

Should We Care About the Composition of Tax-Based Stimulus Packages? An Empirical Investigation

Abstract

This paper investigates the effects of tax policy shocks on major US macroeconomic variables over the 1972:3-2008:4 period within a structural variable (SVAR) framework. We contribute to the growing literature on the topic by analyzing the macroeconomic effects of shocks to distortionary taxation (corporate and labour taxes) and non-distortionary taxation (indirect taxes). Our results suggest that, while shocks to non-distortionary taxes have a temporary effect on output, shocks to distortionary taxes have a much more persistent effect on real economic activity. On the other hand, the initial tax multipliers for distortionary taxes are much lower in terms of magnitude, suggesting a trade-off between short-term and long-term goals of fiscal policy. The positive tax multipliers documented for aggregated taxes in the previous literature are only found for non-distortionary taxation. Further disaggregation of distortionary tax innovations to labour and corporate tax innovations shows that the two tax groups have similar effects on output, but different effects on the price level. Finally, we find that while the multipliers decreased post 1981 for labour and indirect taxes, they increased for corporate taxes, possibly due to increased global capital mobility.

JEL Classification: C32, E60, E62, H20, H30

1. Introduction

In February 2009, the United States passed a fiscal stimulus package totalling US\$787 billion in government spending and tax cuts over a period of two years. The stimulus package, the largest in US history, amounts to an annual average of 2.5% of Gross Domestic Product in each of the two years, with approximately two thirds of the package allocated to tax cuts. The US\$288 billion in tax cuts exceeds the magnitude of any past tax cuts, including those of the Kennedy (US\$54.9 billion in 1964), Reagan (US\$68.7 billion in 1981) and Bush (US\$231 billion in 2004-2005) administrations (Ahern, 2004).

Despite the magnitude of the latest stimulus package, economists such as Paul Krugman (2009) have criticised the package for being both too small and too cautious in light of the weakness of recent economic indicators, including the sharpest fall in employment since the great depression. Consequently, Krugman (2009) predicts the need for a second stimulus package, and also emphasizes the importance of government spending as part of the package to stimulate economic activity. Feldstein (2009) also predicts the need for a second stimulus package, however, he emphasizes the need for any tax changes in the next stimulus package to be focused on providing incentives for households and businesses to engage in spending in order to stimulate economic activity.

The public debate over the stimulus package has so far mainly focused on the size of the package, whereas the macroeconomic effects of the composition and, in particular, the composition of its tax component has been somewhat ignored. However, previous literature has suggested that different tax components of fiscal instruments have different effects in the

short (Arin & Koray, 2005, 2006) and long-run (Gordon & Leeper, 2006; Kneller, Bleaney, & Gemmell, 1999; Lee & Gordon, 2005).

This paper investigates the short-run dynamic response of economic activity to different tax shocks using quarterly data from the US within a Structural Vector-autoregressive (SVAR) framework. We start our empirical analysis by investigating the effects of shocks to distortionary taxation (labour and corporate taxation) versus non-distortionary taxation (indirect taxation). We subsequently disaggregate distortionary shocks further, which allows for a comparative evaluation of the macroeconomic effects of shocks to labour taxes and corporate taxes. We should note that the investigation of the short-term effects of disaggregated tax shocks is inspired by the previous growth literature (Kneller et al., 1999), which has shown that distortionary taxation has a long-run growth-retarding effect, whereas non-distortionary taxation does not. With a few exceptions (Arin & Koray, 2005, 2006), the previous literature has not thoroughly investigated the short-term macroeconomics effects of disaggregated tax components, and no study has investigated the macroeconomic effects of different tax groups in a Structural Vector-Autoregressive (SVAR) framework that controls for automatic stabilizers.

Following the seminal work by Blanchard and Perotti (2002), we use quarterly data for the US and a Structural Vector-Autoregressive framework to investigate the dynamic effects of shocks to different tax groups. The choice of methodology is due to the fact that the Structural VAR (SVAR) model incorporates institutional information about the tax system to identify automatic responses of taxation and spending to output and other macroeconomic variables. Fiscal policy (govt spending and taxation) responds to changes in economic

activity through two main channels: The discretionary channel of policy makers; and the automatic responses embedded in the structure of existing taxation, government spending, and transfer programs. Policy makers are expected to make discretionary spending and taxation decisions based on information about economic activity, however, the decision lags inherent in the process of making discretionary policy changes are widely considered to be larger than one quarter. Thus, by using quarterly data, the contemporaneous effects of economic activity on spending and taxation are isolated to the automatic responses of the fiscal system, which can be inferred from *ex ante* knowledge of the tax and transfer systems. This knowledge is what allows us to identify the system and, hence, trace out the macroeconomic effects on output, prices, and interest rates of a dollar shock to each fiscal variable; in particular, different types of tax revenue. SVAR models based on the Blanchard and Perotti (2002) framework, with modifications to the selection of the macroeconomic variables, have been applied to the US (Perotti, 2005, 2007) and to a range of other OECD countries including Australia (Perotti, 2005), Germany (Heppke-Falk, Tenhofen, & Wolff, 2006), Italy (Giordano, Momigliano, Neri, & Perotti, 2007), Spain (de Castro & Hernandez de Cos, 2006) and the United Kingdom (Perotti, 2005).

Our investigation of fiscal policy effects on economic activity, contributes to the literature by focusing on the short-term dynamic effects of shocks to disaggregated tax policy instruments. Differentiating among corporate, labour (both distortionary), and indirect taxes (non-distortionary) we empirically investigate whether policymakers should pay closer attention to the composition of their stimulus packages. Our results suggest that, while shocks to non-distortionary taxes have a temporary effect on output, distortionary tax innovations;

consistent with findings on their long-run growth effects; have a much more persistent effect on real economic activity. On the other hand, the tax multipliers for distortionary taxes are of much lower magnitude, suggesting a trade-off between short-term and long-term goals of tax-based stimulus packages. Further disaggregation of distortionary tax policy shocks into labour tax shocks and corporate tax shocks, shows that the two tax groups have similar qualitative effects on output, but very different effects on the price level. Shocks to labour, corporate, and indirect taxes are found to have consistent qualitative effects in the full sample period and in the post 1981 period - positive multipliers for indirect taxes and negative multipliers for labour and corporate taxes - yet the relative magnitudes of multipliers of the three components change in the post 1981 period. This may help explain why multipliers for aggregated net taxes were found to change from negative to positive after 1980 in previous studies (Perotti, 2002). In the post 1981 period corporate tax multipliers increase significantly, while labour tax multipliers become significantly smaller. Consequently, corporate tax multipliers overtake labour tax multipliers in magnitude for the post 1981 period. Finally, the positive tax multipliers for net taxes documented in the previous literature (Arin & Koray, 2006) are only found for indirect taxes. Our results suggest that the composition of tax-based stimulus packages is crucial, in terms of both magnitude and timing of their effects on economic activity.

The remainder of this paper is organised as follows: Section 2 summarizes the previous literature on the short- and long-term effects of government spending and taxation. Section 3 describes the quarterly data from OECD. Section 4 outlines the SVAR baseline specification and its modifications used in this paper. Section 5 summarizes the findings including impulse

response diagrams and fiscal multipliers. Section 6 modifies the baseline model to conduct various robustness checks. Section 7 verifies the performance of the methodology based on historical data, and section 8 summarizes the results and draws parallels to policy implications.

2. Previous Literature

2.1 Theoretical Foundations

Different schools of thought have provided conflicting theoretical predictions of the effects of fiscal policy on economic activity. Predictions based on conventional Keynesian theory, which dominated the fiscal policy debate in the past, were found to be increasingly at odds with observed stylized facts in modern developed economies, and were challenged by Real Business Cycle (RBC) and neoclassical dynamic stochastic general equilibrium (DSGE) models. In recent years, new-Keynesian models, underpinned by stronger micro foundations, have generated predictions that match the stylized facts observed in modern developed economies to a greater extent than conventional Keynesian models.

Neoclassical General Equilibrium (GE) models highlight the importance of how fiscal policy is funded in relation to its effect on economic activity. Baxter and King (1993) show that permanent increases in government spending that are financed by lump sum taxes have a positive effect on output and employment, whereas the effect on real wages is negative. Yet, if government spending is instead financed by distortionary taxes, output decreases. This contradicts conventional Keynesian predictions where a balanced budget increase in government spending has unambiguously positive effects on output. Moreover, even in the

case of a permanent increase in government spending financed by a lump sum tax, Baxter and King's (1993) finding of a resulting negative impact on real wages contradicts new-Keynesian predictions and the observed stylized facts of generally pro-cyclical real wages. Dotsey (1994) demonstrates how tax reductions under current budget deficits can have a negative impact on both investment and output, when the deficit increases are financed by future distortionary taxation. In contrast to Dotsey (1994), Ludvigson (1996) shows that deficit financed reductions in distortionary income taxes can have a positive effect on investment and, thus, output even if the deficit increase is expected to be financed by future distortionary taxes. The contradictory results can be explained with the elasticity of labour supply and the level of persistence in government deficits.

In Real Business Cycle (RBC) theory, positive shocks to government spending or negative shocks to taxes raise interest rates, thus, rendering current income relatively more valuable. This causes workers to engage in inter-temporal substitution of labour, which increases the current labour supply and decreases the current real wage rate, eventually increasing employment and output. There is some empirical support for RBC models: McGrattan (1994) demonstrates how a significant proportion of the variation in output and other macro variables can be explained by disturbances in government spending and distortionary taxation (income and capital taxation). Similarly, Braun (1994) investigates the effects of changes in marginal tax rates on economic activity in a RBC model and shows that increases in distortionary taxation reduce the post-tax interest rate. This, in turn, results in the classic RBC reduction in labour supply and consequently in a reduction in employment, consumption, and output, combined with an increase in the real wage. Finn (1998) provides a theoretical RBC

model which explains how shocks to government spending on goods and services have a positive effect on output, employment, and investment, whereas the effect of shocks to government wage spending on these macroeconomic variables is the opposite.

More recently Barry & Devereux (2003) have suggested a dynamic general equilibrium model which predicts expansionary output effects of balanced budget reductions in government spending. A reduction in government spending matched by reductions in taxation is predicted to have a large positive effect on output, although the adjustment occurs gradually. Thereby, the output stimulating effects of spending and taxation reductions are larger in magnitude the larger the initial size of the government sector (measured as government spending relative to GDP).

New-Keynesian theory highlights the importance and implications of market imperfections. It provides a number of possible explanations motivating why real wages and consumption might react positively to a fiscal shock which stimulates output. New-Keynesian models that make such predictions are provided by Gali, Lopez-Salido, & Valles (2007) and Linnemann & Schabert (2003), who base their predictions on the presence of counter-cyclical mark-ups on goods produced by firms, resulting from sticky prices of goods and non-sticky wages. Alternative new-Keynesian models that provide similar predictions of major macroeconomic variables, yet use different mechanisms to explain the presence of counter-cyclical mark-ups, are suggested by Rotemberg & Woodford (1992) and Ravn, Schmitt-Grohe, & Uribe (2006).

Recent theoretical models point to the possible existence of so-called *Non-Keynesian* effects of fiscal policy. Such Non-Keynesian effects on output stem from changes in particular components of government spending or taxation. This increased focus on theories supporting non-Keynesian effects was partially motivated by the growth miracle observed in Ireland, which occurred following fiscal and other reforms, starting in 1986. Between 1986 and 1989, Ireland achieved a consolidation in the government budget, thus eliminating large budget deficits. This consolidation was achieved through drastic reductions in government spending, primarily large reductions in government wage spending, and a reduction in the size of the government sector in general. Contrary to Keynesian wisdom, the aforementioned Irish example of budget consolidation was followed by increased growth, even in the short-run (Alesina et al., 2002). In an empirical investigation covering 18 OECD countries, Alesina et al. (2002) confirmed that the existence of Non-Keynesian effects of fiscal policy extend beyond just Ireland: Government spending on wages has a sizeable negative effect on business investments and profits and, therefore, on output.

These various models, borne out of several different schools of thought, often produce contradicting theoretical predictions of the causes and effects of major macroeconomic variables. Likewise, the results of empirical investigations into the effects of fiscal policy produce very diverse conclusions on the causal effects of fiscal policy variables, even when conducted for the same countries and over identical sample periods. In general most studies have found that government spending multipliers are small and positive, while tax multipliers are small and negative. Some empirical evidence also exists for both negative spending multipliers and positive tax multipliers. However, some of this mixed evidence might be

attributed to the common aggregation of individual components of taxation and government spending, which in reality have contradicting effects on output and other macroeconomic variables.

2.2 VAR based empirical literature

VAR models were first introduced by Sims (1980), and have since been extensively used to analyze monetary policy shocks (Bernanke, 1986; Bernanke & Mihov, 1995, 1998; Blanchard & Quah, 1989; Christiano, Eichenbaum, & Evans, 1996; Leeper, Sims, Zha, Hall, & Bernanke, 1996) and, more recently, to analyze fiscal policy shocks (Blanchard & Perotti, 2002; Burnside, Eichenbaum, & Fisher, 2004; Canova & Pappa, 2003; Canzoneri, Cumby, & Diba, 2002; Edelberg, Eichenbaum, & Fisher, 1999; Fatas & Mihov, 2001; Gali, et al., 2007; Mountford & Uhlig, 2008; Perotti, 2005, 2007; Ramey & Shapiro, 1999).

Four main alternative approaches within the VAR framework have been used to analyze fiscal policy shocks; (1) the narrative, (2) the agnostic, (3) the contemporaneous restrictions (Choleski ordering) and (4) the Structural VAR approach. Among the various fiscal policy VAR studies regarding the US, the qualitative results for the responses of major macroeconomic variables to shocks to aggregated government spending and net taxation are fairly consistent. As shown in Table 1 on page 38, positive shocks to net taxes¹ generally result in negative responses of output (mostly significant) and prices (often insignificant) in the short- and long-term. Despite yielding fairly consistent qualitative results in terms of the response of output and prices across the four major VAR identification approaches, there is significant variation in the findings on the magnitude (quantitative) of the effects on output

¹ Net taxes are defined as the sum of indirect and direct taxes, less transfer payments.

and prices across the approaches. Our choice of the Structural VAR approach is based on theoretical considerations in view of the comparably less restrictive assumptions implied by the methodology, and empirical considerations in regard to the methodology's proven ability to provide results consistent with the stylized facts for major macroeconomic variables. Moreover, the SVAR approach has generally exposed transmission channels² that are consistent with established economic theories.

Structural Vector Auto Regressive Approach

The Structural Vector Auto Regressive (SVAR) model was first developed for monetary policy studies by Bernanke & Mihov (1998), and was pioneered in fiscal policy applications by Blanchard & Perotti (2002). The first fiscal policy SVAR study was conducted for the US by Blanchard & Perotti (2002), using a model with two fiscal variables, namely, government spending and net taxes. Subsequently, in search of transmission channels of fiscal shocks, the methodology has been applied with various model modifications, such as distinguishing between wage and non-wage components of government spending (Perotti, 2007), and the inclusion of macroeconomic variables such as private consumption, investment, and hours worked (Caldara & Kamps, 2008; Perotti, 2002; Perotti, 2005).

The Structural VAR (SVAR) model has an advantage over standard VAR models, in that the identification of the SVAR is less restrictive on the contemporaneous effects of the endogenous variables. Key contemporaneous parameters in the SVAR model can be identified ex ante and are, therefore, not necessarily assumed to all be zero as would be the case with the Choleski ordering. Given that these parameters are typically not all zero; such

² As, for instance, the effects of government spending or taxation shocks on real wages, hours worked, investment, and consumption.

as the contemporaneous effects of output on tax revenue and government spending; the SVAR approach provides a more robust model for the characterization of short-run effects of shocks to government spending and taxation³. SVAR studies for the US (Blanchard & Perotti, 2002; Caldara & Kamps, 2008; Perotti, 2002; 2005, 2007) find that positive shocks to net taxes have a negative impact on output and vice versa. In a study of the transmission mechanisms of fiscal policy, Perotti (2007) controls for the average marginal tax rate, using it as a proxy for distortionary taxation. However, none of the SVAR studies have so far investigated the causal effects of shocks to individual distortionary and non-distortionary components of taxation in the US. Another common thread in the findings of these SVAR studies is that positive government spending shocks have a positive effect on output, real wages, and private consumption. Neoclassical and RBC theory generally cannot explain this positive effect on real wages and consumption, whereas the new-Keynesian theory of counter-cyclical mark-ups and sticky prices does provide an explanation for the pro-cyclical real wage and consumption. The robust results found for transmission effects and effects on major economic variables (output and price level) by the SVAR approach in previous studies, combined with less serious potential biases compared to other identification approaches, makes it the methodology of choice for our analysis of the effects of shocks to different components of taxation on output and other major macroeconomic variables.

Blanchard & Perotti (2002) find that a positive shock to government spending has a positive effect on output, while unexpected increases in taxation have a negative effect on output. They also find that a positive shock to either taxation or spending has a strong negative

³ Of course, the SVAR approach relies on the ability to ex ante identify the automatic responses, some of which are derived from theory and some of which are estimated, as explained in section 4. Methodology

impact on investment, indicating substantial crowding out of government spending shocks. Perotti (2005) investigates the effect of fiscal policy on inflation, interest rates, and output before and after a presumed structural break around 1980, and finds that fiscal multipliers for net taxes and government spending have become substantially smaller over time, especially since the early 1980s. Perotti (2007) uses the Barro & Sahasakul (1983) measure for average marginal tax rates, which serves as a proxy for the distortionary effects of income taxation, in a VAR model examining US data, and investigates how shocks to marginal income taxes transmit into changes in real wages and hours worked. This specification uses the Choleski ordering to achieve identification, which in this special case is equivalent to the SVAR methodology, given the fact that marginal tax rates are policy determined and, hence, do not have automatic responses to macroeconomic variables.

Finally, Caldara & Kamps (2008) investigate and compare the results of fiscal policy investigations using three of the major approaches to VAR identification; the Structural VAR, the narrative, and the sign restrictions approach. Their findings confirm that the mixed results provided by different identification schemes used for tax policy shocks, cannot be reconciled by merely controlling for differences in model specification across previous tax related VAR studies. Perotti (2007) focuses on the effect of government spending shocks and compares the results from a SVAR investigation (backed by new-Keynesian predictions) with those of a narrative approach investigation (backed by neoclassical predictions). The conclusion of this investigation is in favour of the Structural VAR approach, and the author

finds little evidence in favour of the narrative approach due to the issues arising in the identification⁴ of truly exogenous fiscal shocks.

The fact that the narrative and SVAR approaches give different results on the same sample, combined, in particular, with a number of critiques of the narrative approach and the fact that it gives results consistent with models that do not account well for major stylised facts, supports the conclusion that the SVAR approach should be the methodology of choice when investigating the effect of fiscal policy shocks (Fry & Pagan, 2007; Perotti, 2007).

2.3 Growth literature

The growth literature has shown that different components of government spending and taxation have different effects on long-run growth. Using average tax rates⁵ Kneller et al. (1999) find that distortionary taxation (income, corporate, and social taxes) has long-run growth-retarding consequences, whereas non-distortionary taxation does not. They also find that productive government spending⁶ enhances growth, while non-productive government spending⁷ does not. Widmalm (2001), using a large panel of OECD countries over a 35 year period, finds support for the effects of tax structure on economic growth. In particular, Widmalm (2001) finds that a greater reliance on personal income tax in total government revenue has growth-retarding impacts. Lee & Gordon (2005), using top marginal tax rates, investigate the effect of different corporate and personal statutory tax rates in a panel of 70

⁴ The narrative approach identifies historical exogenous shocks based on subjective assessment of historical events through examination of historical documents such as presidential speeches.

⁵ Average tax rates are calculated as the ratio of tax revenues to income (output).

⁶ Productive government spending is defined as expenditure on general public services, defence, education, health, housing, transportation, and communication (Kneller et al., 1999).

⁷ Non-productive government spending is defined as spending on social security, welfare, recreation and economic services (Kneller et al., 1999).

countries over 28 years (1970-1997). They find that higher corporate taxes lead to reductions in future growth rates. The difference in the tax rates used to measure the effect of tax structure on growth in these three studies makes direct comparison complicated, however, they all have in common that components of distortionary taxation have a long-run growth reducing effect while non-distortionary taxes do not.

Given the diverging long-run effects of distortionary and non-distortionary taxation on output growth, and the fact that empirical studies investigating the short-run effects of tax policy shocks have largely focused on tax aggregates, it is logical, and certainly of policy relevance, to investigate the short-run effects of disaggregated tax components.

3. Data

The data is obtained primarily from the OECD Economics Outlook Database 2009, and comprises US quarterly observations from the 3rd quarter of 1972 to the last quarter of 2008. Details on the OECD data series used are contained in Table 2 on page 39. The choice of the US for the investigation is motivated by a number of factors. The United States is the largest economy in the world and has the most comprehensive body of existing fiscal policy literature, on which we can build. Furthermore the availability of average marginal tax rates for the US allows for a further control variable to be used in this tax policy study. The sample period covers all quarters after the fall of the Bretton-Woods system. All nominal values are deflated by the GDP deflator. All variables, with the exception of the interest rate and the average marginal tax rates, are in natural logs.

Following Perotti (2007), the long-term interest rate on 10 year government bonds (Treasury Bonds) is used as a proxy for monetary policy shocks. The distortionary and non-distortionary components of taxation are classified, following Kneller et al. (1999), according to whether a tax component has a distortionary impact on the incentives to work, study, and invest. Hence, income, social security, and corporate taxes are considered to be distortionary. Indirect taxation comprising sales taxes and tariffs, for which evidence suggests no or significantly less growth-retarding long-run effects (Kneller et al., 1999), are considered to be non-distortionary. We further disaggregate distortionary taxes into corporate and labour taxes. Labour taxation includes taxes on household income (including the capital tax) and social security taxes.

The Barro & Sahasakul (1983) average marginal tax, referred to henceforth as Barro AMT⁸ rate, and graphically depicted in Figure 1 on page 41, is the same as that used in previous fiscal policy studies (Burnside et al., 2004; Edelberg et al., 1999; Perotti, 2007). It is used as a proxy to measure distortionary taxation⁹. We use the Barro AMT as a robustness check¹⁰.

Over the sample period changing US administrations and economic conditions have coincided with a number of large changes in the average tax rate (measured as net taxes relative to GDP) and the government spending share of GDP, as seen in Figure 3 on page 43.

Traditionally average tax rates are pro-cyclical, as certain tax revenues such as income and

⁸ The Barro AMT is calculated by Barro & Sahasakul (1983), updated until 1996 by Stephenson (1998) and again until 2004 by Arin et al. (2008), who also compile Barro and Seater average marginal tax rates for Scandinavian countries (Denmark, Sweden and Norway) and the UK.

⁹ The Barro AMT is only available on an annual basis, which potentially reduces the accuracy of the proxy as it does not capture the quarterly variation in marginal tax rates. This is, however, mitigated by the fact that marginal tax rates in most years only change once per year (Perotti, 2007) in relation to the passing of the nation's annual budget.

¹⁰ The results are broadly consistent with the findings from our baseline specifications and are available upon request.

corporate tax revenues¹¹ increase relatively more than output during expansions. Tax policy reforms are the second major cause of the historical fluctuations in average tax rates.

Inflation indexed income tax brackets were first introduced during the Reagan administration (1981:Q1-1989:Q1) as part of the Economic Recovery Tax Act of 1981, which also saw top marginal taxes reduced to 50%. The second major tax reform of the Reagan administration was the Tax Reform Act 1986, which reduced top marginal income tax rates from 50 to 28%. Other major tax policy changes include the Bush (1989:Q1-1993:Q1) 1990 increases in the top marginal personal tax rate to 31% in order to cope with increasing levels in government spending over the preceding decade, and further increases under Clinton (1993:Q1-2001:Q1) to a top marginal rate of 39.5 percent¹². The increasing trend in top marginal rates was reversed under Bush (2001:Q1-2009:Q1) in 2001, when congress passed the Economic Growth And Tax Relief And Reconciliation Act , which commenced the implementation of a long term plan to reduce top marginal rates to 33 percent.

Tax revenues change systematically over the business cycle. These changes partly occur autonomously due to the cyclical nature of average tax rates and partly due to tax reforms and policy changes motivated by the observed economic conditions; in the latter case, the response is subject to a policy lag. By using a Structural VAR model that includes tax revenue and economic activity variables (output, prices, and interest rates) we control for these effects of output on tax revenues (both policy driven and automatic), which allows us to investigate the reverse causality of how shocks to tax variables effect output and prices.

¹¹ More people tend to move into higher income brackets (despite bracket indexation) when income is rising.

¹² The top marginal rate was equal to 36% after the 1993 act of congress. This rate included a surcharge of 10% which left the effective top marginal tax rate at 39.6%.

4. Methodology

4.1 The Model

Our SVAR framework and identification procedure follows seminal work by Blanchard & Perotti (2002), and our benchmark specification includes seven macroeconomic variables:

$$1: \quad \mathbf{x}_t = \mathbf{c} + A(L)\mathbf{x}_{t-1} + \mathbf{u}_t$$

$$\mathbf{x}_t = (g_t = \text{government spending}, \quad s_t = \text{indirect taxation},$$

$$b_t = \text{corporate taxation}, \quad l_t = \text{labour taxation},$$

$$y_t = \text{output (GDP)}, \quad p_t = \text{price level}, \quad r_t = \text{interest rate})$$

where \mathbf{x}_t is a vector collecting the endogenous variables, and $A(L)$ is a lag coefficient polynomial with a lag length of 4 periods, following Blanchard & Perotti (2002), whose significance for our baseline model is confirmed by a LM test¹³. \mathbf{c} is a vector of constants. All variables are real measures except the price level and the interest rate.

The \mathbf{u}_t vector comprises the reduced form error terms, which are generally correlated, and capture the contemporaneous effects of the endogenous \mathbf{x}_t variables on each other. Since the reduced form residuals \mathbf{u}_t are merely linear combinations of the structural fiscal shocks \mathbf{v}_t ¹⁴, the reduced form residuals alone do not allow us to infer how a dollar change in a given fiscal variable affects other macroeconomic variables. Each reduced form error term $u_{i,t}$ can be

¹³ We also use the Akaike information criterion which suggests 6 lags for the 6-variable model (distortionary and non-distortionary taxes), and 3 lags for the 7-variable model (labour, corporate and indirect taxes). Given the varying results for optimal lag length, we stick to the choice of lag length 4, due to this being the convention in SVAR studies using quarterly data (Blanchard & Perotti, 2002; Perotti, 2002; Perotti, 2005, 2007) and the fact that 4 lags are statistically significant at the 5 percent level in our model specifications.

¹⁴ As a matter of convention we denote the vector of structural and serially uncorrelated error terms by \mathbf{v}_t and the vector of reduced form and generally correlated error terms by \mathbf{u}_t .

decomposed into a linear combination of reduced form error terms u_j ($j \neq i$) of all other variables plus the structural error term of the variable itself denoted $v_{i t}$:

$$2: \quad \mathbf{u}_t = \mathbf{A}\mathbf{u}_t + \mathbf{B}\mathbf{v}_t \Rightarrow$$

$$3: \quad \begin{bmatrix} u_{g t} \\ u_{s t} \\ u_{l t} \\ u_{b t} \\ u_{y t} \\ u_{p t} \\ u_{r t} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & \alpha_y^g & \alpha_p^g & \alpha_r^g \\ 0 & 0 & 0 & 0 & \alpha_y^s & \alpha_p^s & \alpha_r^s \\ 0 & 0 & 0 & 0 & \alpha_y^l & \alpha_p^l & \alpha_r^l \\ 0 & 0 & 0 & 0 & \alpha_y^b & \alpha_p^b & \alpha_r^b \\ \gamma_g^y & \gamma_s^y & \gamma_l^y & \gamma_b^y & 0 & \alpha_y^y & \alpha_r^y \\ \gamma_g^p & \gamma_s^p & \gamma_l^p & \gamma_b^p & \gamma_y^p & 0 & \alpha_r^p \\ \gamma_g^r & \gamma_s^r & \gamma_l^r & \gamma_b^r & \gamma_y^r & \gamma_p^r & 0 \end{bmatrix} \begin{bmatrix} u_{g t} \\ u_{s t} \\ u_{l t} \\ u_{b t} \\ u_{y t} \\ u_{p t} \\ u_{r t} \end{bmatrix} + \begin{bmatrix} 1 & \beta_s^g & \beta_l^g & \beta_b^g & 0 & 0 & 0 \\ \beta_g^s & 1 & \beta_l^s & \beta_b^s & 0 & 0 & 0 \\ \beta_g^l & \beta_s^l & 1 & \beta_b^l & 0 & 0 & 0 \\ \beta_g^b & \beta_s^b & \beta_l^b & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} v_{g t} \\ v_{s t} \\ v_{l t} \\ v_{b t} \\ v_{y t} \\ v_{p t} \\ v_{r t} \end{bmatrix}$$

We are interested in investigating the effects of the structural fiscal shocks to government spending, as well as to indirect, labour and corporate taxation ($v_{g t}$, $v_{s t}$, $v_{l t}$ and $v_{b t}$) on the remaining macroeconomic variables (output, prices, and interest rates), hence the choice of matrices A and B. We can rewrite the system in Equation (2) to see that the reduced form errors are in fact only functions of the structural errors, and to illustrate how the structural errors can be recovered¹⁵:

$$4: \quad \mathbf{u}_t = \mathbf{A}\mathbf{u}_t + \mathbf{B}\mathbf{v}_t \Leftrightarrow (\mathbf{I}_7 - \mathbf{A})\mathbf{u}_t = \mathbf{B}\mathbf{v}_t \Leftrightarrow \mathbf{\Gamma}\mathbf{u}_t = \mathbf{B}\mathbf{v}_t \Rightarrow$$

$$5: \quad \mathbf{u}_{g t}^{CA} = \mathbf{\Gamma}\mathbf{u}_t = \mathbf{B}\mathbf{v}_t$$

In general, if we have a system of N endogenous variables, then identification of all parameters in Equation (3) requires the imposition of $((N^2)-N)/2$ restrictions on the parameters in matrices A and B. In practice that means we need to identify the values of at least 21 (since $N=7$) of the parameters in A and B based on empirical, or theoretical, ex ante

¹⁵ Since $\mathbf{v}_t = \mathbf{B}^{-1}(\mathbf{I}_7 - \mathbf{A})\mathbf{u}_t = \mathbf{B}^{-1}\mathbf{\Gamma}\mathbf{u}_t$, we require matrix B to be invertible in order for a solution to exist for the structural shocks. Furthermore $\mathbf{B}^{-1}(\mathbf{I}_7 - \mathbf{A})$ must be of full rank in order for that solution to be unique.

information about structural relations between the variables. These ex ante identified parameters, or elasticities¹⁶, can be either zero, or non-zero, constants.

The structural fiscal error terms ($v_{g_t}, v_{s_t}, v_{l_t}$ and v_{b_t}) capture the discretionary, but random, spending and tax policy shocks, which we are interested in recovering. The α_j^i parameters in (3) capture a combination of two types of shocks: (a) systematic automatic changes in spending and taxation in response to changes in other macro variables (output, price level, and interest rates) and (b) systematic discretionary policy responses of fiscal variables to other macro variables. Due to policy lags, however, the contemporaneous effects α_j^i of non-fiscal macro variables on fiscal variables are assumed to only capture the automatic responses of fiscal policy variables to other macro variables. Therefore, they can be identified ex ante using structural information about the tax and transfer systems. In regards to the fiscal policy variables, systematic discretionary spending decisions can effect within quarter discretionary taxation decisions, and vice versa, depending on whether taxation or spending decisions are made first. Since the β_j^i do not only capture automatic responses, they must be estimated. In order to do this we orthogonalize the structural residuals in the model by imposing restrictions on the β_j^i parameters. Following (Perotti (2007)), we assume that spending decisions are made prior to taxation decisions which means that spending effects taxes contemporaneously, but not the other way around. Hence, $\beta_s^g = \beta_l^g = \beta_b^g = 0$. Also,

¹⁶ Since the variables are in logs, the coefficients have elasticity interpretation. In the case of parameters on interest rates, the functional form is log-level, and level-log in the equation where the interest rate is the dependent variable. In these cases we refer to the parameters as semi-elasticities.

indirect taxation decisions come before labour and corporate tax decisions^{17,18} Hence, $\beta_1^s = \beta_b^s = 0$. Finally, labour tax decisions come before corporate tax decisions. Hence $\beta_b^1 = 0$. With these six contemporaneous restrictions in mind, the B matrix ends up being lower triangular. For identification we then need to impose a further 15 restrictions on the α_j^i parameters in matrix A in Equation (4) (or equivalently in matrix Γ in Equation (5)).

4.2 Calculation of Elasticities

Since elasticities of taxation with respect to both output and prices differ substantially for different components of taxation, we follow Blanchard & Perotti (2002) and take weighted averages of the elasticity of each component (weighted by the share of each tax component in the aggregated tax revenue) for aggregated tax variables.

Personal taxes

We adopt the methodology developed by Blanchard & Perotti (2002) and Perotti (2005) for calculating contemporary elasticities of each tax component with respect to output. Therefore, we disaggregate the tax revenue components into statutory tax rates and labour market structural variables:

$$6: \quad R_t = S(W_t P_t) W_t(E_t) E_t(Y_t)$$

¹⁷ We also try different orderings of the tax revenue variables, which include labour, corporate, and indirect taxes. The results are robust to different orderings of the tax revenue decisions.

¹⁸ In the 6-variable model, which includes government spending and two tax variables (distortionary and non-distortionary tax revenues), we similarly rank non-distortionary taxation before distortionary taxation, and also try the converse finding that the results are robust.

Personal income tax revenue R_t is equal to the product of the average tax rate $S(W_t P_t)$ and the tax base $W_t(E_t)E_t(Y_t)$, which comprises the product of the average real wage $W_t(E_t)$ and employment $E_t(Y_t)$ in a given period. Taking logs and computing the total derivative yields¹⁹:

$$7: \quad dr_t = \frac{\partial s}{\partial w_t} dw_t + \frac{\partial s}{\partial p_t} dp_t + \frac{\partial w_t}{\partial e_t} de_t + \frac{\partial e_t}{\partial y_t} dy_t \Rightarrow$$

$$8: \quad dr_t = \left\{ \left(\left(\frac{\partial s}{\partial w_t} + 1 \right) \frac{\partial w_t}{\partial e_t} + 1 \right) \frac{\partial e_t}{\partial y_t} \right\} dy_t + \frac{\partial s}{\partial p_t} dp_t = \frac{\partial s}{\partial y_t} dy_t + \frac{\partial s}{\partial p_t} dp_t$$

$$\alpha_y^r = \frac{\partial s}{\partial y_t} = \left(\left(\frac{\partial s}{\partial w_t} + 1 \right) \frac{\partial w_t}{\partial e_t} + 1 \right) \frac{\partial e_t}{\partial y_t}$$

$$\alpha_p^r = \frac{\partial s}{\partial p_t}$$

The term $\left(\frac{\partial s}{\partial w_t} + 1 \right)$ represents the elasticity of income tax revenue to real wages, which we obtain from semi-annual estimates by Giorno et al. (1995) until 1995 and, more recently to 2002, by van den Noord et al. (2002). We obtain the contemporaneous elasticity of real wages with respect to employment $\left(\frac{\partial w_t}{\partial e_t} \right)$ from a regression of the log of real wages on the log of contemporaneous employment in addition to one forward and four lags (Perotti, 2005). The elasticity of employment with respect to output $\left(\frac{\partial e_t}{\partial y_t} \right)$ is estimated in a similar fashion. Using these quarterly elasticity estimates for our sample period, and the real wage elasticity of income taxes $\left(\frac{\partial s}{\partial w_t} + 1 \right)$, updated at two-year intervals (Giorno et al., 1995; van den Noord et al., 2002), we calculate the value of α_y^i at these two year intervals, and use the average

¹⁹ Lowercase letters denote natural logs of the respective variables.

value of the computed biannual elasticities as the contemporaneous output elasticity of income taxation in our model.

Social security taxation

The elasticity of social security taxes is obtained in a very similar fashion to that applied to income taxation. In analogy to the calculation of the income tax elasticities, the elasticity with respect to the average real wage is obtained from Giorno et al. (1995) and van den Noord et al. (2002).

Corporate taxation

In the US, corporate tax revenue is directly proportional to corporate profits²⁰. Therefore, the contemporaneous output elasticity of corporate tax revenue is equal to the contemporaneous output elasticity of corporate after-tax earnings. Hence, it can be estimated by regressing the log of real corporate profits on the log of GDP. We estimate this by regressing the log of real corporate profits on the log of real GDP using quarterly data and, following Perotti (2005), we include in the regression the log of the forward and four lags of real GDP. There are various ways through which inflation can affect corporate income and, hence, income taxation in either a positive or negative direction, leaving the net effect extremely difficult to quantify²¹. We follow Perotti (2005) and assume the contemporaneous quarter price elasticity of real corporate tax revenue to equal 0.

²⁰The US corporate tax rate has historically been largely flat, with the vast majority of corporate income in a given quarter being taxed at the same marginal rate.

²¹Svensson (1997) studies the effects of inflation on taxes in Sweden and concludes that it is impossible to quantify the effects of inflation on corporate income tax revenue, thus making the assumption of zero elasticity of corporate taxation with respect to prices.

Indirect taxation

For indirect tax elasticities with respect to output we follow Perotti (2005) and assume an elasticity of unity. Hence, $\alpha_y^s = 1$. The elasticity of the nominal value of indirect taxes with respect to price is assumed to be equal to one (Perotti, 2005), which makes the elasticity of real indirect taxes with respect to price equal to zero. Hence, $\alpha_p^s = 0$.

Other elasticities

Empirical evidence suggests that there is no significant within quarter automatic response of government spending to output (Perotti, 2005). Hence, $\alpha_y^g = 0$. Since both government spending and taxation variables exclude interest payments, we can follow Perotti (2005) and assume that their within quarter response to changes in interest rates is zero. Hence, $\alpha_r^g = \alpha_r^s = \alpha_r^l = \alpha_r^b = 0$.

Having incorporated the identifying ex ante structural information into the system, we now turn to the estimation of the remaining parameter values and the structural shocks, which will allow us to trace the responses of fiscal shocks to output, prices, and interest rates.

4.3 Estimating the system

Given the imposed restrictions, the dependent variable $u_{g,t}^{CA}$ now makes the structural error $v_{g,t}$ exogenous in (10) and allows us to estimate β_g^s consistently in an OLS regression. Likewise we can impose one less restriction on Equation (11) as the restrictions in (10) has made $v_{s,t}$ exogenous, which allows us to recover consistent estimates of two parameters in

(11) by OLS. Continuing with this recursive approach we obtain consistent OLS estimates of the β_j^i parameters in all 4 equations below:

$$9: \quad u_{g_t}^{CA} = u_{g_t} - (\alpha_y^g u_{y_t} + \alpha_p^g u_{p_t} + \alpha_r^g u_{r_t}) = v_{g_t}$$

$$10: \quad u_{s_t}^{CA} = u_{s_t} - (\alpha_y^s u_{y_t} + \alpha_p^s u_{p_t} + \alpha_r^s u_{r_t}) = \beta_g^s v_{g_t} + v_{s_t}$$

$$11: \quad u_{l_t}^{CA} = u_{l_t} - (\alpha_y^l u_{y_t} + \alpha_p^l u_{p_t} + \alpha_r^l u_{r_t}) = \beta_g^l v_{g_t} + \beta_s^l v_{s_t} + v_{l_t}$$

$$12: \quad u_{b_t}^{CA} = u_{b_t} - (\alpha_y^b u_{y_t} + \alpha_p^b u_{p_t} + \alpha_r^b u_{r_t}) = \beta_g^b v_{g_t} + \beta_s^b v_{s_t} + \beta_l^b v_{l_t} + v_{b_t}$$

Recovery of the parameters in the structural equations for the non-fiscal macro variables is based on Equations (13), (14), and (15) respectively. These equations suffer from endogeneity problems, in that the structural error terms are correlated with the reduced form errors used as independent variables. Hence, to consistently estimate Equation (13) for example, we need four instruments that are uncorrelated with the structural error term v_{y_t} , while being correlated with the reduced form errors to be instrumented (u_{g_t} , u_{s_t} , u_{l_t} and u_{b_t}). As instruments we use the structural error terms of the fiscal variables, which we recovered in equations (9) through (12) (v_{g_t} , v_{s_t} , v_{l_t} and v_{b_t}), because these are no longer correlated with the reduced form errors in (13) due the restrictions we have imposed. Having assigned one instrument per endogenous variable, the parameters in (13) are identified. We estimate these parameters using 2-stage-least-squares (2SLS) instrumental variable regression. Similarly, once the coefficients in equation (13) are recovered by 2SLS estimation, the recovered residual v_{p_t} can be used as another instrument to estimate (14). As such, we estimate the last three equations recursively, starting with Equation (13).

$$13: \quad u_{y_t} = \gamma_g^y u_{g_t} + \gamma_s^y u_{s_t} + \gamma_l^y u_{l_t} + \gamma_b^y u_{b_t} + v_{y_t}$$

$$14: \quad u_{p t} = \gamma_g^p u_{g t} + \gamma_s^p u_{s t} + \gamma_l^p u_{l t} + \gamma_b^p u_{b t} + \gamma_y^p u_{y t} + v_{p t}$$

$$15: \quad u_{r t} = \gamma_g^r u_{g t} + \gamma_s^r u_{s t} + \gamma_l^r u_{l t} + \gamma_b^r u_{b t} + \gamma_y^r u_{y t} + \gamma_p^r u_{p t} + v_{r t}$$

Incorporating all the ex ante identified and estimated parameters into Equation (3) yields the following relation between the contemporaneous reduced form errors and structural error terms²²:

$$16: - \begin{bmatrix} -1 & 0 & 0 & 0 & 0 & 0.5 & 0 \\ 0 & -1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0.3 & 0.8 & 0 \\ 0 & 0 & 0 & -1 & 5.0 & 0 & 0 \\ 0.25 & -0.25 & -0.01 & -0.02 & -1 & 0 & 0 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & -1 & 0 \\ 0.03 & -0.01 & 0.00 & 0.03 & 0.04 & 1.29 & -1 \end{bmatrix} \begin{bmatrix} u_{g t} \\ u_{s t} \\ u_{l t} \\ u_{b t} \\ u_{y t} \\ u_{p t} \\ u_{r t} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ -0.1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0.3 & -0.2 & 1 & 0 & 0 & 0 & 0 \\ -0.7 & 0 & 0.5 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} v_{g t} \\ v_{s t} \\ v_{l t} \\ v_{b t} \\ v_{y t} \\ v_{p t} \\ v_{r t} \end{bmatrix}$$

The identification of the contemporaneous coefficients, along with the lag coefficients (four lags) estimated from the reduced form of the VAR, allows us to trace the timing and magnitude of the effects on output, prices, and interest rates in response to alternative tax shocks. The dynamic responses of these variables to a one standard deviation positive shock to the respective fiscal variable at time zero ($t=0$), are graphically depicted in the form of impulse response functions (IRFs) in the following results section.

²² The estimated coefficients in the matrices are displayed here as rounded to one, or in some cases two, decimal places. Whenever the contemporaneous parameters we estimate (γ_j^i and β_j^i) are found to be statistically insignificant at the 10% level, we set their values to zero for the purpose of obtaining results and drawing impulse response functions.

5. Results

5.1 Shocks to Distortionary Taxes

In the 6-variable SVAR containing distortionary and non-distortionary tax revenues, in addition to government spending, output, price level, and interest rates, the response of the model variables to a one standard deviation positive shock to distortionary tax revenues are presented in Figure 4 on page 44. Our empirical results suggest that the output response to distortionary tax innovations is quite long lasting, as real GDP does not return to its original level even after 26 quarters (7 years). This result is consistent with the previous growth literature that has documented growth-retarding effects of distortionary taxes (Kneller et al., 1999). A closer look at the tax multipliers reveals that a 1% increase in distortionary tax revenues is accompanied by 0.17% decrease in output after 11 quarters (3 years). The price response of tax shocks implies that supply side effects cannot be ignored, as we observe a temporary increase in the price level, although it is small in magnitude (0.01%).

5.2 Shocks to Non-Distortionary Taxes

In the 6-variable SVAR containing distortionary and non-distortionary tax revenues, in addition to government spending, output, price level, and interest rates, the responses of the model variables to a one standard deviation positive shock to non-distortionary tax revenues are presented in Figure 4 on page 44. The results suggest that non-distortionary tax shocks have a large initial negative effect on output, with an initial multiplier of -0.20. This effect is, however, very short-lived, becoming insignificant after just 2 quarters. After a period of 14 quarters the output response to the initial shock becomes positive. This might be due to non-accommodating monetary policy, which is in line with the decreasing interest rate.

5.3 Shocks to Labour Taxes

In the 7-variable SVAR model specification we further disaggregate distortionary taxes into labour (income and social security), and corporate taxes, respectively. The responses of the model variables to a one standard deviation positive shock to labour tax revenues are presented in Figure 5 on page 45.

The empirical results suggest that the output response to labour tax innovations dies out after 18 quarters (4.5 years) when output returns to its original trend. The multiplier effect of a shock to labour tax revenue is -0.20 after just 8 quarters, which is both a larger and more immediate response of output than was found for aggregated labour and corporate taxes, as seen in Figure 4 on page 44. Again this result for negative labour tax multipliers is consistent with the documented long-run growth-retarding effects of distortionary taxes (Kneller et al., 1999).

The price level initially increases slightly, with the subsequent price response becoming negative after 9 quarters, with a permanent effect.

5.4 Shocks to Corporate Taxes

In the 7-variable SVAR model containing labour, corporate, and indirect taxes in addition to government spending, output, prices, and interest rates, the responses of the model variables to a one standard deviation positive shock to corporate tax revenues are presented in Figure 5 on page 45.

Our empirical results suggest that the output response to corporate tax innovations is very long lasting, and the shock effect on output is still persistent after 30 quarters (7.5 years),

which is almost twice as long as the response of a comparable shock to labour taxation. The multiplier effect of a shock to corporate tax revenue is -0.07 after 12 quarters, which is a significantly smaller effect than the multiplier effect associated with a labour tax shock, as seen in Figure 5.

The price level initially rises in response to a shock to corporate taxation, with maximum effect attained after 4 quarters and a measurable effect lasting for a total of 9 quarters, after which the price level again gravitates towards its initial level. The direction of the price response contrasts with the response of a comparable positive shock to labour taxes, indicating that the supply side effects of corporate taxes cannot be ignored. That is, firms, at least in part, pass increased tax costs onto consumers, thereby putting upward pressure on the general price level.

6.5 Post 1981 Reforms

The Economic Recovery Tax Act of 1981 first introduced inflation-indexed income tax brackets. During the 1970s the fixed income tax brackets were gradually adjusted upwards in reaction to the then prevailing high levels of inflation, however, average marginal tax rates still increased during that period (as seen in Figure 1 on page 41), as more people moved into higher tax brackets. We suspect that the indexation of tax brackets at the time of the Economic Recovery Tax Act in August of 1981 may have affected the relation between tax revenues and the price level. Therefore, the event may be seen as a contributing factor in a possible structural break in the effects of tax shocks on output and prices, as suggested in

previous fiscal policy studies (Perotti, 2007)²³. As a consequence, we restrict our sample to the period 1981:Q4-2008:Q4 to analyse the effects of tax innovations in the bracket-adjusted era. The corresponding impulse response functions in Figure 6 (shocks to distortionary and non-distortionary taxes), Figure 7 (shocks to labour and corporate taxes) and Figure 8 (shocks to indirect taxes) can be found on pages 46-48.

The seminal paper by Perotti (2005) found negative fiscal multipliers for aggregated net taxes, of which labour, corporate, and indirect taxes are the major components, before 1980, and positive tax multipliers after 1980. Our results suggest that labour and corporate taxes consistently have negative multipliers both before, and after, the policy reforms of the early 1980s, which may be seen as evidence of the importance of also using disaggregated data in short-run fiscal policy analysis. Moreover, we found that labour taxes have larger multipliers (in absolute value terms) than do corporate taxes over the entire sample period. In the post 1981 period, however, this trend seems to have reversed with the corporate tax multiplier of -0.11 being larger than the labour tax multiplier of -0.07. The difference in the corporate tax multipliers between the full sample and the post 1981 sample period is statistically significant at the 10% level in the period between 1 and 7 quarters after an initial shock, with the difference in the labour tax multipliers being statistically significant after just 2 quarters and beyond. Over the full sample period the labour tax multipliers are statistically larger than are the corporate multipliers between 1 and 19 quarters and, in the post 1981 sub-sample, between 1 and 5 quarters²⁴. The increased multiplier for corporate taxes might be due to the

²³ Another important factor is the new and tougher stance on inflation introduced in monetary policy by Paul Volker, who took over as FED chairman in 1979.

²⁴ Tested at the 10% level of significance, differences in comparable responses are significant whenever one estimate lies outside the 10% confidence interval of the other.

increasing importance of global capital flows among the US and other nations in a world of better integrated capital markets.

6. Robustness Checks

6.1 Net Taxes

In the Structural VAR literature the variable most commonly used as a measure of taxation is *net taxes*, which is the tax revenue net of transfer payments from the public sector to firms and households (Blanchard & Perotti, 2002; Caldara & Kamps, 2008; Perotti, 2005, 2007). We have so far used the Kneller et al. (1999) definitions of tax revenues, which are gross of transfers. The reason for this is to allow for the comparison of the documented long-run effects of different tax components with the short-run effects investigated in this paper. In order to robustly reconcile our results regarding the effects of taxation shocks on economic activity in the short-run with the pre-existing short-run SVAR literature, we test whether our results change when we subtract transfer payments from the tax revenue variables used in the 6 and 7-variable models reported in the Results section. We refer to these new tax revenue variables as net distortionary, net non-distortionary, net labour, net corporate, and net indirect taxes.

The results in terms of impulse response functions and confidence bands for output, price level, and interest rates, and the multipliers of the individual tax variables, are virtually identical to those found for the gross tax variables, which are reported in Section 5.

6.2. Marginal Tax Rates

Following Perroti (2007), we use the Choleski ordering to identify the model parameters when employing the average marginal tax rates. When estimating the impact of tax innovations on output, prices, and interest rates, we include tax rates one at a time. As a consequence, the orderings in the 5-variable VARs take the following form: Government spending, marginal tax rate, output, price level, and interest rate. The results obtained are broadly consistent with the findings from our baseline model. In particular, the suggested tradeoff between short-term and long-term goals of tax-based fiscal policy is also reflected in this specification, yielding significantly larger multipliers for the indirect measure²⁵.

7. Residual Analysis

In this section we graphically depict the structural residuals of labour and corporate taxes in the 7-variable SVAR, which allows for a comparison of shocks to these variables to historical events such as changes in US administrations. As Figure 9 on page 49 indicates, major spikes in the structural residuals coincide with major tax shocks in the context of changes in US administrations.

Policy changes to labour and corporate tax rates can be observed as spikes in the structural residuals of the respective labour and corporate taxation revenues. For example, in relation to the 2001 tax cuts following the inauguration of G.W. Bush in the first quarter of 2001, the top marginal personal income tax rate dropped from 45.9 to 41.4% by 2002. This decrease in the

²⁵ Impulse response functions are available on request.

top marginal rate coincided with the negative shock in the structural residuals of labour tax revenues, as seen in Figure 9. Similarly, the Reagan tax cuts, which reduced the top corporate tax rate from 46 to 35% in 1988, are reflected in a substantial negative shock in corporate tax revenues observed towards the end of the Reagan terms.

8. Conclusion

This paper contributes to the literature investigating the effects of fiscal policy on short-run economic performance by analyzing the effects of disaggregated tax innovations on output, prices, and interest rates in a Structural VAR framework. Our results suggest that disaggregated tax shocks have rather different effects on the economy, which underlines the importance of giving careful consideration to the composition of tax-based fiscal stimulus packages. Our findings show, in particular, that non-distortionary tax innovations have large, negative initial multipliers in comparison to distortionary taxes. Consistent with findings in the previous literature, however, non-distortionary tax shocks also exhibit positive multipliers after several quarters. Distortionary taxes, in contrast, have relatively small initial multipliers but a longer lasting effect on output, which corresponds well with findings on their long-term growth-retarding effects. Further disaggregation of distortionary tax innovations into labour and corporate tax innovations suggests that corporate tax shocks have longer lasting effects on output compared to labour tax shocks, with corporate tax multipliers being significantly smaller than labour tax multipliers prior to 1981. An important outcome of this study, in light of the general decrease in multipliers for net taxes documented in previous studies, is the finding that, while labour tax multipliers decreased in the post 1981 period, corporate tax multipliers increased. In fact, the multipliers measured for corporate taxes are found to be

significantly larger than those of labour taxes in the post 1981 period, which may be seen as evidence of the importance of also using disaggregated data in short-run fiscal policy analysis. The increase in multipliers of corporate taxes might be explained by the presumption that increased openness of the US and other developed nations over the past 30 years has augmented tax competition for scarce, internationally mobile capital, and thereby made output more sensitive to changes in corporate tax policy. This warrants further research into the transmission effects of disaggregated tax components. We conclude that in order to better understand the macroeconomic effects of tax innovations, more focus on the analysis of disaggregated tax shocks may not only help to improve our understanding of the consequences of alternative tax-based stimulus packages but may also help to explain the cross-country variation in tax multipliers. Further research might incorporate our research into different countries and different sample periods.

9. Reference List

- Ahern, W. (2004). Comparing the Kennedy, Reagan and Bush Tax Cuts Retrieved 14 June, 2009, from <http://www.taxfoundation.org/news/show/323.html>
- Alesina, A., & et al. (2002). Fiscal Policy, Profits, and Investment. *American Economic Review*, 92(3), 571-589.
- Arin, K. P., Berlemann, M., & Koray, F. (2008). The Taxation-Growth-Nexus Revisited.
- Arin, K. P., & Koray, F. (2005). *FISCAL POLICY AND ECONOMIC ACTIVITY: US EVIDENCE*. Unpublished manuscript.
- Arin, K. P., & Koray, F. (2006). Are Some Taxes Different Than Others? An Empirical Investigation of the Effects of Tax Policy in Canada. *Empirical Economics*, 31(1), 183-193.
- Barro, R. J., & Sahasakul, C. (1983). Measuring the Average Marginal Tax Rate from the Individual Income Tax. *Journal of Business*, 56(4), 419-452.
- Barro, R. J., & Sahasakul, C. (1986). Average Marginal Tax Rates from Social Security and the Individual Income Tax. *Journal of Business*, 59(4), 555-566.
- Barry, F., & Devereux, M. B. (2003). Expansionary Fiscal Contraction: A Theoretical Exploration. *Journal of Macroeconomics*, 25(1), 1-23.
- Baxter, M., & King, R. G. (1993). Fiscal Policy in General Equilibrium. *American Economic Review*, 83(3), 315-334.
- Bernanke, B. S. (1986). Alternative Explanations of the Money-Income Correlation. *Carnegie-Rochester Conference Series on Public Policy*, 25, 49-99.
- Bernanke, B. S., & Mihov, I. (1995). *Measuring Monetary Policy*. Unpublished manuscript.
- Bernanke, B. S., & Mihov, I. (1998). Measuring Monetary Policy. *Quarterly Journal of Economics*, 113(3), 869-902.
- Blanchard, O., & Perotti, R. (2002). An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output. *Quarterly Journal of Economics*, 117(4), 1329-1368.
- Blanchard, O. J., & Quah, D. (1989). The Dynamic Effects of Aggregate Demand and Supply Disturbances. *American Economic Review*, 79(4), 655-673.
- Braun, R. A. (1994). Tax Disturbances and Real Economic Activity in the Postwar United States. *Journal of Monetary Economics*, 33(3), 441-462.
- Burnside, C., Eichenbaum, M., & Fisher, J. D. M. (2004). Fiscal Shocks and Their Consequences. *Journal of Economic Theory*, 115(1), 89-117.
- Caldara, D., & Kamps, C. (2008). *What are the effects of fiscal shocks? A VAR-based comparative analysis*. Unpublished manuscript.
- Canova, F., & Pappa, E. (2003). *Price Dispersions in Monetary Unions: The Role of Fiscal Shocks*. Unpublished manuscript.
- Canzoneri, M., B., Cumby, R., E., & Diba, B., T. (2002). Should the European Central Bank and the Federal Reserve be concerned about fiscal policy? *Proceedings*, 333-389.

- Christiano, L. J., Eichenbaum, M., & Evans, C. (1996). The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds. *The Review of Economics and Statistics*, 78(1), 16-34.
- de Castro, F., & Hernandez de Cos, P. (2006). *The economic effects of exogenous fiscal shocks in Spain: a SVAR approach*. Unpublished manuscript.
- Dotsey, M. (1994). Some Unpleasant Supply Side Arithmetic. *Journal of Monetary Economics*, 33(3), 507-524.
- Edelberg, W., Eichenbaum, M., & Fisher, J. D. M. (1999). Understanding the Effects of a Shock to Government Purchases. *Review of Economic Dynamics*, 2(1), 166-206.
- Fatas, A., & Mihov, I. (2001). *The Effects of Fiscal Policy on Consumption and Employment: Theory and Evidence*. Unpublished manuscript.
- Feldstein, M. (2009). Fall in US household wealth likely to spur a long recession 3 March. Retrieved 20 May, 2009, from <http://www.taipeitimes.com/News/editorials/archives/2009/03/03/2003437472>
- Finn, M. G. (1998). Cyclical Effects of Government's Employment and Goods Purchases. *International Economic Review*, 39(3), 635-657.
- Fry, R., & Pagan, A. (2007). *Some Issues in Using Sign Restrictions for Identifying Structural VARs*: National Centre for Econometric Research.
- Gali, J., Lopez-Salido, J. D., & Valles, J. (2007). Understanding the Effects of Government Spending on Consumption. *Journal of the European Economic Association*, 5(1), 227-270.
- Giordano, R., Momigliano, S., Neri, S., & Perotti, R. (2007). The Effects of Fiscal Policy in Italy: Evidence from a VAR Model. *European Journal of Political Economy*, 23(3), 707-733.
- Giorno, C., Richardson, P., Roseveare, D., & van den Noord, P. (1995). *Estimating Potential Output, Output Gaps and Structural Budget Balances*. Unpublished manuscript.
- Gordon, D. B., & Leeper, E. M. (2006). The Price Level, the Quantity Theory of Money, and the Fiscal Theory of the Price Level. *Scottish Journal of Political Economy*, 53(1), 4-27.
- Hansen, M. (2005). The Irish Growth Miracle: Can Latvia Replicate? *Baltic Journal of Economics*, 5(2), 3-14.
- Haufler, A., & Wooton, I. (1999). Country Size and Tax Competition for Foreign Direct Investment. *Journal of Public Economics*, 71(1), 121-139.
- Henry, J., Hernandez De Cos, P., & Momigliano, S. (2008). The Impact of Government Budgets on Prices: Evidence from Macroeconometric Models. *Journal of Policy Modeling*, 30(1), 123-143.
- Heppke-Falk, K. H., Tenhofen, J., & Wolff, G. B. (2006). *The macroeconomic effects of exogenous fiscal policy shocks in Germany: a disaggregated SVAR analysis*. Unpublished manuscript.
- Kneller, R., Bleaney, M. F., & Gemmell, N. (1999). Fiscal Policy and Growth: Evidence from OECD Countries. *Journal of Public Economics*, 74(2), 171-190.
- Krugman, P. (2009). Behind the Curve 9 March. Retrieved 5 May, 2009, from http://www.nytimes.com/2009/03/09/opinion/09krugman.html?_r=3&ref=opinion

- Lee, Y., & Gordon, R. H. (2005). Tax Structure and Economic Growth. *Journal of Public Economics*, 89(5-6), 1027-1043.
- Leeper, E. M., Sims, C. A., Zha, T., Hall, R. E., & Bernanke, B. S. (1996). What Does Monetary Policy Do? *Brookings Papers on Economic Activity*, 1996(2), 1-78.
- Linnemann, L., & Schabert, A. (2003). Fiscal Policy in the New Neoclassical Synthesis. *Journal of Money, Credit, and Banking*, 35(6), 911-929.
- Ludvigson, S. (1996). The Macroeconomic Effects of Government Debt in a Stochastic Growth Model. *Journal of Monetary Economics*, 38(1), 25-45.
- McGrattan, E. R. (1994). The Macroeconomic Effects of Distortionary Taxation. *Journal of Monetary Economics*, 33(3), 573-601.
- Mountford, A., & Uhlig, H. (2005). *What are the Effects of Fiscal Policy Shocks?* Unpublished manuscript.
- Mountford, A., & Uhlig, H. (2008). *What are the Effects of Fiscal Policy Shocks?* Unpublished manuscript.
- Neri, S. (2001). *Assessing the effects of monetary and fiscal policy*: Bank of Italy, Economic Research Department.
- Perotti, R. (2002). *Estimating the effects of fiscal policy in OECD countries*. Unpublished manuscript.
- Perotti, R. (2005). *Estimating the Effects of Fiscal Policy in OECD Countries*. Unpublished manuscript.
- Perotti, R. (2007). *In Search of the Transmission Mechanism of Fiscal Policy*. Unpublished manuscript.
- Ramey, V. A., & Shapiro, M. D. (1999). *Costly Capital Reallocation and the Effects of Government Spending*. Unpublished manuscript.
- Ravn, M., Schmitt-Grohe, S., & Uribe, M. (2006). Deep Habits. *Review of Economic Studies*, 73(1), 195-218.
- Romer, C. D., & Romer, D. H. (2007). *The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks*. Unpublished manuscript.
- Rotemberg, J. J., & Woodford, M. (1992). Oligopolistic Pricing and the Effects of Aggregate Demand on Economic Activity. *The Journal of Political Economy*, 100(6), 1153-1207.
- Sims, C. A. (1980). Macroeconomics and Reality. *Econometrica*, 48(1), 1-48.
- Stephenson, E. F. (1998). Average Marginal Tax Rates Revisited. *Journal of Monetary Economics*, 41(2), 389-409.
- Svensson, L. E. O. (1997). *Optimal Inflation Targets, 'Conservative' Central Banks, and Linear Inflation Contracts*. Unpublished manuscript.
- van den Noord, P., Buti, M., von Hagen, J., & Martinez-Mongay, C. (2002). Automatic Stabilizers in the 1990s and Beyond *The behaviour of fiscal authorities: Stabilization, growth and institutions* (pp. 130-148): Houndmills, U.K. and New York: Palgrave.
- Widmalm, F. (2001). Tax Structure and Growth: Are Some Taxes Better Than Others? *Public Choice*, 107(3-4), 199-219.

Tables and Figures

Table 1: Responses of GDP and Prices to Taxation Shocks in the US²⁶

Empirical study	Sample period		Price responses			GDP responses		
			1 st	4th	12th	1st	4th	12 th
Taxation shock								
Blanchard & Perotti(2002)	1947–1997	S	_*	_*	_*			
Perotti (2005)	1960–2002	S	+	-	_*	_*	_*	_*
Perotti (2005)	1980–2002	S	-	_*	_*	_*	-	_*
Neri (2001)	1965–1996	S	_*	_*	_*	_*	_*	_*
Mountford & Uhlig (2005)	1955–2000	A	+	+	-	_*	_*	_*
Romer & Romer (2007)	1950-2006	N	-	-	-	_*	_*	_*
Canzoneri, et al.(2002)	1960-2001	A	+	-	-	_*	_*	_*

*Statistically significant at the 10% level (the 0 value of the response variable lies outside the plus/minus one standard deviation confidence bands of the estimated response).

N = Narrative approach. A = Agnostic approach. C = Choleski ordering. S = Structural VAR approach.

²⁶ Source: Henry, Hernandez De Cos, & Momigliano (2008), de Castro & Hernandez de Cos (2006) and the papers referenced under “empirical study” in the table.

Table 2: Data Definitions and Sources

Series name	Abb.	Definition	Source
Price level	P	Gross domestic product price deflator	OECD
Gross Domestic Product	GDP	Gross Domestic Product (GDP), measured based on market value basis	OECD
Government spending ²⁷	G	Government final consumption expenditure + Government capital expenditure	OECD
Non-distortionary taxes	S	Indirect taxes (sales and import taxes)	OECD
Distortionary taxes ^{28 29}	D	Direct taxes on household income ³⁰ +Direct taxes on business +Social security taxes +Other direct taxes and transfers	OECD
Corporate taxes (distortionary)	B	+Direct taxes on business	OECD
Labour taxes (distortionary)	L	Direct taxes on household income +Social security taxes	OECD
Net Taxes	NT	Direct taxes on household income +Direct taxes on business +Social security taxes	OECD

²⁷ Following (Perotti, 2005) Government spending excludes interest payments.

²⁸ Following (Kneller et al., 1999) distortionary and non-distortionary taxes are classified according to the relative effect of the tax component on economic agents' incentives to invest.

²⁹ Following (Perotti, 2005) all tax revenues exclude property income and interest receipts.

³⁰ Direct tax on household income includes other capital taxes and transfers.

		+Other direct taxes and transfers +Indirect taxes (sales tax, tariffs) - Subsidies to firms -Transfers to households -Other transfer to the private sector	
Average marginal taxes	AMT	Average marginal tax rate is the marginal tax rate in each income tax bracket weighted by income of all tax payers, as defined by Barro & Sahasakul (1983)	Arin, Berlemann, & Koray (2008)
Interest rate	R	Nominal interest on 10 year US Treasury Bonds.	OECD

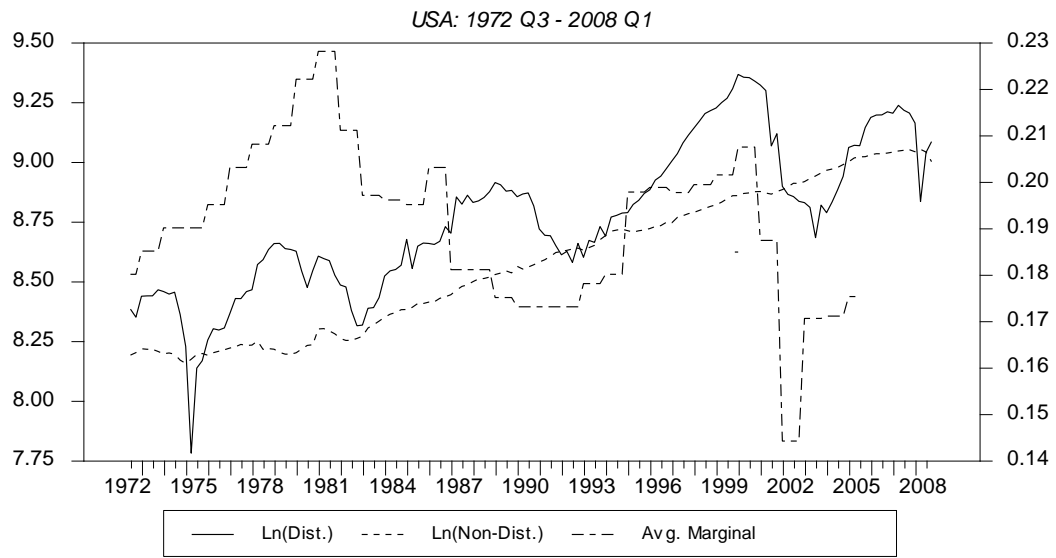
Figure 1: Taxation Measure Comparisons

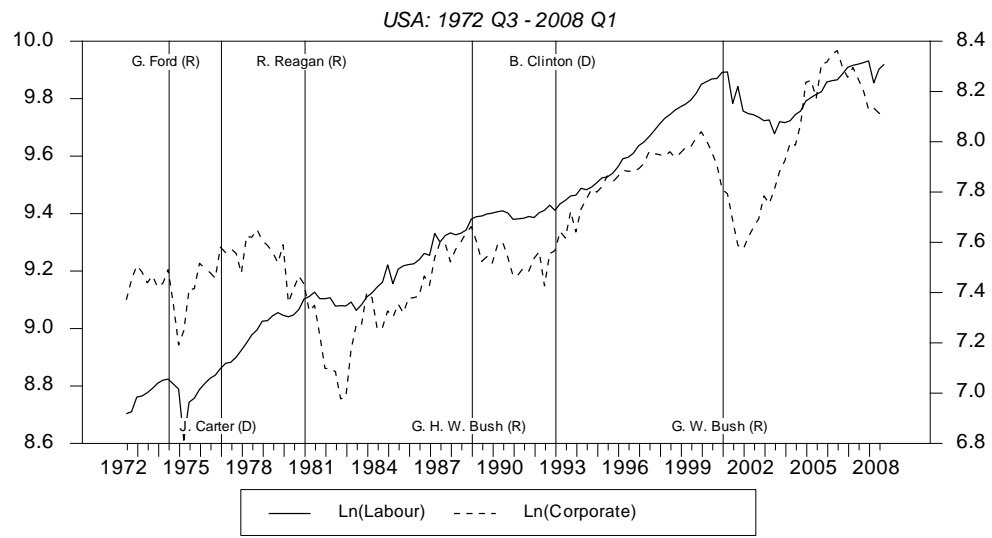
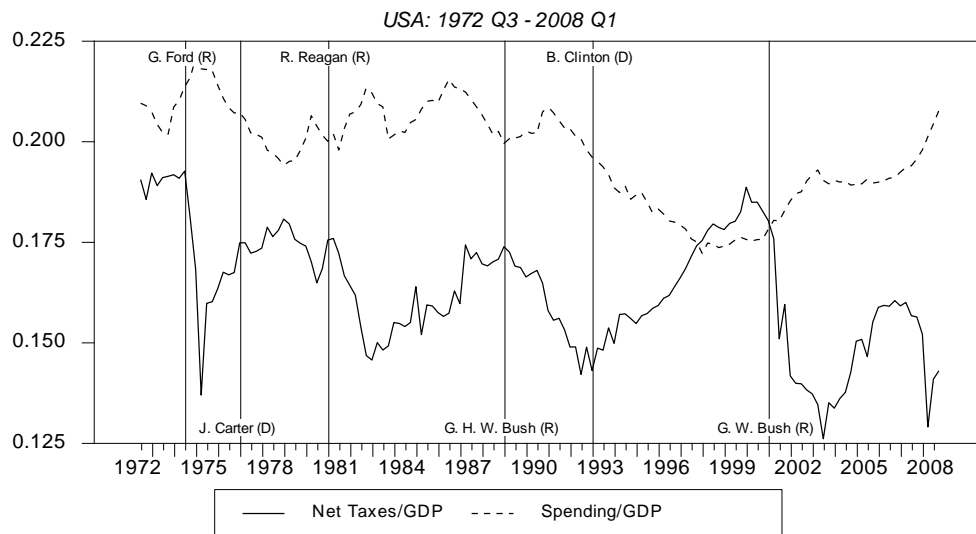
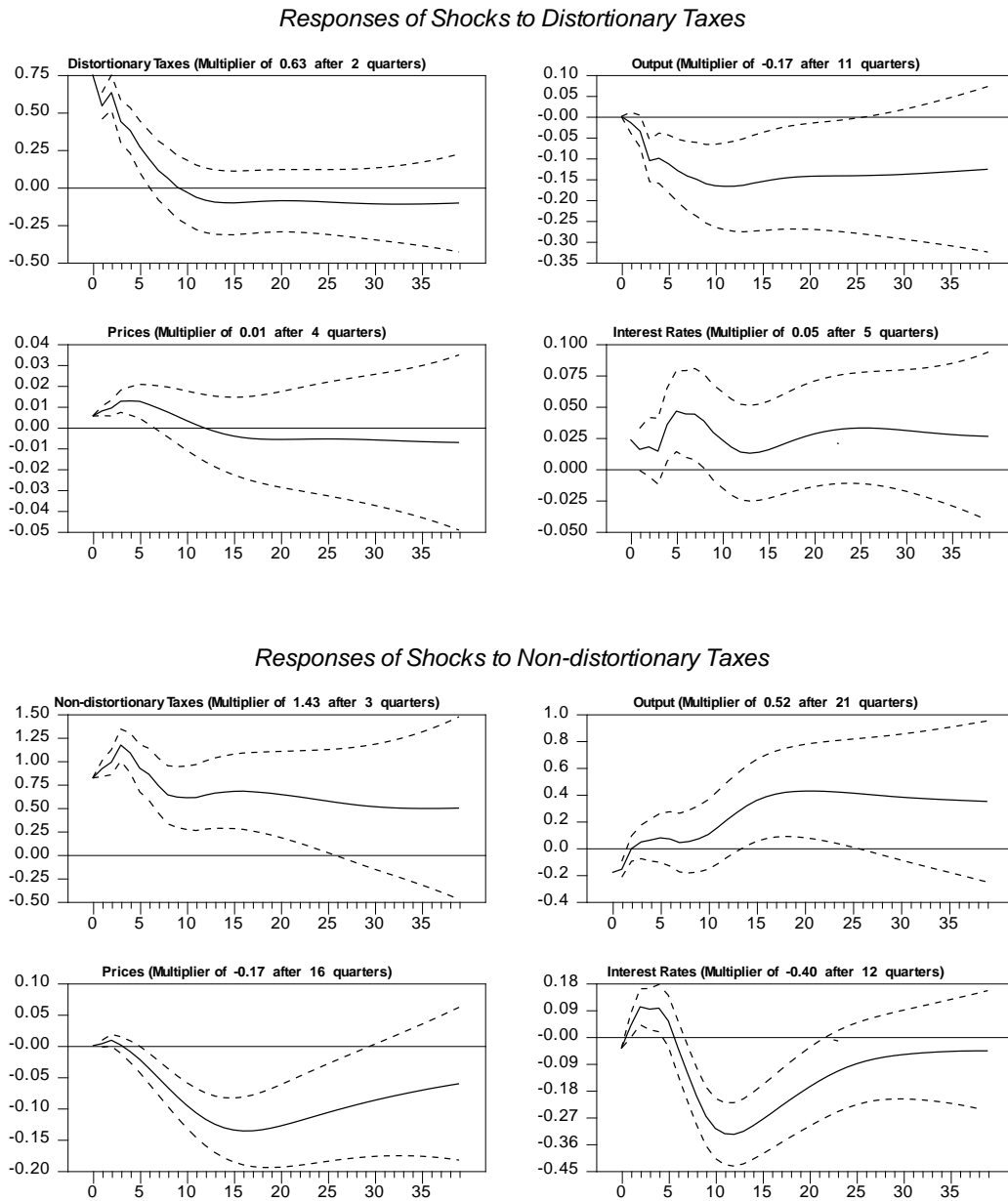
Figure 2: Distortionary Taxes - Labour and Corporate

Figure 3: Net Taxes and Government Spending relative to Output (GDP)



Each vertical line in Figure 3 marks a change of administration. The labels indicate the names of the incoming President.

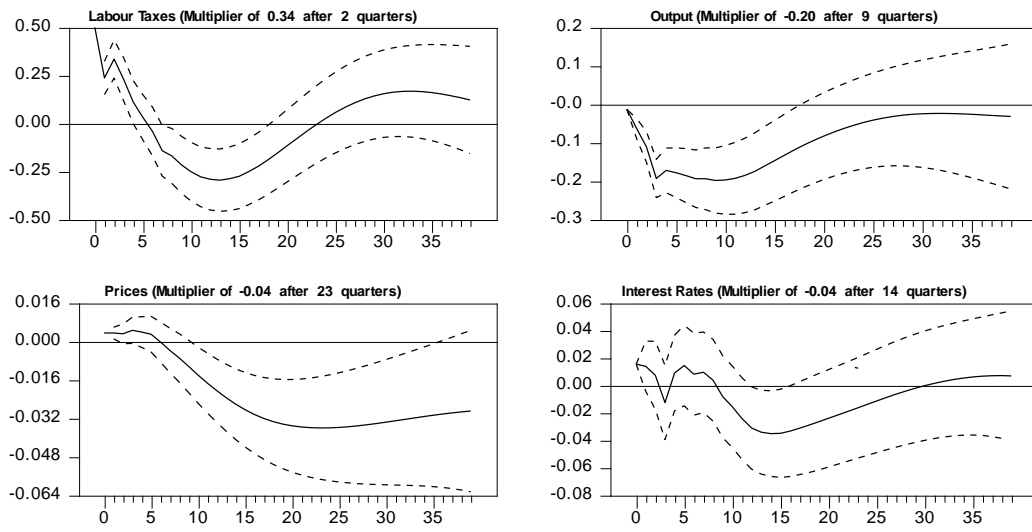
Figure 4: Shocks to Distortionary and Non-Distortionary Tax Revenues (IRFs)³¹



³¹ The Impulse Response Functions (IRFs) are drawn with one standard deviation confidence bands, representing significance of the impulse response at the 10% level. The confidence bands are drawn using a Monte Carlo simulation with 1000 draws from the Wisheart distribution.

Figure 5: Shocks to Labour and Corporate Taxes (IRFs)

Responses of Shocks to Labour Taxes



Responses of Shocks to Corporate Taxes

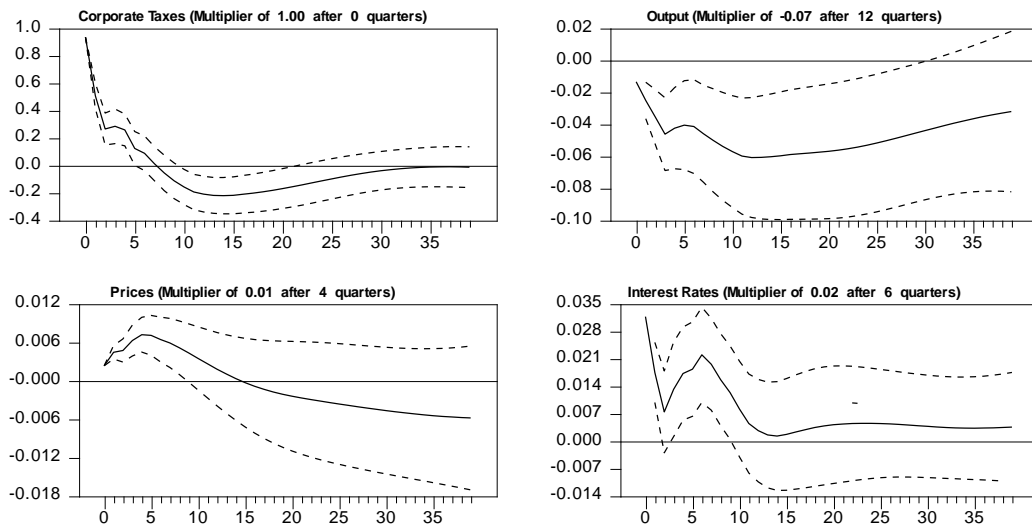
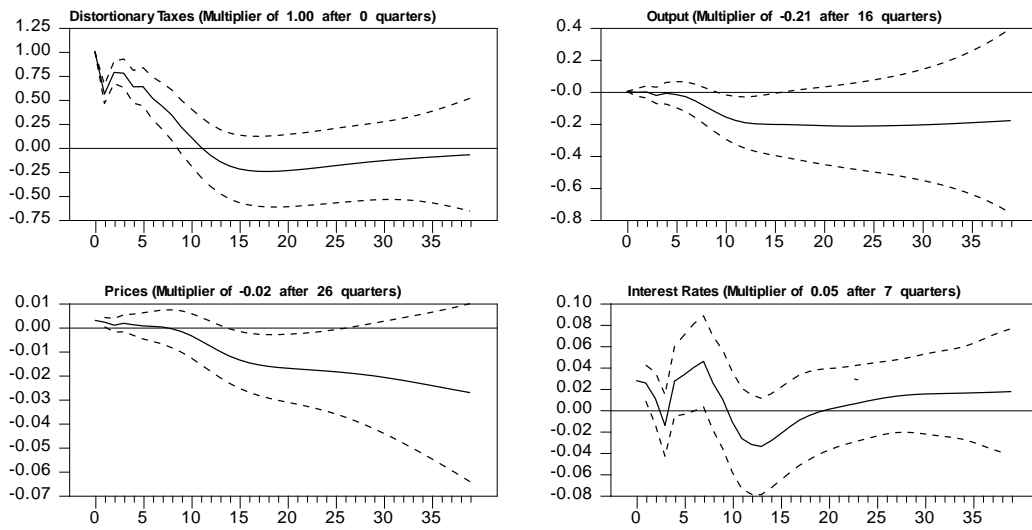


Figure 6: Shocks to Distortionary and Non-Distortionary Taxes (IRF), 1981-2008

Responses of Shocks to Distortionary Taxes



Responses of Shocks to Non-distortionary Taxes

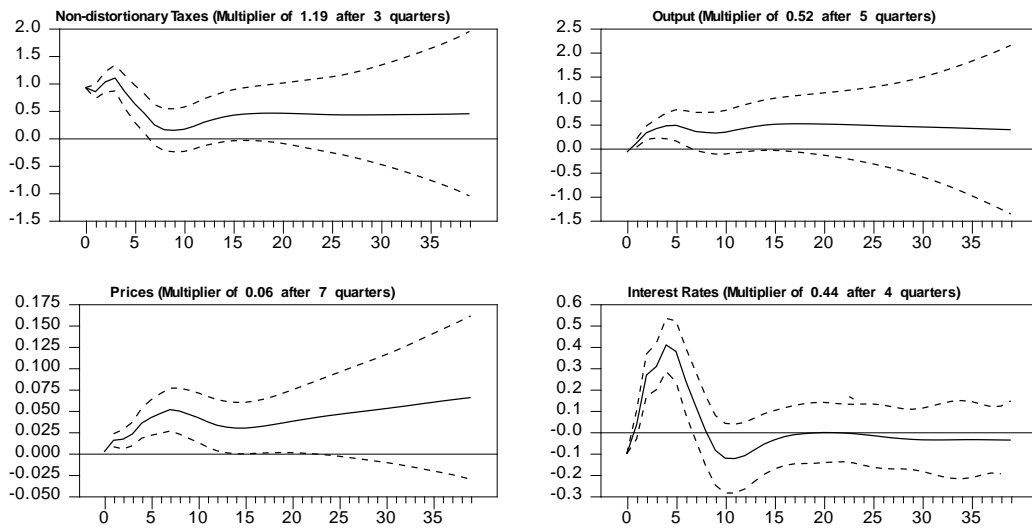
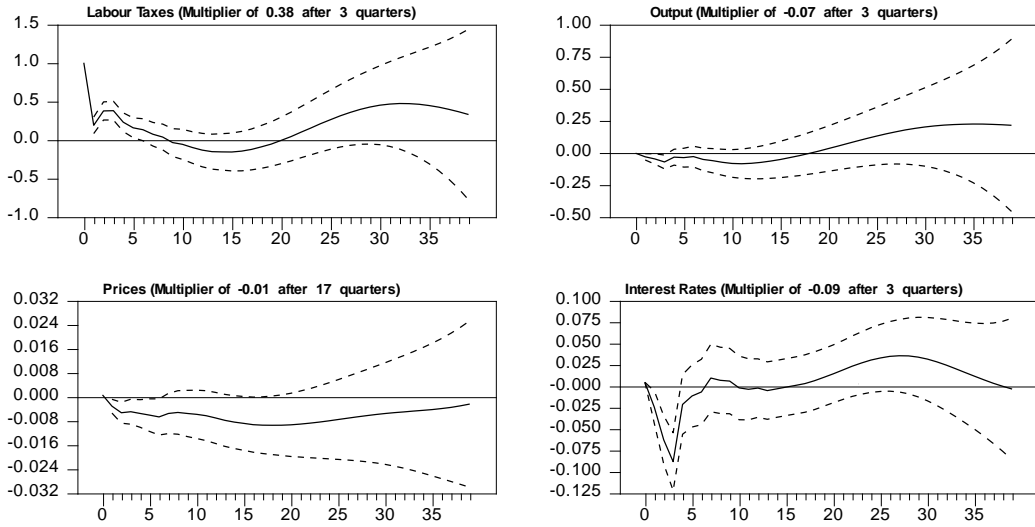


Figure 7: Shocks to Labour and Corporate Taxes (IRF), 1981-2008

Responses of Shocks to Labour Taxes



Responses of Shocks to Corporate Taxes

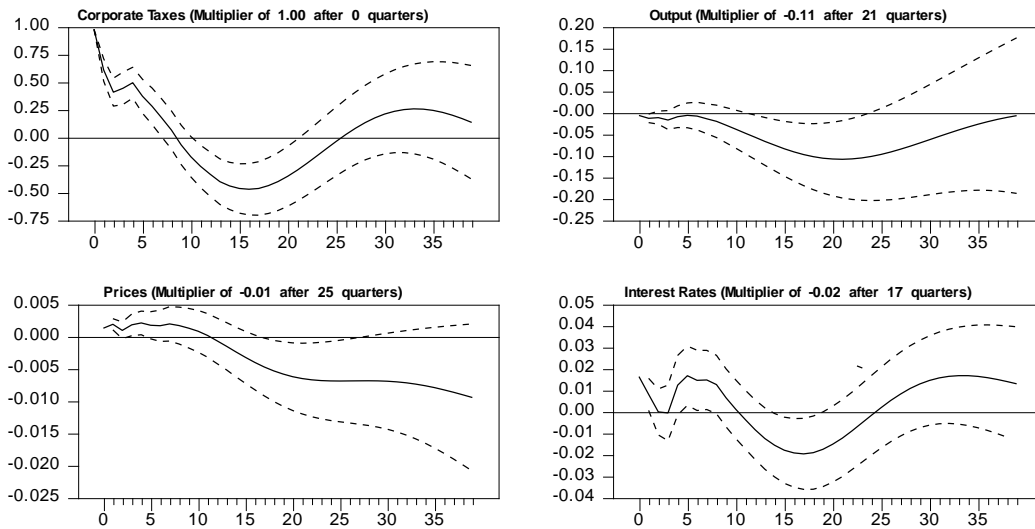


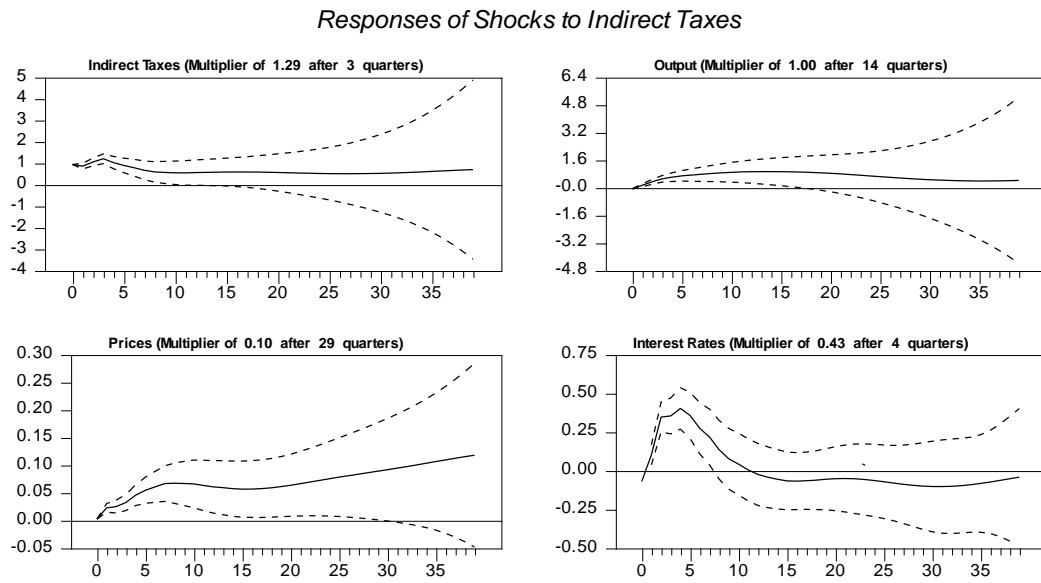
Figure 8: Shocks to Indirect Taxes (IRF), 1981-2008

Figure 9: Residual Analysis (7-SVAR: Labour, Corporate and Indirect Taxes)