Essays on monetary and fiscal policy transmission

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Contents

List of Figures

List of Tables

List of original papers

Working papers:

- Does Trade Integration Alter Monetary Policy Transmission?, Co-authors: Gernot J. Müller, Maik H. Wolters, August 2008, CFS Working Paper No. 2008/29.
- Keynesian Government Spending Multipliers and Spillovers in the Euro Area, Co-author: Volker Wieland, July 2009, CEPR Discussion Paper 7389.
- Fiscal consolidation in Germany, June 2010.

Publications:

- New Keynesian versus Old Keynesian Government Spending Multipliers, Co-authors: John F. Cogan, John B. Taylor, Volker Wieland, *Journal of Economic Dynamics and Control*, 34, 281-295 .

Part I

Introduction

Abstract

In my dissertation I study the transmission of monetary and fiscal policy in New Keynesian DSGE models. In the first chapter we revisit the exchange rate channel in a two-country model of the U.S. and a panel of industrialized countries to analyse how monetary policy transmission in the U.S. changes if it becomes more trade integrated. We find that more openness lowers the sacrifice ratio, although the effect is quantitatively small and depends on the pricing of the firms. In the second chapter we simulate the impact of the U.S. fiscal stimulus package in 2009 on GDP. We find that the government spending multiplier is well below 1. The finding is robust to including rule-of-thumb consumers and simulating the stimulus in the recent recession. In the third chapter we collect the fiscal stimulus measures in the eleven biggest countries of the euro area. Then we do a robustness study by simulating the european package in five different models of the euro area. The macroeconomic models vary in terms of backward-looking decision making of the agents and openness. Our findings provide no support for a Keynesian multiplier. Instead they suggest that additional government spending will reduce private spending for consumption and investment purposes. If government spending faces an implementation lag, the initial effect on GDP may even be negative. In the fourth chapter I estimate a DSGE model for Germany and compute forecasts for the debt-to-GDP ratio. I find that the expected economic recovery will lead to a decrease in Germany's indebtedness in the medium-term given that policy makers stick to the fiscal policy rules.

Zusammenfassung

In der vorliegenden Doktorarbeit befasse ich mich mit der Wirkung und Übertragung von Geld- und Fiskalpolitik in makroökonomischen Modellen. In Kapitel eins untersuchen wir die Auswirkung von zunehmenden Handelsverpflechtungen oder größerer Offenheit von Volkswirtschaften auf die Übertragung von Geldpolitik in einem Neukeynesianischen Zwei-Länder-Modell. Bisherige Analysen zur Übertragung von Geldpolitik in den USA, wie z.B. Christiano, Eichenbaum, and Evans (2005), haben Modelle geschlossener Volkswirtschaften angenommen und konnten empirische Impulsantwortfolgen hinreichend gut erklären. Allerdings werden Volkswirtschaften zunehmend offener. In den USA ist der Anteil der Importe am Bruttoinlandsprodukt von 6 Prozent 1973 auf 16 Prozent gestiegen. Daher untersuchen wir in diesem Kapitel die Frage, wie sehr sich eine größere Offenheit, die wir durch das Verhältnis von Importen zum Bruttoinlandsprodukt messen, auf die Übertragung von Geldpolitik auswirkt, die wir durch den quantitativen Effekt eines geldpolitischen Schocks auf die Produzentenpreisinflation und die heimische Nachfrage messen.
Wir beziehen in unserem Modell strategische Komplementaritäten in die Preissetzung der heimis-

chen Firmen ein, die variierende Gewinnaufschläge implizieren. Über diesen Mechanismus führt eine Zinserhöhung der Zentralbank, die die Währung des heimischen Landes aufwertet zu einem Sinken der Importpreise, welches den Wettbewerbsdruck auf die heimischen Firmen erhöht. Dies reduziert die Gewinnmargen der heimischen Firmen und wirkt dämpfend auf die Produzentenpreise. Auf diese Weise entsteht ein weiterer Wechselkurskanal neben der direkten Auswirkung geringerer Importpreise auf den Konsumentenpreisindex. Die Wirkung dieses Kanals steigt mit zunehmender ökonomischer Offenheit der Volkswirtschaft. Gleichzeitig hängt sie von dem Preissetzungsverhalten der ausländischen Firmen ab. Je größer der Anteil der ausländischen Firmen, die ihre Preise in ausländischer Währung kalkulieren und dann mit dem bestehenden Wechselkurs übersetzen, anstatt ihre Preise direkt im jeweiligen Land zu setzen, desto größer die Wirkung des Wechselkurskanals.

Wir schätzen ein Vektor Autoregressives Modell (VAR), in das wir Konsum, Investment, Produzentenpreisinflation, Zins, Konsumentenpreisinflation und Nettoexporte integrieren, mit Quartalsdaten der USA relativ zu einem Aggregat aus OECD Ländern. Wir kalibrieren die Schlüsselparameter des Modells, indem wir die Differenz der Impulsantwortfolgen des Modells auf einen geldpolitischen Schock und der des VARs mit einem Mechanismus vorgeschlagen von Christiano et al. (2005) minimieren. Wir finden eine geringe Handelspreiselastizität, starke strategische Komplementaritäten der Preissetzung von Firmen und eine geringe Durchreiche von Wechselkursänderungen auf die Importpreise. Die ökonomische Offenheit setzen wir auf 12 Prozent, den Durchschnitt des Import zu Bruttoinlandsprodukt Verhältnisses in den Daten der USA.

Um die Rolle von ökonomischer Offenheit zu untersuchen, berechnen wir den Effekt eines geldpolitischen Schocks in einer Ökonomie die fast geschlossen ist und einer in der Importe 40 Prozent des Bruttoinlandsprodukts ausmachen. Wir finden quantitativ nur einen geringen Unterschied in den Reaktionen von heimischer Inflation und heimischer Nachfrage im Vergleich zur Basiskalibrierung. Das hat zwei Gründe. Der geschätzte Wert für die Handelspreiselastizität liegt nahe an dem Wert für die intertemporale Substitutionselastizität. Dieses führt laut Erceg, Gust, and López-Salido (2007) zu einem geringen Effekt von Änderungen in der ökonomischen Offenheit auf die Modelldynamiken. Zweitens die Durchreiche von Wechselkursänderungen auf die Importpreise ist gering. Dies impliziert einen geringen Effekt des Wechselkurskanals im Modell. Im Prinzip stellen aber strategische Komplementaritäten der Preissetzung von Firmen einen wichtigen Kanal dar, durch welchen zunehmende Handelsverpflechtungen die geldpolitische Übertragung beeinflussen. Wenn wir die Durchreiche von Wechselkursänderungen auf die Importpreise von 11 Prozent, dem geschätzten Wert, auf 40 Prozent erhöhen, steigt die Inflationsreaktion nach einem geldpolitischen Schock um 25 Prozent, wenn die Offenheit der Volkswirtschaft von fast geschlossen auf relativ offen steigt. Wir schliessen daraus, dass geldpolitische Entscheidungsträger sowohl ökonomische Offenheit als auch die Durchreiche von Wechselkursänderungen auf die Importpreise beobachten sollten.

In Kapitel zwei berechnen wir Staatsausgabenmultiplikatoren in einem Neukeynesianischen DSGE Modell basierend auf Smets and Wouters (2007) und vergleichen die Ergebnisse mit denen, die kürzlich zur Politikberatung in den USA verwendet wurden. Wir finden, dass Staatsausgabenmultiplikatoren einer permanenten Staatsausgabenerhöhung in Neukeynesianischen Modellen viel geringer ausfallen als in traditionellen Keynesianischen Modellen. Auch die Annahme, dass die amerikanische Zentralbank die Zinsen in 2009 oder 2009 und 2010 konstant hält vergrößert die Multiplikatoren nur gering. Die Differenzen werden noch größer, wenn man die Effekte des genauen Ausgabenpfads des aktuellen Konjunkturpakets der USA, verabschiedet im Februar 2009, simuliert. Die Multiplikatoren sind kleiner als eins, da privater Konsum und Investitionen verdrängt werden. Der Effekt des Konjunkturpakets im ersten Jahr ist sehr klein. Wenn die Staatsausgaben geringer werden in späteren Jahren der Simulation, wird der Staatsausgabenmultiplikator sogar negativ.

Um die Robustheit der Ergebnisse zu untersuchen, erweitern wir das Smets und Wouters Modell mit einem Anteil keynesianischer Konsumenten, die ihr gesamtes verfügbares Einkommen in jeder Periode konsumieren, schätzen das erweiterte Modell bayesianisch und evaluieren die Auswirkungen des amerikanischen Konjunkturpakets in diesem Modell. Der Staatsausgabenmultiplikator ist über die gesamte Simulationszeit etwas größer, das quantitative Ergebnis ändert sich aber nicht signifikant.

Wir setzen unsere Simulationsergebnisse auch mit der Literatur in Beziehung, die Vektor Autoregressive Modelle oder anderweitige Regressionen verwendet, um Staatsausgabenschocks zu identifizieren und die Effekte auf das Bruttoinlandsprodukt zu messen. In der empirischen Literatur werden Staatsausgabenmultiplikatoren von 0,6 bis 1,7 abhängig von der Identifizierungsstrategie vorgeschlagen. Der typische Zeitpfad der Staatsausgaben in dieser Literatur weicht aber von dem Ausgabenpfad des Konjunkturpakets ab. Nach einer überraschenden Erhöhung der Staatsausgaben, kehren sie langsam zum stationären Zustand zurück. Wir simulieren diesen Staatsausgabenpfad in unserem geschätzten Neukeynesianischen Modell und finden das die Kurzfristeffekte solcher Schocks ungefähr in der Mitte der Ergebnisse dieser Literatur liegen. Dieses Experiment unterstreicht den Nutzen von strukturellen Modellen in der Analyse von Fiskalpolitik, da diese die Reaktion von vorausschauenden Haushalten und Firmen beinhalten.

Die Ergebnisse zur Wirkung des amerikanischen Konjunkturpakets in diesem Kapitel weichen stark von denen im Papier von Christina Romer und Jared Bernstein ab. Sie finden einen sechsfach so starken Effekt des Konjunkturpakets auf das Bruttoinlandsprodukt in den USA und eine um das sechsfache größere Wirkung auf die Beschäftigung. Unsere Ergebnisse werfen zumindest Fragen nach der Robustheit der Ergebnisse von Romer and Bernstein auf.

Wir untersuchen auch, ob unsere Ergebnisse, die wir durch Simulieren des amerikanischen Konjunkturpakets vom stationären Zustand aus erzielt haben, sich auch ergeben, wenn wir in einer tiefen

Rezession weit entfernt vom stationären Zustand starten. Während in einem linearen Modell die Ausgangssituation irrelevant ist, führt die Nullzinsgrenze des Nominalzinses eine wichtige Nichtlinearität ein, die das Ergebnis beeinflussen könnte. Wir simulieren das Smets und Wouters Modell mit aktuellen Daten bis zum ersten Quartal 2009 und erstellen Projektionen der ökonomischen Erholung mit und ohne Konjunkturpaket. Diese Projektionen implizieren, dass die Nullzinsgrenze für zwei bis drei Quartale bindet. Der Effekt des Konjunkturpakets auf das Bruttoinlandsprodukt in den USA liegt sehr nahe an dem Szenario mit konstantem Zins in 2009 und einem Simulieren des Konjunkturpakets vom stationären Zustand aus.

In Kapitel drei erstellen wir eine Übersicht der Konjunkturpakete der elf größten Volkswirtschaften der Europäischen Währungsunion für 2009 und 2010 und berechnen daraus die Höhe der zusätzlichen europäischen Staatsausgaben in Prozent des Bruttoinlandsprodukts. Nach unseren Berechnungen wird das europäische Konjunkturpaket hauptsächlich durch Maßnahmen der deutschen Regierung getrieben und zu einem geringeren Teil durch Maßnahmen der spanischen und französischen Regierung. Wir berechnen dann den Effekt dieser Maßnahmen auf das europäische Bruttoinlandsprodukt mit einem vergleichenden, modelbasierenden Ansatz. Befürworter diskretionärer, fiskalischer Stimuli betonen den keynesianischen Multiplikatoreffekt, der sich durch das Ansteigen von privaten Ausgaben nach einer Erhöhung der Staatsausgaben ergibt und damit zu einem Staatsausgabenmultiplikator größer als eins führt. Wir untersuchen diese Behauptung mit empirischen makroökonomischen Modellen mit keynesianischen Eigenschaften wie Preis- und Lohnrigiditäten.[1] Vier dieser Modelle wurden entwickelt und geschätzt bei Zentralbanken und internationalen Institutionen. Drei dieser Modelle sind neukeynesianische DSGE Modelle, die dem neuesten Stand der Politikanalyse entsprechen.

Wir finden keine Unterstützung für einen keynesianischen Multiplikator. Stattdessen führen zusätzliche Staatsausgaben zu geringeren privaten Ausgaben für Konsum und Investitionen. Die Ursache ist das vorausschauende Verhalten der Haushalte und Firmen. Sie antizipieren höhere steuerliche Belastungen und höhere Zinsen in der Zukunft und reduzieren daher Konsum und Investitionen sofort. Folglich kann der Effekt auf das BIP auch negativ sein, wenn zusätzliche Staatsausgaben zwar bekanntgegeben werden aber mit Verzögerung implementiert werden. Eine geldpolitische Akkommodierung durch Konstanthalten des Nominalzinses in 2009 hilft ist aber nicht ausreichend um das Verdrängen der privaten Ausgaben auszugleichen.

Nur das AWM-Modell der Europäischen Zentralbank, welches vorausschauendes Verhalten weitgehend ignoriert, generiert Staatsausgabenmultiplikatoren, die signifikant größer als 1 sind. Obwohl solche Modelle nützlich für Prognosen in der kurzen Frist sind, wenn es zu keinen größeren Poli-

[1] Die Modelle sind Teil des makroökonomischen Modellarchivs beschrieben in Wieland, Cwik, Mueller, Schmidt, and Wolters (2009).

tikänderungen kommt, sind sie nicht geeignet die Effekte dieser Politikänderungen zu analysieren. Die neukeynesianischen Modelle stattdessen berücksichtigen die wahrscheinliche Reaktion von vorausschauend optimierenden Haushalten und Firmen.
Wir haben auch die Möglichkeit von "Spillover"-Effekten innerhalb der Europäischen Währungsunion mit dem Taylor (1993) Modell analysiert. Dieses Modell, welches vorausschauende, rationale Erwartungen und Preis- und Lohnrigiditäten annimmt, beinhaltet die deutsche, französische und italienische Ökonomie getrennt. Die "Spillover"-Effekte des deutschen Konjunkturpakets auf Frankreich sind sehr gering. Sie werden sogar Ende 2009 leicht negativ im Falle von Italien. Direkte positive Nachfrageeffekte werden durch den negativen indirekten Effekt der Aufwertung des Euro mehr als ausgeglichen.

In Kapitel vier befasse ich mich mit der Dauer und den makroökonomischen Implikationen des Schuldenabbaus in Deutschand. Während der Finanzkrise haben viele Länder weltweit Maßnahmen ergriffen um den Bankensektor zu stabilisieren und zusätzliche diskretionäre Konjunkturpakete beschlossen um die heimische Nachfrage zu stabilisieren. Deutschland hat Anfang 2009 zwei Konjunkturpakete in einer Größenordnung von 3,37% des BIP für 2009 und 2010 verabschiedet. Diese enthalten Infrastrukturprojekte oder die Abwrackprämie auf der Staatsausgabenseite und Einkommenssteuersenkungen auf der Einnahmenseite. Diese Maßnahmen haben die Staatsverschuldung aufgebläht. In Deutschland ist die Verschuldungsrate relative zum BIP auf 77,4% des BIP nach 65,3 Ende 2007 gestiegen. Sie übersteigt den Referenzwert der Maastricht Kriterien jetzt bei fast 18%. Und ein weiterer Anstieg wird durch die Konjunkturpakete in 2010 erwartet. Dieser Anstieg der Verschuldung erhöht die Zinszahlungen des Staates in der Zukunft gegeben gleiche Finanzierungsbedingungen, welches den Spielraum für Fiskalpolitik weiter einengt oder zu einem weiteren Anstieg der Verschuldung führt.
Blanchard, Dell'Ariccia, and Mauro (2010) schlagen in ihrem Papier "*Rethinking Macroeconomic Policy*" vor die Zielverschuldungsraten zu reduzieren. Sie schreiben: "*Still, the lesson from the crisis is clearly that target levels should be lower than those observed before the crisis. The policy implications for the next decade or two are that, when cyclical conditions permit, major fiscal adjustment is necessary and, should economic growth recover rapidly, it should be used to reduce debt-to-GDP ratios substantially, rather than to finance expenditure increases or tax cuts.*" Sie schlagen auch vor mittelfristig glaubwürdige Selbstverpflichtungen oder fiskalische Regeln aufzustellen um die Verschuldung abzubauen. In Deutschland hat die "*Föderalismuskommission II*" vereinbart eine Schuldenbremse ab 2011 einzuführen, welche den Staat verpflichtet die Staatsausgaben inklusive Zinszahlungen auf die Trendstaatseinnahmen anzupassen. Diese Regel erlaubt automatische Stabilisierung, da die Regierung in Rezessionen einen Teil der Staatsausgaben inklusive Zinszahlungen

durch Budgetdefizite bestreiten kann, während sie im Boom Budgetüberschüsse generiert. Defizite und Überschüsse werden auf ein Anpassungskonto gebucht, welches über die Zeit durch Angleichen der Staatsausgaben ausgeglichen werden muss.

Ich leite ein neukeynesianisches DSGE Modell mit detailliertem Fiskalsektor her, welches auf dem Modell von Smets und Wouters basiert. Da der Fokus des Kapitels auf der Staatsverschuldung liegt, ermögliche ich wechselseitige Beeinflussungen von fiskalischen Instrumenten und Verschuldung im Modell. Wie in Kollmann (1998) und Leeper, Plante, and Traum (2010) können die Transfers des Staates, die Einkommenssteuer, die Kapitalsteuer und die Mehrwehrtsteuer auf die Verschuldung des Staates reagieren. Zusätzlich können die Steuern sich auch der Wirtschaftslage entsprechend anpassen um progressive Besteuerung zu ermöglichen. Ich führe eine Schuldenbremse wie beschrieben ein. Aber ich erlaube es, dass Staatsausgaben stärker auf die Wirtschaftslage reagieren, um die Situation vor der Einführung der Schuldenbremse zu beschreiben. Da die Literatur zur Fiskalpolitik die Wichtigkeit von keynesianischen Konsumenten in DSGE Modellen herausstellt, beziehe ich einen Anteil von keynesianischen Konsumenten wie in Gali, López-Salido, and Vallés (2007) zusammen mit vorausschauenden Konsumenten im Modell ein. Ich berücksichtige auch Transfers des Staates, welche gleichmäßig auf keynesianische und vorausschauende Konsumenten verteilt werden.

Ich schätze das Modell mit bayesianischen Techniken auf folgende deutsche Daten vom ersten Quartal 1970 bis zum vierten Quartal 2009: Konsum, Investment, BIP, reale Löhne, geleistete Arbeitsstunden, Inflation, Nominalzins, Staatsverschuldung relativ zum BIP, Einkommenssteuereinnahmen, Mehrwertsteuereinnahmen, Kapitalsteuereinnahmen und Transferleistungen. Ich konzentriere mich insbesondere auf die geschätzten Koeffizienten der Fiskalregeln und deren Implikationen für die Entwicklung der Verschuldung und erstelle Prognosen für die Modellvariablen. Dies ist meiner Ansicht nach das erste Papier, welches den Effekt der Schuldenbremse auf die Staatsverschuldung analysiert und quantifiziert.

Ich finde, dass es durch die erwartete ökonomische Erholung nach der Finanzkrise in 2008 und 2009 möglich ist die Staatsverschuldung relativ zum BIP auf mittlere Sicht signifikant zu reduzieren. Das scheint ein überraschendes Ergebnis zu sein, welches aber möglich ist, wenn die Regierung nicht von den Fiskalregeln abweicht. Die folgenden Kanäle ermöglichen das Ergebnis. Erstens sinkt das Verhältnis von Staatsverschuldung zum BIP direkt, wenn das BIP stärker als die Verschuldung wächst. Zweitens wird erwartet, dass durch die konjunkturelle Erholung die geleisteten Arbeitsstunden und die Reallöhne ansteigen, welches die Einkommenssteuereinnahmen erhöht. Drittens steigen die Durchschnittssteuersätze in der Volkswirtschaft durch die konjunkturelle Erholung. Und die Steuersätze reagieren auf die Verschuldung, welches niedrigere Steuersätze in der Zukunft erwarten lässt, wenn die Verschuldung gesunken ist. Ich erstelle auch bedingte Prognosen, indem ich die Änderungen der fiskalischen Variablen in 2010 durch das Konjunkturpaket und das Wachstumsbeschleuni-

gungsgesetz mit in Betracht ziehe. Ich finde, dass die Konjunkturpakete nur eine geringe Auswirkung auf das BIP haben. Die Verschuldung relativ zum BIP steigt in 2010 stärker an als in der Basisprognose und erreicht den höchsten Wert bei 81,3%. Aber sie kann trotzdem im zweiten Quartal 2015 auf unter 60%, dem Grenzwert der Maastricht Kriterien, sinken. Wenn ich die strikte Schuldenbremse im Modell in 2010 erzwinge und die Elastizität der Einkommenssteuer auf das BIP halbiere, steht die Regierung unter Druck die Staatsausgaben zu reduzieren und die Einkommenssteuersätze zu erhöhen, welches die geleisteten Arbeitsstunden leicht reduziert. Beides verringert die Verschuldung relativ zum BIP schneller, lässt aber das BIP kurzfristig leicht zurückgehen verglichen mit der Basisprognose. Die Unsicherheit der Prognosen wird hauptsächlich durch unvorhergesehene Schocks getrieben.

Part II

Research papers

Chapter 1

Does trade integration alter monetary policy transmission?

1.1 Introduction

Recent research on the monetary transmission mechanism has focused on the quantitative performance of dynamic stochastic general equilibrium (DSGE) models. Specifically, interest has centered on their ability to account for the dynamic effects of monetary policy shocks as apparent from estimated vector autoregression (VAR) models. In a seminal study, Christiano et al. (2005) show that a medium scale New Keynesian model mimics quite closely the VAR-responses to a monetary policy shock of as many as nine variables. This result is obtained while abstracting from external trade altogether. Taken at face value, it suggests that trade integration, or openness, plays no important role for monetary policy transmission—at least as far as a large open economy such as the U.S. is concerned.[1] There is, however, a secular trend in trade integration, suggesting that economies are becoming considerably more open over time. In the U.S., imports, as a fraction of GDP, have risen from about 6 percent in 1973 to 16 percent to date. In fact, as this trend has been accelerating over the last decade, some observers have identified increasing trade integration as an important manifestation of globalization.[2] In this chapter, we investigate more systematically the role of trade integration for monetary policy transmission, where we measure trade integration by the import-to-GDP ratio. Specifically, we assess how increasing openness alters quantitatively the effects of monetary policy shocks on domestic (i.e. producer price) inflation and domestic absorption. We focus on these variables, because

[1] Other studies which employ this approach find similarly satisfactory results for variants of the New Keynesian model. Rotemberg and Woodford (1997), Amato and Laubach (2003), Bovin and Giannoni (2006) and Meier and Müller (2006) are examples. These studies also assume counterfactually closed economy models. Clearly, other studies have explored the empirical performance of open economy DSGE models; yet these studies have typically not been particularly concerned with monetary transmission, see, e.g., Lubik and Schorfheide (2006) and Adolfson, Laséen, Lindé, and Villani (2007).

[2] The consequences of globalization for monetary policy are widely discussed both in academia and among policy makers. Most commentators, taking a fairly general perspective, have argued that globalization does not fundamentally affect the central bank's ability to control the economy, see, e.g., Mishkin (2007) and Bernanke (2007). Changes brought about by globalization may nevertheless require, as Yellen (2006) puts it, "some recalibration of policy responses".

they are well defined in closed economy models as well.

Taking an analytical perspective, earlier work by Clarida, Galí, and Gertler (2001) and Galí and Monacelli (2005) has stressed the similarity between open and closed economy versions of the New Keynesian baseline model. In fact, apart from being a source of additional shocks, 'openness' merely alters some of the reduced-form coefficients of the canonical representation of the model which is, in fact, shown to be isomorphic in closed and open economies. More recently, Erceg et al. (2007) have shown that the difference between closed and open economies in this class of models hinges on the relative size of the intertemporal elasticity of substitution and the trade price elasticity. Moreover, these authors argue that—for reasonable calibrations—increasing openness is unlikely to alter the transmission of domestic shocks, monetary policy shocks inclusive, in a quantitatively important way.

However, taking up the question within the New Keynesian baseline model twists the analysis towards finding no effect of openness. A key assumption underlying the derivation of the New Keynesian Phillips curve and, hence, its isomorphism in closed and open economies, is that the demand functions faced by intermediate goods firms are characterized by a constant elasticity of substitution. This, in turn, implies that the desired markup is independent of the price of competitors, i.e. there are no strategic complementarities in price setting. Such complementarities arise under a more general formulation of the demand functions, or, rather, the underlying aggregation technology. In this case, the isomorphism of the New Keynesian Phillips curve in closed and open economies breaks down. Intuitively, strategic complementarities arise not only with respect to domestic, but also with respect to foreign competitors. Hence, the domestic currency price charged by foreign competitors enters the decision problem of domestic firms and eventually the New Keynesian Phillips curve. Recently, Guerrieri, Gust, and López-Salido (2008) have highlighted the importance of this mechanism in accounting for inflation dynamics.[3]

In this chapter, we take price-setting complementarities into account when exploring the role of openness for monetary transmission. As a result, a new dimension of the exchange rate channel emerges. Traditionally, monetary policy is thought to directly impact CPI-inflation and to indirectly impact domestic inflation via the exchange rate, where the latter effect comes about through changes in demand induced by 'expenditure-switching'. With strategic price-setting complementarities, changes in the exchange rate, which alter the domestic currency prices charged by foreign competitors, directly impact domestic inflation. The importance of this effect increases with i) the extent of strategic complementarities in price-setting; ii) the openness of an economy and iii) the amount of exchange rate pass-through.

Our analysis is based on a medium-scale two-country DSGE model. It features an aggregation tech-

[3]Specifically, they estimate the resulting variant of the New Keynesian Phillips curve on the basis of single equation techniques. Importantly, in contrast to our analysis, they assume that all firms engage in local currency pricing.

nology for the production of final goods which gives rise to strategic complementarities in price-setting; in addition, the aggregation technology determines trade integration by giving unequal weight to domestically produced and imported intermediate goods. The model also features a number of frictions which the literature has found to increase the empirical success of this class of models; notably, we allow exchange rate pass-through to be limited in the short-run. Overall, the model structure is rich enough to provide a quantitatively realistic account of the monetary transmission mechanism such as to allow us to study the quantitative implications of trade integration on monetary transmission.

As a benchmark, we compute impulse responses to a monetary policy shock within a VAR model estimated on quarterly time series data for the U.S. relative to an aggregate of industrialized countries. In addition to standard 'closed-economy' variables, the VAR model also includes CPI-inflation as well as U.S. net exports. We treat the impulse responses as a characterization of the actual monetary transmission mechanism and estimate the structural parameters of the DSGE model employing the minimum distance estimation strategy suggested by Rotemberg and Woodford (1997) and Christiano et al. (2005). To avoid identification problems we fix several parameter values prior to the estimation, most notably the degree of openness which we assume to be 12 percent, i.e. the average import-GDP-ratio of the U.S. in our sample. We estimate the values of nine parameters and find that the estimated model is able to replicate the VAR evidence fairly well for plausible parameter values. Three estimates are particularly noteworthy: a low value for the trade price elasticity, strong complementarities in price-setting and limited exchange rate pass-through.

In order to explore the role of openness, we compute the effects of a monetary policy shock in an economy that is approximately closed and an economy where imports account for 40 percent of GDP. Relative to the baseline economy, there is hardly any difference in the responses of domestic inflation and absorption in these counterfactual economies. Two reasons are key for this result. First, the estimated value for the trade price elasticity is close to intertemporal elasticity of substitution, which, according to the results reported by Erceg et al. (2007), prevents openness from altering the dynamics of the New Keynesian baseline model. Second, as exchange rate pass-through is limited, the exchange rate channel is prevented from operating in a quantitatively important way. We find, however, that strategic complementarities in price-setting would, in principle, constitute an important channel through which openness impacts monetary transmission. Specifically, if we increase the exchange rate pass-through from an estimated value of 12 percent to 40 percent, openness has sizeable effects. In this case, moving from the closed to the very open economy increases the effects of a monetary policy shock on domestic inflation by some 25 percent. As an implication for monetary policy, we stress that the joint evolution of trade integration as well as exchange rate pass-through should be monitored closely.

The remainder of this chapter is organized as follows. In section 1.2 we introduce the details of

the model economy. Section 1.3 presents time series evidence from the estimated VAR model and discusses the estimation of the DSGE model. In section 1.4, we take a closer look at the role of trade integration for monetary transmission. Section 1.5 concludes.

1.2 Model

In this section we develop a two-country DSGE model to study monetary policy transmission in open economies. Most of the model features are standard and familiar from so-called medium scale DSGE models as put forward, for instance, in Christiano et al. (2005) or Smets and Wouters (2005) in a closed economy context.[4] There is a representative household in each country owning the capital stock which is rented together with labor services to intermediate goods producers on a period-by-period basis. Adjusting the level of investment is costly. International financial markets are assumed to be complete.

We assume that in each country there is a continuum of intermediate good producers operating under monopolistic competition and being constrained in price setting à la Calvo. A fraction of these firms invoices exports in their own currency. Using common terminology, these firms are engaging in 'producer currency pricing', or 'PCP' for short. The remaining firms are engaging in 'local currency pricing', or 'LCP', by invoicing domestic sales and exports in the currency of domestic and foreign buyers, respectively. A key aspect of monetary transmission in open economies is the extent of exchange rate pass-through. In our setup it will be smaller, the more pervasive LCP for any given degree of price rigidity.[5]

In each country final goods firms combine domestic and imported intermediate goods to provide households with final goods used for consumption and investment purposes. The aggregation technology employed by final goods firms may imply unequal weights of domestic and imported intermediates in the production of final goods—thereby determining the degree of openness. In addition, the aggregation technology induces demand functions for intermediate goods which are characterized by a non-constant price elasticity of substitution (NCES). Such an aggregation technology has recently been advocated by Gust et al. (2006), and Guerrieri et al. (2008) in an open economy context. Importantly, it induces strategic complementarities in price-setting among intermediate good firms not only with respect to domestic, but also with respect to foreign competitors.[6]

[4] In setting up the model we also draw on earlier work by Chari, Kehoe, and McGrattan (2002), Kollmann (2002), Galí and Monacelli (2005) and Corsetti and Pesenti (2005), among others.

[5] See Bergin (2006) for a similar formulation, Betts and Devereux (1996, 2000) for early contributions and Obstfeld and Rogoff (2000) for a critical discussion. Note that in the present model nominal rigidities are critical for limiting the extent of exchange rate pass-through. Corsetti and Dedola (2005) and Gust, Leduc, and Vigfusson (2006), in contrast, provide real models of limited exchange rate pass-through.

[6] The original closed economy formulation goes back to Dotsey and King (2005) or, more generally, to Kimball (1995). Sbordone (2007) uses a similar technology when discussing the consequences of firm entry for the slope of the New Keynesian Phillips curve. While Gust et al. (2006) and Guerrieri et al. (2008) focus on pass-through and inflation dynamics,

In the following we give a formal exposition of the model, discussing in turn the problems of final goods firms, intermediate good firms, and the representative household. We close the model with a feedback rule to characterize monetary policy. As both countries are symmetric, of equal size, and have isomorphic structures, we focus on the domestic economy, i.e. on the 'home' country. When necessary we refer to foreign variables by means of a star superscript.

1.2.1 Final goods firms

Final goods are composites of intermediate goods produced by a continuum of monopolistic competitive firms in both countries. We use $j \in [0,1]$ to index intermediate good firms as well as their products and prices. Final goods firms operate under perfect competition and purchase domestically produced intermediate goods, $A_t(j)$, as well as imported intermediate goods, $B_t(j)$. Final goods, F_t are not traded across countries, but are used for domestic consumption, C_t, investment, I_t, and government spending, G_t. In each period, market clearing requires that $F_t = C_t + I_t + G_t$.
Letting $P_t^A(j)$ denote the domestic price of a domestically produced intermediate good and $P_t^B(j)$ the domestic price of an imported intermediate good, the problem of the representative final goods firm is to produce F_t while minimizing expenditures given by

$$\int_0^1 P_t^A(j)A_t(j)dj + \int_0^1 P_t^B(j)B_t(j)dj \tag{1.1}$$

subject to

$$\left[V_{Dt}^{\frac{\sigma-1}{\sigma}} + V_{Mt}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} - \left[\frac{1}{(1+\eta)\upsilon} - 1\right] = 1, \tag{1.2}$$

where V_{Dt} and V_{Mt} are defined as follows

$$V_{Dt} = \int_0^1 \omega^{\frac{\sigma}{\sigma-1}} \frac{1}{(1+\eta)\upsilon} \left[\frac{(1+\eta)}{\omega}\frac{A_t(j)}{F_t} - \eta\right]^{\upsilon} dj, \tag{1.3}$$

$$V_{Mt} = \int_0^1 (1-\omega)^{\frac{\sigma}{\sigma-1}} \frac{1}{(1+\eta)\upsilon} \left[\frac{(1+\eta)}{(1-\omega)}\frac{B_t(j)}{F_t} - \eta\right]^{\upsilon} dj. \tag{1.4}$$

Our aggregation technology given by (1.2), (1.3) and (1.4) follows Gust et al. (2006) closely. A few remarks concerning key parameters are in order. The trade price elasticity, i.e. the elasticity which measures the extent of substitution from goods produced at home to those produced abroad for a given change in relative prices, is a key parameter for the international transmission mechanism. In our setup it is a function of several parameters and given by

$$\tilde{\sigma} = \frac{-\sigma}{(\sigma(\upsilon-1)-\upsilon)(1+\eta)}. \tag{1.5}$$

respectively, we explore the implications for monetary transmission.

The elasticity of substitution between goods produced within the same country is generally time varying. In steady state it is constant and given by

$$\epsilon = \frac{1}{1-\upsilon}\frac{1}{1+\eta}. \tag{1.6}$$

The parameter η plays a crucial role for both elasticities. It provides a measure of how strongly our setup deviates from the special case where the elasticity of substitution is constant (CES), which is nested in our model for $\eta = 0$. Finally, the parameter ω measures the weight of domestically produced goods in final goods in steady state. $1-\omega$ measures the fraction of imports in final goods in steady state and thus corresponds to the import-GDP-ratio.

Optimization behavior of domestic and foreign final goods firms gives rise to demand functions for domestically produced intermediate goods

$$A_t(j) = \frac{\omega}{1+\eta}\left[\left(\frac{P_t^A(j)}{P_t^A}\right)^{\frac{1}{\upsilon-1}}\left(\frac{P_t^A}{\Gamma_t}\right)^{\frac{\sigma}{\sigma(\upsilon-1)-\upsilon}}+\eta\right]F_t, \tag{1.7}$$

$$A_t^*(j) = \frac{1-\omega}{1+\eta}\left[\left(\frac{P_t^{A*}(j)}{P_t^{A*}}\right)^{\frac{1}{\upsilon-1}}\left(\frac{P_t^{A*}}{\Gamma_t^*}\right)^{\frac{\sigma}{\sigma(\upsilon-1)-\upsilon}}+\eta\right]F_t^*, \tag{1.8}$$

where Γ_t is a price index defined below. Global demand for a generic good j is then given by

$$Y_t(j) = A_t(j) + A_t^*(j). \tag{1.9}$$

Note that the demand function includes a linear term if $\eta \neq 0$. As a result, price elasticities of demand and the desired markup of intermediate goods firms will be time-varying, or, in other words, price-setting behavior at the level of intermediate goods firms is characterized by strategic complementarities.

The optimization problem of final goods firms implicitly defines price indices. For further reference, it is useful to explicitly distinguish between the prices charged by LCP and PCP-firms. Therefore, let $P_t^{A,PCP}(j)$ and $P_t^{A,LCP}(j)$ denote the domestic price charged by a domestic intermediate goods firm engaged in PCP and LCP, respectively. Letting $\alpha \in [0,1]$ be the fraction of LCP-firms and $(1-\alpha)$ the fraction of PCP-firms, the domestic producer price index P_t^A and the import prices index P_t^B are given by the following expressions:

$$P_t^A = \left(\int_0^\alpha P_t^{A,LCP}(j)^{\frac{\upsilon}{\upsilon-1}}dj + \int_\alpha^1 P_t^{A,PCP}(j)^{\frac{\upsilon}{\upsilon-1}}dj\right)^{\frac{\upsilon-1}{\upsilon}}, \tag{1.10}$$

$$P_t^B = \left(\int_0^\alpha P_t^{B,LCP}(j)^{\frac{\upsilon}{\upsilon-1}}dj + \int_\alpha^1 P_t^{B,PCP}(j)^{\frac{\upsilon}{\upsilon-1}}dj\right)^{\frac{\upsilon-1}{\upsilon}}. \tag{1.11}$$

The price index for final goods is given by

$$\begin{aligned} P_t &= \frac{1}{1+\eta}\Gamma_t + \frac{\eta}{1+\eta}\omega\left(\int_0^\alpha P_t^{A,LCP}(j)dj + \int_\alpha^1 P_t^{A,PCP}(j)dj\right) \\ &+ \frac{\eta}{1+\eta}(1-\omega)\left(\int_0^\alpha P_t^{B,LCP}(j)dj + \int_\alpha^1 P_t^{B,PCP}(j)dj\right), \end{aligned} \tag{1.12}$$

where

$$\Gamma_t = \left[\omega(P_t^A)^{\frac{(\sigma-1)\upsilon}{\sigma(\upsilon-1)-\upsilon}} + (1-\omega)(P_t^B)^{\frac{(\sigma-1)\upsilon}{\sigma(\upsilon-1)-\upsilon}}\right]^{\frac{\sigma(\upsilon-1)-\upsilon}{(\sigma-1)\upsilon}}. \tag{1.13}$$

Finally, letting S_t denote the nominal exchange rate and assuming that the law of one price holds for PCP-firms, we obtain the following relationships:

$$P_t^{B,PCP}(j) = S_t P_t^{B,PCP*}(j); \quad P_t^{A,PCP}(j) = S_t P_t^{A,PCP*}(j). \tag{1.14}$$

1.2.2 Intermediate good firms

The production of intermediate goods, $Y_t(j)$, is governed by a Cobb-Douglas production function

$$Y_t(j) = K_t(j)^{\theta} H_t(j)^{1-\theta}, \tag{1.15}$$

where $H_t(j)$ and $K_t(j)$ denote labor and capital employed by firm j. Letting W_t and R_t denote the nominal wage rate and the rental rate of capital, respectively, minimizing costs implies for (nominal) marginal costs

$$MC_t(j) = \frac{W_t H_t(j)}{(1-\theta)Y_t(j)} = \frac{R_t K_t(j)}{\theta Y_t(j)}. \tag{1.16}$$

We assume that price setting is constrained exogenously by a discrete time version of the mechanism suggested by Calvo (1983). Each firm has the opportunity to change its price with a given probability $1-\xi$. Moreover, we assume that when a firm has the opportunity to do so, it sets the new price in order to maximize the expected discounted value of net profits before the realization of shocks in a given period.[7] Firms that do not reoptimize in a certain period index their price to last period's producer price inflation, where the degree of indexation is given by the parameter $\kappa \in [0,1]$.

In setting the new price $P_t^{A,PCP}(j)$, the problem of a generic PCP-firm is given by

$$\max \sum_{k=0}^{\infty} \xi^k E_{t-1} \left(\frac{Q_{t,t+k} Y_{t+k}(j)}{P_{t+k}} \left[P_t^{A,PCP}(j) \prod_{s=1}^{k} \left(\Pi_{t+s-1}^A\right)^{\kappa} - MC_{t+k} \right] \right), \tag{1.17}$$

subject to the demand function (1.9), the production function (1.15) and the optimality condition on factor inputs (1.16).[8] $\Pi_t^A = P_t^A / P_{t-1}^A$ denotes domestic inflation. Profits are discounted with the stochastic discount factor, $Q_{t,t+1}$, implicitly defined below.

The pricing problem of a generic LCP-firm is subject to the same constraints as those of the PCP-firm. It sets two distinct prices for the domestic and foreign market. The domestic price $P_t^{A,LCP}(j)$ is set to solve

$$\max \sum_{k=0}^{\infty} \xi^k E_{t-1} \frac{Q_{t,t+k} A_{t+k}(j)}{P_{t+k}} \left[P_t^{A,LCP}(j) \prod_{s=1}^{k} \left(\Pi_{t+s-1}^A\right)^{\kappa} - MC_{t+k} \right], \tag{1.18}$$

[7] In other words, period t prices are set conditional on the information period $t-1$, see Christiano et al. (2005).

[8] In our formulation we implicitly assume that demand for intermediate good j is met at all times.

subject to the demand function (1.7), while $P_t^{A,LCP*}(j)$ is set to solve

$$\max \sum_{k=0}^{\infty} \xi^k E_{t-1} \frac{Q_{t,t+k} A_{t+k}^*(j)}{P_{t+k}} \left[S_{t+k} P_t^{A,LCP*}(j) \prod_{s=1}^{k} \left(\Pi_{t+s-1}^B \right)^{\kappa} - MC_{t+k} \right] \tag{1.19}$$

subject to the demand function (1.8).

1.2.3 Households

A representative household allocates consumption expenditures intertemporally on final goods and supplies labor, H_t, to intermediate good firms. The preferences of the household are given by

$$\sum_{t=0}^{\infty} \beta^t \frac{[(C_t - bC_{t-1})^{\mu}(1 - H_t)^{1-\mu}]^{1-\gamma}}{1-\gamma}, \tag{1.20}$$

where β is a time discount factor and $b \in [0, 1)$ measures the extent of consumption habits. The parameters γ and μ are positive constants characterizing preferences.

Households own the domestic capital stock, K_t, which is internationally immobile as are labor services. As in Christiano et al. (2005) it may be costly to adjust the level of investment, I_t. Specifically, the law of motion for capital is given by

$$K_{t+1} = (1 - \delta)K_t + [1 - \Psi(I_t / I_{t-1})]I_t, \tag{1.21}$$

where δ denotes the depreciation rate; restricting $\Psi(1) = \Psi'(1) = 0$ and $\Psi''(1) = \chi > 0$ ensures that the steady state capital stock is independent of investment adjustment costs captured by χ.

A complete set of state-contingent securities is traded at an international level. Letting Ξ_{t+1} denote the period $t+1$ payoff of the portfolio held at the end of period t, the gross short-term nominal interest rate, $(1 + i_t)$, is implicitly defined by $(1 + i_t)^{-1} = E_t Q_{t,t+1}$, while the budget constraint reads as follow

$$W_t H_t + R_t K_t + \Upsilon_t + T_t - P_t (C_t + X_t) = E_t \{ Q_{t,t+1} \Xi_{t+1} \} - \Xi_t. \tag{1.22}$$

Υ_t denotes nominal profits earned by monopolistic firms and transfered to households and T_t denotes lump-sum taxes. We assume that government spending is financed entirely through lump-sum taxes: $T_t = P_t G_t$.

We assume that the household decides on consumption and investment expenditures in period t before period-t uncertainty is revealed. Subject to this additional constraint as well as to (1.21) and (1.22), the household maximizes the expected value of (1.20).

1.2.4 Monetary Policy

To close the model, we assume that monetary policy is characterized by an interest rate feedback rule as in Clarida, Galí, and Gertler (2000). Specifically, we assume for the interest rate

$$i_t = \rho i_{t-1} + (1 - \rho) \left(i + \beta^{-1} \phi_{\pi} \left(\Pi_t^A - \Pi^A \right) + (4F\beta)^{-1} \phi_y \left(F_t - F \right) \right) + \nu_t, \tag{1.23}$$

where letters without time subscript refer to steady state values. The parameter $\rho \in [0, 1]$ captures interest rate smoothing, ϕ_π captures the long-run adjustment of the interest rate to producer price inflation and ϕ_y captures stabilization of domestic absorption.[9] Finally, ν_t represents a zero-mean shock to the short-term interest rate not accounted for by the systematic feedback rule. It thus represents a monetary policy shock.

1.2.5 Model solution

We solve the model numerically by applying standard techniques. Specifically, we use (1.23) together with the linearized first order conditions and constraints of the firms' and household problem as well as their foreign counterparts to determine the equilibrium allocation near the deterministic and symmetric steady state. We use the approximate solution of the model to investigate the effects of monetary policy shocks on the economy. To simplify the analysis, we focus on country differences, i.e. the behavior of a domestic variable relative to its foreign counterpart. Before discussing our strategy to assign parameter values, we briefly turn to the implications of strategic price-setting complementarities for the exchange rate channel of monetary policy transmission.

1.2.6 The exchange rate channel revisited

Strategic complementarities in price-setting may alter monetary policy transmission in open economies by adding a new dimension to the exchange rate channel. Traditionally, two dimensions of the exchange rate channel have been distinguished (see, for instance, Svensson, 2000). First, under sticky prices, nominal exchange rate changes translate into real exchange rate changes that in turn induce an expenditure switching effect. As a result, exchange rate changes alter the demand for domestic goods and thus affect domestic producer prices. Note that in this case, the exchange rate impacts only indirectly—via demand—on domestic inflation. Second, nominal exchange rate changes feed directly into the prices of imported goods and hence into CPI-inflation. Both effects, however depend on the extent of exchange rate pass-through. If import prices are insulated from exchange rate movements, the exchange rate channel is failing to operate along both dimensions.

Strategic price-setting complementarities add a new dimension to the exchange rate channel. In order to show this formally, we focus on the case where exchange rate pass-through is complete ($\alpha = 0$) and derive a variant of the New Keynesian Phillips curve as an approximation of the intermediate

[9] We assume that monetary policy responds to domestic inflation and absorption, because under this assumption we can identify monetary policy shocks in our VAR model in a way which is consistent with our theoretical model. Note also that in open economy models focusing on domestic inflation rather than CPI-inflation is often preferable from a welfare point of view, see Galí and Monacelli (2005). In addition, our formulation of the interest rate rule (1.23) is meant to facilitate a comparison of the parameter values ϕ_π and ϕ_y to those obtained in the empirical literature on interest rate rules where inflation and interest rate are typically annualized.

goods firms' price setting problem around a deterministic, zero inflation steady state:

$$E_{t-1}\pi_t = \beta E_{t-1}\pi_{t+1} + \lambda(1-\Psi)E_{t-1}mc_t + \lambda\Psi(1-\omega)\frac{2\omega\tilde{\sigma}}{\epsilon}E_{t-1}q_t, \tag{1.24}$$

where π_t denotes percentage points of domestic inflation, mc_t measures the percentage deviation of marginal costs from steady state and q_t denotes percentage deviation of the relative price of imports expressed in domestic currency. The coefficient $\lambda = (1-\beta\xi)(1-\xi)\xi^{-1}$ is familiar from the New Keynesian baseline model and provides a measure for the pass-through of marginal costs onto inflation. The coefficient Ψ depends on the extent of strategic complementarities in price-setting and other structural parameters of the model: $\Psi = -1\eta\epsilon(\epsilon(1-\eta)-1)^{-1}$.[10]

The relationship (1.24) governs the dynamics of domestic inflation. Note that if $\eta = 0$, we have $\Psi = 0$ and the term q_t disappears from the Phillips curve. In fact, in this case the Phillips curve takes the form which is well-known from the closed-economy New Keynesian baseline model. Clarida et al. (2001) and Galí and Monacelli (2005) have stressed this isomorphism, i.e. the fact that the form of the Phillips curve for the open economy corresponds to that of the closed economy. This case is nested in our model.

Turning to the case where such complementarities are present ($\eta < 0 \rightarrow \Psi > 0$), we observe that the relative price of imports directly matters for domestic inflation. Consider, for instance, a decrease in the domestic currency price of imports resulting from an exchange rate appreciation. In this case, given strategic price-setting complementarities, domestic producers will find it optimal to lower their prices, because the price charged by foreign competitors is reduced: domestic inflation falls. In addition to the coefficient Ψ, two more parameters govern the strength of this effect. First, the larger the trade price elasticity relative to the elasticity of substitution across domestically produced goods ($\tilde{\sigma}/\epsilon$), the stronger the impact of import prices on domestic inflation. Second, the impact will also be stronger, the more open an economy. This follows from imports making up for a larger fraction of the final goods basket, measured by $1-\omega$.

As a consequence, monetary policy may *directly* impact *domestic* inflation via the exchange rate. A monetary contraction which appreciates the nominal exchange rate and lowers the price of imports reduces domestic inflation. This adds a new dimension to the exchange rate channel, which is not present in models without price-setting complementarities. Its importance, however, depends on the extent of exchange rate pass-through in addition to the parameters discussed above. If import prices are unresponsive to exchange rate changes, the exchange rate channel fails to operate. In order to gauge its importance, we need to quantify the extent of exchange rate pass-through along with other key parameters of the model.

[10] Expression (1.24) abstracts from indexation. In appendix 1.F we derive the New Keynesian Phillips curve considering the general case $\alpha \in [0,1]$. Guerrieri et al. (2008) provide a derivation under the assumption that $\alpha = 1$.

1.3 Estimation

Our model is agnostic as regards the sources of business cycle fluctuations and only allows for monetary policy shocks. Accordingly, by bringing the model to the data, we isolate fluctuations in actual time series which can be attributed to monetary policy shocks. Specifically, we focus on the empirical impulse response functions obtained from a VAR estimated on U.S. time series relative to an aggregate of industrialized countries. We use these statistics to pin down the values of key parameters of the model. Such a limited information approach enables our DSGE model to provide an empirically plausible account of the monetary transmission mechanism.[11]

1.3.1 Empirical impulse response functions

We estimate the VAR on quarterly time series data for the period 1973–2006. We focus on relative variables, i.e. the difference of a variable in the U.S. and its counterpart for an aggregate of industrialized countries, which is meant to proxy for the rest of the world ('ROW' for short), see also Clarida and Gali (1994) and Rogers (1999). Specifically, we consider the log of relative consumption, the log of relative investment, the difference in domestic inflation rates (computed on the basis of the GDP deflator), the difference in short term interest rates, the difference in CPI-inflation rates as well as real net exports for the U.S., where real net exports are defined as the log difference in deflated exports and imports.[12] Letting Y_t denote the vector of endogenous variables, we estimate the structural VAR model

$$A(L)Y_t = \varepsilon_t, \tag{1.25}$$

where $A(L) = \sum_{i=0}^{4} A_i L^i$, $LY_t = Y_{t-1}$ and $E(\varepsilon_t \varepsilon_t') = I$.

In order to identify (relative) monetary policy shocks, we assume that A_0 is lower triangular, i.e. we impose the recursive identification scheme which is frequently employed to study the effects of monetary policy shocks, see Kim (2001) for an open economy context. We attach a structural interpretation only to the innovation in relative short-term interest rates. Hence, what matters for identification is how the other variables in Y_t are ordered relative to this variable, see Christiano, Eichenbaum, and Evans (1999). We order relative consumption, relative investment as well as the differential of domestic inflation before and the differential of CPI-inflation and net exports after the short-term interest rate differential. The implied identification assumptions are consistent with our DSGE model: consumption, investment and domestic inflation are predetermined relative to monetary policy shocks, while consumer (i.e. final goods) prices and real net exports are free to adjust

[11] A natural alternative is to estimate the model using full information techniques. This would require to take a stand of all possible sources of business cycle fluctuations, which we can avoid for the purpose of the present study.

[12] We treat CPI-inflation as the empirical counterpart of the DSGE model's inflation rate for final goods. A detailed description of the data is given in appendix 1.G. We remove a constant linear trend from consumption and investment before computing relative variables.

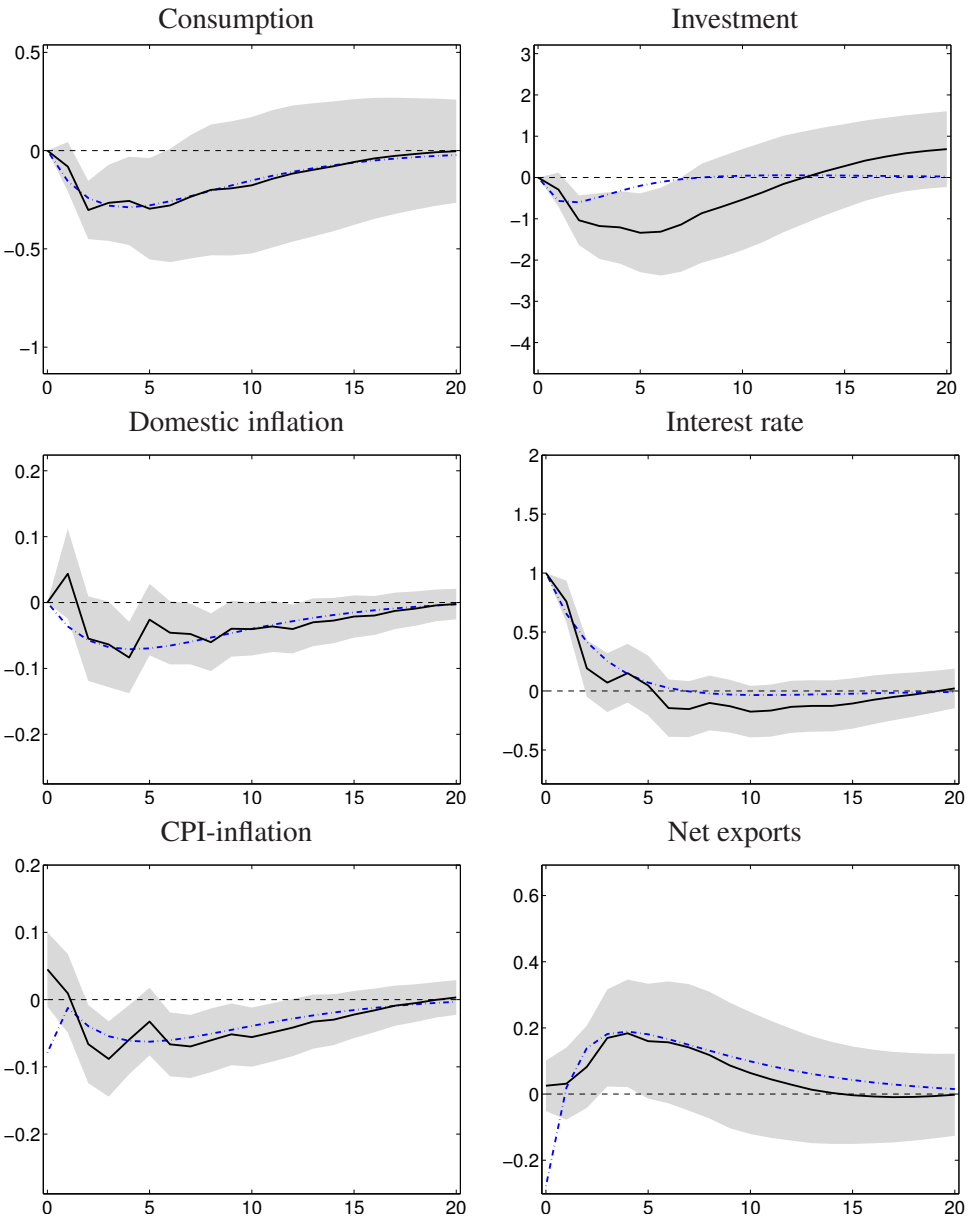


Figure 1.1: Effects of a monetary policy shock

Notes: Shock and responses are in relative terms (U.S. vs. ROW), except for net exports which is the log difference of U.S. exports and imports. Solid line: point estimate; shaded areas: bootstrapped 90 percent confidence intervals; dashed-dotted line: responses of estimated DSGE model; Vertical axes: percent, except for inflation and interest rate (percentage points). Horizontal axes: quarters.

immediately. As in the theoretical model, we are allowing monetary policy to adjust the interest rate contemporaneously to changes in domestic inflation and domestic absorption.[13]

Figure 1.1 displays the impulse responses to a monetary policy shock, i.e. an increase by 100 basis points in the U.S. short rate relative to the aggregate of industrialized countries. The solid line shows the point estimate, while the shaded area measures 90 percent confidence bounds obtained from bootstrap sampling. The upper row shows the responses of consumption and investment in relative terms; for both we find a protracted and hump-shaped decline. While consumption falls by roughly 0.3 percent, investment falls by about 1.25 percent, with the maximum effect occurring between three and six quarters after the shock.

Domestic inflation responds somewhat sluggishly; the maximum decline of about 8 basis points is observed five quarters after the shock. According to our point estimate, it takes another 3 to 4 years for inflation to return to its pre-shock level. The shock to the interest rate differential is mildly persistent, with the short rate returning to its pre-shock level after about one year. The response of CPI-inflation is remarkably close to that of domestic inflation, both from a quantitative and a qualitative point of view. Finally, U.S. net exports display a hump-shaped increase with the maximum effect of about 0.2 percent occurring after about a year.

1.3.2 Estimation of general equilibrium model

The second step of the analysis consists in matching empirical and theoretical impulse responses in order to obtain estimates for the parameters of the DSGE model. This approach has gained popularity in closed economy studies of monetary policy transmission following the pioneering work of Rotemberg and Woodford (1997) and Christiano et al. (2005).

To illustrate this approach, define IR^e to be the empirical impulse response function characterizing the data. The model itself assigns to each admissible vector of structural parameters θ a theoretical impulse response function $IR = IR(\theta)$. We obtain an estimate for the parameter vector of interest, $\widehat{\theta}$, by minimizing the weighted distance between empirical and theoretical impulse response functions, i.e., IR^e and IR:

$$\widehat{\theta} = \arg\min \left(IR^e - IR(\theta)\right)' W \left(IR^e - IR(\theta)\right), \tag{1.26}$$

where W represents a diagonal matrix whose diagonal entries are the reciprocal values of the variance of the empirical impulse responses. Using this weighting matrix ensures that the theoretical impulse

[13] Alternative approaches to identify monetary policy shocks in open economy frameworks consider on monetary aggregates and non-recursive identification schemes, see Eichenbaum and Evans (1995), Cushman and Zha (1997) and Kim and Roubini (2000). More recently, Faust and Rogers (2003) and Scholl and Uhlig (2008) use sign restrictions to achieve identification. These studies have typically been concerned with the behavior of the exchange rate in the face of monetary policy shocks and on the importance of the latter to account for fluctuations in the former. In the present chapter, we are not taking up these issues. Instead, we use the VAR responses as a key statistic to pin down parameter values of our DSGE model.

responses are made to be as close to the empirical ones as possible, in terms of point-wise standard deviations. Regarding the length of the impulse response functions, we consider 20 quarters starting from the second quarter as most variables return to their steady state within 5 years.

The relationship between structural parameters and the implied impulse response functions is non-linear; we therefore obtain theoretical impulse response functions by applying standard numerical techniques. Note that our procedure only admits saddle path stable solution and thus rules out by construction any parameterization of the model which would give rise to equilibrium indeterminacy. Standard errors for $\widehat{\theta}$ are computed using the following expression for the asymptotic variance of our estimator, taken from Wooldridge (2002):

$$\widehat{Avar}\left(\widehat{\theta}\right) = \left(G'WG\right)^{-1}\left(G'W\widehat{\Sigma}WG\right)\left(G'WG\right)^{-1}. \tag{1.27}$$

where $G = \nabla_\theta IR$ represents the Jacobian of the impulse response function generated from the model and $\widehat{\Sigma}$ denotes the variance matrix of the impulse responses obtained from bootstrap sampling.

1.3.3 Parametric setup

In practice, given the number of the structural parameters, it is not possible to identify all of them simultaneously. We therefore fix those parameters prior to the estimation which are either given by first moments of the data or are fairly uncontroversial.

First we set $\omega = 0.88$ which implies an import-to-GDP ratio of 12 percent, the average value for the U.S. in our sample period. Moreover, we set, as, for instance, in Backus, Kehoe, and Kydland (1994) $\beta = 0.99$, $\gamma = 2$ and $\mu = 0.34$ as well as $\theta = 0.36$ and $\delta = 0.025$. In addition, we assume that government spending accounts for 20 percent of GDP, close to the average in our sample period. Regarding price rigidities, we set $\xi = 0.75$, which implies an average duration of prices of one year which is broadly in line with the evidence discussed in Nakamura and Steinsson (2008). We set υ such that the markup earned by intermediate goods firms in steady state is 20 percent.

We are thus left with nine parameters for which we seek to obtain estimates by solving (1.26). We estimate a value for the trade price elasticity, $\tilde{\sigma}$, by adjusting σ according to the relationship (1.5). In addition, we pin down values for the parameters measuring investment adjustment costs, χ, price indexation, κ, habits, b, as well as for those parameters which specify the interest rate feedback rule: ϕ_π, ϕ_y and ρ. Two additional parameters, which are of particular importance for the international monetary transmission mechanism are α, measuring the fraction of LCP-firms and η which is directly related to the degree of strategic price-setting complementarities.

1.3.4 Results

Table 1.1 provides the estimation results. We find plausible point estimates and fairly narrow confidence bounds implied by the standard errors reported in parentheses. The estimated trade price

Table 1.1: Estimated parameter values of DSGE model

Parameter	Description	
$\tilde{\sigma}$	Trade price elasticity	0.48 (0.71)
χ	Investment adjustment costs	1.11 (0.75)
κ	Price indexation	1.00 $(-)$
ϕ_π	Inflation coefficient in policy rule	1.00 (0.50)
ϕ_y	Output coefficient in policy rule	0.02 (0.14)
ρ	Interest rate smoothing	0.67 (0.09)
b	Habits	0.89 (0.05)
α	Share of firms with local currency pricing	0.89 (0.15)
η	NCES-parameter	-10.37 (14.30)

Notes: Parameter estimates obtained from matching DSGE and VAR impulse response functions; standard errors are reported in parentheses. Those parameter values which have been estimated to be at their theoretical bounds have been assumed to take this value prior to estimation; in this case no standard error is reported.

elasticity is below the values often used or found in the literature. Yet several recent studies suggest that a low trade price elasticity may help to account for a larger set of macroeconometric observations, see Lubik and Schorfheide (2006), Kollmann (2006) and de Walque, Smets, and Wouters (2005). Also χ, the parameter capturing investment adjustment costs is somewhat below the value reported in Christiano et al. (2005). This is likely to be the result of the aggregation function of final goods, see the discussion in Backus et al. (1994).

In line with earlier research we also find full indexation of prices, see, for instance, Meier and Müller (2006). Regarding monetary policy we find parameter values which imply a fairly loose monetary stance. Note, however, that our solution procedure rules out equilibrium indeterminacy. The degree of interest rate smoothing is in line with previous findings in the literature, see, for instance, Clarida et al. (2000) for the U.S. We find a considerable amount of habits in consumption, somewhat above the values reported in Smets and Wouters (2005) both for the euro area and the U.S.

For the share of firms engaged in LCP we find a value somewhere between 80 and 99 percent reported by Campa and Goldberg (2005) and Bergin (2006), respectively for the U.S. Finally, the estimate for the parameter η provides a measure for the curvature of our demand functions. Our estimate is somewhat higher than the values assumed by Gust et al. (2006) and Guerrieri et al. (2008), but close to the value assumed by Smets and Wouters (2007) in a closed economy context.

In order to assess the implication of our estimate for η, we display in Figure 1.2 the percentage change in demand for a generic good (vertical axis) resulting from a percentage change in its relative price

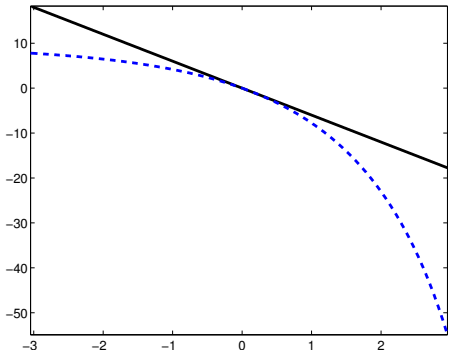


Figure 1.2: Demand function for intermediate goods

Notes: Solid line: CES case ($\eta = 0$); dashed-dotted line: NCES case ($\eta = -10.37$); vertical axes: relative demand in percent; horizontal axes: relative price in percent.

(horizontal axis). The dashed line shows the implied demand function for our estimate of η, while the solid line displays the results for $\eta = 0$ implying a constant elasticity of substitution (CES). Relative to the CES case, our estimate implies strongly curved demand functions. As a result, if the relative price increases, demand falls more than proportionally, while, if the relative price falls, demand increases less than proportionally. This induces strategic complementarities in price-setting, which, ceteris paribus, provides firms with an incentive to adjust prices so as to avoid large deviations from the domestic currency price charged by domestic and foreign competitors.

Given the estimated parameter values, we compute the impulse responses of the model and compare them to those obtained from the VAR model. The dashed-dotted lines in the panels of Figure 1.1 show that the model responses track the empirical responses quite closely. All the responses are within the confidence bounds of the VAR responses, except for the impact response of CPI-inflation and net exports. Also the theoretical response of investment is somewhat less pronounced than its empirical counterpart. The response of the consumption differential, as well as those of domestic inflation and the interest rate are matched particularly closely. Overall, we conclude that the DSGE model—if evaluated at the point estimates—provides a quantitatively satisfactory account of the monetary transmission mechanism as apparent for the estimated VAR model.

1.4 The role of openness in monetary policy transmission

In this section we take up the question which motivates our investigation: does trade integration play a quantitatively important role for the transmission of monetary policy? Given that the estimated DSGE model provides a structural and quantitatively realistic account of the monetary transmission mechanism, it is well suited for counterfactual experiments which allow us to quantify the role of openness. We will also briefly explore some implications for monetary policy.

1.4.1 The role of openness

Several quantitative studies have demonstrated that it is possible to account for the actual transmission mechanism while abstracting from foreign trade altogether, see Christiano et al. (2005). At the same time, economies are bound to become more open as a result of increasing trade integration. While the average import share for the U.S. over the period 1973–2006 has been about 12 percent, it has been increasing secularly: from about 6 percent at the beginning of the sample to about 16 percent at the end of the sample. Interestingly, the trend seems to have been accelerating over the last 10 years or so. Against this background, we compare monetary transmission in the estimated model where imports account for 12 percent to two counterfactual scenarios: an approximately closed economy with imports accounting for less than 0.01 percent and a very open economy with imports accounting for 40 percent of final goods.

Figure 1.3 displays impulse responses of domestic inflation (upper row) and domestic absorption (lower row) to a domestic monetary policy shock, i.e. an exogenous increase in the nominal interest rate by 100 basis points. The responses in the left column are computed using the estimated DSGE model where all parameters, except for ω, are kept at their (estimated) baseline values, notably α measuring the fraction LCP-firms. The dashed lines show the responses for the baseline case where imports account for 12 percent of GDP, while solid lines show the responses for the 'closed' economy; the dashed-dotted line shows the responses for the high-openness scenario. Recall that we focus on domestic inflation and absorption, because these variables are well defined in closed-economy models as well.[14] A comparison of the responses reveals that openness matters very little for the transmission of monetary policy shocks in the estimated model (left column).

In a first step to interpret this results, recall that Clarida et al. (2001) and Galí and Monacelli (2005) have shown that there exists an isomorphic representation of the baseline New Keynesian model for closed and open economies. Specifically, the dynamic 'IS-curve' and the New Keynesian Phillips curve have the same structure. Relaxing the closed economy assumption induces only changes in the parameters governing the pass-through of marginal costs onto domestic inflation and the interest elasticity of demand, i.e. it alters only 'slope' coefficients.[15] More specifically, Erceg et al. (2007) show that the difference between closed and open economies in this class of models can be attributed to the effects of a single composite parameter: the weighted average of the intertemporal elasticity of substitution and the trade price elasticity. As openness determines the relative weights, an increase in openness will alter the dynamic behavior of the economy strongly only if the trade price elasticity

[14] The behavior of CPI inflation and output displays dynamics similar to domestic inflation and absorption, respectively. An exception is the impact period where changes in the nominal exchange rate and net exports dominate the behavior of domestic variables, because the latter are predetermined.

[15] Actually, for certain parameterizations even the difference in the slope coefficients disappears such that 'openness' is merely a source of additional shocks.

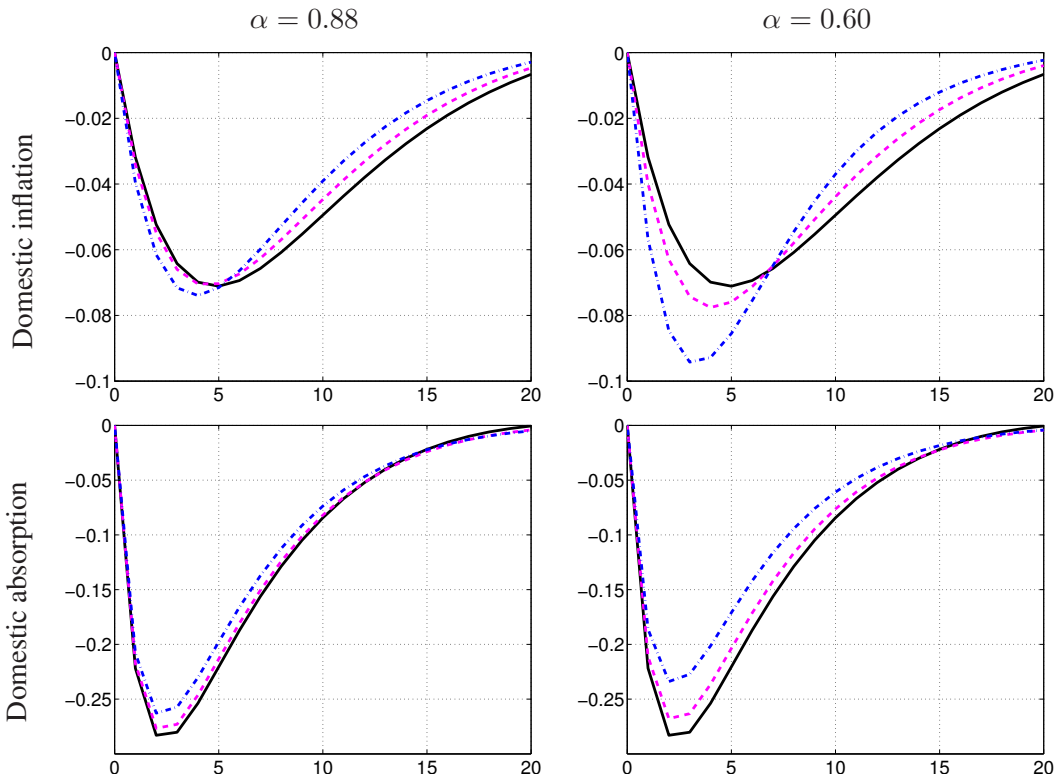


Figure 1.3: Impulse responses to monetary policy shock

Notes: Shock is exogenous increase in domestic nominal interest rate by 100 basis points; lines show response of domestic variables. Solid line displays responses for zero import share; dashed line: 12 percent import share; dashed-dotted line: 40 percent; all parameter values are kept at the values used or obtained in the estimation of the model.

differs considerably from the intertemporal elasticity of substitution.

This result is useful in interpreting our finding. Abstracting from habit formation, our choice of parameter values for μ and γ implies a value for the intertemporal elasticity of substitution for consumption of about $3/4$ which is in the middle of the range of the values discussed in the literature. Our estimate for the trade price elasticity suggests a value which is only slightly lower. It thus appears that because the trade price elasticity and the intertemporal elasticity of substitution are of similar magnitude, openness plays a very limited role in the monetary transmission mechanism.[16]

However, we have so far drawn on a discussion of the New Keynesian baseline model where strategic price-setting complementarities are absent, while we stressed a new dimension of the exchange rate channel emerging under such complementarities, see section 1.2.6. Specifically, in this case openness is likely to alter monetary transmission mechanism as it provides monetary policy with direct leverage on domestic inflation. Yet this effect is not evident in the response of domestic inflation displayed in Figure 1.3—despite our estimate for η which suggests strong complementarities.

[16] In fact, when we increase the trade price elasticity, we find openness to impact more strongly on monetary transmission.

Yet openness and complementarities are not sufficient for this effect to be present. As stressed above, a third condition is a fair amount of exchange rate pass-through. To see this, consider a monetary contraction: only if the resulting appreciation is reflected in foreign competitors charging lower *domestic currency* prices, will domestic firms find it optimal to lower their prices as well. In this case, there will be downward pressure on domestic inflation due to strategic complementarities, in addition to downward pressure resulting from muted demand and marginal costs.

In principle, this dimension of the exchange rate channel can be quite powerful from a quantitative point of view. This is illustrated in the upper right panel of Figure 1.3, which displays the impulse responses of domestic inflation for the different degrees of openness, assuming a higher degree of exchange rate pass-through: we lower the value of α from our estimate of 0.88 to 0.6. In this case, increasing openness induces a much quicker and stronger fall in domestic inflation. In the open economy (40 percent imports, dashed-dotted line) the response peaks after 3 quarters rather than after 5 quarters in the closed economy. Moreover, the strength of the response increases by some 25 percent.[17]

The lower panels of figure 1.3 display the response of domestic absorption for all three openness scenarios, both for $\alpha = 0.88$ (left panel) and $\alpha = 0.6$ (right panel). Generally, domestic absorption falls less in response to the monetary policy shock in the more open economy. The effect of openness, however, is considerably more pronounced if the fraction of LCP-firms is lower, i.e. if exchange rate pass-through is higher. To understand this result, recall that while a monetary policy shock is an exogenous increase in the nominal interest rate, what matters for the dynamic adjustment of domestic absorption is the ex ante real interest rate. Its response depends on the dynamics of CPI-inflation which, in turn, will vary with the degree of openness. On impact, CPI-inflation falls more strongly than domestic inflation, because of the exchange rate appreciation. Yet as the exchange rate overshoots, subsequent changes in the exchange rate tend to raise CPI-inflation relative to domestic inflation—thereby dampening the rise in the real rate. Hence, the fall in domestic absorption is less pronounced in more open economies. Again, this effect is stronger, the more pervasive the exchange rate pass-through.

1.4.2 Implications for monetary policy

Assuming strategic complementarities in price setting, monetary policy gains better control over domestic inflation as trade integration increases, at least in principle. A necessary condition is that import prices are not completely isolated from exchange rate movements. Yet our estimates suggest that exchange rate pass-through is fairly limited. Moreover, several recent studies suggest that ex-

[17] Interestingly, Erceg et al. (2007) also discuss results for the NCES case. However, they still find that the role of openness (for the transmission of technology shocks) is limited which is likely to be the result of assuming that all firms engage in LCP.

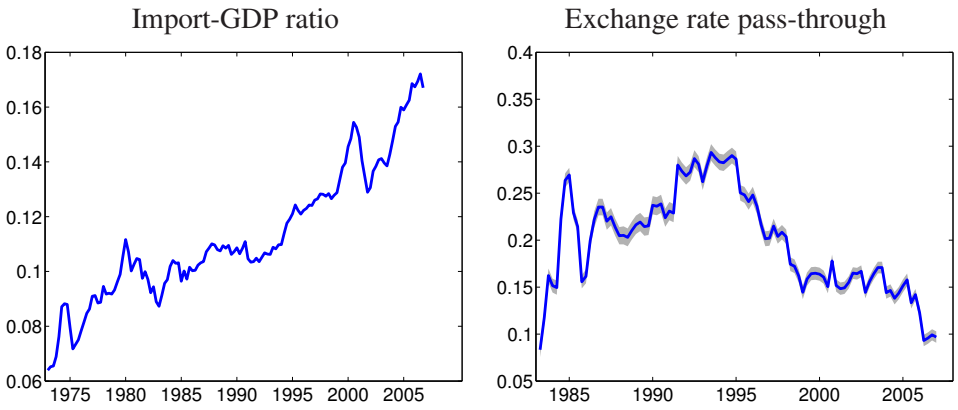


Figure 1.4: Openness and pass-through for the U.S.

Notes: Left panel displays import-GDP ratio; right panel displays reduced form estimate of exchange rate pass-through for 10 year rolling window recursive estimates, shaded area displays two-standard error confidence bounds.

change rate pass-through has been declining over the last one or two decades. Figure 1.4 provides suggestive evidence for recent trends both in trade integration and exchange rate pass-through in the U.S. The left panel displays the import-to-GDP ratio over the period 1973–2006. The right panel displays a reduced-form recursive estimate of exchange rate pass-through for the same period.[18] Our results, suggesting a decline in pass-through over the last 10-15 years, are broadly in line with those obtained in the literature, see, for instance, Marazzi et al. (2005) and Ihrig, Marazzi, and Rothenberg (2006).

Hence, it appears that although openness is on the rise, pass-through will continue to decline, if current trends prevail. This observation has important implications for monetary policy. To assess this more formally, we compute, as a measure for the trade-off faced by monetary policy, the cumulative reduction in domestic absorption relative to the cumulative reduction in domestic inflation for the first year after a monetary policy shock.[19] Again we consider counterfactual scenarios and compare it to our baseline case: an economy which is approximately closed and an economy where imports account for 40 percent. First, we keep pass-through low (at the value implied by our estimate of $\alpha = 0.88$), but allow, in a last experiment, for higher pass-through by lowering α to 0.6.

[18] As it is not possible to obtain rolling window estimates based on the structural estimation approach employed above, we resort to reduced form estimates. Specifically, similar to Gust et al. (2006) we regress recursively, using a 10 year rolling window, the log-differenced relative import price (measured as the nominal price of non-commodity imports of goods and services divided by the CPI-Index) on the log-differenced real effective exchange rate and a constant.

[19] To be precise about the trade-off faced by monetary policy, it would be necessary to specify an objective for monetary policy. Assuming that monetary policy aims at stabilizing both domestic inflation and the output gap, one may argue that there is no real trade-off in the present model: if both monetary authorities stabilize domestic inflation perfectly, they are likely to stabilize the output gaps as well. However, this is only true in the absence of cost-push shocks, which are typically found to be an important source of business cycle fluctuations, see Smets and Wouters (2007). While our model is agnostic about the sources of business cycle fluctuations, our measure for the monetary policy trade-off might provide some idea of how much reduction in domestic demand is necessary in order to engineer a certain reduction in domestic inflation. Our measure is thus related to the sacrifice ratio, except that we do not consider a permanent reduction in inflation.

Table 1.2: Monetary policy trade-off

$1-\omega$	α	
0.00	0.88	4.8
0.12	0.88	4.5
0.40	0.88	3.9
0.40	0.60	2.6

Notes: Right column measures cumulative reduction in domestic absorption relative to domestic inflation for the first year after monetary policy shock.

Table 1.2 reports the results, which confirm our earlier findings. As a result of strategic price-setting complementarities, monetary policy has *direct* leverage on domestic inflation, which operates irrespectively of a contraction in demand. The more open the economy, the stronger this effect appears. At the same time, domestic absorption falls by less, because the monetary contraction implies a smaller increase in the real interest rate. Both effects tend to improve our trade-off measure. Yet from a quantitative point of view, this improvement is contained if pass-through is limited—as becomes apparent from the results of the fourth experiment (last row) where pass-through is increased to counterfactually high levels.

It thus appears that, as long as exchange rate pass-through remains limited, increasing trade openness has little bearing on the monetary transmission mechanism and the trade-off faced by monetary policy.[20] As a matter of fact, current trends suggest that while trade integration is increasing, pass-through is decreasing. Yet it is conceivable that both phenomena are intertwined at a fundamental level. While the present framework has allowed us to study isolated the effects of features, it seems worthwhile to explore the possibility of a joint cause for both trends in future research.[21]

1.5 Conclusion

In this chapter we explore the role of trade integration for monetary policy transmission. First, we develop a New Keynesian DSGE model featuring two symmetric countries and several frictions which recent business cycle research has found to be important in accounting for several macroeconometric observations. In addition, following Gust et al. (2006), Sbordone (2007) and Guerrieri et al. (2008), we assume a fairly general aggregation technology for final goods. It induces strategic complemen-

[20] Erceg et al. (2007) simulate the reduction of the inflation target incorporated in an interest rate feedback rule using the SIGMA model of the FED. They compute the sacrifice ratio for different degrees of openness finding no important role for the latter. Note, however, that while they assume strategic complementarities in price-stetting, they also assume LCP such that import prices are isolated from exchange rate changes in the short-run.

[21] Dornbusch (1987) argues that the extent of exchange rate pass-through and goods market integration are jointly determined. Gust et al. (2006) also link trade integration and exchange rate pass-through in a framework with strategic complementarities. However, they abstract from nominal rigidities.

tarities in price-setting with respect to domestic and foreign competitors such that domestic firms will find it optimal to adjust their prices in response to exchange rate changes which alter the domestic currency price of imports—a new dimension of the exchange rate channel by which monetary policy gains direct leverage over domestic inflation.

In order to quantify the effects of openness on monetary transmission, we estimate, in a first step, a VAR on U.S. time series relative to an aggregate of industrialized countries. We identify monetary policy shocks by imposing an identification scheme which is consistent with our theoretical model and trace out the transmission mechanism through impulse response functions. In a second step, we find parameter values of the DSGE model by matching its impulse responses to those obtained from the VAR. We find that the estimated model is generally able to mimic the empirical response functions quite closely. Importantly, for the model to do so, we require a low value for the trade price elasticity and the exchange rate pass-through, but strong complementarities in price-setting.

In a third step, we compare the effects of a monetary policy shock in the estimated model where imports account for 12 percent of final goods to two alternative scenarios: an economy which is approximately closed and one in which imports account for 40 percent. We find the effects on domestic inflation and absorption to be almost identical. Closer inspection reveals two reasons underlying this finding. First, the estimated value of the trade price elasticity is close to the intertemporal elasticity of substitution. In this case, openness has been shown to induce little change in the New Keynesian baseline model, see Erceg et al. (2007). Second, as regards the new dimension of the exchange rate channel, we find that limited exchange rate pass-through prevents it from having strong quantitative effects. If we repeat our experiment while assuming higher exchange rate pass-through, the effects of monetary policy shocks become considerably stronger.

Finally, turning to the implications for monetary policy, we stress that while increasing openness could, in principle, improve the trade-off faced by monetary policy, such a development is likely to be prevented by low exchange rate pass-through. At current trends, it appears that while trade integration, or openness, is on the rise, exchange rate pass-through is declining as far as major industrialized countries are concerned. We conclude that while policy makers should keep a close eye on the joint development of openness and exchange rate pass-through, future research may investigate possible causes underlying these trends.

Appendices

1.F The New Keynesian Phillips curve

In the following, we go through the main steps of deriving the New Keynesian Phillips curve equation (1.24). We split the derivation into 3 parts. In part one we solve the pricing problem of a generic intermediate good LCP-firm in the domestic market (eq. 1.18). Part 2 solves the pricing problem of a generic intermediate good PCP-firm in the domestic market (eq. 1.17). In part 3 we bring the first parts together using the first order approximation of the definition of the producer price index.

Pricing problem of LCP-firm

Defining $I_{t+k} = \prod_{s=1}^{k}(\Pi_{t+s-1}^{A})^{\kappa}$ and maximizing equation (1.18) subject to the demand function (1.7), we derive the following first order condition

$$E_{t-1}\sum_{k=0}^{\infty}\xi^{k}Q_{t,t+k}\left(P_{t+k}\right)^{-1}I_{t+k}\left[1-\left(1-\frac{MC_{t+k}}{I_{t+k}P_{t}^{A,LCP}(j)}\right)\epsilon_{t+k}(j)\right]A_{t+k}(j)=0, \quad (1.28)$$

where the elasticity of demand for good j in the domestic market is

$$\epsilon_{t+k}(j)=\frac{1}{1-\upsilon}\left[1+\eta\left(\frac{P_{t}^{A,LCP}(j)I_{t+k}}{P_{t+k}^{A}}\right)^{\frac{1}{1-\upsilon}}\left(\frac{P_{t+k}^{A}}{\Gamma_{t+k}}\right)^{\frac{-\sigma}{\sigma(\upsilon-1)-\upsilon}}\right]^{-1}. \quad (1.29)$$

Rewriting equation (1.28) using the definition of real marginal cost $MC_t^R = \frac{MC_t}{P_t^A}$, defining the contract price as $P_t^{AQ,LCP}(j) = \frac{P_t^{A,LCP}(j)}{P_t^A}$ and linearizing gives

$$E_{t-1}\left[\widehat{P}_{t}^{AQ,LCP}(j)\right]=\sum_{k=1}^{\infty}(\beta\xi)^{k}E_{t-1}\left[\widehat{\Pi}_{t+s}^{A}-\kappa\widehat{\Pi}_{t+s-1}^{A}\right]$$
$$+(1-\beta\xi)\sum_{k=0}^{\infty}(\beta\xi)^{k}E_{t-1}\left[\widehat{MC}_{t+k}^{R}-\frac{1}{\epsilon-1}\widehat{\epsilon}_{t+k}(j)\right].$$

In the above equation all variables are expressed in log-deviations from steady-state. Log-linearizing the elasticity of demand for good j equation (1.29), with $\Gamma_t^Q = \frac{\Gamma_t}{P_t^A}$, we get

$$\widehat{\epsilon}_{t+k}(j)=-\eta\epsilon\left(\widehat{P}_{t}^{AQ,LCP}(j)-\sum_{k=1}^{\infty}\left(\widehat{\Pi}_{t+s}^{A}-\kappa\widehat{\Pi}_{t+s-1}^{A}\right)\right)+\eta\tilde{\sigma}\widehat{\Gamma}_{t+k}^{Q}. \quad (1.30)$$

Substituting this expression for the demand elasticity in the first order condition, we have

$$E_{t-1}\left[\widehat{P}_t^{AQ,LCP}(j)\right] = \sum_{k=1}^{\infty}(\beta\xi)^k E_{t-1}\left[\widehat{\Pi}_{t+s}^A - \kappa\widehat{\Pi}_{t+s-1}^A\right]$$
$$+\left(\frac{1-\beta\xi}{1-\frac{\eta\epsilon}{\epsilon-1}}\right)\sum_{k=0}^{\infty}(\beta\xi)^k E_{t-1}\left[\widehat{MC}_{t+k}^R - \frac{\eta\epsilon}{\epsilon-1}\frac{\tilde{\sigma}}{\epsilon}\widehat{\Gamma}_{t+k}^Q\right].$$

Using the definition of the steady state markup $\mu = \frac{\epsilon}{\epsilon-1}$ and the definition of $\Psi = \frac{-\eta\mu}{1-\eta\mu}$, this expression after quasi-differencing can be written as

$$E_{t-1}\left[\widehat{P}_t^{AQ,LCP}(j) - \beta\xi\widehat{P}_{t+1}^{AQ,LCP}(j)\right] = \beta\xi E_{t-1}\left(\widehat{\Pi}_{t+1}^A - \kappa\widehat{\Pi}_t^A\right)$$
$$+(1-\beta\xi)E_{t-1}\left[(1-\Psi)\widehat{MC}_t^R + \Psi\frac{\tilde{\sigma}}{\epsilon}\widehat{\Gamma}_t^Q\right].$$

The log-linearized version of the competitive price index equation (1.13) in the domestic country implies that

$$\widehat{\Gamma}_t^Q = (1-\omega)\widehat{q}_t, \tag{1.31}$$

where $q_t = \frac{P_t^B}{P_t^A}$ is the relative import price in domestic currency. Using this to substitute for the relative competitive price index above we get

$$E_{t-1}\left[\widehat{P}_t^{AQ,LCP}(j) - \beta\xi\widehat{P}_{t+1}^{AQ,LCP}(j)\right] = \beta\xi E_{t-1}\left(\widehat{\Pi}_{t+1}^A - \kappa\widehat{\Pi}_t^A\right)$$
$$+(1-\beta\xi)E_{t-1}\left[(1-\Psi)\widehat{MC}_t^R + \Psi\frac{\tilde{\sigma}}{\epsilon}(1-\omega)\widehat{q}_t\right].$$

Pricing problem of PCP-firm

We can derive a similar expression for the PCP-firms. Maximizing equation (1.17) subject to the demand function (1.9), we derive the following first order condition:

$$E_{t-1}\sum_{k=0}^{\infty}\xi^k Q_{t,t+k}\left(P_{t+k}\right)^{-1} I_{t+k}\left[Y_{t+k} - \left(1 - \frac{MC_{t+k}}{I_{t+k}P_t^{A,PCP}(j)}\right)\left(\epsilon_{t+k}^H(j)A_{t+k}(j) + \epsilon_{t+k}^F(j)A_{t+k}^*(j)\right)\right] = 0,$$

where the elasticity of demand for good j in the domestic market is similar to the LCP-firms problem

$$\epsilon_{t+k}^H(j) = \frac{1}{1-\upsilon}\left[1 + \eta\left(\frac{P_t^{A,PCP}(j)I_{t+k}}{P_{t+k}^A}\right)^{\frac{1}{1-\upsilon}}\left(\frac{P_{t+k}^A}{\Gamma_{t+k}}\right)^{\frac{-\sigma}{\sigma(\upsilon-1)-\upsilon}}\right]^{-1}, \tag{1.32}$$

and the elasticity of demand for good j in the foreign market is given by

$$\epsilon_{t+k}^F(j) = \frac{1}{1-\upsilon}\left[1 + \eta\left(\frac{P_t^{A,PCP}(j)I_{t+k}}{S_{t+k}P_{t+k}^{A*}}\right)^{\frac{1}{1-\upsilon}}\left(\frac{P_{t+k}^{A*}}{\Gamma_{t+k}^*}\right)^{\frac{-\sigma}{\sigma(\upsilon-1)-\upsilon}}\right]^{-1}. \tag{1.33}$$

Linearizing the first order condition of the firms problem using $P_t^{AQ,PCP}(j) = \frac{P_t^{A,PCP}(j)}{P_t^A}$ gives

$$E_{t-1}\left[\widehat{P}_t^{AQ,PCP}(j)\right] = \sum_{k=1}^{\infty}(\beta\xi)^k E_{t-1}\left[\widehat{\Pi}_{t+s}^A - \kappa\widehat{\Pi}_{t+s-1}^A\right]$$
$$+(1-\beta\xi)\sum_{k=0}^{\infty}(\beta\xi)^k E_{t-1}\left[\widehat{MC}_{t+k}^R - \frac{1}{\epsilon-1}\omega\widehat{\epsilon}_{t+k}^H(j) - \frac{1}{\epsilon-1}(1-\omega)\widehat{\epsilon}_{t+k}^F(j)\right].$$

Linearizing both demand elasticities defining $\Gamma_t^{Q*} = \frac{\Gamma_t^*}{P_t^{A*}}$ and the law-of-one-price gap as $q_t^{A*} = \frac{S_t P_t^{A*}}{P_t^A}$ gives

$$\widehat{\epsilon}_{t+k}^H(j) = -\eta\epsilon\left(\widehat{P}_t^{AQ,PCP}(j) - \sum_{k=1}^{\infty}\left(\widehat{\Pi}_{t+s}^A - \kappa\widehat{\Pi}_{t+s-1}^A\right)\right) + \eta\tilde{\sigma}\widehat{\Gamma}_{t+k}^Q,$$
$$\widehat{\epsilon}_{t+k}^F(j) = -\eta\epsilon\left(\widehat{P}_t^{AQ,PCP}(j) - \sum_{k=1}^{\infty}\left(\widehat{\Pi}_{t+s}^A - \kappa\widehat{\Pi}_{t+s-1}^A\right) - \widehat{q}_{t+k}^{A*}\right) + \eta\tilde{\sigma}\widehat{\Gamma}_{t+k}^{Q*}.$$

Substituting the demand elasticities into the first order condition and simplifying yields

$$E_{t-1}\left[\widehat{P}_t^{AQ,PCP}(j)\right] = \sum_{k=1}^{\infty}(\beta\xi)^k E_{t-1}\left[\widehat{\Pi}_{t+s}^A - \kappa\widehat{\Pi}_{t+s-1}^A\right]$$
$$+(1-\beta\xi)\sum_{k=0}^{\infty}(\beta\xi)^k E_{t-1}\left[(1-\Psi)\widehat{MC}_{t+k}^R + \Psi\omega\frac{\tilde{\sigma}}{\epsilon}\widehat{\Gamma}_{t+k}^Q + \Psi(1-\omega)\frac{\tilde{\sigma}}{\epsilon}\widehat{\Gamma}_{t+k}^{Q*} + \Psi(1-\omega)\widehat{q}_{t+k}^{A*}\right].$$

After quasi-differencing, the expression can be rewritten as

$$E_{t-1}\left[\widehat{P}_t^{AQ,PCP}(j) - \beta\xi\widehat{P}_{t+1}^{AQ,PCP}(j)\right] = \beta\xi E_{t-1}\left(\widehat{\Pi}_{t+1}^A - \kappa\widehat{\Pi}_t^A\right)$$
$$+(1-\beta\xi)E_{t-1}\left[(1-\Psi)\widehat{MC}_t^R + \Psi\omega\frac{\tilde{\sigma}}{\epsilon}\widehat{\Gamma}_t^Q + \Psi(1-\omega)\frac{\tilde{\sigma}}{\epsilon}\widehat{\Gamma}_t^{Q*} + \Psi(1-\omega)\widehat{q}_t^{A*}\right].$$

One can linearize the competitive price index in the foreign country analogously to the one in the home country defining the relative export price in foreign currency as $q_t^{B*} = \frac{P_t^{A*}}{P_t^{B*}}$:

$$\widehat{\Gamma}_t^{Q*} = -\omega\widehat{q}_t^{B*} \tag{1.34}$$

Using this expression and equation (1.31) to substitute for the relative competitive price indices above we get

$$E_{t-1}\left[\widehat{P}_t^{AQ,PCP}(j) - \beta\xi\widehat{P}_{t+1}^{AQ,PCP}(j)\right] = \beta\xi E_{t-1}\left(\widehat{\Pi}_{t+1}^A - \kappa\widehat{\Pi}_t^A\right)$$
$$+(1-\beta\xi)E_{t-1}\left[(1-\Psi)\widehat{MC}_t^R + \Psi(1-\omega)\omega\frac{\tilde{\sigma}}{\epsilon}\widehat{q}_t^B - \Psi(1-\omega)\omega\frac{\tilde{\sigma}}{\epsilon}\widehat{q}_t^{B*} + \Psi(1-\omega)\widehat{q}_t^{A*}\right].$$

New Keynesian Phillips Curve

The log-linearized version of the producer price index, equation (1.10), reads as

$$\alpha \widehat{P}_t^{AQ,LCP}(j) + (1-\alpha)\widehat{P}_t^{AQ,PCP}(j) = \frac{\xi}{1-\xi}\left(\widehat{\Pi}_t^A - \kappa \widehat{\Pi}_{t-1}^A\right). \tag{1.35}$$

Using the final equations in the two subsections above to substitute for the contract prices of LCP- and PCP-firms one finally obtains a general formulation for the New Keynesian Phillips curve:

$$E_{t-1}\left(\widehat{\Pi}_t^A - \kappa\widehat{\Pi}_{t-1}^A\right) = \beta E_{t-1}\left(\widehat{\Pi}_{t+1}^A - \kappa\widehat{\Pi}_t^A\right)$$
$$+\lambda E_{t-1}\left[(1-\Psi)\widehat{MC}_t^R + \Psi\left((1-\omega)(\alpha+(1-\alpha)\omega)\frac{\tilde{\sigma}}{\epsilon}\widehat{q}_t^B - (1-\omega)\omega(1-\alpha)\frac{\tilde{\sigma}}{\epsilon}\widehat{q}_t^{B*} + (1-\omega)(1-\alpha)\widehat{q}_t^{A*}\right)\right]$$

with $\lambda = (1-\beta\xi)(1-\xi)\xi^{-1}$.

The special cases with $\alpha = 0$ and $\eta = 0$ are discussed in section 1.2.6. Here we briefly discuss the case of incomplete pass-through ($0 < \alpha < 1$) and strategic complementarities in price setting ($\eta < 0$). In addition to the closed economy Phillips curve or the open economy Phillips curve without strategic complementarities three additional terms show up: $\widehat{q}_t^B$, $\widehat{q}_t^{B*}$ and $\widehat{q}_t^{A*}$. We discuss the underlying economics in turn focusing on a monetary contraction which appreciates the nominal exchange rate.

A reduction of the relative import price $\widehat{q}_t^B$, induces domestic LCP firms to reduce their prices as their demand elasticity increases with a decrease of the import price index relative to the domestic price index. Domestic PCP-firms react in a similar way; in addition they adjust their price to changes in the relative export prices.

Following a nominal appreciation, the relative export price of PCP-firms expressed in foreign currency, $\widehat{q}_t^{B*}$, increases. Recall that PCP-firms can adjust export prices only through adjustments in domestic prices which are then translated via the law of one price into foreign currency. Hence, the increase in the export price, puts downward pressure on (domestic currency) price of PCP-firms.

Following a nominal appreciation, the export prices of PCP-firms increase relative to the export prices of LCP-firms—in foreign currency terms. This is captured by a decrease in $\widehat{q}_t^{A*}$. As the PCP-firms can adjust their export price only by adjusting their domestic price, this puts additional downward pressure on domestic prices of PCP-firms.

All these effects become stronger with the degree of strategic price-setting complementarities η and the import share $1-\omega$. As stressed in the main text, the effects also depend on the degree of exchange rate pass-through. Note that if there are only LCP-firms ($\alpha = 1$), the last two terms in the New Keynesian Phillips Curve drop out and only real marginal cost and the relative import price govern the domestic inflation dynamics. Yet, in this case import prices do not directly respond to exchange rate changes.

1.G Data

Our data are obtained from the OECD Economic Outlook database, see OECD (2007). The ROW aggregate comprises data for Canada, the U.K., Japan and the Euro area. We use data for private consumption (volume), private fixed investment (excl. stockbuilding, volume), and the deflator for private consumption and the deflator for GDP. The latter series are used to construct the CPI-inflation and domestic inflation, respectively.

To construct a measure for net exports of the U.S., we deflate exports (exports of goods and services, value, local currency) and imports (imports of goods and services, value, local currency) with their deflators (export or import price goods and services, local currency) and compute the log-difference of both series. Measures for the short term interest rates are also obtained from the Economic Outlook database (interest rate, short-term) except for the Euro area. In this case we draw on data (STN) from the Area-Wide Model database of the ECB, see Fagan, Henry, and Mestre (2001).

To compute the ROW series, we calculate quarterly growth rates and aggregate these series on the basis of GDP weights (PPP-adjusted, year 2000), based on data from the IMF (2007). To obtain levels, we cumulate aggregated growth rates.

Chapter 2

New Keynesian versus Old Keynesian Government Spending Multipliers

2.1 Introduction

In a recent paper [1] Christina Romer, Chair of the President's Council of Economic Advisers, and Jared Bernstein, Chief Economist of the Office of the Vice-President, provided numerical estimates of the impact of an increase in government spending on GDP and employment in the United States. Such estimates are a crucial input for the policy making process. They help determine the appropriate size and timing of countercyclical fiscal policy packages and they help inform members of the Congress and their constituents about whether a vote for a policy is appropriate. For packages approaching 1 trillion USD including interest, as in 2009, the stakes are enormous. The estimated economic impacts matter.

The Romer-Bernstein estimates are based on two particular quantitative macroeconomic models - one from the staff of the Federal Reserve Board and the other from an unnamed private forecasting firm. By averaging the impacts generated by these two models, they estimate that an increase in government purchases of 1 percent of GDP would induce an increase in real GDP of 1.6 percent compared to what it otherwise would be. Their results are shown in Figure 2.1. Also shown in Figure 2.1 are the estimated effects of exactly the same policy change-a permanent increase in government purchases-as reported in another study published a number of years ago by one of us. [2]

It is clear from Figure 2.1 that the results are vastly different between the different models. Perhaps the most important difference is that in one case higher government spending keeps on adding to GDP "as far as the eye can see," while in the other case the effect on GDP diminishes as non-government

[1] See Romer and Bernstein (2009), Appendix 1, page 12. Their paper was written during the transition period in early January before Christina Romer was sworn in as Chair of the Council of Economic Advisers. The first version of this chapter was circulated immediately after a modified version of the Obama Administrations fiscal stimulus proposal was passed into law in February 2009 as NBER working paper 14782.

[2] See Taylor (1993), Figure 5-8A, page 166. This is a rational expectations model with staggered wage and price setting and thus could be described as "new Keynesian" as defined below.

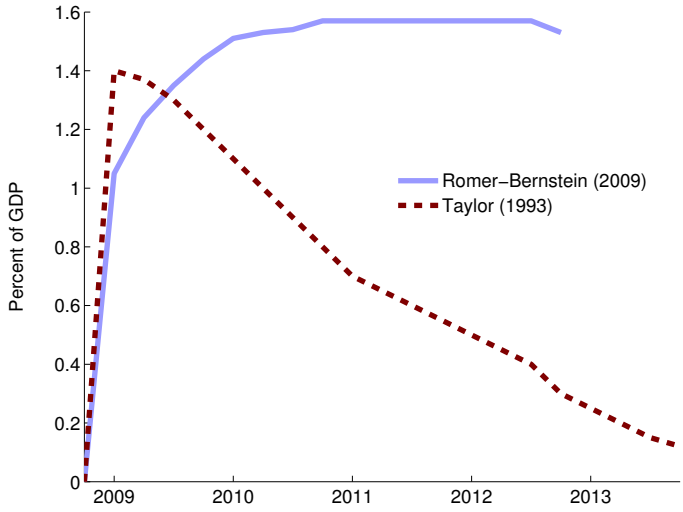


Figure 2.1: Estimated Impact on GDP of a Permanent Increase in Government Purchases of 1 percent of GDP

components are crowded out by government spending.

Macroeconomists remain quite uncertain about the quantitative effects of fiscal policy. This uncertainty derives not only from the usual errors in empirical estimation but also from different views on the proper theoretical framework and econometric methodology. Therefore, robustness is a crucial criterion in policy evaluation. Robustness requires evaluating policies using other empirically-estimated and tested macroeconomic models. From this perspective Figure 2.1 is a concern because it shows that the Romer-Bernstein estimates apparently fail a simple robustness test, being far different from existing published results of another model. For these reasons an examination of the Romer-Bernstein results is in order.

2.2 The Need for an Alternative Assessment

We think it is best to start by conducting a fresh set of simulations with a macroeconomic model other than one of those used in Figure 2.1. We focus on the Smets-Wouters model of the U.S. economy.[3] The Smets-Wouters model is representative of current thinking in macroeconomics. It was recently published in the American Economic Review and is one of the best known of the empirically-estimated "new Keynesian" models. It is very similar to, and "largely based on" according to Smets and Wouters, another well-known empirically-estimated new Keynesian model developed by Chris-

[3]See Smets and Wouters (2007) for a complete review of their model. It determines 14 endogenous variables: output, consumption, investment, the price of capital, the capital stock, capital services, the capital utilization rate, labor supply, the interest rate, the inflation rate, the rental rate on capital, the wage rate, the marginal product of labor, and the marginal rate of substitution between work and consumption. The 14 equations include forward looking consumption, investment, price and wage setting as well as several identities.

tiano et al. (2005). The Smets-Wouters model was highlighted by Woodford (2009) as one of the leading models in his review of the current consensus in macroeconomics.[4]

The term "new Keynesian" is used to indicate that the models have forward looking, or rational, expectations by individuals and firms, and some form of price rigidity, usually staggered price or wage setting. The term also is used to contrast these models with "old Keynesian" models without rational expectations of the kind used by Romer and Bernstein.[5] New Keynesian models rather than old Keynesian models are the ones commonly taught in graduate schools because they capture how people's expectations and microeconomic behavior change over time in response to policy interventions and because they are empirically estimated and fit the data. They are therefore viewed as better for policy evaluation. In assessing the effect of government actions on the economy, it is important to take into account how households and firms adjust their spending decisions as their expectations of future government policy changes.

We first show that the assumptions made by Romer and Bernstein about monetary policy-essentially an interest rate peg for the Federal Reserve-are highly questionable according to new Keynesian models. We therefore modify that assumption and look at the impacts of a permanent increase in government purchases of goods and services in the alternative model. According to the alternative model the impacts are much smaller than those reported by Romer and Bernstein.

We then consider more realistic scenarios. We look at the impact when government spending follows the fiscal policy legislation enacted in February 2009 and we look at a scenario in which monetary policy is more responsive. For these scenarios the impact with the alternative model is even smaller.

2.3 The Problem with an Interest Rate Peg

Romer and Bernstein assume that the Federal Reserve pegs the interest rate-the federal funds rate-at the current level of zero for as long as their simulations run. Given their assumption that the spending increase is permanent, this means forever. In fact, such a pure interest rate peg is prohibited in new Keynesian models with forward-looking households and firms because it produces calamitous economic consequences. As Thomas Sargent and Neil Wallace [6] pointed out more than thirty years ago, a pure interest rate peg will lead to instability and non-uniqueness in a rational expectations model. Inflation expectations of households and firms become unanchored and unhinged and the

[4] See Woodford (2009), which also contains a useful survey of the whole "new Keynesian" literature.

[5] There is a rational expectations version of the FRB/US model. We simulated a permanent increase in government purchases in this version and found that the multipliers declined sharply over time unlike those reported by Romer and Bernstein (2009) but similar to the Taylor (1993) rational expectations model as shown in Figure 2.1. We infer that the FRB/US model and the private sector model used by Romer and Bernstein are not new Keynesian models with rational expectations. Also, as explained below, new Keynesian models would not allow an assumption of a constant zero interest rate forever.

[6] See Sargent and Wallace (1975). Though the Sargent and Wallace model assumes perfectly flexible prices the same results hold in models with sticky prices.

price level may explode in an upward spiral.

A permanent increase in government spending as a share of GDP would eventually raise the real interest rate. This is the mechanism by which other shares of spending (consumption, investment, and net exports) would be reduced to make room for the increased government share. With the Fed holding the nominal interest rate constant at the current value near zero, and thus below inflation, the lower real rate would cause inflation to rise and accelerate without limit. Thus the combination of a permanent increase in government spending and the Fed setting the interest rate at zero would lead to hyperinflation.

If the combination of a permanent government spending increase and a zero interest rate peg were assessed by the Smets-Wouters model or, for that matter, any of the new Keynesian models, the economy's projected performance would reflect the aforementioned consequences. To achieve stability of output and inflation in such a model one must instead assume that, at some point, the federal funds rate is allowed to move above zero and respond to the state of the economy rather than be held fixed. For the simulations presented here we therefore assume that the Federal Reserve only keeps the federal funds rate constant for a finite period of time after which it moves the interest rate depending on what is happening to the economy. We begin by assuming that it keeps the interest rate equal to zero and constant through 2009 and 2010 and then follows a standard monetary policy rule thereafter. Thus, in 2011, nominal interest rates will change somewhat and forward-looking households and firms will incorporate this monetary policy response in their decision making. Keeping interest rates constant for two years still does not seem very realistic and would likely result in an increase in inflation, but it is certainly more realistic than pegging the interest rates at zero forever, or even for four years.

2.4 Government Spending Multipliers: New Keynesian versus Old Keynesian

Table 2.1 shows the response of real GDP to a permanent increase in government purchases of 1 percent of GDP in the new Keynesian model and contrasts these with the average of the two models of Romer and Bernstein. The simulations are done using a new database of macroeconomic models designed explicitly with the purpose of doing such policy evaluation and robustness studies.[7] The increase in government spending is assumed to start in the first quarter of calendar 2009. The forward looking models require explicit assumptions about what household's and firms expect. Our assumption is that, as of the first quarter of 2009, people expect the government spending increase to continue permanently (as in the Romer-Bernstein policy specification), and that the spending increase is ini-

[7]The model database is described in Wieland, Cwik, Mueller, Schmidt and Wolters (2009) and used in a model comparison exercise by Taylor and Wieland (2009).

tially debt-financed. The Smets-Wouters model assumes that any increase in debt used to finance the increased government spending is paid off with interest by raising taxes in the future. We assume that these taxes are "lump sum" in the sense that they not affect incentives to work, save or invest. They do, however, lower future after tax earnings and thereby wealth. If we took such incentive effects into account the increase in government spending would eventually reduce real GDP. Hence, our assumptions err on the side of overestimating the size of the impact of government spending on real GDP.

Table 2.1: Permanent Increase in Government Spending (federal funds rate zero in 2009 and 2010)

	2009Q1	*2009Q4*	*2010Q4*	*2011Q4*	*2012Q4*
Romer/Bernstein	1.05	1.44	1.57	1.57	1.55
Smets/Wouters	1.03	0.89	0.61	0.44	0.40

Note: Impact of a Permanent Increase in Government Spending by 1 Percent of GDP, Percentage increase in real GDP, federal funds rate set to zero throughout 2009 and 2010.

Observe that the Smets-Wouters model predicts a much smaller boost to GDP than the estimates reported by Romer and Bernstein. The Smets-Wouters multiplier is smaller throughout the whole simulation period, and by 2011 is only about one-third the size of the Romer-Bernstein multiplier. The Smets-Wouters model also shows a rapid reduction in the size of the impact over time. Overall the Smets-Wouters impacts are very similar in size and timing to those found in the Taylor (1993) model shown in Figure 2.1. In sum, the Romer-Bernstein estimates are much more optimistic in their GDP estimates than the alternative model considered here.

The Smets-Wouters model predicts that the increase in GDP by the end of 2009 is smaller than the increase in government expenditures itself; that is, the multiplier is less than one. Thus, the model predicts that government "stimulus" quickly produces a permanent contraction in private sector investment and/or consumption. Note that the magnitude of the contraction grows over time. By the end of 2012, for each dollar of "stimulus", the flow of goods and services produced by the private sector falls by sixty cents.

2.5 Alternative Assumptions about Monetary Policy

Table 2.2 shows what would happen if the length of time for which the federal funds rate is anticipated to remain constant is shorter and extends only through the end of 2009. In other words we now assume that the Fed starts following its feedback rule for policy starting in 2010 rather than waiting until 2011. The impacts in Table 2.2 are uniformly smaller through 2011 than those in Table 2.1 because interest rates can begin to increase earlier (in 2010 rather than 2011) accelerating the crowding-out process in the new Keynesian model. Note that the differences between the Smets-Wouters simulations in Table

Table 2.2: Permanent Increase in Government Spending (federal funds rate zero in 2009)

	2009Q1	*2009Q4*	*2010Q4*	*2011Q4*	*2012Q4*
Romer/Bernstein	1.05	1.44	1.57	1.57	1.55
Smets/Wouters	0.96	0.67	0.48	0.41	0.40

Note: Impact of a Permanent Increase in Government Spending by 1 Percent of GDP, Percentage increase in real GDP, federal funds rate set to zero throughout 2009.

2.1 and 2.2 are not nearly as large as the differences between either of these and the Romer-Bernstein impacts. In what follows we will continue with the assumption that the Fed can start to increase interest rates if necessary in 2010.

2.6 A More Realistic Path for Government Purchases

Although a permanent increase in government purchases of goods and services is a good way to understand the properties of a model, it is not a realistic description of the fiscal policy packages under consideration in the United States and other countries recently nor of the final 787 billion USD fiscal stimulus package enacted and signed into law [8] on February 17, 2009. For example, about half of that fiscal stimulus package consists of transfer payments for unemployment assistance, nutritional aid, and health and welfare payments, and temporary tax cuts. In addition, the package does not provide for an immediate permanent increase in government purchases of goods and services. Most of the purchases authorized by the law are one-time and phased in, with the lion's share of the purchases completed within four years.

Table 2.3 shows the U.S. fiscal stimulus package's impact on the federal deficit and federal government purchases in billions of dollars. The government purchases column corresponds to the permanent increase in government purchases simulated and reported in Tables 2.1 and 2.2 except of course that it is not permanent. Observe that 21 billion USD or just 2.6 percent of the total 787 billion USD increase in the deficit spending occurs in fiscal year 2009, which is when the economy is expected to be weakest.[9] Federal purchases then increase in 2010, stay relatively steady for two years, and then begin to decline again in 2012. Since the stimulus bill is a mixture of increased transfer payments, tax refunds, and higher government purchases, the path for the deficit is different from the path of the increase in government purchases.

One component of federal government transfers-certain transfers going to state and local governments-is similar to federal purchases in that the funds are to be used by the states to purchase goods and services. These intergovernmental transfers, which consist mainly of funds for education

[8]The official name of the legislation is The American Recovery and Reinvestment Act of 2009.

[9]The U.S. government's 2009 fiscal year runs from October 1, 2008 to September 30th, 2009.

Table 2.3: Government Purchases in the February 2009 Stimulus Legislation

Fiscal year	Increase in federal purchases	Increase in transfers to states, localities	Increase in federal deficit
2009	21	48	184
2010	47	107	400
2011	46	47	134
2012	36	8	36
2013	25	4	27
2014	27	0	22
2015	11	0	5
2016	-2	0	-8
2017	-3	0	-7
2018	-2	0	-6

Notes: Increased Deficit, Federal Government Purchases, and Transfers to State and Local Governments for Purchases of Goods and Services in the February 2009 Stimulus Legislation (billions of dollars). Increase in federal deficit excludes impact of interest payments on the public debt incurred to finance the stimulus package. Authors' calculations derived from Congressional Budget Office.

and public safety activities, are shown in the third column of Table 2.3. During the first three years, these government transfers exceed federal purchases. It is difficult to determine how much of the transfers to states and localities will ultimately result in an increase in spending on goods and services. States and localities might use some or all of the funds to avoid raising taxes or increasing borrowing. To the extent that they do, the transfer would not produce a net increase in government purchases of goods and services. Romer and Bernstein (2009) assume that 60 percent of these transfers go to purchases of goods and services. In keeping with that assumption, we consider in what follows the impact on GDP of an increase in government purchases equal to column 2 plus 60 percent of column 3 in Table 2.3. We assume that the path of purchases is constant for all the quarters within a fiscal year and that, as assumed Romer and Bernstein (2009), there is a one quarter lag in the effect of the increase of transfers to states and localities on their purchases of goods and purchases. We also experimented with other interpolation schemes but the results were not substantially different and we focus here on the simple constant level assumption.

Figure 2.2 presents the results of the simulation. The bar graph shows the increased government purchases as a share of GDP, and the line graph shows the impact of the increase in purchases on real GDP according to the Smets-Wouters model.

The quarters in Figure 2.2 refer to the calendar year rather than the fiscal year. We show the results through 2013 even though we simulate the impacts over the full ten years. The model solution techniques that we employ take into account the particular nonlinear time profile of government spending

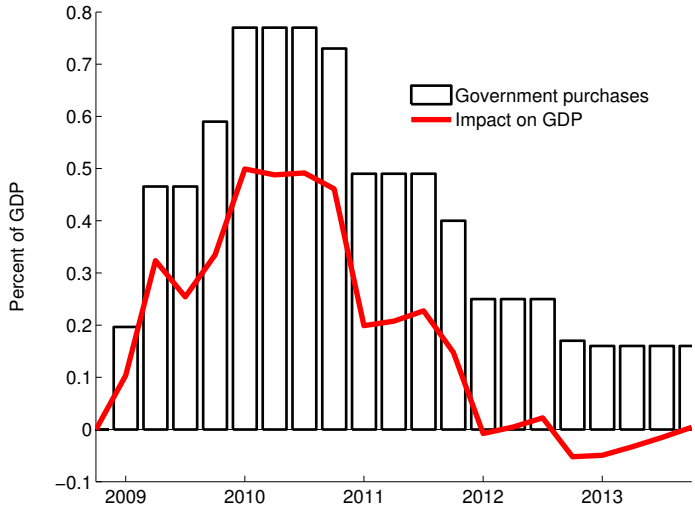


Figure 2.2: Estimated Output Effects of Government Purchases in the February 2009 Stimulus Legislation.

Notes: Government purchases equal federal purchases plus 60 percent of transfers to state and local governments for purchases of goods and services.

and ensure that households and firms form appropriate expectations. [10]

2.7 Estimated Impacts

According to the Smets-Wouters model, the impacts of this package on GDP are very small. But particularly worrisome is that during the first year the estimated stimulus is minor and then even turns down in the third quarter. Why the very small effect in the first year?

The answer comes in part from the timing of the government expenditures and the forward-looking perspective of households. The small amount of government spending in the first year is followed by a larger increase in the second year. Households and firms anticipate the second year increase during the first year. They also anticipate that ultimately the expenditures will be financed by higher taxes. The negative impact of the delayed government spending and the negative wealth effect on private consumption of higher anticipated future taxes combine to reduce the positive impact of the stimulus. As a result, the first-year GDP impact is initially small and turns down.

In the Smets-Wouters model there is also a strong crowding-out of investment. Hence, both consumption and investment decline as a share of GDP in the first year according to the Smets-Wouters model. This negative effect is offset, as shown in Figure 2.2, by the increase in government spending in the first year, but it causes the multiplier to be below one right from the start. Figure 2.3 shows the

[10]The fiscal stimulus simulations with anticipated government spending plans and temporarily constant nominal interest rates require using nonlinear solution techniques. The methodology we use is described in Juillard (1996) and implemented in DYNARE. This solution approach builds on earlier work by Laffarge (1990) and Fair and Taylor (1983).

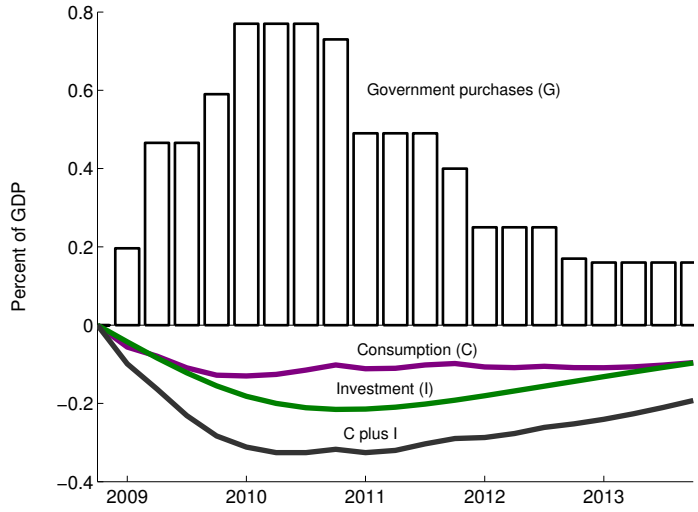


Figure 2.3: Crowding-Out of Consumption and Investment

Notes: Government purchases are as in Figure 2.2.

impact on consumption and investment.

Note that as the government purchases come back down in 2013, the multiplier turns negative. The declines in consumption plus investment are greater than the increases in government spending. Though not shown in Figure 2.2, the simulations show that the impact on GDP is negative for many years beyond 2013.

Because of the negative effects on consumption and investment, it is possible to get negative GDP multipliers in the first year with government purchases paths slightly different from those in Figures 2.2 and 2.3. For example, a sharper increase in government spending in the second year compared to the first leads to more crowding out of consumption and investment in the first year and the multiplier can turn negative. In fact, our simulations of the first stimulus bill passed by the House of Representatives in 2009 had this property, but changes by the conference committee and revised estimates of the path of government purchases by the Congressional Budget Office removed the negative multiplier.

The simulations reported in Figures 2.2 and 2.3 are based on the assumption that the Fed starts following its feedback rule for policy starting in the first quarter of 2010. Of course, the increase in GDP would be greater if the zero interest rate policy is maintained till the end of 2010 as in the simulation of a more permanent increase in government spending reported in Table 2.1. In this case, GDP would rise by almost 0.8 percent in 2010 when most of the additional spending occurs. But even under this less realistic assumption regarding the Fed's policy response, the GDP effect of ARRA spending remains around $\frac{1}{4}$ of the Romer-Bernstein estimates.

2.8 Too Keynesian or not Keynesian enough?

A possible criticism of new Keynesian models such as Christiano et al. (2005) and Smets and Wouters (2007) is that they are not Keynesian enough, because they assume that all households are forward-looking and optimize their spending decisions. Some have suggested that one should allow for the possibility that some households follow "rules of thumb" like the original Keynesian consumption function with a high and constant marginal propensity to consume. Others have proposed to assume that many households are constrained to consume all their current income.[11]

However, it is also possible to criticize new Keynesian models because they are too Keynesian. In contrast with real business cycle models, the estimated new Keynesian models assume "sticky prices" by introducing staggered price and wage setting. But as Chari, Kehoe, and McGrattan (2009) have emphasized the models go further in the Keynesian direction by assuming "the backward indexation of prices" in "a mechanical way" which amplifies Keynesian aggregate demand effects of policy.

It is well understood that the standard real business cycle model predicts increases in government spending to crowd out private consumption due to the negative wealth effect that arises from higher current or future taxes (see for example Baxter and King (1993)). The particular time path of taxes is irrelevant if they are raised lump sum - the so-called Ricardian equivalence property. Thus, bringing the model of Smets and Wouters more in line with standard real business cycle analysis as proposed by Chari et al. (2009) would further strengthen the case against the "old" Keynesian multipliers used by Romer and Bernstein (2009).

The more interesting question is whether introducing "old" Keynesian rule-of-thumb consumers in New-Keynesian models would change our findings significantly. To address this question we extend the Smets-Wouters model to allow for two types of consumers. The rule-of-thumb consumers spend all their after-tax labor income whereas the others take into account expected future earnings and taxes and make optimal consumption and savings decisions. In the presence of rule-of-thumb consumers, the Ricardian equivalence property fails to hold and the time path of lump-sum taxes influences aggregate outcomes. As in Gali et al. (2007) we assume that the particular path for taxes is determined by a fiscal policy rule which responds to the level of government spending and government debt. Taxes are raised from both types of consumers.

We re-estimate all the parameters of the model including the share of rule-of-thumb consumers and the parameters of the fiscal policy rule. The additional model equations and the estimation results are discussed in detail in Appendix 2.M. For the purpose of better comparability we use the same data set on U.S. economic aggregates as in Smets and Wouters (2007). Using Bayesian methods requires

[11] Models of consumption with an exogenous share of rule-of-thumb consumers were proposed by Campbell and Mankiw (1989). More recently, Coenen and Straub (2005) and Gali et al. (2007) have investigated the implications of this assumption for fiscal policy in New Keynesian models.

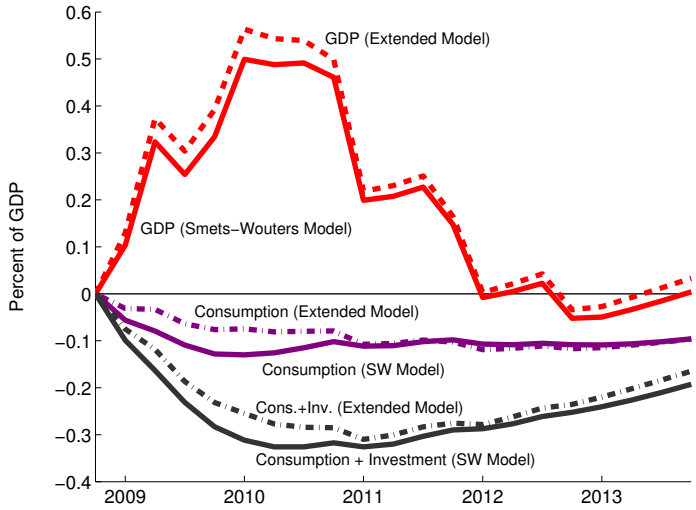


Figure 2.4: Estimated Impact of ARRA Government Purchases in New-Keynesian models with and without rule-of-thumb consumers

specifying a prior belief on the parameters. We choose a prior mean of 0.5 for the share of rule-of-thumb consumers. This value is at the high end of those found in the literature. Our estimation shows that the U.S. data is better fit by a smaller value. We obtain a posterior mean for the share of rule-of-thumb consumers of 27%.

As to the fiscal policy rule the response of lump-sum taxes to government debt is estimated to be 0.06, while the fraction of increased government spending that is immediately financed by higher taxes has a posterior mean of about 0.13. This reaction function implies a considerable build-up of government debt after an increase in government spending that is paid back slowly over time.

Figure 2.4 reports the impact of government spending increases implied by the American Recovery and Reinvestment Act in our model with rule-of-thumb consumers compared to the impact in the Smets-Wouters model previously shown in Figure 2.2. As one might have expected the GDP effect of ARRA spending is greater in the presence of rule-of-thumb consumers. However, the difference remains of modest magnitude. The maximum increase above baseline comes to 0.56% in the first quarter of 2010 relative to 0.5% in the Smets-Wouters model. Thus, a medium-size new Keynesian model that allows for households that simply consume current income and fits U.S. data quite well, still implies much smaller multiplier effects than the models considered in Romer and Bernstein (2009) for important practical policy analysis. The multiplier remains well below unity reaching a maximum of 0.73 in the first quarter of 2010.

As shown in the lower half of Figure 2.4 increased government spending continues to crowd out private spending on consumption and investment goods in the estimated model with rule-of-thumb consumers. This finding stands in contrast to the study of Gali et al. (2007). There are several reasons

for this difference. Our empirical estimate of the share of rule-of-thumb consumers is lower than their assumed value of 0.5.[12] Furthermore our estimated model allows for wage rigidities. As a result, real wages increase more moderately after a rise in government spending and induce less of a boost to disposable income and consumption of rule-of-thumb consumers. Finally, the negative wealth effects induced by the ARRA spending plan are relatively large.

2.9 Reduced-Form Empirical Evidence and the Importance of Anticipation Effects

So far, we have investigated the magnitude of government spending multipliers and the effects of the ARRA legislation using estimated structural macroeconomic models of the U.S. economy. However, there also exists a large literature that utilizes reduced-form methods in order to identify the likely effects of government spending shocks on the U.S. economy. As emphasized by Ramey (2009) this literature remains divided on central questions such as whether the GDP effect is greater than unity and whether private spending rises or falls in response to government spending increases. She points out that studies using VAR techniques in which identification is achieved by assuming that government spending is pre-determined within the quarter typically find a larger effect of government spending on GDP and crowding-in of consumption (e.g. Blanchard and Perotti (2002), Fatas and Mihov (2001) or Gali et al. (2007)) while studies using the Ramey-Shapiro "war dates" (e.g. Ramey and Shapiro (1998), Burnside, Eichenbaum, and Fisher (2004), Ramey (2009)) indicate a smaller GDP effect and crowding-out of consumption.

Indeed, a closer look at the above-mentioned studies as well several more recent empirical analyses reveals a wide range of estimates of the GDP impact of government spending due to difficulties in identifying the presumed government spending shocks. Using VAR techniques, Blanchard and Perotti (2002) find a government spending multiplier close to one, Fatas and Mihov (2001) estimate it to be greater than one, while Gali et al. (2007) obtain a high-end estimate of 1.7 after two years that could be used as support of the Romer-Bernstein calculations.[13] These studies find that private consumption increases following a government spending shock. Using a different identification approach based on sign restrictions on VAR impulse responses, Mountford and Uhlig (2009) estimate a multiplier well below one for a deficit financed government spending shock. In their analysis, consumption does not

[12] Our estimate with U.S. data is similar to euro area estimates of 25 to 35% obtained by Coenen and Straub (2005) and Ratto, Roeger, and in't Veld (2009), respectively. The likely effects of euro area fiscal stimulus are investigated in several macroeconomic models by Cwik and Wieland (2009) and tend to confirm our findings for the United States.

[13] The higher estimates implied by VAR models such as Gali et al. (2007) are perhaps less surprising once one recognizes that regressions of output on lagged values of itself and other variables are similar to the type of Keynesian-style models with backward-looking expectations that are known to generate greater multiplier effects and appear to have been used by Romer-Bernstein in their calculations. Gali et al. (2007) also make use of the Congressional Budget Office estimate of potential output, which is essentially a model construct in line with traditional Keynesian analysis, in defining some of the variables entering the VAR as gap variables.

move much in response to government spending.

Clearly, identification is a problem which is why other studies focus on military spending and attempt to collect additional information on the timing of particular changes. Ramey (2009) shows that increases in military spending and non-defense spending are anticipated several quarters before they occur. Consequently, it is important to capture the timing of the news about future increases government spending correctly. Her multiplier estimates based on an extension of the Ramey and Shapiro (1998) "war dates" and new data series on defense news lie between 0.6 and 0.8 when World War II is excluded, and near unity with World War II included. Similar empirical findings are reported by Barro and Redlick (2009). They identify a defense spending multiplier of 0.6 to 0.7 including the World War II period. In addition, they obtain some evidence that the spending multiplier may reach unity in states with an unemployment as high as 12%. Their findings also indicate a significantly negative effect of defense-spending shocks on private investment and net exports.

It remains to relate our analysis of the impact of the ARRA legislation with estimated structural macroeconomic models to the above-mentioned studies of government spending shocks. One advantage is that the timing and nature of the anticipation of fiscal spending packages due to the ARRA is known and need not be identified from macroeconomic time series. Of course, in estimating the structural models one also obtains empirical monetary and fiscal policy reaction functions. Thus, we can conduct a simulation in our models that is similar to the experiments considered by the above-mentioned VAR studies, namely a one-time surprise increase in government spending that dies out slowly according to an anticipated autoregressive process. The outcomes of these simulations are shown in Figure 2.5.

The initial effect of a typical government spending shock in the Smets-Wouters model and in our version of the model with rule-of-thumb consumers lies roughly in the middle of the wide range of estimates obtained in the reduced-form empirical studies reviewed above. The first-quarter impact on GDP in the model with rule-of-thumb consumers is slightly above unity. The average over the first year is 0.81, which is consistent with studies such as Ramey (2009) and Barro and Redlick (2009). The GDP effect however is smaller than in the simulations reported in Tables 2.1 and 2.2, because the spending increase is less than permanent and because the zero bound is not in force. With regard to private consumption, the model with rule-of-thumb consumers delivers a smaller response of consumption. Interestingly, in simulations with one year of constant interest rates we obtain a small crowding-in effect.

The ARRA legislation, however, implies a different time profile of government spending than the autoregressive profile implied by standard impulse response functions, reaching its peak in the second year of the plan. In practice, such a delay and built-up period is unavoidable in executing fiscal stimulus packages because effective implementation of new projects takes time. Estimated structural

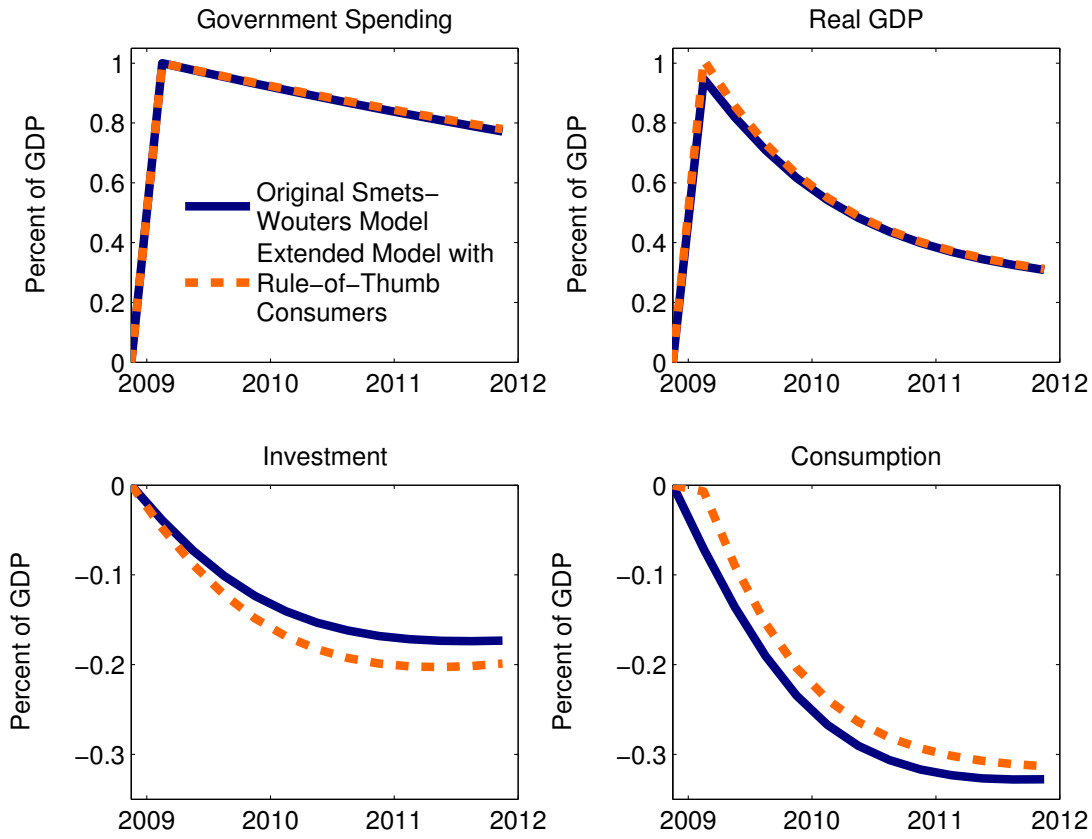


Figure 2.5: Estimated Impact of a Gradually Phased-out Government Spending Shock

Notes: The estimated impact in the Original Smets-Wouters model is displayed by solid lines and the impact in the Extended Model with Rule-of-Thumb Consumers by dashed lines.

macroeconomic models that account for a forward-looking and optimizing response of private sector decision makers to changes in government policies are the appropriate tool for quantifying the likely impact of such changes. Such models are better able to quantify the effect of the anticipation of future government spending and tax changes upon announcement of a stimulus package such as the ARRA. Thus, it is important to use them in the type of practical policy analysis conducted by Romer and Bernstein (2009).

2.10 Fiscal stimulus in the 2008/09 recession and the zero bound on nominal interest rates

Many commentators on the monetary and fiscal responses to the 2008/09 recession have argued that the special circumstance of near zero nominal interest rates provides a strong argument in favour of fiscal stimulus. The argument goes as follows: the Federal Reserve might want to lower nominal interest rates further but is prevented from doing so by the zero-interest-rate floor that arises because savers can use cash as a zero-interest bearing asset. As a consequence, the Fed may not want to increase interest rates as output rises as it usually does and instead accommodates the fiscal stimulus for some time. Christiano, Eichenbaum, and Rebelo (2009) suggest that fiscal multipliers can be much larger than usual in such circumstances. They make use of an estimated New-Keynesian DSGE model due to Altig, Christiano, Eichenbaum, and Linde (2004).

In our simulations using the Smets-Wouters model in sections 2.4 to 2.8 we have already taken into account this argument by assuming a constant funds rate for up to two years and then a return to a stabilizing rule. This assumption induces a nonlinearity, which has important anticipation effects. Nevertheless, this period of monetary accommodation only causes a modest increase in the government spending multiplier. An even longer period of monetary accommodation would be needed to obtain a more significant increase in multiplier effects as in Christiano et al (2009).

Nevertheless, a reasonable question to ask is whether our findings could be influenced by the fact that we simulate the fiscal stimulus as a deviation from the model's steady state. Clearly, the U.S. economy was still in a deep recession in the first quarter of 2009 when the fiscal packages were enacted. In a linear model, it would make no difference if the stimulus is simulated in deviation from steady state or in a scenario far below this level. In the linear case one can simply apply the simulation to any baseline of interest to the policy maker. In a nonlinear model, however, this need not be true any more. For this reason, we conduct further sensitivity analysis to check whether our findings still hold if the fiscal stimulus is applied in a deep recession during which the federal funds rate may be endogenously constrained at the zero bound for some time.

We simulate the Smets-Wouters model with the actual U.S. data through the 1st quarter of 2009. Then, we compute projections of the recovery implied by this model with and without the additional

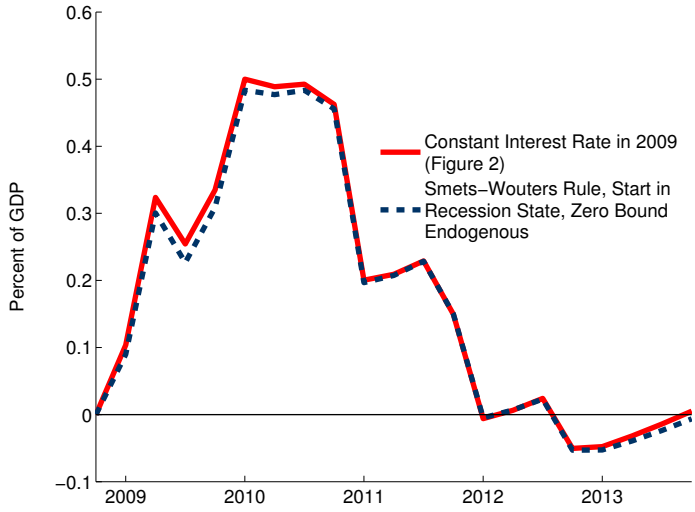


Figure 2.6: Estimated GDP Impact of ARRA Government Purchases on Projections of the Smets-Wouters model based on Actual U.S. Data throughout 09Q:1

government spending. This projection is calculated in a version of the model that incorporates the non-negativity restriction on the federal funds rate.[14] Whether or not the federal funds rate endogenously visits the zero bound depends on the monetary policy rule that determines the systematic response of the Federal Reserve to economic developments.

If we use the Taylor rule then the zero-interest floor does not become a binding constraint for monetary policy. The simulated recovery is sufficiently quick so that Taylor's rule would prescribe an increase in the funds rate. If we use instead the interest rate rule originally estimated by Smets and Wouters along with the other equations in their model, then the funds rate endogenously visits the zero bound in the second and third quarter of 2009. Figure 2.6 reports the difference in GDP projections with and without the ARRA government purchases (dashed line). The underlying simulations are carried out with monetary policy following the Smets-Wouters rule and start in the first quarter of 2009 from an output gap of -6 $\frac{1}{2}$ percent annualized. Thus, the difference between the two simulations shown in Figure 2.6 is comparable to the results shown previously in Figure 2.2 but computed at a state far away from the steady-state level of output. We find that the GDP impact of the additional government purchases remains very close in magnitude to the scenario in Figure 2.2 that is indicated by the solid line in Figure 2.6 and was simulated as a deviation from steady-state with a constant funds rate for four quarters.

[14]The functional form chosen for the non-negativity constraint is the same as in earlier analysis of the implications of the zero-interest rate floor by Orphanides and Wieland (2000), Coenen, Orphanides, and Wieland (2004) and Coenen and Wieland (2003).

2.11 Impacts of an Entire U.S. Stimulus Package

Although the simulations in this chapter have focussed on government spending multipliers in the case of changes in government purchases of goods and services, it is possible to say something about the impact of the broader U.S. fiscal stimulus package, which also includes tax rebates and one-time transfer payments to individuals. For this purpose we focus on the impact in the fourth quarter of 2010 where the size of the increased government purchases (including 60 percent of transfers to states and localities for this purpose) is .73 percent of GDP and the impact on GDP is .46 percent, implying a multiplier in that quarter of .63 (=.46/.73). We choose this quarter for two reasons. First, as shown in Figure 2.2, it is close to the quarter of maximum GDP impact, so by choosing this quarter we will in no way be understating the results. In fact, the impact declines sharply after this quarter. Second, this is the quarter for which Romer and Bernstein (2009) report their widely-cited calculation that the fiscal stimulus package of February 2009 will increase GDP by 3.6 percent and employment by 3.5 million. Hence, the last quarter of 2010 is useful for comparison purposes.

As Table 2.3 shows, the deficit (excluding interest payments) increases by more than the increase in government purchases in fiscal year 2009 through 2011. The lion's share of the difference between the deficit and purchases, 80 percent, consists of temporary tax rebates and entitlement benefits for unemployment insurance, Medicaid benefits, health insurance subsidies, and cash welfare payments. The fourth quarter of 2010 (calendar year) is the first quarter of fiscal year 2011. In fiscal year 2011, the deficit minus purchases is 41 billion USD (=134-93=41). However, this is a large decrease from fiscal year 2010 where the difference is 246 billion USD (400-154=246). So for the purpose of estimating the impact of the broader package in 2010Q4 (calendar) we take the average of fiscal year 2010 and 2011, or the average of 41 and 246, which is 144 billion USD or about 1 percent of GDP.

How much of this "non-government-purchases" increase in the deficit should we add to government purchases to compute the impact on GDP? To the extent that the tax rebates and transfers to individuals are temporary, permanent income theory, even in the presence of liquidity effects, says that the impact on consumption and thereby aggregate demand will be small. Although there is a great deal of uncertainty, a review of the literature over the years suggests that the marginal propensity to consume for such tax and transfer payments is at most 0.3, though it will depend on timing, expectations, and other factors. Recent aggregate evidence suggests that it may be much smaller. For example, an examination of the Economic Stimulus Act of 2008 indicates that the impact of the tax rebates on consumption was insignificantly different from zero.[15] Transfers to individuals, such as entitlement payments for unemployment compensation, and health and welfare benefits, could be expected to have an effect on consumption similar to temporary tax rebates. Although such payments may temporarily boost household income, they also create employer incentives for layoffs and for household

[15]The estimated regression coefficients reported in Taylor (2009) are not statistically different from zero.

members to delay their return to work. In sum, in our view, a coefficient of .3 for the impact of these tax and transfers payments on consumption is likely an upper bound and certainly a generous assumption about the size of the impact.

In any case, by assuming that the impact on consumption of the extra 1 percent discretionary increase in the deficit is .3 percent of GDP and using the above mentioned multiplier of .63 the impact will be to increase GDP by an additional .19 percent. If we add this to the .46 percent GDP increase from purchases, the total impact will be to increase GDP by.65 percent in the fourth quarter of 2010 compared to what it would otherwise be.

Romer and Bernstein (2009) calculated that the impact of the 2009 stimulus package would be to raise GDP by 3.6 percent by the fourth quarter of 2010, which is 6 times greater than our calculation based on the new Keynesian model simulations of the impact of purchases and a generous assessment of the impact of tax rebates and temporary transfers.

Romer and Bernstein (2009) also give an estimate of the increase in employment from the fiscal package. They assume an additional 1 million jobs for each 1 percent increase in real GDP. Thus they estimate an increase of 3.5 million jobs as a result of the fiscal policy package enacted in February 2009. Using the same method our estimate is closer to $\frac{1}{2}$ million additional jobs. To put that smaller number into perspective it is less than the 598 thousand payroll jobs lost in the single month of January 2009 while the fiscal policy packages were being debated.

Romer and Bernstein also report job estimates in a number of private sector industries which would have to be radically scaled down if the numbers we have calculated are correct. In addition, our finding of crowding-out of private consumption and investment due to the increase in government purchases raises doubts about the estimate that 90 percent of the jobs will be created in the private sector. Indeed, with the impact of government purchases on GDP (.46) nearly three times greater than the impact of tax rebates and transfers on GDP (.19), a net decline in private sector jobs is likely.

2.12 Conclusions and Outlook

In this chapter we used a modern empirical approach to estimate government spending multipliers, and we contrasted these multipliers with those that have recently been used in practice to analyze fiscal policy in the United States. We focused on an empirically estimated macroeconomic model-the Smets-Wouters model-recently published in the American Economic Review. As attested by leading macroeconomic researchers, such as Michael Woodford in his recent survey, this model well represents new Keynesian macroeconomic thinking of the kind that many macroeconomists now teach their graduate students and use in their research.

We find that the government spending multipliers from permanent increases in federal government purchases are much less in new Keynesian models than in old Keynesian models. The differences

are even larger when one estimates the impacts of the actual path of government purchases in fiscal packages, such as the one enacted in February 2009 in the United States or similar ones discussed in other countries. The multipliers are less than one as consumption and investment are crowded out. The impact in the first year is very small. And as the government purchases decline in the later years of the simulation, the multipliers turn negative.

To further investigate the robustness of our findings we extend the model of Smets and Wouters to allow for a share of "old" Keynesian rule-of-thumb households that consume all their disposable income, estimate the extended model and re-evaluate the likely impact of the ARRA government purchases. Then, the multiplier effect is slightly more pronounced but without changing our quantitative findings significantly. We also relate our analysis with estimated structural models to contributions using reduced-form VAR models and regression analysis in order to identify government spending shocks and their effects. A review of this literature suggests a wide range of multiplier effects from 0.6 to 1.7 depending on the particular approach to identification. The typical time profile of government spending studied in this literature differs from the ARRA spending plan. Following an initial surprise increase government spending gradually returns to steady state. We simulate this time profile in our estimated New Keynesian models and find that the short-run effect of such shocks in our models lie roughly in the middle of the estimates by this literature. This experiment underscores the need for analysis with estimated structural models that account for the reaction of forward-looking optimizing households and firms in assessing the likely impact of changes in government policies.

The estimates reported in this chapter of the impact of fiscal stimulus packages are in stark contrast to those reported in the paper by Christina Romer and Jared Bernstein. They report impacts on GDP for a broad fiscal package that are six times larger than those implied by government spending multipliers in a typical new Keynesian model and our calculations based on generous assumptions of the impacts of tax rebates and transfers on GDP. They also report job estimates that are six times larger than these alternative models, and the impacts on private sector jobs are likely to be at variance with the alternative models by an even larger amount. At the least, our findings raise serious doubts about the robustness of the models and the approach currently used for practical fiscal policy evaluation.

We also investigate whether our findings obtained by simulating the increase in additional spending as a deviation from the steady-state of the economy would also result from a simulation starting in deep recession far away from the steady-state. While the choice of baseline for the policy experiment is irrelevant in linear models, the zero-interest rate floor on nominal interest rates introduces an important nonlinearity that may affect our assessment. We simulate the Smets-Wouters model with the actual U.S. data through the 1st quarter of 2009 and compute projections of the recovery with and without the additional government spending. These projections imply that the funds rate would visit the zero-interest-rate floor for two to three quarters. The GDP impact of the additional govern-

ment purchases remains fairly close to the scenario simulated as a deviation from steady-state with a constant funds rate for four quarters.

We have shown that the anticipation of the time profile of government spending and the monetary policy response have an important influence on the likely impact of fiscal stimulus in the U.S. economy. It is useful to explore such anticipation effects further. While our analysis is predicated on the view that U.S. monetary policy will eventually act to stabilize inflation, an interesting study by Davig and Leeper considers the anticipation of a shift to a monetary regime that would de-stabilize the economy if maintained. Such a belief, they argue, would induce greater short-run multiplier effects. By contrast, Corsetti, Meier, and Mueller (2009) suggest that the anticipation of a more conservative fiscal stance that aims to contain the rise in government debt by promising future spending cuts would support greater short-run effects. However such a belief is inconsistent with the ARRA spending plan and would have required announcing very substantial spending cuts starting as soon as the end of 2010 as discussed in Wieland (2010).

The longer-run effects of the American Recovery and Reinvestment Act will also be influenced by two other factors that we have not accounted for in our model simulations. First, increases in future taxes will be of a distortionary nature rather than lump-sum and therefore tend to depress output in the long-run below the steady-state level assumed in our simulations. Uhlig (2009) indicates that this long-run cost of short-run fiscal stimulus could be substantial. On the optimistic side, there is a possibility that some of the additional government spending has an investment- rather than consumption-character and would induce a positive long-run effect on output as suggested by countering the negative effect of distortionary taxation. Due to implementation lags, however, expansionary government investment can lead to a short-run contraction of output as indicated in Leeper, Walker, and Yang (2009).

Appendices

2.M The New-Keynesian DSGE model with Rule-of-Thumb Consumers

This appendix discusses how we have extended the Smets and Wouters model to include rule-of-thumb consumers and reports the estimates we have obtained. We only review the model equations that result from the extension. For the remainder of the model equations the reader is referred to the appendix of Smets and Wouters (2007).

Households

There is a continuum of households indexed by $h \in [0, 1]$. A share $1 - \omega$ of these households makes optimizing, forward-looking decisions. They are indexed by $j \in [0, 1 - \omega)$. These households have access to financial markets. They buy and sell government bonds and accumulate physical capital that they rent to firms. They receive wage income and dividend payments from the firms and pay taxes $T_{j,t}$ in a lump-sum fashion to the government. Their decisions made so as to maximize a utility function that is non-separable in consumption $C_{j,t}$ and labour supply $L_{j,t}$. Their maximization problem corresponds to the problem solved by all households in the Smets and Wouters model.
The remaining share ω of households - the "rule-of-thumb'ers" - is indexed by $i \in [1 - \omega, 1]$. They simply consume their disposable income which is given by the wage income $W_t^h L_t$ minus lump-sum taxes:

$$C_{i,t} = \frac{W_t^h L_t}{P_t} - \frac{T_{i,t}}{P_t} \tag{2.1}$$

Labor unions set the same nominal wage rate for both types of households. Hence, labour supply is equalized across the two groups. Aggregating over all households implies that overall consumption is a weighted average of the consumption function of rational and rule-of-thumb consumers:

$$C_t = \int_0^1 C_{h,t} dh = (1 - \omega) C_{j,t} + \omega C_{i,t} \tag{2.2}$$

Government policy

The government purchases the final good G_t, issues bonds B_t and raises lump-sum taxes to finance government spending. Aggregate taxes correspond to $T_t = (1-\omega)T_{j,t} + \omega T_{i,t}$. The government budget constraint is then given by

$$P_t G_t + B_{t-1} = T_t + \frac{B_t}{R_t} \tag{2.3}$$

Log-linearized model

Detrending the model variables with a deterministic trend γ and log-linearizing equations (2.1) to (2.3) results in three linear relationships that need to be added to the Smets and Wouters model:

$$\widehat{c}_{i,t} = \frac{w_*^h L_*}{c_*}(\widehat{w}_t + \widehat{L}_t) - \frac{y_*}{c_*}\widehat{t}_t \tag{2.4}$$

$$\widehat{c}_t = (1-\omega)\widehat{c}_{j,t} + \omega\widehat{c}_{i,t} \tag{2.5}$$

$$\widehat{b}_t = R_* \left(\frac{\widehat{b}_{t-1}}{\pi_*} + \widehat{g}_t - \widehat{t}_t \right) \tag{2.6}$$

Steady-state consumption is set equal for rational and rule-of-thumb consumers to simplify the log-linearization: $C_i = C_j = C$. The level of debt in steady-state is assumed to be zero. Furthermore we assume that both types of households pay lump-sum taxes in equal proportions. Lump-sum taxes, government debt and government spending are defined as a percentage of steady-state output.
Smets and Wouters (2007) effectively disregard taxes and government debt dynamics because their model exhibits the Ricardian equivalence property. Because all households act in a rational, forward-looking manner, and because taxes are raised in lump-sum fashion, the particular time path of debt and taxes is irrelevant. In our model with rule-of-thumb households, however, the speed at which government debt is paid off with higher taxes matters for the model dynamics. Therefore we close the model by defining a log-linear fiscal policy rule as suggested in Gali et al. (2007):

$$\widehat{t}_t = \phi_b \widehat{b}_t + \phi_g \widehat{g}_t \tag{2.7}$$

The parameters of the fiscal policy rule, ϕ_b and ϕ_g, determine the elasticities of lump-sum taxes with respect to government debt and government spending.

Estimation

Just like Smets and Wouters (2007) we use Bayesian inference methods to estimate our New Keynesian model with rule-of-thumb consumers.[16] For better comparability we also use the Smets-Wouters

[16]Matlab routines for solution and estimation procedures are implemented in DYNARE. It is important to note that the estimation can be carried out on the linearized model, while the fiscal stimulus simulations with anticipated government spending plans and temporarily constant nominal interest rates require using nonlinear solution techniques.

data set on U.S. macroeconomic aggregates covering the period 1966:1-2004:4 and consider identical prior distribution as starting point in the parameter estimation. With regard to the prior distribution of household types and the parameters of the fiscal policy rule we consider values similar to Smets and Wouters (2007). Specifically, we assume that ω has a Beta distribution with mean 0.5 and standard deviation 0.1. This prior is at the high end of what is found in the literature. The parameter prescribing the response of lump-sum taxes to debt, ϕ_b, is assumed to follow an Inverted Gamma distribution with mean 0.1 and degrees of freedom equal to 2. The coefficient on government spending in the fiscal policy rule is set to a Normal distribution with mean 0.1 and standard deviation 0.05.

Our estimation results indicate that the new parameters are well identified. The posterior mode of the share of rule-of-thumb consumers is estimated to be 28.6% with a standard deviation of 6.2%. The posterior mean is 26.5%. Thus, the data clearly drive the estimate of the parameter downwards from the prior of 50%. The parameters of the fiscal policy rule are significant and of reasonable magnitude. The posterior mode of the elasticity of lump-sum taxes to debt is estimated to be 0.043. An increase in government debt of 1% of GDP leads to an increase in lump-sum taxes of 0.05%. The posterior mode for the elasticity of lump-sum taxes to government spending is estimated to be 0.12. Hence 1/8 of an increase in government spending is financed by lump-sum taxes directly. The other part is initially financed with debt and eventually implies higher taxes later on. The estimates of the other parameters change relative to Smets and Wouters (2007) but the differences remain moderate. Selected estimates are reported in Table 2.4.

Table 2.4: Estimates of Key Model Parameters

		Smets-Wouters (2007)	Our Estimates of the New-Keynesian DSGE Model with Rule-of-Thumb Consumers			
		post. mean	prior mean	post. mode	s.d.	post. mean
ω	Share of non-Ricardian households	-	0.5	0.286	0.062	0.2651
σ_c	Inverse of intertemporal elasticity of substitution	1.380	1.500	1.332	0.134	1.286
h	Degree of habit formation	0.713	0.700	0.660	0.055	0.673
ξ_p	Sticky prices (Calvo parameter)	0.652	0.500	0.639	0.058	0.645
ι_p	Price indexation	0.243	0.500	0.194	0.083	0.221
σ_l	Inverse of labour supply elasticity	1.838	2.000	1.963	0.566	1.869
ξ_w	Sticky wages (Calvo parameter)	0.706	0.500	0.769	0.053	0.730
ι_w	Wage indexation	0.585	0.500	0.646	0.124	0.617
ϕ_b	Elasticity of lump-sum taxes with respect to debt	-	0.100	0.043	0.012	0.0531
ϕ_g	Elasticity of lump-sum taxes with respect to government spending	-	0.100	0.124	0.048	0.1242

Chapter 3

Keynesian government spending multipliers and spillovers in the euro area

3.1 Introduction

In 2008 and early 2009 governments around the world announced major fiscal stimulus packages. Resorting to discretionary fiscal policy to an unprecedented degree, they hoped to alleviate the recessionary impact of the global financial crisis. U.S. Congress, for example, approved 787 billion dollars of additional spending, transfers and tax reductions with the 2009 *American Recovery and Reinvestment Act*. The European Union initiated the *European Economic Recovery Plan* while national European governments announced their own fiscal stimuli. The German government, which was initially criticized for not spending enough, eventually announced two "*Konjunkturpakete*" in a row.[1]

The impact of such announcements and the implied measures is difficult to assess, because many factors play a role. Proponents of fiscal stimulus emphasize the Keynesian multiplier effect. It follows from the national accounts' spending identity when combined with the text-book Keynesian consumption function. A country's gross domestic product is equated with total spending, which consists of private consumption, investment, net exports and government expenditures. Consumption is believed to increase with after-tax income. Consequently, a debt-financed increase in government spending boosts total spending (and therefore total GDP) more than one for one.[2] Since spending

[1] A prominent critic was Paul Krugman, who accused the German government of "boneheadedness" in an article in the New York Times of Dec 12, 2008, titled "The economic consequences of Mr. Steinbrück". He wrote: "*The world economy is in a terrifying nose-dive, yet Mr. Steinbrueck, (the German finance minister) is standing firm against any extraordinary fiscal measures, ... In Europe it is very hard to do a fiscal expansion unless it is coordinated ... The reason is that the European economy is so integrated ... As a result, the multiplier on fiscal expansion within any given European country is much less than the multiplier on a coordinated fiscal expansion. ... if Germany prevents an effective European response, this adds significantly to the severity of the global downturn. ... in short, there's a huge multiplier effect at work; unfortunately, what it's doing is multiplying the impact of the current German government's boneheadedness.*"

[2] The national accounts spending identity is given by, $Y = C+I+EX-IM+G$. The Keynesian consumption function implies that consumption increases with after-tax income: $0 < dC/d(Y-T) < 1$. It is then concluded that a debt-financed increase in government spending boosts total spending by more than one for one: $1 < dY/dG = 1/(1 - dC/d(Y-T))$.

may partly be diverted to imports, proponents have lobbied for coordinated stimulus packages across Europe. Critics of fiscal stimulus, however, argue that government spending will displace private consumption and investment (cf. Barro (2009)). Consumers will anticipate future tax burdens and save rather than spend, while government borrowing will drive up interest rates and crowd out private investment.

In a recent paper Christina Romer, Chair of the U.S. President's Council of Economic Advisers, and Jared Bernstein, Chief Economist of the Office of the Vice-President, provided numerical estimates of the impact of an increase in government spending on GDP and employment in the United States. They estimate that an increase in government purchases of 1 percent of GDP would induce an increase in real GDP of 1.6 percent compared to what it otherwise would be.[3] Given this multiplier effect they project that a package similar in size to the ARRA legislation would boost U.S. GDP by 3.6 percent. Cogan, Cwik, Taylor, and Wieland (2010), however, show that this conclusion is not robust. Government spending multipliers in alternative, empirically estimated New-Keynesian models are much smaller. For example, estimates of the GDP effects of ARRA legislation obtained with the model of Smets and Wouters (2007) are only one-sixth as large as the estimates of Romer and Bernstein (2009).

This chapter aims to assess the magnitude of the stimulus programs announced by Euro area governments in 2008 and 2009 and quantify their effect on economic activity. A macroeconomic model is needed to distinguish the impact of government actions on the economy from other factors. Because of modeling uncertainty, it is essential that policy evaluations be robust to alternative assumptions. For this reason, we compare the impact of the fiscal packages using several empirically-estimated macroeconomic models of the euro area. The focus is on model simulations of the planned increase in government spending rather than increases in transfers and tax rebates, because spending is supposed to exhibit the largest Keynesian multiplier effect.

The models considered in this comparison are due to Smets and Wouters (2003), Laxton and Pesenti (2003), Ratto et al. (2009), Taylor (1993) and Fagan, Henry, and Mestre (2005).[4] All five models exhibit Keynesian features such as sluggish adjustment due to price and wage rigidities. Thus, they are well-suited to investigate possible rationales for Keynesian demand management. Several of these models have been developed and used at policy institutions such as the European Central Bank, the European Commission, or the International Monetary Fund. The first four model are best described as New-Keynesian models. These models account for forward-looking decisions by households and firms that anticipate future changes in government policies. The models of Smets and Wouters (2003),

[3] See Romer and Bernstein (2009), Appendix 1, page 12. This paper was written during the transition period in early January before Christina Romer was sworn in as Chair of the Council of Economic Advisers.

[4] The models are available in a new macroeconomic model archive for comparative analysis described in more detail in Wieland et al. (2009). For analysis of monetary policy see Taylor and Wieland (2009). Earlier euro area model comparisons have been conducted by Hughes-Hallett and Wallis (2004) and Kuester and Wieland (2010).

Laxton and Pesenti (2003) and Ratto et al. (2009) also belong to the class of models often referred to as New-Keynesian dynamic stochastic general equilibrium (DSGE) models. Such models fully incorporate recent advances in terms of microeconomic foundations from real-business-cycle models and combine them with Keynesian-style rigidities.

We find that New-Keynesian models provide no support for a traditional Keynesian multiplier effect. The European spending plans would result in a reduction in private sector spending for consumption and investment purposes. Households and firms reduce spending in anticipation of future tax burdens and higher interest rates. Implementation lags of government spending worsen the impact on GDP. Even if monetary policy is assumed to counteract the upward pressure on the nominal interest rate in 2009, the negative effect of fiscal stimulus on private spending remains. By contrast, the model of Fagan et al. (2005) largely ignores forward-looking motives for private decision-making and provides a more traditional Keynesian perspective. This model supports a strong Keynesian multiplier effect, but the boom is followed by a bust. Thus, the cumulative effect of government on private spending eventually turns negative. More importantly, models with backward-looking dynamics are not as well-suited for the analysis of major policy changes as the New-Keynesian models. Instead, they are used primarily for short-term forecasting.

In addition, we use the multi-country model of Taylor (1993) to assess the likely spill-over effects within the euro area. Since half of the euro area stimulus is derived from the German stimulus plan, we investigate the spill-over effect of German spending in the absence of similar measures in other euro area countries. We find that the positive direct demand effect of German spending on other euro area economies is largely offset by the indirect negative effect of euro appreciation.

3.2 Euro area fiscal stimulus packages for 2009 and 2010

Table 3.1 provides an overview of discretionary fiscal policy measures announced by the 11 largest euro area economies. In terms of GDP, these economies account for 99 percent of the euro area. We have collected information from the publicly available stability programs that national finance ministries prepared for the European Commission and compared these numbers to estimates obtained by Saha and von Weizsäcker (2009).

Detailed information on the construction of our estimates is given in Appendix 3.F. Since we focus on studying the effect of discretionary measures, changes in fiscal balances resulting from automatic stabilizers are not included. **Table 3.1** reports information on the total amount of the respective fiscal package and the implied increase in government expenditures separately. The total also includes temporary tax deductions, rebates and transfers. The amounts are reported in billions of Euro and in relative shares in percent of 2008 GDP.

The fiscal stimuli differ substantially in terms of magnitude and composition. By far the largest stim-

Table 3.1: Overview of the fiscal stimulus packages in the euro area

	Total fiscal package (bln Euro)		Expenditures (bln Euro)		Total fiscal package (percent of GDP)		Expenditures (percent of GDP)	
country	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*	*2009*	*2010*
Austria	4.9	4.6	1.4	1	1.71	1.63	0.48	0.36
Belgium	1.3	1.2	0.9	0.8	0.36	0.33	0.27	0.24
Germany	35.9	48.4	18	13.6	1.44	1.93	0.72	0.54
Greece	0	0	0	0	0.00	0.00	0.00	0.00
Spain	26.8	14.7	12.1	0	2.44	1.34	1.10	0.00
Finland	2.4	2.4	0.4	0.4	1.25	1.25	0.23	0.23
France	17	4	16.3	4	0.87	0.2	0.83	0.2
Ireland	0	0	0	0	0.00	0.00	0.00	0.00
Italy	-0.3	-0.8	3.1	0.2	-0.02	-0.05	0.19	0.01
Netherlands	3.1	2.9	0.2	0	0.53	0.49	0.03	0.00
Portugal	1	0.3	0.9	0.3	0.6	0.18	0.54	0.18
EU-11	92	77.6	53.2	20.4	1.01	0.85	0.58	0.22

Source: Saha and von Weizsäcker (2009) "Estimating the size of the European stimulus packages for 2009 An Update" and the stability programs provided by the finance ministries for the European Commission.

ulus package has been enacted in Germany: 84.3 billion Euro spread over 2009 and 2010. In relative terms these measures amount to 3.37 percent of GDP. Thus, the German package is approaching the magnitude of the ARRA stimulus in the United States adjusted for the size of the economy. However, the U.S. measures are spread over four years. The German stimulus corresponds to 49.7 percent of the total EU-11 stimulus according to the information we have been able to put together. In terms of government expenditures, the German share in the EU-11 stimulus comes to 42.9 percent.

The second largest package was announced by the Spanish government, roughly 41.5 billion Euro, and the third largest is the French stimulus of about 21 billion Euro. Other countries launched smaller fiscal measures and some none at all. In total, the euro area stimulus measures of the eleven largest economies sum to 1.01 percent of euro area GDP in 2009 and 0.85 per cent in 2010, much less than the U.S. stimulus. Of these measures government purchases amount to 0.58 percent of GDP in 2009 and 0.22 percent in 2010.

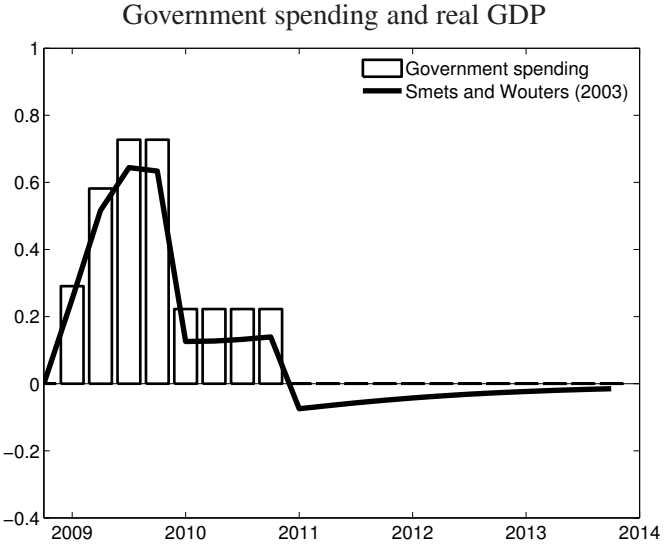
3.3 The estimated impact of announced government expenditures on euro area GDP

Cogan et al. (2010) consider two empirically estimated macroeconomic models of the U.S. economy, one developed by Taylor (1993) and the other one by Smets and Wouters (2007). Their analysis of the consequences of the ARRA legislation focuses primarily on the Smets and Wouters model, which is representative of current thinking in macroeconomics. It is very similar to, and "largely based on"

according to Smets and Wouters, another well-known empirically-estimated New-Keynesian DSGE model developed by Christiano et al. (2005). In earlier work, Smets and Wouters (2003) estimated a version of this model with data from the euro area. Thus, we start by assessing the effect of the additional expenditures announced by national governments on euro area economic activity in that model. We focus attention on government expenditures such as direct purchases and similar measures, because traditional Keynesian analysis suggests that government expenditures have a greater multiplier effect than tax reductions or additional transfers. The purpose of the model simulation is to evaluate the effect of the fiscal measures in isolation from other disturbances that may currently influence actual economic outcomes.

Figure 3.1 reports the increase in government expenditures (bar chart) together with the resulting effect on euro area real GDP (solid black line). It is assumed that governments are able to start spending immediately in the first quarter of 2009. The initial increase is phased in below the average of 0.58 percent of GDP for 2009 and increases above the average level in the second part of the year. Possible implementation lags and their consequences will be discussed later on.

Figure 3.1: The impact on euro area GDP in the Smets and Wouters (2003) model



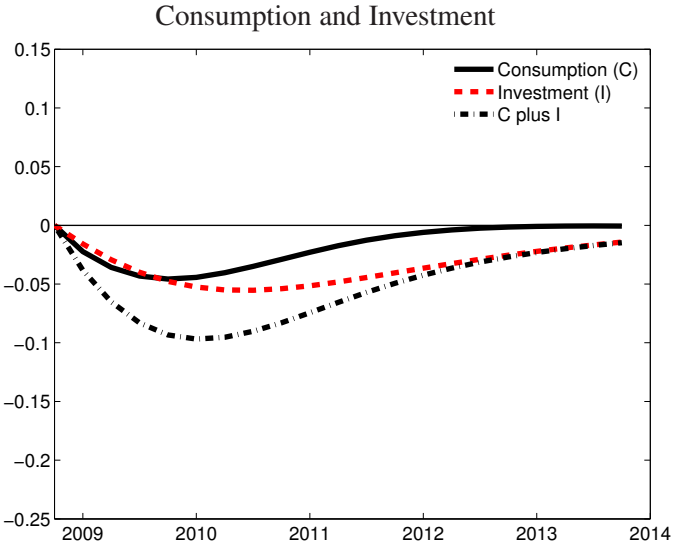
Notes: Quarterly annualized government spending is depicted by the bars in percent of GDP: 0.29085 in 2009Q1, 0.5817 in 2009Q2, 0.727125 in 2009Q3 and 2009Q4 and 0.2225 in 2010.

Euro area GDP increases as a result of additional government spending. However, the simulation does not exhibit a traditional Keynesian multiplier effect that would imply a greater than one-for-one increase in GDP relative to government spending. Instead, the increase in GDP is significantly smaller than the associated boost to government expenditures. Once government spending returns to baseline at the end of 2010, GDP even declines. By implication, the increase in government spending must be

displacing rather than multiplying private spending. As shown in **Figure 3.2**, the dynamic response of private sector demand for consumption or investment purposes is negative. Private consumption and investment decline immediately and stay below baseline until well after the end of the fiscal stimulus. The simulation assumes that consumers' and firms' expectations incorporate the time profile of government spending as announced by national governments.

These findings on European stimulus using the euro area model of Smets and Wouters (2003) are similar to the results for the U.S. economy reported by Cogan et al. (2010). The mechanism of private sector displacement is related to the forward-looking perspective of households and firms. Households and firms anticipate from the start that government expenditures increase for two years in a row. They also anticipate that debt-financed expenditures will ultimately lead to higher taxes in the future. The negative wealth effect on private consumption of higher anticipated future taxes reduces the positive impact of the stimulus. In addition, there is also a strong crowding out of investment. This crowding-out effect is reinforced by an increase in real interest rates.

Figure 3.2: Private spending in the Smets and Wouters (2003) model



Modeling uncertainty and robustness

The euro area is still a young monetary union. Historical relationships may have changed due to the shift in monetary regime and comparable cross-country data series are limited and short. The model of Smets and Wouters (2003), for example, is estimated with historical, pre-EMU data. Their euro area measures are artificial aggregates obtained by adding up national data from a period of differential monetary policies and fixed but adjustable exchange rates. Thus, modeling uncertainty is particularly pronounced and comparative analysis is crucial to obtain robust conclusions as shown in

Kuester and Wieland (2010). To this end we make use of a new database of macroeconomic models designed explicitly with the purpose of doing such policy evaluations and robustness studies.[5]

First, we consider two other New-Keynesian DSGE models of the euro area for comparison. We use the term "New-Keynesian" to indicate that the models assume forward-looking (rational) expectations by individuals and firms, and some form of price rigidity, usually staggered price or wage setting. The term "DSGE", which stands for "dynamic stochastic general equilibrium", indicates that these models fully incorporate microeconomic foundations consistent with the optimizing decision-making of representative households and firms, similar to earlier real-business cycle models that assumed fully flexible prices. The model of IMF researchers Laxton and Pesenti (2003) was developed at the same time as the Smets and Wouters model, but its parameters were calibrated rather than estimated with artificial pre-EMU data. It includes two countries, the euro area and the Czech republic. It is referred to as the "Small IMF model" in the model comparison because IMF staff have also developed several larger macroeconomic models of the world economy.[6]

The other model was developed by researchers at the European Commission. Ratto et al. (2009) named the model "QUEST III" and we refer to it as the "EU-Quest" model. This model is estimated with quarterly euro area data from 1981Q1 to 2006Q1 thereby including a large part of EMU history. Another important departure from the assumptions made by Smets and Wouters (2003) and Laxton and Pesenti (2003) concerns the treatment of households. These models have been criticized for assuming that all households are forward-looking and optimize their spending decisions. Instead, it has been proposed that one allows for the possibility that many households follow "rules of thumb" like the original Keynesian consumption function with a constant marginal propensity to consume, or that they are constrained to consume all their current income (see, for example, Gali et al. (2007)). Ratto et al. (2009) estimate that 35 % of households in the euro area are liquidity-constrained in this manner.[7]

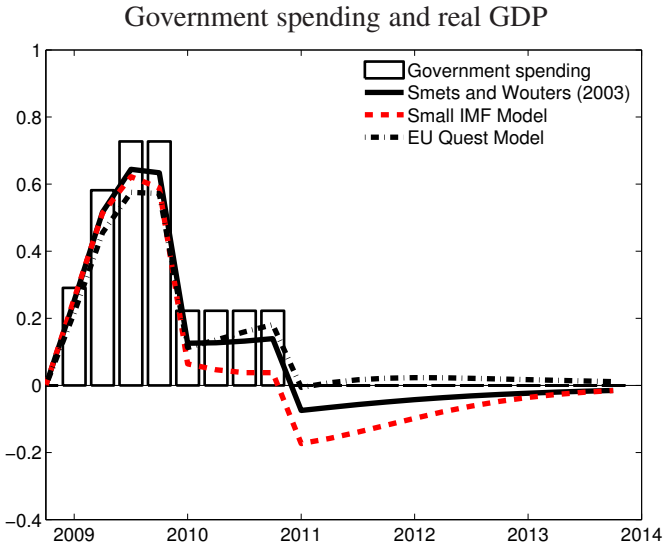
Figure 3.3 reports the effect of planned spending by euro area governments on real GDP in the Small IMF and EU-Quest models. Output follows a path that is similar to the simulation of the Smets and Wouters model. Neither the updated empirical estimates nor the extensions accounting for the openness of the euro area economy or the presence of liquidity-constrained consumers fundamentally alter the effect of the Euro area government spending measures. In both models consumption and investment decline from the start rather than being multiplied in traditional Keynesian fashion. The

[5] A detailed description of this database and the comparative approach to modeling and policy analysis is provided by Wieland et al. (2009).

[6] One such model is MULTIMOD, a dynamic multi-country macro model of the world economy (see Laxton, Isard, Faruqee, Prasad, and Turtelboom (1998) for an introduction). Its companion model with microeconomic foundations is called Global Economy Model (GEM) and described in Pesenti (2008). IMF staff also developed another structural model for the analysis of fiscal and monetary policy called GIMF, which is described in Kumhof and Laxton (2007).

[7] This finding is similar to estimates reported by Coenen and Straub (2005) and Forni, Monteforte, and Sessa (2009). The latter authors obtain estimates between 30 and 40% for the euro area.

Figure 3.3: Models of IMF and EU-Commission researchers



negative effect is even slightly more pronounced than in the Smets and Wouters model in 2009.

This finding may appear surprising, because it has been suggested that the presence of liquidity-constrained households can induce crowding-in of consumption following a government spending shock in New-Keynesian DSGE models (see for example Gali et al. (2007)). However, Coenen and Straub (2005), show that it is empirically unlikely that an increase in government spending crowds in consumption even with such assumptions. They find that the estimated share of constrained households is not sufficient to overturn the negative wealth effects that are internalized by the forward-looking households. The Quest model further corroborates their finding.

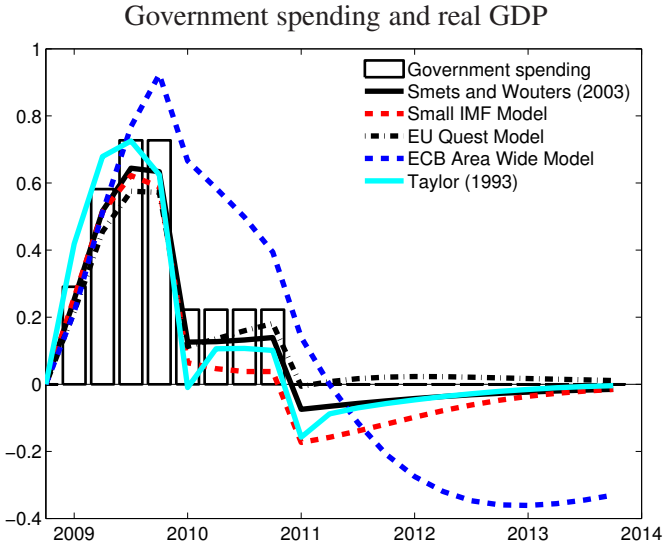
Some have criticized New-Keynesian DSGE models for being too similar to real business cycle models and incorporating too little of the lessons derived from earlier New Keynesian models with rational expectations or more traditional Keynesian models with backward-looking dynamics. Thus, we introduce two more models in the comparison, the model of the G7 economies by Taylor (1993) and the ECB's area-wide model of Fagan et al. (2005).[8]

The Taylor model is interesting because it is a multi-country model. It allows us to look at euro area member economies such as France, Germany and Italy, separately. Furthermore, this model offers a different perspective on households and firms. They are assumed to be forward-looking and forming rational expectations, but Ricardian equivalence is not enforced as in the Smets and Wouters model. We simulate a euro area-wide fiscal stimulus for Germany, France and Italy combined. The exchange rates between these three economies are fixed. Short-term nominal interest rates are identical and set

[8]We use the linearized version of Dieppe, Kuester, and McAdam (2005).

according to a policy rule with area-wide targets.[9] As shown in **Figure 3.4** the initial boost to GDP in the first three quarters of 2009 is slightly greater than in the Smets an Wouters (2003) model. The effect on GDP is smaller, however, in 2010 and slightly more negative in 2011. A small crowding-in effect is observed in the first two quarters, but it is quickly overwhelmed and followed by a decline in consumption and investment.

Figure 3.4: The Taylor (1993) G-7 model and the ECB's area-wide model



The ECB's area-wide model provides a more traditional Keynesian outlook on fiscal stimulus. It exhibits significant crowding-in effects of consumption and investment that raise output in 2010 twice as high as the remaining increase in government spending. This result is obtained, because the model assumes backward-looking behavior. Expectations are represented by lagged values of the variables to be forecasted. Furthermore, private consumption is modeled as a function of disposable income and wealth, with the latter defined as cumulative savings. Thus, households are not modeled as forward-looking decision makers. The simulation of the ECB's area-wide model indicates that the Keynesian multiplier effect in the first two and a half years will be followed by a significant slump in subsequent years. Such an oscillatory response is common to dynamic models with backward-looking dynamics. It is neglected by the simple static text-book analysis of the Keynesian multiplier discussed in the introduction of this chapter.

We conclude from this comparison that significant short-run Keynesian multiplier effects appear in models with backward-looking dynamics but disappear if forward-looking, optimizing motivations for households' and firms' decision making are allowed for in the analysis. It is noteworthy that

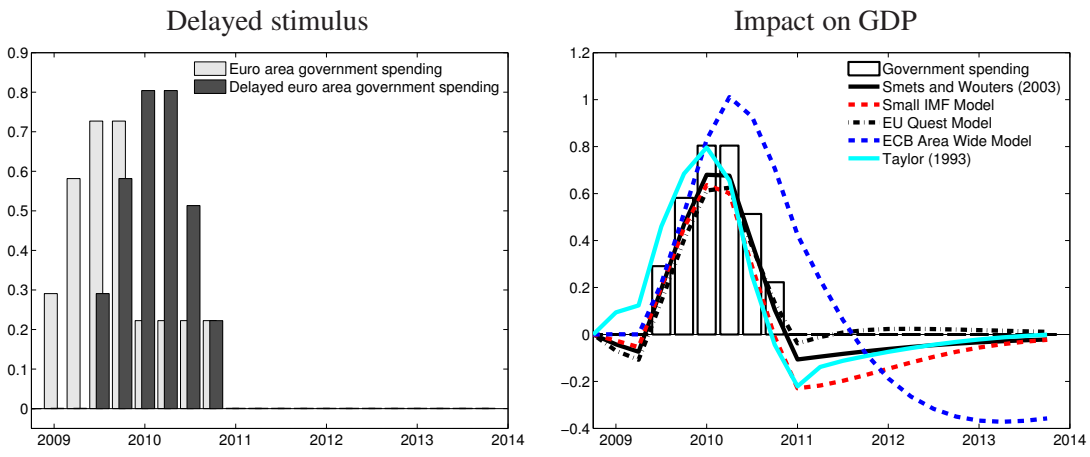
[9] Wieland (1996) previously used the Taylor model to study the implications of a shift from the Bundesbank-dominated European Monetary System with policy focused on German targets to a monetary union with area-wide targets.

models such as the ECB area-wide model have been criticized for assuming backward-looking, adaptive behavior. Fagan et al. (2005) themselves consider the backward-looking approach as adequate for short-term forecasts, but unsatisfactory with regard to the evaluation of major policy changes. Henry, de Cos, and Momigliano (2004) show that the introduction of more forward-looking elements in the ECB area-wide model substantially reduce the government spending multiplier.[10] Recently, ECB staff have introduced a New-Area-Wide model, which is more similar to the Smets and Wouters and EU-Quest models (see Christoffel, Coenen, and Warne (2008)).

Implementation lags and negative stimulus

So far, we assumed that governments start spending immediately following the announcement of their fiscal packages. Realistically, many spending measures take more time to be implemented. Even if the packages have passed parliament rather quickly, the planning of specific expenditures by the authorities who are expected to execute them still takes additional time. Once government authorities have decided and planned specific budgets, the particular work projects still need to be selected. The offers of companies applying for tenders need to be prepared and then compared by the authorities. Delays of several months should be expected as long as the selection process is sufficiently rigorous to avoid wastage of government funds. We recognize such limitations by shifting expenditures planned for the first half of 2009 to 2010 in the model simulations. This shift is shown graphically in the left panel of **Figure 3.5**.

Figure 3.5: Implementation lags and anticipation effects



The three-New Keynesian DSGE models (Smets and Wouters, Small IMF, EU-Quest) project that

[10]Interestingly, the comparison of euro area macroeconomic models in Kuester and Wieland (2010) suggests that models which allow for an important influence of forward-looking decision-making by households and firms have fared better in terms of fitting euro area inflation and output dynamics since the start of monetary union.

GDP will decline in the first half of 2009 due to the implementation lag. Thus, negative stimulus would occur just at the time when positive stimulus is most needed. This finding is particularly disconcerting for proponents of fiscal stimulus, because this class of models is judged by many to be the best currently available framework for policy evaluation.[11] By contrast, the traditional backward-looking features of the ECB's area-wide model ensure that output remains unchanged in the first two quarters of 2009. In this model, the stimulative effects are realized once government spending is implemented successfully from summer 2009 onwards. Interestingly, the model of Taylor (1993) indicates the possibility of a slight boost ahead of the delayed stimulus.

Further insight regarding these differential results may be obtained from the comparison of consumption and investment dynamics in **Figure 3.6**. In the Smets and Wouters model and the Small IMF model the negative impact of the delayed government spending and the negative wealth effect on private consumption of higher anticipated future taxes combine to slow down the economy. Households and firms see through the future discretionary spending stimulus. They reduce spending immediately to save for higher taxes later. This effect also dominates in the EU-QUEST model even though one third of the households are constrained to consume current income.

The earlier-generation New-Keynesian model of Taylor(1993) does not generate the same strong Ricardian effects as the current vintage of New-Keynesian DSGE models. Households and firms make forward-looking decisions. However, their expectations are influenced more by the positive impact of additional government spending in the near term. This expectation leads to additional spending in the first two quarters.[12] Finally, the ECB's area-wide model essentially delivers the same assessment as in the simulation without implementation lag, except that the crowding-in of consumption and investment is delayed by two quarters. Again, backward-looking dynamics induce a big oscillatory effect. The boost is followed by a slump.

Interest rates and accommodative monetary policy

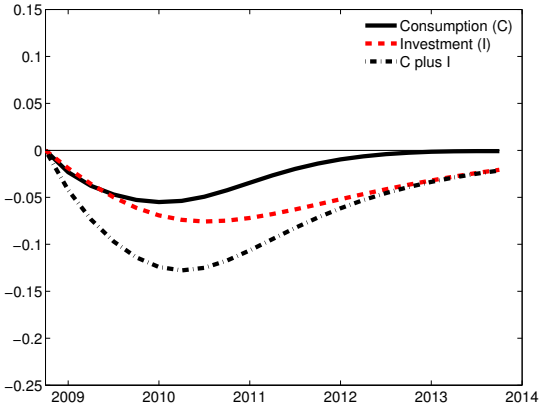
It is well-known that fiscal policy may suffer implementation lags and that it puts upward pressure on real interest rates that reinforces crowding-out of private consumption and investment. By contrast, the central bank is able to implement monetary policy changes immediately. Thus, proponents of fiscal stimulus have emphasized that the central bank could accommodate fiscal policy for some time in order to strengthen the overall stimulus. Romer and Bernstein (2009), for example, assumed that monetary policy keeps the nominal interest rate constant. Cogan et al. (2010) point out that a permanent peg would lead to instability and non-uniqueness in New-Keynesian models. They

[11] See for example the survey of Woodford (2009).

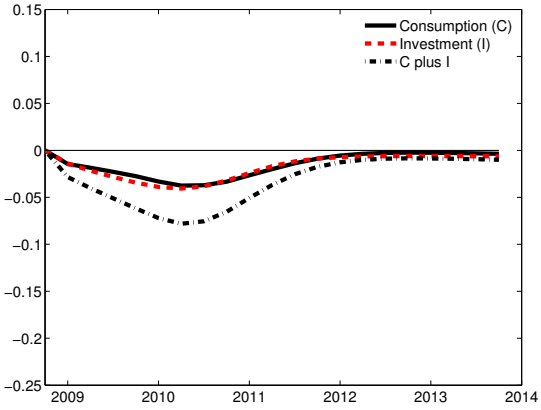
[12] Perhaps, current research on credit-constrained but still forward-looking households as in Roeger and in't Veld (2009) may come closer to this effect.

Figure 3.6: Consumption and investment with delayed stimulus

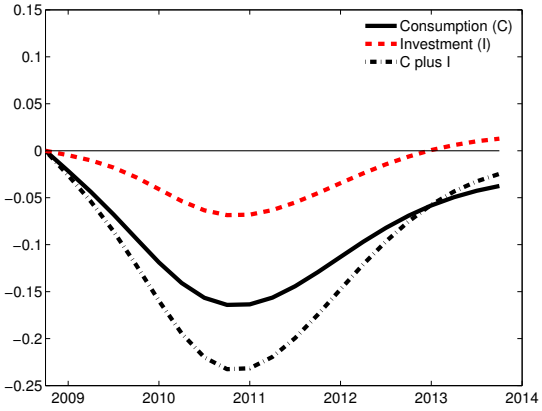
Smets and Wouters Model



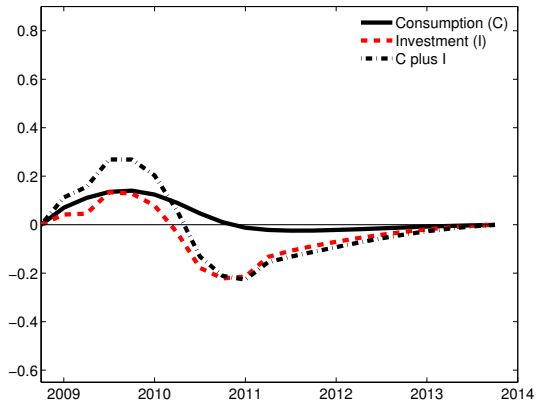
EU-QUEST Model



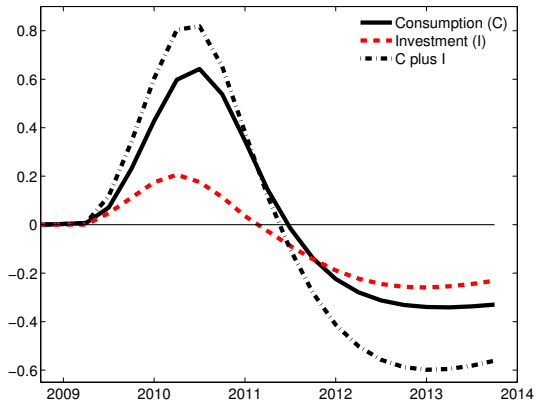
Small IMF Model



Taylor (1993)



ECB Area Wide Model



consider instead that the Fed would act to prevent any increase in the interest rate due to fiscal stimulus for one or two years. Afterwards, central bank policy is assumed to return to a policy rule that ensures a greater than one-for-one response to rising inflation. Such a rule avoids explosive and self-fulfilling increases in inflation.

The euro area model simulations presented so far have been conducted under the assumption that ECB monetary policy follows an interest rate rule that stabilizes output and inflation. The particular policy rule implemented in all the models considered in this chapter is taken from Gerdesmeier and Roffia (2004). The rule is estimated with euro area data. It was also used by Kuester and Wieland (2010) in a comparative study of the first generation of euro area models developed at the ECB. It is a rule for setting the short-time nominal interest rate, r_t as a function of inflation, output and the lagged interest rate:

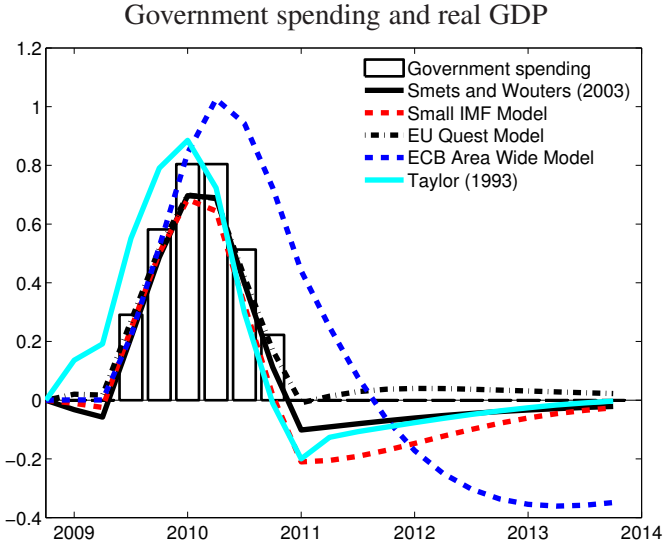
$$r_t = 0.66 r_{t-1} + 0.66 \pi_t + 0.10 y_t \tag{3.1}$$

Here, r_t is the quarterly nominal interest rate (annualized), π_t is the year-on-year inflation rate and y_t is the output gap. Monthly data from 1985 to 2002 was used in estimation.

Instead, we now introduce the possibility that the ECB deviates from the rule in order to accommodate the fiscal stimulus. Specifically, the ECB is assumed to promise keeping the nominal interest rate constant throughout 2009. This assumption introduces an additional nonlinearity into the analysis. The monetary accommodation is anticipated by forward-looking households and firms. Thus, crowding-out effects, to the extent that they arise due to an increase in interest rates following the announcement of fiscal stimulus, are eliminated. In 2010 policy is assumed to return to the policy rule, thereby keeping inflation under control in the longer run. The effect of euro area government spending on GDP with constant interest rates in 2009 is shown in **Figure 3.7**. The year of monetary accommodation implies little change from our earlier findings. The initial negative stimulus in the New-Keynesian DSGE models of Smets and Wouters (2003) and Laxton and Pesenti (2003) is muted but not reversed. In the EU Quest model output the initial negative effect on output is eliminated. All three DSGE models still exhibit crowding-out effects over the 8 quarters of fiscal stimulus. The reason is that the original 2009 increase in interest rates in response to fiscal stimulus was not that large in the first place. The small initial crowding-in effect in the Taylor model and the larger crowding-in effect in the ECB's area-wide model are reinforced somewhat.

What should one make of these differential assessments with multiple macroeconomic models? We propose to focus on the cumulative effect of government expenditures on GDP relative to the resources spent by the government. This difference measures the cumulative private spending multiplication or displacement over a given horizon. It is reported in **Table 3.2** for the simulations with delayed stimulus and constant interest rates in 2009. The first column shows the cumulative effect over two years, that is from the first quarter of 2009 to the first quarter of 2011. Over this period, the

Figure 3.7: Impact on euro area GDP: constant interest rates in 2009



three New-Keynesian DSGE models indicate significant private spending displacement. The Taylor model indicates a value near zero, while the ECB's area-wide model suggests a small net increase. However, over a four-year horizon all five models agree that government spending will crowd-out private spending to a significant extent as shown in the middle column.

Table 3.2: Cumulative GDP net off government spending

Percentage increase in real GDP			
	EU fiscal package (2011Q1)	EU fiscal package (2013Q4)	US fiscal package (2013Q4)
Smets and Wouters (2003)	-0.20	-0.34	-1.32
ECB Area Wide Model	0.37	-0.18	-0.01
Taylor (1993)	0.04	-0.11	-0.55
Small IMF Model	-0.26	-0.56	-1.68
EU Quest Model	-0.11	-0.02	-1

Notes: Delayed euro area fiscal stimulus package as in Figure 3.7 assumed for the results in column 2 and 3. The interest rate is assumed constant in 2009. The cumulated euro area stimulus amounts to 0.80 percent of euro area GDP (see Table 3.1) and the cumulated US government purchases to 2.21 percent of US GDP.

Would the results be better if only the euro area governments would have enacted a greater stimulus? So far, only Germany has announced measures that come close to the spending program initiated in the United States under the ARRA legislation (in terms relative to GDP). As a counterfactual we consider the possibility that other euro area governments follow suit and a package similar in magnitude to the ARRA is implemented symmetrically across Europe. To this end, we study the impact of the package simulated by Cogan et al. (2010) for the United States in the models of the euro

area economy. This package implies significant additional spending for four years. The cumulative impact on GDP net of government spending by the end of the fourth year is shown in the third column of **Table 3.2**. The four New Keynesian models indicate that discretionary fiscal stimulus will substantially reduce private spending and investment. In the ECB's area-wide model the negative effect is delayed.

3.4 Fiscal stimulus and spillover effects in the euro area

Advocates of fiscal stimulus in the euro area were particularly concerned with spillover effects and the potential for free-riding. The rationale was that unilateral stimulus in one country, for example in Spain, would partly be diverted to a greater demand for import goods. As a result, other euro area trading partners, say Germany, France or Italy, would benefit from Spanish fiscal stimulus. They would even have an incentive to go slow on domestic stimulus while encouraging other countries, a behavior referred to as "free-riding". This criticism was directed in particular at the German government that was perceived to have most room for additional fiscal spending thanks to past budget consolidation.[13] As indicated by our review of announced fiscal packages in the euro area, the German government eventually announced by far the largest fiscal stimulus measures accounting for almost 50 % of the total euro area stimulus. Thus, the question now is whether the effect of German government spending increases will pull along other euro area countries. Analyzing this question requires an estimated macroeconomic multi-country model that accounts for a sufficient number of euro area member economies separately. Unfortunately, such models are still relatively rare. One model at our disposal is the Taylor (1993) model of the G7 economies. We use it to quantify the effect of the spending measures announced by the German government on Germany, France and Italy.

Table 3.3 reports the effects on German, French and Italian GDP from the first quarter of 2009 to the fourth quarter of 2012. The first three row indicate the outcome when these countries form a monetary union, in other words, when the exchange rates are fixed and monetary policy aims at stabilizing union-wide targets. Interestingly, the spill-over effects are rather small. In Italy they even turn negative by the end of 2009. This finding is obtained even though the estimated export demand equations for Italy and France indicate an economically significant direct foreign demand effect with Germany as an important trading partner. This direct demand effect is overwhelmed by the indirect effect of a real appreciation of the Euro. The fiscal expansion in Germany puts upward pressure on the euro relative to the currencies of countries outside the monetary union (United States, Canada, United Kingdom and Japan). As a result, France and Italy loose competitiveness and exports to countries outside the euro area decline.

To further explore the role of the exchange rate in fiscal stimulus we conduct a counterfactual sim-

[13] An example, is the contribution of Paul Krugman cited in the first footnote in the introduction.

Table 3.3: Impact of German government expenditures

Percentage increase in real GDP					
	2009Q1	2009Q4	2010Q4	2011Q4	2012Q4
Monetary union					
France	0.040	0.038	0.012	-0.01	0.002
Germany	0.746	0.696	0.429	-0.087	-0.153
Italy	0.015	-0.011	-0.050	-0.059	-0.02
Flexible exchange rates					
France	0.058	0.065	0.023	-0.021	-0.014
Germany	0.675	0.527	0.267	-0.127	-0.072
Italy	0.047	0.057	0.027	-0.016	-0.017

Notes: The impact of the German fiscal stimulus package is simulated with the Taylor-Model. Euro area inflation and output gap are defined as a weighted average of German, French and Italian values. In the case of the monetary union simulation the euro area nominal interest rate reacts to euro area inflation and output gap. We assume no change in the fiscal policy of France and Italy.

ulation with flexible exchange rates between France, Germany and Italy and independent monetary policies. In this case, the effect of fiscal stimulus in Germany is reduced, because it is faced with a larger appreciation of its currency vis-a-vis others. The spill-over effects to France and Italy, however, would be positive. As emphasized by Wieland (2006) it is important to account for this regime change in assessing the extent of likely spill-overs between euro area member economies. While empirical VAR studies that use data from before and after monetary union will confound the differential spill-over effects from these two periods, they may be distinguished by using a structural model. The findings with the Taylor (1993) model underscore the drawbacks of discretionary fiscal stimulus in the euro area. It would be of interest to estimate a New-Keynesian DSGE model of the G-7 economies with more recent data and conduct a robustness analysis.

3.5 Conclusions

In this chapter we have constructed an estimate of the additional government expenditures in the euro area in conjunction with the measures announced in national fiscal stimulus packages for 2009 and 2010. According to our calculations the euro area stimulus is primarily driven by measures taken by the German government and to a smaller part by the Spanish and French governments. We have then used a comparative, model-based approach to assess the likely impact of these measures on euro area GDP. Proponents of discretionary fiscal stimulus emphasize the Keynesian multiplier effect that implies that additional government spending would induce an increase in private spending and therefore a greater than one-for-one effect on aggregate GDP. We investigate this proposition by using

empirical macroeconomic models with Keynesian features such as price and wage rigidities. Four of the models we use have been developed and estimated at central banks and international institutions. Three of these models are New-Keynesian DSGE models that represent the current state of the art of policy analysis.

Our findings provide no support for a Keynesian multiplier. Instead they suggest that additional government spending will reduce private spending for consumption and investment purposes. The reason is the forward-looking behavior of households and firms. They anticipate higher tax burdens and higher interest rates in the future and therefore reduce consumption and investment. Thus, the initial effect on GDP may even be negative if government spending faces an implementation lag. Monetary accommodation in terms of a constant level of the nominal interest rate for all of 2009 helps but is not sufficient to offset the crowding-out of private spending.

Only the ECB's area-wide model, which largely ignores forward-looking behavior, is found to generate government spending multipliers that are significantly above one. Although such models are useful for short-term forecasting in the absence of major policy changes they are not well-suited for analyzing the effect of such changes. The New-Keynesian models instead account for the likely response of forward-looking optimizing households and firms.

We have also analyzed the possibility of spillover effects within the euro area using the Taylor (1993) model. This model, which assumes forward-looking, rational expectations and price and wage rigidities, accounts for the French, German and Italian economies separately. The spillover effects of the German stimulus measures with regard to France are very small. They even turn slightly negative in the case of Italy at the end of 2009. Direct demand effects are overwhelmed by the indirect effect of euro appreciation. For further research on euro area spillovers it would be of interest to estimate a multi-country New-Keynesian DSGE model with more recent data and conduct a robustness analysis.

In this chapter, we have investigated the possibility of Keynesian multiplier effects using empirical macroeconomic models with Keynesian features. In contrast with real business cycle models, the estimated New-Keynesian models assume "sticky prices" by introducing staggered price and wage setting. But as Chari et al. (2009) have emphasized the models go further in the Keynesian direction by assuming "the backward indexation of prices" in "a mechanical way" which amplifies Keynesian aggregate demand effects of policy. Addressing this criticism by eliminating these features from the New Keynesian models would tend to further strengthen the case against discretionary fiscal stimulus. For example, Uhlig (2009) considers a neoclassical growth model with endogenous labor and various fiscal instruments and concludes that massive expansions in government spending such as the ARRA package in the United States come at substantial costs in terms of total output over the longer run.

Appendices

3.F Country details on the fiscal packages in the euro area

Netherlands

Category	Measure	2009 (bln Euro)	2010 (bln Euro)
Tax cuts	Accelerated depreciation of investments	0.90	0.90
	Tax cuts for SMEs	2.00	2.00
		2.90	**2.90**
Extra spending	Unemployment benefits (working hours reduction)	0.20	0.00
		0.20	**0.00**

Source: Estimating the size of the European stimulus packages for 2009 An Update, Netherlands stability programme December 2008 Addendum.

Ireland

Category	2009 (bln Euro)	2010 (bln Euro)
Tax cuts	0	0
	0	**0**
Extra spending	0	0
	0	**0**

Source: Estimating the size of the European stimulus packages for 2009 An Update, Addendum to the Irish Stability Programme Update January 2009.

Portugal

Category	Measure	2009 (bln Euro)	2010 (bln Euro)
Tax cuts	Special support to economic activity, exports and SME	0.10	0.00
		0.10	**0.00**
Extra spending	Modernisation of schools	0.30	0.30
	Fostering Renewable Energies, Energy Efficiency and Energy Transmission Infrastructure	0.25	0.00
	Modernisation of technological infrastructure, new generation broadband networks	0.05	0.05
	Protecting employment and strengthening social protection	0.30	0.00
		0.90	**0.30**

Source: Portuguese Republic Stability and Growth Programme 2008 - 2011, January 2009 Update, "Investment and Employment Initiative (IEI)" Programme.

Belgium

Category	Measure	2009 (bln Euro)	2010 (bln Euro)
Tax cuts	Measures for construction sector	0.30	0.30
	No tax on credit insurance	0.02	0.02
		0.32	**0.32**
Extra spending	Higher unemployment pay	0.10	0.00
	Energy subsidy to households	0.14	0.14
	Higher social security allocations	0.51	0.51
	Investments into green technology	0.02	0.02
	Larger fund for energy cost reduction	0.01	0.01
	Accelerated public investments	0.12	0.12
	Lower cost of using food safety agency	0.03	0.03
		0.93	**0.83**

Source: Estimating the size of the European stimulus packages for 2009 An Update

Germany

Category	Measure	2009 (bln Euro)	2010 (bln Euro)
Tax cuts	Degressive depreciation deduction	1.94	4.33
	Higher tax-free allowances for companies	0.24	0.37
	Suspension of car tax on on new vehicles	0.44	0.13
	Tax deductibility of professionel commute	4.00	4.00
	Package for tax burden reduction, stabilisation of Social security contributions and investment in families	4.22	12.04
	Income tax cut	2.90	6.04
	Reduction in health insurance contributions	3.00	6.50
	State payment of 50 percent social insurance for short-time workers	1.15	1.15
	Reform of car tax	0.09	0.17
		17.98	**34.73**
Extra spending	Investments into transport infrastructure	1.00	1.00
	Longer eligibility for short-time compensation	0.00	0.00
	Improvement of regional economic structure	0.30	0.00
	Infrastructure investment programme	8.65	8.68
	Innovation support programme	0.45	0.45
	Retraining and stronger job service	1.59	1.59
	Increased child benefits	4.42	2.84
	Premium for new car purchases	1.50	0.00
	Increased housing benefits	0.06	0.06
		17.97	**13.62**

Source: Estimating the size of the European stimulus packages for 2009 An Update, Brot und Butter Brief " Der Wirtschaftskrise entgegensteuern", GDP: OECD Economic Outlook, Gross domestic product, value, market prices.

Greece

Category	2009 (bln Euro)	2010 (bln Euro)
Tax cuts	0	0
	0	**0**
Extra spending	0	0
	0	**0**

Source: Estimating the size of the European stimulus packages for 2009 An Update, Addendum to the 2008 update of the Hellenic Stability and Growth Programme 2008 - 2011, February 2009.

Spain

Category	Measure	2009 (bln Euro)	2010 (bln Euro)
Tax cuts	Longer tax-exemption of saving accounts for housing purchases even if no house is bought	0.03	0.03
	Extended eligibility for tax deductions when selling houses	0.11	0.11
	Reduction in employer social contributions for hiring previously unemployed workers	0.08	0.08
	permanent tax measures (major reform of direct taxation 2007 + additional tax measures)	14.5	14.5
		14.72	**14.72**
Extra spending	Employment Plan	1.1	0.00
	Public Investment Fund	8.00	0.00
	Sector specific support	3.00	0.00
		12.1	**0.00**

Source: Estimating the size of the European stimulus packages for 2009 An Update, Stability Programme update Spain 2008-2011.

Finland

Category	Measure	2009 (bln Euro)	2010 (bln Euro)
Tax cuts	New building and renovation (increase in household tax deduction)	0.10	0.10
	Tax cuts and improvements in benefits (Tax cuts on labour and pension income, lower VAT)	1.83	1.83
		1.93	**1.93**
Extra spending	Transport routes, infrastructure and energy projects	0.08	0.08
	Business subsidies, R and D	0.36	0.36
		0.44	**0.44**

Source: Estimating the size of the European stimulus packages for 2009 An Update, Stability Programme update for Finland 2008, information on the fiscal measures (12.2008).

France

Category	Measure	2009 (bln Euro)	2010 (bln Euro)
Tax cuts	Reduced obligation to contribute to social insurance conditional on new hiring, for very small firms	0.70	0.00
		0.70	**0.00**
Extra spending	Direct public investment (government and local government)	6.50	4.00
	Sectoral subsidies: housing industry, subsidies to building, renovation, buyers and renters	1.20	0.00
	Sectoral subsidies: car industry	0.60	0.00
	Increased payment to the endowment for the basic income provision	0.80	0.00
	Employment policies	0.50	0.00
	State-owned enterprises investment	4.05	0.00
	Social package (announced on 18.02.2009)	2.60	0.00
		16.25	**4.00**

Source: Estimating the size of the European stimulus packages for 2009 An Update, French Stability Programme 2009-2012.

Italy

Category	Measure	2009 (bln Euro)	2010 (bln Euro)
Tax cuts	No increase of highway toll	0.09	0.00
	Tax cut for productivity bonuses	0.46	0.15
	Deductibility of corporate tax from regional corporate tax	1.19	1.19
	Deferred VAT payments	0.19	0.19
	Municipal infrastructure investment	0.00	0.00
	Voluntary revision of company book values	-2.76	0.00
	More tax inspections	-1.88	-1.88
	Tax inspections of private associations	-0.15	-0.15
	Increased taxation of TV services	-0.47	-0.47
		-3.33	**-0.97**
Extra spending	Spending on low income families	2.40	0.00
	Aid to house mortgages	0.35	0.00
	Unemployment benefits	0.10	0.10
	Financing of strategic infrastructure	0.06	0.00
	Increased tax revenue costs	0.05	0.05
	Renewal of school cleaning contracts	0.11	0.00
		3.07	**0.15**

Source: Estimating the size of the European stimulus packages for 2009 An Update, Italys stability programme 2008 update, Decree-Law no. 185/2008.

Austria

Category	Measure	2009 (bln Euro)	2010 (bln Euro)
Tax cuts	Early implementation of income tax reform	2.30	2.30
	Degressive depreciation deduction	0.23	0.34
	Reduced VAT rate on medication	0.28	0.28
	Tax exemptions	0.16	0.16
	Burden reduction for families with children	0.51	0.51
		3.48	**3.59**
Extra spending	Regional employment initiatives	0.08	0.08
	Spending package, September 2008	0.40	0.00
	Additional research expenditure	0.05	0.05
	Mandatory kindergarten year for all	0.07	0.07
	Energy saving cheques	0.10	0.00
	Investment in public facilities	0.36	0.52
	Advancing of railroad investments	0.24	0.24
	Subsidies to house saving scheme	0.02	0.02
	Investments into broad-band internet infrastructure	0.01	0.00
	"Mittelstandsfonds"- venture capital fund for SMEs	0.04	0.04
		1.37	**1.02**

Source: Estimating the size of the European stimulus packages for 2009 An Update, Österreichisches Finanzministerium.

Chapter 4

Fiscal consolidation in Germany

4.1 Introduction

During the financial crisis the majority of countries worldwide has introduced considerable measures to stabilize the banking sector and additional discretionary fiscal packages to stabilize domestic demand. Germany for instance has launched two "*Konjunkturpakete*" in the beginning of 2009 with a size of 3.37% of GDP for 2009 and 2010. They include for instance infrastructure investment programs or the "*Abwrackprämie*" on the government spending side and income tax cuts on the revenue side.[1] This has lead to a large build up of debt. In Germany the debt to GDP ratio has increased to 77.4% of GDP after 65.3% in the end of 2007, which now exceeds the reference value of the Maastricht Treaty by almost 18%.[2] And a further increase is to be expected through the discretionary fiscal packages in 2010. Clearly, a further increase in the debt level increases government interest rate payments in the future given equal financing conditions, which leads to less room for fiscal policy or an even greater increase in the debt level.

Blanchard et al. (2010) propose in their paper "*Rethinking Macroeconomic Policy*" to reduce target debt levels. They write: "*Still, the lesson from the crisis is clearly that target levels should be lower than those observed before the crisis. The policy implications for the next decade or two are that, when cyclical conditions permit, major fiscal adjustment is necessary and, should economic growth recover rapidly, it should be used to reduce debt-to-GDP ratios substantially, rather than to finance expenditure increases or tax cuts.*" They also propose to use medium-term fiscal frameworks like credible commitments and fiscal rules to reduce debt-to GDP ratios. In Germany the "*Föderalismuskommission II*" agreed to introduce a debt brake from 2011 onwards, which demands government spending including interest on outstanding debt to be on average equal to trend revenues. This rule acts as an automatic stabilizer since the government finances in a recession part of the interest pay-

[1] See Cwik and Wieland (2009) for an overview of the fiscal packages of the eleven biggest euro area countries.

[2] The Maatricht Treaty obliges Member States of the European Union to avoid deficits exceeding 3% of GDP and debt levels above 60% of GDP.

ments and spending by running deficits, while in booms it runs surpluses. Surpluses and deficits are booked on an adjustment account, which is cleared over time through cutting or raising future government spending.

In this chapter I study the duration and macroeconomic implications of fiscal consolidation in Germany. I construct a DSGE model with a detailed fiscal policy specification. The model builds on the New-Keynesian DSGE model à la Smets and Wouters (2007), which has shown to fit the data well. Because the focus of this chapter is on government debt, I allow for rich dynamics induced by the interactions between policy variables and debt. Following Kollmann (1998) and Leeper et al. (2010) government transfers, the income tax, capital tax and consumption tax can respond to government indebtedness. In addition the income, consumption and capital tax rate can adjust to the state of the economy to allow for progressive taxation. I introduce a debt brake for government spending as described above, but allow spending to respond stronger to the state of the economy to describe the economy before the introduction of the debt brake. Since the literature on fiscal policy has emphasized the importance of non Ricardian consumers in DSGE models, I introduce a share of rule-of-thumb consumers as described in Gali et al. (2007) together with forward-looking households in the model. I also include government transfers, which are paid to Ricardian and non Ricardian households in equal proportions. The model is estimated on German data from 1970Q1 up to 2009Q4 with Bayesian techniques using the following 12 time series: consumption, investment, GDP, the real wage, hours worked, inflation, the interest rate, the government debt to GDP ratio, the government labour income tax, consumption tax and capital tax revenues and transfer payments. I especially focus on the estimates for the fiscal rule parameters and their implications for the evolution of debt. To my knowledge this is the first paper, which analyses and quantifies the impact of the debt brake on the evolution of the debt-to-GDP ratio in Germany.

I find that through the expected economic recovery after the severe financial crisis in 2008 and 2009, it is possible to reduce the debt-to-GDP ratio significantly in the medium-term. This seems surprising, but it is feasible if the government sticks to the policy rules. The following channels are at work. First the debt-to-GDP ratio decreases directly when GDP increases faster than debt. Second through the economic recovery hours worked and real wages are expected to increase leading to higher labour income tax revenues. Third the average tax rates in the economy increase through the economic recovery. And finally the tax rates react to debt, which leads to lower expected tax rates in the future, when debt is decreasing. I also compute conditional forecasts implementing the effects of the "*Konjunkturpaket*" and "*Wachstumsbeschleunigungsgesetz*" in 2010. I find that the stimulus packages have only a moderate effect on GDP. The debt-to-GDP ratio increases stronger in 2010 than in the baseline forecasts and peaks at 81.3%. But still it is expected to be lower than the Maastricht criteria of 60% in the second quarter of 2015. Enforcing the debt brake and halving the output elasticity of

the labour income tax from 2010 on puts more pressure on the government to reduce spending and increases the labour income tax rate, which lowers hours worked. Both measures lead to a faster reduction in the debt-to-GDP ratio on the cost of reducing GDP slightly in the short-run compared to the baseline forecast scenario. The uncertainty of the forecasts given by the error bands is mainly driven by unforeseen shocks.

The remainder of the chapter is organized as follows. Section 4.2 provides a description of the DSGE model. Section 4.3 explains the estimation procedere and section 4.4 employes the estimated model to run forecast scenarios for the debt-to-GDP ratio. Section 4.5 concludes.

4.2 Model

In this section I develop a closed economy New-Keynesian DSGE model to study fiscal consolidation in Germany. Most of the model features are standard and familiar from so-called medium scale DSGE models, as put forward, for instance, in Christiano et al. (2005) or Smets and Wouters (2007). A fraction of the representative households are forward-looking, smooth their consumption over time by buying domestic government bonds, own the capital stock, which is rented together with labor services to intermediate goods producers on a period-by-period basis and pay value added tax, labour income tax and capital income tax. The other fraction, the rule-of-thumb consumers, consume their after tax labour income. They work an equal proportion of their time as Ricardian households and receive the same wage. Adjusting investment is costly.

I assume there is a continuum of intermediate good producers operating under monopolistic competition and being constrained in price setting à la Calvo. They produce using a Cobb-Douglas production function and rent capital and labour services in competitive factor markets. Labour services are provided by an intermediate labour union sector, which pools labour services from Ricardian and non Ricardian households and set wages. Wages are sticky á la Calvo. Final goods firms combine intermediate goods to provide private consumption, investment and government consumption.

I introduce a policy rule for government spending into the model. Fiscal authorities are forced to consume and transfer to households on average as much as they earn, which consists of capital, labour income and consumption taxes, but they are allowed to react to the current state of the economy. Differences between trend revenues and spending are booked on an adjustment account, which is cleared over time. Taxes and transfers are adjusted via fiscal rules to changes in the overall debt level and the state of the economy. I close the model with a characterization of monetary policy in terms of an interest feedback rule. In the following I give a formal exposition of the model.

4.2.1 Firms

Final goods are composites of intermediate goods produced by a continuum of monopolistic competitive firms and are used for domestic consumption, C_t, investment, I_t, and government spending, G_t. I use $i \in [0, 1]$ to index intermediate good firms as well as their products and prices. Final goods firms operate under perfect competition and purchase intermediate goods, $Y_t(i)$. They use the following Kimball aggregation technology with the elasticity of demand being an increasing function of the relative price of the intermediate good $P_t(i)$ and the final good P_t

$$\int_0^1 G\left(\frac{Y_t(i)}{Y_t}; \lambda_{p,t}\right) di = 1 \tag{4.1}$$

G is a concave and increasing function such that $G(1) = 1$ and $(1 + \lambda_{p,t})$ is the time-varying price markup with

$$\ln \lambda_{p,t} = (1 - \rho_p) \ln \lambda_p + \rho_p \ln \lambda_{p,t-1} + \theta_p \epsilon_{p,t-1} + \epsilon_{p,t} \tag{4.2}$$

The representative final goods firms produce Y_t while minimizing expenditures. The resulting demand function for an individual intermediate good i is given by

$$Y_t(i) = Y_t G^{'-1}\left[\frac{P_t(i)}{P_t} \int_0^1 G^{'}(\frac{Y_t(i)}{Y_t})\frac{Y_t(i)}{Y_t} di\right] \tag{4.3}$$

The production of intermediate goods, $Y_t(i)$, is governed by a Cobb-Douglas production function

$$Y_t(i) = Z_t K_t^s(i)^{\alpha} \left[\gamma^t L_t(i)\right]^{1-\alpha} - \gamma^t \Phi, \tag{4.4}$$

where $L_t(i)$ and $K_t^s(i)$ respectively denote labour and capital employed by firm i and Φ denotes fixed costs of production, which are set so that profits are zero in steady state. γ^t represents the labour-augmenting deterministic growth rate in the economy and Z_t governs total factor productivity, which is given by the following shock process

$$\ln Z_t = \rho_z \ln Z_{t-1} + \epsilon_{z,t} \tag{4.5}$$

where $\epsilon_{z,t}$ is iid distributed. Let W_t and R_t^k denote the nominal wage rate and the rental rate of capital, respectively. Minimizing the costs of producing intermediate goods implies for (nominal) marginal costs

$$MC_t = \alpha^{-\alpha}(1 - \alpha)^{-(1-\alpha)} W_t^{1-\alpha} (R_t^k)^{\alpha} \gamma^{-(1-\alpha)t} (Z_t)^{-1}, \tag{4.6}$$

which are independent of the level of production and identical across firms, because both factors of production can be adjusted freely across firms.

I assume that price setting is constrained exogenously by a discrete time version of the mechanism suggested by Calvo (1983). Each firm has the opportunity to change its price with a given probability

$1-\xi_p$. Firms that do not reoptimize in a certain period index their price to a combination of last period's inflation and steady state inflation π_*, where the degree of indexation to last periods inflation is given by the parameter $\iota_p \in [0,1]$.

The optimal price $\widetilde{P}_t(i)$ set by the firm that is allowed to re-optimize at time t results from the following optimization problem

$$\max E_t \sum_{s=0}^{\infty} \xi_p^s \frac{\beta^s \Xi_{t+s} P_t}{\Xi_t P_{t+s}} \left[\widetilde{P}_t(i) \left(\Pi_{l=1}^{s} \pi_{t+l-1}^{\iota_p} \pi_*^{(1-\iota_p)} \right) - MC_{t+s} \right] Y_{t+s}(i) \tag{4.7}$$

subject to the demand function defined by (4.3).[3]

4.2.2 Households

There is a continuum of households indexed by $h \in [0,1]$. A share $1-\omega$ of these households makes optimizing, forward-looking decision. They are indexed by $j \in [0, 1-\omega)$. These households have access to financial markets. They buy and sell government bonds $B_t(j)$ and accumulate physical capital $K_t(j)$. Given capital utilization costs $a(u_t(j))$ they decide, how much of the accumulated capital they rent to firms. They receive wage income $W_t^h(j)L_t(j)$, transfers from the government T_t, dividend payments from the firms and profits from the labour unions denoted Div_t and pay capital tax τ_t^k, consumption tax τ_t^c and labour income tax τ_t^n to the government. Their decisions made so as to maximize a utility function that is separable in consumption $C_t(j)$ and labour supply $L_t(j)$. I use an additive separable utility function to make consumption and hours worked substitutes, which corresponds to the findings in the German data, and specifically the log utility function for consumption to ensure a balanced steady state growth path as put forward in King, Plosser, and Rebelo (1988).

$$E_t \sum_{s=0}^{\infty} \beta^s \log(C_{t+s}(j) - \lambda C_{t+s-1}) - \frac{1}{1+\sigma_l} L_{t+s}(j)^{1+\sigma_l} \tag{4.8}$$

subject to the budget constraint

$$\begin{aligned}
&(1+\tau_{t+s}^c) C_{t+s}(j) + I_{t+s}(j) + \frac{B_{t+s}(j)}{d_t P_{t+s}} \leq (1-\tau_{t+s}^n) \frac{W_{t+s}^h(j) L_{t+s}(j)}{P_{t+s}} \\
&+(1-\tau_{t+s}^k) \left[\frac{R_{t+s}^k u_{t+s}(j) K_{t+s-1}(j)}{P_{t+s}} - a(u_{t+s}(j)) K_{t+s-1}(j) \right] \\
&+\frac{B_{t+s-1}(j) R_{t+s-1}}{P_{t+s}} + \tau_{t+s}^k \delta K_{t+s-1}(j) + T_{t+s}(j) + \frac{Div_{t+s}}{P_{t+s}}
\end{aligned}$$

the capital accumulation equation

$$K_t(j) = (1-\delta) K_{t-1}(j) + \mu_t \left[1 - S\left(\frac{I_t(j)}{I_{t-1}(j)} \right) \right] I_t(j) \tag{4.9}$$

[3] Profits are discounted with the stochastic discount factor of the Ricardian households, $\frac{\beta^s \Xi_{t+s} P_t}{\Xi_t P_{t+s}}$, that are the final owners of the firms.

and the definition of employed capital

$$K_t^s(j) = u_t(j)K_{t-1}(j) \tag{4.10}$$

where $\lambda \in [0,1]$ measures the extent of consumption habits and δ denotes the depreciation rate. I assume for simplicity that the utilisation costs of physical capital and physical capital depreciation are exempted from taxation as in Coenen, McAdam, and Straub (2008). It may be costly to adjust the level of investment, I_t. Here S is the adjustment cost function, with $S(\gamma) = S'(\gamma) = 0$ and $S'' > 0$ ensures that the steady state capital stock is independent of the investment adjustment costs.[4] d_t is an exogenous premium in the return to bonds given by

$$\ln d_t = \rho_d \ln d_{t-1} + \epsilon_{d,t} \tag{4.11}$$

and μ_t is a stochastic shock to the price of investment relative to consumption goods of the following form

$$\ln \mu_t = \rho_\mu \ln \mu_{t-1} + \epsilon_{\mu,t} \tag{4.12}$$

The remaining share ω of non Ricardian households is indexed by $s \in [1-\omega, 1]$. They simply consume their disposable income which is given by the after-tax wage income and the transfer payments from the government.

$$(1+\tau_t^c)C_t(s) = (1-\tau_t^n)\frac{W_t^h L_t(s)}{P_t} + T_t(s) \tag{4.13}$$

Aggregating over all households implies that overall consumption is a weighted average of the consumption function of rational and rule-of-thumb consumers

$$C_t = \int_0^1 C_{h,t}dh = (1-\omega)C_{j,t} + \omega C_{s,t} \tag{4.14}$$

Labour packers buy the labour supplied by the households from labour unions $l \in [0,1]$, package L_t using the following aggregation technology and resell it to the intermediate goods producers.

$$L_t = \left[\int_0^1 L_t(l)^{\frac{1}{1+\lambda_{w,t}}} dl\right]^{1+\lambda_{w,t}} \tag{4.15}$$

$(1+\lambda_{w,t})$ denotes the time varying wage markup in the labour market driven by the moving average process of the form

$$\ln \lambda_{w,t} = (1-\rho_w)\ln \lambda_w + \rho_w \ln \lambda_{w,t-1} + \theta_w \epsilon_{w,t-1} + \epsilon_{w,t} \tag{4.16}$$

The labour packers maximize profits in a perfectly competitive environment leading to the following demand for individual labour l.

$$L_t(l) = \left(\frac{W_t(l)}{W_t}\right)^{-\frac{1+\lambda_{w,t}}{\lambda_{w,t}}} L_t \tag{4.17}$$

[4] See Christiano et al. (2005).

where W_t is the aggregate wage index. Labour unions allocate and differentiate the labour services from the households and set the same nominal wage rate for both types of households. They choose the wage given nominal rigidities á la Calvo subject to the labour demand equation (4.17) and the following household labour supply decision

$$\frac{W_t^h}{P_t} = \frac{(1+\tau_t^c)}{(1-\tau_t^n)}(C_t - \lambda C_{t-1})L_t^{\sigma_l} \tag{4.18}$$

The wage setting problem for a union that can adjust its wage in period t, $\widetilde{W}_t(l)$, becomes

$$\max E_t \sum_{s=0}^{\infty} \xi_w^s \frac{\beta^s \Xi_{t+s} P_t}{\Xi_t P_{t+s}} \left[W_{t+s}(l) - W_{t+s}^h \right] L_{t+s}(l) \tag{4.19}$$

with $W_{t+s}(l) = \widetilde{W}_t(l)(\Pi_{l=1}^s \gamma \pi_{t+l-1}^{\iota_w} \pi_*^{1-\iota_w})$. Labour unions that cannot adjust the wage in a given period index their wage to a combination of last periods inflation and steady state inflation, where ι_w denotes the degree of indexation to last periods inflation.

4.2.3 Fiscal and monetary authorities

The government raises consumption, capital and labour income taxes and decides on government expenditures subject to the following budget constraint

$$G_t + T_t + \frac{R_{t-1}B_{t-1}}{P_t} = \frac{\Psi_t}{P_t} + \frac{B_t}{P_t} \tag{4.20}$$

where real government revenues are given by

$$\frac{\Psi_t}{P_t} = \tau_t^n \frac{W_t^h L_t}{P_t} + \tau_t^k K_{t-1} \left(\frac{R_t^k u_t}{P_t} - a(u_t) - \delta \right) + \tau_t^c C_t \tag{4.21}$$

I define the fiscal rule for government spending in the following way building on an approach by Mayer and Staehler (2009).

$$(R_{t-1} - \gamma\pi_t)\frac{B_{t-1}}{P_t} + G_t + T_t = \frac{\Psi_* \gamma^{t(1+\phi_y^g)}}{P_*} \left(\frac{Y_*}{Y_t} \right)^{\phi_y^g} - \rho \frac{AC_{t-1}}{P_t} + \upsilon_t \gamma^t \tag{4.22}$$

If ϕ_y^g is equal to zero this rule corresponds to the german debt brake.[5] Real government spending, transfer payments and interest on outstanding real debt must be equal to real trend revenues $\frac{\Psi^*}{P^*}$ to ensure a structural balanced budget in the medium-term. To allow for countercyclical fiscal policy in the short-run, government spending can exceed contemporaneous government revenues in recessions, which needs to be balanced through government surpluses in booms. To describe fiscal policy before the introduction of the debt brake, I allow ϕ_y^g to vary. A value greater than zero indicates a stronger

[5] The German debt brake was proposed by the "*Föderalismuskommission II*", signed into law from the German parliament on the 29th May 2009 and becomes operative in 2011. However, the rule will be legally binding for the federal government from 2016 onwards and for the state governments from 2020 onwards.

countercyclical fiscal stance, whereas a value lower than zero more procyclical fiscal spending. Differences between government spending and trend revenues are booked on an adjustment account AC_t. ρ denotes the fraction of the amount on the adjustment account, which is cleared every period and υ_t is a discretionary government spending shock process to explain nonsystematic changes in government spending

$$\upsilon_t = \rho_\upsilon \upsilon_{t-1} + \epsilon_{\upsilon,t}. \tag{4.23}$$

The evolution of the adjustment account is defined by

$$\frac{AC_t}{P_t} = (1-\rho)\frac{AC_{t-1}}{P_t} + \upsilon_t \gamma^t + \left(\frac{\Psi_* \gamma^{t(1+\phi_y^g)}}{P_*} \left(\frac{Y_*}{Y_t} \right)^{\phi_y^g} - \frac{\Psi_t}{P_t} \right) \tag{4.24}$$

As in Kollmann (1998), I assume that taxes are adjusted to stabilize government debt. Additionally the tax rates respond to the state of the economy to allow for automatic stabilization i.e. progressive taxation.

$$\tau_t^n = \left(\frac{B_{t-1}}{P_{t-1}\gamma^{t-1}} \right)^{\phi_b^n} \left(\frac{Y_t}{\gamma^t} \right)^{\phi_y^n} \tau_t^{n,\epsilon} \tag{4.25}$$

$$\tau_t^c = \left(\frac{B_{t-1}}{P_{t-1}\gamma^{t-1}} \right)^{\phi_b^c} \left(\frac{Y_t}{\gamma^t} \right)^{\phi_y^c} \tau_t^{c,\epsilon} \tag{4.26}$$

$$\tau_t^k = \left(\frac{B_{t-1}}{P_{t-1}\gamma^{t-1}} \right)^{\phi_b^k} \left(\frac{Y_t}{\gamma^t} \right)^{\phi_y^k} \tau_t^{k,\epsilon} \tag{4.27}$$

where ϕ_b^n, ϕ_b^c and ϕ_b^k measure the elasticity of labour income, consumption and capital tax to government debt and ϕ_y^n, ϕ_y^c and ϕ_y^k the elasticity of the tax rates w.r.t. output. AR(1) processes $\tau_t^{n,\epsilon}$, $\tau_t^{c,\epsilon}$ and $\tau_t^{k,\epsilon}$ are included, which capture the persistence in the tax rates.

$$\ln \tau_t^{n,\epsilon} = \rho_{\tau^n} \ln \tau_{t-1}^{n,\epsilon} + \epsilon_{\tau^n,t} \tag{4.28}$$

$$\ln \tau_t^{c,\epsilon} = \rho_{\tau^c} \ln \tau_{t-1}^{c,\epsilon} + \epsilon_{\tau^c,t} \tag{4.29}$$

$$\ln \tau_t^{k,\epsilon} = \rho_{\tau^k} \ln \tau_{t-1}^{k,\epsilon} + \epsilon_{\tau^k,t} \tag{4.30}$$

The fiscal rule for transfer payments is defined in a similar way. Transfers are reduced, when debt increases and are increased when output falls below trend to capture higher transfer payments in recessions i.e. higher unemployments benefits.

$$T_t = \left(\frac{B_{t-1}}{P_{t-1}\gamma^{t-1}} \right)^{-\phi_b^T} \left(\frac{Y_t}{\gamma^t} \right)^{-\phi_y^T} T_t^\epsilon \tag{4.31}$$

T_t^ϵ is a AR(1) process explaining persistent non systematic movements in transfers

$$\ln T_t^\epsilon = \rho_T \ln T_{t-1}^\epsilon + \epsilon_{T,t}. \tag{4.32}$$

I assume that monetary policy is characterized by an interest rate feedback rule as in Smets and Wouters (2007). Specifically, I assume for the interest rate

$$\frac{R_t}{R_*} = \left(\frac{R_{t-1}}{R_*}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi_*}\right)^{\psi_1} \left(\frac{Y_t}{Y_t^*}\right)^{\psi_2}\right]^{1-\rho_R} \left(\frac{Y_t/Y_{t-1}}{Y_t^*/Y_{t-1}^*}\right)^{\psi_3} r_t \tag{4.33}$$

where R_* is the steady state gross nominal interest rate and Y_t^* is the natural output level defined as the output level in absence of nominal frictions. The parameter $\rho_R \in [0, 1]$ captures interest rate smoothing. Finally, r_t represents a shock to the short-term interest rate not-accounted for by the systematic feedback rule. It thus represents a monetary policy shock

$$\ln r_t = \rho_r \ln r_{t-1} + \epsilon_{r,t}. \tag{4.34}$$

The following resource constraint closes the model

$$Y_t = C_t + I_t + G_t + Nex_t + a(u_t)K_{t-1} \tag{4.35}$$

where Nex_t is an autocorrelated stochastic shock reflecting the effects of changes in foreign demand on net exports, which is given by

$$Nex_t = \rho_{nex} Nex_{t-1} + \epsilon_{nex,t}. \tag{4.36}$$

I assume that debt, government revenues, transfers and government spending grow in steady state with the same rate than output. Therefore I detrend the variables including the fiscal policy variables with a fixed common growth trend γ^t. Then the equations are linearized around the deterministic steady state.

4.3 Estimation

I use quarterly German data for the period 1970Q1-2009Q4 to estimate the model with Bayesian estimation techniques and match the following 12 variables: the log difference of real consumption ($dlCons_t$), real investment ($dlInv_t$), real GDP ($dlGDP_t$) and the real wage ($dlWage_t$), log hours worked ($lHours_t$), the log difference of the GDP-Deflator (dlP_t), the quarterly short-run interest rate ($Interest_t$), government debt ($ldebt_t$), government labour income tax revenues and social security benefits received ($linctax_t$), consumption tax revenues ($lconstax_t$), capital tax revenues ($lcaptax_t$) and social security benefits paid ($ltransfer_t$).[6] All government variables are expressed relative to GDP. The following measurement equations are employed to link the model variables to the data.

[6] A detailed description of the data is given in appendix 4.H.

$$\begin{bmatrix} dlGDP_t \\ dlCons_t \\ dlInv_t \\ dlWage_t \\ lHours_t \\ dlP_t \\ Interest_t \\ ldebt_t \\ linctax_t \\ lconstax_t \\ lcaptax_t \\ ltransfer_t \end{bmatrix} = \begin{bmatrix} \gamma^m \\ \gamma^m \\ \gamma^m \\ \gamma^m \\ l^m \\ \pi^m \\ r^m \\ b^m \\ \Psi_n^m \\ \Psi_c^m \\ \Psi_k^m \\ t^m \end{bmatrix} + \begin{bmatrix} \widehat{y}_t - \widehat{y}_{t-1} \\ \widehat{c}_t - \widehat{c}_{t-1} \\ \widehat{i}_t - \widehat{i}_{t-1} \\ \widehat{w}_t - \widehat{w}_{t-1} \\ \widehat{l}_t \\ \widehat{\pi}_t \\ \widehat{r}_t \\ \frac{\widehat{b}_t}{b_*} - \widehat{y}_t \\ \frac{\widehat{\Psi}_t^n}{\Psi_*^n} - \widehat{y}_t \\ \frac{\widehat{\Psi}_t^c}{\Psi_*^c} - \widehat{y}_t \\ \frac{\widehat{\Psi}_t^k}{\Psi_*^k} - \widehat{y}_t \\ \frac{\widehat{t}_t}{t_*} - \widehat{y}_t \end{bmatrix} \tag{4.37}$$

where dl stands for 100 times the log difference and l for 100 times the log. $\widehat{x}_t = \frac{x_t - x}{x}$ defines the percentage deviation of a variable from trend. $\gamma^m = 100(\gamma - 1)$ denotes the common quarterly trend growth rate, π^m the quarterly steady state inflation rate, r^m the steady state nominal interest rate, l^m steady state hours worked, b_* the steady state debt-to-GDP ratio, with $b^m = 100 \ln(b_*)$, Ψ_*^n the steady state ratio of labour income tax revenues to GDP, Ψ_*^c the steady state ratio of consumption tax revenues to GDP, Ψ_*^k the steady state ratio of capital tax revenues to GDP and t_* the ratio of steady state social security benefits paid by the government to GDP. Ψ_i^m with $i \in [n, c, k]$ is given by $\Psi_i^m = 100 \ln\left(\Psi_*^i\right)$ and t^m by $t^m = 100 \ln(t_*)$.

I estimate the mode of the posterior distribution by maximizing the log posterior kernel, which combines the prior information on the parameters with the likelihood of the data. Then the Metropolis-Hastings algorithm is used to evaluate the whole posterior distribution and the marginal likelihood of the model. [7]

A few parameters are kept fixed throughout the estimation. The depreciation rate, δ, is set to 2.5 %, which is uncontroversial and the steady state wage markup, $(1 + \lambda_w)$, to 1.5. The curvature parameter of the Kimball aggregator in the goods market η, which is given by $\eta = 1/\lambda_p \left[\frac{2 + \frac{G'''}{G''}}{1 + \frac{G''}{G'}} - 1\right]$, is not identified. Therefore I fix it to 10 analogous to Smets and Wouters (2007). The steady state government debt to GDP ratio, b_*, is calibrated to 0.426, which corresponds to the mean of this variable using the whole estimation sample from 1970 up to now. I calibrate the steady state tax revenues to GDP ratios in the same way, where the ratio of labour income tax revenues plus social security benefits received to GDP, Ψ_*^n, is set to 0.282, the consumption tax revenues ratio, Ψ_*^c, to 0.115 and the capital income tax revenues ratio, Ψ_*^k, to 0.004. The sample mean of social security

[7] All estimations are executed with Dynare (http://www.cpremap.cnrs.fr/dynare). A sample of 5,000,000 Metropolis-Hastings draws was created (neglecting the first 1,000,000 draws).

benefits paid by the government relative to GDP, t_*, is 0.177. The income, consumption and capital tax rates in steady state are calculated to match the tax revenues to GDP ratios stated above. See **Table 4.1** for an overview of the calibrated parameters. Finally, the government spending to GDP ratio in steady state is pinned down to ensure that the government budget constraint is fulfilled.

Table 4.1: Calibrated parameters for the estimated model

	Parameter	Value
δ	Depreciation rate	0.025
$(1+\lambda_w)$	Wage markup	1.5
η	Curvature parameter Phillips Curve	10
b_*	SS debt to GDP ratio	0.426
Ψ_*^n	Income tax revenues ratio	0.282
Ψ_*^c	Consumption tax revenues ratio	0.115
Ψ_*^k	Capital tax revenues ratio	0.004
t_*	Transfers to GDP ratio	0.177
τ^n	SS labour income tax rate	0.48
τ^c	SS consumption tax rate	0.17
τ^k	SS capital tax rate	0.13
G_*	Government spending to GDP ratio	0.22

4.3.1 Prior distributions of the estimated parameters

I estimate 43 parameters and 12 standard deviations of the shock innovations. The parameter χ governing the capital utilisation costs is given by $\chi = \frac{1}{1+\frac{a'}{a''}}$, where a' and a'' are the first and second oder derivatives of the capital utilisation cost function w.r.t. capital utilisation evaluated at the steady state. The estimated parameter β^m, which drives the discount factor is defined as follows $\beta^m = 100(\frac{1}{\beta} - 1)$. **Tables 4.3** and **4.4** in the appendix show the assumptions for the prior distributions, which are similar to Smets and Wouters (2007) for the standard model parameters. I assume the same inverse gamma distribution with mean 0.1 and standard deviation 2 for all the 12 shock innovations. For the AR(1) coefficients of the shock processes I select analogous to Smets and Wouters (2007) a beta distribution with mean 0.5 and standard deviation 0.2. For the share of rule-of-thumb consumers ω I assume a beta distribution with mean 0.3 and standard deviation 0.1, with the mean being close to the finding of Coenen and Straub (2005), who estimate the share of rule-of-thumb consumers in the euro area. There is no evidence on the parameter ρ, which governs the fraction of the amount on the adjustment account, which is cleared every period. Mayer and Staehler (2009) find, that a small value of 0.05 is welfare optimal in their calibrated model given the tuple [0.00,0.05,0.10,0.15,0.20]. Therefore I choose an inverse gamma distribution with mean 0.1 and standard deviation 2. I assume for the elasticities of the tax rates with respect to debt and output the same prior distribution as

for the ρ parameter reflecting my view that tax rates are adjusted sluggishly by the government. It is controversial in the literature if fiscal policy reacted procyclical or countercyclical in Germany. Gali and Perotti (2003) find empirically for a sample from 1980-2002 a procyclical fiscal stance on discretionary fiscal measures and a countercyclical stance on automatic stabilizers. Therefore I set a rather flat prior for the elasticity of government spending w.r.t. output using a normal distribution with mean 0 and standard deviation 0.5.

4.3.2 Posterior distributions of the estimated parameters

The results of the posterior maximization can be find in **Tables 4.3** and **4.4** in the appendix, which display the posterior mode and mean together with the 90% confidence bands for all the estimated 55 parameters. **Figures 4.4** and **4.5** in the appendix show graphically the prior and posterior distributions of the structural model parameters and the parameters of the shock processes. The estimated shock standard deviations are reasonable. The investment specific technology shock is with 1.34 of a larger value, which could be partly due to the inclusion of the recent recession, which was captured in DSGE models through large negative demand and investment shocks. Additionally the standard deviation of the innovation to the capital tax rate is with 2.74 large. Capital taxes and capital tax revenues seem to fluctuate stronger than predicted by the model. This could be due to the fact, that I don't include dividend payments from intermediate firms into capital taxation or that legal features like accounting policies amplify the variability of the observed capital tax revenues. The AR(1) coefficients in the shock processes for the fiscal variables are quite high with values close to 0.95, which capture the persistence in the decision making of government policy. The standard structural parameters of the model look also reasonable. The Calvo parameter in the goods market is with a value of 0.88 quite high despite strategic complementarities through a Kimball type aggregator for final goods. But Smets and Wouters (2003) find with 0.909 a value of similar magnitude in their estimated model for the euro area without Kimball aggregator and inflation persistence was even higher in Germany compared to other european countries. The estimates for the indexation parameters in the goods and labor market and the degree of habit formation are found to be low with values of 0.11, 0.27 and 0.11, respectively. There seem to be enough persistence in the model, that additional parameters to generate ad hoc persistence are hardly needed. The estimate for the coefficient on inflation in the monetary policy rule is 1.4. Thus monetary policy reacts moderately to movements in inflation despite the strong commitment to price stability during the Bundesbank regime in the 80s and 90s and the ECB policy thereafter. This could be due to the inclusion of the 70s in the data sample. I estimate with 56% a high share of non Ricardian consumers in the model. The estimate is of double the size than the one by Cogan et al. (2010) for the U.S., despite lower wage inequality in Germany compared to the U.S. Maybe this is due to the fact, that I assumed an equal allocation of transfers between Ricardian and

non Ricardian consumers and in reality transfers are allocated primarily to non Ricardian households. I estimate the fraction of the adjustment account which is cleared every period to 0.18. This value is higher than the one assumed in Mayer and Staehler (2009). The elasticities of the tax rates w.r.t. debt are 0.06, 0.05 and 0.14, i.e. tax rates are slowly adjusted to the debt level in Germany. But I find higher estimates for the elasticities of the tax rates w.r.t. output, which are 0.28, 0.53 and 1.14, respectively. Especially the average capital tax rate seem to move very strongly with the business cycle. Transfers relative to GDP react only slightly to debt and the business cycle. I find a very limited movement of this ratio in the data too, where transfers move slowly between 14 and 20% of GDP. I estimate the posterior mean of ϕ_y^g to 0.24 i.e. government spending is higher in bad times than in good times, which points to some degree of countercyclical government spending. But the estimate is not significantly different from zero. Together with an increase of transfers in recessions and lower average tax rates in recessions, fiscal policy reacts countercyclical in the model.
The dynamics of fiscal policy in the model are quite complex, with all fiscal instruments reacting to debt and the business cycle. As Uhlig (2009) pointed out the effect of discretionary fiscal policy depends very strongly on the reaction of the other fiscal instruments to a higher level of government spending. Corsetti et al. (2009) bring forward that the government spending multiplier increases if government spending reacts to the debt level i.e. after an increase in government spending the government announces spending cuts in the future. With the tax rates also reacting to movements in debt and the state of the economy the overall evolution of the fiscal variables depends on the size of the parameters in the fiscal rules.

4.4 Debt Forecasts

In this section I use the estimated model for Germany decribed before to construct density forecasts for the debt-to-GDP ratio from the first quarter of 2010 until 2020 to see how fiscal consolidation in Germany in the medium-term could take place if fiscal policy sticks to the estimated fiscal policy rules for spending, transfers and taxes. The adjustment of fiscal instruments in practise depends on political negotiations and results of the elections, which leads to variability in the parameters of the fiscal policy rules over time. I take this uncertainty regarding the parameters in the model into account and pick 5,000 Metropolis-Hastings draws of the posterior parameter distributions randomly. For each parameter combination a forecast for the model variables is then computed using the linear model solution. Additionally policy makers don't have perfect foresight and don't know certainly how the economy will evolve in the future. To cope with this uncertainty I create every period random draws from the distributions of the 12 shock innovations in the model and add them to the model solution while computing the forecasts.

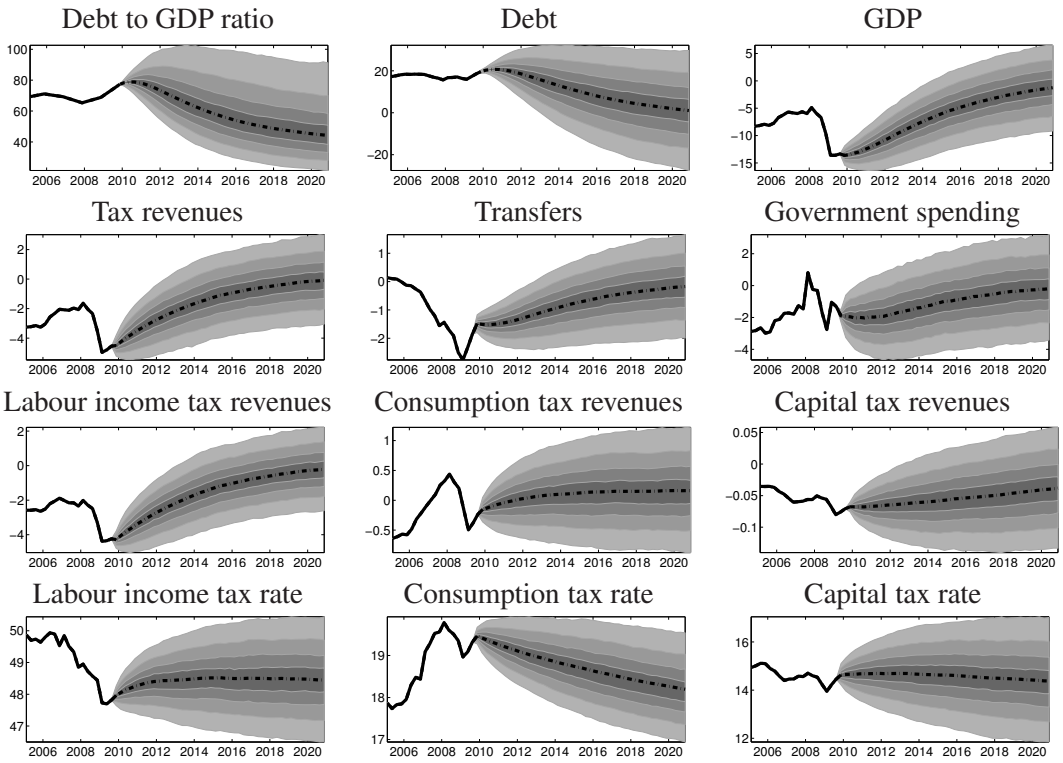


Figure 4.1: Forecasts

Notes: 5000 subdraws of the Metropolis Hastings algorithm and draws from the shock distributions are used to generate density forecasts. Smoothed variables from 2005 until 2010 are displayed with a solid black line, the mean forecast by a dashed-dotted black line and the 10th up to the 90th percentiles are displayed by grey shaded areas.

Figure 4.1 shows a panel of forecasts for the main fiscal variables. For each forecast the 10th up to the 90th percentiles are plotted. Thus the widest error band includes 80% of the 5,000 generated forecasts and the dashed-dotted black line displays the mean of the forecasts. I also plotted the last observations of the smoothed variables from 2005 on to show how the variables evolved before the start of the forecasts (black solid line). Overall one can see that there is great uncertainty in the forecasts for the fiscal variables. This is not surprising since the evolution of the fiscal stance depends to a large degree on political negotiations and not only on economic and government budget conditions. The widest forecast band for the debt-to-GDP ratio in the first row of column one ranges between 100% and 40% in 2013, which is a wide range. The result is mainly driven by the large standard deviations of the shock innovations especially for the residuals of the fiscal instruments. This leads to forecast uncertainty in the fiscal instruments, which can be seen in the forecasts for the other fiscal variables. But the majority of forecasts predict a fiscal consolidation given the fiscal policy rules, the parameter estimates and the shock distributions. The mean forecast for the debt to GDP ratio shows a slight increase from 77.4% in the last quarter of 2009 until 79% in the third quarter of 2010 and afterwards decreases and the error bands above the mean forecast are wider than below.

The main reason is the predicted recovery of GDP in Germany. The GDP variable in the last column of the first row displays the percentage deviation of GDP from the estimated linear trend, which grows by 0.41% every quarter. In the beginning of 2010 GDP in Germany was 13-14% below the trend growth path mainly through the financial crisis in the recent years, which lead to a big slump in GDP as can be seen by the historical time series displayed with a solid black line. The mean forecast for GDP predicts a recovery of GDP and a GDP growth rate above the trend. This is in line with the expectations of the economic research institutes. The OECD for instance predicts an annual growth rate of around 2% for the next years.[8] This has several implications for the evolution of the fiscal instruments and especially the debt-to-GDP ratio. First when GDP growth faster than the common growth trend and debt growth with trend this reduces ceteris paribus the debt to GDP ratio. Second with the economic recovery capital employed increases due to higher capital utilisation and investment. The increase in capital employed raises the marginal product of labour and therefore leads unions to enforce higher wages. Hours worked by the households increase slightly, too. Additionally the negative risk premium shock, which captures partly the impact of the financial crisis in the model, diminishes, which leads to a recovery of consumption of Ricardian households. Both the increase in hours worked and the higher wages paid to Ricardian and non-Ricardian households makes the labour income increase and leads to higher labour income tax revenues, which can be seen from the first chart in row three displaying the percentage deviation of labour tax revenues from the common growth trend. Consumption tax revenues and capital tax revenues increase slightly too -see chart

[8] See the OECD Economic Outlook 87 published May 2010.

two and three in row three- through the recovery of consumption and the increase in revenues from renting capital employed. All effects reduce the budget deficit and reduce debt. Third the tax rates act as automatic stabilizers. Due to progressive taxation for labour income tax and capital tax and tax allowances the average tax rate is lower when the economy is in a recession than in a boom. Therefore with the economic recovery the average tax rates are expected to increase leading to further revenues. The last row of **Figure 4.1** shows the three distortionary tax rates in percentage points, where the labour income tax rate consists of the income tax rate plus the fraction of the labour income, which is paid for social security benefits. As one can see in the first figure the average labour income tax rate is projected to increase slightly in the next years. But fourth the tax rates also react to the debt status. I plotted the debt in percentage deviation from the common growth trend in the second column of row one. Debt is expected to shrink through the increase in tax revenues discussed above. This lowers the interest payments by the government and offers room for lowering tax rates. Therefore the labour income tax rate is projected to increase only slightly and the consumption tax rate and the capital tax rate decrease. The fiscal rule for government spending keeps spending almost constant until 2013 although the rule allows the government to react more countercyclical than the debt brake. A lower debt burden after 2012, which decreases interest payments on debt, offers room for slight increases in government spending and transfers. This can be seen from the second and third chart in row two, which show transfer payments by the government and spending in percentage deviation from the common growth trend.

In the forecasts of the model I do not take into account how the evolution of debt effects the interest rate. Laubach (2010) estimates a significant positive impact of expected budget deficits and the expected debt-to-GDP ratio on long-term real interest rates in the US. Taking this channel into account the fiscal consolidation in Germany would lower future interest payments on outstanding government debt further. This would offer even more room for additional government spending or lowering tax rates.

4.4.1 Conditional forecasts

Some parts of the German Konjunkturpaket and the Wachstumsbeschleunigungsgesetz enacted by the government on 9th November 2009 become operative in 2010. Therefore these measures, which increase the debt-to-GDP ratio in 2010, are not included in the forecasts in the section above. In Appendix 4.G I list in detail the fiscal measures and the size of both programs and group them to the fiscal instruments in the model. **Table 4.2** contains an overview for the five fiscal instruments in the model. Measures to lower the income tax wedge, which sum up to 29.6 billion euro or 1.24% of 2009 GDP, build the major part of the Konjunkturpaket in 2010, which consists of the reduction in health insurance contributions, tax deductibility of professionel commute or direct income tax cuts. Addi-

Table 4.2: Germany‘s fiscal stimulus measures in 2010

	Konjunkurpakete		Wachstumsbeschleunigungsg.		Total fiscal packages	
	bln Euro	*% of GDP*	*bln Euro*	*% of GDP*	*bln Euro*	*% of GDP*
Income tax	29.6	1.24	0	0	29.6	1.24
Consumption tax	0.4	0.02	1	0.04	1.4	0.06
Capital tax	4.7	0.20	2.4	0.10	7.1	0.30
Spending	10.1	0.42	0	0	10.1	0.42
Transfers	4.5	0.19	5	0.21	9.5	0.40
All instruments	49.3	2.06	8.4	0.35	57.7	2.41

Source: German Finance Ministry: Brot und Butter Brief " Der Wirtschaftskrise entgegensteuern", and "Wachstumsbeschleunigungsgesetz".

tional government spending has a size of 10.1 billion euro mainly due to the infrastructure investment program. The major part of the Wachstumsbeschleunigungsgesetz are higher tax exemptions for dependent children and child benefits with a value of 4.6 billion euro, which I grouped as transfers. Changes in the legislation of business tax, which are estimated to lower capital tax revenues by 2.4 billion euro in 2010 are the second biggest part. Overall both programs are expected to lower the tax base by 57.7 billion euro or 2.41% of 2009 GDP in 2010. To take the effect of these fiscal changes on the forecast for the german debt-to-GDP ratio into account I compute conditional forecasts. I add in every quarter in 2010 a discretionary government spending shock in the size of 0.105% of GDP and a transfer shock in the size of 0.10% of GDP to the model solution, together with the random shock realisations, while computing the forecasts.[9] Additionally, I use the baseline forecasts for the different tax revenues in 2010 in the subsection above and lower the respective tax rates to decrease the labour income tax, consumption tax and capital tax revenues in the amount of 0.31%, 0.015% and 0.075% of GDP every quarter in 2010.

Figure 4.2 shows the conditional density forecasts including the stimulus programs. Overall the picture does not change much. The mean forecast for the debt-to-GDP ratio is expected to peak at a value of 81.3% in the last quarter of 2010 compared to 79% in the baseline forecast and some forecast scenarios drive the debt-to-GDP ratio up to 110% of GDP compared to 100% before. Thus the uncertainty increases further. One can see the reduction in tax rates due to the stimulus programs especially the one for the capital tax rate, which lowers tax revenues in 2010. The capital tax rate decreases stronger than the other distortionary taxes due to the lower overall capital tax revenues. Therefore a reduction of 0.3% of GDP has a sizeable effect on capital tax revenues but not on overall tax revenues. The fiscal expansion through both stimulus programs has only a moderate effect on GDP. GDP increases by 0.7% from -12.6% below trend to -11.9% below trend in the last quarter of

[9]The size of the quarterly discretionary government spending and transfer shock is 1/4 of the value stated in **Table 4.2**.

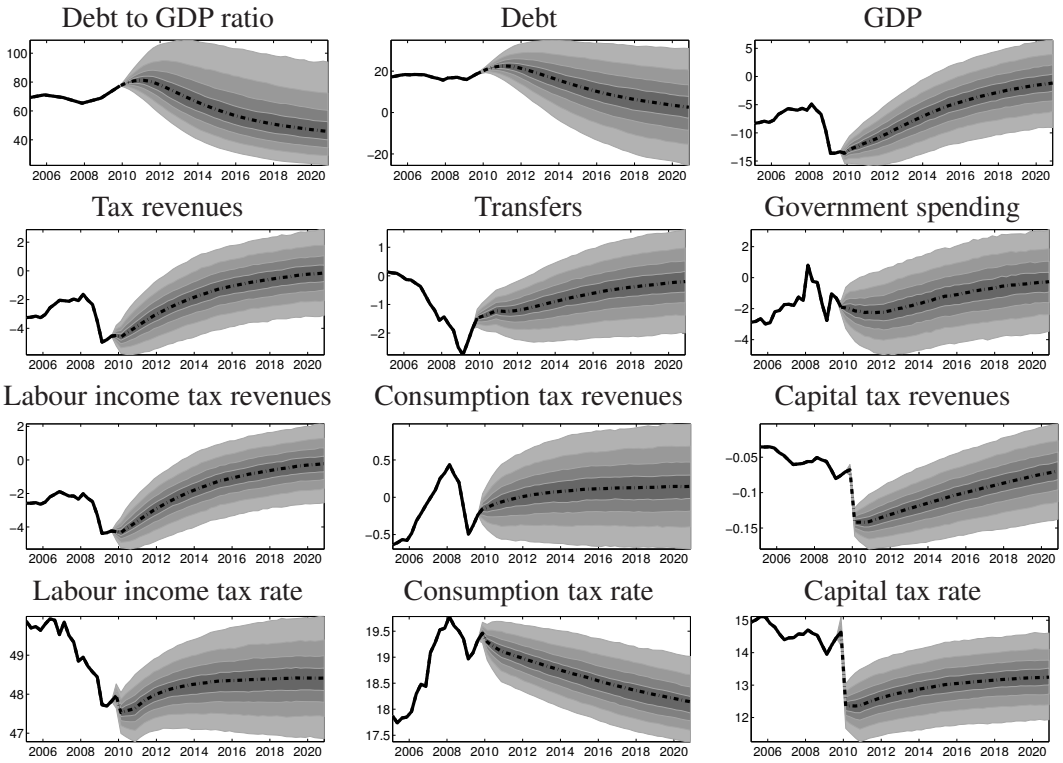


Figure 4.2: Conditional forecasts

Notes: 5000 subdraws of the Metropolis Hastings algorithm, draws from the shock distributions and shocks in the size of the Konjunkturpaket and the Wachstumsbeschleunigungsgesetz for 2010 are used to generate density forecasts. Smoothed variables from 2005 until 2010 are displayed with a solid black line, the mean forecast by a dashed-dotted black line and the 10th up to the 90th percentiles are displayed by grey shaded areas.

2010 compared to the baseline mean forecast. Thus the stimulus programs are expected to support GDP in 2010 but at a high cost of increasing debt, which prolongs the fiscal consolidation. Still the economic recovery after the financial crisis drives higher tax revenues leading to a fiscal consolidation in Germany, where the debt-to-GDP ratio is expected to be lower than 60% of GDP and thus below the critical value of the Maastricht criteria in the second quarter of 2015. This seems optimistic and is only possible if the government sticks to the fiscal policy rules and doesn't increase discretionary transfers and spending, when the budget situation improves and no unforeseen crisis emerge, which deteriorates the GDP recovery. But as we can see from the historical debt-to-GDP series (solid black line), the debt-to-GDP ratio also declined between 2005Q4 and 2007Q4 from 71.1% to 65.3%, which implies a similar annual decrease in the variable than the one, which is projected by the mean of the conditional forecasts from the end of 2009 until 2015.

4.4.2 German debtbrake

In this subsection I analyse how the medium-term forecasts change if I enforce the german debt brake in the model from 2010 on, although the rule becomes operative in 2011 and legally binding not until 2016. Since the government knows that the rule will be binding in the future, it may adjust its fiscal instruments already in 2010 to fulfill the requirements of the debt brake more easily later on. In addition I lower the output elasticity of the labour income tax rate by one half to see how the results change if for instance the progressive income tax tariff would be flattened. I fix ϕ_y^g to 0, which is lower than the estimated posterior mean of 0.23. Thus transfers, government spending, interest on outstanding debt and the amount of debt which is cleared need to be equal to trend revenues. This allows for countercyclical fiscal policy but less than in the case of $\phi_y^g > 0$. If revenues are lower than trend the government will run a budget deficit and a budget surplus vice versa, but there need to be a structural balanced budget. Additionally I allow the labour income tax rate to vary less with the business cycle by setting ϕ_y^n to 0.15, which is almost half of the posterior mean used for the baseline forecasts. **Figure 4.3** contains the resulting evolution of the fiscal variables.

As one can see from the chart for government spending in the third column of the second row, the debt brake forces the government to lower spending immediately by 0.6% of GDP in the first quarter of 2010 from -1.9% below trend to almost -2.5% below trend. Later on when tax revenues pick up and the debt level is reduced spending increases slightly like in the baseline forecasts. With the lower output elasticity of the labour income tax rate, it fluctuates less with the business cycle, leading to an immediate increase in the average labour income tax rate. This increases the wedge between the labour income before and after tax making it less profitable for households to work. Therefore hours worked decrease slightly. Both the lower demand for firms final goods through lower government spending and the increase in the labour income tax, which reduces hours worked, lowers the mean

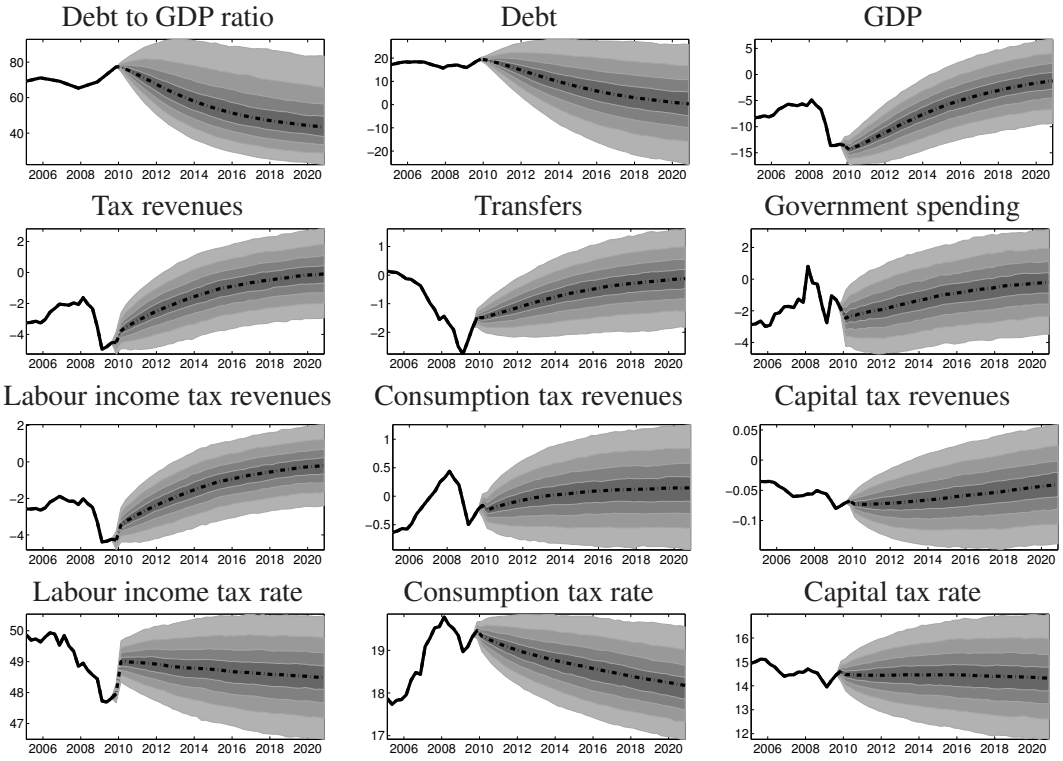


Figure 4.3: Counterfactual forecasts

Notes: 5000 subdraws of the Metropolis Hastings algorithm and draws from the shock distributions are used to generate density forecasts setting $\phi_y^g = 0$ and $\phi_y^n = 0.15$. Smoothed variables from 2005 until 2010 are displayed with a solid black line, the mean forecast by a dashed-dotted black line and the 10th up to the 90th percentiles are displayed by grey shaded areas.

GDP forecast slightly compared to the baseline forecasts. On the other hand the debt-to-GDP ratio decreases faster than in the baseline scenario.

4.5 Conclusion

In this chapter I compute density forecasts for Germany's debt-to-GDP ratio. Therefore I derive a DSGE Model for Germany based on Christiano et al. (2005) or Smets and Wouters (2007) integrating non-Ricardian consumers as well as Ricardian consumers, adding distortionary taxes like consumption tax, capital tax and labour income tax, a fiscal rule for transfers and a framework to simulate the effects of the German debt brake. Then I estimate the model on 12 German time series including the major fiscal time series like the debt-to-GDP ratio, direct tax revenues and social security benefits received by the government, indirect tax revenues, capital tax revenues and social security benefits paid. I find that all fiscal instruments react significantly to debt and the state of the economy, with the exemption of the parameter ϕ_y^g, which indicates how countercyclical the government allocates their spending. In a final step I compute density forecasts taking account of parameter uncertainty and shock uncertainty.

I find that through the expected economic recovery after the severe financial crisis in 2008 and 2009, it is possible to reduce the debt-to-GDP ratio significantly in the medium-term although the uncertainty of the forecasts given by the error bands is large mainly driven by unforeseen shocks. The following channels are important for the result. The economic recovery reduces directly the debt-to-GDP ratio. Hours worked and real wages are expected to increase leading to higher labour income tax revenues. The average tax rates in the economy rise through the economic recovery, but are expected to decrease later on, when debt is reduced. I also compute conditional forecasts implementing the effects of the two "*Konjunkturpakete*" and the "*Wachstumsbeschleunigungsgesetz*" in 2010. I find that GDP in 2010 is stimulated only moderately through the stimulus packages. The debt-to-GDP ratio increases stronger than in the baseline forecasts, peaks at 81.3% and is expected to be lower than the Masstricht criteria of 60% in the second quarter of 2015. Enforcing the debt brake and halving the output elasticity of the labour income tax from 2010 on, puts more pressure on the government to reduce spending and increases the labour income tax rate, which lowers hours worked. Both measures lead to a faster reduction in the debt-to-GDP ratio on the cost of reducing GDP slightly in the short-run compared to the baseline forecast scenario.

Overall the results show that fiscal consolidation in Germany is possible in the medium-term in times of expected economic recoveries or booms, if the government sticks to the fiscal policy rules, uses the expected increases in tax revenues to consolidate the budget and doesn't increase discretionary spending. With this model I look at the evolution of the debt-to-GDP ratio over the business cycle and the implications of fluctuations of GDP on this ratio. Hence the model does not take developments

into account, which drive the trend of debt and GDP, like demographic issues. Germany's population will grow slowlier or shrink in the future and people are expected to become older on average. This drives up social security payments and will lead to a lower trend growth rate, both increasing future debt. But with a fiscal consolidation in the medium-term Germany would certainly be better prepared for the requirements in the longer term.

Appendices

4.F Estimation results

Table 4.3: Prior and posterior distributions of the shock processes

Parameter		Prior distribution			Posterior distribution				
		type	mean	std.dev.	mode	std.dev.	mean	5 %	95 %
ρ_z	Technology shock	beta	0.50	0.20	0.97	0.01	0.97	0.96	0.98
ρ_p	Price mark-up shock	beta	0.50	0.20	0.09	0.01	0.41	0.19	0.61
ρ_μ	Investment shock	beta	0.50	0.20	0.26	0.01	0.28	0.19	0.37
ρ_d	Risk premium shock	beta	0.50	0.20	0.92	0.01	0.89	0.84	0.94
ρ_r	MP shock	beta	0.50	0.20	0.17	0.02	0.23	0.10	0.35
ρ_w	Wage mark-up shock	beta	0.50	0.20	0.98	0.00	0.98	0.96	0.99
ρ_υ	Gov. spend. shock	beta	0.50	0.20	0.96	0.00	0.95	0.92	0.98
ρ_{nex}	Net exports shock	beta	0.50	0.20	0.98	0.01	0.96	0.93	1.00
ρ_{τ^n}	Labour tax	beta	0.50	0.20	0.96	0.01	0.95	0.93	0.98
ρ_{τ^c}	Consumption tax	beta	0.50	0.20	0.98	0.03	0.97	0.96	0.99
ρ_{τ^k}	Capital tax	beta	0.50	0.20	0.98	0.01	0.98	0.97	1.00
ρ_T	Transfers	beta	0.50	0.20	0.95	0.01	0.95	0.94	0.97
θ_p	MA price mark-up	beta	0.50	0.20	0.28	0.01	0.42	0.23	0.60
θ_w	MA wage mark-up	beta	0.50	0.20	0.83	0.02	0.78	0.63	0.90
ϵ_z	Technology shock	invg	0.10	2.00	0.48	0.03	0.48	0.43	0.53
ϵ_p	Price mark-up shock	invg	0.10	2.00	0.47	0.03	0.46	0.40	0.52
ϵ_μ	Investment shock	invg	0.10	2.00	1.34	0.08	1.34	1.16	1.53
ϵ_d	Risk premium shock	invg	0.10	2.00	0.28	0.02	0.30	0.23	0.37
ϵ_r	MP shock	invg	0.10	2.00	0.21	0.01	0.21	0.19	0.24
ϵ_w	Wage mark-up shock	invg	0.10	2.00	0.53	0.04	0.50	0.42	0.59
ϵ_υ	Gov. spend. shock	invg	0.10	2.00	0.96	0.06	0.98	0.82	1.15
ϵ_{nex}	Net exports shock	invg	0.10	2.00	0.83	0.05	0.82	0.75	0.90
ϵ_{τ^n}	Labour tax	invg	0.10	2.00	0.67	0.04	0.69	0.61	0.76
ϵ_{τ^c}	Consumption tax	invg	0.10	2.00	1.06	0.16	1.07	0.97	1.17
ϵ_{τ^k}	Capital tax	invg	0.10	2.00	2.74	0.06	2.70	2.48	2.93
ϵ_T	Transfers	invg	0.10	2.00	0.25	0.02	0.26	0.23	0.28

Notes: Prior and posterior distributions for the estimated shocks processes. Estimates obtained from Bayesian estimation of the DSGE model using German data from 1970:1-2009:4.

Table 4.4: Prior and posterior distributions of the structural parameters

Parameter		Prior distribution			Posterior distribution				
		type	mean	std.dev.	mode	std.dev.	mean	5 %	95 %
ξ_w	Calvo wages	beta	0.50	0.10	0.64	0.01	0.65	0.53	0.72
ξ_p	Calvo prices	beta	0.50	0.10	0.90	0.00	0.88	0.86	0.91
ι_w	Indexation wages	beta	0.50	0.15	0.40	0.02	0.27	0.16	0.38
ι_p	Indexation prices	beta	0.50	0.15	0.36	0.01	0.11	0.04	0.18
	SS price markup	norm	1.25	0.13	1.89	0.01	1.93	1.82	2.05
S''	Investment adj. cost	norm	4.00	1.50	6.17	0.08	5.89	4.40	7.31
λ	Habit formation	beta	0.70	0.10	0.10	0.00	0.11	0.10	0.12
ω	non Ricardian cons.	beta	0.30	0.10	0.55	0.01	0.56	0.49	0.63
σ_l	Labour supply elas.	norm	2.00	0.75	0.88	0.04	0.80	0.55	1.08
χ	Capital utilization	beta	0.50	0.15	0.13	0.01	0.15	0.09	0.20
α	Capital share	norm	0.30	0.05	0.13	0.00	0.13	0.10	0.15
ρ_R	Int. rate smoothing	beta	0.75	0.10	0.94	0.00	0.93	0.91	0.96
ψ_1	Inflation response	norm	1.50	0.25	1.69	0.01	1.40	1.24	1.58
ψ_2	Outputgap response	norm	0.13	0.05	0.15	0.00	0.13	0.08	0.18
ψ_3	Diff. outputgap resp	norm	0.13	0.05	0.23	0.00	0.25	0.22	0.28
ρ	AC clearing	invg	0.10	2.00	0.23	0.04	0.18	0.08	0.27
ϕ_y^g	Government spending	norm	0.00	0.50	0.22	0.02	0.24	-0.11	0.77
ϕ_b^n	Labour tax	invg	0.10	2.00	0.06	0.01	0.06	0.04	0.09
ϕ_b^c	Consumption tax	invg	0.10	2.00	0.04	0.01	0.05	0.02	0.07
ϕ_b^k	Capital tax	invg	0.10	2.00	0.07	0.05	0.14	0.03	0.27
ϕ_b^t	Transfers	invg	0.10	2.00	0.02	0.00	0.02	0.02	0.03
ϕ_y^n	Labour tax	invg	0.10	2.00	0.25	0.02	0.28	0.16	0.38
ϕ_y^c	Consumption tax	invg	0.10	2.00	0.55	0.02	0.53	0.36	0.69
ϕ_y^k	Capital tax	invg	0.10	2.00	1.19	0.07	1.14	0.64	1.66
ϕ_y^t	Transfers	invg	0.10	2.00	0.02	0.00	0.02	0.02	0.03
$\overline{\gamma}$	Trend growth rate	norm	0.40	0.10	0.41	0.00	0.41	0.38	0.43
$\overline{l}$	SS hours worked	norm	0.00	2.00	-1.90	0.04	-1.86	-2.78	-0.78
$\overline{\pi}$	SS inflation rate	gamm	0.63	0.10	0.62	0.00	0.48	0.41	0.57
$\overline{\beta}$	Discount rate	gamm	0.25	0.10	0.13	0.01	0.35	0.20	0.45

Notes: Prior and posterior distributions for the estimated structural parameters. Parameter estimates obtained from Bayesian estimation of the DSGE model using German data from 1970:1-2009:4.

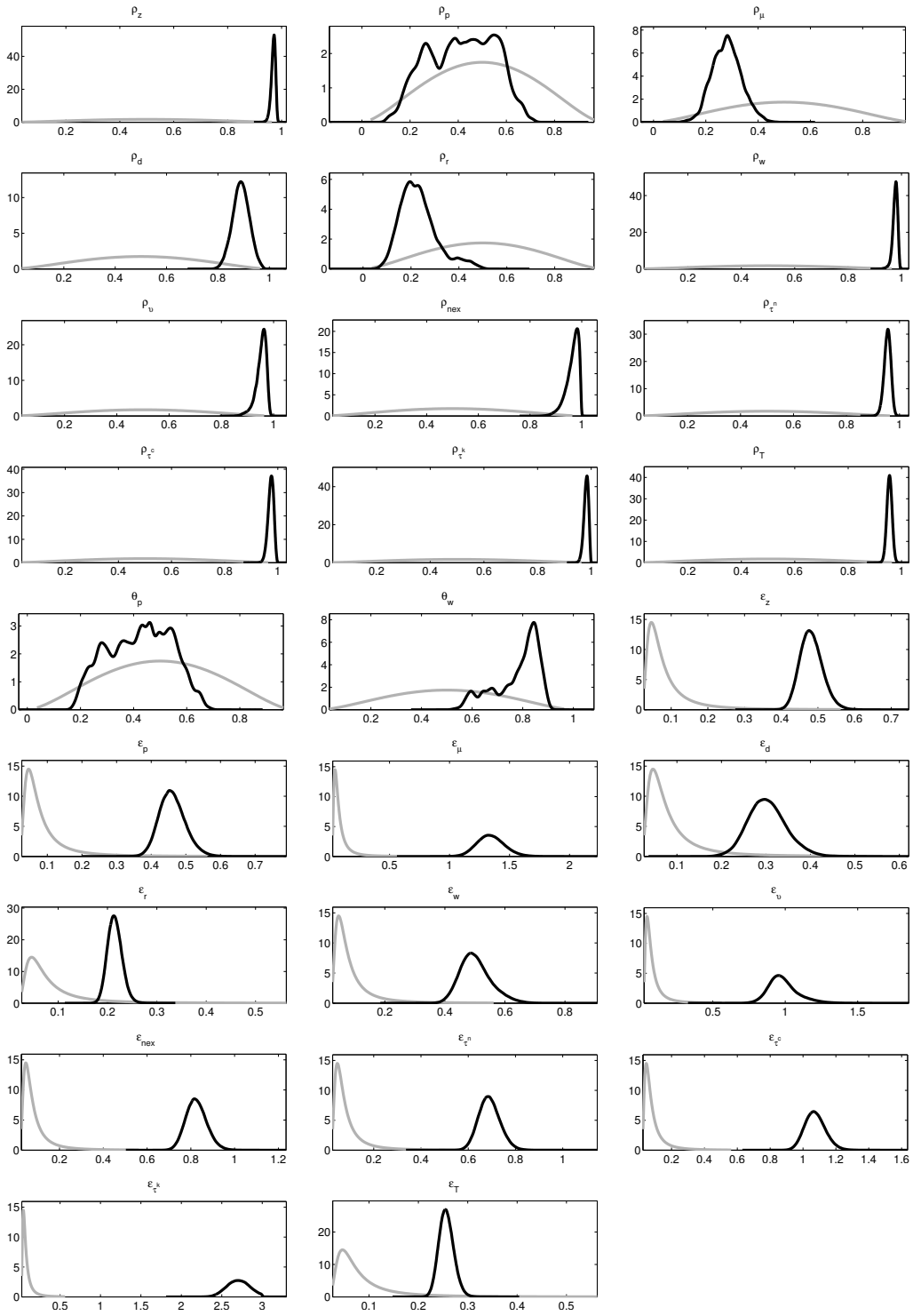


Figure 4.4: Prior and posterior distributions of the shock processes

Notes: Prior (solid grey) vs. posterior (solid black) distributions for the estimated shocks processes. Estimates obtained from Bayesian estimation of the DSGE model using German data from 1970:1-2009:4.

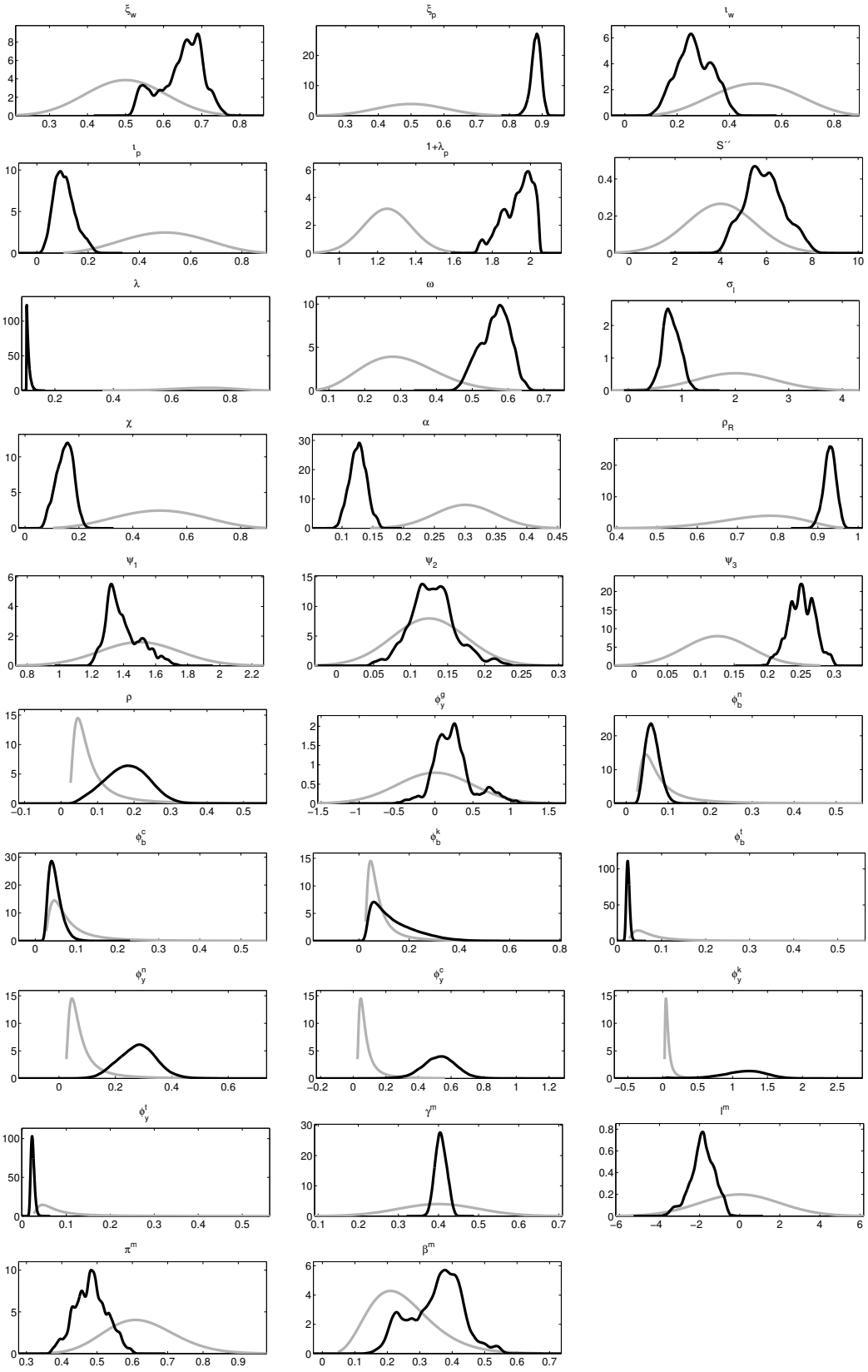


Figure 4.5: Prior and posterior distributions of the structural parameters

Notes: Prior (solid grey) vs. posterior (solid black) distributions for the estimated structural parameters. Estimates obtained from Bayesian estimation of the DSGE model using German data from 1970:1-2009:4.

4.G Details of Germany´s fiscal stimulus measures in 2010

Konjunkturpakete

Instrument	Measure	(bln Euro)
Income tax	Tax deductibility of professionel commute	4.00
	Package for tax burden reduction, stabilisation of social security contributions and investment in families	11.91
	Income tax cut	6.04
	State payment of 50% social insurance for short-time workers for short-time workers	1.15
	Reduction in health insurance contributions	6.50
Consumption tax	Suspension of car tax on new vehicles	0.13
	Reform of car tax	0.17
	Decrease of tax on Biodiesel	0.13
Capital tax	Higher tax-free allowances for companies	0.37
	Degressive depreciation deduction	4.33
Spending	Investments into transport infrastructure	1.00
	Infrastructure investment programme	8.68
	Innovation support programme	0.45
Transfers	Retraining and stronger job service	1.59
	Increased child benefits	2.84
	Increased housing benefits	0.06
		49.31

Source: Brot und Butter Brief " Der Wirtschaftskrise entgegensteuern", German Finance Ministry

Wachstumsbeschleunigungsgesetz

Instrument	Measure	(bln Euro)
Consumption tax	Decrease of VAT on Hotels and restaurants	1.00
Capital tax	Changes in the legislation of business tax	2.40
Transfers	Higher tax exemption for dependent children and child benefits	4.60
	Lower inheritance tax	0.40
		8.40

Source: Wachstumsbeschleunigungsgesetz, German Finance Ministry

4.H Data

The data I employ are from the OECD Economic Outlook Database. For the period 1970:1-1991:1 I use data for West-Germany, which are scaled so that the observation in the first quarter of 1991 matches the observation for reunified Germany in this quarter. Precisely I use the following OECD time series: Gross domestic product, volume, market prices (DEUGDPV, WGRGDPV), Gross domestic product, deflator, market prices (DEUPGDP,WGRPGDP), Private final consumption expenditure, value (DEUCPAA, WGRCPAA), Private non-residential gross fixed capital formation, volume (DEUIBV, WGRIBV), Private non-residential fixed capital formation, deflator (DEUPIB, WGRPIB), Total employment (DEUET, WGRET), Short-term interest rate (DEUIRS, WGRIRS), Trend labour force (DEULFS, WGRLFS), Hours worked per employee, total economy (DEUHRS, WGRHRS), Compensation rate, total economy (DEUWSST, WGRWSST), General government gross financial liabilities, as a percentage of GDP (DEUGGFLQ, WGRGGFLQ), Capital tax and transfers receipts, value (DEUTKTRG, WGRTKTRG), Indirect taxes, value (DEUTIND, WGRTIND), Total direct taxes, value (DEUTY, WGRTY), Social security contribution received by general government, value (DEUSSRG, WGRSSRG), Social security benefits paid by general government, value (DEUSSPG, WGRSSPG).

I use the general government gross financial liabilities variable of the OECD instead of gross debt according to the Maastricht criterion, which is not available for West-Germany before 1991. The concepts differ in two respects. Gross debt according to the Maastricht criterion does not include trade credits and advances and government bonds are valued at market value not nominal value. Times series in monthly frequency are converted to quarterly frequency by using the average of the monthly rates. Annual fiscal data are converted to quarterly data by assuming that the variable grows with the same rate during the year.

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