The Dynamic Effects of Changes in Business and Income Taxes on Output: Evidence from American Fiscal Policy

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This paper examines the effects of various fiscal shocks on economic activity. Evidence from a structural vector autoregression confirms that government purchases increase GDP and private consumption, while taxes have the opposite effect. Paradoxically, the findings support the (mostly) non-Keynesian view that government spending negatively affects private output. An analysis of specific types of taxes yields an even more nuanced conclusion. In accordance with the new Keynesian and neoclassical schools, social security taxes have a severely negative effect on GDP. On the other hand, personal and corporate income taxes have only weak effects on fluctuations in output. Surprisingly, GDP responds disproportionately to movements in indirect business taxes. Consequently, policymakers should adopt a tax-oriented Keynesian approach to fiscal stimulus, in which the broadest types of taxes are reduced the most.

1. Introduction

On February 13, 2009 the United States Senate passed a $787 billion fiscal stimulus package by a vote of 246-183.[1] To the surprise of President Barack H. Obama, no Republicans voted in favor of the bill. The opposition had two major points of contention with the legislation: 1) most of the package consisted of government spending rather than tax cuts and 2) the plan violated the government's long-term budget constraint. Although the party-line vote reflected deep ideological differences among politicians, it also revealed pre-existing disagreements between economists over the role of fiscal policy. Among the so-called stimulus skeptics, many neoclassical and new Keynesian economists objected to the implementation of Obama's plan, claiming that taxation or monetary policy would be more effective in managing the recession.[2] This dissent corresponds with the neoclassical position that the purpose of fiscal policy is to increase economic efficiency and long-term growth (Judd 1987 and Taylor 2000). Other skeptics sided with the Ricardian theory that changes in government spending or taxation have neutral effects on national consumption (Barro 1974). Conversely, traditional Keynesians maintained that fiscal policy (especially public spending) can effectively counter short-term deviations in output and private consumption (Modigliani 1961).

In this study, I empirically test the Keynesian fiscal hypothesis by determining whether changes in government spending and taxes have economically meaningful effects on output. More pertinent to the recent discourse over the subject, I investigate the relative merits of various fiscal shocks—with special consideration given to business and

[1] Stout, David, "Stimulus Bill Passes in the House with No G.O.P. Support," *The New York Times*, February 14, 2009, A1.
[2] For more information, refer to Greg Mankiw's Blog.

income taxes. In order to measure the short-term effects of changes in spending and taxes, I extend the research of Blanchard and Perotti (2002). First, I replicate Blanchard and Perotti's structural vector autoregression (VAR) of net taxes, government purchases, and output. This VAR confirms the Keynesian fiscal multiplier hypothesis. The evidence shows that government spending and tax cuts are associated with higher output and private consumption—refuting Ricardian equivalence. Furthermore, the results corroborate with Blanchard and Perotti's original conclusion that spending shocks have a somewhat stronger effect on output. On the other hand, the VAR contradicts the Keynesian consensus in the sense that increases in government spending have much weaker (and negative) effects on the private sector than reductions in taxes.

Second, I decompose net taxes into five types: indirect business taxes, personal income taxes, social security taxes, corporate income taxes, and net transfers. I modify the VAR approach in order to measure of the effect of shocks in these individual categories. I find that social security withholdings and indirect business taxes have strongly negative effects on GDP. Evidence with respect to the latter, however, is statistically very weak. Contrary to neoclassical theory, personal income taxes and corporate income taxes have only slight negative effects on output and its components. Net transfers also have little effect on economic activity. I conclude that these estimates support a less traditional version of Keynesian theory, in which broad tax reductions are the best means for increasing GDP and its private components. For the remainder of this treatment, I: 1) review the recent literature about the effects of tax policy, 2) establish a VAR model and procedure for indentifying the structural shocks in the fiscal variables, 3) present my results with regard to the contemporaneous and dynamic effects of the fiscal variables, and 4) analyze and critique the VAR findings.

2. Literature Review

Most empirical research on the short-term effects of taxes seek to test either the Ricardian equivalence hypothesis or its more general counterpart—the Life Cycle Permanent Income Hypothesis (LCPIH). If LCPIH is correct, then households should respond to transitory shocks in income (possibly from tax reductions) by slightly increasing—or smoothing—consumption over a long period of time. More strictly, if Ricardian equivalence holds, an increase in private saving should completely offset public dissaving. On the other hand, if households behave in a Keynesian manner, an increase in the national debt (from tax cuts) will have positive effects on consumption and potential negative effects on private investment. In this section, I outline some of the key literature that supports either a Ricardian or Keynesian outcome.

In terms of the consumption function, economists have conducted several different types of empirical research on the effect of fiscal shocks on households' propensities to consume. The earliest econometric literature tends to estimate the effect of fiscal shocks through aggregate time series regressions. Hall (1978) affirms LCPIH by regressing consumption on disposable income, but notes that fiscal stimuli may still affect consumption if the change in disposable income is unanticipated and perceived as permanent. Blinder (1981) confirms this intuition with a time series study on tax shocks. These results show that aggregate consumption responds much more due to permanent tax decreases than tax rebates. In fact, 81 percent of a permanent tax reduction is spent within two years of its distribution. However, Blinder estimates that both types of tax cuts have significantly positive effects on consumption. Hence, the early time series tests of Ricardian equivalence generally favor a Keynesian view of the response of consumption to tax shocks.

Another technique is to evaluate micro-level data on expenditure receipts. Agarwal, Liu, and Souleles (2007) extend the research of Gross and Souleles (2002) in order to determine whether credit card data support Ricardian equivalence. According to the data, consumers *initially* used the 2001 federal income tax rebate to pay off the balance on their credit card account, but increased consumption expenditures within six to nine months upon receiving the rebate. Agarwal, Liu, and Souleles note that individuals who were credit constrained increased consumption expenditures far more than any other group in the sample (pp. 1010). Ultimately, the authors argue that these results support the hypothesis that credit constraints enable deficit-financed tax reductions to have non-neutral effects on consumption and saving. Although Ricardian economists may raise objections to this statement, Agarwal, Liu, and Souleles successfully resolve some of the key issues with survey-based analysis. One such improvement is that the authors process data that are based on credit card records rather than self-reported expenditure accounts. This aspect greatly reduces measurement error. Thus, Agarwal, Liu, and Souleles establish a compelling micro-level procedure for testing Ricardian equivalence.

With respect to macro-level research, Blanchard and Perotti (2002) introduce one of the better approaches to testing Ricardian equivalence. The economists construct a four-variable structural VAR that shows that government spending and net taxes have significantly positive and negative effects on consumption, respectively. This estimation technique has several distinct advantages over conventional time series regressions and simulations. First, VAR is preferable to simulations because it analyzes actual data and relies on a minimal set of theoretical assumptions. As a result, VAR has a fairly high level of theoretical robustness. Second, through the use of residual identifications, VAR has the flexibility to impose institutional or theoretical assumptions on the data. This structure allows for a more explicit evaluation of the effect of tax shocks on consumption. Thus, the methodology of Blanchard and Perotti combines the strengths of both simulations and event-studies in order to assess Ricardian theory.

Moreover, the advantages of this new approach are obvious by the fact that subsequent econometric studies have employed analogous procedures. Fatas and Mihov (2001) and Giordano *et al.* (2007) replicate the above research with a slightly different set of identifications and cases. Both papers find that Ricardian equivalence does not hold. Fatas and Mihov even claim that Keynesian theory is more predictive of the impact of tax policy on real economic activity than neoclassical theory. In contrast, Perotti (2005) uses a six-variable VAR (he adds inflation and interest rates as control variables) in order to estimate the effects of fiscal shocks in five OECD countries. Perotti finds that the impulse response of consumption to fiscal shocks has weakened since 1980. While this analysis may support Ricardian equivalence, Perotti further notes that fiscal shocks are increasingly affecting real interest rates. Hence, the effectiveness of fiscal policy may be weakening for reasons that are non-Ricardian (but perhaps neoclassical).

The VAR approach has also provided evidence on fiscal hypotheses that are not directly related to Ricardian equivalence. Blanchard and Perotti (2002) show through their VAR analysis that negative tax shocks have positive effects on output and private investment. Therefore, the findings generally support the Keynesian view that tax policy can shift aggregate demand. However, Blanchard and Perotti estimate that increases in *both* taxes and government expenditures have strong negative effects on investment. This outcome contradicts the conventional Keynesian view that the two fiscal adjustments have opposing effects (pp. 3). Furthermore, Perotti (1999) indicates that high amounts of national debt can move an economy into a so-called non-Keynesian region. In this region, private sector households and firms do not believe that the government can credibly finance tax reductions (or spending increases) through an increase in national debt. Thus, deficit-financed fiscal shocks have a non-positive effect on output in countries with high levels of debt.

Furthermore, some non-VAR techniques support a number of neoclassical views on the effects of specific types of taxes. Dahan and Hercowitz (1998) analyze the effect of income tax policy on economic activity in Israel. Dahan and Hercowitz assert that the Israeli macroeconomic time series is especially tractable, because of its high level of variation in fiscal, monetary, and growth variables. The most notable result of the article's regressions is that high income taxes are associated with low rates of saving. In accordance with neoclassical theory, this outcome indicates that income taxes lead to distortionary effects on saving, and therefore, a lower steady-state of growth. Conversely, the computer simulations of Gale and Orszag (2005) project that the Bush income tax reductions *increase* the user cost of capital. The causal rationale for this prediction is that the Bush tax cuts increase the national debt, such that they increase the real interest rate and decrease private investment. Hence, neoclassical policies that are not revenue-neutral may be suboptimal because they inhibit investment and potential growth.

A series of studies have additionally investigated the optimality of labor income taxes. Scott (2007) generates GMM estimates on the efficiency and revenue effects of labor income taxes. Scott argues that a close evaluation of his estimates shows that bond markets are incomplete. Due to these imperfect markets, the government's primary concern should be to ensure that it satisfies its intertemporal budget constraint. Similar to Chari, Christiano, and Kehoe (1994), Scott's evidence supports the position that the optimal labor income tax is positive and relatively constant. Meanwhile, Feldstein (1995 and 1999) finds that the elasticity of taxable income on labor is greater than unity in the United States, because households evade taxes by substituting nontaxable compensation for taxable income. This inelasticity of taxable income implies a dead-weight loss that exceeds the revenue gains from higher income taxes. Thus, the optimal policy is to minimize the marginal rate of income taxes on labor. Moreover, Feldstein (1996, pp. 158) uses OLS regressions to estimate that the social security tax structure is associated with a nearly 60 percent reduction private saving. Feldstein states that this finding justifies the neoclassical theory that the optimal net income tax structure is uniform across all households.[3]

In this paper, I test (as many as possible of) the above claims on the effects of tax policy by decomposing the net taxes variable in Blanchard and Perotti's VAR specification. To my knowledge, this study is the first instance in which a VAR is employed in order to measure the effects of changes in specific types of taxes, as opposed

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[3] Social security taxes are not uniform because the present values of social security benefits vary according to age, gender, and income.

to the effects of changes in a lump-sum of all taxes. I hope to test a broader set of hypotheses than Blanchard and Perotti address in their original VAR. I also replicate the research of Blanchard and Perotti in order to confirm their findings on the short-term effects of tax and government spending shocks. These two procedures offer an assortment of evidence that complements the existing research on the relationship between fiscal policy and economic activity.

3.1 The Baseline VAR

My baseline VAR follows the same specification as Blanchard and Perotti:

$$Y_t = A(L, q)Y_{t-1} + U_t. \qquad (1)$$

In this equation, Y_t is the three-dimensional vector $[T_t, G_t, X_t]'$; where T_t is net tax revenues, G_t is government purchases of goods and services, and X_t is GDP. A(L, q) is a four-quarter distributed lag polynomial that accounts for quarter-dependence in the variables (see the next subsection). U_t is the vector of generally correlated residuals $[\tau_t, g_t, x_t]'$; where τ_t is for taxes, g_t is for expenditures, and x_t is for GDP. I also use three variations of the above specification. In the first alternative, Y_t is the four-dimensional vector $[T_t, G_t, X_t, X_t^k]'$, where X_t^k is the k^{th} component of GDP. In the second alternative, Y_t is the vector $[T_t^i, T_t^j, G_t, X_t]'$, where T_t^i is the i^{th} component of net taxes and T_t^j is the sum of all other tax components. Finally, the third alternative decomposes both taxes and output with the vector $[T_t^i, T_t^j, G_t, X_t, X_t^k]$. All of these specifications follow the same functional form as equation (1).

Unless otherwise stated, all samples include seasonally-adjusted quarterly data from 1960:1 to 2007:4. All variables are measured in logarithmic real per capita terms.[4] I define net taxes (TAX) to be equal to the sum of indirect business taxes (IND), personal income taxes (PIT), social security taxes (SST), and corporate income taxes (CIT) minus net transfers (NTR).[5] Conversely, government spending (GOV) is the total of all federal, state, and local purchases. The third variable—GDP—is the sum of government spending, consumption (CON), private investment (INV), and exports (EXP) minus imports (IMP). More detailed information on the data is provided in the second section of the appendix.

3.2 Stationarity in the Endogenous Variables

In order to effectively estimate the covariance matrices in equation (1), one needs transform the data into a set of stationary variables. In addition to the standard procedure of first-differencing the data, I use several techniques in order to achieve stationarity. First, I add a set of (exogenous) dummy variables in order to control for variation during periods of (extremely) discontinuous movement in the tax variables. For instance, I control for a large temporary tax cut by including a dummy for 1975:2 in all reduced-form equations. (I discuss this issue more thoroughly in section 4.1.) Second, equation (1) includes a four-quarter distributed lag polynomial for all endogenous variables. This polynomial has two distinct characteristics: it allows for deterministic trends in the data

[4] All of the data has been converted into chained 2000 US dollars. I use the GDP deflator to convert all variables into real terms, since this method allows me to characterize all data as shares of GDP. This aspect has a minimal effect on the data (Blanchard and Perotti 2002).
[5] Net interest and dividend payments are included in the net transfers component.

and it allows for quarter-dependence. The deterministic trends remove any upward drift in the variables (see section 4.1). To allow for these trends, all reduced-form equations include quadratic and linear terms for change over time.

With regard to quarter-dependence, I include dummy variables for three of the four quarters in a year. More formally, this feature can be represented as:

$$Y_t = B_0(L)^*Y_{t-1} + B_1(L)^*\mathbf{q_1}^*Y_{t-1} + B_2(L)^*\mathbf{q_2}^*Y_{t-1} + B_3(L)^*\mathbf{q_3}^*Y_{t-1} + U_t.$$

In this equation, q_1, q_2, and q_3 are dummy variables for quarter one, quarter two, and quarter three, respectively. Like the other dummies, the quarter-dependent terms are treated as exogenous with respect to the VAR system ($B_0[L]^*Y_{t-1}$ is endogenous). This element of the model accounts from the tendency of some types of taxes to be collected almost exclusively in the fourth quarter of each year.[6] Due to methodological issues, I do not use quarter-dependent dummies for the structural decomposition of the VAR.[7] I use the quarter-dependent dummies for estimating the structural identifications of the VAR. Then I obtain the impulse response functions from an identified VAR, which does *not* include quarter-dependent dummies. In this sense, I do not completely remove quarter-dependence from the data. However, the outlined procedure is far better than any obvious alternative and allows me to assume stationarity in the data.

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[6] Blanchard and Perotti (2002) aptly argue that the normal seasonal-adjustment process does not adequately control for quarter-dependence. The argument follows that seasonal-adjustment does not address quarter-specific differences in the *interactions* between GDP and taxes. See Blanchard and Perotti's paper for a more rigorous explanation of this fact.

[7] Using the quarter-dependent dummies in such a manner eliminates all of the degrees of freedom, according to Blanchard and Perotti. I have confirmed this limitation through my own experimentation.

3.3 Identifications

In order to identify the uncorrelated residuals (or structural shocks) e_t^{τ}, e_t^{g}, and e_t^{x}, I use Blanchard and Perotti's system of equations:

$$\begin{aligned} \tau_t &= a_1 x_t + a_2 e_t^{g} + e_t^{\tau} \\ g_t &= b_1 x_t + b_2 e_t^{\tau} + e_t^{g} \\ x_t &= c_1 \tau_t + c_2 g_t + e_t^{x}. \end{aligned} \qquad (2)$$

The residuals τ_t, g_t, and x_t represent the unexpected changes in taxes, government expenditures, and GDP, respectively. In the first equation, $a_1 x_t$ is the contemporaneous response of taxes to an unexpected movement in GDP. The component $a_2 e_t^{g}$ is the response of taxes to a structural shock in government purchases and the component e_t^{τ} is the structural shock to taxes. The other two equations follow an analogous interpretation.

Similarly, I identify the decomposition of GDP with the equations:

$$\begin{aligned} \tau_t &= a_1 x_t + a_2 e_t^{g} + e_t^{\tau} \\ g_t &= b_1 x_t + b_2 e_t^{\tau} + e_t^{g} \\ x_t &= c_1 \tau_t + c_2 g_t + e_t^{x} \\ x_t^{k} &= d_1 \tau_t + d_3 g_t + e_t^{xk}. \end{aligned} \qquad (3)$$

These equations have essentially the same interpretation as system (2). The only difference between the two identifications is the inclusion of x_t^{k}—the unanticipated movement of the k^{th} component of GDP. In order to find the coefficients in systems (2) and (3), I use the same three-step procedure as Blanchard and Perotti.

First, I exploit institutional information about taxes, transfers, and government spending in order to find a_1 and b_1. Since the VAR specification classifies transfers as a component of net taxes, government spending is largely composed of discretionary expenditures that do not automatically respond to fluctuations in GDP. With regard to discretionary changes to spending, research indicates that policymakers and legislatures typically take more than one quarter to respond to output shocks (Blanchard and Perotti 2002). In addition to this recognition lag, government purchases are subject to notable implementation lags due to the practical limitations of quickly expanding or contracting government programs. Thus, I assume that b_1 is zero, meaning that output shocks have no contemporaneous effect on shocks in government spending.

For a_1, I find the elasticities of net taxes to GDP. To calculate these values, I use the techniques of Blanchard and Perotti, and Giorno *et al.* (1995). To start with, let $\boldsymbol{T_t}$ denote the *level* of net taxes—tax revenue minus transfer, interest, and dividend payments—at time t. Also, $\boldsymbol{T_t^i}$ is the level of the ith tax (or transfer) at time t. The reader should notice that $\boldsymbol{T_t}$ is in dollar terms, rather than logarithmic terms (as is the case with T_t). This distinction allows $\boldsymbol{T_t^i}/\boldsymbol{T_t}$ to express the level of tax i as a share of net taxes. Also, $ή_t^i$ indicates the output elasticity of the ith tax type. With these tax shares and elasticities, I express the elasticity of net taxes to GDP (a_1) at time t to be:

$$a_{1(,\,t)} = \sum (ή_t^i * \boldsymbol{T_t^i}/\boldsymbol{T_t}) \text{ for all i.} \qquad (4)$$

In words, a_1 is equal to the weighted sum of the various tax elasticities. One of the most important aspects of this calculation is that a_1 does not have a constant value. Instead the above expression is evaluated for each quarter, allowing the value of a_1 to change over time. I further examine the implications of this characteristic in section 4.2. Moreover, I provide details on the retrieval of $ή_t^i$ in the third section of the appendix.

Second, with a_1 and b_1, I have the *cyclically-adjusted* shocks for net taxes and government spending. The adjusted residuals for taxes are $\tau_t – a_1x_t$ (or $a_2e_t^g + e_t^\tau$), where a_1 is calculated for each quarter. The adjusted residuals for spending are g_t (or $b_2e_t^\tau + e_t^g$), since b_1 equals zero. Because these adjusted residuals are uncorrelated with x_t, I use them as instruments to estimate c_1 and c_2 in a regression of x_t on τ_t and g_t. For the identifications in system (3), I use the adjusted residuals as instruments for a regression of x_t^k on τ_t and g_t. This regression estimates d_1 and d_2.

Third, I identify a_2 and b_2. The cyclically-adjusted residuals for taxes and government spending are not strongly correlated. Thus, I estimate a_2 by restricting b_2 to zero and regressing $\tau_t - a_1x_t$ on e_t^g. Conversely, I find b_2 by restricting a_2 to zero and regressing g_t on e_t^τ. I use the latter procedure to estimate the dynamic effects of taxes and the former procedure to estimate the dynamic effects of government spending. In other words, the fiscal variable that I am testing is ordered first, unless otherwise noted.

Next, I identify the VAR for the decomposition of taxes:

$$\begin{aligned}
\tau_t^i &= a_1x_t + a_2e_t^g + a_3e_t^{\tau j} + e_t^{\tau i} \\
\tau_t^j &= b_1x_t + b_2e_t^g + b_3e_t^{\tau i} + e_t^{\tau j} \\
g_t &= c_1x_t + c_2e_t^{\tau i} + c_3e_t^{\tau j} + e_t^g \\
x_t &= d_1\tau_t^i + d_2\tau_t^j + d_3g_t + e_t^x.
\end{aligned} \qquad (5)$$

τ_t^i is the correlated residual for the single component of net tax revenues that I am testing, while τ_t^j is the residual for the aggregate of all other tax components. In contrast to system (3), this system contains an additional dimension, because both shocks τ_t^i and τ_t^j are allowed to have contemporaneous effects on output.

Finally, I combine systems (3) and (5) in order to identify the decomposition of taxes and GDP:

$$\begin{aligned}
\tau_t^i &= a_1x_t + a_2e_t^g + a_3e_t^{\tau j} + e_t^{\tau i} \\
\tau_t^j &= b_1x_t + b_2e_t^g + b_3e_t^{\tau i} + e_t^{\tau j} \\
g_t &= c_1x_t + c_2e_t^{\tau i} + c_3e_t^{\tau j} + e_t^g \\
x_t &= d_1\tau_t^i + d_2\tau_t^j + d_3g_t + e_t^x \\
x_t^k &= f_1\tau_t^i + f_2\tau_t^j + f_3g_t + e_t^{xk}.
\end{aligned} \qquad (6)$$

The three-step methodology for retrieving the coefficients of systems (5) and (6) is quite comparable to the procedure for systems (2) and (3).

To begin with, I estimate a_1, b_1, and c_1. The coefficient c_1 (like b_1 in systems [2] and [3]) is restricted to zero. I can use $ή_t^i$ for the values of a_1—since a_1 is, by definition, the elasticity of tax i to GDP during quarter t. The values of b_1 are a bit more difficult to find. These calculations are made using an expression that is similar to equation (4):

$$b_{1(,t)} = \sum (ή_t^j * \boldsymbol{T_t^j}/[\boldsymbol{T_t}-\boldsymbol{T_t^i}]) \text{ for all } j \neq i. \qquad (7)$$

The main difference between equations (7) and (4) is that the numerator and denominator of equation (7) negate the tax of type i. Both a_1 and b_1 change over time.

Second, I back-out the cyclically-adjusted residuals for taxes and government spending: $\tau_t^i - a_1x_t$, $\tau_t^j - b_1x_t$, and g_t. I use these adjusted shocks as instruments to estimate d_1, d_2, and d_3 through a regression of x_t on τ_t^i, τ_t^j, and g_t. For system (6), the instruments further allow me to determine f_1, f_2, and f_3 from a regression of x_t^k on τ_t^i, τ_t^j, and g_t.

Finally, I order taxes of type i first by restricting a_2 and a_3 to zero. This assumption provides me with the structural shocks $e_t^{\tau i}$ (they are $\tau_t^i - a_1x_t$). Taxes that are not of type i are ordered second, which implies that b_2 is equal to zero. I find b_3 by regressing τ_t^j on $e_t^{\tau i}$. Finally, I retrieve c_2 and c_3 by regressing g_t on $e_t^{\tau i}$ and $e_t^{\tau j}$.

The above steps identify the structural shocks for my VAR model. I am now prepared to estimate impulse responses of GDP and its components to structural shocks in government spending and net taxes. Moreover, I am able to characterize the dynamic effects of shocks in specific types of taxes.

4.1 Characteristics of the Data

Figure 1 and Figure 2 (on the following pages) illustrate the path of the major variables over time. Not surprisingly all of the variables demonstrate an upward trend. GDP and consumption closely follow a deterministic trend, while investment and the fiscal variables are subject to significant short-term fluctuations. Table 1 shows the results from a battery of augmented Dickey-Fuller tests for unit roots in the data. All of these tests reject the null hypothesis of a unit root at a 95 percent level of significance. In other words, each series consistently fluctuates about a deterministic trend. Accordingly, I allow for a deterministic trend in my VAR specifications (including both quadratic and linear terms for change over time). Blanchard and Perotti also make this assumption in their VAR.[8]

Table 1: Augmented Dickey-Fuller test statistics.

Series	**t-statistic**	**p-value**	**Series**	**t-statistic**	**p-value**
GDP	-5.3553	0.0001	TAX	-5.3553	0.0001
CON	-5.9087	0.0000	IND	-6.2179	0.0000
INV	-7.8133	0.0000	PIT	-5.7419	0.0000
NEXP	-9.0701	0.0000	SST	-6.1001	0.0000
EXP	-4.9661	0.0003	CIT	-6.3675	0.0000
IMP	-8.9588	0.0000	NTR*	-6.2478	0.0000
GOV	-3.9148	0.0133	NID	-6.2478	0.0000

Notes: The null hypothesis is the presence of a unit root in the first differences of each series (a deterministic trend and four lags are allowed); net transfers (NTR) in the results section is equal to NTR* plus NID (I ran this sum through the Dickey-Fuller test); an abbreviation key is available in the first section of the appendix. Sample: 1960:1-2007:4.

[8] Blanchard and Perotti (2002) take an agnostic approach with regard to the deterministic trend assumption. They report two results for all of their regressions: one using a deterministic trend and one using a stochastic trend. The results under the stochastic trend are essentially the same as those under the deterministic approach. Thus, I simply defer to the Dicker-Fuller statistics and run all my VARs under the deterministic assumption.

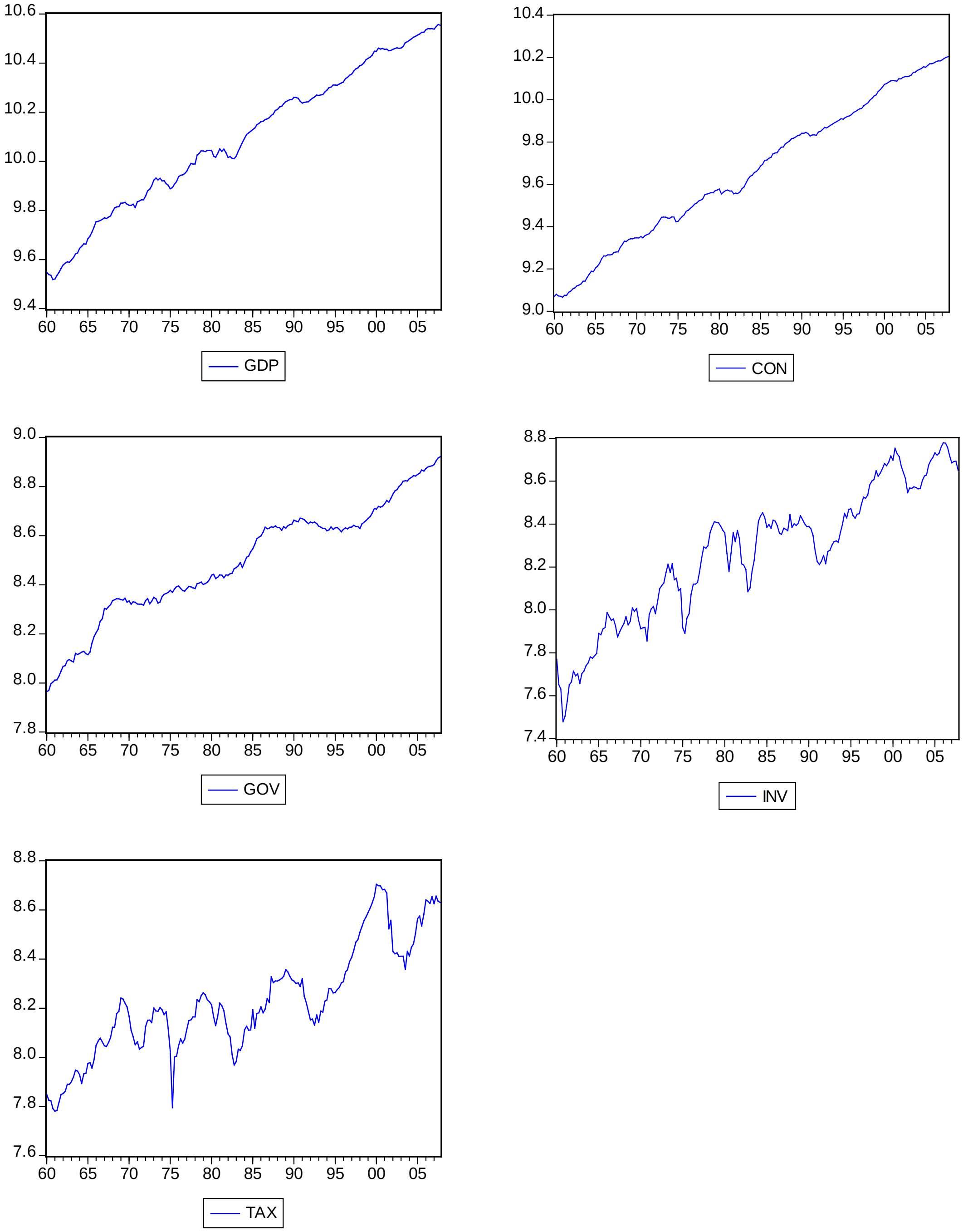

Figure 1: Logarithms of per capita GDP, government spending, net taxes, consumption, and private investment over time. (Export and import graphs are available in the appendix.) Sample: 1960:1-2007:4.

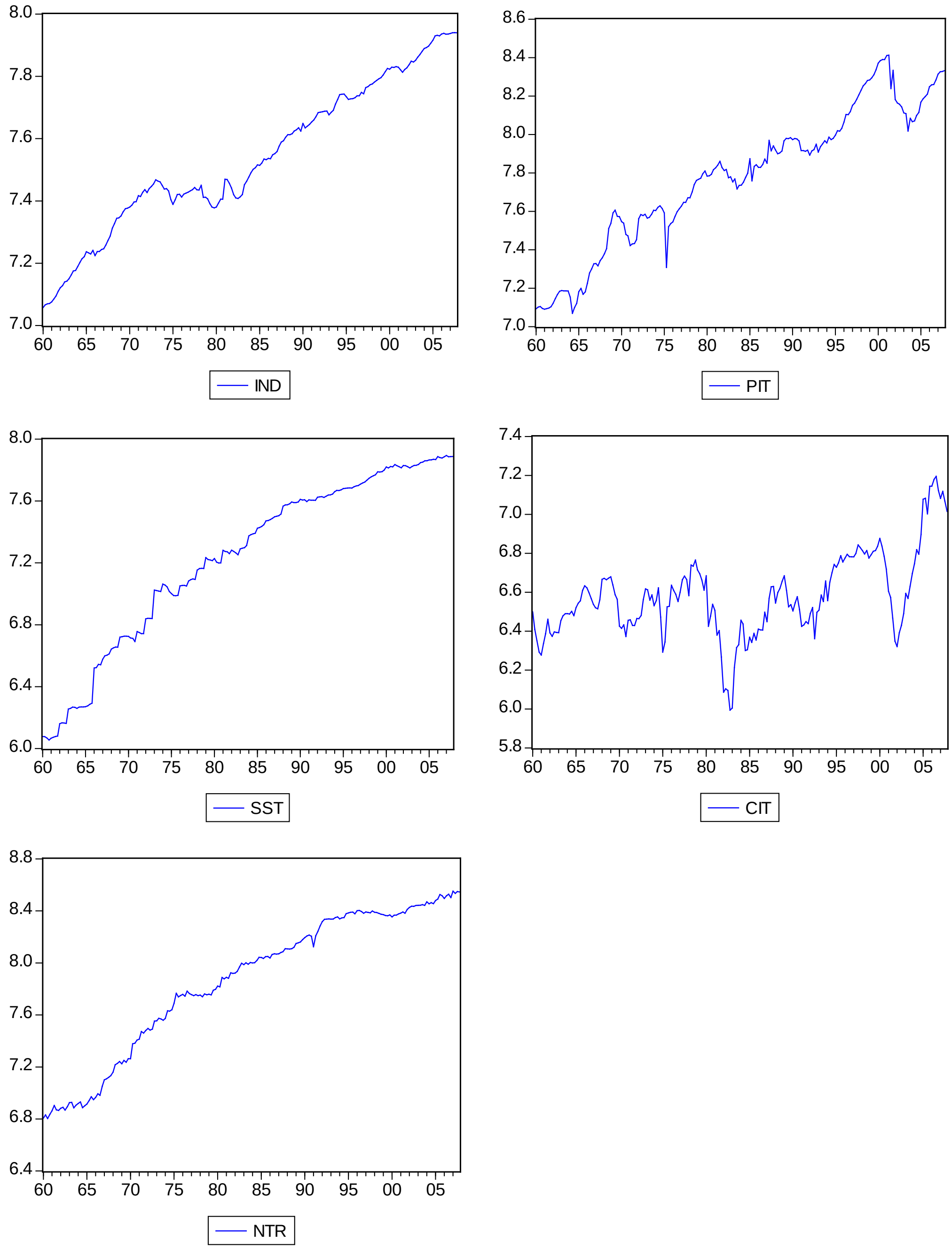

Figure 2: Logarithms of per capita indirect business taxes, social security taxes, net transfers, personal income taxes, and corporate income taxes over time. Sample: 1960:1-2007:4.

Turning to the high-frequency characteristics of the data, Figure 3 and Figure 4 show depictions of the reduced-form residuals. In order to construct these graphs, I run the simplest VAR possible for each variable, allowing for quadratic and linear trends in the data (but excluding dummies or quarter-dependence). In essence, Figure 3 and Figure 4 report unanticipated movements in the variables. This procedure enables me to identify extreme breaks in the data that cannot be explained by a stochastic response. Based on these graphs, I found six such fluctuations in the data. The largest shock is a massive temporary tax cut in 1975 (Figure 3, TAX Residuals), which is dummied in all reduced-form regressions. The earliest shocks occur in 1966 and 1973 due to changes in the withholding rate of payroll taxes (Figure 4, SST Residuals). To account for these shifts, I include dummies in 1966 and 1973, when estimating the contemporaneous and dynamic effects of social security taxes. I use a 1991 dummy for regressing equations that endogenize net transfers (Figure 4, NTR Residuals). I believe that this discontinuity in the data is due to the Savings and Loan bailout of 1991. I also include a September 11th dummy for government spending, net taxes, and personal income taxes.[9]

The final discontinuity occurs for indirect business taxes in 1981 (Figure 4, IND Residuals). I am not sure what event causes this break.[10] However, I dummy indirect business taxes in order to guarantee the robustness of my estimates. In fact, for all results that follow this subsection, the underlying equations include dummy variables for the pertinent specifications. In most instances, the dummies for the various tax variables have little effect on the structural VAR estimates (see section A.6). More detailed information on the dummy variables is available in section A.4.

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[9] The graphs show evidence of a September 11th effect in net taxes and personal income taxes.

[10] My best guess is that state and local governments raised sales taxes during the 1981 recession in order to compensate for lost revenue.

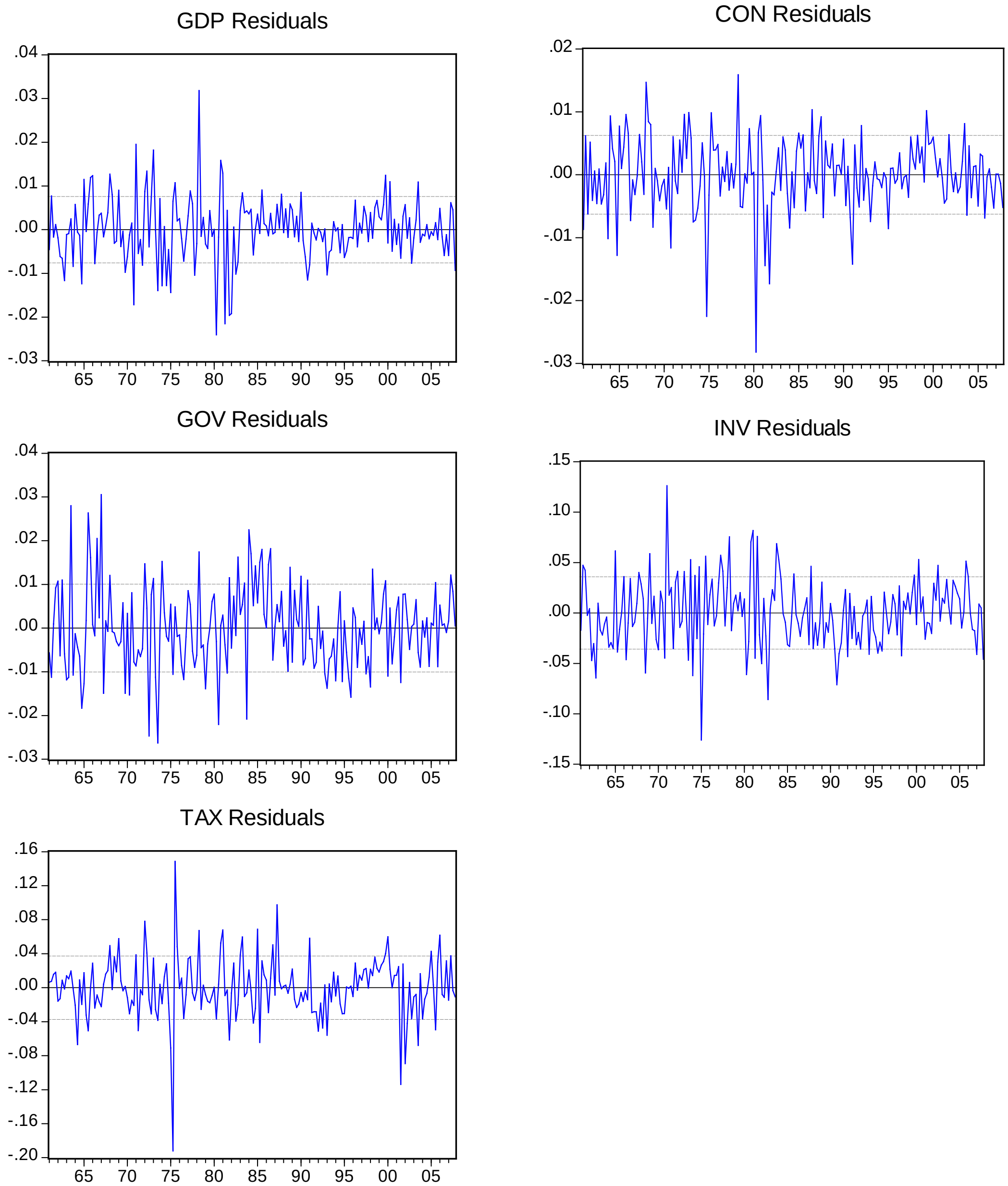


Figure 3: Reduced-form residuals (in logarithms) of GDP, government spending, net taxes, consumption, and private investment. (Export and import graphs are in the appendix.)

Notes: Reduced-form equations allow for deterministic trends in the data, but neither quarter-dependence nor dummy variables. Sample: 1960:1-2007:4.

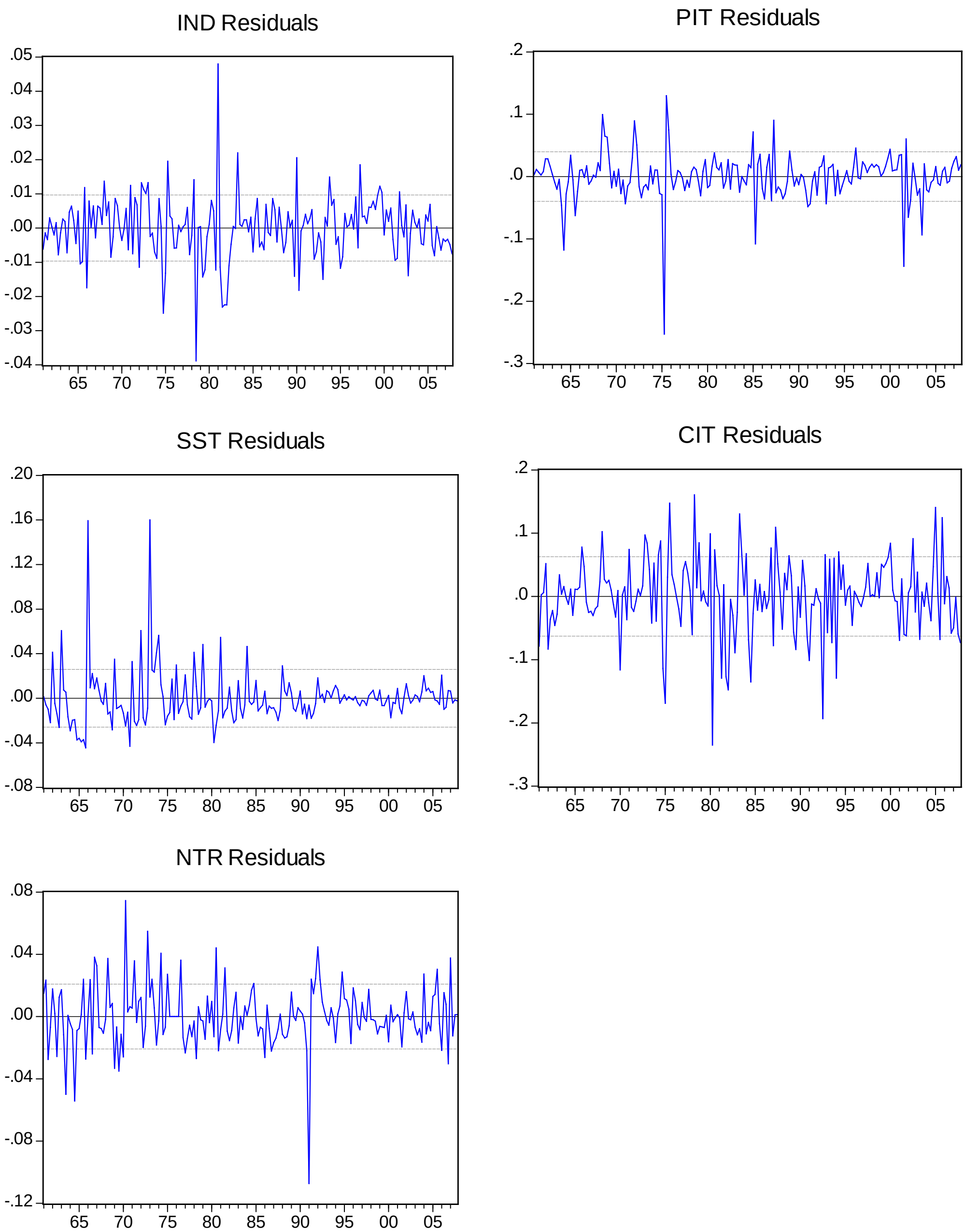


Figure 4: Reduced-form residuals (in logarithms) of indirect taxes, social security taxes, net transfers, personal income taxes, and corporate income taxes.

Notes: Reduced-form equations allow for deterministic trends in the data, but neither quarter-dependence nor dummy variables. Sample: 1960:1-2007:4.

4.2 Contemporaneous Effects

With the identification procedures and major elements of the data explained, I can summarize the contemporaneous relationships between the variables. The most important coefficient is a_1—the automatic effect of unanticipated movements in GDP on tax revenues. Table 2 shows a synopsis of the a_1 values for systems (2), (3), (5), and (6). The mean value of the a_1 coefficient in systems (2) and (3) is 2.46. This value indicates that a one percent exogenous increase in GDP leads to a 2.46 percent increase in net tax revenues. The value of a_1 increases over time because of increases in the elasticities for personal income taxes (Table 2, PIT) and social security taxes (Table 2, SST). Another reason for variation in the elasticity of taxes to GDP is that the weight assigned to each type of tax shifts across time.[11] The same principle holds for the values of b_1 (in systems [5] and [6]) that are reported in Table 3. For instance, the GDP elasticity of all taxes—excluding indirect business taxes—increased from 2.32 in 1969 to 6.85 in 1992.

Table 2: Elasticities of net taxes and type i^{th} taxes to GDP (estimations of a_1).

	TAX	**IND**	**PIT**	**SST**	**CIT**	**NTR**
Mean	2.46	1.00	0.95	0.68	3.83	-0.20
Standard Deviation	0.47	0.00	0.55	0.04	0.00	0.00
Minimum	1.72	1.00	0.42	0.62	3.83	-0.20
Maximum	3.21	1.00	1.87	0.75	3.83	-0.20

Notes: TAX = net transfers; IND = indirect business taxes; PIT = personal income taxes; SST = social security taxes; CIT = corporate income taxes; NTR = net transfers. Sample: 1960:1-2007:4.

Table 3: Elasticities of type j^{th} taxes to GDP (estimations of b_1 in equation [5]).

	TAX	**IND**	**PIT**	**SST**	**CIT**	**NTR**
Mean	NA	4.05	5.34	3.90	2.11	2.86
Standard Deviation	NA	1.24	1.91	1.40	0.62	0.52
Minimum	NA	2.32	2.78	1.95	1.10	2.08
Maximum	NA	6.85	10.41	6.87	3.04	3.95

Notes: The j^{th} type of tax represents all tax revenues that are *not* in the tax type indicated by the header of each column (see equation [7] for details). Sample: 1960:1-2007:4.

[11] Recall that a_1 in system (2) is a weighted average of the elasticities of each tax type to GDP.

The above tax elasticities allow me to calculate the contemporaneous effects of tax and government spending shocks. Table 4 reports the remaining identifications for Blanchard and Perotti's original specification (systems [2] and [3]):

Table 4: Contemporaneous effects of net tax and government spending shocks.

	Baseline	**CON**	**INV**	**EXP**	**IMP**
A2	-0.21	-0.24	-0.04	-0.20	-0.29
B2	-0.06	-0.47	-0.50	-0.05	-0.07
C1	-0.48	-0.45	-0.44	-0.03	-0.39
C2	1.12	1.01	1.04	0.08	1.07
D1	NA	-0.32	-0.20	-0.03	0.09
D2	NA	0.13	-0.03	0.05	0.58

Notes: All numbers report the dollar change in the regressand from a one dollar shock in the regressor; all reduced-form equations include quarter-dependent lags (1-4) and dummies for 1975:2 and 2001:3; rows indicate coefficients; columns indicate the corresponding system of equations. Sample: 1960:1-2007:4.

A2 = effect of e_t^g on τ_t (τ_t = shock in TAX; e_t^g = structural shock in GOV)
B2 = effect of e_t^τ on g_t (g_t = shock in GOV; e_t^τ = structural shock in TAX)
C1 = effect of τ_t on x_t (x_t = shock in GDP)
C2 = effect of g_t on x_t
D1 = effect of τ_t on x_t^k (k is indicated by the header of each column)
D2 = effect of g_t on x_t^k
Baseline = system (2) (no decomposition of GDP)
CON, INV, EXP, IMP = permutations of system (3).

Notice that, in contrast with Table 2 and Table 3, the estimations in Table 4 are not reported as elasticities. The identifications in systems (2) and (3) must all be elasticities—and have been estimated as such. However, for the purposes of interpretation, I have converted these coefficients to represent the dollar change in the dependent variable due to a one dollar change in the independent variable.[12] Thus, a $1.00 shock in taxes is associated with a $0.48 intra-quarter decrease in GDP. Conversely, a $1.00 government spending shock is estimated to increase GDP by $1.12 within the quarter. The tax

[12] I achieve this conversion by calculating the elasticity times the mean value of the dependent variable (in dollars, not logarithms) divided by the mean value of the independent variable. In other words, I find the average derivative that is implied by the elasticity. In this sense, the reported estimates are the average responses of the dependent variables to the independent variables. One can reconvert my estimates back to elasticities by using the descriptive statistics in section A.2.

estimate is quite sensitive to the use of instruments (it is positive if τ_t is not cyclically-adjusted for the elasticity of taxes to GDP). On other hand, the government spending estimate is not sensitive to the use of instruments (since its elasticity to GDP is assumed to be zero). Moreover, both estimates are generally robust to the decomposition of GDP (see the rows C1 and C2). Overall, the contemporaneous effects of tax and spending shocks on GDP (negative for the former and positive for the latter) are consistent with economic theory.

Table 4 also reports correlations between structural shocks in taxes and unanticipated movements in government spending (and vice versa). These estimates are usually low and indicate a low correlation between cyclically-adjusted tax shocks and government expenditure shocks. However, the correlations are somewhat higher when consumption and investment are included in the VAR. I explore the importance of this matter with regard to variable ordering in section 5.2. The sign and magnitude of the other coefficients (D1 and D2) are fairly intuitive. Positive tax shocks are associated with moderate declines in consumption (CON), investment (INV), and net exports (EXP – IMP). Meanwhile, positive government spending shocks are associated with increases in private consumption, but decreases in investment and net exports.

All of the above results are qualitatively representative of the identifications for the specifications that decompose net taxes (systems [5] and [6]). In most cases, shocks in the components of net taxes have negative contemporaneous effects on economic activity. The estimated effect of government spending shocks on GDP is positive—similar to the coefficients in Table 4. Finally, the shocks in the components of taxes are close to uncorrelated with government spending (although the shocks in the types of net taxes are moderately correlated with each other). The only notable distinction between the estimates of the benchmark model and the decomposition model is that some types of taxes have stronger effects on economic activity than others. For instance, indirect business taxes have very strong contemporaneous effects on output, while the other components have less influence. For the sake of brevity, I report the identifications for the decomposition of taxes and all alternative models in section A.6.

4.3 Dynamic Effects of Government Spending and Taxes

Using the identifications in Table 4, I estimate the following impulse responses from a one dollar structural shock in government spending:[13]

Table 5: Responses to a structural shock in government spending.

Variable	**Q2**	**Q4**	**Q8**	**Q20**	**Peak**
TAX	-0.16*	-0.12	-0.09	-0.01	-0.22* (1)
GOV	1.07*	1.51*	1.78	1.45	1.78 (9)
GDP	0.91	0.51	0.44	0.61	1.12* (1)
CON	0.18*	0.16	0.11	0.06	0.18* (2)
INV	-0.06*	-0.08*	-0.07*	-0.02	-0.08* (4)
EXP	0.03	-0.20*	-0.10	0.00	-0.20* (4)
IMP	0.00	-1.16	1.78	2.32	2.83* (15)

Notes: All numbers are in terms of the dollar response to a one dollar shock; all reduced-form equations include lags 1 through 4 and dummies for 1975:2 and 2001:3; structural shocks are retrieved from the identifications in Table 4 ($b_2 = 0$); QX = X quarters after shock; Peak = maximum response (quarter of peak in parentheses); asterisk indicates that zero is outside of the one standard error bands. Sample: 1960:1-2007:4.

Clearly, increases in government spending have strong positive effects on GDP. This positive effect, however, diminishes over time. A $1.00 structural shock in spending is linked with an intra-quarter increase in GDP of $1.12, but only a $0.51 increase in GDP

[13] As is the case with the contemporaneous effects, I report my results in terms of the dollar response to a one dollar shock in the explanatory variable. The original output is in terms of a logarithmic response to a one standard deviation shock. These statistics are obviously very difficult to interpret. Therefore, I scale my original results by the product of the contemporaneous response (in dollars) and the inverse of the dynamic response (in logarithms) during the first quarter. Similar to Blanchard and Perotti (2002), this procedure produces the *average* dynamic response of each variable in the data.

after one year. Furthermore, government spending shocks tend to crowd-out the private sector. In Table 5, private sector output (GDP – GOV) decreases by 1.00 dollar in the first four quarters. This pattern is due to a decrease in private investment and net exports. Meanwhile, the Keynesian hypothesis is partially confirmed by increases in private consumption. This pattern of Keynesian consumption coupled with decreases in national savings consistently holds across my alternative specifications (though the precise estimates vary).

For shocks in net taxes, I find the following impulse responses:

Table 6: Responses to a structural shock in net taxes.

Variable	**Q2**	**Q4**	**Q8**	**Q20**	**Peak**
TAX	0.83*	0.72*	0.42	-0.22	0.88* (1)
GOV	-0.08*	-0.09*	-0.08*	-0.05	-0.09* (4)
GDP	-0.45*	-0.36*	-0.23	-0.23	-0.51* (1)
CON	-0.41*	-0.33*	-0.40	-0.62	-0.62* (20)
INV	0.35*	0.62	0.73	0.26	0.75 (5)
EXP	0.00	0.06*	0.09*	0.00	0.11* (6)
IMP	-0.06*	0.00	0.00	-0.01	-0.07* (1)

Notes: All numbers are in terms of the dollar response to a one dollar shock; all reduced-form equations include lags 1 through 4 and dummies for 1975:2 and 2001:3; structural shocks are retrieved from the identifications in Table 4 ($a_2 = 0$); QX = X quarters after shock; Peak = maximum response (quarter of peak in parentheses); asterisk indicates that zero is outside of the one standard error bands. Sample: 1960:1-2007:4.

Compared with the responses to government spending shocks, net tax shocks have weaker effects on output. A $1.00 shock in net taxes leads to a peak decline in GDP of $0.51. On the other hand, tax shocks have a more direct effect on the private economy. The peak decline in the private economy (GDP – GOV) is $0.59, while the peak decline in consumption is $0.62 (the peak response of consumption to spending is a mere $0.18). One puzzling result is that net taxes have a positive effect on private investment. The evidence on this relationship is fairly weak. Most of the one standard error bands of these estimates contain zero and do not correspond with the other estimates (i.e. the sum of consumption, investment, net exports, and government spending does not equal GDP). In fact, the response of investment to tax shocks is quite sensitive to the ordering of the identifications. I discuss this robustness issue in section 5.2. For now, I ignore the response of investment and conclude that net tax shocks are negatively associated with GDP and private output.

For a visual representation of the above results, I have appended the original impulse response graphs (Figure 5 and Figure 6). I have also removed the standard error bands in all graphs. This practice is necessary for visual convenience, since the standard errors are very large in certain circumstances. The magnitude of the impulse responses are difficult to interpret because they are calculated in terms of the logarithmic response to a one standard deviation structural shock in spending or taxes. In order to evaluate the statistical and practical significance of the estimates, I recommend consulting the summary tables. In all tables, an asterisk indicates that the one standard error bands do not contain zero. Nevertheless, the graphs provide the general profile for each impulse response. The graphs depict the same effects as indicated by the tables, only in terms of different units. Government spending shocks positively affect GDP, while tax shocks have the reverse effect. The impulse responses tend to converge toward zero over a very substantial period of time (several years). Thus, the estimates show that fiscal shocks have fairly strong and persistent effects on GDP and its components.

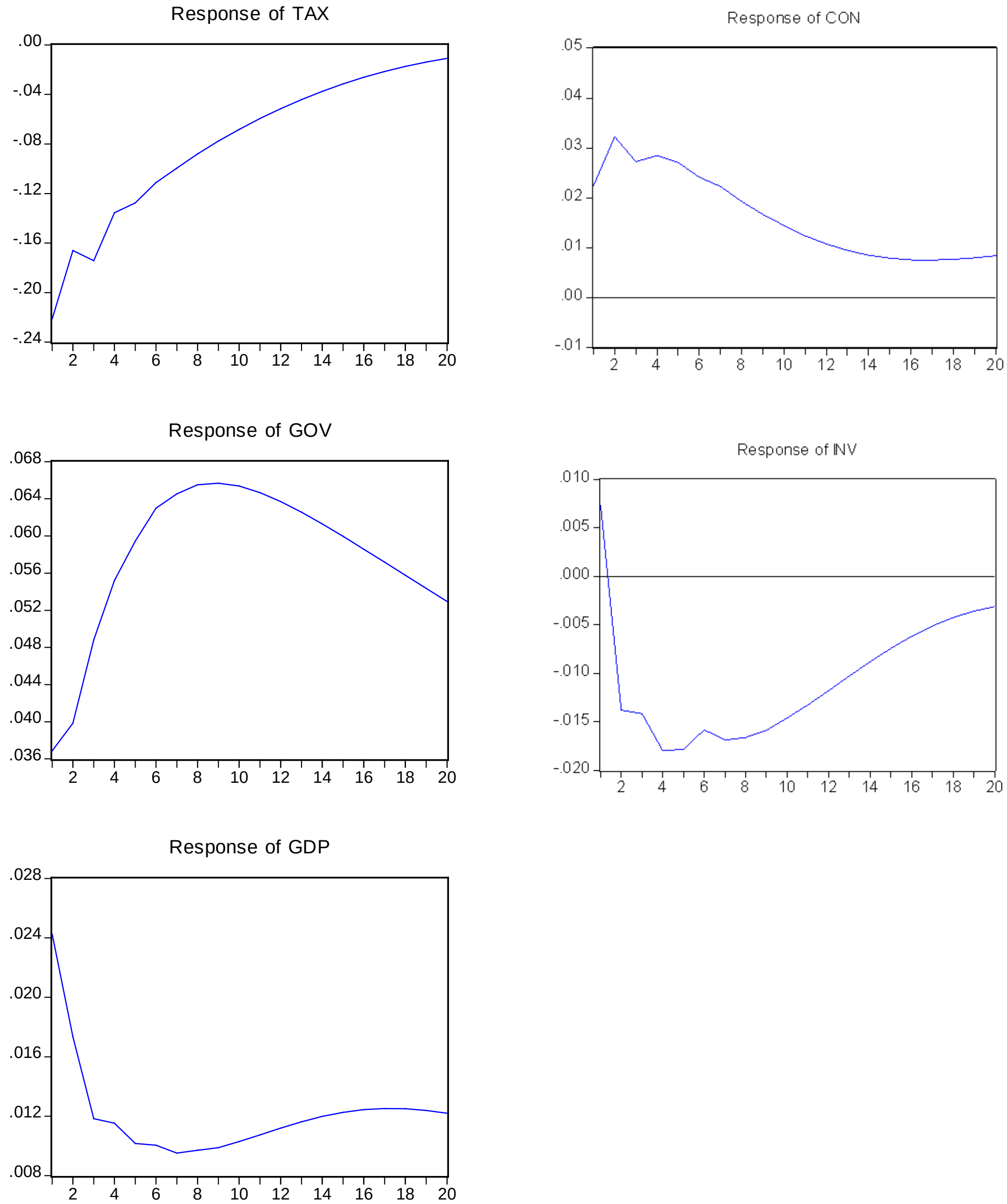


Figure 5: Responses of net taxes, government spending, GDP, consumption, and private investment to a structural government spending shock. (Export and import graphs are in the appendix.)

Note: Reports the logarithmic responses to a one standard deviation shock. Sample: 1960:1-2007:4.

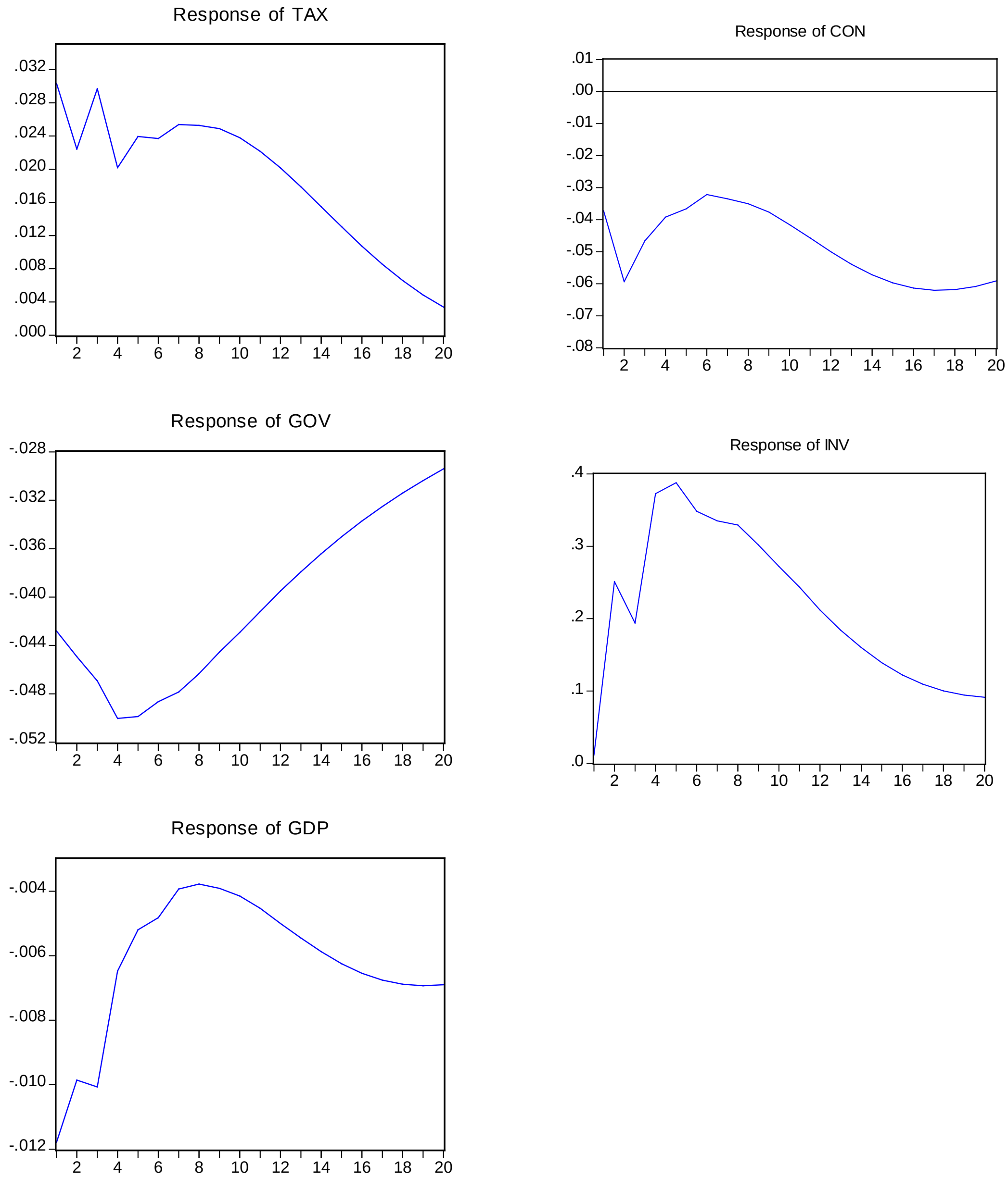


Figure 6: Responses of net taxes, government spending, GDP, consumption, and private investment to a structural net tax shock. (Export and import graphs are in the appendix.)

Note: Reports the logarithmic responses to a one standard deviation shock. Sample: 1960:1-2007:4.

4.5 Decomposing Taxes

Now I estimate the dynamic effects of each type of net tax on GDP and its components. The first type of tax that I evaluate is indirect business taxes (IND). Table 7 reports the impulse responses to a structural shock in these taxes:

Table 7: Responses to a structural shock in indirect business taxes.

Variable	**Q2**	**Q4**	**Q8**	**Q20**	**Peak**
IND	0.90*	1.08	0.18	-2.46	1.08 (1)
NOTIND	0.43	0.43	1.05	0.39	1.17 (10)
GOV	-0.60	-0.63	-0.57	-0.34	-0.63 (4)
GDP	-3.77	-1.63	0.25	-2.14	-4.40 (1)
CON	-1.40	-0.58	0.00	-0.85	-1.40 (2)
INV	2.64*	7.04	7.13	0.59	7.13 (8)
EXP	-0.59	2.57	3.46	0.20	3.56 (10)
IMP	-0.36	-0.03	0.04	0.01	-0.44 (1)

Notes: All numbers are in terms of the dollar response to a one dollar shock; all reduced-form equations include lags 1 through 4 and dummies for 1975:2 and 1981:1; structural shocks are retrieved from the identifications in Table A3 ($a_2 = a_3 = b_2 = 0$); NOTIND = TAX – IND; QX = X quarters after shock; Peak = maximum response (quarter of peak in parentheses); asterisk indicates that zero is outside of the one standard error bands. Sample: 1960:1-2007:4.

These estimates are unfortunately not very convincing. The standard errors for the impulse response paths are extremely large. Moreover, some of the estimates are implausible. For instance, the response of private investment to a $1.00 increase in indirect taxes is *positive* $7.04 after one year. Meanwhile, the response of GDP is *negative* $1.63 after one year. Based on these results, I conclude that the VAR provides weak evidence that indirect business taxes have a strong negative effect on GDP. I examine some options for improving these estimates in section 5.2. (For the graphical illustration of these estimates see Figure 7.)

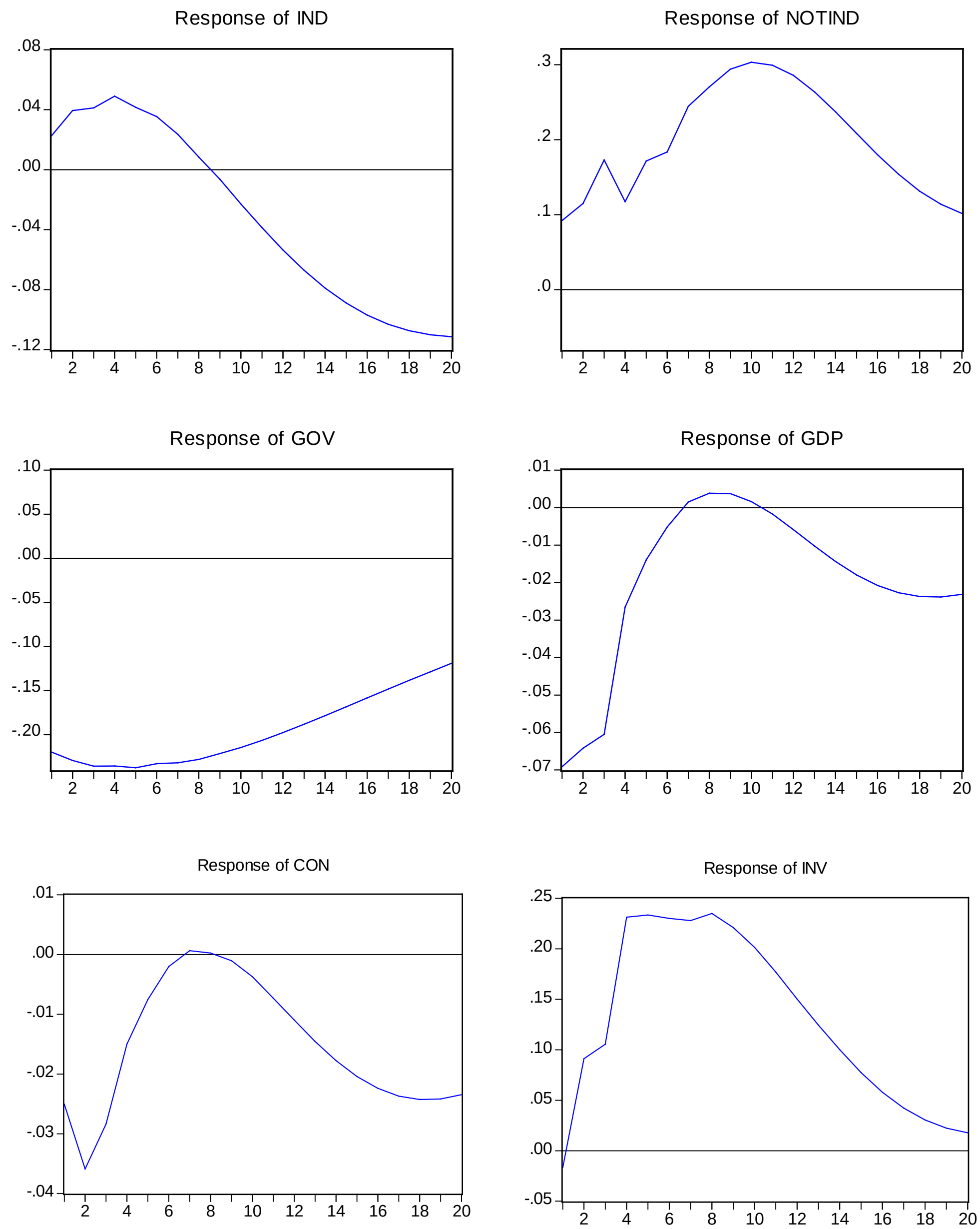


Figure 7: Responses of net taxes (top two panels), government spending, consumption, GDP, and private investment to a structural indirect business tax shock. (Export and import graphs are in the appendix.)

Note: Reports the logarithmic responses to a one standard deviation shock. Sample: 1960:1-2007:4.

After indirect business taxes, personal income taxes (PIT) are the second type of net tax that I assess (Table 8 and Figure 8). The response of GDP to a $1.00 shock in personal income taxes is quite weak. The peak reduction in GDP is only $0.21 and becomes positive after three quarters (Figure 8). The effect of personal income taxes is close to neutral for consumption (CON) and positive for savings (INV + EXP – IMP). This observation decidedly refutes the Keynesian view of fiscal policy and validates Ricardian equivalence. On the other hand, the low effects of personal income taxes challenge the neoclassical claim that labor and capital income taxes should be minimized.[14] Admittedly, the effects of personal income taxes are slightly larger, if the 2001 dummy is omitted (results in the appendix). However, this discrepancy is probably attributable to a higher (negative) correlation between personal income taxes and government expenditures—when the 2001 dummy is removed. Consequently, the evidence shows that shocks in personal income taxes have relatively small effects.

Table 8: Responses to a structural shock in personal income taxes.

Variable	Q2	Q4	Q8	Q20	Peak
PIT	0.66	1.52	1.73	0.14	1.80 (6)
NOTPIT	0.49	0.26	0.04	0.03	0.56 (1)
GOV	-0.05	-0.09	-0.04	-0.04	-0.09 (4)
GDP	-0.08	0.08	0.06	-0.14	-0.21 (1)
CON	0.00	0.02	-0.01	-0.05	-0.05 (20)
INV	0.10	-0.20	0.08	0.16	0.16 (20)
EXP	-0.08	-0.31*	-0.44*	-0.01	-0.58 (7)
IMP	-0.26*	-0.94*	-0.90	-0.38	-1.01* (5)

Notes: All numbers are in terms of the dollar response to a one dollar shock; all reduced-form equations include lags 1 through 4 and dummies for 1975:2 and 2001:3; structural shocks are retrieved from the identifications in Table A5 ($a_2 = a_3 = b_2 = 0$); NOTPIT = TAX – PIT; QX = X quarters after shock; Peak = maximum response (quarter of peak in parentheses); asterisk indicates that zero is outside of the one standard error bands. Sample: 1960:1-2007:4.

[14] Chari, Christiano, and Kehoe (1994) offer an edifying perspective on why positive taxes on capital may be optimal under real business-cycle assumptions. Their overall thesis is that capital income taxes optimize output when they are positive and decreasing. This conclusion corresponds with my results, which show that shocks in capital income taxes may not have strong negative effects in the short-run.

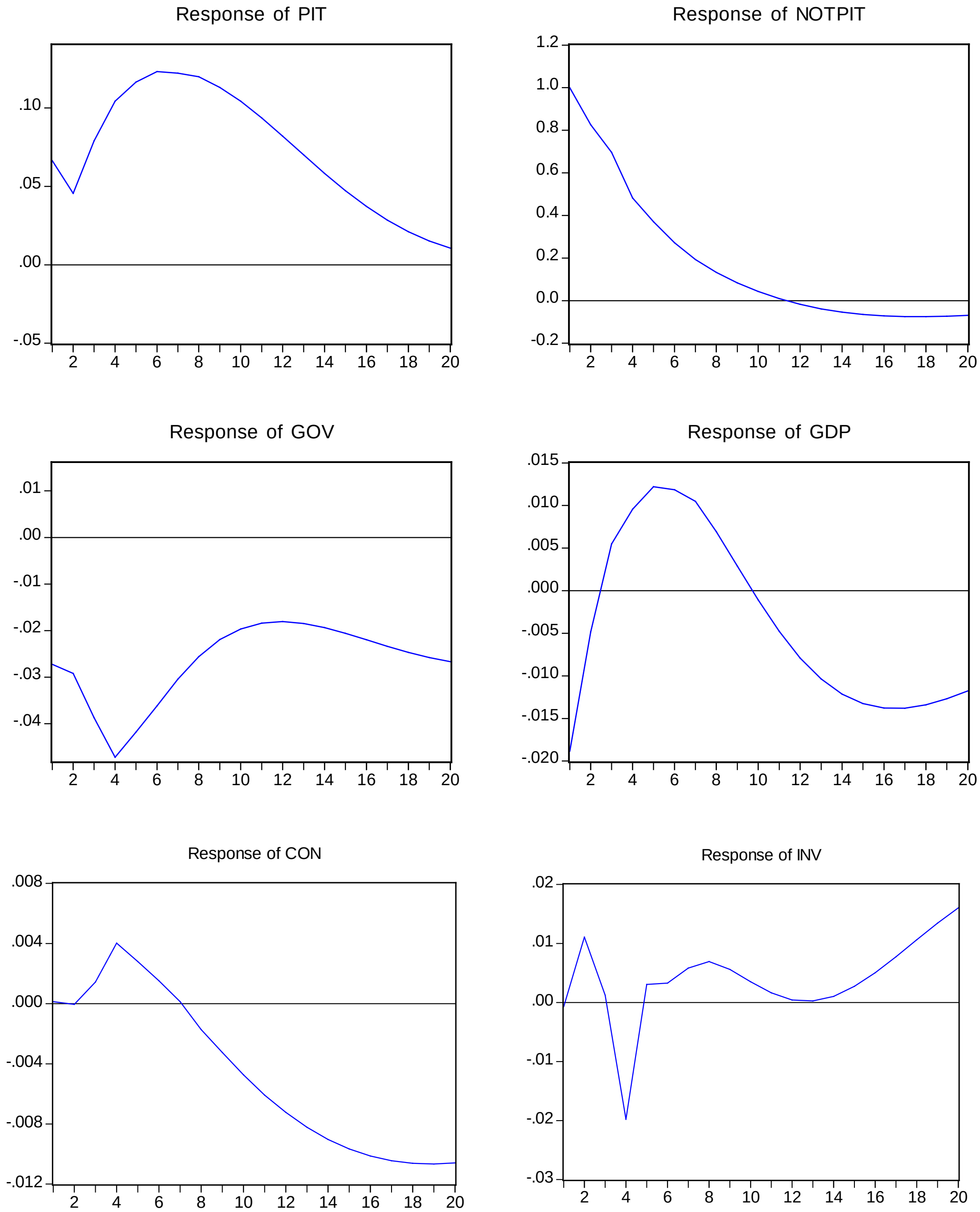


Figure 8: Responses of net taxes (top two panels), government spending, consumption, GDP, and private investment to a structural personal income tax shock. (Export and import graphs are in the appendix.)

Note: Reports the logarithmic responses to a one standard deviation shock. Sample: 1960:1-2007:4.

Social security taxes are the first type of net tax to have practically *and* statistically significant effects on GDP and its components.[15] (By statistically significant, I mean that zero is not contained by the one standard error bands at most of the point estimates.) Table 9 reports that a structural shock in social security taxes is linked to a peak decrease of $0.78 in GDP. Perhaps even more profound, a social security tax shock of $1.00 leads to a nearly proportional (negative) response in private consumption after two years. Although these estimates correspond with the Keynesian model, they also support the neoclassical position that marginal tax rates on labor have substantial effects on the economy. My findings corroborate with the neoclassical perspective in sense that social security tax shocks have medium to long-term effects on output and consumption (Figure 9). This pattern indicates that higher marginal rates on the employee (and the employer) cause a large dead-weight loss in the labor market. Similarly, the initial increase in private investment may show a shift of resources from labor to capital that is caused by the substitution effect (the income effect dominates after several quarters).

Table 9: Responses to a structural shock in social security taxes.

Variable	**Q2**	**Q4**	**Q8**	**Q20**	**Peak**
SST	0.63*	-0.17	-0.52	-0.69	0.98* (1)
NOTSST	0.13*	0.10*	-0.03	0.10	0.15* (1)
GOV	-0.08*	-0.10*	-0.10*	-0.08	-0.10* (6)
GDP	-0.31*	-0.51*	-0.72*	-0.43	-0.78 (10)
CON	-0.62*	-0.76	-0.93	-0.53	-0.95 (9)
INV	0.47*	0.05*	-0.33	0.21	0.47* (2)
EXP	1.11*	1.64*	1.17	-0.79	1.64* (4)
IMP	1.22*	1.29	-0.95	-2.38	-2.99* (15)

Notes: All numbers are in terms of the dollar response to a one dollar shock; all reduced-form equations include lags 1 through 4 and dummies for 1975:2, 1966:1, and 1973:1; structural shocks are retrieved from the identifications in Table A7 ($a_2 = a_3 = b_2 = 0$); NOTSST = TAX – SST; QX = X quarters after shock; Peak = maximum response (quarter of peak in parentheses); asterisk indicates that zero is outside of the one standard error bands. Sample: 1960:1-2007:4.

[15] The results are also robust to the elimination of the 1966 and 1973 dummy variables. The impulse responses to this alternative specification are in the appendix.

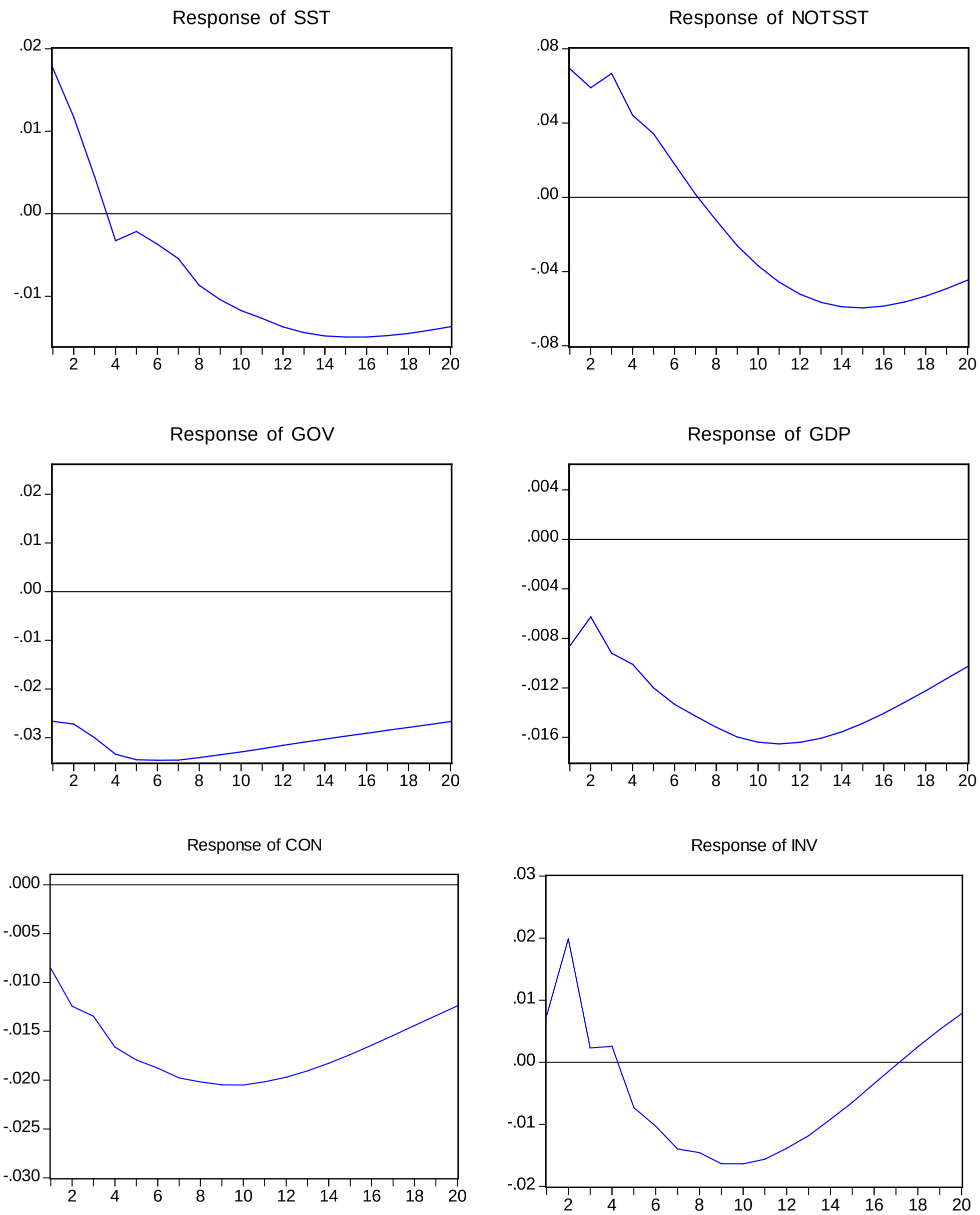


Figure 9: Responses of net taxes (top two panels), government spending, consumption, GDP, and private investment to a structural social security tax shock. (Export and import graphs are in the appendix.)

Note: Reports the logarithmic responses to a one standard deviation shock. Sample: 1960:1-2007:4.

Surprisingly, structural shocks in corporate income taxes (CIT) have essentially a neutral effect on GDP. Moreover, Table 10 shows that a $1.00 increase in corporate income taxes has a moderately *positive* effect on private investment and a moderately negative effect on consumption. These results are unintuitive and contrary to most neoclassical models. These estimates may not be reliable because the corporate income tax is the smallest component of net taxes (see section A.2). Figure 4 also indicates that the time series for corporate taxes is fairly volatile. Thus, the VAR approach is probably not the best method for measuring the dynamic effects of corporate income taxes. Even with the above caveats, the estimates are (weakly) statistically significant. My best causal explanation for these results is that corporations may be using tax aversion strategies that obfuscate the real economic effects of higher corporate income taxes. For example, corporations may respond to higher tax rates by attempting to hide profits through artificial investments.

Table 10: Responses to a structural shock in corporate income taxes.

Variable	**Q2**	**Q4**	**Q8**	**Q20**	**Peak**
CIT	0.40*	0.15*	-0.11	-0.38	0.44* (1)
NOTCIT	0.13*	0.12*	0.13*	0.03	0.17* (1)
GOV	-0.17*	-0.19*	-0.19*	-0.07	-0.19* (6)
GDP	-0.02*	-0.01*	-0.01	-0.02	-0.03 (1)
CON	-0.37*	-0.23	-0.16	-0.19	-0.37* (2)
INV	0.27*	0.36*	0.40*	0.05	0.36* (4)
EXP	0.07	0.55*	0.70*	-0.13	0.55* (8)
IMP	-0.08	0.53*	0.30	0.00	0.53* (4)

Notes: All numbers are in terms of the dollar response to a one dollar shock; all reduced-form equations include lags 1 through 4 and a dummy for 1975:2; structural shocks are retrieved from the identifications in Table A2 ($a_2 = a_3 = b_2 = 0$); NOTCIT = TAX – CIT; X2 = X quarters after shock; Peak = maximum response (quarter of peak in parentheses); asterisk indicates that zero is outside of the one standard error bands. Sample: 1960:1-2007:4.

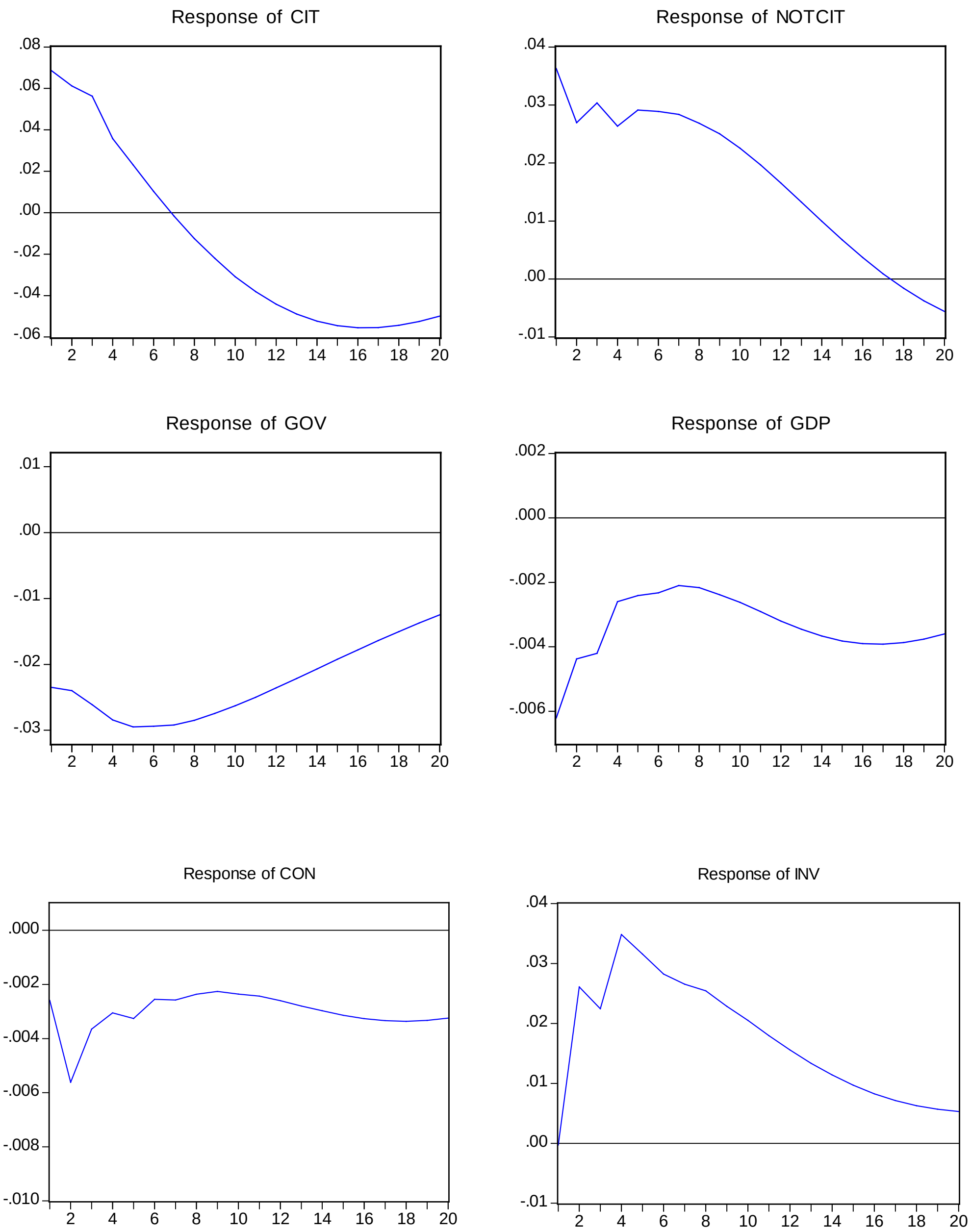


Figure 10: Responses of net taxes (top two panels), government spending, consumption, GDP, and private investment to a structural corporate income tax shock. (Export and import graphs are in the appendix.)

Note: Reports the logarithmic responses to a one standard deviation shock. Sample: 1960:1-2007:4.

In contrast to government spending, the estimated effect of net transfer payments (NTR) is slightly negative. A $1.00 structural shock in net transfers is linked with a peak $0.18 decrease in GDP after seven quarters (Table 11 and Figure 11). More intuitively, the shock in transfers is associated with a modest increase in consumption and decrease in savings. These latter effects, however, are not robust to the omission of the 1991 dummy (results in the appendix). The instability of these results indicates that net transfers have relatively weak effects on economic activity. Since most economists view transfer payments as mechanisms of wealth (re)distribution rather than demand management, these findings are not surprising. In section 5.2, I investigate whether these results are robust to modifications in a_1.

Table 11: Responses to a structural shock in net transfers.

Variable	**Q2**	**Q4**	**Q8**	**Q20**	**Peak**
NTR	0.63*	0.67*	0.65	-0.02	0.98* (1)
NOTNTR	0.13*	0.09	-0.03	0.00	0.22* (1)
GOV	0.03	0.02	-0.01	-0.03	0.03* (2)
GDP	-0.07	-0.16	-0.17	0.00	-0.18 (7)
CON	0.14*	0.00	-0.02	0.01	0.14* (2)
INV	-0.01*	-0.01	-0.01	0.00	-0.02* (1)
EXP	-0.01*	-0.09*	-0.12	0.06	-0.13* (5)
IMP	0.06*	0.01	0.00	0.02	0.06* (1)

Notes: All numbers are in terms of the dollar response to a one dollar shock; all reduced-form equations include lags 1 through 4 and dummies for 1975:2 and 1991:1; structural shocks are retrieved from the identifications in Table A9 ($a_2 = a_3 = b_2 = 0$); NOTNTR = TAX – NTR; QX = X quarters after shock; Peak = maximum response (quarter of peak in parentheses); asterisk indicates that zero is outside of the one standard error bands. Sample: 1960:1-2007:4.

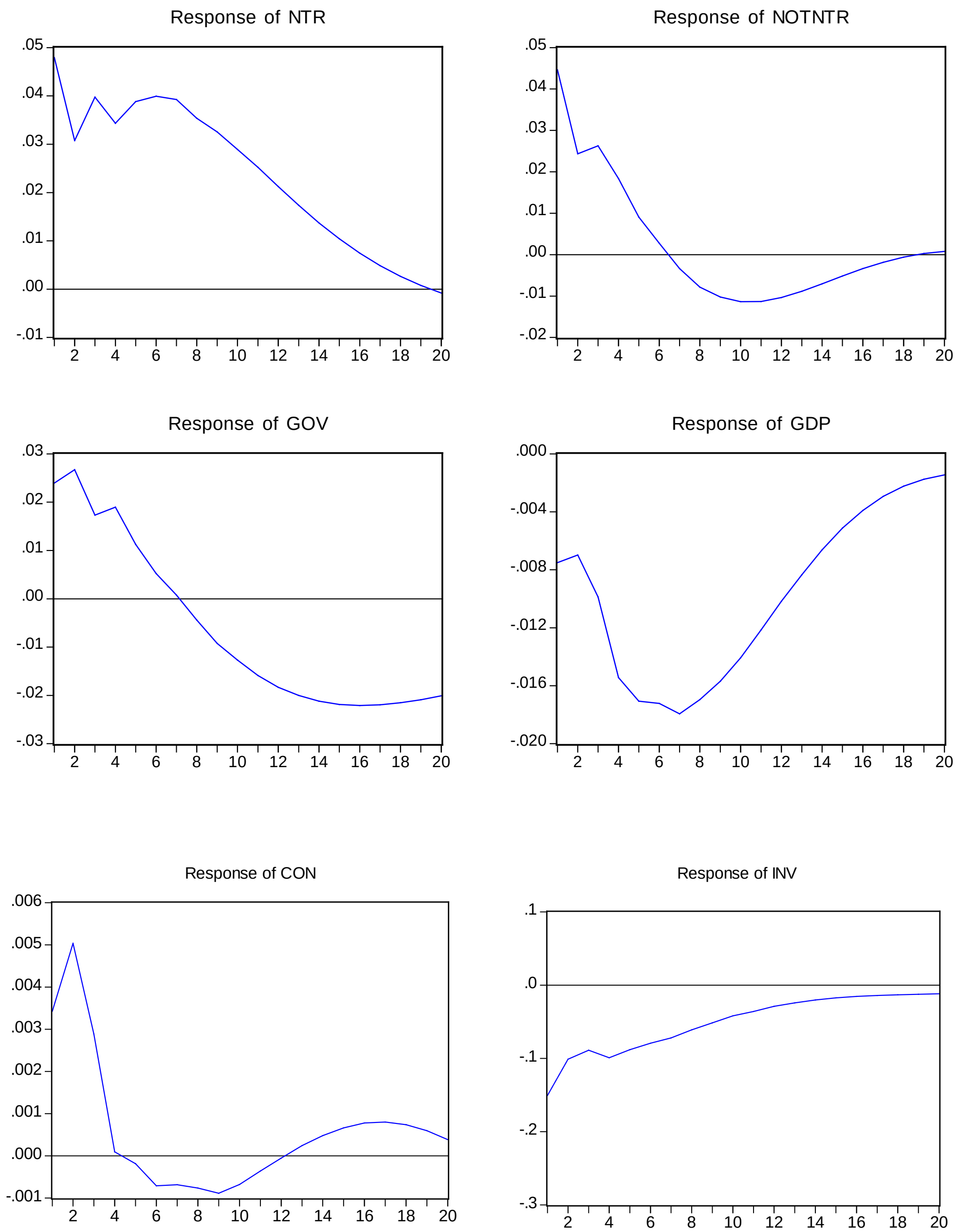


Figure 11: Responses of net taxes (top two panels), government spending, consumption, GDP, and private investment to a structural net transfers shock. (Export and import graphs are in the appendix.)

Note: Reports the logarithmic responses to a one standard deviation shock. Sample: 1960:1-2007:4.

5.1 The Dynamic Effects of Fiscal Shocks and Policy

I evaluate the stimulative qualities of each tax type by three criteria: the effect of each tax type on GDP, the impact of each tax type on the composition of GDP, and the feasibility at which a shock in each tax type can be appropriately timed. Since the present Congress and President seem to favor increases in government spending, I treat the performance of spending shocks as the benchmark for my assessment. With respect to the first criterion, government spending has a greater impact on GDP than almost every type of tax. This large (and immediate) effect of government spending is not surprising, because government spending is a component of GDP.[16] In fact, a $1.00 increase in government spending increases GDP (roughly) proportionally. The only taxes that have a greater effect on output are indirect business taxes. However, the dynamic effects of indirect business taxes have large standard errors and are not robust to methodological modifications (see the next section). After indirect business taxes, social security taxes have about three-fourths as much influence on GDP as government spending. All other components of net taxes have little impact on GDP.

For the second criterion, government spending is quite ineffective. An increase in government spending leads to a net decrease in private output and investment. Such a dominant crowding-out effect indicates that the gains from increased government spending may not be sustainable. Conversely, reductions in net taxes have strong positive effects on private consumption and savings. Again, the most convincing evidence shows that social security taxes have the strongest link to the private sector. For instance, a $1.00 decrease in social security taxes is associated with a $0.95 (peak) increase in

[16] Recall that government spending does not include net transfers.

consumption. Indirect business taxes have comparable dynamic effects, but the one standard error bands of the estimates tend to contain zero. Personal and corporate income taxes have moderately negative effects on consumption, while net transfers have slightly positive effects on consumption. Since social security taxes and indirect business taxes have the highest influence on private consumption, a reduction in these categories of taxes seems to be the optimal approach for stimulating economic welfare.[17] Thus, assuming that policymakers are more concerned with welfare (private consumption) than output (GDP), broad tax cuts may be a preferable mechanism for fiscal stimulus.

The third criterion is not directly tested by my research. The VAR measures the impulse response of the variables *after* a structural fiscal shock occurs. Therefore, the VAR allows one to assess response lags, but neither decision nor implementation lags. For instance, government spending shocks have a large effect on GDP (mostly by definition) within one quarter. Nevertheless, this result provides no evidence on the time that policymakers consume either deciding to change spending or implementing the proscribed spending projects. The decision-making lag is probably comparable among the various fiscal mechanisms (although the lag is shorter for monetary policy).[18] The implementation lags, however, are quite different. For example, the Congressional Budget Office estimates that most of the spending in the Obama stimulus plan will accrue after 2010 (two years after the approval of the bill).[19] Meanwhile, tax reductions (if properly designed) would require no more than one budgetary cycle (one year) to take

[17] Kleven and Kreiner (2003) prove that taxes tend to have destabilizing effects on the economy. In particular, the authors show that taxes on earned income can magnify the negative effects of economic contractions on social welfare.
[18] See Taylor (2000) for a comparison of fiscal and monetary lags in the United States.
[19] Ruggeri, Amanda, "CBO: Stimulus Bill Could Meet Obama's Job Creation Goal in Short Term," *U.S. News and World Report*, February 5, 2009.

full effect. This institutional characteristic implies that tax cuts are likely to be much timelier in managing short-run output than government expenditures. Furthermore, I argue that social security taxes have the shortest implementation lag. A reduction in the marginal rate for social security taxes would immediately decrease the payroll withholdings of most individuals, and thus, increase their disposable income.[20]

Overall, I advocate for a reduction in social security taxes (or other broad taxes) as the best fiscal policy for stimulating short-term economic growth. While government purchases have a greater effect on GDP, social security taxes are easier to implement and have a stronger effect on private consumption. In order to finance this decrease in social security taxes, I propose increases in certain types of indirect business taxes or reductions in non-countercyclical transfer payments.[21] Reductions in government spending or increases in income taxes are suboptimal solutions, since the VAR indicates that such actions would inhibit output.[22] Decreases in transfer payments could take the form of an increase in the eligibility age for social security. In other words, a decrease in social security revenue could be offset by a decrease in social security benefits. This option may be appropriate because net transfers have little impact on GDP. An alternative approach could be to raise revenue by increasing specific types of indirect business taxes. Although indirect business taxes have strong negative effects on output, not all taxes in this classification are equal. For instance, the deadweight-loss of a given sales tax depends upon the elasticities of the corresponding market supply and demand functions. Policymakers could raise taxes on goods that have inelastic supply and demand

[20] To President Obama's credit, his stimulus plan has resulted in some small immediate reductions in payroll withholdings.
[21] A countercyclical component of net transfers would be something like unemployment insurance or healthcare benefits for the underemployed.
[22] I am wary of the potential long-term consequences of increasing income taxes.

schedules—at a minimal economic cost. A similar option could be to increase Pigovian taxes (such as those on carbon-emissions) in order to offset external social costs.

I should mention a final remark about the limitations of the above policy prescription. One important caveat to the VAR evidence is that it only applies to the short-term effects of the fiscal variables. This analysis does not produce conclusions about the long-term ramifications of fiscal shocks. For this reason, an Obama adviser would probably say that the objective of the stimulus plan is not only to stimulate output in the short-term, but to invest in strategic technologies and increase the path of growth in the long-term. Quite plausibly, government investment in public works—such as infrastructure—could have positive effects on output (and social welfare). However, this element of the Obama plan does not reconcile the fact that spending is subject to implementation lags. Thus, such investment is largely ineffective in managing short-term fluctuations in demand. Neoclassical economists, of course, could also object to my study by claiming that it does not capture the long-term positive effects of reduced taxes on capital gains and corporate profits. Again, this assertion is reasonable, but does nothing to refute my findings with respect to the dynamic effects of personal and corporate income taxes. The effects of these shocks on output appear to be relatively small in the short-run. Nevertheless, further research is necessary in order to assess the long-term effects of changes in government spending and net taxes.

5.2 A Discussion on the VAR Approach

The structural VAR model has some potential weaknesses. To begin with, the ordering of the variables is one likely source for inconsistency in the results, because it effectively assumes that certain contemporaneous relationships are zero. For instance, in the estimation of the responses to government spending shocks, I assume that a structural shock in net taxes has no contemporaneous effect on government spending. In other words, I order the government spending variable first. I use the opposite ordering for the estimation of responses to net tax shocks. Because these ordering assumptions place rather stringent constraints on the model, I test the robustness of this approach. Table 12 and Table 13 report the results for government spending and net taxes, when I order the variable that I am testing second—instead of first. These dynamic effects are comparable to my initial results in Table 5 and Table 6. One notable difference is that both government spending and net taxes have significantly negative effects on private investment.[23] Interestingly, this feature corresponds more closely to Blanchard and Perotti's (2002) findings than the estimates of my benchmark specification. Furthermore, the new estimates provide even stronger evidence in favor of the hypothesis that increases in government spending and net taxes encroach upon the private sector.

Table 12: Responses to a structural shock in government spending (net taxes ordered first).

Variable	**Q2**	**Q4**	**Q8**	**Q20**	**Peak**
TAX	0.08	0.08	-0.10	0.02	0.22* (1)
GOV	0.99*	1.04*	0.93*	0.45	1.06* (5)
GDP	1.01*	0.46	0.27	0.38	1.14* (3)
CON	0.26	0.24	0.22	0.37	0.40 (17)
INV	-0.36*	-0.48	-0.44	-0.18	-0.50* (5)
EXP	0.02	-0.80*	-0.95*	-0.18	-0.95* (8)
IMP	0.40*	0.02	-0.12	-0.02	0.58* (1)

Notes: All numbers are in terms of the dollar response to a one dollar shock; all reduced-form equations include lags 1 through 4 and dummies for 1975:2 and 2001:3; structural shocks are retrieved from the identifications in Table 4 (a_2 = 0); QX = X quarters after shock; Peak = maximum response (quarter of peak in parentheses); asterisk indicates that zero is outside of the one standard error bands. Sample: 1960:1-2007:4.

[23] Remember that government spending had only a slight negative effect on investment, while net taxes had a positive effect.

Table 13: Responses to a structural shock in net taxes (government spending ordered first).

Variable	Q2	Q4	Q8	Q20	Peak
TAX	0.50*	0.35	0.10	0.02	0.87* (1)
GOV	0.00	-0.01	-0.02	-0.01	-0.02 (11)
GDP	-0.43*	-0.67	-0.38	-0.19	-0.67* (4)
CON	-0.45*	-0.51	-0.27	0.00	-0.51* (4)
INV	-0.08*	-0.17	-0.02	0.00	-0.20* (1)
EXP	-0.01	-0.03	-0.07	-0.07	-0.10 (12)
IMP	0.01	-0.04	-0.23	-0.11	-0.28 (10)

Notes: Same as Table 12, except $b_2 = 0$.

Next, I apply the same robustness check to indirect business taxes (Table 14).[24] Similar to net taxes, the alternative ordering yields a negative association between movements in indirect business taxes and private investment. This outcome is contrary to the original specification, which indicates a strongly positive response in investment. I prefer the alternative estimate because it is much more intuitive and corresponds nicely with the dynamic effects on GDP (that is, the components of GDP sum to roughly equal GDP). Another deviation from the original estimates is that indirect taxes have a negative effect on exports. This relationship could exist due to the changes in tariffs—a member of indirect business taxes.[25] Moreover, the finding reveals the general difficulty in estimating the effects of indirect taxes. Because indirect business taxes include many different types of specific taxes, the estimates on its effects are inherently unstable. I recommend a more thorough analysis of indirect taxes in order to disentangle the various (and competing) effects that are linked to the variable. All other tax components are insensitive to ordering changes (except for the previously mentioned changes to the response of investment).

[24] The relative ordering of the i^{th} and j^{th} taxes makes little difference.
[25] The United States does not tax exports, but higher tariffs on imports are likely to be correlated with higher import tariffs in partner countries.

Table 14: Responses to a structural shock in indirect business taxes (government spending ordered first).

Variable	Q2	Q4	Q8	Q20	Peak
IND	0.94	1.09	0.90	-0.06	1.10 (5)
NOTIND	-0.09	-1.74	-0.51	-0.13	-1.74 (4)
GOV	-0.11	-0.26	-0.44	-0.52	-0.58 (15)
GDP	-5.36*	-3.70	-0.32	-1.21	-5.36* (2)
CON	-0.58*	-0.60	-0.08	-0.19	-0.60 (4)
INV	-5.87	-1.50	-0.90	-0.60	-6.16* (1)
EXP	-1.78*	-1.38	-1.19	1.19	-1.78* (2)
IMP	-0.06	-0.05	-0.07	0.00	-0.08 (6)

Notes: All numbers are in terms of the dollar response to a one dollar shock; all reduced-form equations include lags 1 through 4 and dummies for 1975:2 and 1981:1; structural shocks are retrieved from the identifications in Table A3 ($c_2 = c_3 = a_3 = 0$); NOTIND = TAX – IND; QX = X quarters after shock; Peak = maximum response (quarter of peak in parentheses); asterisk indicates that zero is outside of the one standard error bands. Sample: 1960:1-2007:4.

The final robustness check is on the parameter a_1 (the elasticity of the i^{th} tax to GDP). Blanchard and Perotti test the robustness of the results for net taxes with respect to a_1 and conclude that moderate changes in the parameter make little difference (I conducted their test and had the same experience). However, in my study, a_1 may be influential on the results for individual types of net taxes. The assumed values of a_1 for business and income taxes are constructed by identities and relatively strong empirical evidence, respectively (section A.3). For these taxes, I believe the assumed values of a_1 are approximately accurate. On the other hand, the output elasticity of net transfers is extremely imprecise. I use Blanchard and Perotti's value of negative 0.2. However, Blanchard and Perotti admit that this value is empirically unsupported. The authors report that the elasticity is negative 0.1 at the annual frequency. Hence, the magnitude of negative 0.2 is probably not too small. Thus, I perform a VAR in which a_1 is twice as large (negative 0.4) as the original specification. This modification produces virtually indistinguishable estimates (Table 15), when compared with those from the initial model (Table 11). In both circumstances, the effects of net transfers are very weak.

Table 15: Responses to a structural shock in net transfers (a_1 = -0.4).

Variable	**Q2**	**Q4**	**Q8**	**Q20**	**Peak**
NTR	0.48*	0.46*	0.53	0.04	0.76* (1)
NOTNTR	0.06*	0.04	-0.01	0.02	0.12* (1)
GOV	0.02	0.02	0.00	-0.02	0.02 (2)
GDP	-0.09	-0.19	-0.18	-0.07	-0.26* (1)
CON	0.18*	0.14	0.11	0.02	0.18* (2)
INV	-0.01	-0.01	-0.01	0.00	-0.01* (1)
EXP	0.00	-0.01	-0.01	0.00	-0.01* (5)
IMP	0.03	0.01	0.02	0.03	0.03* (1)

Notes: All numbers are in terms of the dollar response to a one dollar shock; all reduced-form equations include lags 1 through 4 and dummies for 1975:2 and 1991:1; structural shocks are retrieved from the identifications in Table A11 ($a_2 = a_3 = b_2 = 0$); NOTNTR = TAX – NTR; QX = X quarters after shock; Peak = maximum response (quarter of peak in parentheses); asterisk indicates that zero is outside of the one standard error bands. Sample: 1960:1-2007:4.

One last element of my VAR design that is worth examining is the exclusion of a number of standard economic variables. The VAR model essentially ignores the government's budget constraint. This issue is quite important, since deficit-financed tax reductions and government spending increases tend to have long-term negative effects on the economy vise-a-vise a higher debt burden (Perotti 1999). Inclusion of a nation debt variable in the VAR could help remedy this shortcoming. Second, the model does not endogenize the various monetary variables (such as interest rates, exchange rates, and inflation). A combined monetary-fiscal model may offer the most compelling evidence on the potency of different policies. Perotti (2005) conducts a VAR that includes interest rates and inflation.[26] In this version of the VAR, the positive effects of government spending have weakened since 1980. Clearly, debt and monetary variables are influential on the VAR estimates. Therefore, a model that endogenizes either national debt or

[26] Perotti adds these variables mainly because of an observed association between inflation and government spending.

monetary variables (or both) may offer improved estimates for the dynamic effects of changes in business and income taxes on output.

6. Conclusion

Structural vector autoregression confirms that government purchases increase GDP and private consumption, while taxes have the opposite effect. Paradoxically, the findings support the (mostly) non-Keynesian view that government spending negatively affects private output. An analysis of specific types of taxes yields an even more nuanced conclusion. In accordance with the new Keynesian and neoclassical schools, social security taxes have a severely negative effect on GDP. However, personal and corporate income taxes have only weak effects on short-term fluctuations in output. Surprisingly, GDP responds disproportionately to movements in indirect business taxes. Consequently, policymakers should adopt a tax-oriented Keynesian approach to fiscal stimulus, in which the broadest types of taxes are reduced the most. Since the evidence on indirect business taxes is statistically weak and sensitive to changes in model parameters, I advocate for reductions in the marginal rate of social security taxes as a means to stimulate short-term economic activity. Such measures are relatively powerful and easy to implement. Still, future research is needed in order to predict the long-term ramifications of such a policy. Moreover, if at all feasible, econometric models should endogenize monetary and debt variables in order to test the robustness of the conclusions in this study.

A. Appendix

A.1 Key Abbreviations

Abbreviation	Variable	Abbreviation	Variable
GDP	GDP	TAX	Net Taxes
CON	Consumption	IND	Indirect Business Taxes
INV	Investment	PIT	Personal Income Taxes
EXP	Exports	SST	Social Security Taxes
IMP	Imports	CIT	Corporate Income Taxes
NEXP	Net Exports	NTR	Net Transfers
GOV	Government Spending	NID	Net Interest and Dividends

A.2 Collecting the Data

The table below summarizes the variables and data sources for my study:

Variable	Definition	Data Source
Indirect Business Taxes	FG Sales Tax Receipts + FG Production Tax Receipts + SL Sales Tax Receipts + SL Production Tax Receipts.	NIPA
Personal Income Taxes	FG Personal Income Tax Receipts + SL Personal Income Tax Receipts.	NIPA
Social Security Taxes	FG Social Security Tax Receipts.	NIPA
Corporate Income Taxes	FG Corporate Income Tax Receipts + SL Corporate Income Tax Receipts (SL Excluded in Blanchard and Perotti [2002]).	NIPA
Net Transfers*	(FG Net Transfer Payments to Persons + SL Net Transfer Payments to Persons).	NIPA
Net Interest and Dividends	(FG Grants-in-Aid + FG Net Interest Paid + SL Net Interest Paid + SL Dividends Received).	NIPA
Net Taxes	Indirect Business Taxes + Personal Income Taxes + Social Security Taxes + Corporate Income Taxes – (Net Transfers* + Net Interest and Dividends).	NIPA
GDP Elasticities of Tax Revenue	(Elasticity of Tax i to Tax Base i)(Elasticity of Tax Base i to GDP).	Blanchard and Perotti (2002) and Giorno, *et al.* (1995)
GDP and its Private Components	Gross Domestic Product, Private Consumption, Private Investment, Exports and Imports.	NIPA
Government Spending	FG Purchases of Goods and Services (consumption and investment) + SL Purchases of Goods and Services (consumption and investment).	NIPA

Notes: NIPA = National Income and Product Accounts; FG = Federal; SL = State and Local.

All of the above data are available through the NIPA from 1960-2007, except for the elasticities of tax revenue with respect to GDP. I also use population and deflator estimates from the NIPA in order to convert all data into real per capita terms. I recalculate tax elasticities by using the techniques of Blanchard and Perotti, which I explain in the next section.

The table on the next page reports a summary of the data in my study in seasonally-adjusted real per capita terms.[27] GDP and its components are shown on the top rows of the table. (Notice that the means of consumption, private investment, net exports, and government spending sum to the mean of GDP.) From 1960 to 2007, the average value of GDP is $25,167.68 per person. Of course, GDP and its components increase steadily over the period of the sample—as indicated by the minimum and maximum values. Interestingly, government spending rises at a relatively gradual rate because it does *not* include net transfers to persons. This characteristic in the data is evident in the second set of rows, which indicate that the average net of taxes is $3,826.53, as opposed to $5,018.36 for government spending. The former number is greatly reduced by the fact that it includes net transfers. Since 1960, net transfers (the sum of NTR* and NID) have increased at a steady rate and now compose almost 80 percent of net taxes. Personal income taxes and indirect business taxes are the next largest components of net taxes.[28] The two smallest components of taxes are social security taxes and corporate income taxes. These two variables are quite different, though, because the former increases steadily during the same period that latter stagnates.

[27] Recall that the actual data are in logarithms. Also, all figures are converted to chained 2000 US dollars using the GDP deflator.
[28] Indirect business taxes include sales taxes and taxes on production. Blanchard and Perotti define these taxes as simply indirect business taxes, but NIPA has since changed its terminology.

Descriptive statistics of the VAR data.

	GDP	CON	INV	NEXP	EXP	IMP	GOV
Mean	25167.68	16534.05	4072.70	-457.38	2227.89	2685.27	5018.36
Standard Deviation	7101.27	5406.54	1209.60	649.86	1108.62	1673.99	1133.58
Minimum	13612.00	8658.07	1770.31	-2283.16	691.27	560.67	2879.42
Maximum	38438.00	27020.16	6494.39	266.29	4806.31	6709.49	7491.75

	TAX	IND	PIT	SST	CIT	NTR*	NID
Mean	3826.53	1928.26	2538.76	1575.61	737.77	2370.38	583.49
Standard Deviation	887.18	456.17	877.44	714.86	169.26	1077.78	306.23
Minimum	2392.53	1161.87	1175.41	426.33	401.08	4395.04	1078.28
Maximum	6029.36	2808.23	4503.66	2680.54	1333.18	688.61	182.35

Notes: All statistics are reported in terms of levels of real dollars per capita (rather than logarithms); net transfers (NTR) is equal to NTR* plus NID; the legend for the abbreviations of these variables is presented in the first section of the appendix. Sample: 1960:1-2007:4.

A.3 Tax Elasticities

I base all elasticities on the general formula $\acute{\eta}_t^i = \acute{\eta}_{t,X} * \acute{\eta}_{t,B}$, where $\acute{\eta}_{t,X}$ is the elasticity of the tax base to GDP and $\acute{\eta}_{t,B}$ is the elasticity of tax revenue to the tax base. Below I outline the process at which I attain the solution to this formula for each type of tax.

Indirect Business Taxes

Based on Blanchard and Perotti (2002), I assume that $\acute{\eta}_{t,X}$ and $\acute{\eta}_{t,B}$ are both equal to 1.00 at any time t. This assumption is plausible, but potentially imprecise. Most indirect taxes are excise taxes on sales or purchases. Thus, the tax base is essentially synonymous with output and the tax base must be unit elastic to GDP. However, this conclusion may not be quite correct, because goods are not uniformly taxed in the United States. Still, 1.00 is probably a pretty close approximation of $\acute{\eta}_{t,X}$. Also, since revenue from indirect taxes is a fairly constant share of the tax base (sales taxes are usually assessed at some constant rate), $ή_{t, B}$ is close to 1.00.

Personal Income Taxes

I obtain values of $ή_{t, X}$ and $ή_{t, B}$ from the objective function T = t(W)*W(E)*E(X), where T is personal income tax revenues, t is the tax rate, W is wages, E is employment, and X is GDP. I define the tax base to be W*E. From these assumptions, I derive $ή_{t, X}$ from H/(F+1), where H is the elasticity of employment to output and F is the elasticity of earnings to employment. I find $ή_{t, B}$ from (FD + 1)/(F+1), where D is the elasticity of tax revenue to earnings (see Blanchard and Perotti [2002]). I obtain H and F from Blanchard and Perotti. I base D on the results of Giorno *et al.* (1995). I find that the elasticity of the tax base to GDP is 0.26—a constant. The elasticity of tax revenue to the tax base, however, varies from 1.62 in 1960:1 to 7.19 in 2007:4 because the value of D increases over time.

Social Security Taxes

I treat social security taxes in the same manner as personal income taxes. The only difference is that social security taxes have different values of D. Thus, the elasticity of the tax base to GDP is still 0.68, while the elasticity of tax revenue to the tax base changes. To be precise, $ή_{t, B}$ is 0.89 in 1960:1 and increases gradually to 1.10 in 2007:4.

Corporate Income Taxes

I assume $ή_{t, B}$ to be equal to 0.85 any time time t. Since corporate income taxes consist of a fairly constant proportion of profits (the tax base), $ή_{t, B}$ should be close to one. However, Blanchard and Perotti report that collection lags cause the elasticity to decrease to 0.85, if the data are assessed at a quarterly frequency. Since this institutional characteristic is unlikely to change dramatically over time, I accept Blanchard and Perotti's estimate as reasonably accurate. I recalculate the value of $ή_{t, X}$ due to its sensitivity to the frequency of the data and its relatively high value. I obtain $ή_{t, X}$ by regressing the change in the logarithm of real per capita corporate profits (from NIPA) on the change in the logarithm of real per capita GDP. This $ή_{t, X}$ is approximately the same as the value that is estimated by Blanchard and Perotti. Thus, I use Blanchard and Perotti's value—4.50—for $ή_{t, X}$.

Net Transfers

The evidence is inconclusive on the values of $ή_{t, B}$ and $ή_{t, X}$. In contrast to annual data, quarterly data probably yield a negative, but fairly inelastic relationship between transfers and unanticipated movements in GDP. For instance, unemployment claims are typically lagging indicators of economic activity. Thus, unemployment payments may not respond to changes in GDP within a single quarter. Blanchard and Perotti assume $ή_t^{NTR}$ to be equal to -0.2. Without any obvious alternative, I defer to this approximation in my benchmark model.

A.4 Dummy Variables

1966 Dummy

Time period: 1966:1.
Lags: 0-1.
Use: Specifications that (explicitly) include SST.
Cause of discontinuity: Introduction of social security health benefits (see Runyon [1973] for more information).

1973 Dummy

Time period: 1973:1.
Lags: 0-4.
Use: Specifications that (explicitly) include SST.
Cause of discontinuity: Second increase in social security taxes due to Medicare legislation (see Runyon [1973] for more information).

1975 Dummy

Time period: 1975:2.
Lags: 0-4.
Use: *All* reduced form-equations.
Cause of discontinuity: Large temporary tax cut (see Blanchard and Perotti [2002] or Blinder [1981] for more information).

1981 Dummy

Time period: 1981:1.
Lags: 0-4.
Use: Specifications that (explicitly) include IND.
Cause of discontinuity: Unknown.

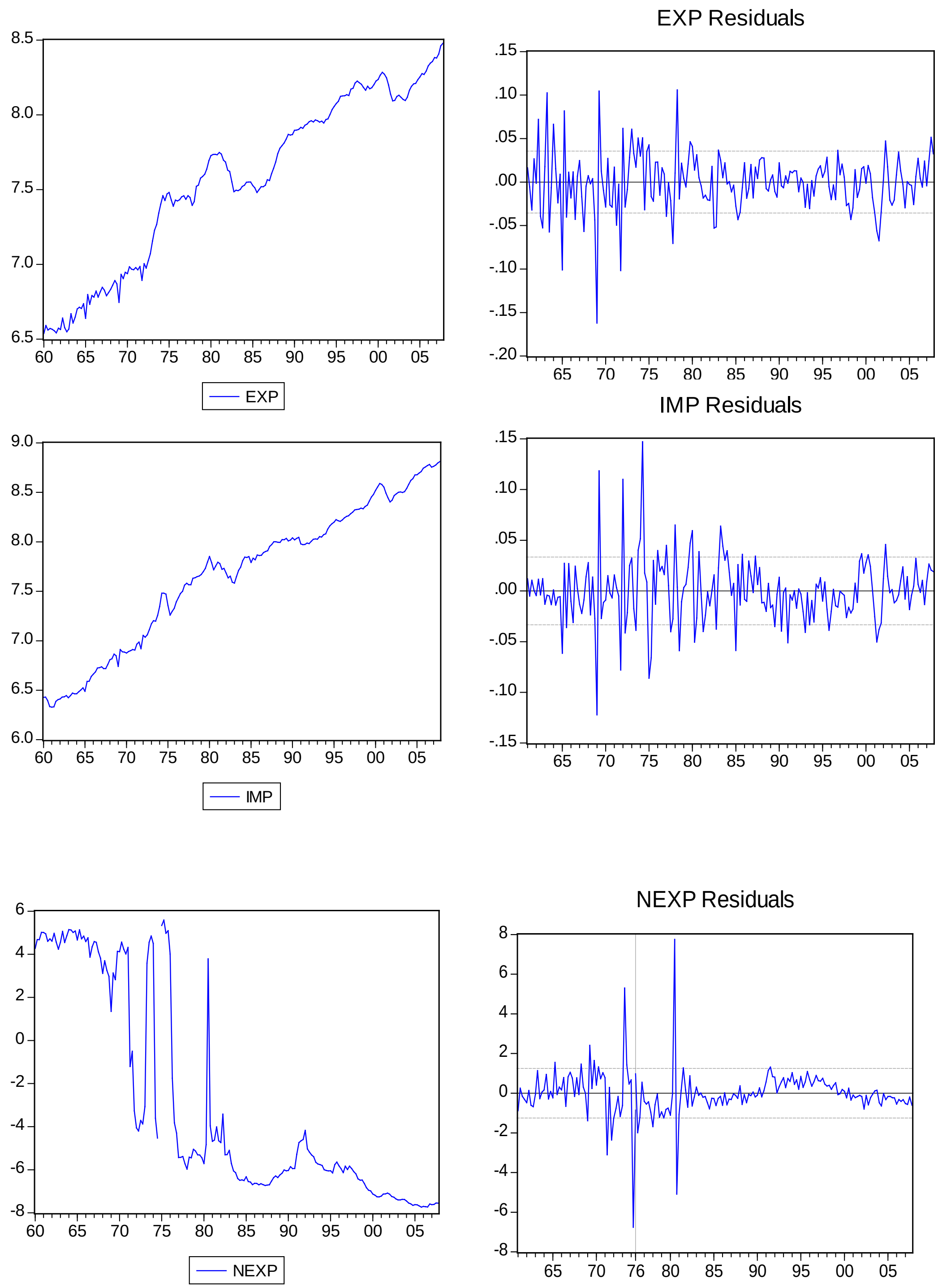
1991 Dummy

Time period: 1991:1.
Lags: 0-4.
Use: Specifications that (explicitly) include NTR.
Cause of discontinuity: Savings and Loan bailout (see Auerbach, Gokhale, and Kotlikoff [1992] for more information).

2001 Dummy

Time period: 2001:3.
Lags: 0-7.
Use: Specifications that (explicitly) include TAX or PIT.
Cause of discontinuity: September 11th (see House and Schapiro [2006] for more information).

A.5 Characteristics of Export and Import Data



Notes: Variables are measured in logarithms; reduced-form equations (on the graphs to the right) allow for deterministic trends in the data, but neither quarter-dependence nor dummy variables.

A.6 Detailed Structural Identification Estimates

Table A1: Contemporaneous effects of net tax and government spending shocks (excludes 2001 dummy).

	Baseline	CON	INV	EXP	IMP
A2	-0.20	-0.28	-0.31	-0.27	-0.27
B2	-0.04	-0.06	-0.06	-0.06	0.08
C1	-0.51	-0.45	-0.45	-0.25	-0.28
C2	1.29	1.16	1.22	1.06	1.24
D1	NA	-0.24	-0.22	-0.02	0.07
D2	NA	0.37	-0.01	0.07	0.53

Notes: All numbers report the dollar change in the regressand from a one dollar shock in the regressor; all reduced-form equations include quarter-dependent lags (1-4) and a dummy for 1975:2; rows indicate coefficients; columns indicate corresponding system of equations. Sample: 1960:1-2007:4.

A2 = effect of e_t^g on τ_t (τ_t = shock in TAX; e_t^g = structural shock in GOV)
B2 = effect of e_t^τ on g_t (g_t = shock in GOV; e_t^τ = structural shock in TAX)
C1 = effect of τ_t on x_t (x_t = shock in GDP)
C2 = effect of g_t on x_t
D1 = effect of τ_t on x_t^k (k is indicated by the header of each column)
D2 = effect of g_t on x_t^k.

Table A2: Contemporaneous effects of corporate income tax, non-corporate income tax, and government spending shocks.

	Baseline	CON	INV	EXP	IMP
B3	0.17	0.19	0.10	0.23	0.21
C2	-0.16	-0.17	-0.18	-0.20	-0.21
C3	-0.01	-0.02	-0.02	-0.01	-0.01
D1	0.14	0.17	0.05	0.46	0.45
D2	-0.34	-0.44	-0.38	-0.45	-0.44
D3	1.06	1.04	1.04	0.92	1.04
F1	NA	0.26	0.21	0.32	0.83
F2	NA	-0.21	-0.05	-0.08	0.06
F3	NA	0.23	0.06	0.07	0.57

Notes: All numbers report the dollar change in the regressand from a one dollar shock in the regressor; all reduced-form equations include quarter-dependent lags (1-4) and a dummy for 1975:2; rows indicate coefficients; columns indicate corresponding system of equations. Sample: 1960:1-2007:4.

B3 = effect of $e_t^{\tau i}$ on τ_t^j (τ_t^j = shock in TAX – CIT; $e_t^{\tau i}$ = structural shock in CIT)
C2 = effect of $e_t^{\tau i}$ on g_t (g_t = shock in GOV)
C3 = effect of $e_t^{\tau j}$ on g_t ($e_t^{\tau j}$ = structural shock in TAX – CIT)
D1 = effect of τ_t^i on x_t (x_t = shock in GDP; τ_t^i = shock in CIT)
D2 = effect of τ_t^j on x_t
D3 = effect of g_t on x_t
F1 = effect of τ_t^i on x_t^k (k is indicated by the header of each column)
F2 = effect of τ_t^j on x_t^k
F3 = effect of g_t on x_t^k
Baseline = system (5) (no decomposition of GDP)
CON, INV, EXP, IMP = permutations of system (6).

Table A3: Contemporaneous effects of indirect business tax, non-indirect business tax, and government spending shocks.

	Baseline	CON	INV	EXP	IMP
A2	-0.09	-0.07	-0.07	-0.04	-0.10
B2	-0.10	-0.16	-0.17	-0.10	0.00
B3	0.37	0.27	0.28	0.20	0.21
C2	-0.57	-0.54	-0.54	-0.68	-0.73
C3	-0.02	-0.03	-0.03	-0.01	0.00
D1	-4.40	-6.96	-7.69	-8.83	-8.53
D2	-0.32	-0.29	-0.31	-0.13	-0.20
D3	1.35	1.12	1.12	1.04	1.22
F1	NA	-1.01	-6.16	-0.79	-0.44
F2	NA	-0.15	-0.04	0.04	-0.02
F3	NA	0.36	-0.04	0.04	0.61

Notes: All numbers report the dollar change in the regressand from a one dollar shock in the regressor; all reduced-form equations include quarter-dependent lags (1-4) and dummies for 1975:2 and 1981:1; rows indicate coefficients; columns indicate corresponding system of equations. Sample: 1960:1-2007:4.

A2 = effect of g_t on τ_t^i (τ_t^i = shock in IND; g_t = shock in GOV)
B2 = effect of g_t on τ_t^j (τ_t^j = shock in TAX – IND)
B3 = effect of $e_t^{\tau i}$ on τ_t^j ($e_t^{\tau i}$ = structural shock in IND)
C2 = effect of $e_t^{\tau i}$ on g_t
C3 = effect of $e_t^{\tau j}$ on g_t ($e_t^{\tau j}$ = structural shock in TAX – IND)
D1 = effect of τ_t^i on x_t (x_t = shock in GDP)
D2 = effect of τ_t^j on x_t
D3 = effect of g_t on x_t
F1 = effect of τ_t^i on x_t^k (k is indicated by the header of each column)
F2 = effect of τ_t^j on x_t^k
F3 = effect of g_t on x_t^k
Baseline = system (5) (no decomposition of GDP)
CON, INV, EXP, IMP = permutations of system (6).

Table A4: Contemporaneous effects of indirect business tax, non-indirect business tax, and government spending shocks (excludes 1981 dummy).

	Baseline	CON	INV	EXP	IMP
B3	0.45	0.49	0.32	0.27	0.41
C2	-0.56	-0.45	-0.48	-0.56	-0.62
C3	-0.02	-0.03	-0.04	-0.01	-0.04
D1	-4.73	-4.52	-4.89	-4.95	-5.78
D2	-0.10	-0.12	-0.10	0.01	-0.02
D3	1.24	1.19	1.25	1.15	1.35
F1	NA	-0.70	-3.98	-0.45	-0.22
F2	NA	-0.17	0.04	0.02	0.16
F3	NA	0.39	0.00	0.06	0.62

Notes: Same as previous table, except the 1981 dummy is excluded. The alternative ordering of the shocks (A2 and B2) is also excluded.

Table A5: Contemporaneous effects of personal income tax, non-personal income tax, and government spending shocks.

	Baseline	CON	INV	EXP	IMP
B3	0.56	-0.15	-0.17	-0.08	-0.10
C2	-0.05	-0.08	-0.06	0.00	0.01
C3	-0.04	-0.07	-0.08	-0.06	-0.07
D1	-0.21	-0.25	0.01	-0.01	-0.03
D2	-0.20	-0.37	-0.32	-0.30	-0.31
D3	1.29	1.20	1.17	1.02	1.19
F1	NA	0.01	0.10	0.08	0.15
F2	NA	-0.20	0.04	0.05	0.22
F3	NA	0.41	0.10	-0.03	0.54

Notes: All numbers report the dollar change in the regressand from a one dollar shock in the regressor; all reduced-form equations include quarter-dependent lags (1-4) and dummies for 1975:2 and 2001:3; rows indicate coefficients; columns indicate corresponding system of equations. Sample: 1960:1-2007:4.

B3 = effect of $e_t^{\tau i}$ on τ_t^j (τ_t^j = shock in TAX – PIT; $e_t^{\tau i}$ = structural shock in PIT)
C2 = effect of $e_t^{\tau i}$ on g_t (g_t = shock in GOV)
C3 = effect of $e_t^{\tau j}$ on g_t ($e_t^{\tau j}$ = structural shock in TAX – PIT)
D1 = effect of τ_t^i on x_t (x_t = shock in GDP; τ_t^i = shock in PIT)
D2 = effect of τ_t^j on x_t
D3 = effect of g_t on x_t
F1 = effect of τ_t^i on x_t^k (k is indicated by the header of each column)
F2 = effect of τ_t^j on x_t^k
F3 = effect of g_t on x_t^k
Baseline = system (5) (no decomposition of GDP)
CON, INV, EXP, IMP = permutations of system (6).

Table A6: Contemporaneous effects of personal income tax, non-personal income tax, and government spending shocks (excludes 2001 dummy).

	Baseline	CON	INV	EXP	IMP
B3	0.13	-0.16	-0.18	-0.12	-0.14
C2	-0.24	-0.06	-0.05	0.01	0.01
C3	-0.07	-0.08	-0.08	-0.07	-0.08
D1	-0.12	-0.11	0.08	-0.04	0.04
D2	-0.08	-0.35	-0.27	-0.28	-0.29
D3	1.26	1.16	1.15	1.00	1.13
F1	NA	0.08	0.07	0.07	0.11
F2	NA	-0.25	0.07	0.07	0.24
F3	NA	0.43	-0.07	-0.02	0.54

Notes: Same as previous table, except the 2001 dummy is excluded.

Table A7: Contemporaneous effects of social security tax, non-social security tax, and government spending shocks.

	Baseline	**CON**	**INV**	**EXP**	**IMP**
B3	0.15	0.15	0.04	0.12	0.30
C2	-0.08	-0.13	-0.09	0.00	0.00
C3	-0.05	-0.04	-0.05	-0.03	-0.04
D1	-0.39	-0.80	-0.71	-0.68	-0.69
D2	-0.35	-0.35	-0.29	-0.27	-0.32
D3	1.13	1.12	1.06	1.03	1.08
F1	NA	-0.43	0.21	0.53	1.36
F2	NA	-0.18	-0.12	-0.04	0.07
F3	NA	0.44	-0.17	0.01	0.53

Notes: All numbers report the dollar change in the regressand from a one dollar shock in the regressor; all reduced-form equations include quarter-dependent lags (1-4) and dummies for 1975:2, 1966:1, and 1973:1; rows indicate coefficients; columns indicate corresponding system of equations. Sample: 1960:1-2007:4.

B3 = effect of $e_t^{\tau i}$ on τ_t^j (τ_t^j = shock in TAX – PIT; $e_t^{\tau i}$ = structural shock in PIT)
C2 = effect of $e_t^{\tau i}$ on g_t (g_t = shock in GOV)
C3 = effect of $e_t^{\tau j}$ on g_t ($e_t^{\tau j}$ = structural shock in TAX – PIT)
D1 = effect of τ_t^i on x_t (x_t = shock in GDP; τ_t^i = shock in PIT)
D2 = effect of τ_t^j on x_t
D3 = effect of g_t on x_t
F1 = effect of τ_t^i on x_t^k (k is indicated by the header of each column)
F2 = effect of τ_t^j on x_t^k
F3 = effect of g_t on x_t^k
Baseline = system (5) (no decomposition of GDP)
CON, INV, EXP, IMP = permutations of system (6).

Table A8: Contemporaneous effects of social security tax, non-social security tax, and government spending shocks (excludes 1966 and 1973 dummies).

	Baseline	**CON**	**INV**	**EXP**	**IMP**
B3	-0.17	-0.23	-0.38	-0.20	-0.32
C2	0.00	-0.04	0.00	0.12	0.08
C3	-0.04	-0.06	-0.06	-0.03	-0.03
D1	0.16	-0.23	0.01	0.03	-0.10
D2	-0.19	-0.42	-0.22	-0.30	-0.33
D3	1.22	1.16	1.10	1.05	1.14
F1	NA	-0.22	0.25	0.64	1.07
F2	NA	-0.28	-0.04	-0.02	0.10
F3	NA	0.45	-0.12	0.05	0.53

Notes: Same as previous table, except the 1966 and 1973 dummies are excluded.

Table A9: Contemporaneous effects of net transfer, tax, and government spending shocks.

	Baseline	CON	INV	EXP	IMP
B3	0.22	0.07	0.23	0.27	0.07
C2	0.03	0.05	0.06	-0.01	0.06
C3	-0.10	-0.10	-0.10	-0.06	-0.07
D1	-0.08	0.02	0.03	-0.09	0.01
D2	-1.16	-1.14	-1.07	-1.13	-1.20
D3	1.18	1.06	1.01	0.93	1.08
F1	NA	0.10	-0.02	0.04	0.09
F2	NA	-1.24	-1.90	-0.08	0.91
F3	NA	0.37	-0.17	0.03	0.50

Notes: All numbers report the dollar change in the regressand from a one dollar shock in the regressor; all reduced-form equations include quarter-dependent lags (1-4) and dummies for 1975:2 and 1991:1; rows indicate coefficients; columns indicate corresponding system of equations. Sample: 1960:1-2007:4.

(See Table A7 for legend.)

Table A10: Contemporaneous effects of net transfer, tax, and government spending shocks (excludes 1991 dummy).

	Baseline	CON	INV	EXP	IMP
B3	0.15	0.03	0.16	0.13	0.02
C2	0.04	0.05	0.06	0.03	0.06
C3	-0.10	-0.10	-0.25	-0.07	-0.08
D1	0.10	0.25	0.14	0.08	0.14
D2	-1.15	-1.12	-1.09	-1.13	-1.20
D3	1.22	1.10	1.13	0.95	1.13
F1	NA	0.30	-0.04	0.10	0.15
F2	NA	-0.73	-1.68	0.02	0.92
F3	NA	0.42	-0.15	0.06	0.54

Notes: Same as previous table, except the 1991 dummy is excluded.

Table A11: Contemporaneous effects of net transfer, tax, and government spending shocks (a_1 = -0.4).

	Baseline	CON	INV	EXP	IMP
B3	0.03	-0.07	0.11	0.14	-0.07
C2	0.03	0.06	0.06	-0.01	0.06
C3	-0.10	-0.09	-0.10	-0.06	-0.07
D1	0.07	-0.03	0.15	0.04	0.15
D2	-1.16	0.23	-1.07	-1.13	-1.20
D3	1.18	1.06	1.01	0.93	1.08
F1	NA	0.15	0.06	0.06	0.12
F2	NA	-0.86	-1.43	-0.02	0.77
F3	NA	0.37	-0.17	0.02	0.42

Notes: Same as Table A9, except a_1 = -0.4 instead of -0.2.

A.7 Alternative Impulse Response Statistics

Responses to a structural shock in government spending (excludes 2001 dummy).

Variable	Q2	Q4	Q8	Q20	Peak
TAX	-0.06*	-0.05	-0.02	0.01	-0.07* (1)
GOV	1.06*	1.56*	1.88	1.24	1.88 (8)
GDP	1.08*	0.92	0.73	0.54	1.29* (1)
CON	0.56*	0.52	0.24	0.17	0.61* (2)
INV	-0.01	0.00	-0.01	0.00	0.02* (1)
EXP	0.03	-0.26*	-0.09	0.11	-0.26* (4)
IMP	0.48	-0.11	3.50	3.02	4.51 (12)

Notes: All numbers are in terms of the dollar response to a one dollar shock; all reduced-form equations include lags 1 through 4 and a dummy for 1975:2; structural shocks are retrieved from identifications in Table A1; QX = X quarters after shock; Peak = maximum response (quarter of peak in parentheses); asterisk indicates that zero is outside of the one standard error bands. Sample: 1960:1-2007:4.

Responses to a structural shock in net taxes (excludes 2001 dummy).

Variable	Q2	Q4	Q8	Q20	Peak
TAX	0.83*	0.72*	0.42	-0.22	0.88* (1)
GOV	-0.08*	-0.09*	-0.08*	-0.05	-0.09* (4)
GDP	-0.45*	-0.36*	-0.23	-0.23	-0.51* (1)
CON	-0.41*	-0.33*	-0.40	-0.62	-0.62* (20)
INV	0.35*	0.62	0.73	0.26	0.75 (5)
EXP	0.00	0.06*	0.09*	0.00	0.11* (6)
IMP	-0.06*	0.00	0.00	-0.01	-0.07* (1)

Notes: same as top table.

Responses to a structural shock in indirect business taxes (excludes 1981 dummy).

Variable	Q2	Q4	Q8	Q20	Peak
IND	0.69*	1.15	0.18	-1.94	1.15 (4)
NOTIND	0.40	0.37	0.41	0.18	0.59* (3)
GOV	-0.59*	-0.64	-0.65	-0.36	-0.66 (6)
GDP	-4.60*	-2.98	-1.49	-2.14	-4.73* (1)
CON	-0.99*	-0.82	-0.53	-0.68	-6.55* (2)
INV	3.98*	10.52	9.15	3.13	10.52 (4)
EXP	-0.84	-1.53	-0.71	1.03	-1.53 (4)
IMP	-0.16	-0.06	-0.04	-0.02	-0.22* (1)

Notes: Same as top table, except the identifications come from Table A4.

Responses to a structural shock in personal income taxes (excludes 2001 dummy).

Variable	Q2	Q4	Q8	Q20	Peak
PIT	0.63*	0.50	0.20	0.11	0.89* (1)
NOTPIT	-0.19*	-0.15	-0.06	-0.03	-0.24* (1)
GOV	-0.26*	-0.24	-0.32	-0.21	-0.33 (10)
GDP	-0.13*	-0.15	-0.14	-0.06	-0.17* (3)
CON	0.08	0.16	-0.12	-0.29	-0.32 (4)
INV	0.07	-0.21	0.00	0.08	-0.21 (4)
EXP	-0.13*	-0.46*	-0.62*	-0.01	-0.66* (7)
IMP	-0.18*	-0.26*	-0.21	-0.05	-0.26* (4)

Notes: All numbers are in terms of the dollar response to a one dollar shock; all reduced-form equations include lags 1 through 4 and a dummy for 1975:2; structural shocks are retrieved from identifications in Table A6; QX = X quarters after shock; Peak = maximum response (quarter of peak in parentheses); asterisk indicates that zero is outside of the one standard error bands. Sample: 1960:1-2007:4.

Responses to a structural shock in social security taxes (excludes 1966 and 1973 dummies).

Variable	Q2	Q4	Q8	Q20	Peak
SST	0.47*	0.08	-0.12	-0.06	0.90* (1)
NOTSST	-0.12*	-0.16*	-0.14*	-0.02	-0.17* (3)
GOV	-0.01	0.00	-0.01	-0.04	-0.04 (20)
GDP	-0.05	-0.86*	-1.23*	-0.11	-1.23* (8)
CON	0.00	-0.77*	-1.35*	-0.39	-1.43* (9)
INV	-0.25	-0.53*	-0.81	0.34	-0.85* (7)
EXP	0.73*	0.04	-0.13	-0.13	0.73* (2)
IMP	0.56*	-0.05	-0.21	0.43	1.07* (1)

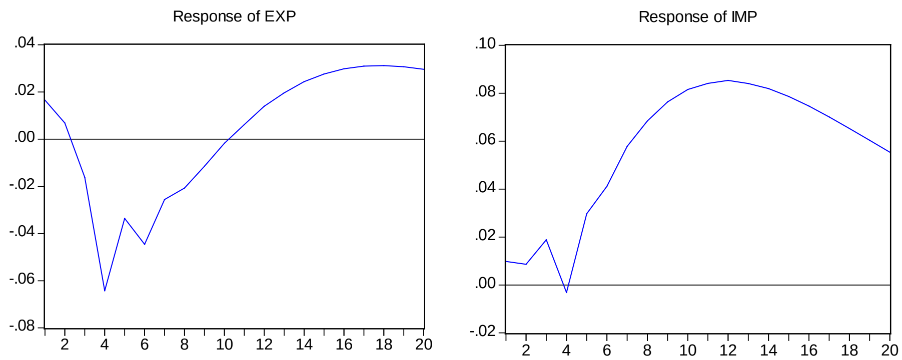
Notes: Same as top table, except identifications come from Table A8.

Responses to a structural shock in net transfers (excludes 1991 dummy).

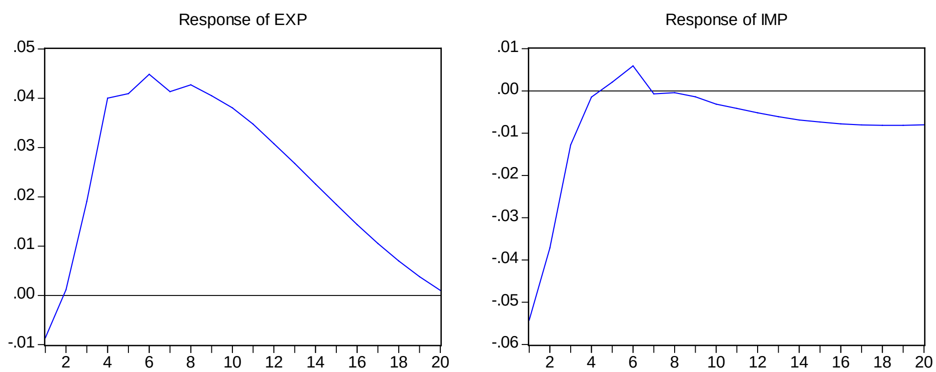
Variable	Q2	Q4	Q8	Q20	Peak
NTR	0.61*	0.72*	0.64	-0.09	1.02* (1)
NOTNTR	0.09*	0.06	-0.03	0.00	0.15* (1)
GOV	0.02	0.02	-0.04	-0.06	-0.07* (15)
GDP	-0.09	-0.16	-0.16	-0.02	-0.24 (6)
CON	-0.30*	-0.62*	-0.60	0.05	-0.65 (6)
INV	-0.03	-0.03	-0.02	-0.01	-0.04 (1)
EXP	-0.19*	-0.13	-0.31	0.01	-0.32 (7)
IMP	0.10*	0.02	-0.02	0.03	0.15* (1)

Notes: Same as the top table, except identifications come from Table A10.

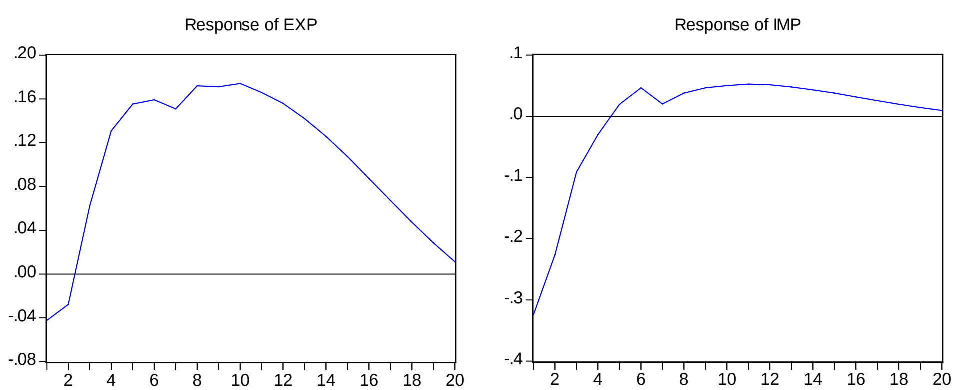
A.8 Export and Import Impulse Response Graphs



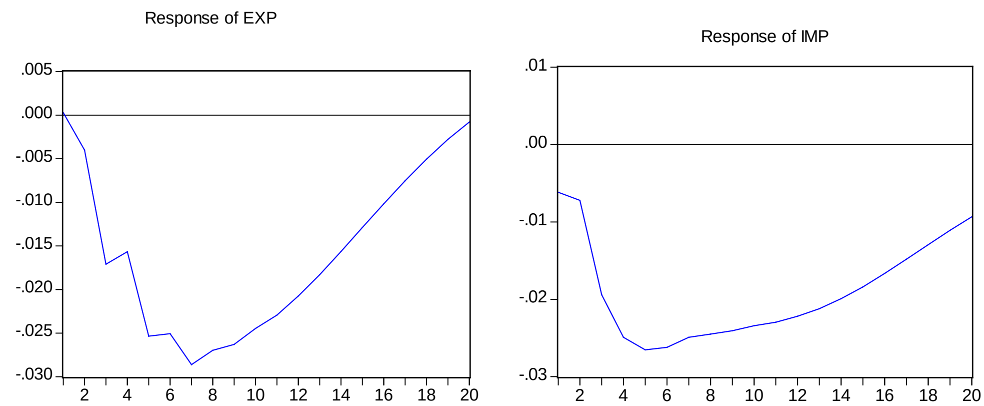
Responses to a structural shock in government spending (see Figure 5 for notes).



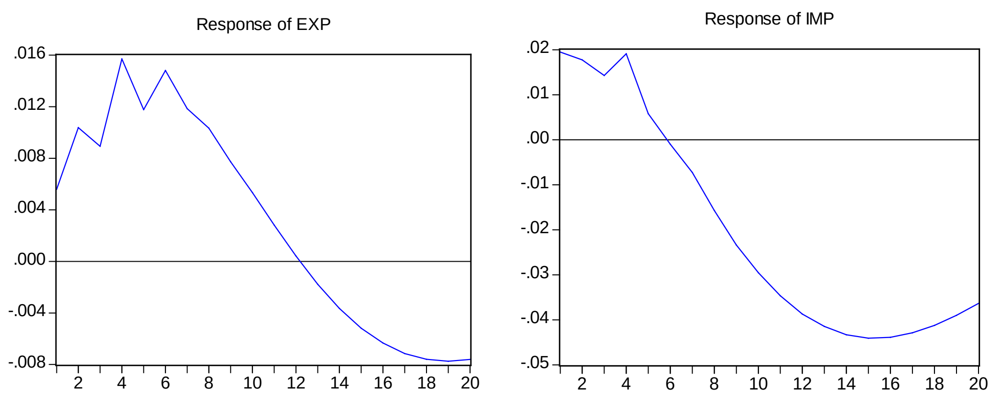
Responses to a structural shock in net taxes (see Figure 6 for notes).



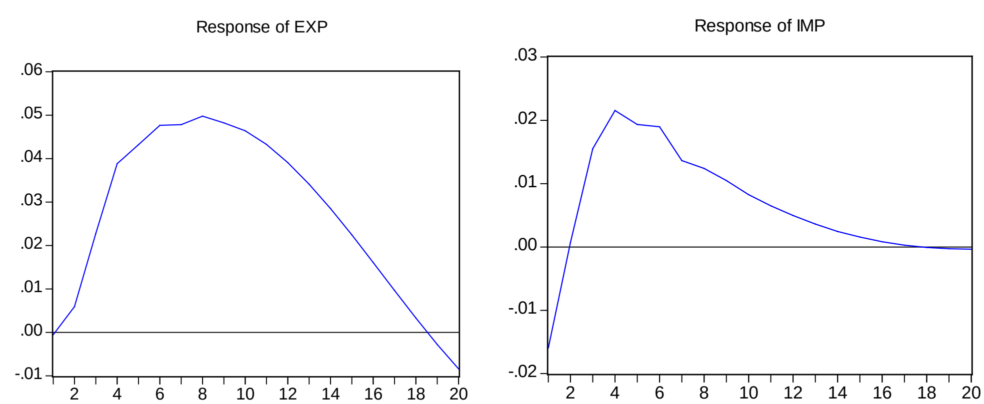
Responses to a structural shock in indirect business taxes (see Figure 7 for notes).



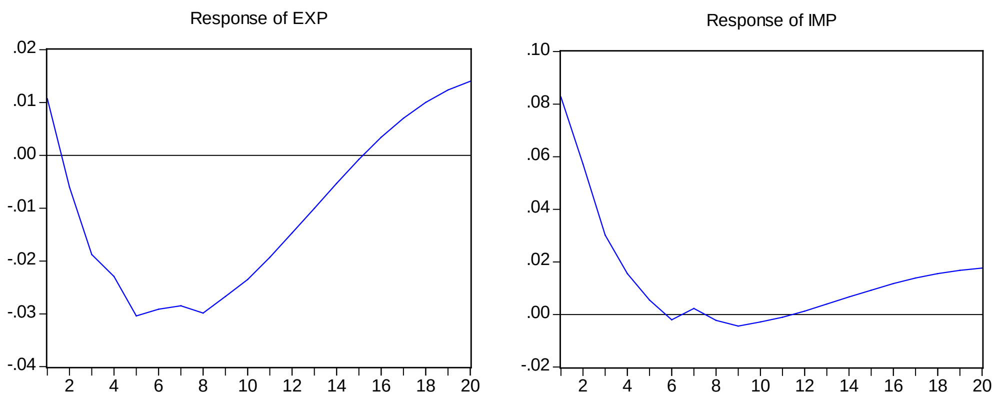
Responses to a structural shock in personal income taxes (see Figure 8 for notes).



Responses to a structural shock in social security taxes (see Figure 9 for notes).



Responses to a structural shock in corporate income taxes (see Figure 10 for notes).



Responses to a structural shock in net transfers (see Figure 11 for notes).

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