_w)(1-\xi_w)}{(1+\beta)\,\xi_w\left(1+\frac{(1+\lambda_w)\sigma_N}{\lambda_w}\right)} \times \\
& \times \left[\widehat{w}_t - \sigma_N\widehat{N}_t - \frac{\sigma_c}{1-h}(\widehat{C}_t - h\widehat{C}_{t-1}) - \frac{\overline{\tau}^c}{1+\overline{\tau}^c}\widehat{\tau}_t^c - \frac{\overline{\tau}^n}{1-\overline{\tau}^n}\widehat{\tau}_t^n - \varepsilon_t^N\right] + \eta_t^w.
\end{aligned} \tag{142}$$

A.3 The effects of (positive) government revenue (tax rates) shocks

Similarly to the case of government spending shocks, the baseline model predicts that (positive) shocks to different tax rates do not lead to non-Keynesian effects over output, although the Keynesian multiplier is rather small. However, the effects of the three types of distortionary taxation are somewhat different:

(i) In a perfectly competitive labor market, a labor income tax rate shock (figure A1) leads clearly to Keynesian effects. Both consumption and investment decrease, *via* a direct negative effect on disposable income and *via*

an increase in the interest rate, caused by an higher inflation generated by the increase in real wages and, hence, marginal costs. In a monopolistic competitive labor market (figure A2), the negative effects over consumption and, particularly, investment are less marked as there is a much lower and smoother effect on real wages, marginal costs, inflation and the interest rate;

(ii) In the case of a capital income tax shock, in a perfectly competitive labor market (figure A3), there is some evidence of expansionary effects on impact over consumption but not over investment. By increasing the cost of capital, and thus reducing investment and the capital stock, the shock leads to a decrease in the marginal productivity of labor, and thus in wages. This leads to a reduction of marginal costs, inflation and, hence, the interest rate, generating a substitution effect that raises private consumption, but that is not sufficient to offset the negative direct effect over investment. Lower marginal costs also induce an increase in profits that generates a partially offsetting effect on private investment. In the presence of a monopolistic competitive labor market (figure A4) the amplitude of the real wage decrease is reduced and, hence, the effect on profits is lower, generating a larger decrease in investment;

(iii) Finally, in the case of a consumption tax shock, in a perfectly competitive labor market (figure A5) there is evidence of expansionary effects on investment. The decrease in the interest rate, which contributes to an higher investment, is not enough to offset the negative direct effect over consumption, though. The results are similar for the alternative labor market specification (figure A6).

FIGURE A1 - Labor income tax shock

(perfectly competitive labor market)

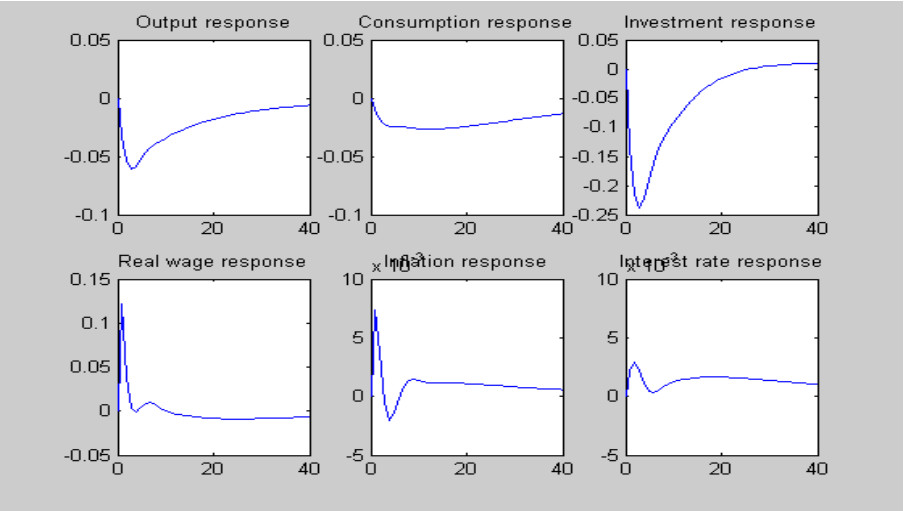


FIGURE A2 - Labor income tax shock

(monopolistic competition in labor market)

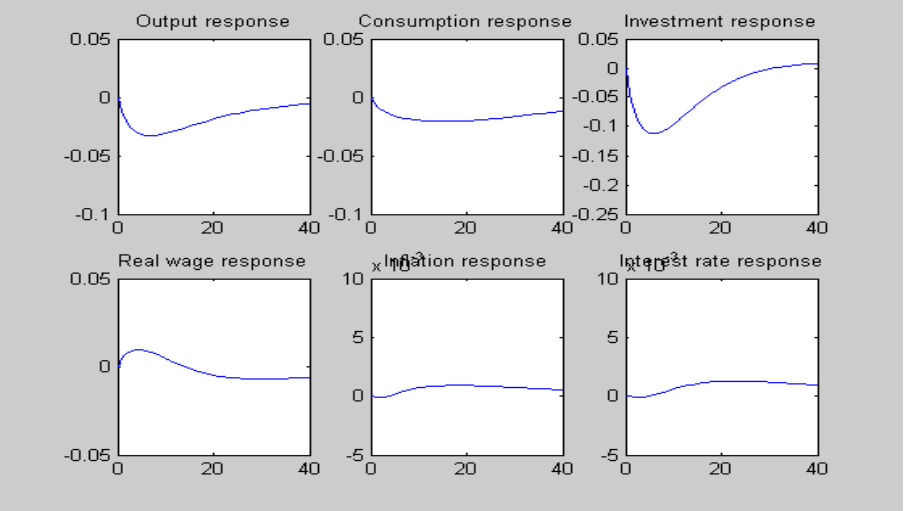


FIGURE A3 - Capital income tax shock

(perfectly competitive labor market)

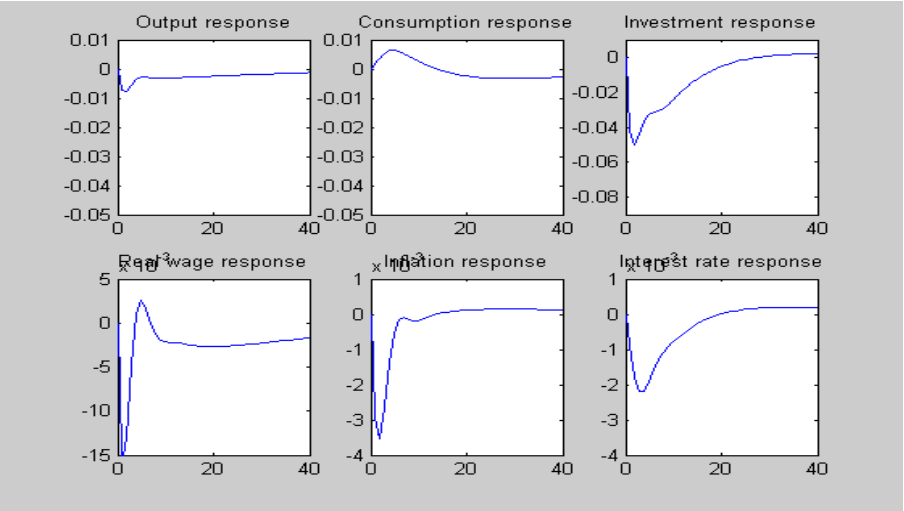


FIGURE A4 - Capital income tax shock

(monopolistic competition in labor market)

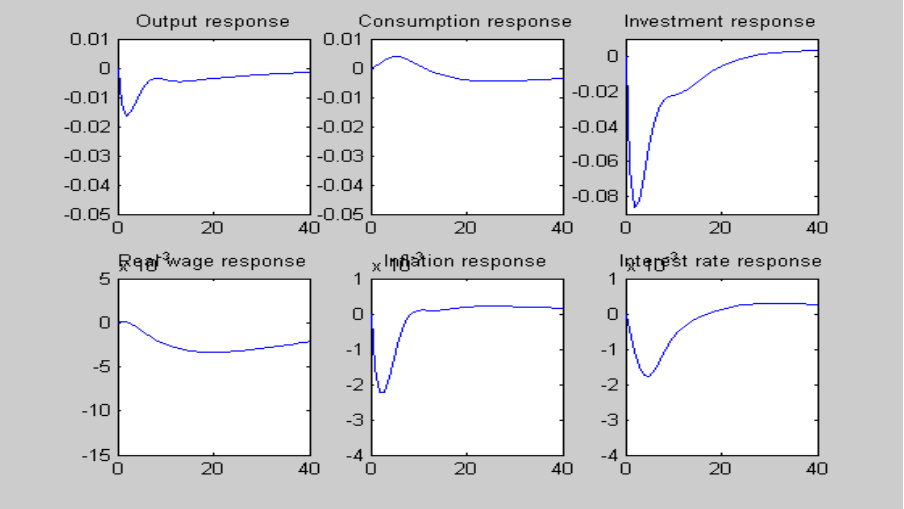


FIGURE A5 - Consumption tax shock

(perfectly competitive labor market)

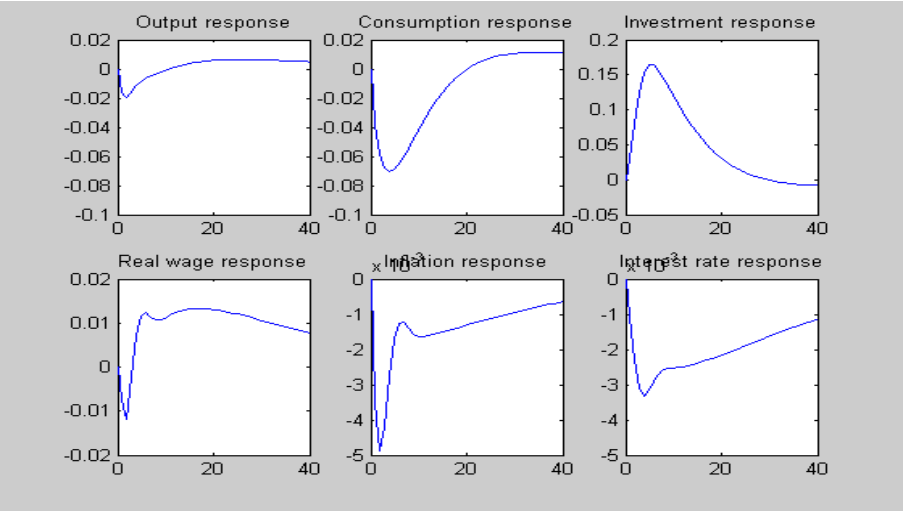
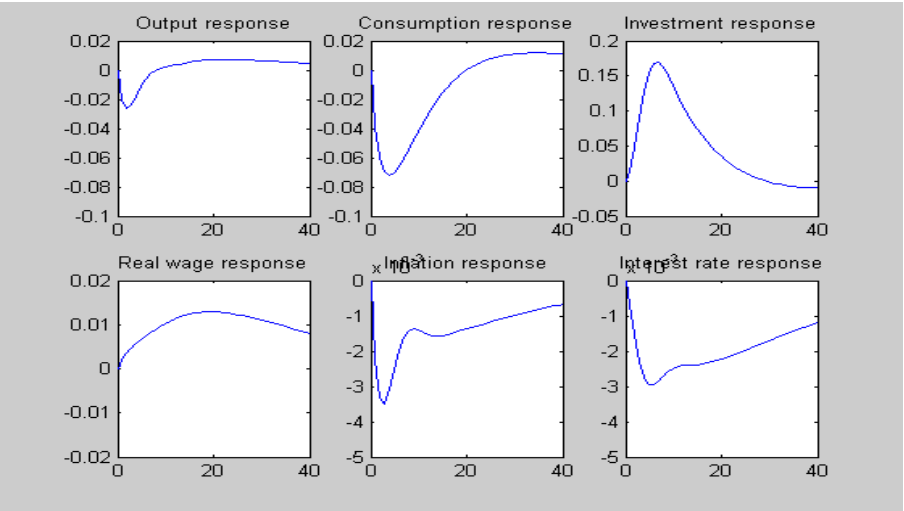


FIGURE A6 - Consumption tax shock

(monopolistic competition in labor market)



A.4 Budget deficits/debt and long-term interest rates: a summary

Table A.1 - Budget Deficits/Debt and Long-Term Interest Rates

Reference	Sample	Deficit/Debt	Impact on Interest Rates
Cohen and Garnier (1991)	G7, 1971-90	Deficit	40 to 55 bp
Elmendorf (1993)	US, 1971-87	Deficit	40 bp
Ford and Laxton (1995)	9 developed, 1977-93	Debt	15 to 50 bp
Helbling and Wescott (1995)	8 developed, 1963-90	Debt	10 to 20 bp
Knot and de Haan (1995)	5 EU, 1960-89	Deficit	40 to 60 bp
Orr *et al* (1995)	17 OECD, 1981-94	Deficit	15 bp
Vamvoukas (1997)	Greece, 1950-93	Deficit	20 bp
Cebula (2000)	US, 1973-95	Deficit	86 bp
Reinhart and Sack (2000)	19 OECD, 1981-2000	Deficit	9 bp
Reinhart and Sack (2000)	G7, 1981-2000	Deficit	12 bp
Lindé (2001)	Sweden, 1982-96	Deficit	20 bp
Chalk and Tanzi (2002)	EU-11 + UK, 1970-98	Debt	1 to 6 bp
Canzoneri *et al* (2002)	US, 1992-2002	Deficit	41 to 60 bp
Afonso and Strauch (2003)	Port. + Germ., 2002	Deficit	5 to 10 bp
Laubach (2003)	US, 1976-2003	Deficit	20 to 40 bp
Laubach (2003)	US, 1976-2003	Debt	5 bp
Bernoth et al (2004)	EU, 1991-2002	Deficit	3 to 5 bp
Egen and Hubard (2004)	US, 1976-2003	Deficit	20 to 40 bp
European Commission (2004)	Euro-11, 1990-2002	Deficit	15 to 20 bp
Faini (2004)	Euro-11, 1979-2002	Deficit	35 bp
Faini (2004)	Euro-11, 1979-2002	Debt	5 to 7 bp
Hauner and Kumar (2006)	G7, 1960-2005	Deficit	13 to 24 bp
Kinoshita (2006)	19 OECD, 1971-2004	Deficit	20 to 25 bp
Kinoshita (2006)	19 OECD, 1971-2004	Debt	1 to 5 bp
Ardagna et al (2007)	16 OECD, 1960-2002	Deficit	10 bp
Ardagna et al (2007)	16 OECD, 1960-2002	Debt	0 to 4 bp
Chinn and Frankel (2007)	7 developed, 1988-2004	Debt	8 to 11 bp
Aisen and Hauner (2008)	60 countries, 1970-2006	Deficit	16 to 26 bp
Schuknecht et al (2008)	Euro-13, 1991-2005	Deficit	4 bp
Ardagna (2009)	16 OECD, 1960-2002	Deficit	25 to 33 bp

Note: The values represent the impact on long-term interest rates of a 1 pp change in the budget deficit or debt to GDP ratio

A.5 The steady-state of the model

In this appendix we show the equations that allow us to solve the steady-state of the model in chapter 5. This version of the steady-state has thirteen variables ($\overline{Y}$, $\overline{C}$, $\overline{R}$, $\overline{I}$, $\overline{K}$, $\overline{q}$, $\overline{r}^k$, $\overline{N}$, $\overline{w}$, $\overline{N^p}$, $\overline{N^g}$, $\overline{G^{lp}}$ and $\overline{G^{hp}}$) and thirteen equations, as follows:

$$\overline{R} = \frac{1}{\beta}, \tag{143}$$

$$\overline{q} = 1, \tag{144}$$

$$\overline{r}^k = \frac{\frac{1}{\beta} - \delta\overline{\tau}^k + \delta - 1}{1 - \overline{\tau}^k}, \tag{145}$$

$$\overline{I} = \delta\overline{K}, \tag{146}$$

$$\frac{\overline{w}\overline{N^p}}{\overline{r}^k\overline{K}} = \frac{1-\alpha}{\alpha}, \tag{147}$$

$$\frac{1}{\mu} = \overline{w}^{(1-\alpha)}\left(\overline{r^k}\right)^{\alpha}\left(\overline{G^{lp}}\right)^{-\gamma}\left(\overline{G^{hp}}\right)^{-\eta}\left(\overline{N^g}\right)^{-\nu}\alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}, \tag{148}$$

$$\left[(1-h)\,\overline{C}\right]^{-\sigma_c}(1-\overline{\tau}^n)\overline{w} = (1+\lambda_w)\overline{N}^{\sigma_N}(1+\overline{\tau}^c) \text{ or } \left[(1-h)\,\overline{C}\right]^{-\sigma_c}(1-\overline{\tau}^n)\overline{w} = \overline{N}^{\sigma_N}(1+\overline{\tau}^c), \tag{149}$$

$$\overline{Y} = \overline{K}^{\alpha}\overline{N^p}^{(1-\alpha)}\left(\overline{G^{lp}}\right)^{\gamma}\left(\overline{G^{hp}}\right)^{\eta}\overline{N^g}^{\nu}, \tag{150}$$

$$\overline{N} = \overline{N^p} + \overline{N^g}, \tag{151}$$

and

$$\frac{\overline{C}}{\overline{\overline{Y}}} = 1 - \frac{\overline{G^{lp}}}{\overline{Y}} - \frac{\overline{G^{hp}}}{\overline{Y}} - \frac{\overline{I}}{\overline{\overline{Y}}}. \tag{152}$$

In order to simplifying the algebra, we impose three non-restrictive assumptions concerning the stability of some SS ratios:

$$\frac{\overline{C}}{\overline{\overline{Y}}} = \gamma_c = 0.6, \tag{153}$$

$$\frac{\overline{G^{hp}}}{\overline{Y}} = \gamma_{g^{hp}} = 0.03, \tag{154}$$

and

$$\frac{\overline{N^g}}{\overline{\overline{N^p}}} = 0.19. \tag{155}$$

After combining and rearranging the previous thirteen equations, we obtain the analytical solution for the model's steady-state. The solutions for the steady-state values of real wage, private labor, investment and output in the monopolistic competition scenario are as follows:

$$\overline{w} = \frac{\alpha^{\frac{\alpha}{(1-\alpha)}}(1-\alpha)\left(\overline{G^{lp}}\right)^{\frac{\gamma}{(1-\alpha)}}\left(\overline{G^{hp}}\right)^{\frac{\eta}{(1-\alpha)}}\left(\overline{N^g}\right)^{\frac{\nu}{(1-\alpha)}}}{\mu^{\frac{1}{(1-\alpha)}}\overline{r}^{k\frac{\alpha}{(1-\alpha)}}}, \tag{156}$$

$$\overline{N^p} = \frac{(1-\alpha)^{\alpha}\left(\overline{r^k}\right)^{\alpha}\overline{Y}}{\alpha^{\alpha}\overline{w}^{\alpha}\left(\overline{G^{lp}}\right)^{\gamma}\left(\overline{G^{hp}}\right)^{\eta}\overline{N^g}^{\nu}}, \tag{157}$$

$$\overline{I} = \frac{\alpha^{(1-\alpha)}\delta\overline{w}^{(1-\alpha)}\overline{Y}}{(1-\alpha)^{(1-\alpha)}\left(\overline{r^k}\right)^{(1-\alpha)}\left(\overline{G^{lp}}\right)^{\gamma}\left(\overline{G^{hp}}\right)^{\eta}\overline{N^g}^{\nu}}, \tag{158}$$

and

$$\overline{Y}^{(\sigma_N+\sigma_c)} = \frac{(1-\overline{\tau}^n)\overline{w}^{(1+\alpha\sigma_N)}\alpha^{(\alpha\sigma_N)}\left(\overline{G^{lp}}\right)^{(\gamma\sigma_N)}\left(\overline{G^{hp}}\right)^{(\eta\sigma_N)}\overline{N^g}^{(\nu\sigma_N)}}{(1-\alpha)^{(\alpha\sigma_N)}\left(\overline{r^k}\right)^{(\alpha\sigma_N)}(1-h)^{\sigma_c}\gamma_c^{\sigma_c}(1+\overline{\tau}^c)\left(1+\frac{\overline{N^g}}{\overline{N^p}}\right)^{\sigma_N}(1+\lambda_w)}. \tag{159}$$

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