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Marginal income tax rates and the U.K. economy: three essays

Eon-Seon Rym
Louisiana State University and Agricultural and Mechanical College

MARGINAL INCOME TAX RATES AND THE U.K. ECONOMY: THREE ESSAYS

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Eon-Seon Rym
B.A., Chung-Ang University, 1987
M.S., Chung-Ang University, 1989
M.S., Louisiana State University, 1998
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ABSTRACT

This dissertation investigates the role of fiscal policy on economic activity by analyzing the response of major macroeconomic variables to innovations to the average marginal income tax rate (AMTR) measures in the U.K. by employing vector autoregressive (VAR) models. We identify these innovations by making certain assumptions about fiscal policy and then analyze the dynamic behavior of output, the interest rate, the exchange rate, and the trade balance in response to an increase in AMTR by studying the impulse response functions (IRFs) derived from the VAR and structural VAR (SVAR) approaches.

The first essay focuses upon the calculation of the AMTR in the U.K. by using the methodologies of Seater (1982, 1985) and Barro and Sahasakul (1983, 1986).

The second essay uses a VAR model to estimate the dynamic effects of fiscal policy shocks on macroeconomic variables in the U.K. We find that in response to an increase in AMTR, output falls, the trade balance improves, and the exchange rate depreciates. The results are quite robust to changing the ordering of the Choleski decomposition and using a different lag length.

The third essay employs a SVAR model that imposes long run restrictions, and estimates the dynamic effects of fiscal policy shocks on macroeconomic variables in the U.K. Our findings indicate that a positive innovation to AMTR, which results in a permanent increase in the AMTR, reduces output, raises the interest rate, and depreciates the exchange rate. These results are robust with respect to different lag lengths and different orderings of fiscal policy variables.

The empirical findings from the SVAR model are similar to those from the earlier benchmark model. The point estimates of impulse response functions for the SVAR models lie within the confidence intervals for the previous benchmark model, which implies that there are no significant differences between the benchmark and the SVAR models.

CHAPTER 1

INTRODUCTION

In analyzing the transmission of monetary policy, vector autoregressive (VAR) models have been employed as a popular tool for a long period of time. Like monetary policy analysis, recent research analyzing the transmission of fiscal policy has also employed the VAR analysis. In addition to a number of studies that incorporate government spending into VAR models, a few studies have attempted to investigate the effects of tax policy innovations.

Ramey and Shapiro (1997) find that the effects of military buildups on a variety of macroeconomic aggregates are consistent with the predictions of a multi-sector neoclassical model; consumption, real wages and manufacturing productivity fall in response to exogenous military buildups in the post-World War II United States. Edelberg, Eichenbaum and Fisher (1999) analyze the effects of exogenous shocks to real government defense spending in the U.S. within VAR models. They conclude that models in which real wages rise after a positive shock to government purchases are inconsistent with the data. Clarida and Prendergast (1999) present some empirical results on the dynamic relationship between fiscal policy and the real exchange rate in the G3 countries since the advent of floating exchange rates. They find a similarity across the G3 countries in their estimated dynamic responses to a fiscal shock. For several years, the real exchange rate appreciates in response to an expansionary fiscal shock. However, eventually, the process is reversed; the real exchange rate overshoots and actually depreciates relative to its initial prevailing before the fiscal shock. Fatás and Mihov (2000) examine the effects of exogenous shocks to real government purchases in a

semi-structural VAR model using the U.S. data. They find that real GDP increases only initially and returns to its origin level after some time, the price level falls significantly, and there is a temporary positive effect on the T-Bill rate following a positive government expenditure shock.

Blanchard and Perotti (2002) estimate the dynamic effects of shocks to government spending and taxes on economic activity in the United States in the postwar period. By using a structural VAR approach, they show that positive government spending shocks have a positive effect on output, and positive tax shocks have a negative effect. Perotti (2002) investigates the effects of fiscal policy on GDP, prices and interest rates in 5 OECD countries using a structural VAR model. He shows that a shock to government expenditures has a positive effect on GDP, a negative effect on prices, and a significant effect on the real short-term interest rate.[1]

This dissertation analyzes the macroeconomic effects of fiscal policy in the U.K. using a VAR approach. The previous literature commonly uses government expenditures in fiscal policy. When taxes are used as a fiscal policy measure, it is generally tax revenue. Blanchard and Perotti (2002) and Perotti (2002) use the revenue variable as net taxes (total tax revenue minus transfers), van Aarle, Garretsen and Gobbin (2001) use total government revenue, and Fatás and Mihov (2000) use both lump sum and distortionary taxation. The economically meaningful measure, however, is the average marginal tax rate that I use in this dissertation. The average marginal income tax rate affects decisions to work, produce, save, and invest. I also calculate the average tax rate. However, in case of the graduated income tax rate, the average tax rate does not tell us directly the fraction of income that the "representative" person gets to keep at the

[1] See Ramey and Shapiro (1997) for a useful summary of the earlier literature.

margin. Therefore, the average tax rate may not provide an adequate basis for determining the allocative effects of taxation. E. Frank Stephenson (1998) reports the average tax rate and three different average marginal income tax rates in the U.S. And Burnside, Eichenbaum, and Fisher (2000) use Stephenson's average marginal tax rate to investigate the response of real wages and hours worked to an exogenous shock in fiscal policy; the fiscal shocks are characterized by highly correlated increases in government purchases, average marginal tax rates and hours worked as well as persistent declines in real wages in the U.S.

To insure the VAR analysis yields meaningful information on the effects of fiscal policy, the exogenous shocks to fiscal policy must be separated from policy makers' systematic response to nonfiscal developments in the economy; hence, fundamental identification problems must be solved. Four different identification schemes for fiscal policy shocks have been used in the literature. Ramey and Shapiro (1997) used a "narrative approach" similar to that used by Romer and Romer (1989) to identify exogenous shocks to defense spending in the U.S. They construct a dummy variable that captures the Korean war military built-up, the Vietnam War built-up, and the Carter-Reagan military built-up. The Ramey-Shapiro dummy variable is used by Edelberg, Eichenbaum, and Fisher (1999) and Burnside, Eichenbaum, and Fisher (2000).

A second approach imposes a recursive causal structure, which is called the Wold causal structure, on the contemporaneous relations among model variables to identify fiscal policy shocks. In this approach, it is assumed that economic variables are determined in a block recursive way. Hence, one-way causation from variables higher in the ordering is assumed; all contemporaneous correlation between two variables is

attributed to the variable higher in the order, while there is no contemporaneous feedback from variables lower in the ordering to those higher in the ordering. Consequently, fiscal policy shocks are estimated by decomposing variance-covariance matrices of the ordinary least squares residuals in VAR models in a triangular fashion (Choleski decomposition). The identification schemes of Fatás and Mihov (2000) and Favero (2002)[2] rely on Choleski ordering to identify fiscal shocks.

A third approach is akin to a structural VAR, which is developed by Blanchard and Perotti (2002). Identification is achieved by exploiting decision lags in fiscal policy and by using institutional information about the elasticity of fiscal variables to economic activity. In this type of approach, an explicit structural model is used to specify simultaneous interactions among variables in a system, although recursive structures are sometimes chosen for some variables in the system. Perotti (2002) is a good example of this approach, which extends Blanchard and Perotti (2002) to take into account monetary policy and inflation.

The last approach employs a structural VAR by imposing long run restrictions. This approach was pioneered by Blanchard and Quah (1989) and Shapiro and Watson (1988). Van Aarle, Garretsen and Gobbin (2001) is a good example of this approach, which is used to explain the effects of monetary and fiscal policy. I am going to use this approach for my dissertation to investigate the long run effects of fiscal policy.

Currently, an average marginal tax rate measure is available only for the U.S., which is calculated by Seater (1982, 1985), Barro and Sahasakul (1983, 1986), and Stephenson

[2] In Fatás and Mihov (2000), government spending is ordered first: other endogenous macroeconomic variables (output and prices) are not allowed to affect government spending contemporaneously. Favero (2002) investigates the behavior of monetary and fiscal authorities in the Euro area; fiscal shocks are identified by analogy to monetary shocks, namely by imposing the condition that they cannot affect output and prices contemporaneously; hence, fiscal variables are ordered last.

(1998). Consequently, the first step in the dissertation is to construct an average marginal tax rate measure for the U.K. Chapter 2 provides the explanation and calculation of the average marginal income tax rates for the U.K. by using the methodology of Seater (1982, 1985) and Barro and Sahasakul (1983, 1986).

In Chapter 3, we investigate the role of fiscal policy on economic activity by analyzing the response of major macroeconomic variables to innovations to the average marginal income tax rates in the U.K. by employing VAR models. We find remarkably similar results across six different models in the estimated dynamic responses to fiscal policy shocks, and the results are quite robust to changing the ordering of Choleski decomposition. In response to a positive innovation to average marginal income tax rates, output falls, the trade balance improves, and the exchange rate depreciates for all models.

Chapter 4 analyzes the macroeconomic effects of fiscal policy in the U.K. using a structural vector autoregressive (SVAR) approach by imposing long run identifying restriction. Again, we find remarkably similar results across six different models in the estimated dynamic responses to fiscal policy shocks when we impose long run restrictions. Our results indicate that a positive innovation to average marginal tax rates, which results in a permanent increase in the marginal tax rate, has a negative effect on output in the short run and a positive effect on the exchange rate which lasts for a long period of time. The initial increase in the interest rate, however, presents a puzzle. These empirical findings are robust with respect to different average marginal tax rate measures and to alternative orderings.

Finally, the research concludes with summary and conclusions in chapter 5.

CHAPTER 2

AVERAGE MARGINAL TAX RATES IN THE U.K. ECONOMY

2.1. Introduction

Macroeconomic analysis of fiscal policies stresses the theoretical importance of taxation as a determinant of economic decision-making. However, in spite of the general understanding that taxes are powerful policy instruments, the assessment of macroeconomic implications of tax policies has been prevented by serious limitations in the measurement of relevant aggregate tax rates. For example, even though marginal income tax rates are an important element of incentives and constraints affecting economic decisions in the intertemporal framework used in modern fiscal policy analysis, the data on marginal income tax rates have been lacking for all countries except the U.S.

The measurement of tax rates for macroeconomic models has proven to be a difficult task. The large literature on the measurement of marginal income tax rates proposes different strategies to combine information on statutory tax schedules, tax returns, and tax codes with data on income distribution and household surveys. Seater (1982, 1985) and Barro and Sahasakul (1983, 1986) introduce average marginal tax rate series for the United States individual income tax return.

John J. Seater (1982) describes the new statistical series on the marginal federal income tax rates for private individuals in the United States since the beginning of federal income taxes and then analyzes the behavior of the series over time.[3] Seater (1985) compares his data on the marginal tax rates and his method of construction of the marginal tax rates with those of Barro and Sahasakul.

[3] Seater (1982, 1985) defines each tax bracket's marginal tax rates as the ratio of the difference between the tax bill of that bracket and the tax bill of the previous bracket divided over the difference between the income earned by individuals in the same two tax brackets.

Robert J. Barro and Chaipat Sahasakul (1983, 1986) construct appropriately weighted average marginal tax rate (AMTR) measures for 1916-80 and show that the explicit marginal rate from the tax schedule is the right concept for many purposes. They use the data on average marginal tax rates in a study of the effects of government policies on aggregate output, employment, and other macroeconomic variables. They show that the time-series data on average marginal tax rates are useful in testing the implications of alternative macroeconomic theories. They test for a different impact of temporary versus permanent shifts in marginal tax rates on output, employment, and other macroeconomic variables. Although the weighted averages of statutory marginal tax rates are useful for many purposes (e.g., studying the underground economy or compensation in untaxed fringe benefits), they fail to explain the positive relationship between deductions and incomes that are present in the U.S. tax system.[4]

E. Frank Stephenson (1998) extends through 1994 the estimates of average marginal income and social security tax rates of Seater (1982, 1985) and Barro and Sahasakul (1983,1986), and he introduces a return-weighted social security tax rate. His results show that the average marginal tax rates decrease after 1981, but that the rates are still high by historical standards because of the large increase in the average marginal social security tax rate.

The remainder of this chapter is organized as follows. Section 2.2 explains the average marginal tax rate in the U.K. economy. Section 2.3 describes the changes in AMTR in the U.K. tax system. Section 2.4 concludes.

[4] More precisely, it only accounts for deductions if they push a taxpayer into a lower tax bracket. Barro and Sahasakul (1983, 1986) compute aggregate marginal tax rates by taking a weighted average of the statutory tax rates listed in income tax schedules. Because their analysis is based on statutory taxes, the estimates are biased upward to the extent that credits, exemptions, and deductions are not taken into account.

2.2. The Average Marginal Tax Rate in the U.K. Economy

The marginal tax rates are important to assess the economic effects of taxation; the marginal tax rates on income affect decisions to work, produce, save, and invest. The concept of the average marginal tax rate (AMTR) is very simple in theory, and it is easy to quantify at a microeconomic level. However, calculating the average marginal tax rates that apply at a national or international level is less straightforward for several reasons. First, the tax systems include different forms of taxation affecting the same tax base, such as individual income taxes levied on wages and social security taxes, both of which constitute a tax on labor income. At the international level, the situation is complicated by differences in the structure of tax systems and limitations of the information available on tax revenues and income distribution. Second, the complexity and variety of tax exemptions, deductions, and credits make it difficult to estimate the actual tax burden from information on statutory tax rates. Third, the tax revenue data and tax system do not conform to the aggregate concepts of a macroeconomic model. Finally, most available methods for calculating aggregate marginal tax rates require data on the distribution of income consistent with income tax schedules and returns and with the schedule of social security contributions.[5]

To calculate the average marginal tax rate (AMTR), I follow the methodology employed by John J. Seater (1982, 1985) and Robert J. Barro and Chaipat Sahasakul (1983, 1986). The average tax rate (ATR) is calculated as the ratio of total income tax to total income obtained from the website[6] (*Inland Revenue Statistics*) and the *Annual Abstract of Statistics on Office for National Statistics* in the United Kingdom (U.K.),

[5] See Easterly and Rebelo (1993).
[6] The website address is "http://www.inlandrevenue.gov.uk. The website has all data about taxes and revenue.

which is in the first column in table 1. Total income is the total of earned income and investment income assessable for each year from the Annual Survey of Personal Incomes and income tax is calculated as the liability for the income tax year, regardless of when the tax may have been paid or how it was collected.

Average marginal tax rates (AMTRs) for the U.K. are constructed for the period 1948-1998 by employing the methodology of John J. Seater (1982, 1985).[7] The data are presented in the third column of Table 2.1. Following Seater (1982, 1985), AMTR for year i is calculated according to the following formula;

$$AMTR_i = \sum_i \frac{T_i - T_{i-1}}{Y_i - Y_{i-1}} \cdot W_i \ ,$$

where the summation is over the income classes in the data. T_i is the income tax[8], and Y_i is the total income before tax[9] in classes i, which is the total of earned income and investment income. W_i is the share of income in class i.[10] There are a few difficulties in calculating the average marginal tax rates. First, on the income tax table in each year, the last income class is open-ended and has no midpoint. Therefore, we used the value of the last income class to be the midpoint.[11] Second, a few of highest income classes were grouped together because the *Annual Abstract of Statistics on Office for National*

[7] The average marginal tax rate is computed as a weighted average of the individual value of marginal tax rate, using the fractions of total income in each bracket as the weights.

[8] From the *Inland Revenue Statistics* in the United Kingdom, "Income tax is calculated as the liability for the income tax year, regardless of when the tax may have been paid or how it was collected. The income tax was calculated without deduction for relief at basic rate given at source in each year. Estimates of tax liability allow for relief at basic rate as at high rates. The provision of basic rate relief at source on most mortgage interest thus produces higher estimates of tax due than in previous years."

[9] The distributions cover only incomes as computed for tax purposes. Earned income covers employment income (including employees' superannuation contributions, the taxable value of taxable benefits in kind, but excluding employment expenses).

[10] The share of income is the weighted by total income in each class.

[11] On the income tax table in each year, each income class has a range, such as 0 to 4,195, 4,195 to 4,500, 4,500 to 5,000,…, 100,000 to 200,000, and over 200,000. We use the midpoint of each income class except the last income class; 2,096, 4,346, 4,750,…, 150,000, 200,000.

Statistics in the United Kingdom (U.K.) does not report the income within a particular class if there are only one or two individuals within that class but rather groups a few adjacent classes together. Third, there are a few returns reported in the non-taxable income group with negative income in some years. These were excluded because their inclusion would have introduced a slight error in the weight used in the weighted average.

Robert J. Barro and Chaipat Sahasakul (1983, 1986) calculated the weighted averages of the statutory marginal income tax rate, using as weights both shares of total income and shares of returns, which are called Barro1 and Barro2 on the fourth and fifth column respectively. On their average marginal tax rates, Y_i is the total income after tax.

Table 2.1. Average Tax Rate and Three Different Average Marginal Tax Rates on the U.K.

Year	ATR	Seater	Barro1	Barro2
1948	13.6	20.9	72.4	14.3
1949	13.3	20.8	62	14.9
1950	12.7	38.5	76.7	31.1
1951	13.2	20.6	61.8	16.4
1952	11.5	18.1	59.7	12.9
1953	10.8	17.0	40.2	11.4
1954	11.3	18.6	48.2	13.9
1955	11.0	18.1	40.7	14.0
1956	11.4	18.8	38.5	15.4
1957	11.7	20.5	48.6	35.2
1958	12.1	19.3	46.3	16.4
1959	11.3	18.7	34.8	15.2
1960	12.3	19.9	42.3	16.7
1961	12.1	19.2	55.0	16.9
1962	12.3	19.3	33.1	16.6
1963	11.8	18.8	32.2	16.5
1964	12.8	19.9	34.8	18.0
1965	14.5	22.2	43.5	20.8
1966	14.5	21.8	39.3	21.2
1967	15.0	22.4	38.8	22.3
1968	16.1	23.7	41.7	24.4

(Table 2.1. continued)

Year	ATR	Seater	Barro1	Barro2
1969	17.5	25.5	45.8	27.5
1972	16.5	24.2	40.1	26.4
1973	17.5	25.2	41.7	28.2
1974	20.7	28.7	53.3	34.7
1975	22.1	29.9	51.0	37.6
1976	22.0	30.1	50.7	37.0
1977	20.0	28.2	46.2	33.7
1978	19.2	26.7	41.8	31.1
1979	18.1	24.4	34.3	27.4
1980	18.9	25.5	36.0	30.5
1981	19.9	26.6	38.4	32.0
1982	19.5	26.1	36.6	30.5
1983	19.8	27.2	38.1	32.8
1984	19.5	26.8	38.3	31.4
1985	13.2	23.9	33.5	27.0
1986	17.8	24.4	34.7	27.9
1987	17.4	23.5	33.2	26.0
1988	15.7	20.7	27.3	22.7
1989	16.0	21.7	28.9	23.2
1990	16.9	22.7	30.4	24.8
1991	16.5	23.0	31.2	25.4
1992	15.9	22.9	30.7	24.2
1993	17.4	24.6	33.4	27.4
1994	17.9	25.1	34.6	28.1
1995	18.2	25.6	35.5	28.9
1996	17.8	24.9	34.3	27.2
1997	17.2	24.1	32.8	26.1
1998	17.7	24.6	33.8	26.3

According to the average marginal tax rate data of the U.K. on table 2.1, the three different average marginal income tax rates (Seater, Barro1 and Barro2 types of tax rates) are greater than the average tax rate (ATR), which is the ratio of income tax revenue to aggregate income before tax, in the same year because of the progressive tax system in the U.K. Barro and Sahasakul (1983, 1986) were more interested in person-weighted average marginal tax rates than in income-weighted numbers. They constructed indices of average marginal tax rates where the individual rates are weighted by numbers of

returns rather than by total income. The indices weighted by numbers of returns are typically much lower than those weighted by total income. Therefore, the Barro1 measure is greater than the Barro2 measure because of the unequal distribution of income. The Barro1 measure exceeds Seater's measure because the total income before tax in Seater's measure is greater than the total income after tax in the Barro 1 measure.[12]

Barro and Sahasakul (1983) have suggested different method for constructing average marginal income tax rates from the *Inland Revenue Statistics* data. Their measures are broadly similar to the Seater's, but there are some substantial differences between the two. Barro and Sahasakul (1983) compute AMTRs by taking income after tax and weighted averages of the tax rates listed in the income tax schedule. This procedure generates a substantially higher value of the AMTR than does Seater's approach because the latter uses income after tax whereas the former uses income before tax. Seater's AMTR uses the right concept of income, income before tax. Therefore, we prefer Seater's measure. [13]

From the correlation matrix for the tax rate measures on Table 2.2, we see that the average tax rate (ATR) measure and Seater's AMTR measure, the average tax rate (ATR) measure and the Barro 2 AMTR measure, and Seater's AMTR measure and the Barro 2 AMTR measure are highly correlated each other. However, the Barro 1 AMTR measure

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[12] These results are similar to the results of Stephenson (1998) for the U.S. Stephenson (1998) calculates the average marginal income tax rates (1913-1994), which are the average tax rate (ATR), the ratio of income tax revenue to adjust gross income (AGI), the Seater-type series of average marginal effective income tax rates (AMEITR) weighted by shares of AGI in each income class, and Barro and Sahasakul's marginal statutory income tax rate (AMSITR), weighted by shares of AGI and shares of returns, respectively. He finds that all of the average marginal tax rate measures are greater than the corresponding average tax rate because of the progressive tax system in the U.S. The average marginal statutory tax rate weighted by income is greater than the average marginal statutory tax rate weighted by income is greater than the average marginal statutory tax rate weighted by returns because of the unequal distribution of income, and the average marginal statutory tax rate weighted by income exceeds the average marginal effective income tax rate (AMEITR) because the latter accounts for deductions from income subject to taxation.

[13] For more detail see Seater (1985)

is not highly correlated with the others. Although the correlation of Barro 1 with the other measures is low, the results reported later are similar across all average marginal tax rate measures.

Table 2.2. Correlations of Average Marginal Income Tax Rates

	ATR	Seater	Barro 1	Barro 2
ATR	1.000	0.9536	0.176	0.841
Seater	0.954	1.000	0.330	0.900
Barro 1	0.176	0.330	1.000	0.332
Barro 2	0.841	0.900	0.332	1.000

2.3. Changes in the U.K. Tax System

In England, the income tax was introduced in 1799 (announced in 1798) as a means of paying for the war against the French forces under Napoleon. In 1927, Chancellor Winston Churchill set up the Income Tax Codification Committee, which condensed the 800 provisions of 19 different Acts, and the decisions of 1800 court cases, into a single code. It reported in 1936, but, with the Second World War intervening, was not considered in detail until 1952.

For many years, a distinctive feature of the U.K. tax system has been characterized by a very wide basic rate band; most taxpayers had the same marginal tax rates. In the 1980s, other countries have substantially reduced the complexities of their tax schedules, and the wide rate band has become less unusual.

Table 2.3 shows the income tax schedule that operated in four postwar years, with thresholds reflated to 1988 levels by the change in average earnings.

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1980s, other countries have substantially reduced the complexities of their tax schedules, and the wide rate band has become less unusual.

Table 2.3. Income Tax Rates and Thresholds in the U.K., 1948-1989[14]

1948/49		1966/67		1978/79		1988/89	
Rate	threshold	Rate	threshold	Rate	threshold	Rate	threshold
12	750	15.5	750	12	750	15.5	750
24	3,750	23.3	2,380	24	3,750	23.3	2,380
36	30,000	32	15,300	36	30,000	32	15,300
55	37,000	43	19,150	45	23,000		
57.5	45,000	46	23,000	50	26,000		
62.5	60,000	51	30,600	55	29,000		
67.5	75,000	61.5	38,300	60	33,000		
72.5	90,000	67	46,000	65	37,000		
77.5	120,000	72.5	61,000	70	43,000		
82.5	150,000	78	77,000	75	56,000		
87.5	180,000	83.5	92,000	83			
92.5	225,000	89	115,000				
95		91.5					

Note: The rate is percentage (%), and the threshold is pound. The average earnings for a male full-time worker in the U.K. in 1988/89 were 12,500 pounds.

Table 2.3 shows the income tax schedule that operated in four postwar years, with thresholds reflated to 1988 levels by the change in average earnings.

The apparent complexity of this table is misleading; in practice the effects of the schedules were quite simple. In 1948/49, there were two reduced rates (12 percent and 24 percent) for those with low taxable incomes, and then a very wide band up to 30,000 pounds where the basic rate applied. Although there were thirteen tax rates, almost everyone paid 36 percent. In 1966/67, although high tax rates began slightly earlier, it was almost the same as before at a taxable income of 15,300 pounds (32 percent). In 1978/79, the higher tax rate due on taxable earnings in excess of 18,600 pounds was paid

[14] Table 2.2 is on the "*Inland Revenue Statistics"* from the website "http://www.inlandrevenue.gov.uk."

by 3.62 percent of the population (see Table 2.4). By 1988/89, only one higher income tax rate was left, and it was paid by 5.02 percent of the population.

Table 2.4. Percentage of U.K. Taxpaying Population Paying Tax Rates over 40 Percent, 1978/79 and 1988/89

Rates in excess of	1978/79	1983/84	1988/89
40	3.62	4.43	5.02
45	2.52	2.53	
50	1.76	1.49	
55	1.35	0.71	
60	0.95	0.36	
65	0.69		
70	0.48		
75	0.33		
83	0.16		
Total	3.62	4.43	5.02

Source: Inland Revenue, Inland Revenue Statistics, various years.
Note: The rate is percentage (%).

Reducing the level and number of higher tax rates was an important objective of the Thatcher government. In the first Conservative budget in June 1979 the top rate of tax on earned income was cut from 83 percent to 60 percent (see Table 2.4). However, the number of taxpayers paying rates of 40 or 45 percent actually increased. No further major changes to higher rates occurred between 1979 and 1988. Then all but one of the higher rates was abolished, leaving a two-rate system with a 25 percent basic rate and a single higher rate of 40 percent.

The value-added tax[15] was introduced and the surtax[16] was removed in 1973, but was replaced by higher rates of income tax for those with high incomes. After these

[15] The value-added tax (VAT) is the most important indirect tax in the United Kingdom, accounting for around one-half of total indirect tax revenue. All traders whose annual turnover exceeds £22,100 are liable to VAT on their output; however, registered traders may recover any VAT that has been charged on their purchases. Thus intermediate transactions are effectively free of VAT and the incidence of the tax falls on final consumption.
[16] The surtax is the super high income tax for high-income people, which is introduced by Lloyd George in 1909.

changes all the average marginal tax rates increased. From 1973 to 1975, the average tax rate increased from 17.5 percent to 22.1 percent, Seater's tax rate measure increased from 25.2 percent to 29.9 percent, and Barro1 and 2 measures increased from 41.7 percent to 51 percent and from 28.2 percent to 37.6 percent, respectively. But after this period, the tax rates gradually fell.

From 1979 to 1988, three major tax reform packages were introduced. After the election of the first Thatcher government in 1979, the tax rates were greatly reduced. The basic rate of income tax was reduced from 33 percent to 30 percent with the long-term goal of a reduction to 25 percent. The maximum income tax rate was reduced from 83 percent to 60 percent beginning in 1979. Income tax thresholds have been raised in successive budgets and are now 22 percent higher in real terms than in 1979. Therefore, Seater's tax rate measure decreased from 26.7 percent to 24.4 percent, and Barro 1 and 2 measures decreased from 41.8 percent and 31.1 percent to 34.3 percent and 27.4 percent, respectively.

The second tax reform came in the first budget of the Thatcher government's second term in office in 1984. The new chancellor, Nigel Lawson, proclaimed a "tax reform budget". Personal taxation was affected by the withdrawal of a few minor tax expenditures, especially partial relief for life insurance contributions. Seater's tax rate measure fell from 26.8 percent to 23.9 percent, and Barro 1 and 2 measures also went down from 38.3 percent and 31.4 percent to 33.5 percent and 27 percent, respectively.

The third tax reforms in 1988 cut the top income tax rate to 40 percent and the number of rate bands was reduced to two.[17] Seater's tax rate measure fell from 23.5

[17] See Table 3.2. On 1988/89, there are two tax rate bands (25% and 40 %).

percent to 20.7 percent, and the Barro 1 and 2 measures fell from 33.2 percent and 26 percent to 27.3 percent and 22.7 percent, respectively.

There was no major tax reform after 1990. However, since 1990, a married woman has been taxed independently on her income with her own personal allowance.[18] From 1990 to 1998, the average tax rate increased from 16.9 percent to 17.7 percent, Seater's tax rate measure increased from 22.7 percent to 24.6 percent, and the Barro1 and 2 measures increased from 30.4 percent to 23.8 percent and from 24.8 percent to 26.3 percent, respectively.

2.4. Conclusion

Using the methodology of Seater (1982, 1985) and Barro and Sahasakul (1983, 1986), we have calculated the average tax rate and three different average marginal tax rate (AMTR) measures for the U.K. Three different average marginal tax rate measures are greater than the average tax rate (ATR) in the same year because of the progressive tax system in the U.K. Barro's AMTR measure weighted by total income (Barro 1) is greater than Barro's AMTR measure weighted by number of returns (Barro 2) because of the unequal distribution of income, and Barro's AMTR measure weighted by total income exceeds Seater's AMTR measure because the total income before tax in Seater's AMTR measure is greater than the total income after tax in the Barro's AMTR measure weighted by total income. From the correlation matrix for the alternative AMTR measures, we see that the average tax rate (ATR) measure and Seater's AMTR measure, the average tax rate (ATR) measure and the Barro 2 AMTR measure, and Seater's AMTR measure and the Barro 2 AMTR measure are highly correlated each other.

[18] The fight for equality in tax had begun with the Married Woman's Property Act of 1882. In 1992, Her Majesty the Queen elected to pay tax on her income, a move designed to bring the monarchy closer to the people. Queen Victoria had also paid income tax for a time after its reintroduction in 1842.

Because of changes in U.K. tax policy, the average tax rate and three different AMTR measures have changed over time.

CHAPTER 3

THE EFFECTS OF AVERAGE MARGINAL TAX RATES ON UK ECONOMY: A VAR APPROACH

3.1. Introduction

Using a vector autoregressive model, this chapter investigates the role of fiscal policy on economic activity by analyzing the response of major macroeconomic variables to innovations to the average marginal income tax rates in the U.K.

Monetary policy has received a great deal of attention as a tool of stabilization policy, and vector autoregressive (VAR) models have been employed extensively to analyze the effects of monetary policy shocks. However, fiscal policy has received much less attention in economic research until recently. Moreover, despite a number of studies that incorporate government spending into VAR models, only a few have attempted to investigate the effects of tax policy innovations. For example, Edelberg, Eichenbaum and Fisher (1999) analyze the effects of exogenous shocks to real government spending in the U.S. within VAR models. Ramey and Shapiro (1997) find that the effects of military buildups on a variety of macroeconomic aggregates are consistent with the predictions of a multi-sector neoclassical model; consumption, real wages and manufacturing productivity fall in response to exogenous military buildups in the post-World War II United States. Clarida and Prendergast (1999) present some empirical results on the dynamic relationship between fiscal policy and the real exchange rate in the G3 countries since advent of floating exchange rates.[19] Blanchard and Perotti (2002) estimate the dynamic effects of shocks to government spending and taxes on

[19] They find a similarity across the G3 countries (U.S., German and Japan) in their estimated dynamic responses to a fiscal shock. The real exchange rate appreciates in response to an expansionary fiscal policy where the fiscal policy variable is defined as the structural primary budget surplus relative to potential gross domestic product.

economic activity in the United States in the postwar period. They use a structural VAR approach and show that positive government spending shocks have a positive effect on output while positive tax shocks have a negative effect. Fatás and Mihov (2000) examine the effects of exogenous shocks to real government purchases in a semi-structural VAR model using U.S. data. They find that real GDP increases only initially and returns to its original value after some time, the price level falls significantly, and there is a temporary positive effect on the T-Bill rate in response to a positive government expenditure shock. Perotti (2002) investigates the effects of fiscal policy on GDP, prices and interest rates in 5 OECD countries, using a structural VAR model. He shows that a shock to government spending has a positive effect on GDP, a negative effect on prices, and a significant effect on the real short-term interest rate.[20]

In this chapter, we use a measure of the average marginal tax rate rather than tax revenues as a proxy for fiscal policy. Economic agents respond to incentives, and changes in average marginal tax rates create incentives to work more or less. For example, a decrease in average marginal tax rates may motivate workers to work more, which in turn leads to a higher level of output. A change in tax revenue, on the other hand, may be due to either a change in tax rates or a cyclical or secular change in the level of output. If there is no change in the tax rate, the resulting change in tax revenues may incorrectly be interpreted as a change in fiscal policy. Therefore, a better understanding of fiscal policy requires the use of marginal tax rates rather than tax revenues.[21]

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[20] In the post-1980, the real short-term interest rate falls as usual in the U.S. and in the U.K., and it increases in the other three countries out of five (Australia, Canada, and West German).

[21] Theoretically, the increasing average tax rate (ATR) decreases output. However, according to the Appendix H, we find that output increases in the response of ATR innovation.

It should be noted that not all tax rate changes are exogenous. Tax rates may be varied in response to current and prior economic conditions and this reflects an endogenous response of the tax rate. Exogenous changes in the VAR context are measured as the unpredictable component of tax rates.

Our results show that output falls, the exchange rate depreciates, and the trade balance improves in response to a positive innovation to average marginal tax rates. These results are robust to the use of different measures of average marginal tax rates (Seater's average marginal tax rate measure and Barro's two measures of average marginal tax rates), and different orderings for the Choleski decomposition used to identify exogenous tax rate changes.

This chapter is organized as follows. Section 3.2 presents the data. Section 3.3 presents the methodology about the lag length structures, the VAR model and its estimation. Section 3.4 discusses the empirical analysis of the effects of average marginal tax rates (AMTR) on major macroeconomic variables. Section 3.5 concludes.

3.2 Data

The data in this chapter are from the Webstract database and the previous chapter. Real gross domestic product (GDPR), nominal gross domestic product (GDP), real government consumption expenditures (CGR), the government bond yield (RMGBM, medium term yield on five-year British government securities), real exports of goods and services (XNAR), real imports of goods and services (MNAR), the monetary base (MBASE) and the nominal exchange rate (RX, pounds per US dollar) are obtained from the Webstract database. The data used in this analysis, except for the interest rate and the nominal exchange rate, are quarterly seasonally adjusted time series for the sample

period 1957:1 – 1998:4. National income accounts variables are in billions of 1990 pounds.

From the previous chapter, we have three different tax rate measures (Seater's average marginal tax rate measure and the two different average marginal tax rate measures of Barro), which are based on annual data. In this section, annual data are transformed to the quarterly data by using the method of interpolation[22], which is the method used to obtain values for missing observations. The simplest case is linear interpolation, where a missing point is simply a linear combination of the given data points. Thus, if X_t is an observation or an estimate of a variable at time t and X_{t+2} is an observation or an estimate of the same variable at time $t+2$, the linearly interpolated estimate at time $t+1$, assumed equally spaced between t and $t+2$, is given as $X_{t+1} = \frac{X_t + X_{t+2}}{2}$. Another method of interpolation, the exponential interpolation, is linear in the logarithms of the variables. Thus, the geometric mean is $X_{t+1} = \sqrt{X_t * X_{t+2}}$.[23]

Using the above two methods of interpolation, we get six different average marginal tax rates, which are Seater's average marginal tax rate measure calculated by linear interpolation (T1) and by exponential interpolation (T4), Barro's average marginal tax rate measure weighted by total income and calculated by the linear interpolation (T2) and, and the one calculated by exponential interpolation (T5), and Barro's average marginal tax rate measures weighted by numbers of returns (T3 and T6, respectively).

[22] See Intriligator, M.D., *Econometric Models, Techniques, and Applications*, 1978, Prentice-Hall, Inc., for a discussion of interpolation, extrapolation, splicing, and smoothing, p57-p76.

[23] Two other interpolation methods are available in RATS. Data from these interpolations are very similar to the above-interpolated data. The interpolated data using RATS is the same as the linear interpolation data, and the distribution data using RATS is similar to the linear interpolation data.

3.3. Methodology

3.3.1. Lag Structures in VAR Models

In most vector autoregressive (VAR) models, one of the critical elements in VAR analysis is the determination of the lag structure of the VAR model. In fact, Braun and Mittnik (1993) show that misspecification of the lag length generates inconsistent coefficient estimates and hence results in distortions in impulse responses and variance decompositions. More recently, Lee (1997) also points out that underparameterization (lower order lag length than true lag length) results in estimation bias, while overparameterization (high order lag length than true lag length) results in a loss of degrees of freedom and estimation efficiency. Since the impulse response functions are functions of estimated reduced form coefficients, both underparameterization and overparameterization may lead to less precise inferences. Thus, the determination of lag structure is a very important issue in assessing the effects of policy shocks in VAR models.

Therefore, a lag length must be chosen before the VAR is estimated. A variety of lag specification tests have been employed: likelihood ratio tests, the Akaike information criterion (AIC), the Schwarz information criterion (SIC), the Hannan-Quinn information criterion (HQC) and the bias-corrected Akaike information criterion (AIC_{BC}).[24] Lutz

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[24] We also note that there are several statistical criteria to determine the lag length in a VAR model. The Akaike information criteria (AIC), Schwarz information criteria (SIC), Hannan-Quinn information criteria (HQC) and the bias-corrected Akaike information criterion, among others, are good examples.

Kilian compares the following lag selection criterion:

$$SIC(p) = \ln|\overline{\Sigma}_{\mu}(p)| + \frac{\ln T}{T}(N^2 p) \quad \text{(Schwarz Information Criterion)}$$

$$HQC(p) = \ln|\overline{\Sigma}_{\mu}(p)| + \frac{2\ln\ln T}{T}(N^2 p) \quad \text{(Hannan-Quinn Criterion)}$$

Kilian (2001) has recently analyzed the effects of mis-specifying the lag length in a VAR. He finds that the effects of over and under-fitting the lag order are highly asymmetric for VAR summary statistics that involve higher order dynamics like impulse response functions (IRFs), variance decompositions (VDCs) and long run forecasts. Kilian finds that the SIC typically underfits the true lag, the HQC underestimates the true lag but with smaller probability than SIC, the AIC selects the true lag most frequently but overfits frequently, and the AIC_{BC} reduce the tendency of the AIC to overfit but underfits more often than AIC. Kilian argues the order of preference is AIC, AIC_{BC}, HQC and SIC.

All the variables in this model are in natural logarithms except the interest rate. The seven variables included in the VAR are the real domestic gross product (y = log (GDPR)), real government expenditures (g = log (CGR)), the price level (p = log (GDP/GDPR)), the monetary base (mb = log (MBASE)), the interest rate (r), the trade balance (tb = log (XNAR/MNAR)), and the nominal exchange rate (er = log (RX)), which are explained in more detail in Appendix A.

In this section, we choose two different lag structures for the VAR model. One of these choices is strictly based on the AIC following Kilian's results. Using the AIC, we chose 6 as the optimal lag length which was also the maximum lag. The other choice is based on the convention in empirical research, and the lag length chosen by most researchers is chosen as the lag length.

$AIC(p) = \ln|\overline{\Sigma}_{\mu}(p)| + \frac{2}{T}(N^2 p)$ (Akiake Information Criterion)

$AIC_{BC}(p) = T(\ln|\overline{\Sigma}_{\mu}(p)| + N) + 2b\{N^2 p + \frac{N(N+1)}{2}\}$ (Bias-Corrected AIC).

T = effective sample size,

$\overline{\Sigma}_{\mu}$ = maximum likelihood estimate of the variance-covariance matrix, and

p = lag order.

Christiano, Eichenbaum, and Evans (1996)[25] analyze the identification of the monetary policy shocks in a VAR model using a lag of four quarters. Blanchard and Perroti (1999) analyze the responses of real GDP and components of output to a fiscal policy shock by using a VAR model with 4 lags. In addition to these two studies, there are a large number of studies that arbitrarily choose a lag length of 4, without any formal tests of lag length, when quarterly data are used. Therefore, we also employ a lag length of 4 in our empirical analysis to check the sensitivity of our results to different lag lengths.

3.3.2. Vector Autoregressive (VAR) Model and Estimation

A vector autoregressive (VAR) model can be considered as the reduced form of a dynamic simultaneous econometric model, a reduced form model where no explanations of the instantaneous relationships among variables are provided. VAR models are the most commonly used multivariate time series models in macroeconomics and have especially been used to estimate the effects of policy actions.

There are several reasons for the popularity of these models. One is the ability of VAR models to provide predictions that are comparable to those of large-scale structural models. In addition, VARs allow for a very general interaction and feedback among the relevant variables without having to arbitrarily classify them as endogenous and exogenous.

More specifically, if $Y_t = (y_{1t}, y_{2t}, \ldots, y_{kt})'$ is a covariance stationary vector of k time series containing t observations and e_t is a vector of random errors, the general form of the vector autoregressive model without any deterministic part is given by:

[25] Chiristiano, Eichenbaum, and Evans (1998) offer three interpretations of monetary policy shocks: (1) exogenous shocks to the preferences of monetary authority, (2) shocks to private agents' expectations about the Federal Reserve policy, and (3) various technical factors like the measurement error in the preliminary data available to the Federal Open Committee at the time it make decisions.

$$A_p(L)\, Y_t \;=\; e_t,$$

$$(kxk)\ (kx1)\ \ (kx1)$$

where $A_p(L) = I - A_1 L - A_2 L - \ldots - A_p L^p$ is a matrix polynomial in the lag operator L, and $e_t = (e_{1t}, e_{2t}, \ldots, e_{kt})'$ is a vector of random shocks identically, independently, and normally distributed with zero mean and covariance matrix Ω, $e_t \sim N(0, \Omega)$.

To investigate the response of macroeconomic variables to tax policy innovations, VAR models are employed. Each model comprises the following variables: output (y), government expenditures (g), the price level (p), the monetary base (mb), interest rate (r), the trade balance (tb), the exchange rate (er), and an income tax rate measure (six different income tax rate measures are considered: Seater's average marginal tax rate (T1 and T4) and the two different average marginal tax rate measures of Barro (T2 and T5, and T3 and T6, respectively).

The shocks to tax policy are identified from an unrestricted Choleski decomposition of the variance-covariance matrix. It is assumed that all the variables in the VAR models have a particular ordering, and the higher ranked variables in the ordering are assumed to cause contemporaneous changes in variables lower in the ordering. Two Wold causal orderings are estimated in this section. The benchmark scheme orders the fiscal variables first. The variables are ordered as follows: t, g, y, p, mb, r, tb, er. Secondly, following Fatas and Mihov (2000),[26] the ordering of the fiscal policy variables is changed to check for robustness.[27] In this case the variables are ordered as follows: g,

[26] The analysis in Fatás and Mihov (2000) is closely related to Blanchard and Perotti (1999). Also the responses of real GDP and components of output to changes in government spending are analyzed for the case of the U.S. The difference is in the specification of the benchmark VAR and in the identification.
[27] An alternative to the VAR approach is advocated by Edelberg, Eichenbaum and Fisher (1999) and Burnside, Eichenbaum and Fisher (2000). They argue against using VAR based innovations in fiscal

t, y, p, mb, r, tb, er. If we assume that government spending is set in nominal terms by the government, then current period shocks to the price level (p) will affect the real value of government purchases. The price level (p) should therefore precede government purchases (g). If tax rates are not indexed for inflation, then current period changes in the price level (p) may affect the average marginal tax rate. Therefore, the last ordering considered is p, g, t, y, mb, r, tb, er. In each case, one-standard deviation confidence intervals are obtained from a Monte Carlo simulation based on 1,000 draws.

3.4. An Empirical Analysis of the Effects of Average Marginal Tax Rates

In this section, we analyze the effects of the average marginal tax rate (AMTR) innovations on the endogenous variables of the model. Before beginning the discussion on the empirical findings, we would like to highlight the predictions that most economic models are in consensus with respect to the effects of tax rate changes on output, the price level, interest rate, and the exchange rate.

There is some controversy about the effects of tax rates changes on aggregate demand. According to traditional Keynesian models, an increase in AMTR decreases the marginal propensity to consume and therefore leads to a reduction in aggregate demand. According to models where Ricardian equivalence holds, on the other hand, a change in AMTR, holding government purchases constant, leaves aggregate demand unchanged. Changes in marginal tax rates also generate supply-side effects. In addition to its' effects on aggregate demand, an increase in AMTR decreases the incentives to work and therefore leads to a reduction in labor supply and eventually to a reduction in aggregate supply. While the predicted outcome of an increase in AMTR on output is

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variables as measures of policy shifts and propose a study based on including dummies for three episodes of military build-ups.

unambiguously negative, the effect on the price level is ambiguous. Prices rise if aggregate supply falls more than aggregate demand, and prices fall otherwise. The traditional IS-LM model predicts that interest rates should fall in response to an increase in AMTR. Open economy extensions of the IS-LM model or the asset market models of exchange rate determination predict a depreciation of the national currency in terms of the foreign currency in response to an increase in AMTR and an improvement of the trade balance.

Section 3.4.1 analyzes the effects of the average marginal tax rate (AMTR) innovations when the average marginal tax rate (t) is ordered first, and section 3.4.2 checks for the robustness of these results by ordering government expenditures (g) first and the average marginal tax rate (t) second and then by ordering the price level (p) first, government spending (g) second, and the average marginal tax rate (t) third.

3.4.1. The Effects of AMTR Shocks When t is Ordered First

We examine the effects of average marginal tax rate (AMTR) shocks on the other variables in the model by analyzing the impulse response functions of real government expenditures (g), the real gross domestic product (y), the price level (p), the monetary base (mb), the interest rate (r), the trade balance (tb), and the exchange rate (er: pounds per dollar) to a one standard deviation shock to a measure of the average marginal tax rate (t). Since there are six different marginal tax rate measures employed, the models are estimated and the impulse response functions are calculated for each average marginal tax rate measure. The Wold causal ordering for the benchmark model is as follows: t, g, y, p, mb, r, tb, and er. Figure 3.1 (each Figure contains Panels A through F) presents the impulse response functions of all model variables to a one standard deviation

positive shock to T1, T2, T3, T4, T5, and T6, respectively, which are reported for a horizon of 48 quarters in Figure 3.1. T1 is Seater's AMTR measure, T2 is Barro's AMTR measure weighted by total income (Barro1 type of AMTR), and T3 is Barro's AMTR measure weighted by the number of returns (Barro 2 type of AMTR), which are calculated by linear interpolation. T4 is Seater's AMTR measure, T5 is Barro's AMTR measure weighted by total income, and T6 is Barro's AMTR weighted by the number of returns, which are calculated by the exponential interpolation. In Figure 3.1, the middle lines represent the point estimates, while two other lines denote plus and minus one standard deviation bands.

3.4.1.1. The Effects of AMTR Shocks When t is Ordered First and the Lag Length is 6

The impulse response functions of t, g, y, p, mb, r, tb, and er to a one standard deviation shock of a measure of the AMTR (t) are presented in Figure 3.1. Panels A through F present the response of t, g, y, p, mb, r, tb, and er to the six different AMTR measures employed, which are T1, T2, T3, T4, T5, and T6 respectively, for a horizon of 48 quarters. The appropriate lag length for the estimations has been determined as 6 using the Akaike Information Criterion (AIC).[28]

In Panel A, a positive innovation to T1 (Seater's type of AMTR measure calculated by linear interpolation) results in a temporary increase in AMTR (T1) and has short term effects on government expenditures (g), output (y), the price level (p), the monetary base (mb) the interest rate (r), the trade balance (tb), and the exchange rate (er), which gradually disappear after some time. For example, the response of AMTR to a T1 innovation is positive until the 13th quarter, but is not significantly different from zero

[28] An optimal lag of 6 is determined after choosing a maximum lag length of 6.

after the 13th quarter, which implies that the innovation is temporary in nature. The response of government expenditures (g) to a T1 innovation increases between the 1st and the 3rd and between the 4th and the 12th quarters, which means that a temporary change in marginal tax rates has a transitory positive effect on the government expenditures. In response to a temporary positive innovation in T1, output (y) declines in the 2nd and between the 3rd and the 6th quarters and increases between the 10th and the 23rd quarters. The positive response of output (y) can be due to the feedback effect generated by the depreciation on the exchange rate and the following improvement of the trade balance and an increase in the monetary base. The price level (p) and the monetary base (mb) significantly increase between the 23rd and the 45th and between the 13th and the 44th quarters, respectively, in response to an increase in AMTR. The positive response of the monetary base indicates that the central bank expands the monetary base in response to a contractionary tax shock. The rise in the monetary base in turn helps explain the rise in the price level. The initial response of the interest rate (r) to T1 innovation is positive, which lasts only for a quarter, and decreases between the 7th and the 10th quarters. In response to a temporary innovation in T1, the exchange rate (er), which is expressed as pounds per U.S. dollar, rises until the 14th quarter and decreases between the 20th and the 26th quarters. Likewise, the trade balance (tb) improves significantly in response to an innovation to T1 between the 1st and the 11th quarters. A positive shock to T4 (Seater's type of AMTR measure calculated by exponential interpolation) in Panel D generates results that are very similar to those generated by a shock to T1.

In Panel B, a positive shock to T2 (Barro 1 type of AMTR measure calculated by linear interpolation), which appears to be a temporary increase in AMTR (T2), has short run effects on government expenditures (g), output (y), the price level (p), the monetary base (mb), the interest rate (r), the trade balance (tb), and the exchange rate (er). The response of government expenditures (g) to a T2 innovation increases between the 1st and the 3rd quarters, which implies that a temporary change in AMTR (T2) has positive effect on the government expenditures (g). In response to a temporary positive innovation in T2, output (y) declines between the 3rd and the 7th quarters and increases between the11th and the 19th quarters, and the interest rate (r) also significantly increases in the 1st quarter and declines between the 6th and the 11th quarters. The price level (p) increases on the 6th and after the 21st quarters, and the monetary base (mb) increases significantly between the 10th and the 34th quarters in response to a T2 innovation. The positive response of the monetary base indicates that the central bank expands the monetary base in response to a contractionary tax shock. The rise in the monetary base in turn helps explain the rise in the price level. The trade balance (tb) also improves significantly until the 11th quarter. In response to a temporary shock to T2, the exchange rate (er) rises until the 11th quarter and decreases between the 17th and the 26th quarters. A positive innovation to T5 (Barro 1 type of AMTR measure calculated by exponential interpolation) in Panel E has very similar results to those generated by a shock to T2.

In Panel C, a positive innovation to T3 (Barro 2 type of AMTR measure calculated by linear interpolation) results in a temporary increase in AMTR (T3), and has short term effects on government expenditures (g), output (y), the price level (p), the monetary base

(mb), the interest rate (r), the trade balance (tb), and the exchange rate (er) that taper off after some time.[29] For example, the confidence bands of government expenditures (g) to T3 innovation increase until the 12th and between the 18th and the 35th quarters, and the interest rate (r) increases initially, which means that a temporary change in AMTR has positive effect on the government expenditures (g) and the interest rate (r). In response to a T3 innovation, output (y) decreases temporarily until the 6th quarter and increases between the 10th and the 22nd quarters, which implies that the positive response of output (y) can be due to the feedback effect generated by the depreciation on the exchange rate and the following improvement of the trade balance. In response to a positive innovation to T3, the price level (p) increases initially and after the 20th quarter, and the monetary base (mb) is positive and significant after the14th quarter. The positive response of the monetary base indicates that the central bank expands the monetary base in response to a contractionary tax shock. The rise in the monetary base in turn helps explain the rise in the price level. The response to of the exchange rate (er) is significantly positive until the 14th quarter. This implies an extended period of depreciation of the exchange rate. The trade balance (tb) improves significantly in response to an innovation to T3 until the 10th quarter. A positive shock to T6 (Barro 2 type of AMTR measure calculated by exponential interpolation) generates results that are very similar to those generated by a shock to T3.

Most of these empirical findings are consistent with the implications of traditional macroeconomic models. An increase in average marginal tax rates initially leads to a decrease in output, depreciation of the exchange rate, and improvement in the trade

[29] The price level (p) and the monetary base (mb) look like permanent increased on Panel C in Figure 3.1. But, I find, on Appendix B, the price level (p) and the monetary base (mb) increase temporarily for a horizon of 60 quarters.

balance, as suggested by theory. The empirical finding that the price level and the monetary base are rising in response to a positive AMTR innovation implies that the increase in the price level is correlated with the increase in the monetary base. The positive response of the monetary base indicates that the central bank expands the monetary base in response to a contractionary tax shock.

One puzzling aspect of the empirical findings is the initial but temporary increase in interest rates in response to a tax increase. Traditional macroeconomic models predict a decrease in interest rates. Even though the point estimates of interest rates decline over time, these are not significantly different from zero.

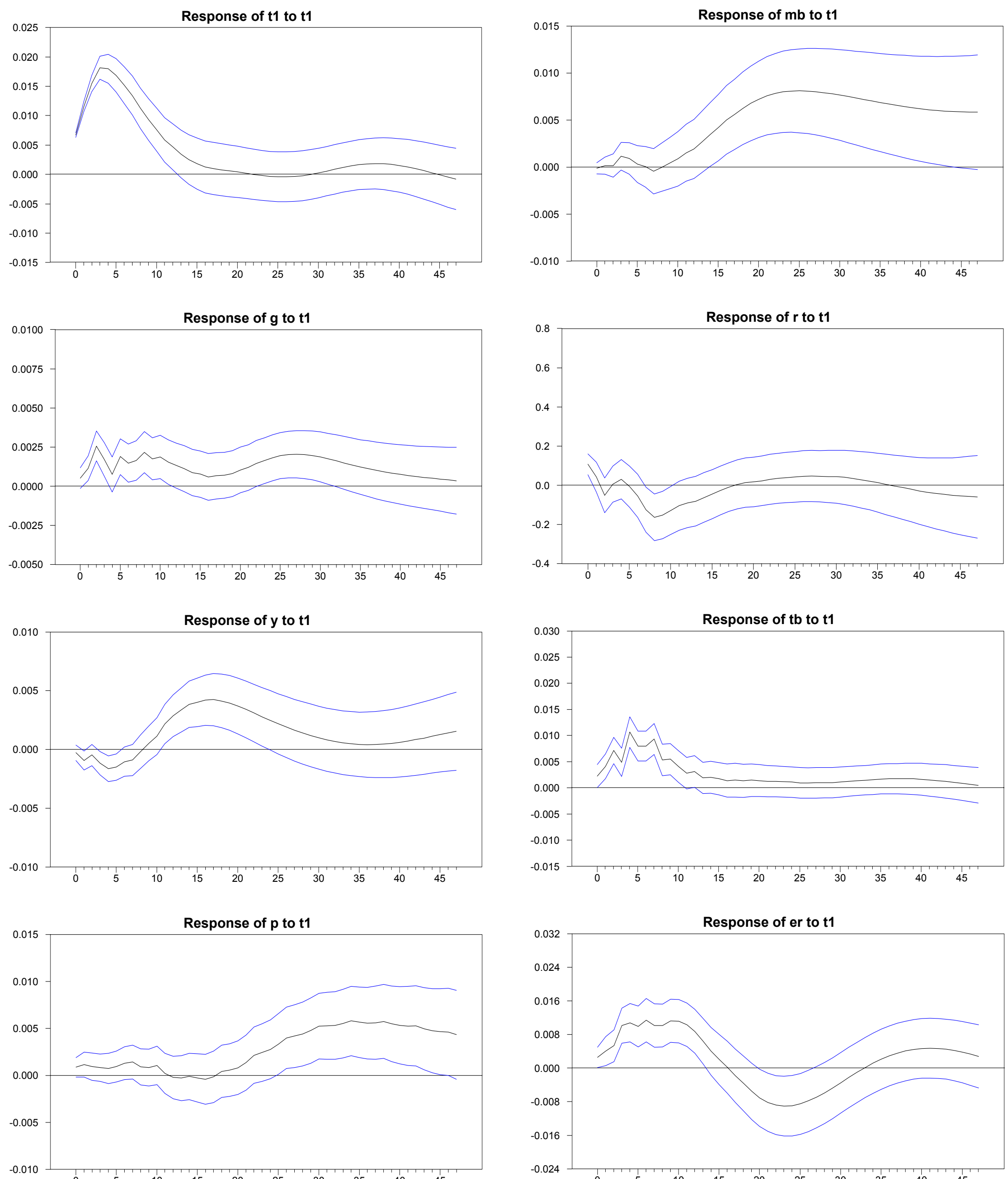
Figure 3.1. The Effects of AMTR Shocks When t is Ordered First and the Lag Length is 6

Impulse response functions of the real government expenditures (g), the real gross domestic product (y), the price level (p), the monetary base (mb), the interest rate (r), the trade balance (tb), and the exchange rate pounds per U.S. dollar (er) to a one standard deviation shock to each of the AMTR (t) measures are presented. The Wold causal ordering is as follows: t, g, y, p, mb, r, tb, and er. The appropriate lag length for the estimations has been determined as 6 using the AIC.

Tax	T	G	y	P	Mb	r	tb	er
T1	Increase	increase	decrease increase	increase	Increase	increase decrease	increase	increase decrease
T2	Increase	increase	decrease increase	increase	Increase	increase decrease	increase	increase decrease
T3	Increase	increase	decrease increase	increase	increase	increase	increase	increase
T4	Increase	increase	decrease increase	increase	increase	increase decrease	increase	increase decrease
T5	Increase	increase	decrease increase	increase	increase	increase decrease	increase	increase decrease
T6	Increase	increase	decrease increase	increase	increase	increase	increase	increase

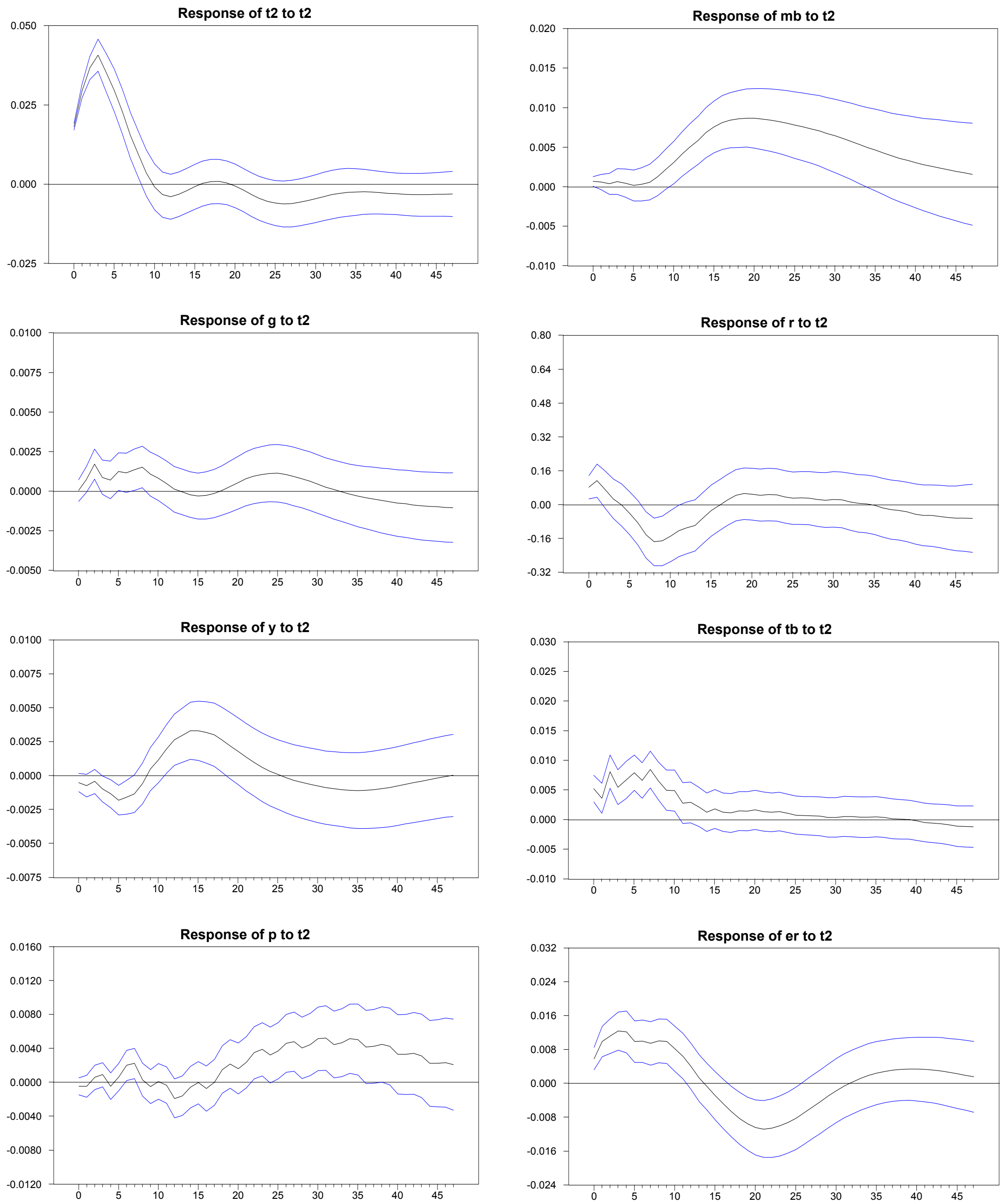
(Figure continued)

Panel A. Shock of T1: T1, g, y, p, mb, r, tb, er



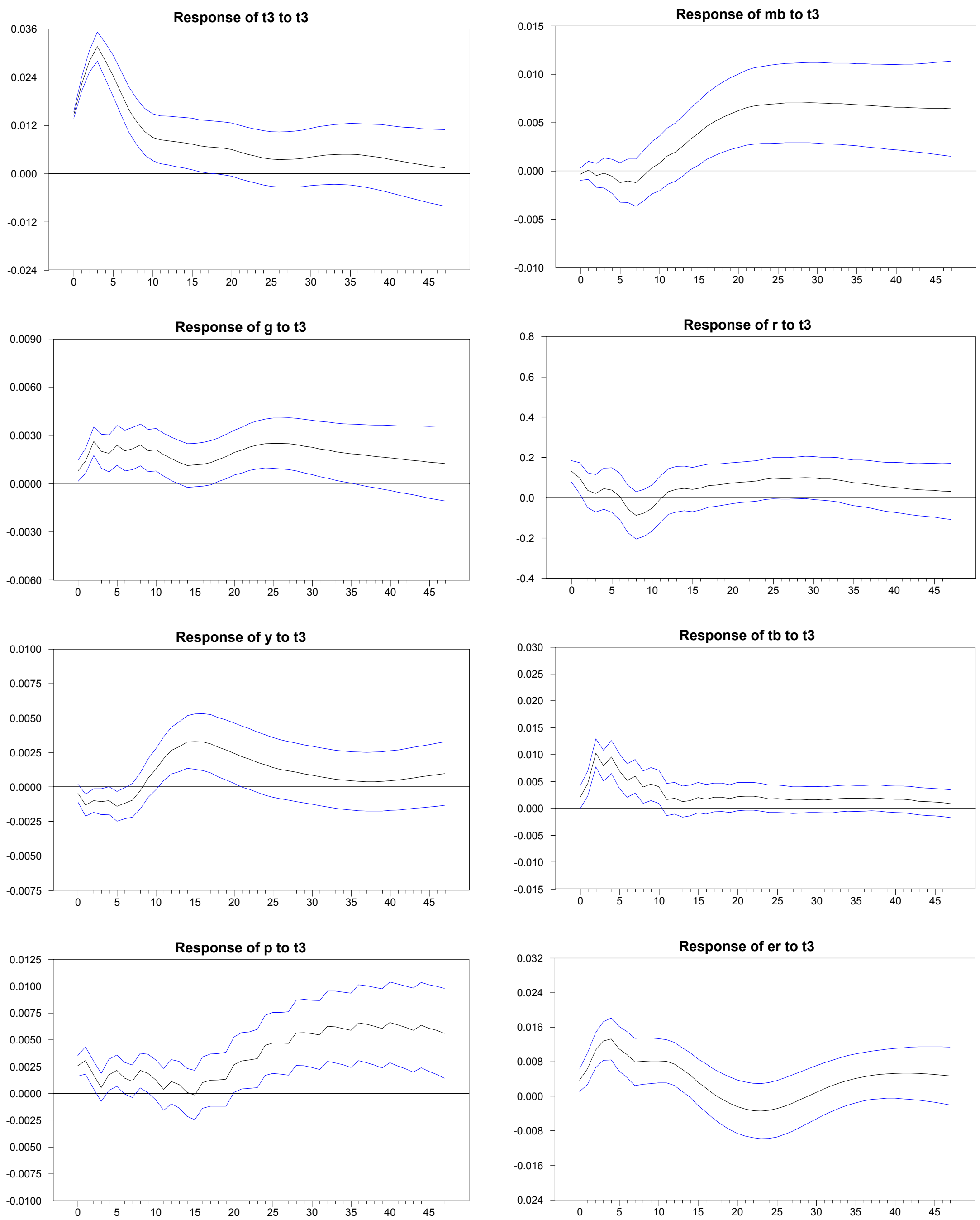
(Figure continued)

Panel B. Shock of T2: T2, g, y, p, mb, r, tb, er



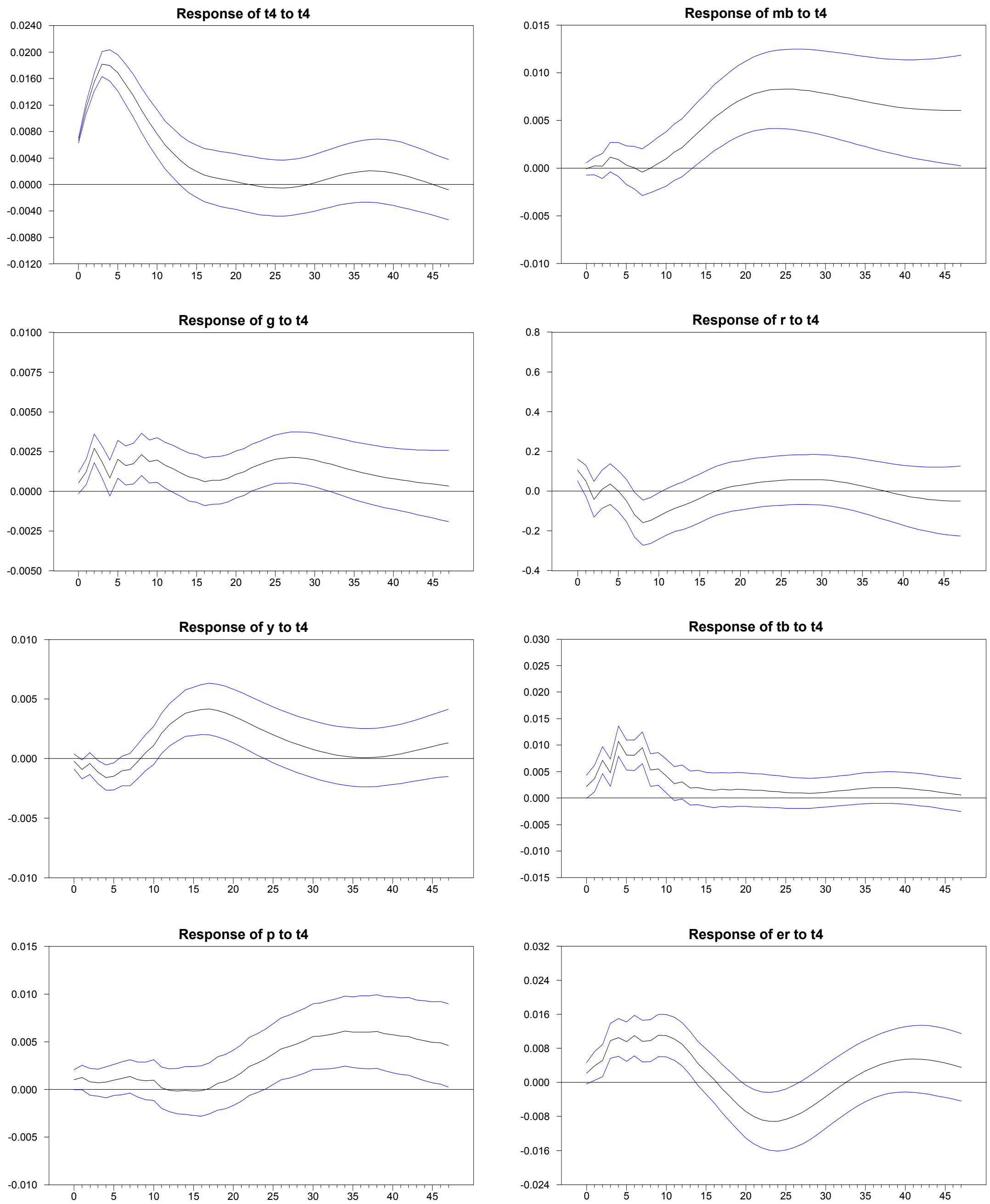
(Figure continued)

Panel C. Shock of T3: T3, g, y, p, mb, r, tb, er



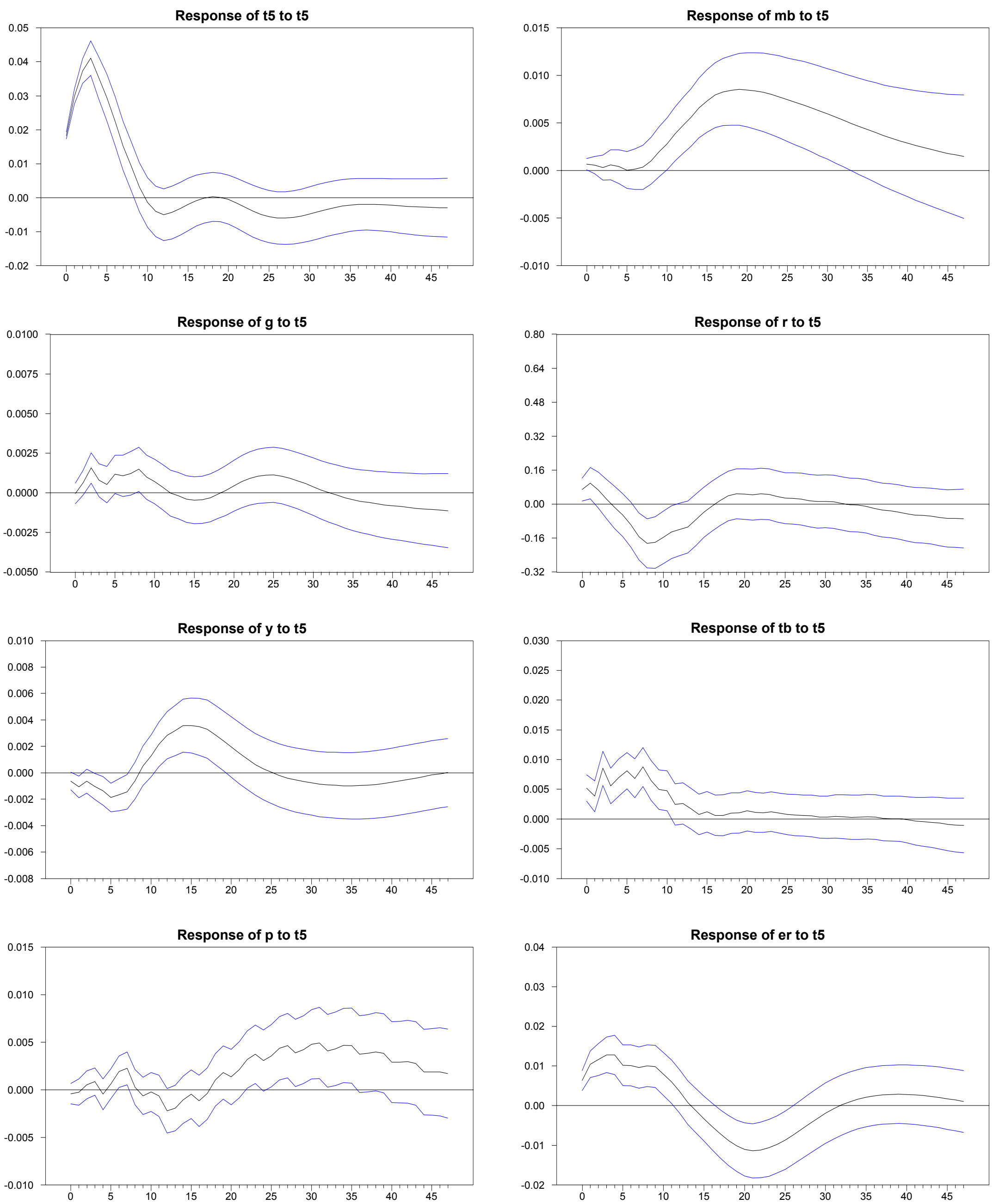
(Figure continued)

Panel D. Shock of T4: T4, g, y, p, mb, r, tb, er



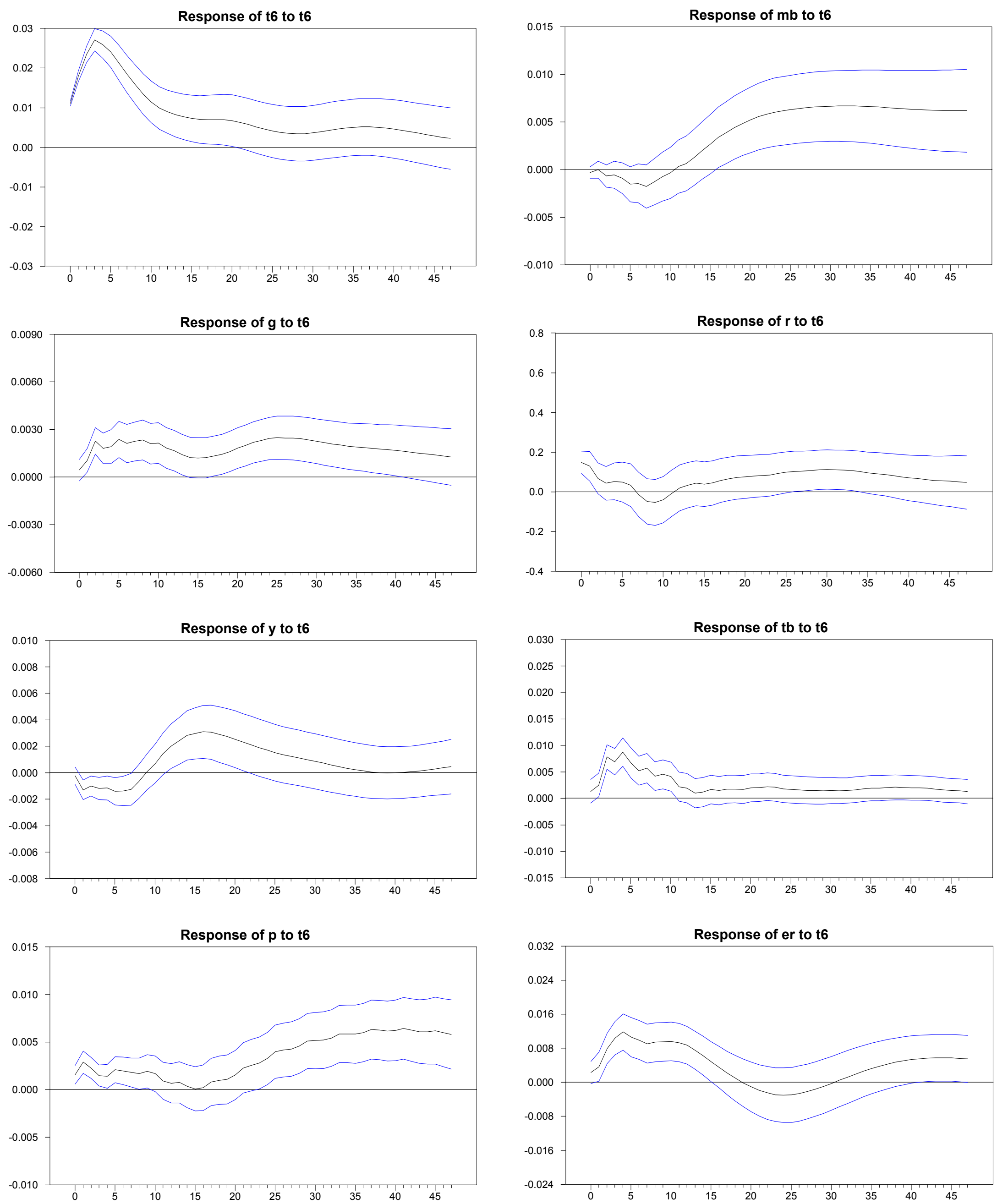
(Figure continued)

Panel E. Shock of T5: T5, g, y, p, mb, r, tb, er



(Figure continued)

Panel F. Shock of T6: T6, g, y, p, mb, r, tb, er



3.4.1.2. The Effects of AMTR Shocks When t is Ordered First and the Lag Length is 4

Christiano, Eichenbaum, and Evans (1996) analyze the identification of the monetary policy shocks in a VAR model with four lags. Blanchard and Perroti (1999) analyze the responses of real GDP and components of output to a fiscal policy shock by using a VAR model with 4 lags. In addition to these two studies, there are a large number of studies that arbitrarily choose a lag length of 4, without any formal tests of lag length, when quarterly data are used. Therefore, we also employ a lag length of 4 in our empirical analysis to check the sensitivity of our results to different lag lengths.

The point estimates of impulse response functions of the 4-lag VAR models lie within the confidence intervals of the previous 6-lag VAR models. This implies that there are no significant differences between the 6-lag and the 4-lag VAR models.

The impulse responses of AMTR innovations on government expenditures (g), output (y), the price level (p), the monetary base (mb), the interest rate (r), the trade balance (tb), and the exchange rate (er) for a horizon of 48 quarters are presented in Appendix C. The Wold causal ordering is as follows: t, g, y, p, mb, r, tb, and er, and the system is estimated for a lag length of 4.

3.4.2. Checks for Robustness

In this section we check for the robustness of the results presented in the previous section by ordering government expenditures (g) before the average marginal tax rate (t), and by ordering the price level (p) before the policy variables, government expenditures (g) and the average marginal tax rate (t).

3.4.2.1. The Effects of AMTR Shocks When g is Ordered First

Fatas and Mihov (2000) compare the dynamic impact of fiscal policy on macroeconomic variables implied by a large class of general equilibrium models with the empirical results from an identified vector autoregression in which government spending (g) is ordered first. Therefore, the Wold causal ordering is as follows: g, t, y, p, mb, r, tb, and er. This ordering is based on the assumption that the government first makes the decision to spend and then determines the relevant tax rate. The impulse response functions of g, t, y, p, mb, r, tb, and er to a one standard deviation shock of the AMTR (t) measures are presented in Appendices D and E. Panels A through F present the response of g, t, y, p, mb, r, tb, and er to the six different AMTR measures employed, which are T1, T2, T3, T4, T5, and T6 respectively, for a horizon of 48 quarters.

Since the point estimates of the impulse response functions lie within the confidence intervals of the benchmark model where t is ordered first, there are no significant differences between the two VAR models. Therefore, when the lag length is 6, the results are quite robust to changing the ordering between g and t of the Choleski decomposition.

The empirical findings in the VAR models with 4 lags are similar to these with the benchmark model. The point estimates of impulse response functions for models with 4 lags lie within the confidence intervals for the previous benchmark model, which implies that there are no significant differences between the 6 lags and the 4 lags VAR models.

When government expenditures (g) is ordered first, in response to an increase in average marginal tax rates the price level rises, the exchange rate depreciates, and the

trade balance improves. The initial response of the interest rate is positive in the first quarter as it is with 6 lags but later we see a decline and leveling off of the interest rate.

3.4.2.2. The Effects of AMTR Shocks When p is Ordered First

If government spending is set in nominal terms by the government, then current period changes in the price level (p) will affect the real value of government purchases. Thus, the price level (p) should precede government purchases (g). If tax rates are not indexed for inflation, then current period changes in the price level (p) may affect the average marginal tax rate. Therefore, the Wold causal ordering is as follows: p, g, t, y, mb, r, tb, and er.

The impulse response functions of p, g, y, mb, r, tb, and er to a one standard deviation shock of the AMTR (t) measures are presented in Appendix E and F. Panels A through F present the response of g, y, p, mb, r, tb, and er to the six different AMTR measures employed, which are T1, T2, T3, T4, T5, and T6 respectively, for a horizon of 48 quarters.

Since the point estimates of the impulse response functions where p is ordered first lie within the confidence intervals of the benchmark model, there are no significant differences between the two VAR models which orders t first or p first. When the price level (p) is ordered first and the lag length is 6, we find that the results are quite robust to changing the ordering of the Choleski decomposition.

The empirical findings in VAR models with 4 lags are very similar to those of the benchmark model. The point estimates of impulse response function for the 4-lag VAR models lie within the confidence intervals of the previous benchmark model, which

implies that there are no significant differences between the 6-lag and the 4-lag VAR models**.**

3.5. Conclusion

This chapter has used a VAR model to estimate the impact of the dynamic effects of fiscal policy shocks (three different AMTR measures: Seater's average marginal tax rate measure and two different average marginal tax rate measures of Barro) on seven macroeconomic variables (government expenditures, output, the price level, the monetary base, the interest rate, the trade balance, and the exchange rate) in the U.K.

There is some controversy about the effects of tax rates changes on aggregate demand. According to the traditional Keynesian models an increase in AMTR decreases the marginal propensity to consume and therefore leads to a reduction in aggregate demand. According to models where Ricardian equivalence holds, on the other hand, a change in AMTR, holding government purchases constant, leaves aggregate demand unchanged. Changes in marginal tax rates also generate supply-side effects. An increase in AMTR decreases the incentives to work and therefore leads to a reduction in labor supply and eventually to a reduction in aggregate supply. While the predicted outcome of an increase in AMTR on output is unambiguously negative, the effect on the price level is ambiguous. Prices rise if aggregate supply falls more than aggregate demand, and prices fall otherwise. The traditional IS-LM model predicts that interest rates should fall in response to an increase in AMTR. Open economy extensions of the IS-LM model or the asset market models of exchange rate determination predict a depreciation of the national currency in terms of the foreign currency in response to an increase in AMTR and an improvement of the trade balance.

Most of these empirical findings are consistent with the implications of traditional macroeconomic models summarized above. An increase in average marginal tax rates leads to a decrease in output, depreciation of the exchange rate, and improvement in the trade balance, as suggested by the theory. The positive response of the monetary base suggests that the central bank expands the monetary base in response to a contractionary tax shock. The increase in the monetary base helps explain the increase in the price level.

One puzzling aspect of the empirical findings is the initial increase in interest rates in response to a tax increase. Traditional macroeconomic models predict a decrease in interest rates. Even though the point estimates of interest rates decline over time, these are not significantly different from zero, except for a shock to T1 (T4) and T2 (T5). When we use Seater and Barro1 measures of the AMTRs (T1 (T4) and T2 (T5)), the response of the interest rate is negative as predicted by theory.

These results are robust to the use of different lag lengths, and different orderings for the Choleski decomposition.

CHAPTER 4

THE EFFECTS OF AVERAGE MARGINAL TAX RATES ON THE U.K. ECONOMY: A SVAR APPROACH

4.1. Introduction

One of the recent approaches in the literature that analyzes the transmission of fiscal policy to the macroeconomy uses vector autoregressive (VAR) models. In monetary policy analysis the VAR approach has been a popular tool of analysis already for a longer period.[30] This chapter analyzes the macroeconomic effects of fiscal policy (the effects of average marginal tax rates) in the U.K. using a structural vector autoregressive (SVAR) approach. The SVAR model employed in this chapter analyzes the effects of marginal tax rates on the economy when long run identifying restrictions are imposed.

The first SVAR model was constructed by B.S. Bernanke (1985). Shapiro and Watson (1988) and Blanchard and Quah (1989), however, were the first to impose long run identifying restrictions within the context of the SVAR approach. Blanchard (1989) and Blanchard and Quah (1989) concentrate on long run identifying restrictions in identifying demand and supply shocks to the economy. Building upon these two papers, Gali (1992) proposes a set of identifying restrictions that contains a combination of short term and long-term restrictions. In another influential analysis, Bayoumi and Eichengreen (1992) use the SVAR approach to identify aggregate demand and supply shocks in the European Union (EU) and to assess to which extent the EU countries

[30] The use of VAR models to measure the impact of monetary policy, however, is not completely uncontroversial as Rudebusch (1998) argues. In particular, the interpretation of the monetary residuals as true monetary policy innovations has been questioned. In fiscal policy context the interpretation of the fiscal errors as policy innovations is possibly even more doubtful given that there are typically lags between policy announcement and implementation. Concerning the SVAR, in addition, the identifying restrictions that are imposed sometimes meet criticism; the SVAR results are typically sensitive to some extent to the set of identifying restrictions that is imposed. These criticisms necessarily also apply to our analysis, but we have no way to circumvent them.

constitute an optimal currency area by distinguishing between symmetric and asymmetric shocks. Aarle, Garretsen and Gobbin (2001) estimate a SVAR of monetary and fiscal policy transmission in the Euro-area; first, the European Monetary Union (EMU) countries are considered as an aggregate entity and then the SVAR model of the aggregate EMU countries is compared with SVAR models of the U.S. and Japan.

SVARs have recently also been applied to fiscal policy analysis. Blanchard and Perotti (2002) use a SVAR model to characterize the dynamic effects of shocks in government spending and taxes on economic activity in the U.S. in the post-war periods. The VAR model consists of taxes, government spending and gross domestic product (GDP), all in real and per capita terms. It is assumed that economic activity does not affect policy contemporaneously, except for the automatic stabilization in the tax and transfer system.

In this chapter, we estimate the effect of fiscal policy (the effects of average marginal tax rates) on macroeconomic variables in the U.K. by using a SVAR approach that imposes long run identifying restrictions. Our results indicate that a positive innovation to average marginal tax rates (T), which results in a permanent increase in the marginal tax rate, has a negative effect on output and positive effects on the interest rate and the exchange rate, that disappear after some time. These results are robust with respect to other different average marginal tax rate measures and are also quite robust to changing the ordering for Choleski decomposition.

This chapter is structured as follows. Section 4.2 presents a brief overview of the data and methodology about the lag length determination, and the structural vector autoregressive (SVAR) model. Section 4.3 estimates the SVAR approach imposing long

run identifying restrictions and analyzes the response of output, government expenditures, the monetary base, price level, interest rate and the exchange rate to marginal tax rate innovations. Section 4.4 discusses the robustness of the results to changing the ordering for Choleski decomposition. Section 4.5 concludes.

4.2 Data and Methodology

4.2.1 Data and Lag Length Determination

The data in this chapter are from the Webstract database and the previous chapters, which are the real gross domestic product (Y), real government expenditures (G), the price level (P), the interest rate (R), the nominal exchange rate (ER), the monetary base (MB), and the six different average marginal tax rates (AMTR)[31], which are explained in more detail in Appendix A. All the variables are in natural logarithms except the interest rate, and are first differenced before estimation in this chapter.

We use the Akaike information criterion (AIC) to check the lag length selection based on Kilian's results that show that the AIC selects the true lag most frequently. A discussion of this article is presented in Chapter 3. Based on the AIC, we choose 5 as the lag length for the SVAR models employed in this chapter.[32]

Christiano, Eichenbaum, and Evans (1996) analyze the identification of the monetary policy shocks in a VAR model using a lag of four quarters. Blanchard and Perroti (1999) analyze the responses of real GDP and components of output to a fiscal policy shock by using a SVAR model with 4 lags. In addition to these two studies, there are

[31] The six different average marginal tax rates are Seater's average marginal tax rate measure calculated by linear interpolation (T1) and by the exponential interpolation (T4), Barro's average marginal tax rate measure weighted by total income and calculated by the linear interpolation (T2) and, and the one calculated by exponential interpolation (T5), and Barro's average marginal tax rate measures weighted by numbers of returns (T3 and T6, respectively).
[32] An optimal lag length of 5 is determined after choosing a maximum lag length of 6.

large numbers of studies that arbitrarily choose a lag length of 4, without any formal tests of lag length, when quarterly data are used. Therefore, we also employ a lag length of 4 in our empirical analysis to check the sensitivity of our results to different lag lengths.

4.2.2 Structural Vector Autoregressive (SVAR) Model and Estimation

The structural vector autoregressive (SVAR) models impose long run restrictions on an ordinary VAR model. An unrestricted VAR model assumes

$$\Delta x_t = A\ (L)\ e_t \quad \text{---- (1)}$$

which is written in moving average form. x is a vector of covariance stationary macroeconomic variables, $A(L)$ is a polynomial matrix of lag length l, L is the lag operator and e is a vector of reduced form innovations in the elements of x with variance-covariance matrix $E(e_t \cdot e_t') = \Sigma$. These reduced form innovations are assumed to be correlated and cannot be interpreted as purely structural innovations. The SVAR model focuses on relating the vector x to a vector of structural innovations (u_t),

$$\Delta x_t = B\ (L)\ u_t \quad \text{---- (2)}$$

where $B(L)$ is a polynomial matrix in L. In this SVAR, u_t is a vector of serially and contemporaneously uncorrelated, normalized structural residuals with $E\ (u_t\, u_t') = I$ and $CC' = \Sigma$. If the vector of reduced form innovations is a linear combination of the structural residuals (if $e_t = Cu_t$), then $\Delta x_t = A(L)Cu_t = B(L)u_t$. Therefore, $A(L)C = B(L)$, which means it can enable the identification of the structural innovations from the reduced form innovations in the VAR. $B(L)$ is a lag polynomial where the B's are coefficient matrices at the respective lags of the errors. In this way the structural form (2) can be obtained from the estimates of the reduced form representation (1), provided that B is full rank.

The structural VAR model (2) imposes identifying restrictions upon the VAR model (1) and the structural innovations are recovered from an estimated VAR. The identification is achieved in practice by imposing long run restrictions. The advantage of using long run restrictions is that in many instances, economic theory provides more guidance about long run relationships than about short run dynamics. Zero restrictions on the elements of the *B* matrix are equivalent to imposing that the impact effect of a given shock on a certain variable is null, which can be achieved by setting the appropriate elements in *B(0)* to zero. Long run constraints are imposed by setting the appropriate elements of *B(1)*, the sum of the moving average coefficients that represents the effects on the levels of the variables, to zero. In order to identify exactly a VAR model of n endogenous variables, we need to impose $(n^2-n)/2$ restrictions on the structural model (2).

4.3. An Empirical Analysis of the Effects of AMTR Shocks When T is Ordered First

Before beginning the discussion on the empirical findings, we would like to highlight the predictions that most economic models are in consensus with respect to the effects of tax rate changes on output, the price level, interest rate, and the exchange rate.

There is some controversy about the effects of tax rates changes on aggregate demand. According to traditional Keynesian models, an increase in AMTR decreases the marginal propensity to consume and therefore leads to a reduction in aggregate demand. According to models where Ricardian equivalence holds, on the other hand, a change in AMTR, holding government purchases constant, leaves aggregate demand unchanged. Changes in marginal tax rates also generate supply-side effects. An increase in AMTR decreases the incentives to work and therefore leads to a reduction in labor supply and eventually to a reduction in aggregate supply. While the predicted

outcome of an increase in AMTR on output is unambiguously negative, the effect on the price level is ambiguous. Prices rise if aggregate supply falls more than aggregate demand, and prices fall otherwise. The traditional IS-LM model predicts that interest rates should fall in response to an increase in AMTR. Open economy extensions of the IS-LM models or the asset market models of exchange rate determination predict a depreciation of the national currency in terms of the foreign currency in response to an increase in AMTR.

We use the SVAR model to look at the important policy interdependency, which is the one between government spending and taxes. An important question in the literature concerns the existence of any causality between government spending and taxes. This issue of causality can be phrased as the "tax and spend" vs. the "spend and tax" view. According to the former, changes in tax rate cause changes in government spending, whereas the latter supposes that changes in government spending induce adjustments in the tax rate in order to match the changes in financing needs. Blanchard and Perotti (2002), and Fatás and Mihov (2000) investigate the effects of both type of causality by imposing the appropriate identifying restrictions on revenue and spending shocks in both regimes in their fiscal SVAR model.

In this section, a SVAR model with long run restrictions is estimated and the effects of average marginal tax rates on output, government expenditures, the price level, interest rate, the exchange rate and the monetary base are analyzed. The vector x of macroeconomic variables that are included in the SVAR analysis consists of the real gross domestic product (Y), the average marginal tax rate (T) measures, real government

expenditures (G), the price level (P), the interest rate (R), the exchange rate (ER), and the monetary base (MB);

$$x = [T, G, Y, MB, P, R, ER]'.$$ [33]

To identify the structural innovations from the VAR model, twenty-one identifying restrictions are required. These are: (1) government expenditures shocks do not have a permanent effect on T, (2) output shocks do not have a permanent effect on T, (3) monetary shocks do not have a permanent effect on T, (4) price level shocks do not have a permanent effect on T, (5) interest rate shocks do not have a permanent effect on T, (6) exchange rate shocks do not have a permanent effect on T, (7) output shocks do not have a permanent effect on G, (8) monetary shocks do not have a permanent effect on G, (9) price level shocks do not have a permanent effect on G, (10) interest rate shocks do not have a permanent effect on G, (11) exchange rate shocks do not have a permanent effect on G, (12) a monetary shocks do not have a permanent effect on Y, (13) price level shocks do not have a permanent effect on Y, (14) interest rate shocks do not have a permanent effect on Y, (15) exchange rate shocks do not have a permanent effect on Y, (16) price level shocks do not have a permanent effect on MB, (17) interest rate shocks do not have a permanent effect on MB, (18) exchange rate flow shocks do not have a permanent effect on MB, (19) interest rate shocks do not have a permanent effect on P, (20) exchange rate flow shocks do not have a permanent effect on P, and (21) exchange rate shocks do not have a permanent effect on R.[34]

[33] This ordering is based on the assumption "tax and spend", which implies that the government first determines the tax rate and government spending is adjusted to the tax rate over time.

[34] Restrictions (1) and (2) imply that in the long run fiscal policy is set independently of the state of the economy. Restrictions (1) and (2) do not constrain any short-run fiscal effects, but constrain long run effects. The problem with these restrictions is that they imply that the state of the economy in the long run has no effect on government expenditures or tax rates. Most macroeconomists argue that fiscal policy should be set with regard to the long run consequences of policy.

Similar restrictions are found in other SVAR analysis with monetary and/or fiscal policy instruments. For example, van Aarle, Garretsen and Gobbin (2001) use ten restrictions on five macroeconomic variables. Ideally, one would like the identifying restrictions to follow strictly from the properties of a small theoretical model of monetary and fiscal policies that one would like to test. In the literature often a small AD-AS model is constructed to motivate the identifying restrictions.[35]

4.3.1. The Effects of AMTR Shocks When T is Ordered First and the Lag Length is 5.

From the SVAR estimation, impulse response functions can be calculated which show the effects of average marginal tax rates innovations on output, government spending, the monetary base, the price level, the interest rate and the exchange rate. Figure 4.1 (Panel A through F) provides the impulse response functions of AMTR, output, government expenditure, the monetary base, the price level, the interest rate and the exchange rate to a one standard deviation AMTR shock for the U.K., which is reported for a horizon of 48 quarters. The one-standard deviation confidence intervals are obtained from a Monte Carlo simulation based on 1,000 draws. On the impulse responses of the SVAR models, the middle lines represent the point estimates, while two other lines denote plus and minus one standard deviation bands.

In Panel A, a positive innovation to T1 (Seater's type of AMTR measure calculated by linear interpolation) results in a permanent increase in AMTR (T1), unlike the unrestricted VAR model in levels, does not have any significant effects on the price level (P) and the monetary base (MB), and has a significant effect on government expenditures (G), output (Y), the interest rate (R) and the exchange rate (ER), which gradually fades

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[35] See Blanchard (1989) and Gali (1992) for a discussion.

away after some time. For example, the response of AMTR (T1) to a T1 innovation is positive in the long run, which implies that the innovation is permanent in nature.[36] The response of the price level (P) and the monetary base (MB) to a T1 innovation are not significantly different from zero, which implies that a permanent change in marginal tax rates has no effect on the price level (P) and the monetary base (MB). In response to a permanent positive innovation in T1, the government expenditure (G) increases on the 3rd quarter, output (Y) decreases between the 4th and the 11th quarters and the interest rate (R) increases until the 5th quarter, and then fades away rather quickly. In response to a permanent innovation to T1, the exchange rate (ER), which is expressed as pounds per U.S. dollar, significantly increases between 5th and the 38th quarters. This implies an extended period of depreciation of the exchange rate. A positive shock to T4 (Seater's type of AMTR measure calculated by exponential interpolation) in Panel D generates results that are very similar to those generated by a shock to T1, but the response of exchange rate (ER) to a T4 innovation is permanent.

In Panel B, a positive shock to T2 (Barro 1 type of AMTR measure calculated by linear interpolation), which appears to be a permanent increase in AMTR (T2), has a significant effect on output (Y), the interest rate (R) and the exchange rate (ER), and does not have any significant impact on government expenditures (G), the monetary base (MB), and the price level (P). In response to a permanent positive innovation to T2, output (Y) significantly decreases between the 4th and the 10th quarters, the interest rate (R) increases until the 3rd quarter and the exchange rate (ER) increases significantly until the 32nd quarter. However, the responses of the government expenditures (G), the

[36] Upper case letters are used to define the variables used in the SVAR model since the SVAR model is first estimated in first differences and then the responses are accumulated.

monetary base (MB), and the price level (P) to a T2 innovation are not significantly different from zero, which implies that a permanent change in AMTR (T2) has no long run effects on government expenditures (G), the monetary base (MB), and the price level (P). A positive innovation to T5 (Barro 1 type of AMTR measure calculated by exponential interpolation) in Panel E has very similar results to those generated by a shock to T2.

In Panel C, a positive innovation to T3 (Barro 2 type of AMTR measure calculated by linear interpolation) results in a permanent increase in AMTR (T3), has no significant effects on the monetary base (MB) and the price level (P), and has a significant effect on output (Y), government expenditures (G), the interest rate (R) and the exchange rate (ER) that taper off after some time. In response to a permanent positive innovation to T3, output (Y) temporarily decreases between the 3rd and the 14th quarters, the government expenditure (G) significantly increases between the 2nd and the 10th quarters, the interest rate (R) increases until the 4th quarter, and the exchange rate (ER) significantly increases between the 8th and the 17th quarters. A positive shock to T6 (Barro 2 type of AMTR measure calculated by exponential interpolation) generates results that are very similar to those generated by a shock to T3.

Therefore, a positive innovation to AMTR (T), which results in a permanent increase in the marginal tax rate, has a negative effect on output (Y) and positive effects on the interest rate (R) and the exchange rate (ER), that disappear after some time. Of these results, the response of output (Y) to an increase in AMTR (T) is consistent with most macroeconomic models. The empirical finding that output (Y) is not significantly different from zero over long horizons indicates that the supply-side effects of tax rate

changes could be weak. It appears that the changes in AMTR (T) affect the exchange rate by affecting expected exchange rates and that is why the exchange rate depreciates for an extended period of time.

If economic agents believe that an increase in AMTR (T) results in a decrease in output, there will be a decrease in money demand and therefore a decrease in interest rates. Under interest rate parity, this would imply an increase (depreciation) of the current exchange rate ($E_{£/\$}$). If the increase in AMTR (T) is permanent, not only the current ($E_{£/\$}$) but also the expected ($E^{e}_{£/\$}$) exchange rate will increase (depreciate), which will increase the expected rate of return on dollar deposits ($ERR_{\$}$). Therefore, even though in reality the interest rates do not change and may move in the opposite direction for a short period of time, it is possible for the expectations to play self-fulfilling prophecy role. The initial rise of the interest rate in response to a rise in AMTR (T), however, is puzzling and requires further investigation.

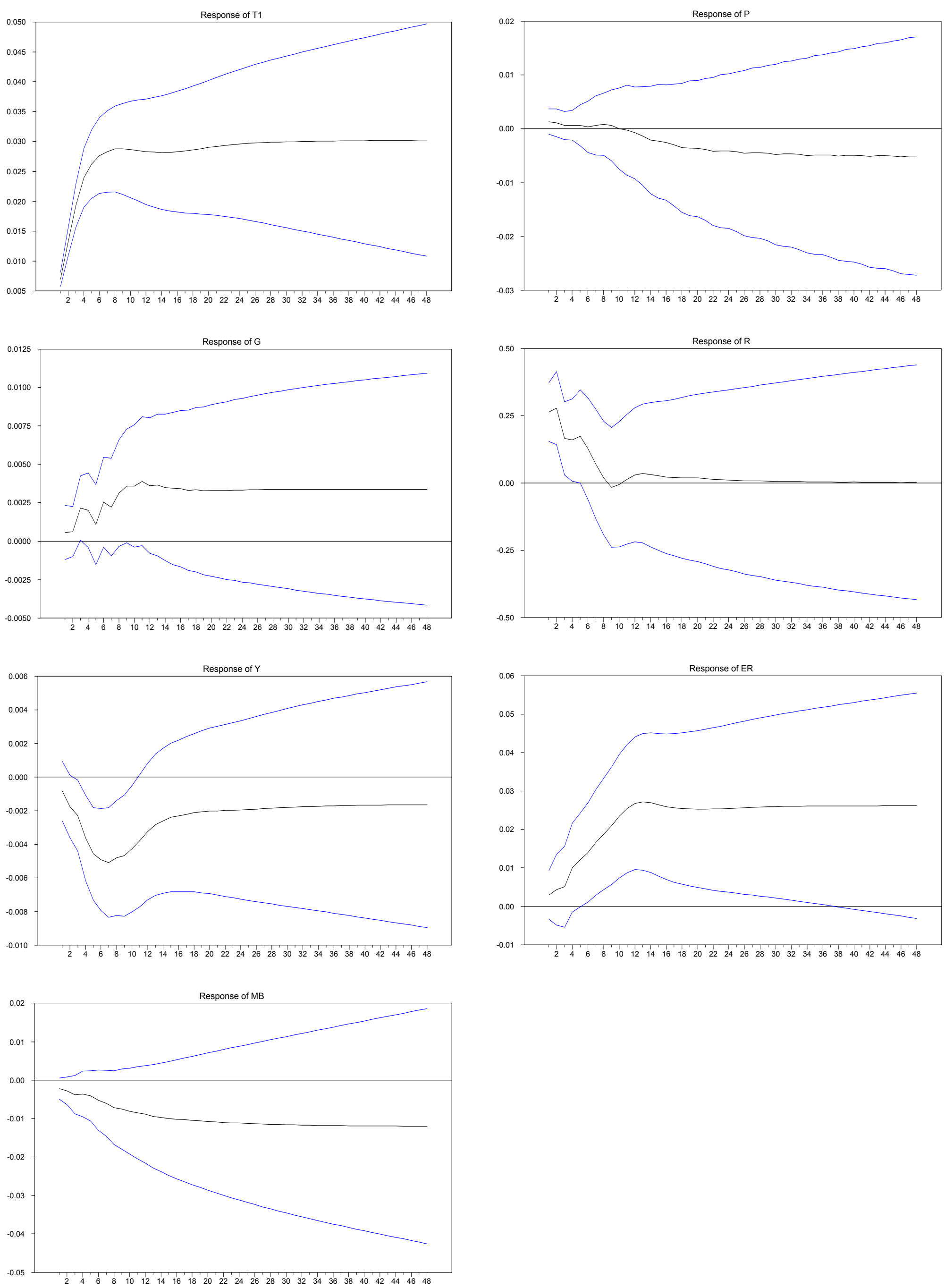
Figure 4.1 The Effects of AMTR Shocks When T is Ordered First and the Lag Length is 5.

Impulse response functions of the real government expenditures (G), the real gross domestic product (Y), the price level (P), the interest rate (R), the exchange rate (ER), and the monetary base (MB) to a one standard deviation shock to each of the average marginal tax rate (T) measures are presented. The appropriate lag length for the estimations has been determined as 5 using the AIC.

Tax	T	G	Y	MB	P	R	ER
T1	increase	increase	decrease	not significant	not significant	increase	increase
T2	increase	not significant	decrease	not significant	not significant	increase	increase
T3	increase	increase	decrease	not significant	not significant	increase	increase
T4	increase	not significant	decrease	not significant	not significant	increase	increase
T5	increase	not significant	decrease	not significant	not significant	increase	increase
T6	increase	not significant	decrease	not significant	not significant	increase	increase

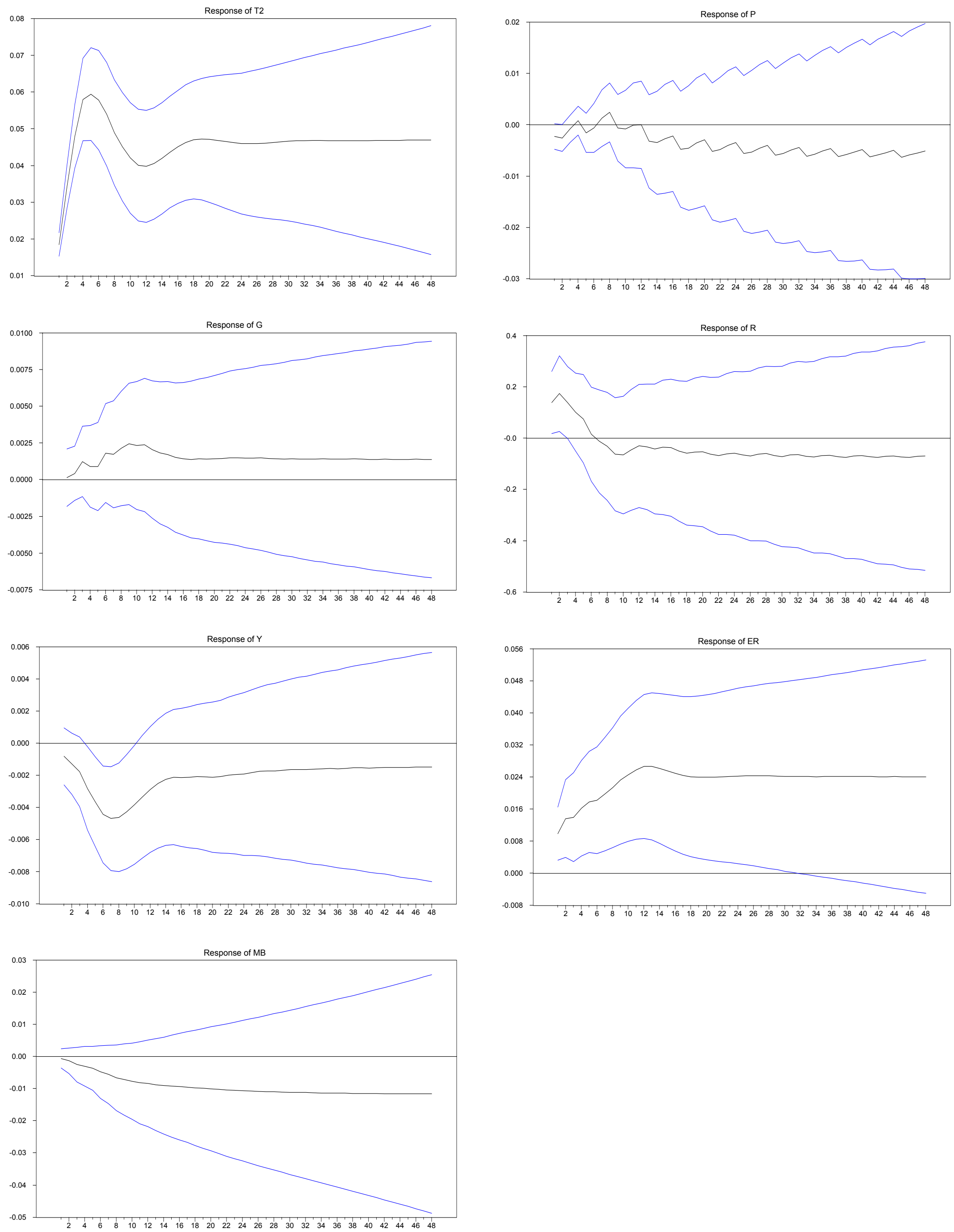
(Figure continued)

Panel A: Shock to T1: T1,G,Y,MB,P,R,ER



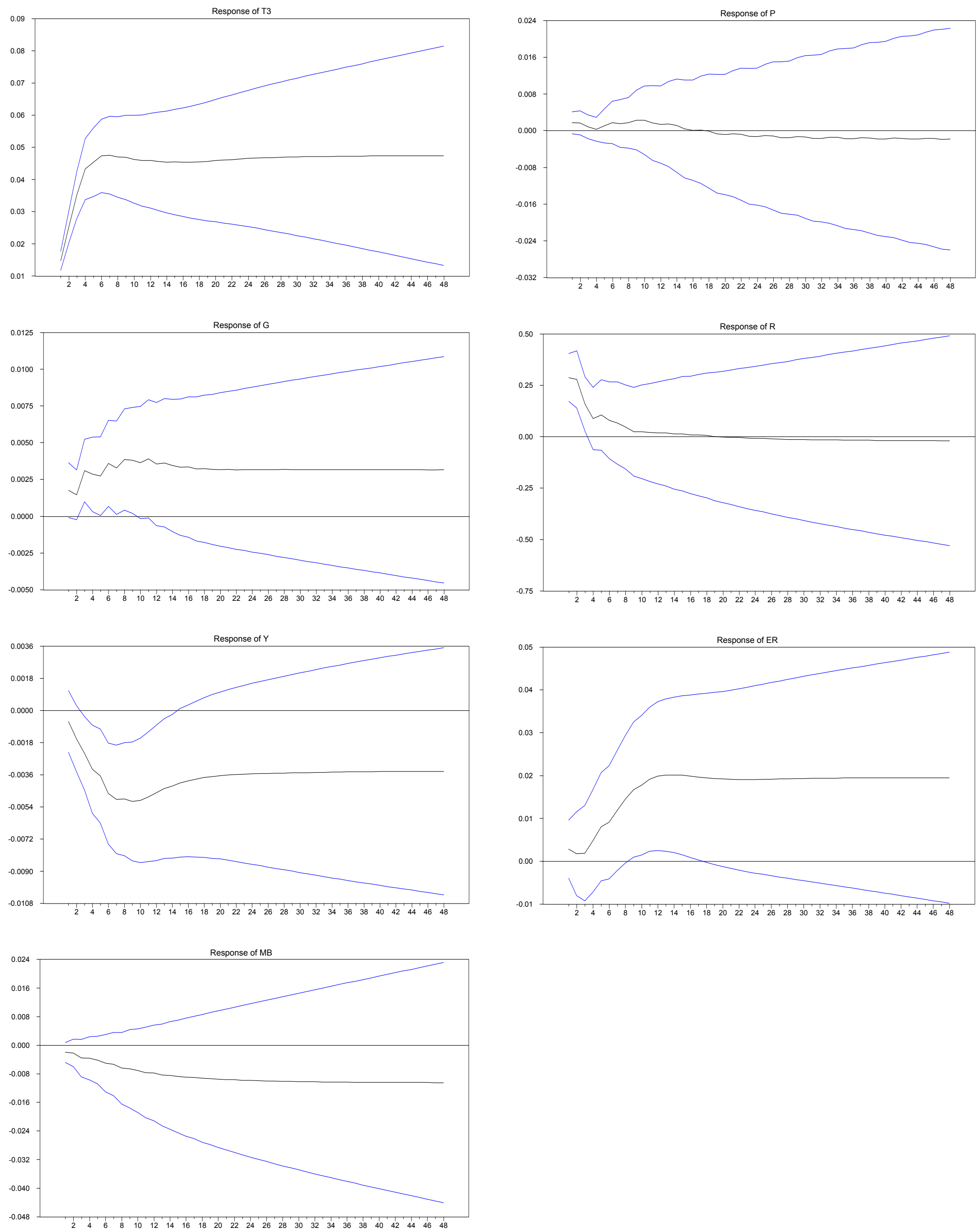
(Figure continued)

Panel B: Shock to T2: T2,G,Y,MB,P,R,ER



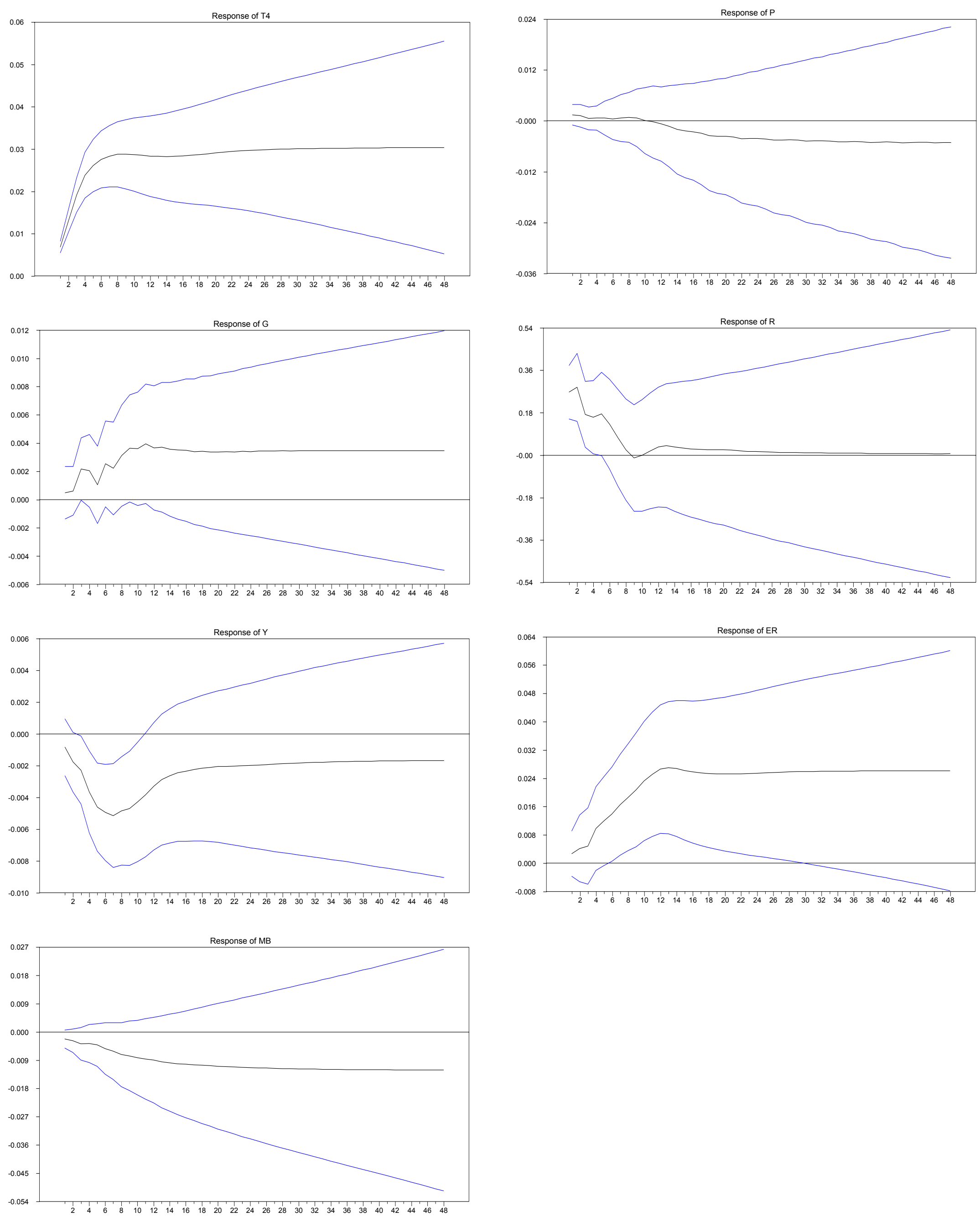
(Figure continued)

Panel C: Shock to T3: T3,G,Y,MB,P,R,ER



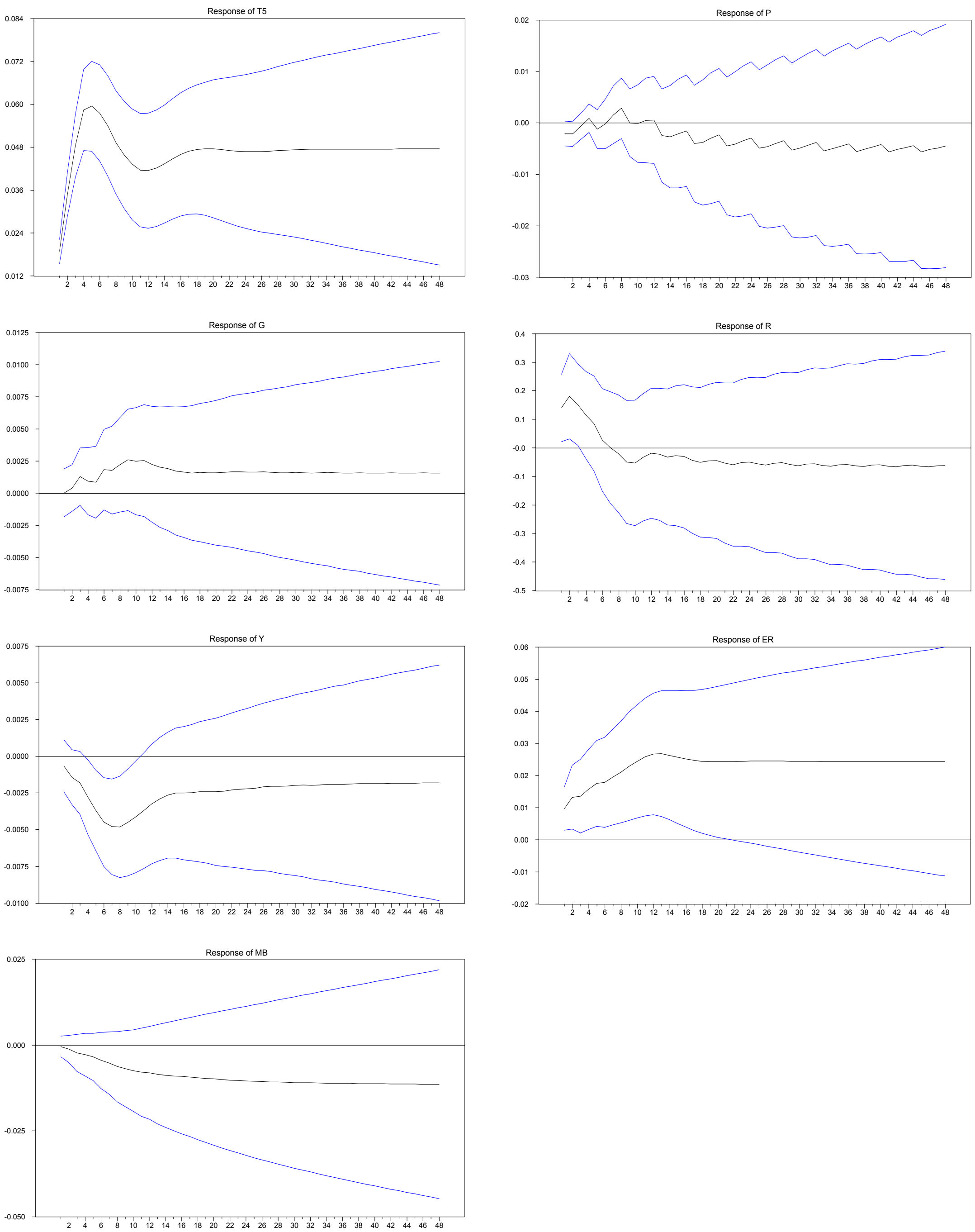
(Figure continued)

Panel D: Shock to T4: T4,G,Y,MB,P,R,ER



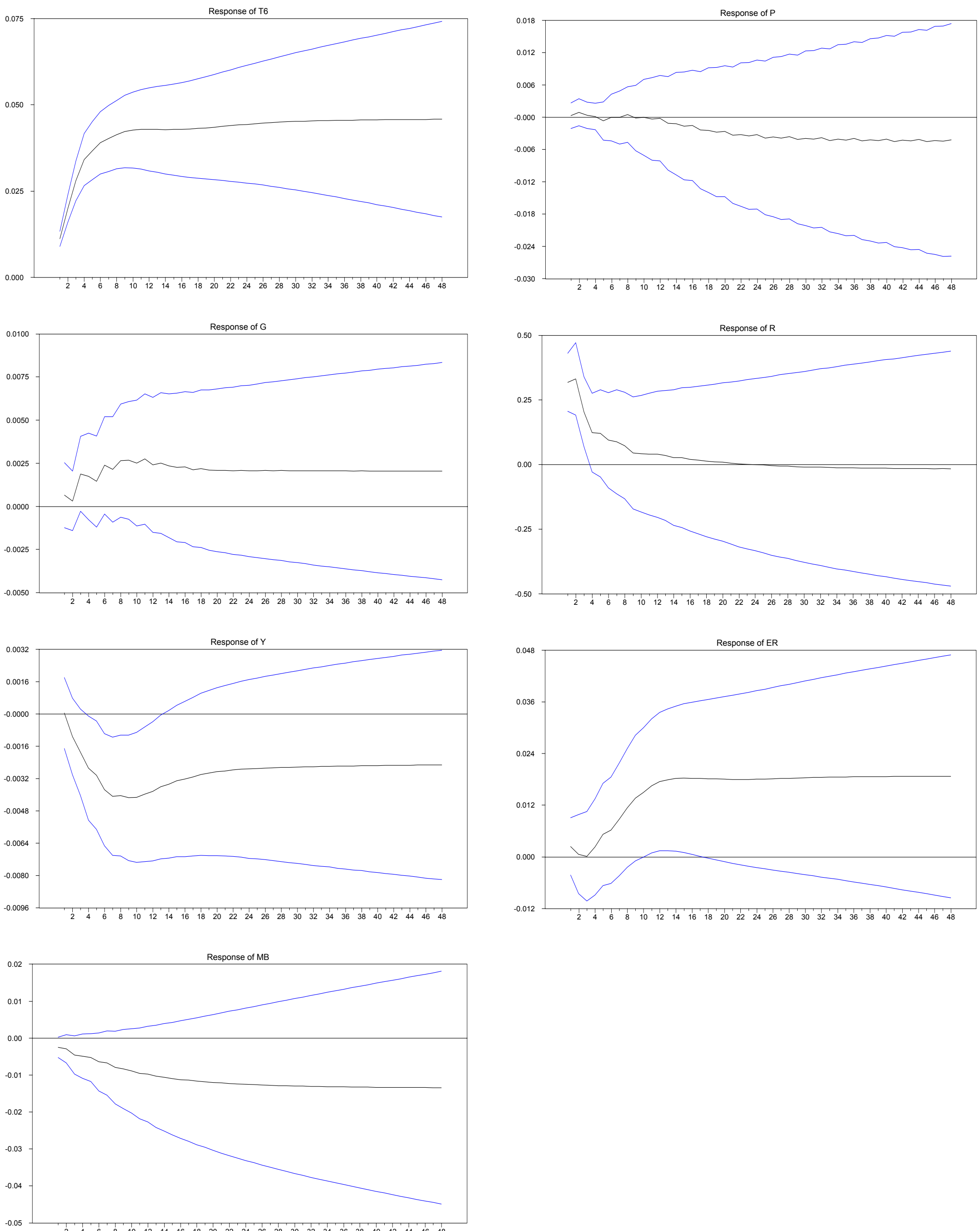
(Figure continued)

Panel E: Shock to T5: T5,G,Y,MB,P,R,ER



(Figure continued)

Panel F: Shock to T6: T6,G,Y,MB,P,R,ER



4.3.2.The Effects of AMTR Shocks When T is Ordered First and the Lag Length is 4.

Christiano, Eichenbaum, and Evans (1996) analyze the identification of the monetary policy shocks in a VAR model with four lags. Blanchard and Perroti (1999) analyze the responses of real GDP and components of output to a fiscal policy shock by using a VAR model with 4 lags. In addition to these two studies, there are a large number of studies that arbitrarily choose a lag length of 4, without any formal tests of lag length, when quarterly data are used. Therefore, we also employ a lag length of 4 in our empirical analysis to check the sensitivity of our results to different lag lengths.

The point estimates of impulse response functions of the 4-lag VAR models lie within the confidence intervals of the previous benchmark model, which implies that there are no significant differences between the benchmark and the 4-lag VAR models.

The impulse responses of AMTR innovations on government expenditures (G), output (Y), the price level (P), the monetary base (MB), the interest rate (R), and the exchange rate (ER) for a horizon of 48 quarters are presented in Appendix H, which is estimated for a lag length of 4.

4.4. An Empirical Analysis of the Effects of AMTR Shocks When G is Ordered First

The long run restrictions imposed in the previous section order the average marginal tax rate (T) before government expenditures (G), which assumes that the government first makes a decision about the tax rates and then adjusts its spending accordingly. This assumption may or may not be true and the results may be sensitive to this ordering. Therefore, in this section, we estimate a SVAR model with long run restrictions that replace the average marginal tax rate (T) and government expenditures (G) in the ordering in order to check the robustness of our results.

The vector x of macroeconomic variables that are included in the SVAR analysis consists of real government expenditures (G), the average marginal tax rate (T) measures, the real gross domestic product (Y), the monetary base (MB), the price level (P), the interest rate (R), and the exchange rate (ER);

$$x = [G, T, Y, MB, P, R, ER]'.$$

To identify the structural innovations from the VAR model, twenty-one identifying restrictions are required. These are: (1) AMTR shocks do not have a permanent effect on G, (2) output shocks do not have a permanent effect on G, (3) monetary shocks do not have a permanent effect on G, (4) price level shocks do not have a permanent effect on G, (5) interest rate shocks do not have a permanent effect on G, (6) exchange rate shocks do not have a permanent effect on G, (7) output shocks do not have a permanent effect on T, (8) monetary shocks do not have a permanent effect on T, (9) price level shocks do not have a permanent effect on T, (10) interest rate shocks do not have a permanent effect on T, (11) exchange rate shocks do not have a permanent effect on T, (12) monetary shocks do not have a permanent effect on Y, (13) price level shocks do not have a permanent effect on Y, (14) interest rate shocks do not have a permanent effect on Y, (15) exchange rate shocks do not have a permanent effect on Y, (16) price level shocks do not have a permanent effect on MB, (17) interest rate shocks do not have a permanent effect on MB, (18) exchange rate shocks do not have a permanent effect on MB, (19) interest rate shocks do not have a permanent effect on P, (20) exchange rate shocks do not have a permanent effect on P, (21) exchange rate shocks do not have a permanent effect on R.

4.4.1. The Effects of AMTR Shocks When G is Ordered First and the Lag Length is 5

From the SVAR estimation, impulse response functions can be calculated which show the effects of macroeconomic fiscal policy (the effects of average marginal tax rates) innovations on output, government spending, the monetary base, the price level, the interest rate and the exchange rate. Appendix I (Panel A through F) provides the impulse response functions of AMTR, output (Y), government expenditure (G), the monetary base (MB), the price level (P), the interest rate (R) and the exchange rate (ER) to a one standard deviation AMTR shock for the U.K., which is reported for a horizon of 48 quarters. The one-standard deviation confidence intervals are obtained from a Monte Carlo simulation based on 1,000 draws. On the impulse responses of the SVAR models, the middle lines represent the point estimates, while two other lines denote plus and minus one standard deviation bands.

Since the point estimates of the impulse response functions lie within the confidence intervals of the benchmark model where T is ordered first, there are no significant differences between the two VAR models. When the lag length is 5, the results are quite robust to changing the ordering between G and T of the Choleski decomposition.

Therefore, a positive innovation to AMTR (T), which results in a permanent increase in the marginal tax rate, has a negative effect on output (Y) and positive effects on the interest rate (R) and the exchange rate (ER), that disappear after some time. Of these results, the response of output (Y) to an increase in AMTR (T) is consistent with some macroeconomic models. The empirical finding that output (Y) is not significantly different from zero over long horizons indicates that the supply-side effects of tax rate changes could be weak. It appears that the changes in AMTR (T) affect the exchange

rate by affecting expected exchange rates and that is why the exchange rate depreciates for an extended period of time.

If economic agents believe that an increase in AMTR (T) results in a decrease in output, there will be a decrease in money demand and therefore a decrease in interest rates. Under interest rate parity, this would imply an increase (depreciation) of the current exchange rate ($E_{£/\$}$). If the increase in AMTR (T) is permanent, not only the current ($E_{£/\$}$) but also the expected ($E^e_{£/\$}$) exchange rate will increase (depreciate), which will increase the expected rate of return on dollar deposits ($ERR_\$$). Therefore, even though in reality the interest rates do not change and may move in the opposite direction for a short period of time, it is possible for the expectations to play self-fulfilling prophecy role. The initial rise of the interest rate in response to a rise in AMTR (T), however, is puzzling and requires further investigation.

4.4.2. The Effects of AMTR Shocks When G is Ordered First and the Lag Length is 4

The point estimates of the impulse response functions of the 4-lag VAR models lie within the confidence intervals of the previous benchmark model, which implies that there are no significant differences between the benchmark and the 4-lag VAR models.

The impulse responses of AMTR innovations on government expenditures (G), output (Y), the price level (P), the monetary base (MB), the interest rate (R), and the exchange rate (ER) for a horizon of 48 quarters are presented in Appendix J, which is estimated for a lag length of 4.

4.5. Conclusion

This chapter has used a SVAR model which imposes long run restrictions to estimate the impact of dynamic effects of fiscal policy shocks (three different AMTR

measures: Seater's average marginal tax rate measure and two different average marginal tax rate measures of Barro) on seven macroeconomic variables (AMTR (T), output (Y), government expenditure (G), the monetary base (MB), the price level (P), the interest rate (R) and the exchange rate (ER)) in the U.K.

Our results indicate that a positive innovation to average marginal tax rates (T), which results in a permanent increase in the marginal tax rate, has a negative effect on output, an initial positive effect on the interest rate and an increase in the exchange rate for an extended period of time. These results are robust with respect to different lag length and different orderings of fiscal policy variables. When government expenditures (G) are ordered first, the point estimates of impulse response functions lie within the confidence intervals of the benchmark model where the average marginal income tax rate (T) is ordered first, which implies that there are no significant differences between two VAR models. When government expenditures (G) is ordered first and the lag length is 5, the results are quite robust to changing the ordering of the Choleski decomposition.

The empirical findings from the SVAR models with 4 lags are in some ways similar to these with the benchmark model. The point estimates of impulse response functions for the 4-lag SVAR models lie within the confidence intervals for the previous benchmark model, which implies that there are no significant differences between the benchmark and the 4 lags SVAR models. Therefore, the results are quite robust to changing the lag length on all models.

CHAPTER 5

CONCLUSIONS

This dissertation investigates the role of fiscal policy on economic activity by analyzing the response of major macroeconomic variables to innovations to the average marginal income tax rate measures in the U.K. by employing vector autoregressive models.

In the first essay, using the methodology of Seater (1982, 1985) and Barro and Sahasakul (1983, 1986), we calculate and explain the average tax rate and three different average marginal income tax rate measures in the U.K. Three different average marginal tax rate measures are greater than the average tax rate in the same year because of the progressive tax system in the U.K. Barro's average marginal tax rate measure weighted by total income is greater than Barro's average marginal tax rate measures weighted by numbers of returns because of the unequal distribution of income, and Barro's average marginal tax rate measure weighted by total income exceeds Seater's average marginal tax rate measure because the total income before tax in Seater's measure is greater than the total income after tax in Barro 1 measure.

We use the above three different average marginal tax rate measures to investigate the effects of fiscal policy on the macroeconomy in the next two essays.

The second essay uses a vector autoregressive model to estimate the dynamic effects of fiscal policy shocks on seven macroeconomic variables in the U.K. Most of these empirical findings are consistent with the implications of traditional macroeconomic models. An increase in average marginal tax rates initially leads to a decrease in output, depreciation of the exchange rate, and improvement in the trade balance, as suggested by

the theory. The empirical findings that the price level and the monetary base are rising in response to a positive AMTR innovation can be explained by the proposition that increases in the monetary base raise aggregate demand and hence price. The positive response of the monetary base is consistent with the argument that the central bank expands the monetary base in response to a contractionary tax shock.

One puzzling aspect of the empirical findings is the initial significant increase in interest rates in response to a tax increase. The traditional macroeconomic models predict a decrease in interest rates. Over time the interest rate returns to its initial level.

These results are quite robust to using the different lag length and changing the ordering of Choleski decomposition.

When government expenditures are ordered first, the point estimates of the impulse response functions lie within the confidence intervals of the benchmark model where the average marginal tax rate is ordered first, which implies that there are no significant differences between the two VAR models. Therefore, when the lag length is 6, the results are quite robust to changing the ordering between government expenditures and the average marginal tax rate of the Choleski decomposition.

When government expenditures (g) is ordered first, the price level rises, the exchange rate depreciates, and the trade balance improves in response to an increase in average marginal tax rates. The initial response of the interest rate is positive in the first quarter as it is with 6 lags but later we see a decline and leveling off of the interest rate.

When the price level is ordered first, the point estimates of impulse response functions lie within the confidence intervals of the benchmark model, which implies that there are no significant differences between two VAR models. Therefore, when the

price level (p) is ordered first and the lag length is 6, the results are quite robust to changing the ordering of the Choleski decomposition.

The empirical findings from VAR models with 4 lags are similar to those from the benchmark model. The point estimates of impulse response function for the 4-lag VAR models lie within the confidence intervals of the previous benchmark model, which implies that there are no significant differences between the benchmark and the 4-lag VAR models. Therefore, the results are quite robust to changing the lag length on all models.

The third essay employs a structural vector autoregressive model to estimate the dynamic effects of fiscal policy shocks on seven macroeconomic variables in the U.K. by imposing long run restrictions. A positive innovation to AMTR (T), which results in a permanent increase in the marginal tax rate, has a negative effect on output (Y) and positive effects on the interest rate (R) and the exchange rate (ER), that disappear after some time. Of these results, the response of output (Y) to an increase in AMTR (T) is consistent with most macroeconomic models. The empirical finding that output (Y) is not significantly different from zero over long horizons indicates that the supply-side effects of tax rate changes could be weak. It appears that the changes in AMTR (T) affect the exchange rate by affecting expected exchange rates and that is why the exchange rate depreciates for an extended period of time.

If economic agents believe that an increase in AMTR (T) results in a decrease in output, there will be a decrease in money demand and therefore a decrease in interest rates. Under interest rate parity, this would imply an increase (depreciation) of the current exchange rate ($E_{£/\$}$). If the increase in AMTR (T) is permanent, not only the

current ($E_{£/\$}$) but also the expected ($E^e_{£/\$}$) exchange rate will increase (depreciate), which will increase the expected rate of return on dollar deposits ($ERR_\$$). Therefore, even though in reality the interest rates do not change and may move in the opposite direction for a short period of time, it is possible for the expectations to play self-fulfilling prophecy role. The initial rise of the interest rate in response to a rise in AMTR (T), however, is puzzling and requires further investigation.

These results are robust with respect to different lag length and different orderings of fiscal policy variables. When government expenditures (G) are ordered first, the point estimates of impulse response function for a shock to the tax rate lie within the confidence intervals of the benchmark model where the average marginal income tax rate (T) is ordered first, which implies that there are no significant differences between two SVAR models. When the lag length is 5, the results are quite robust to changing the ordering between the average marginal income tax rate and government expenditures of the Choleski decomposition.

The empirical findings that follow the SVAR models with 4 lags are similar to these with the benchmark model. The point estimates of impulse response function of the 4-lag SVAR models lie within the confidence intervals of the previous benchmark model, which implies that there are no significant differences between the benchmark and the 4-lag SVAR models. Therefore, the results are quite robust to changing the lag length on all models.

A positive innovation to AMTR has short run effects on government expenditures, output, the interest rate, and the exchange rate in both VAR and SVAR models. The response of AMTR is a temporary positive effect in the VAR model, but is a permanent

positive effect in the SVAR model in response to a temporary positive innovation in AMTR.   A positive shock of AMTR has significantly positive effect on the price level, the monetary base, and the trade balance in the VAR model, but has no effect on the price level and the monetary base in the SVAR model.

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APPENDIX A. DATA OF THE U.K. (SOURCE OF NATIONAL STATISTICS): 1957:1-1998:4

Three different Marginal Tax Rates Measures (Seater's AMTR, and Barro1's and 2's AMTRs)

RR (RMGBM): the real Government bond yield-medium term (Par yield on five-year (short-dated) British government securities)

ER (RX): the nominal exchange rate pounds per US dollar

GDPR (GDPR): the real Gross Domestic Product (billions of 1990 pound)

GDP (GDP): the nominal Gross Domestic Product (billions of 1990 pound)

P: the price index (P = log (GDP/GDPR))

G (CGR): the real Government consumption expenditures (billions of 1990 pound)

X (XNAR): the real Export of goods and services (billions of 1990 pound)

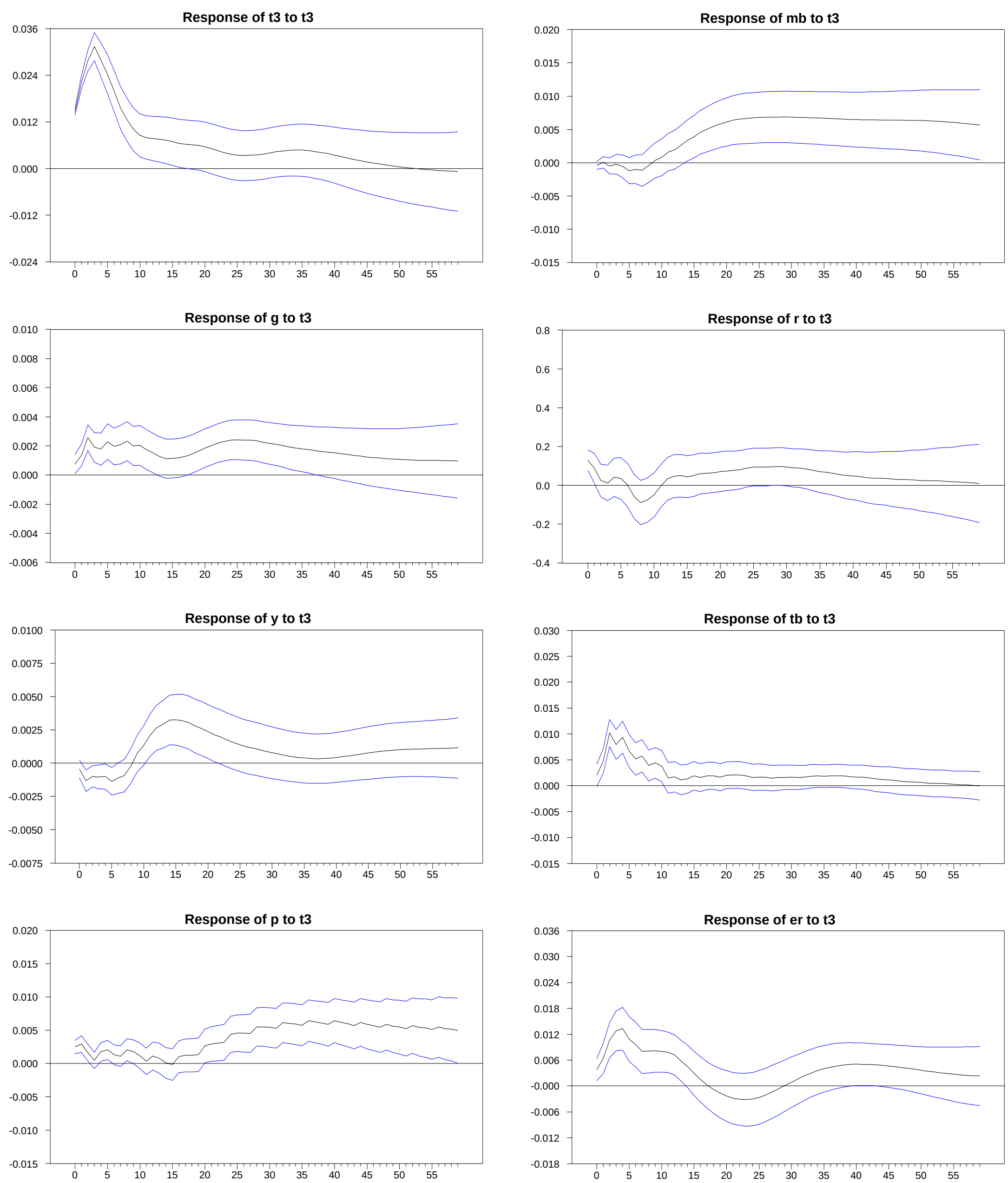
M (MNAR): the real Imports of goods and services (billions of 1990 pound)

MB (MBASE); the Monetary Base (billions of 1990 pound), which is notes and coin + banks' operational deposits, from Bank of England

TB: the Trade Balance (TB = log (X/M))

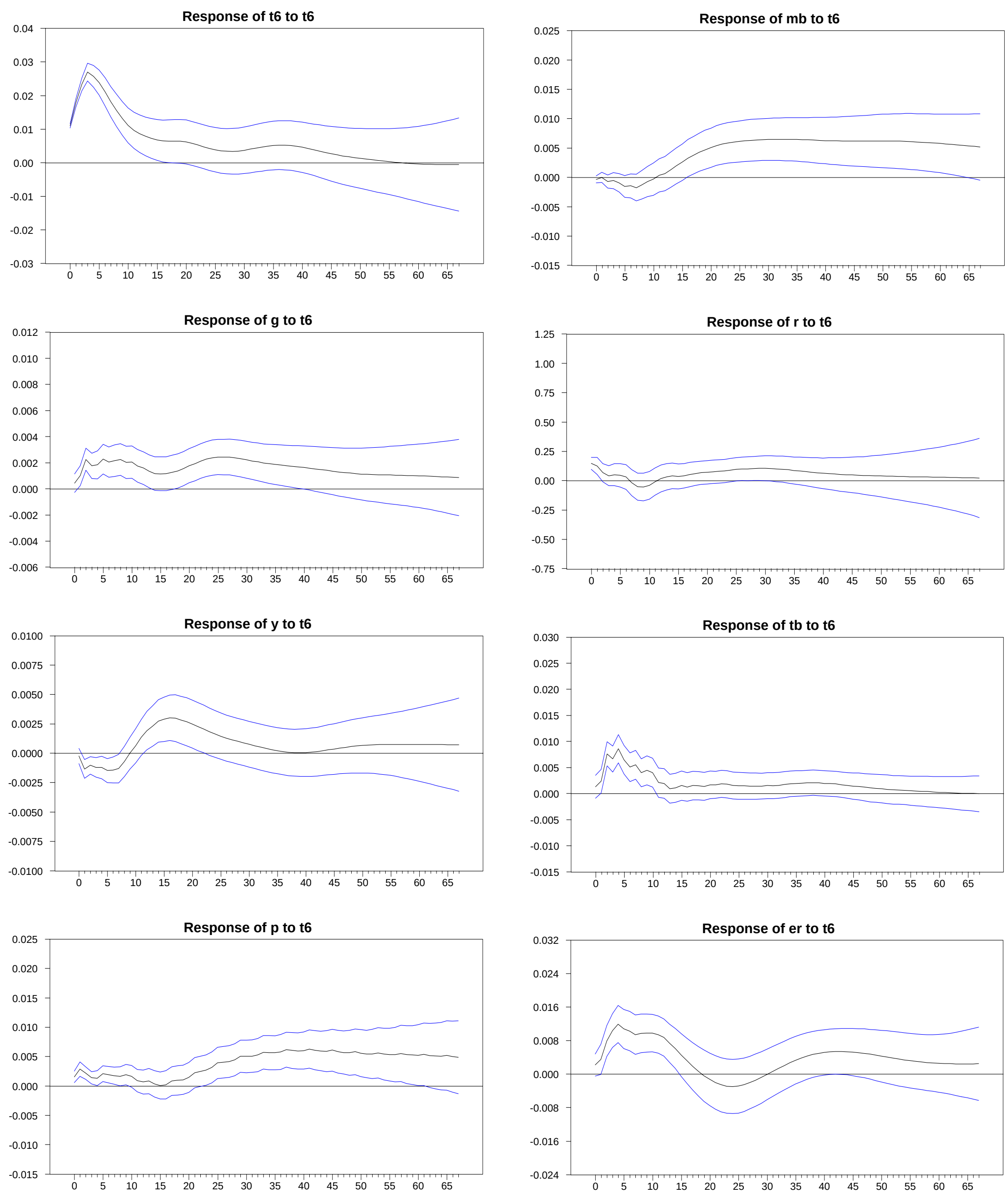
APPENDIX B. THE EFFECTS OF AMTR SHOCKS WHEN T IS ORDERED FIRST AND THE LAG LENGTH IS 6

Panel C. Shock of T3: T3, g, y, p, mb, r, tb, er



(APPENDIX B continued)

Panel F. Shock of T6: T6, g, y, p, mb, r, tb, er



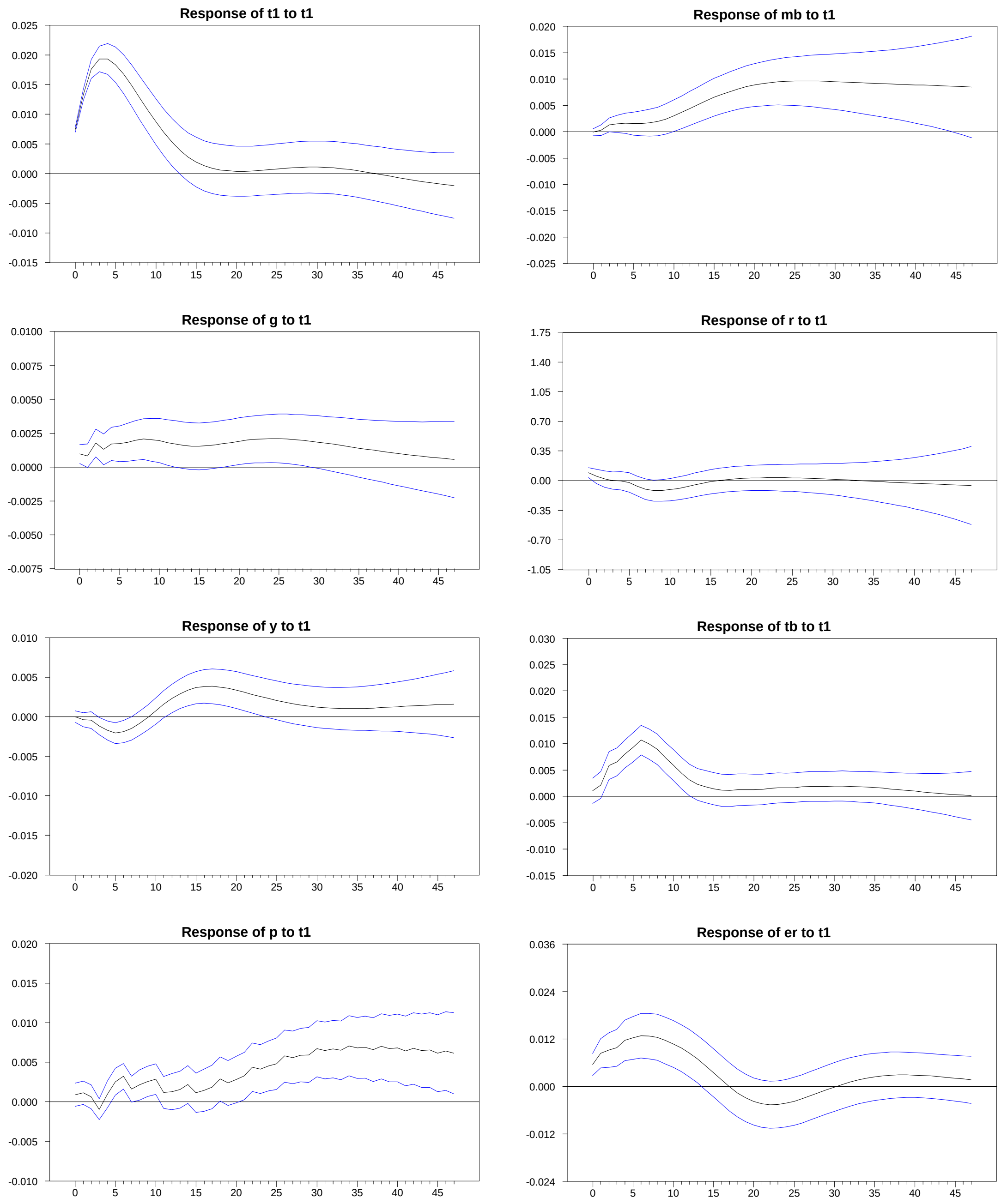
APPENDIX C. THE EFFECTS OF AMTR SHOCKS WHEN T IS ORDERED FIRST AND THE LAG LENGTH IS 4

Impulse response functions of real government expenditures (g), the real gross domestic product (y), the price level (p), the monetary base (mb), the interest rate (r), the trade balance (tb), and the exchange rate pounds per U.S. dollar (er) to a one standard deviation shock to each of the average marginal tax rate (t) measures are presented. The Wold causal ordering is as follows: t, g, y, p, mb, r, tb, and er. The appropriate lag length for the estimations has been determined as 4 for quarterly data.

Tax	t	g	y	p	mb	r	tb	er
T1	increase	increase	decrease increase	increase	increase	increase	increase	increase
T2	increase	increase	decrease increase	decrease increase	increase	decrease	increase	increase decrease
T3	increase	increase	decrease increase	increase	increase	increase	increase	increase
T4	increase	increase	decrease increase	increase	increase	increase	increase	increase
T5	increase	increase	decrease increase	decrease increase	increase	decrease	increase	increase decrease
T6	increase	increase	decrease increase	increase	increase	increase	increase	increase

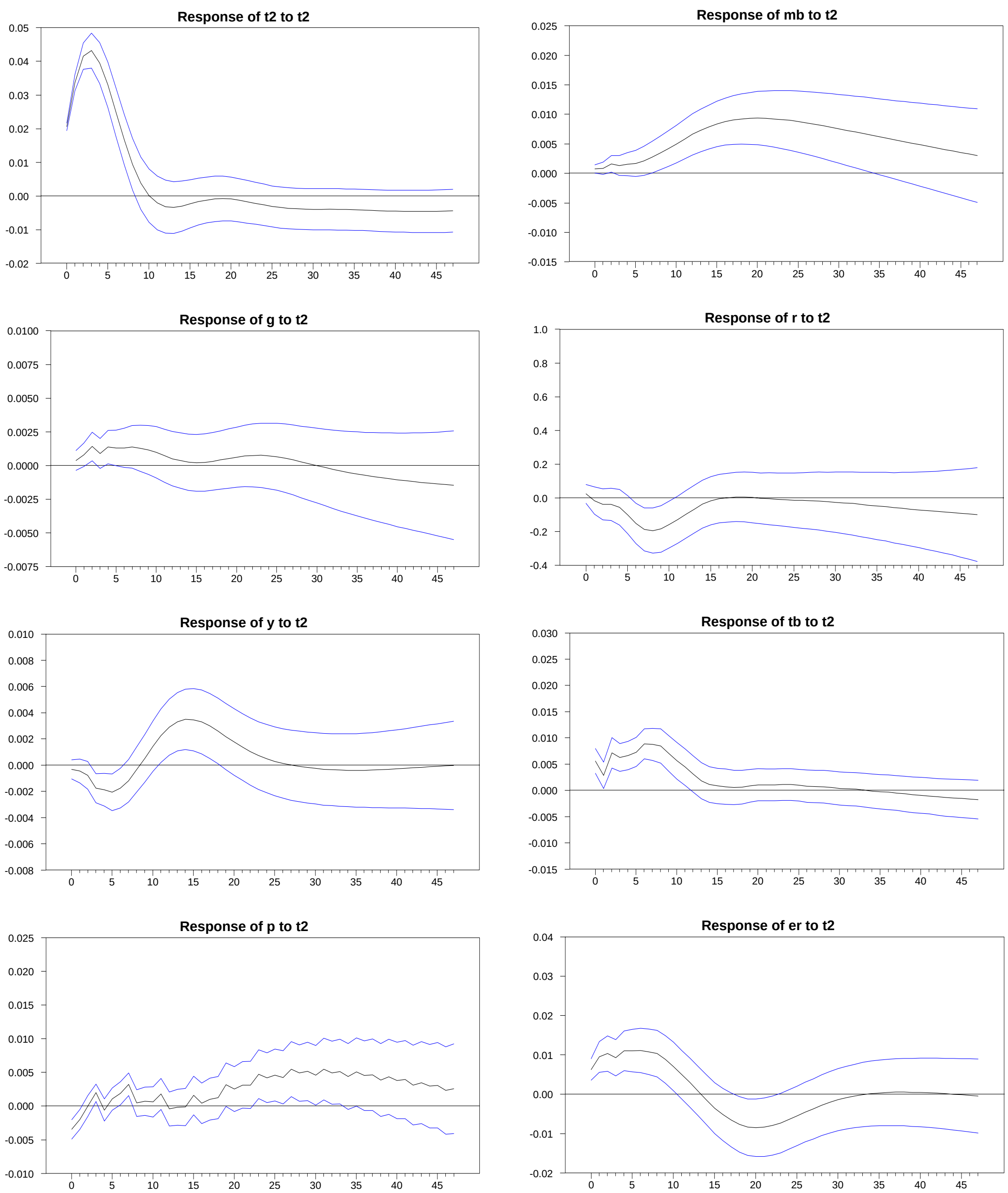
(APPENDIX C continued)

Panel A. Shock of T1: T1, g, y, p, mb, r, tb, er



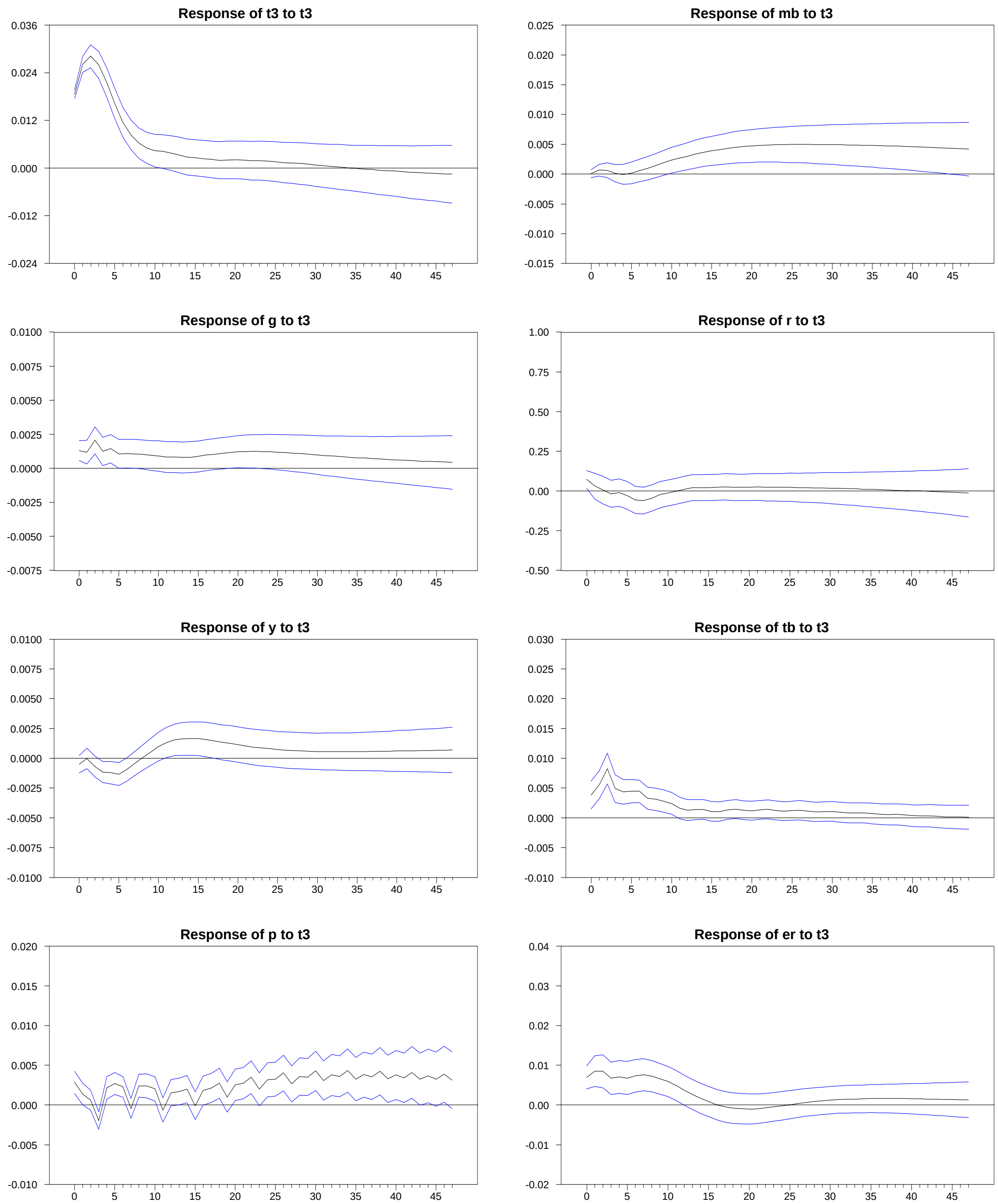
(APPENDIX C continued)

Panel B. Shock of T2: T2, g, y, p, mb, r, tb, er



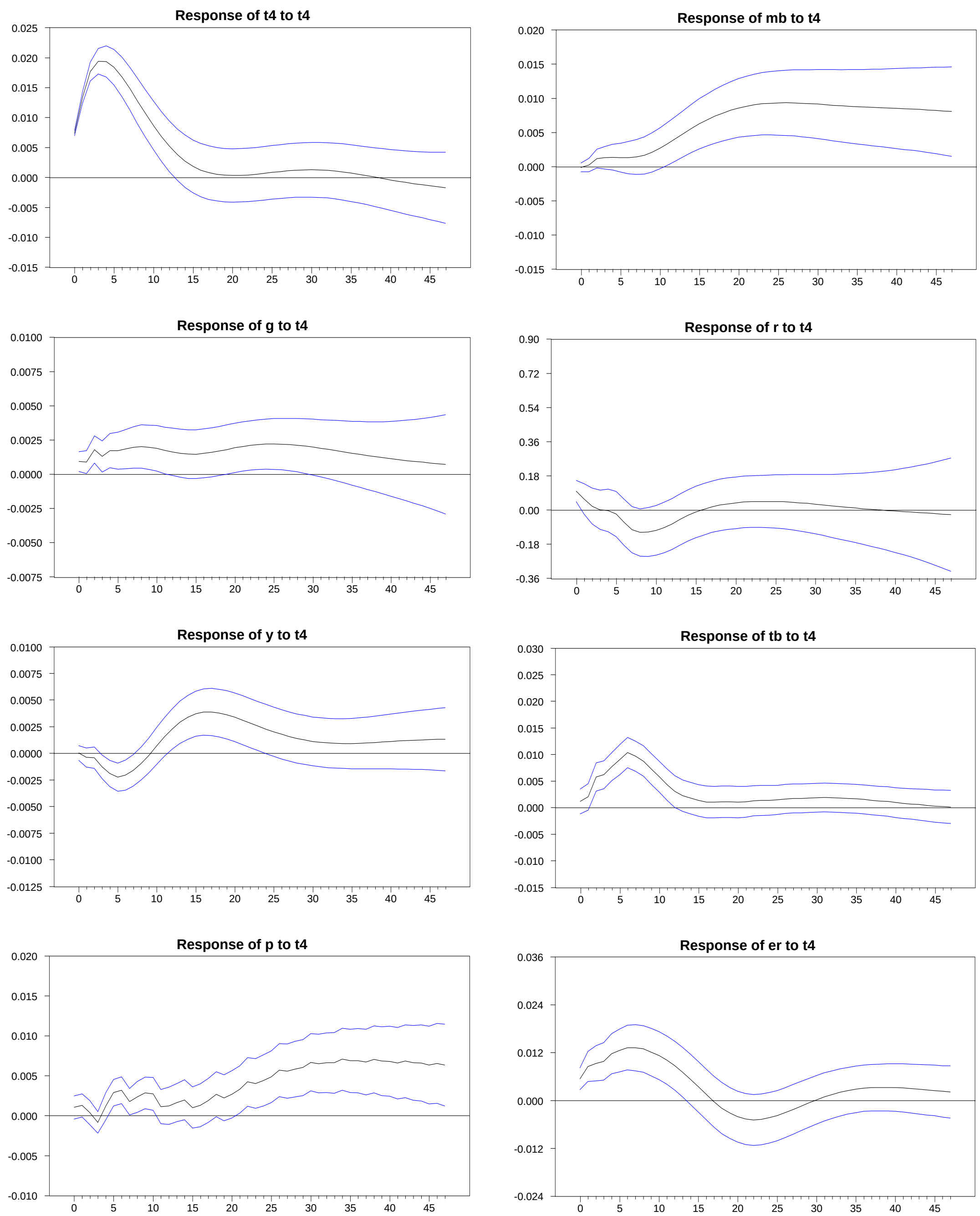
(APPENDIX C continued)

Panel C. Shock of T3: T3, g, y, p, mb, r, tb, er



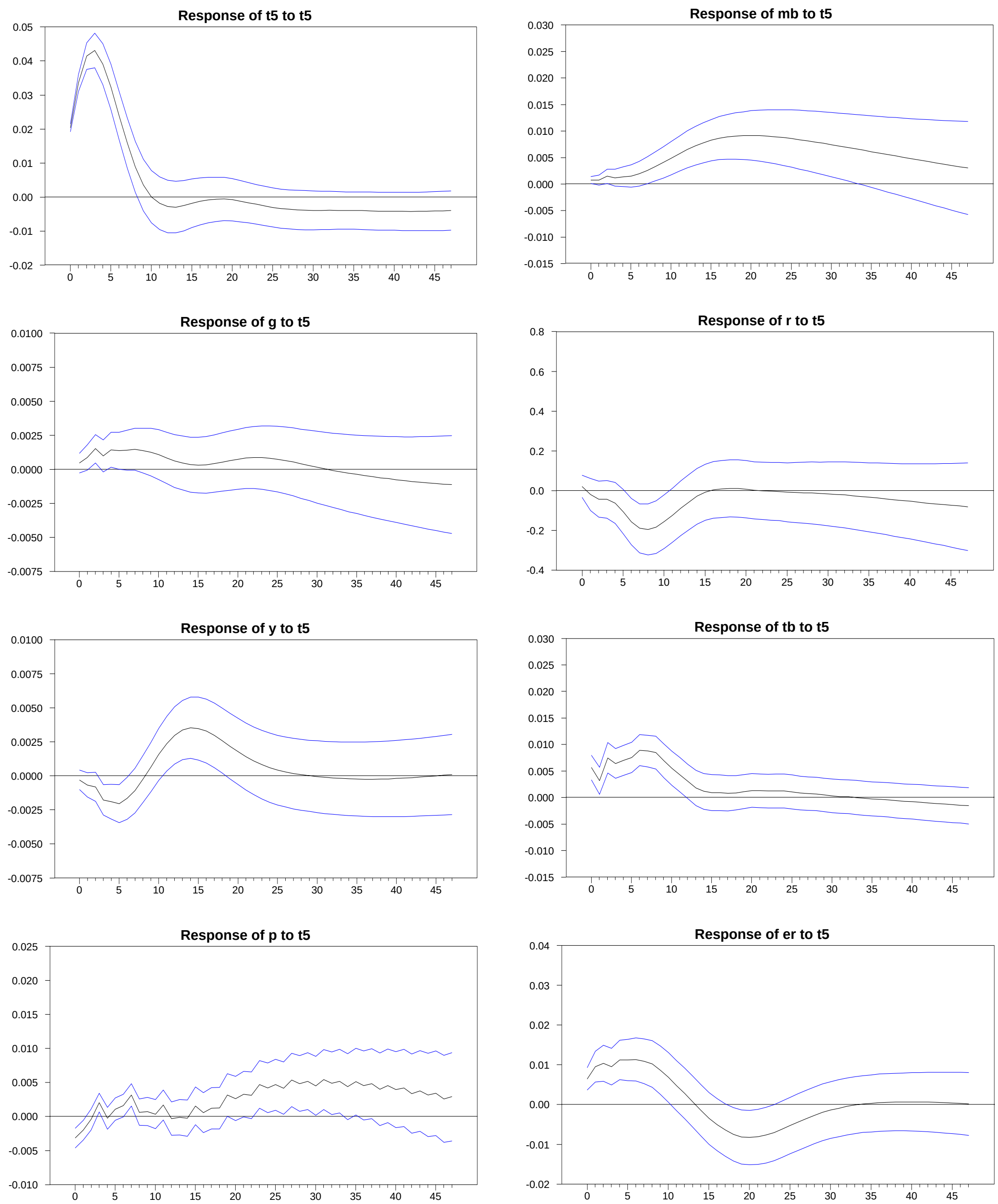
(APPENDIX C continued)

Panel D. Shock of T4: T4, g, y, p, mb, r, tb, er



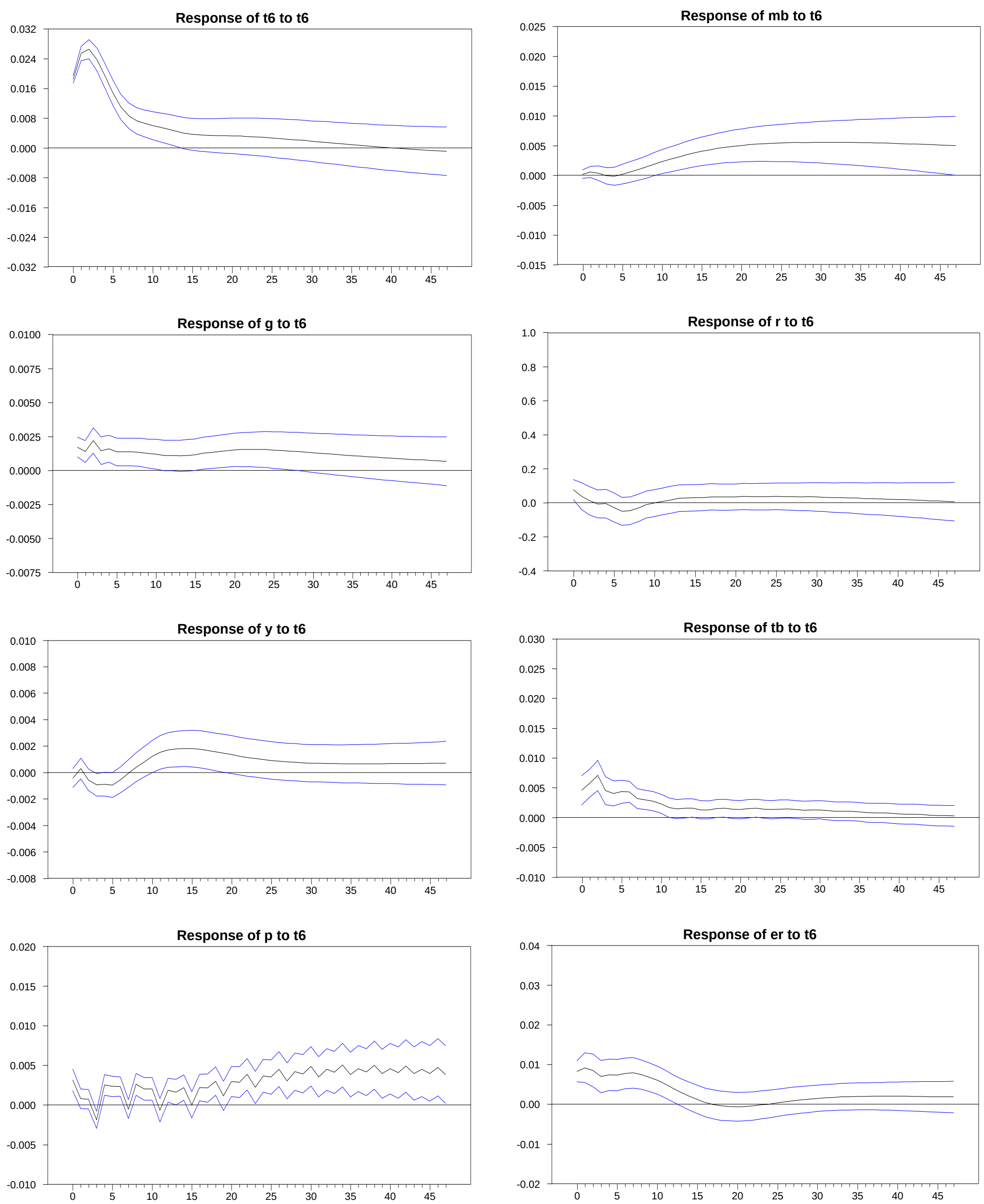
(APPENDIX C continued)

Panel E. Shock of T5: T5, g, y, p, mb, r, tb, er



(APPENDIX C continued)

Panel F. Shock of T6: T6, g, y, p, mb, r, tb, er



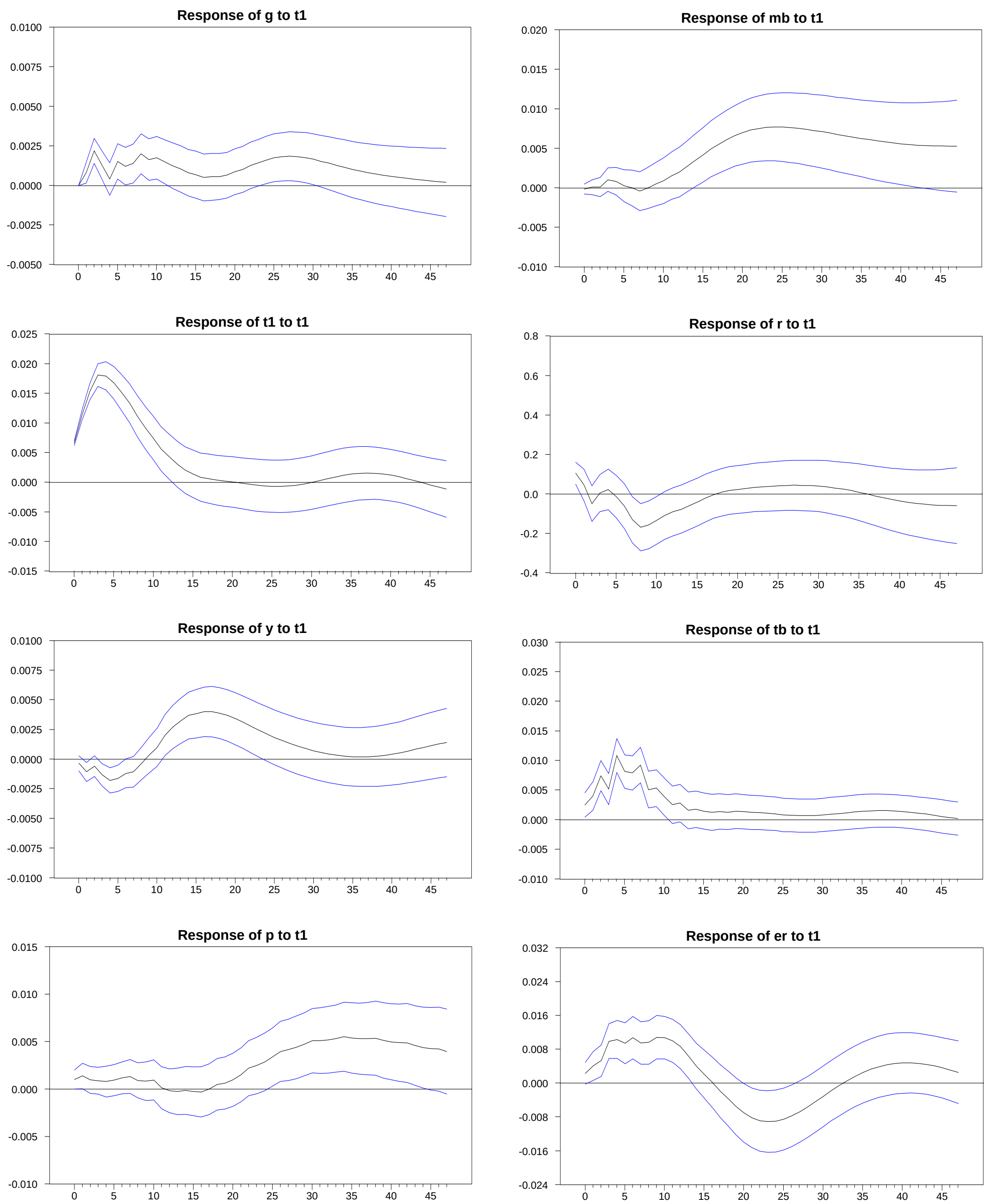
APPENDIX D. THE EFFECTS OF AMTR SHOCKS WHEN G IS ORDERED FIRST AND THE LAG LENGTH IS 6

Impulse response functions of the real government expenditures (g), the real gross domestic product (y), the price level (p), the monetary base (mb), the interest rate (r), the trade balance (tb), and the exchange rate pounds per U.S. dollar (er) to a one standard deviation shock to each of the average marginal tax rate (t) measures are presented. The Wold causal ordering is as follows: g, t, y, p, mb, r, tb, and er. The appropriate lag length for the estimations has been determined as 6 using the AIC.

Tax	g	t	y	P	mb	r	tb	er
T1	increase	increase	decrease increase	increase	increase	increase decrease	increase	increase decrease
T2	increase	increase	decrease increase	increase	increase	increase decrease	increase	increase decrease
T3	increase	increase	decrease increase	increase	increase	increase	increase	increase
T4	increase	increase	decrease increase	increase	increase	increase decrease	increase	increase decrease
T5	increase	increase	decrease increase	increase	increase	increase decrease	increase	increase decrease
T6	increase	increase	decrease increase	increase	increase	increase	increase	increase

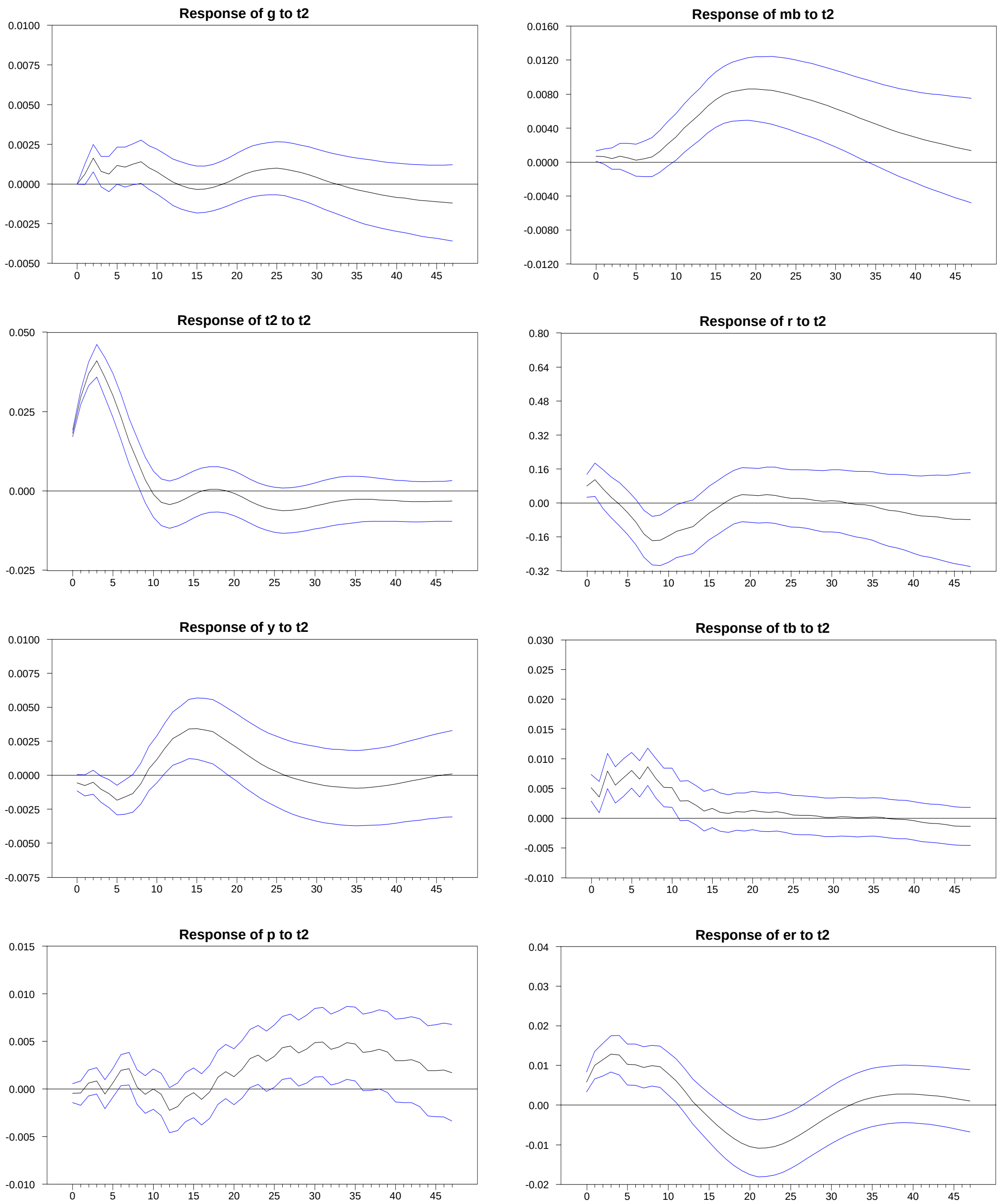
(APPENDIX D continued)

Panel A. Shock of T1: g, T1, y, p, mb, r, tb, er



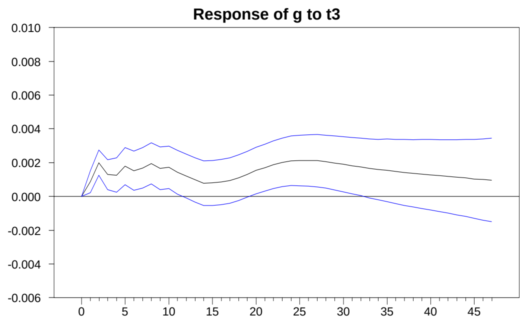
(APPENDIX D continued)

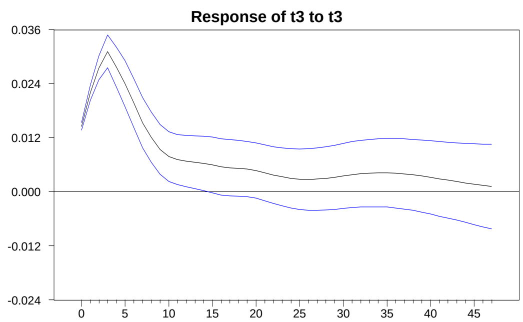
Panel B. Shock of T2: g, T2, y, p, mb, r, tb, er

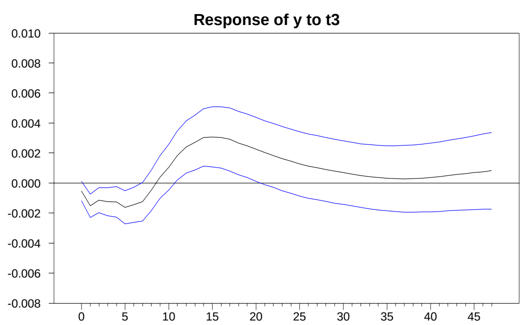


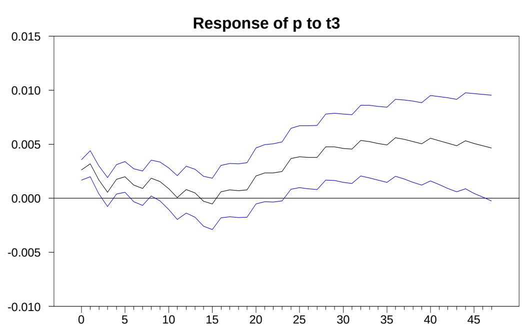
(APPENDIX D continued)

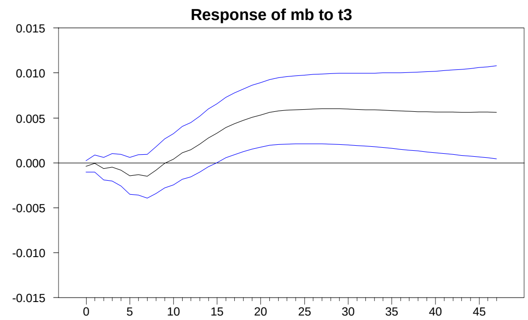
Panel C. Shock of T3: g, T3, y, p, mb, r, tb, er

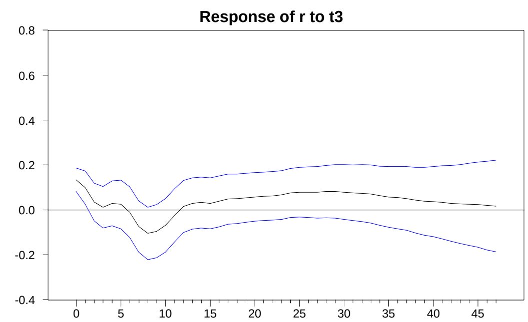


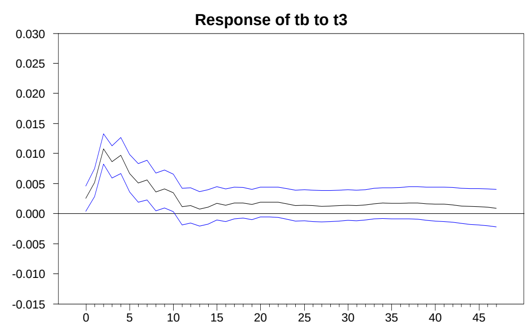


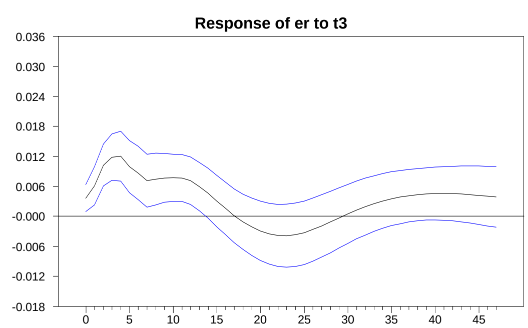






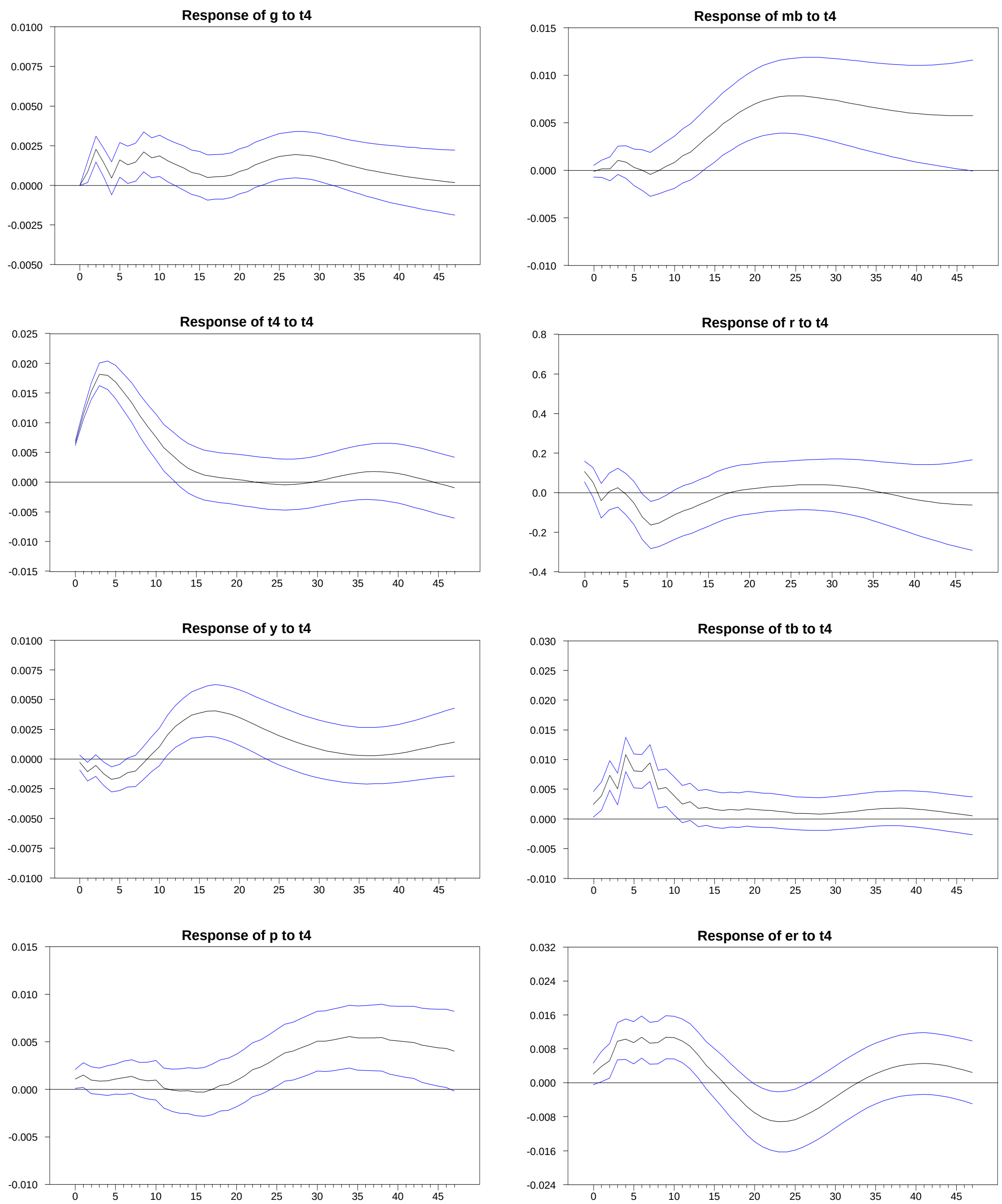






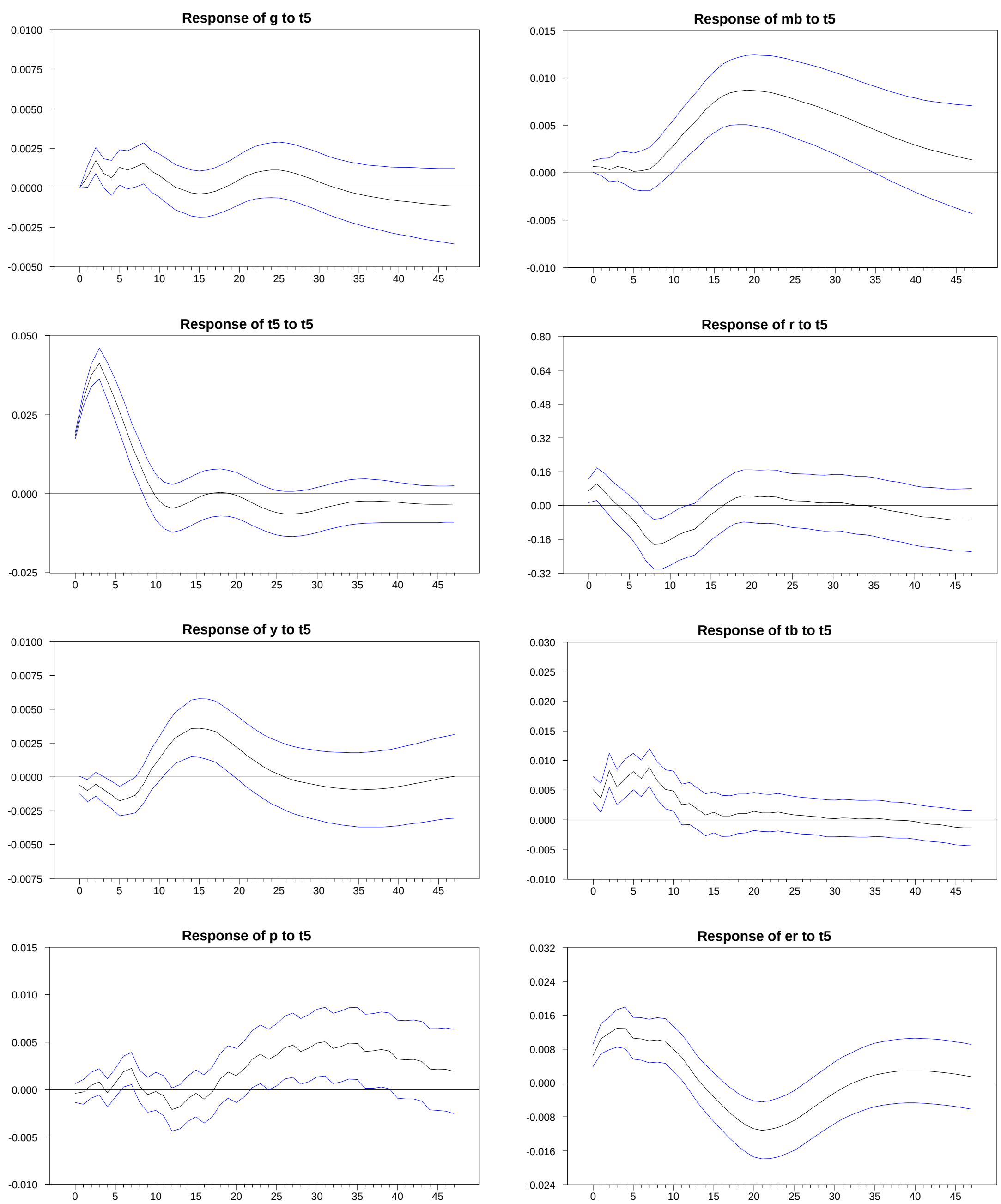
(APPENDIX D continued)

Panel D. Shock of T4: g, T4, y, p, mb, r, tb, er



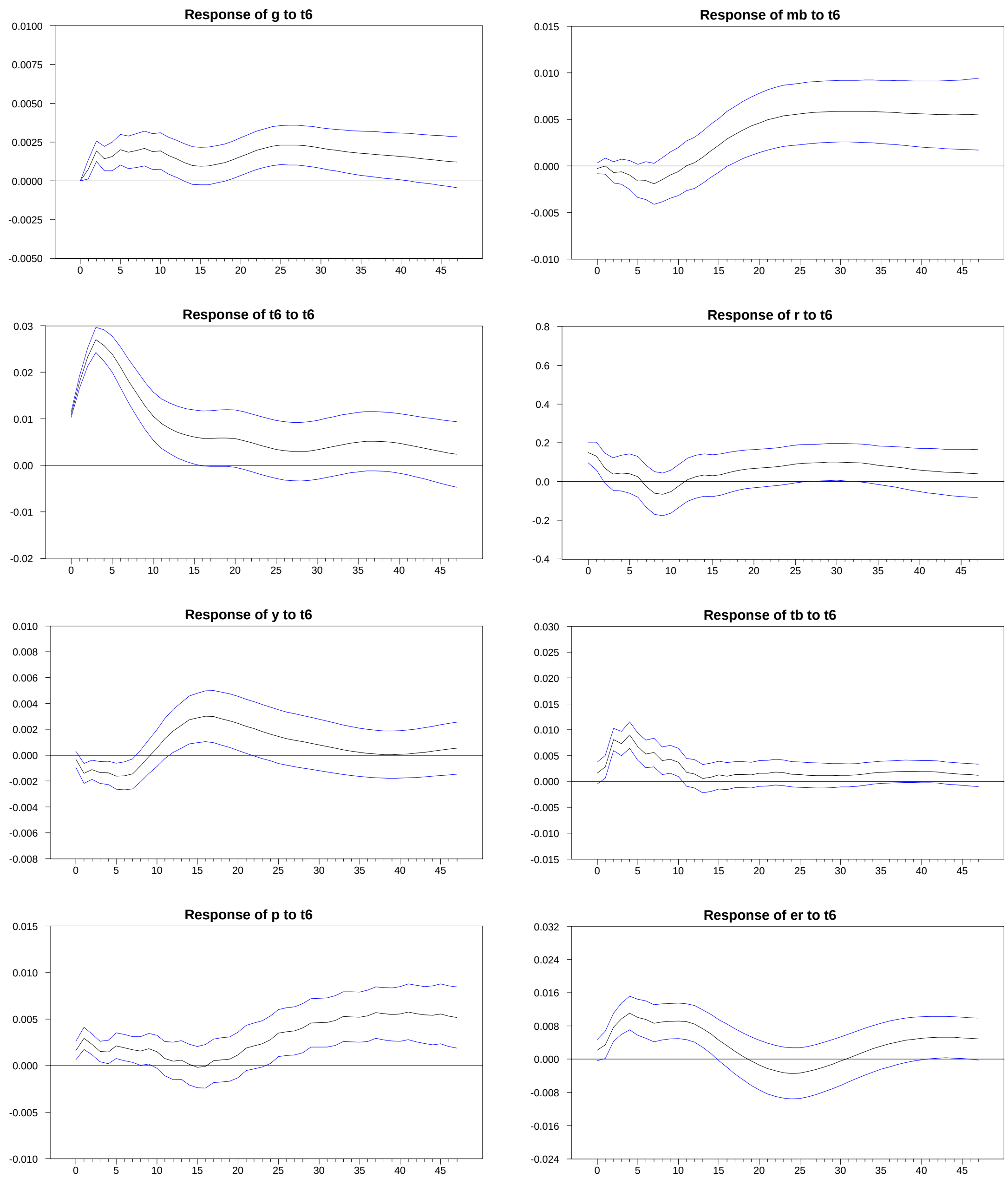
(APPENDIX D continued)

Panel E. Shock of T5: g, T5, y, p, mb, r, tb, er



(APPENDIX D continued)

Panel F. Shock of T6: g, T6, y, p, mb, r, tb, er



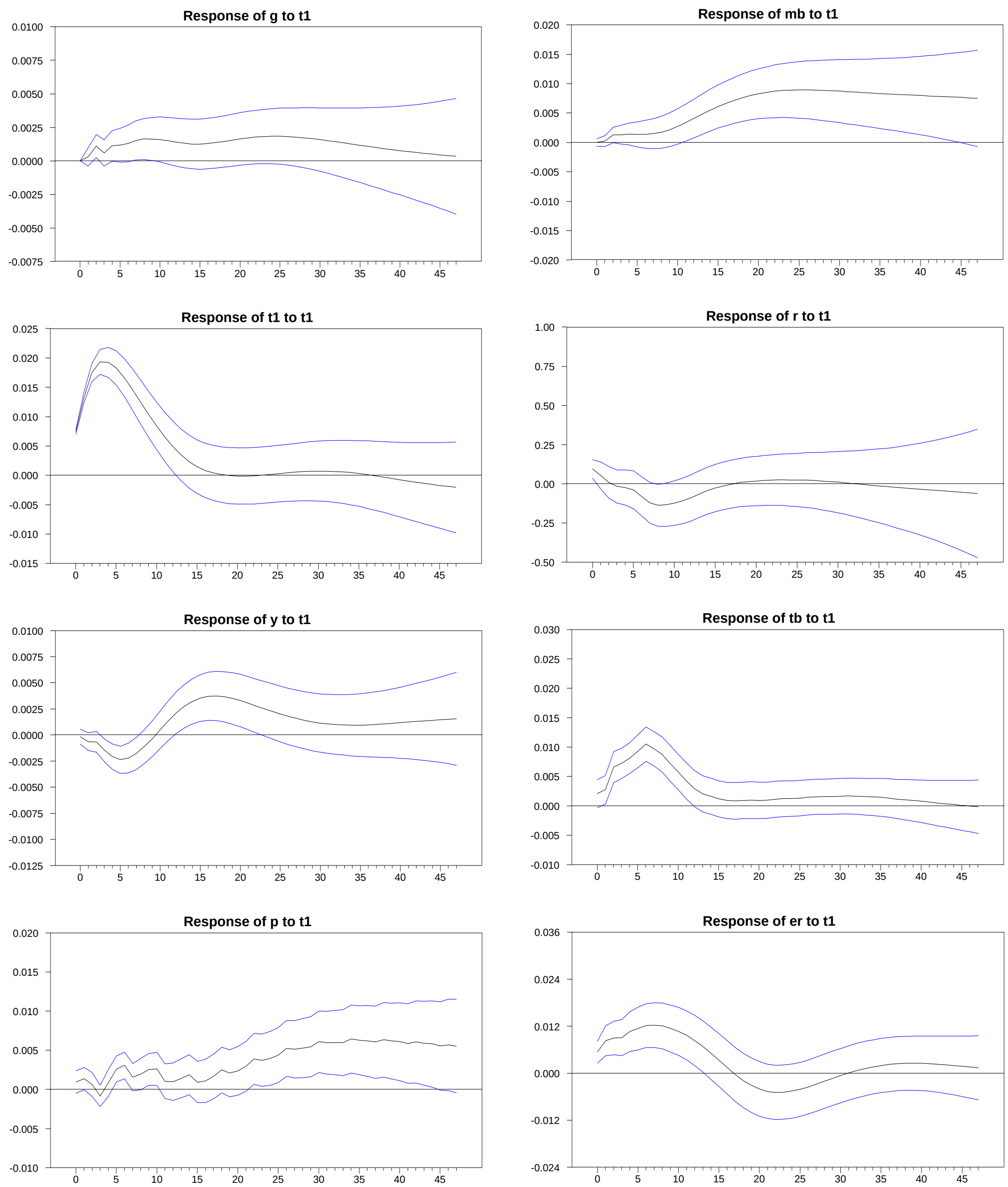
APPENDIX E. THE EFFECTS OF AMTR SHOCKS WHEN G IS ORDERED FIRST ANDTHE LAG LENGTH IS 4

Impulse response functions of the real government expenditures (g), the real gross domestic product (y), the price level (p), the monetary base (mb), the interest rate (r), the trade balance (tb), and the exchange rate pounds per U.S. dollar (er) to a one standard deviation shock to each of the average marginal tax rate (t) measures are presented. The Wold causal ordering is as follows: g, t, y, p, mb, r, tb, and er. The appropriate lag length for the estimations has been chosen as 4.

Tax	g	T	y	P	mb	r	tb	er
T1	increase	increase	decrease increase	increase	increase	increase decrease	increase	increase
T2	increase	increase	decrease increase	decrease increase	increase	decrease	increase	increase decrease
T3	increase	increase	decrease	increase	increase	increase	increase	increase
T4	increase	increase	decrease increase	increase	increase	increase decrease	increase	increase
T5	increase	increase	decrease increase	decrease increase	increase	decrease	increase	increase decrease
T6	increase	increase	decrease	increase	increase	increase	increase	increase

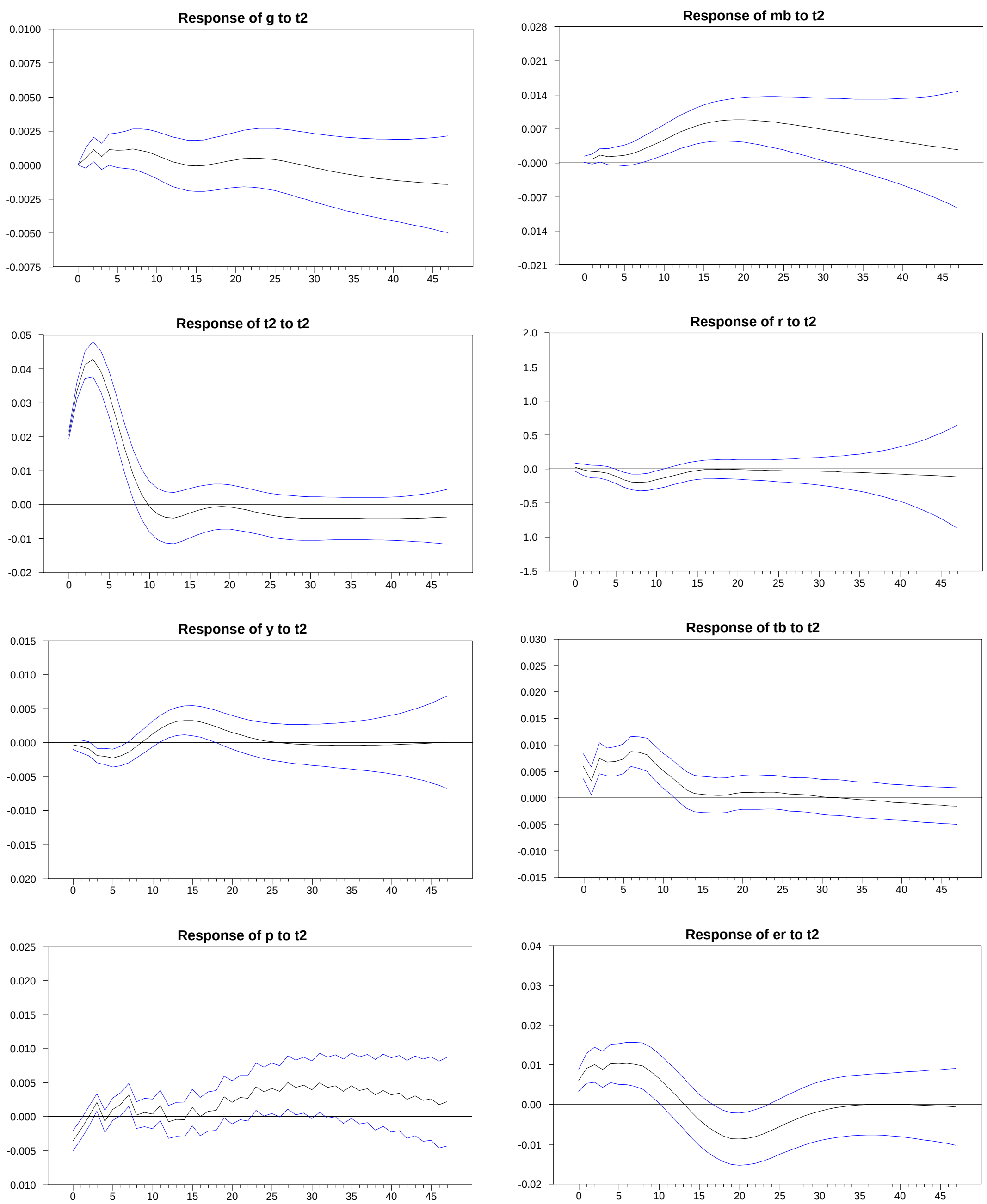
(APPENDIX E continued)

Panel A. Shock of T1: g, T1, y, p, mb, r, tb, er



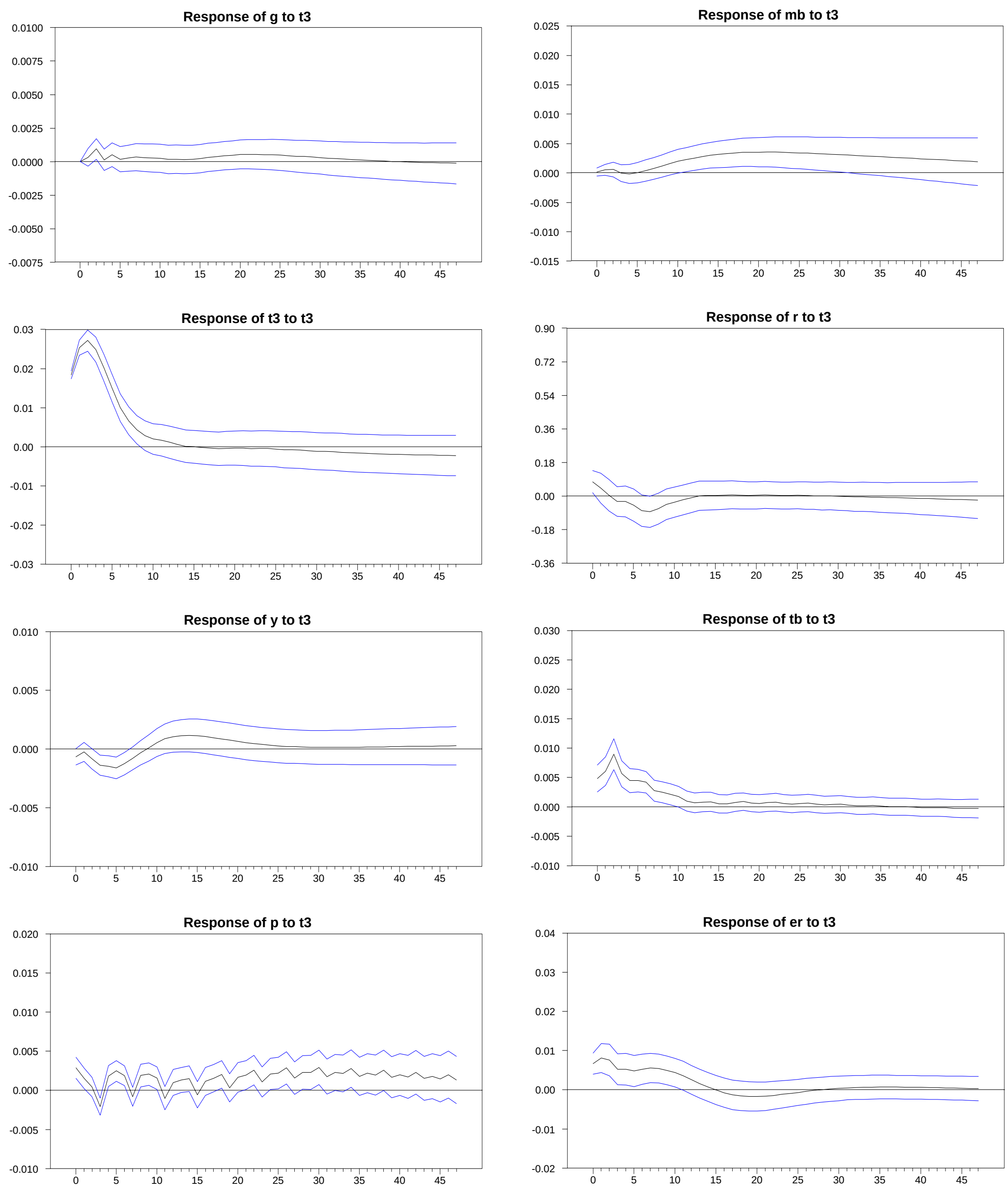
(APPENDIX E continued)

Panel B. Shock of T2: g, T2, y, p, mb, r, tb, er



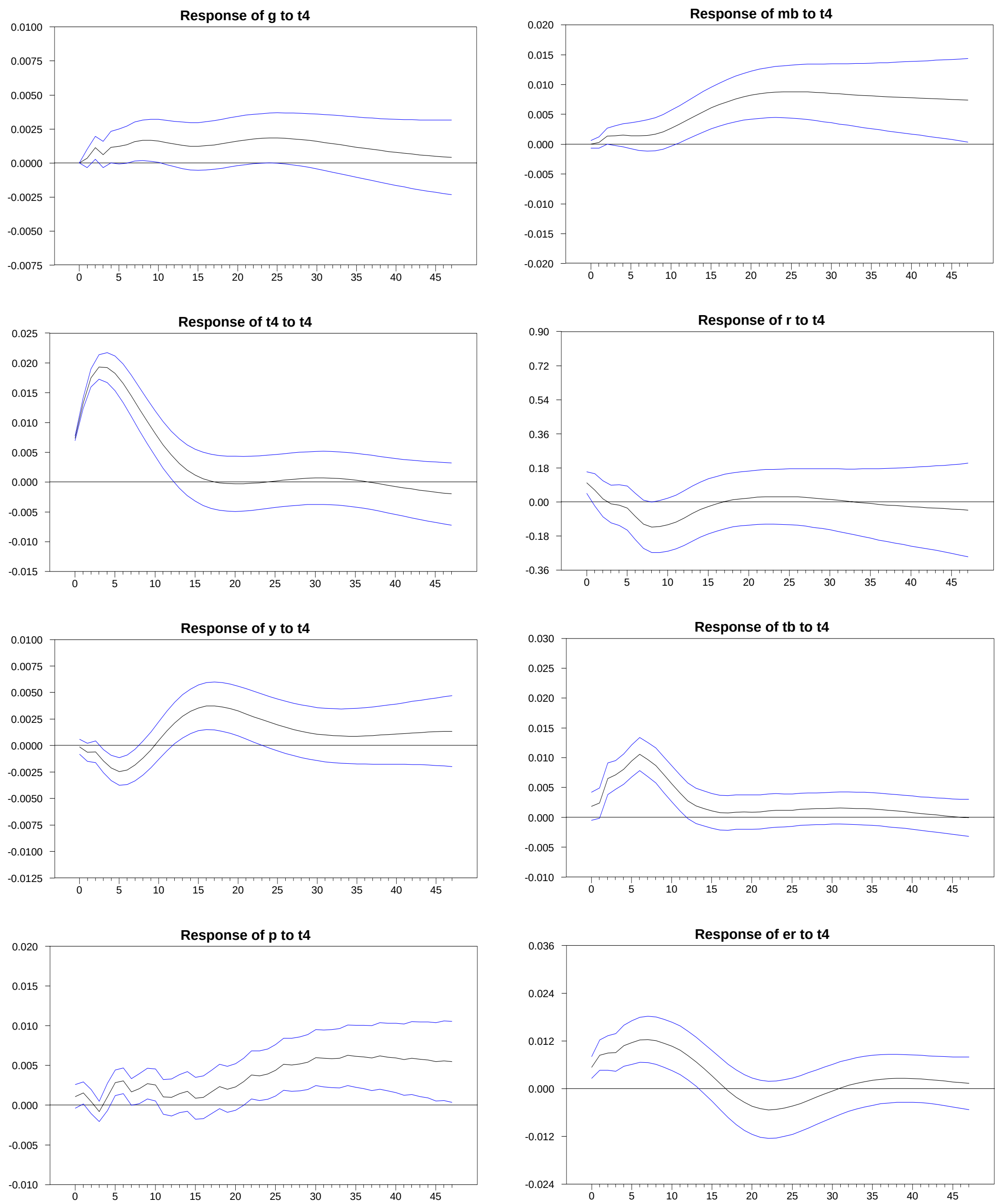
(APPENDIX E continued)

Panel C. Shock of T3: g, T3, y, p, mb, r, tb, er



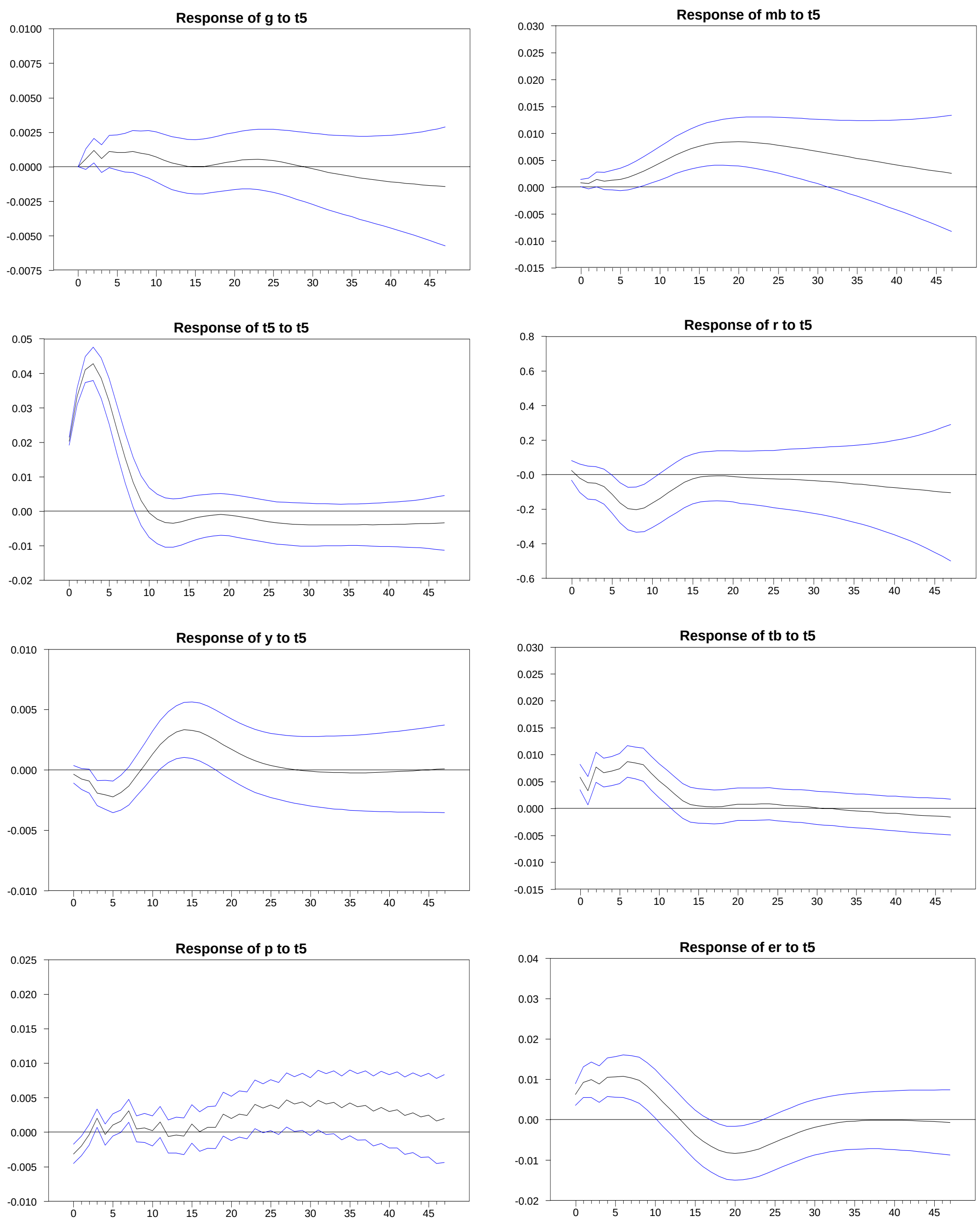
(APPENDIX E continued)

Panel D. Shock of T4: g, T4, y, p, mb, r, tb, er



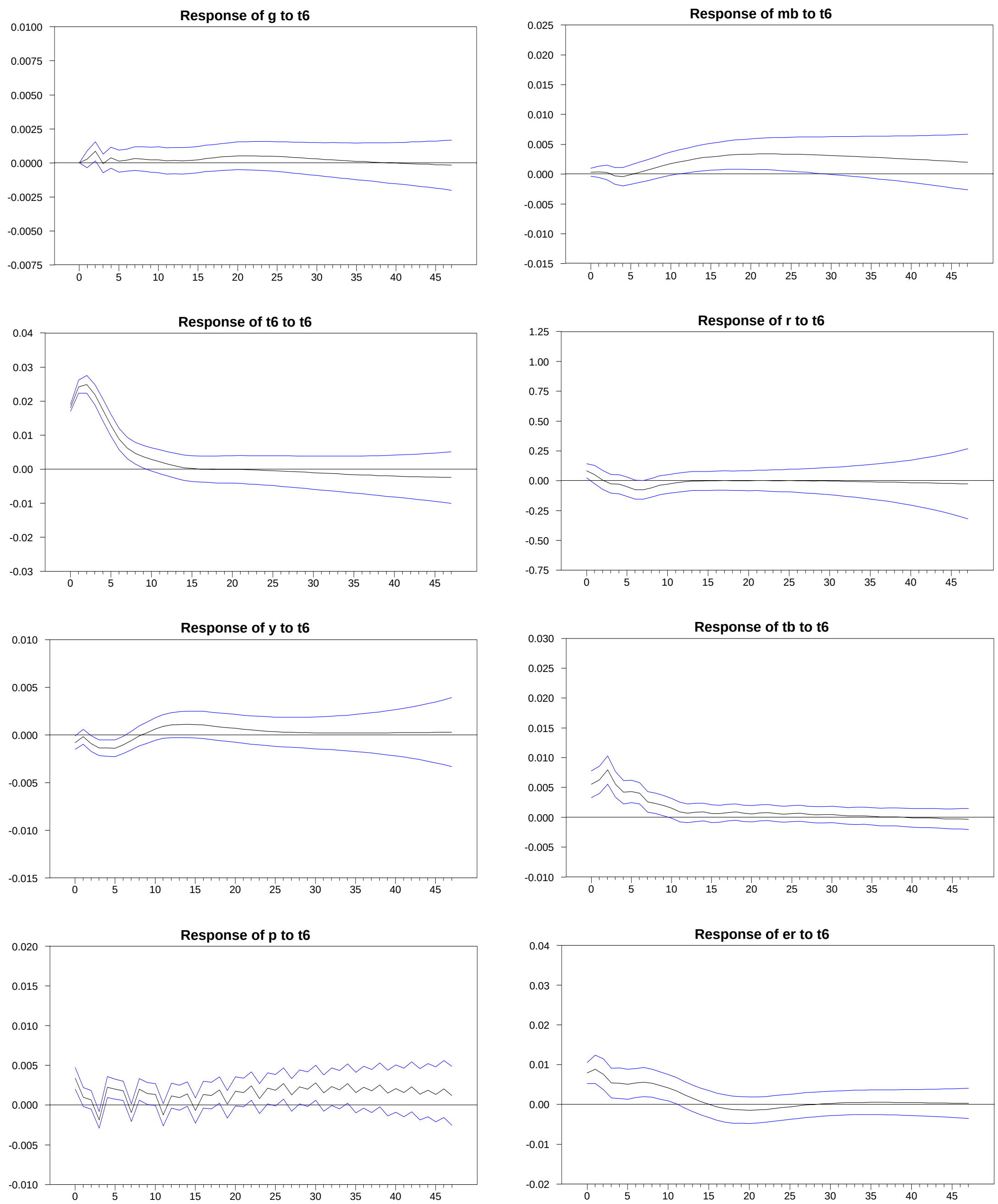
(APPENDIX E continued)

Pane E. Shock of T5: g, T5, y, p, mb, r, tb, er



(APPENDIX E continued)

Panel F. Shock of T6: g, T6, y, p, mb, r, tb, er



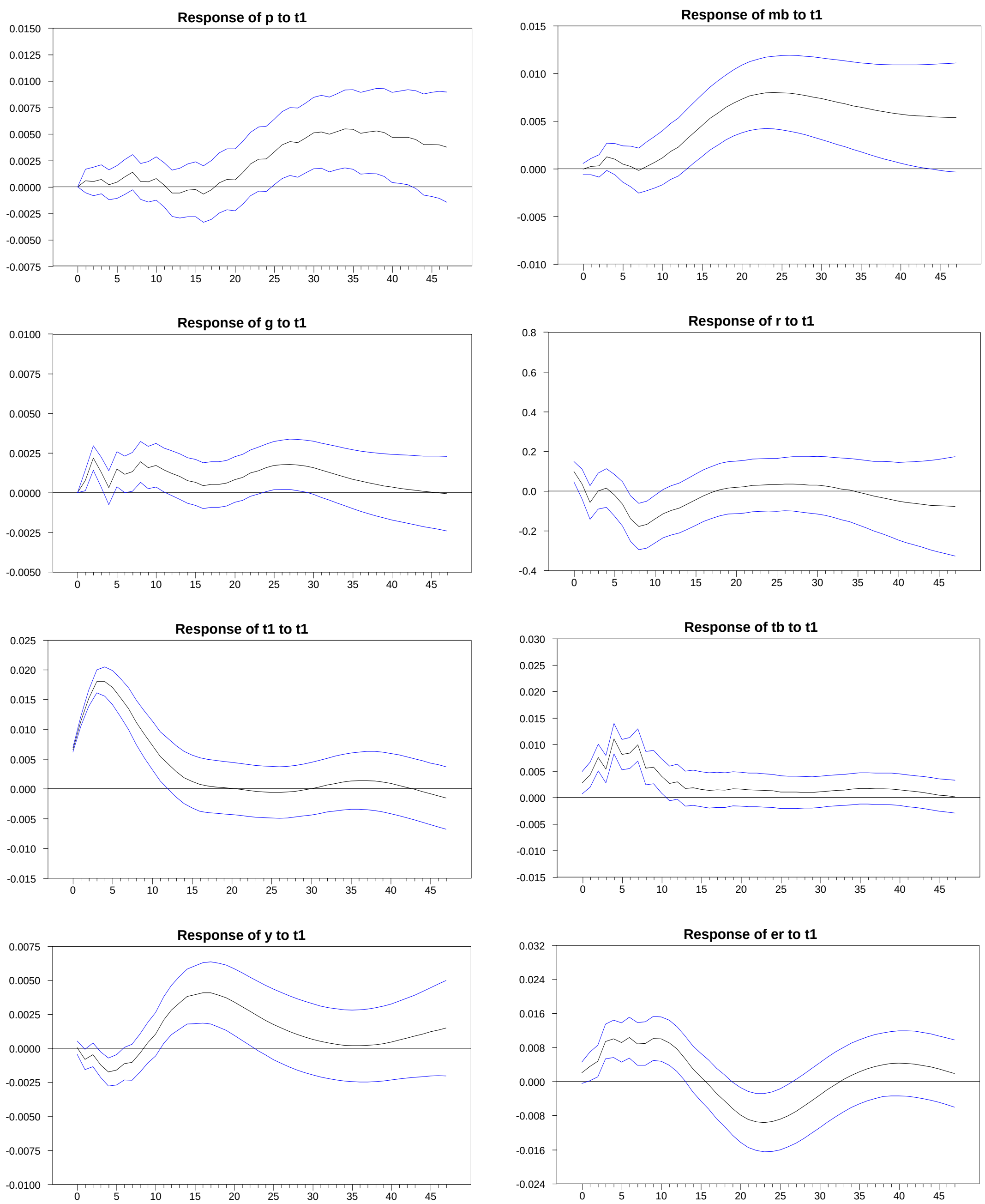
APPENDIX F. THE EFFECTS OF AMTR SHOCKS WHEN P IS ORDERED FIRST AND THE LAG LENGTH IS 6

Impulse response functions of the real government expenditures (g), the real gross domestic product (y), the price level (p), the monetary base (mb), the interest rate (r), the trade balance (tb), and the exchange rate pounds per U.S. dollar (er) to a one standard deviation shock to each of the average marginal tax rate (t) measures are presented. The Wold causal ordering is as follows: p, g, t, y, mb, r, tb, and er. The appropriate lag length for the estimations has been determined as 6 using the AIC.

Tax	p	g	t	Y	mb	r	Tb	er
T1	increase	increase	increase	decrease increase	increase	increase decrease	Increase	increase decrease
T2	increase	increase	increase	decrease increase	increase	increase decrease	Increase	increase decrease
T3	increase	increase	increase	decrease increase	increase	increase	Increase	increase
T4	increase	increase	increase	decrease increase	increase	increase decrease	Increase	increase decrease
T5	increase	increase	increase	decrease increase	increase	increase decrease	Increase	increase decrease
T6	increase	increase	increase	decrease increase	increase	increase	Increase	increase

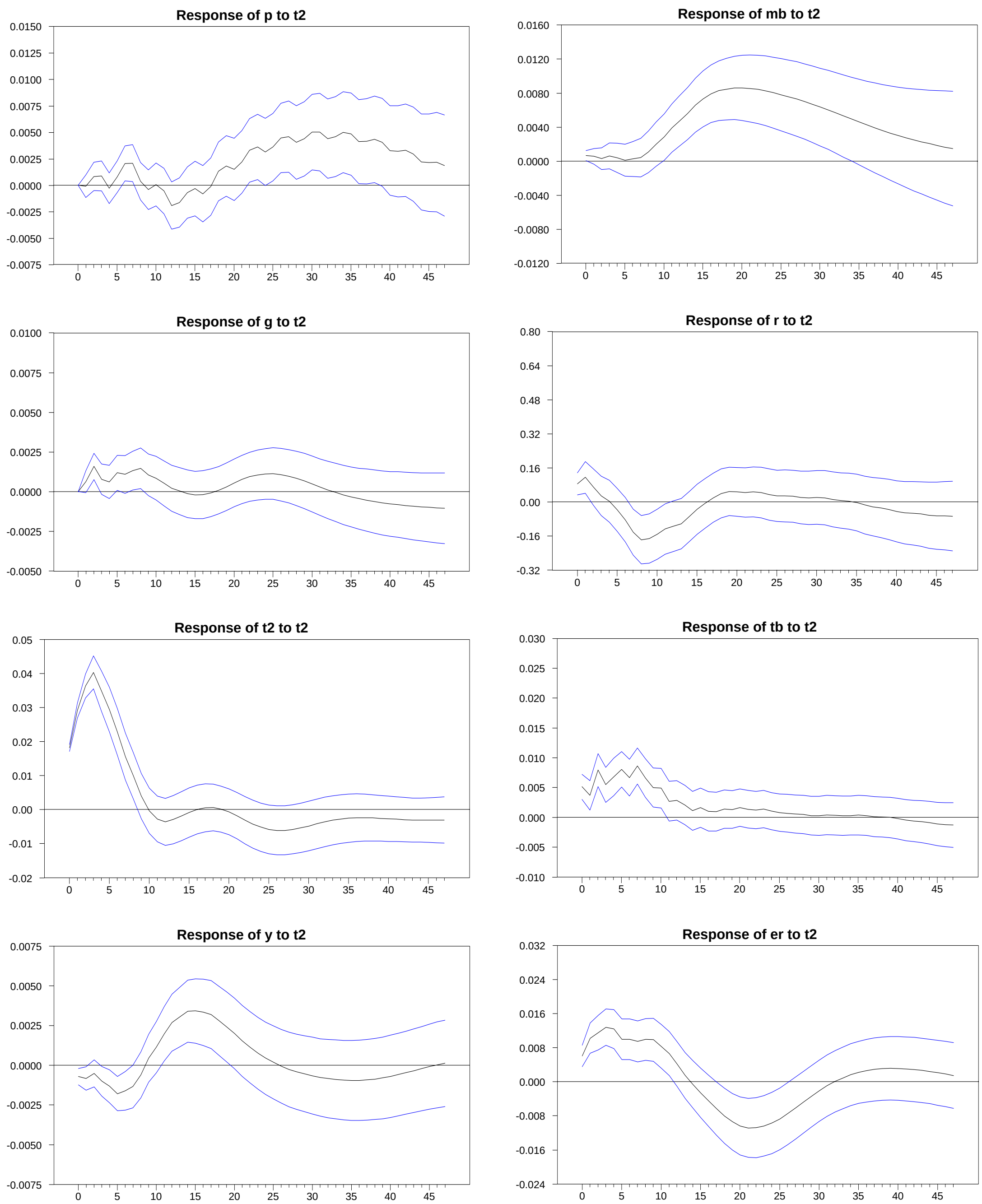
(APPENDIX F continued)

Panel A. Shock of T1: p, g, T1, y, mb, r, tb, er



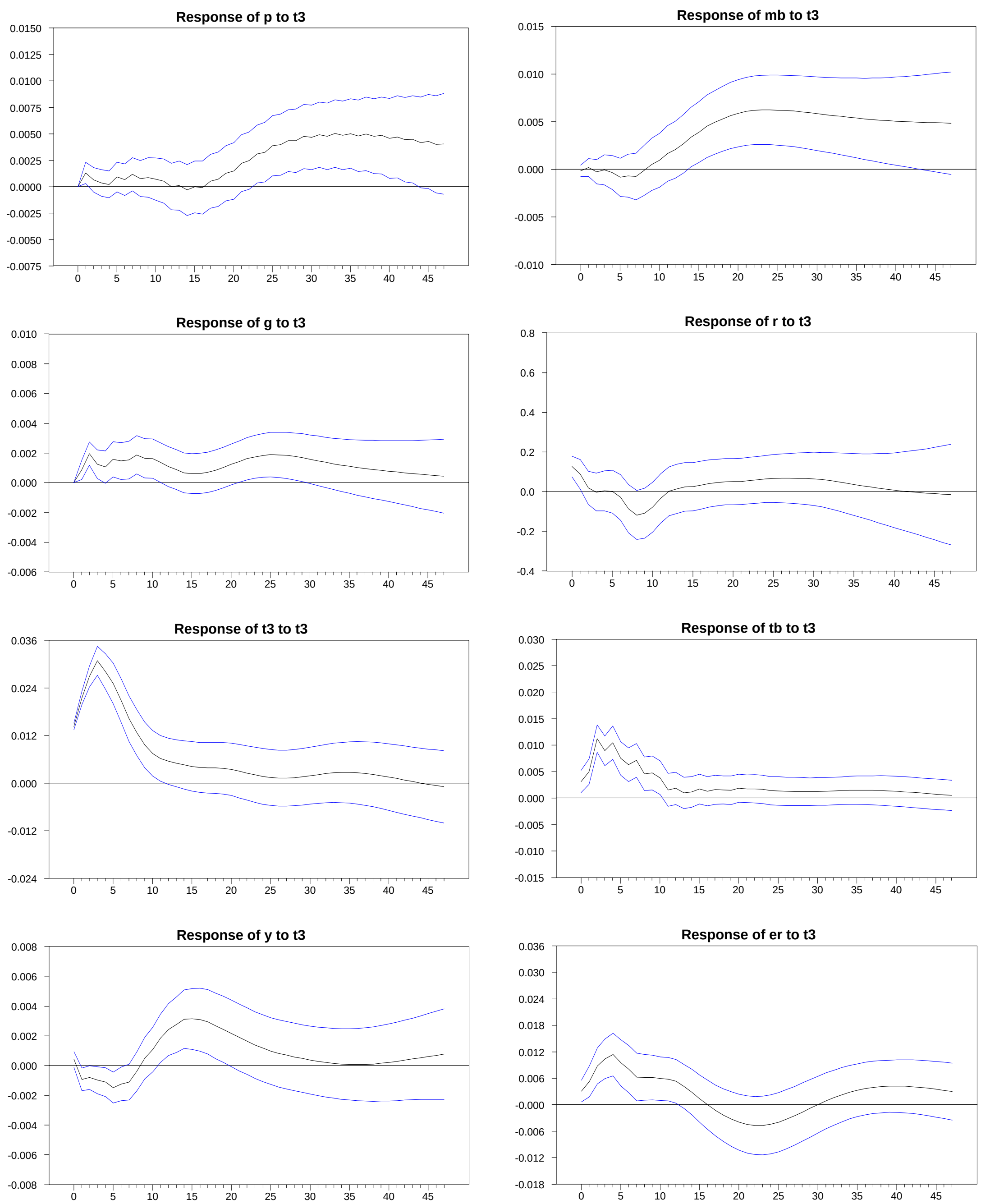
(APPENDIX F continued)

Panel B. Shock of T2: p, g, T2, y, mb, r, tb, er



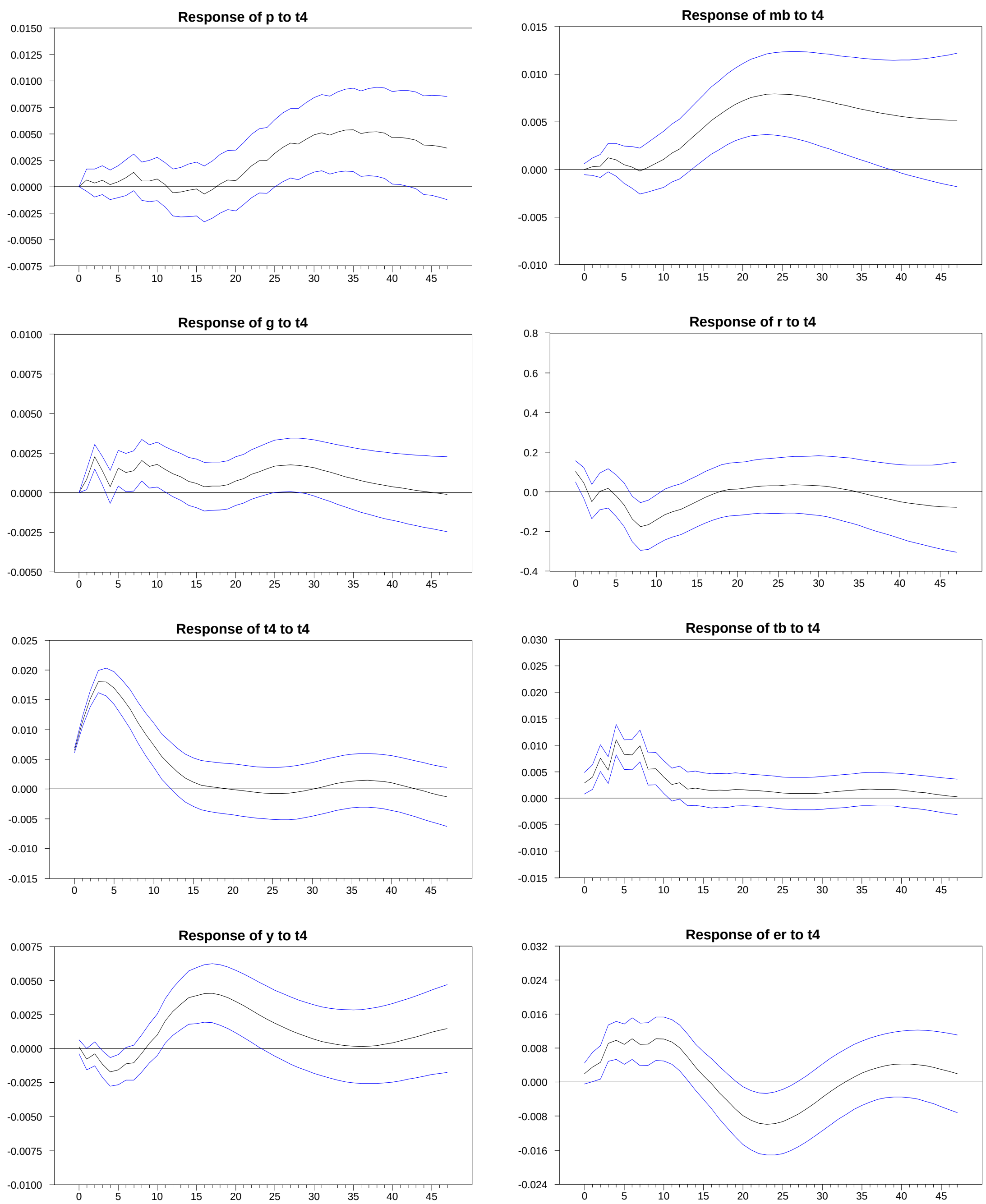
(APPENDIX F continued)

Panel C. Shock of T3: p, g, T3, y, mb, r, tb, er



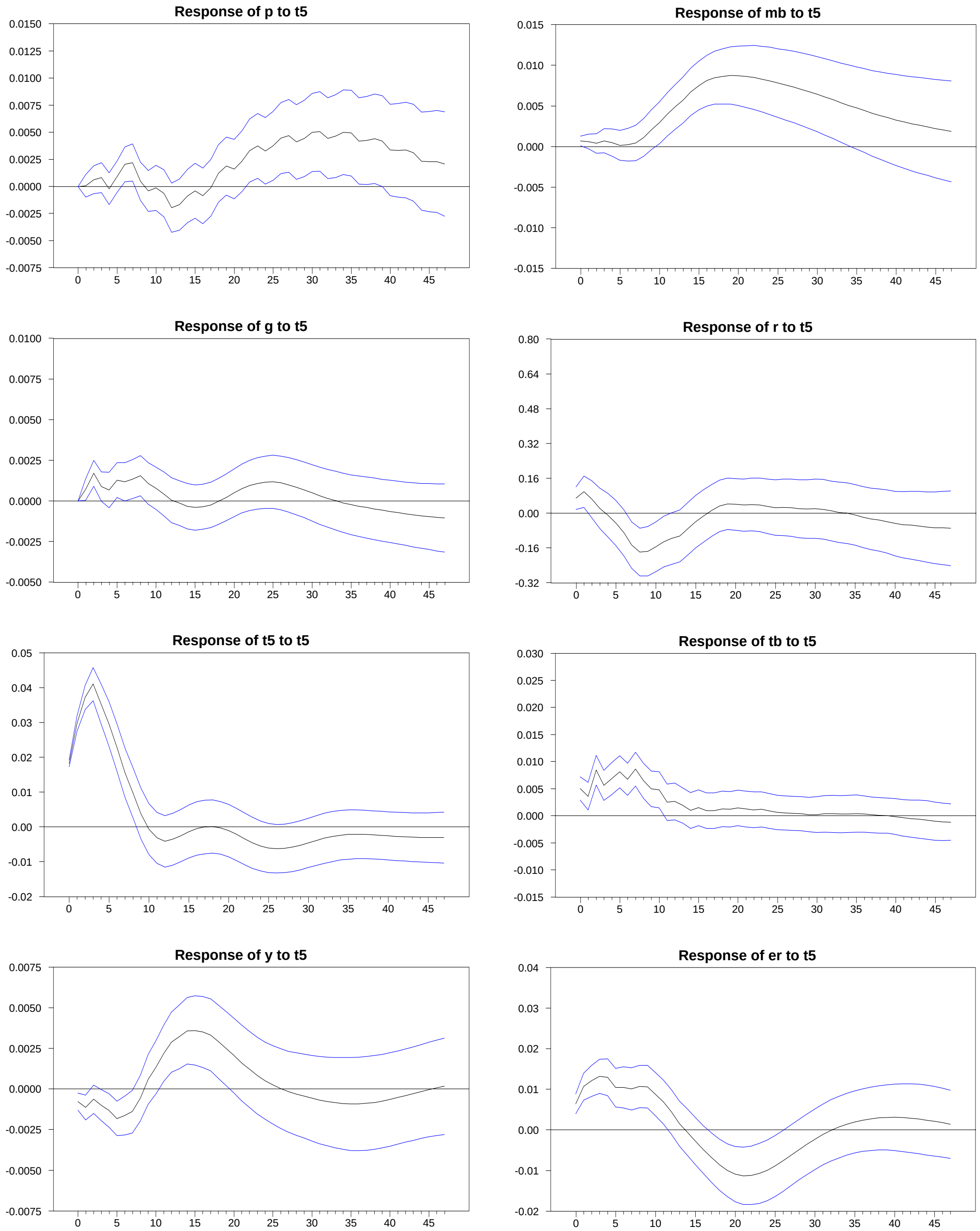
(APPENDIX F continued)

Panel D. Shock of T4: p, g, T4, y, mb, r, tb, er



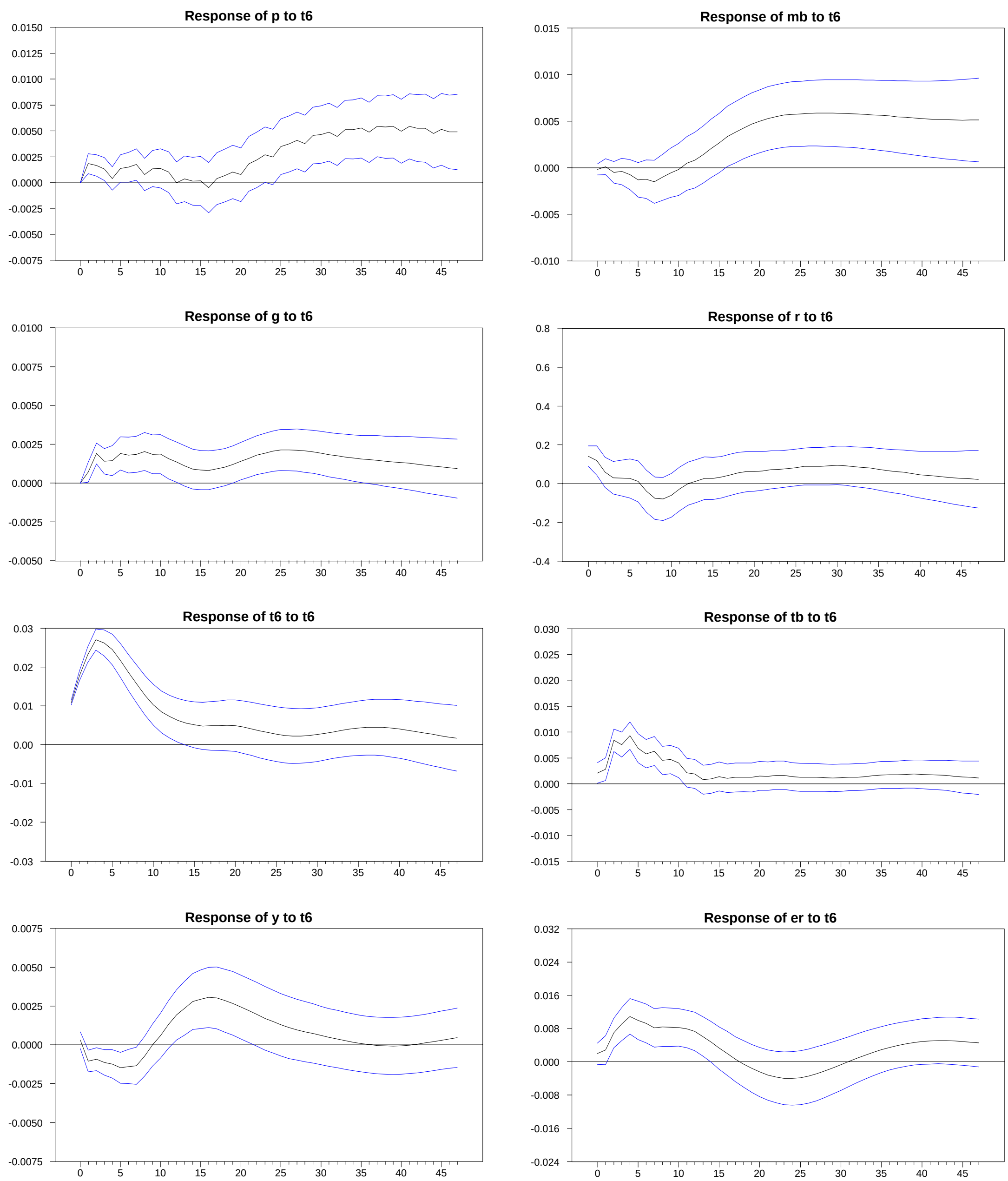
(APPENDIX F continued)

Panel E. Shock of T5: p, g, T5, y, mb, r, tb, er



(APPENDIX F continued)

Panel F. Shock of T6: p, g, T6, y, mb, r, tb, er



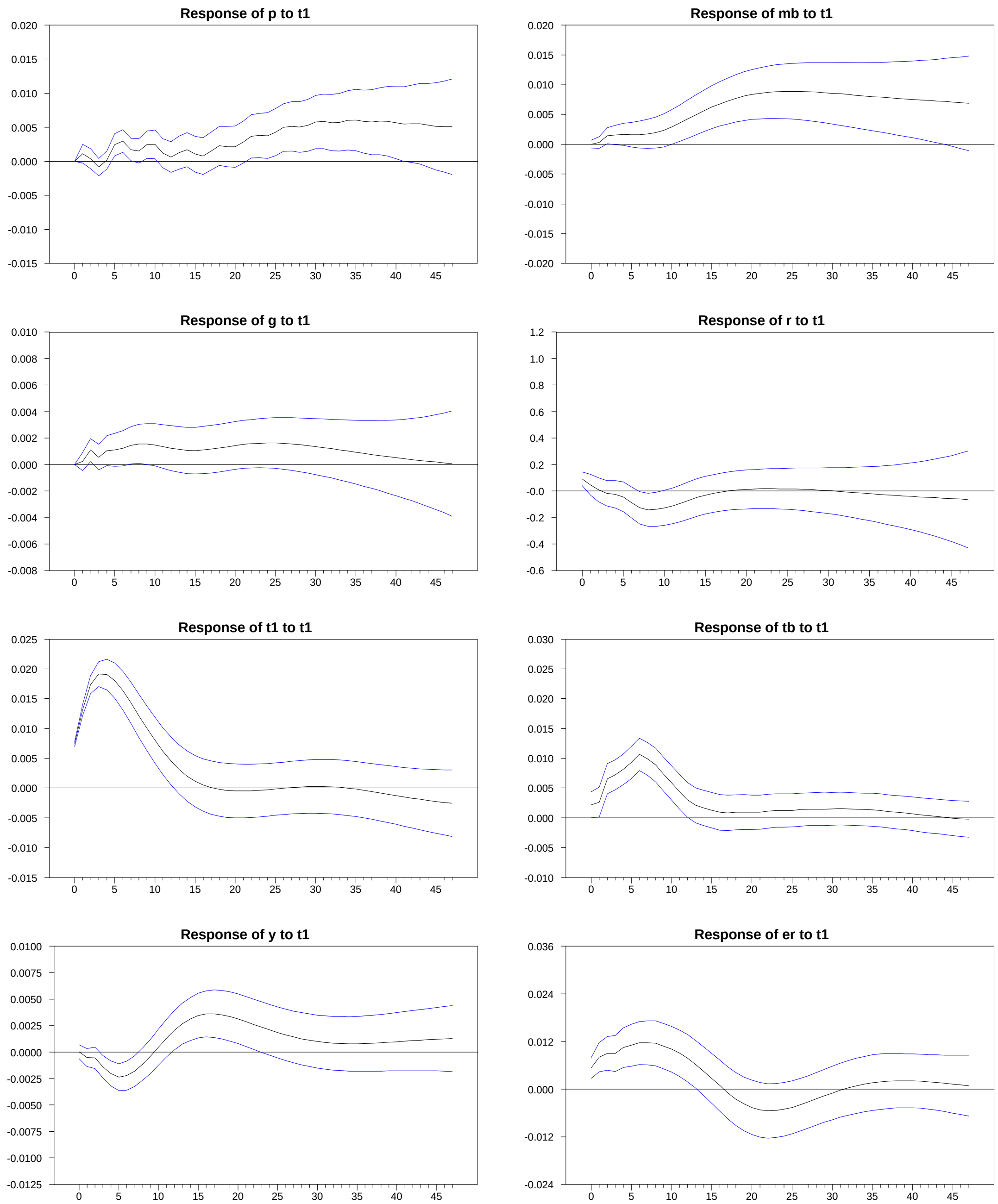
APPENDIX G. THE EFFECTS OF AMTR SHOCKS WHEN P IS ORDERED FIRST AND THE LAG LENGTH IS 4

Impulse response functions of the real government expenditures (g), the real gross domestic product (y), the price level (p), the monetary base (mb), the interest rate (r), the trade balance (tb), and the exchange rate pounds per U.S. dollar (er) to a one standard deviation shock to each of the average marginal tax rate (t) measures are presented. The Wold causal ordering is as follows: p, g, t, y, mb, r, tb, and er. The appropriate lag length for the estimations has been chosen as 4.

Tax	p	g	t	Y	mb	r	tb	er
T1	increase	increase	increase	decrease increase	increase	increase decrease	increase	increase
T2	increase	increase	increase	decrease increase	increase	decrease	increase	increase decrease
T3	decrease increase	increase	increase	decrease	increase	decrease	increase	increase
T4	increase	increase	increase	decrease increase	increase	increase decrease	increase	increase
T5	increase	increase	increase	decrease increase	increase	decrease	increase	increase decrease
T6	decrease increase	increase	increase	decrease	increase	decrease	increase	increase

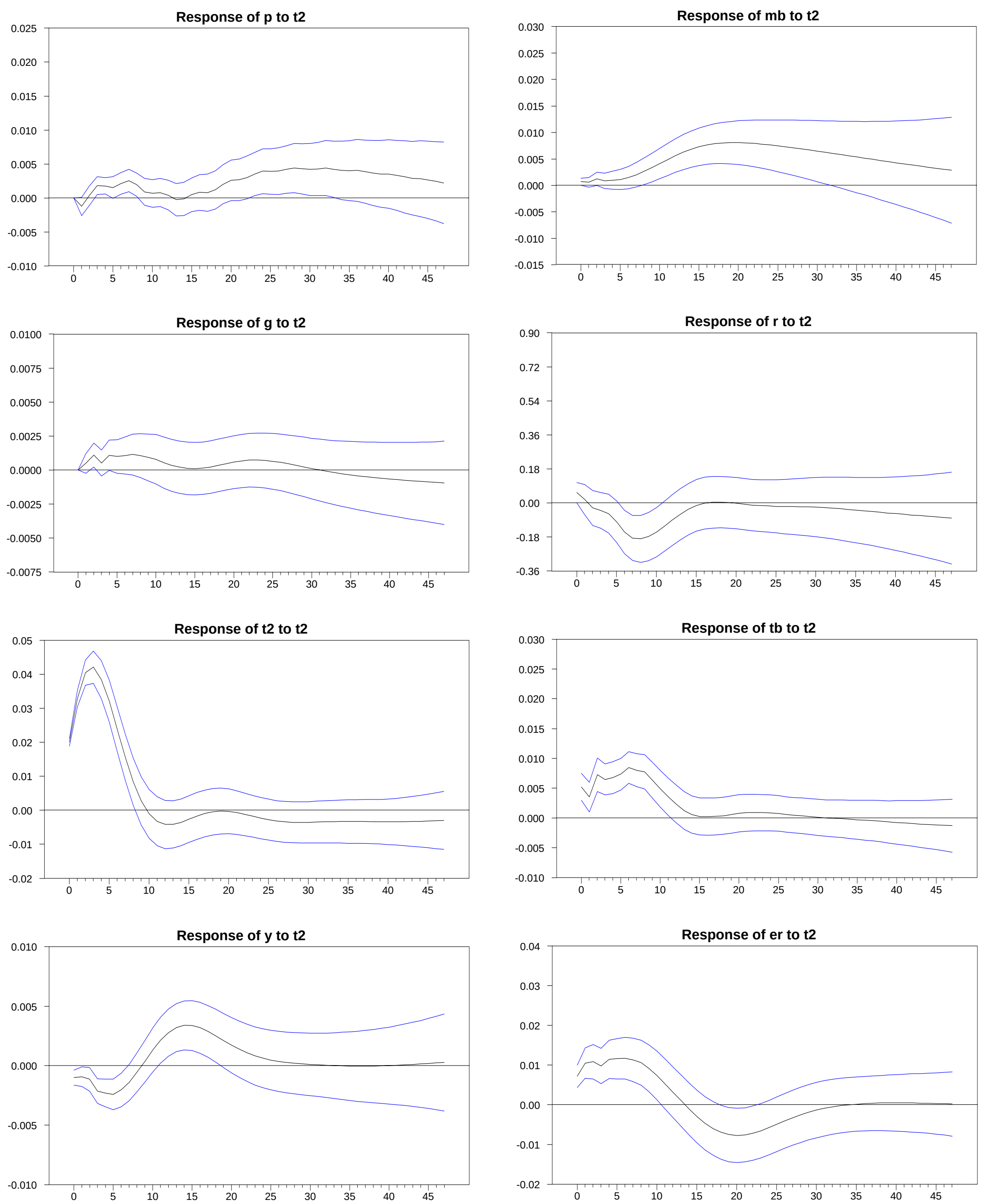
(APPENDIX G continued)

Panel A. Shock of T1: p, g, T, y, mb, r, tb, er



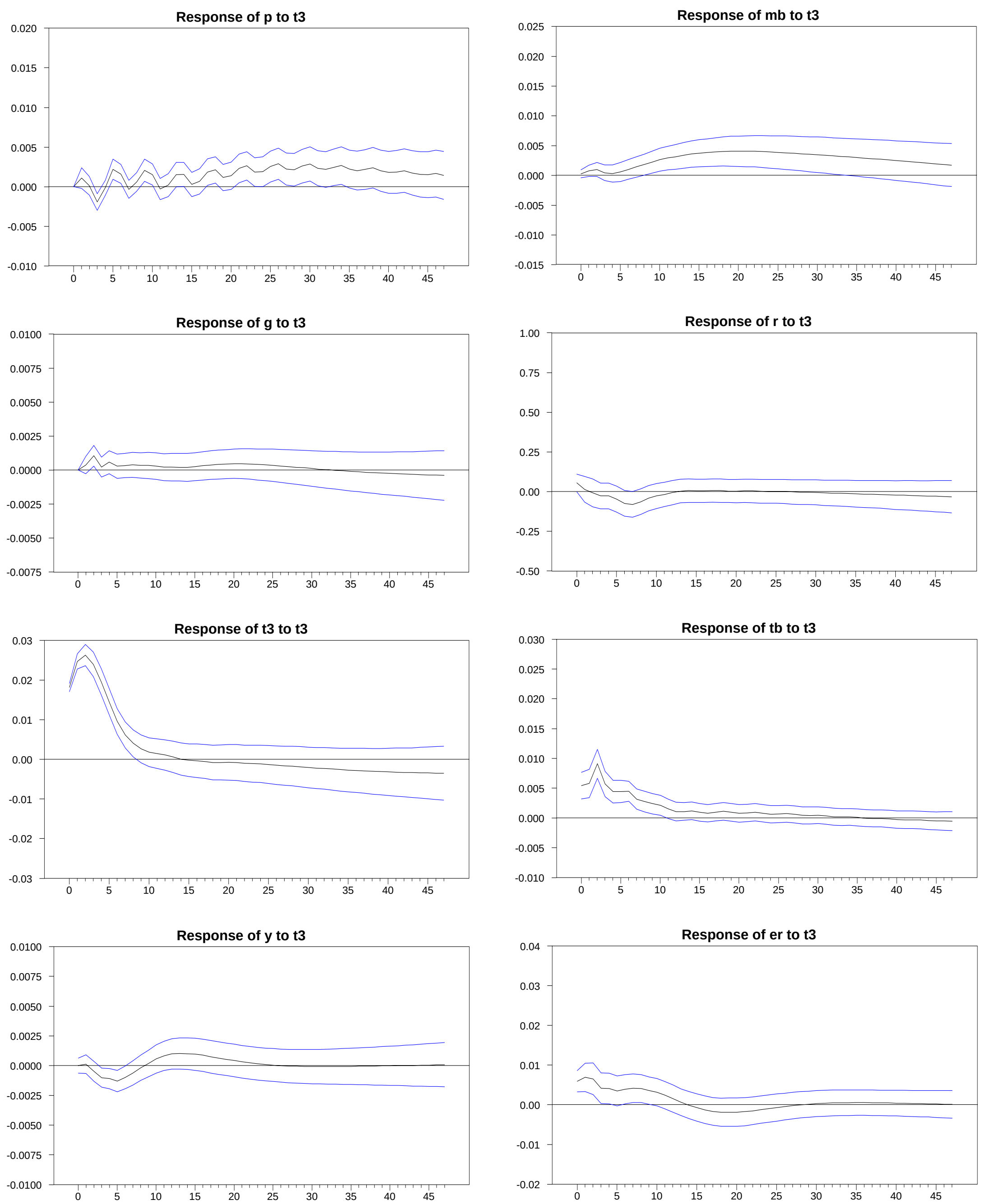
(APPENDIX G continued)

Panel B. Shock of T2: p, g, T2, y, mb, r, tb, er



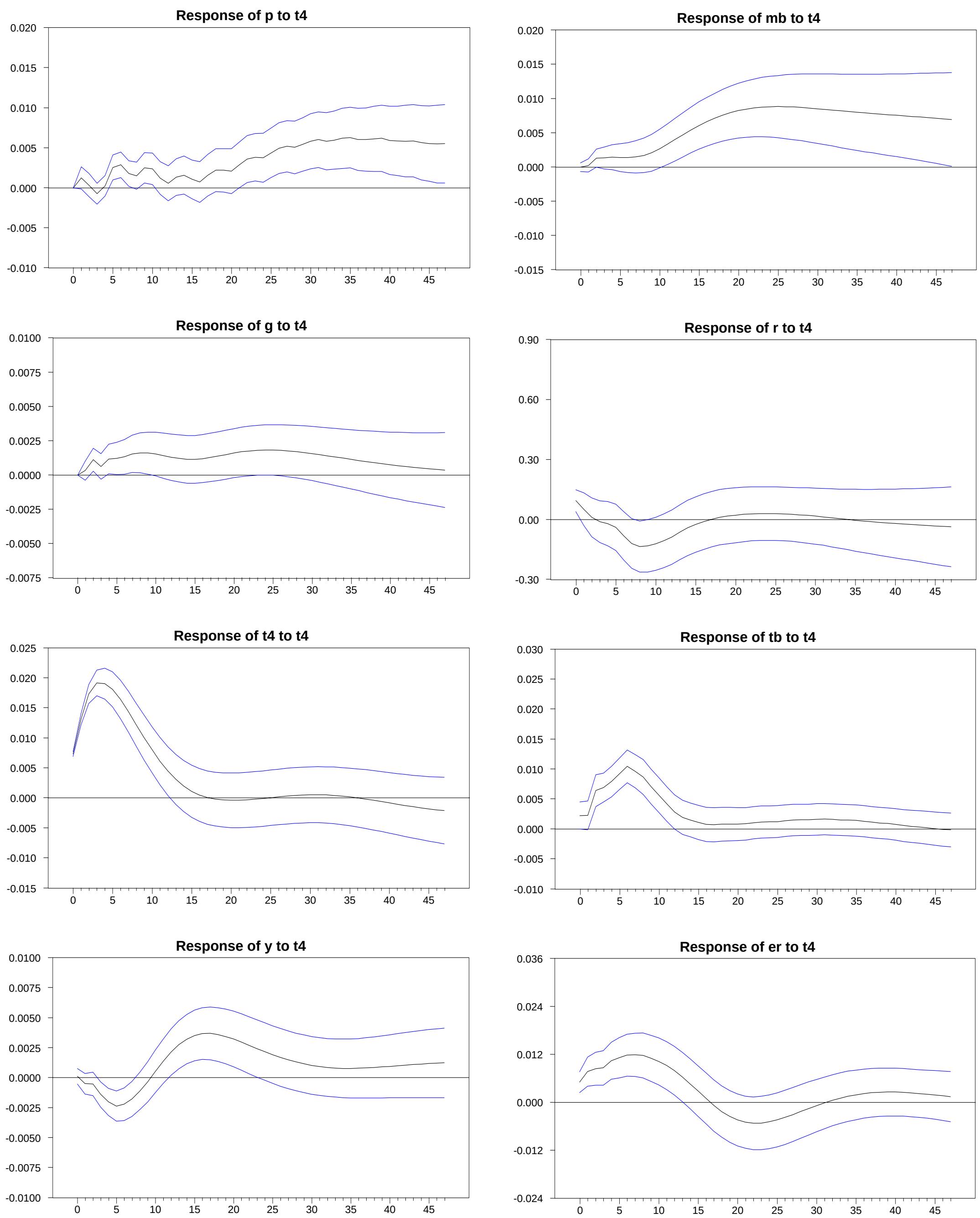
(APPENDIX G continued)

Panel C. Shock of T3: p, g,T3, y, mb, r, tb, er



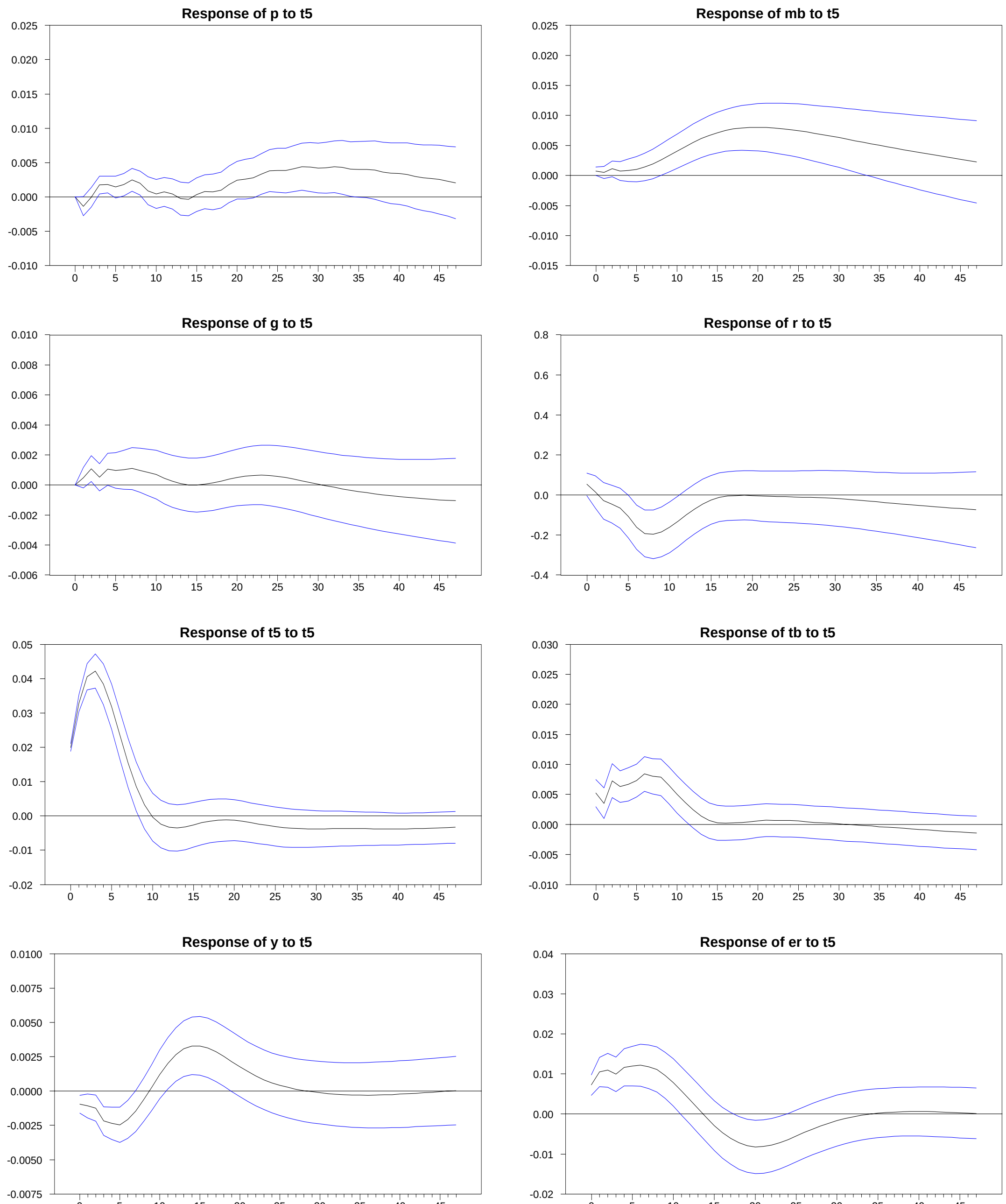
(APPENDIX G continued)

Panel D. Shock of T4: p, g, T4, y, mb, r, tb, er



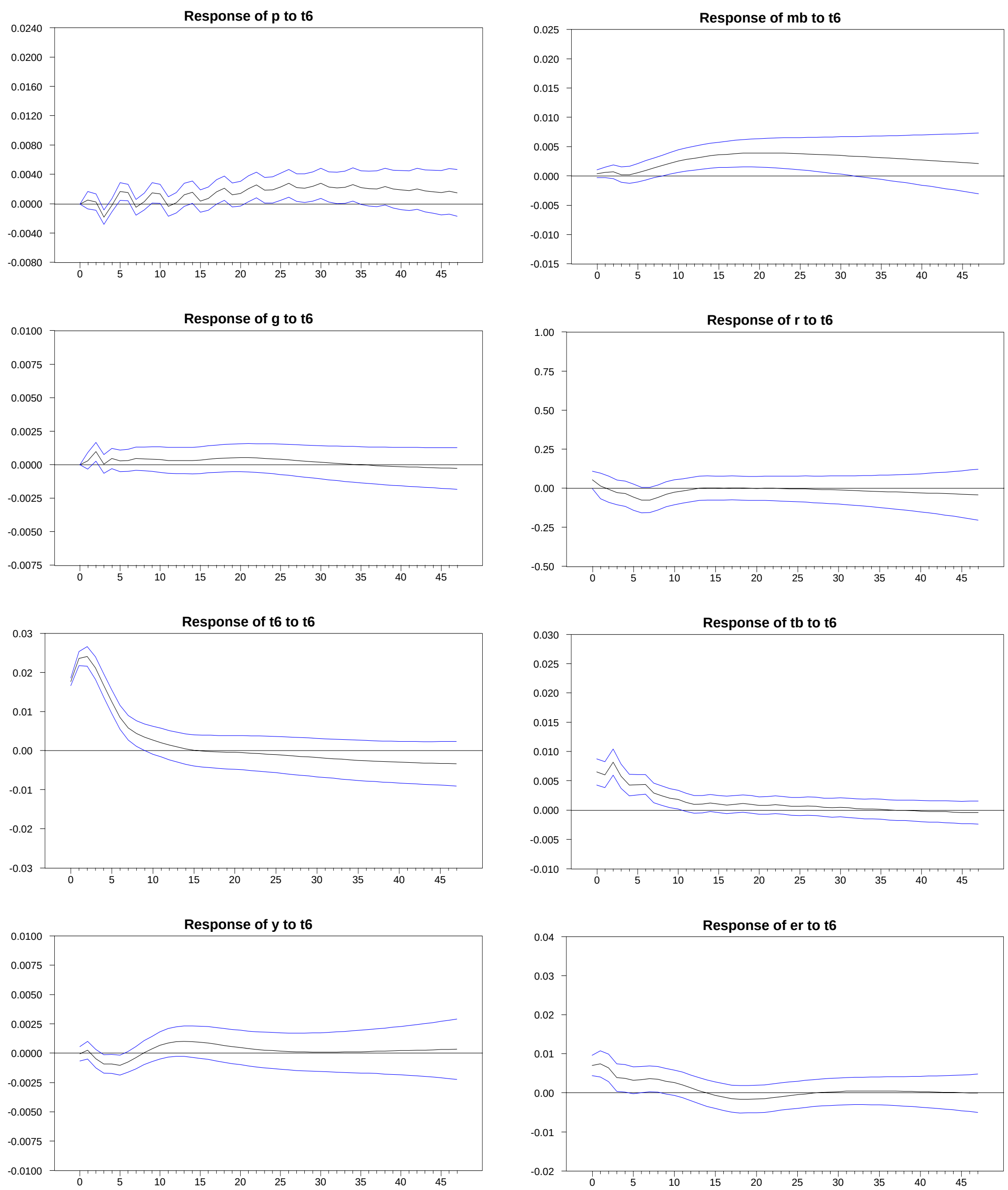
(APPENDIX G continued)

Panel E. Shock of T5: p, g, T5, y, mb, r, tb, er



(APPENDIX G continued)

Panel F. Shock of T6: p, g, T6, y, mb, r, tb, er



APPENDIX H. THE EFFECTS OF ATR SHOCKS ON VAR (LAG LENGTH = 6)

Panel A and B. The Effects of ATR Shocks When ATR is Ordered First and the Lag Length is 6

Impulse response functions of the real government expenditures (g), the real gross domestic product (y), the price level (p), the monetary base (mb), the interest rate (r), the trade balance (tb), and the exchange rate pounds per U.S. dollar (er) to a one standard deviation shock to each of the ATR measures are presented. The Wold causal ordering is as follows: ATR, g, y, p, mb, r, tb, and er. The appropriate lag length for the estimations has been determined as 6 using the AIC.

Tax	ATR	g	y	p	mb	r	tb	er
ATR1	increase	increase	increase	increase	increase	decrease	increase	increase decrease
ATR2	increase	increase	decrease increase	increase	increase	increase	increase	increase

Panel C and D. The Effects of ATR Shocks When g is Ordered First and the Lag Length is 6

The Wold causal ordering is as follows: g, ATR, y, p, mb, r, tb, and er. The appropriate lag length for the estimations has been determined as 6 using the AIC.

Tax	G	ATR	y	p	mb	r	tb	er
ATR1	increase	increase	increase	increase	increase	decrease	increase	increase decrease
ATR2	increase	increase	decrease increase	increase	increase	decrease	increase	increase

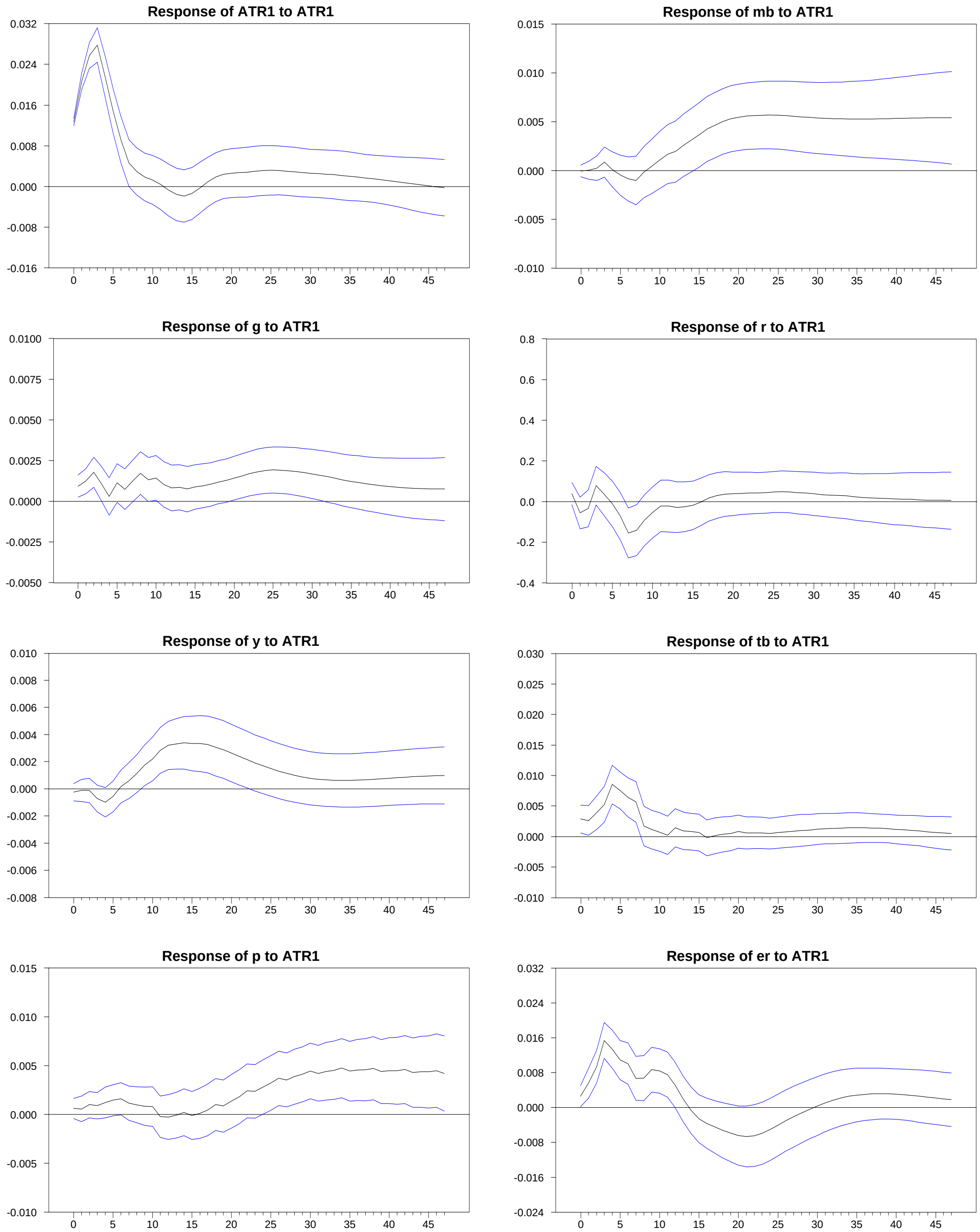
Panel C and D. The Effects of ATR Shocks When g is Ordered First and the Lag Length is 6

The Wold causal ordering is as follows: p, g, ATR, y, mb, r, tb, and er. The appropriate lag length for the estimations has been determined as 6 using the AIC.

Tax	P	g	ATR	y	mb	r	tb	er
ATR1	increase	increase	increase	decrease increase	increase	decrease	increase	increase decrease
ATR2	increase	increase	increase	increase	increase	decrease	increase	increase

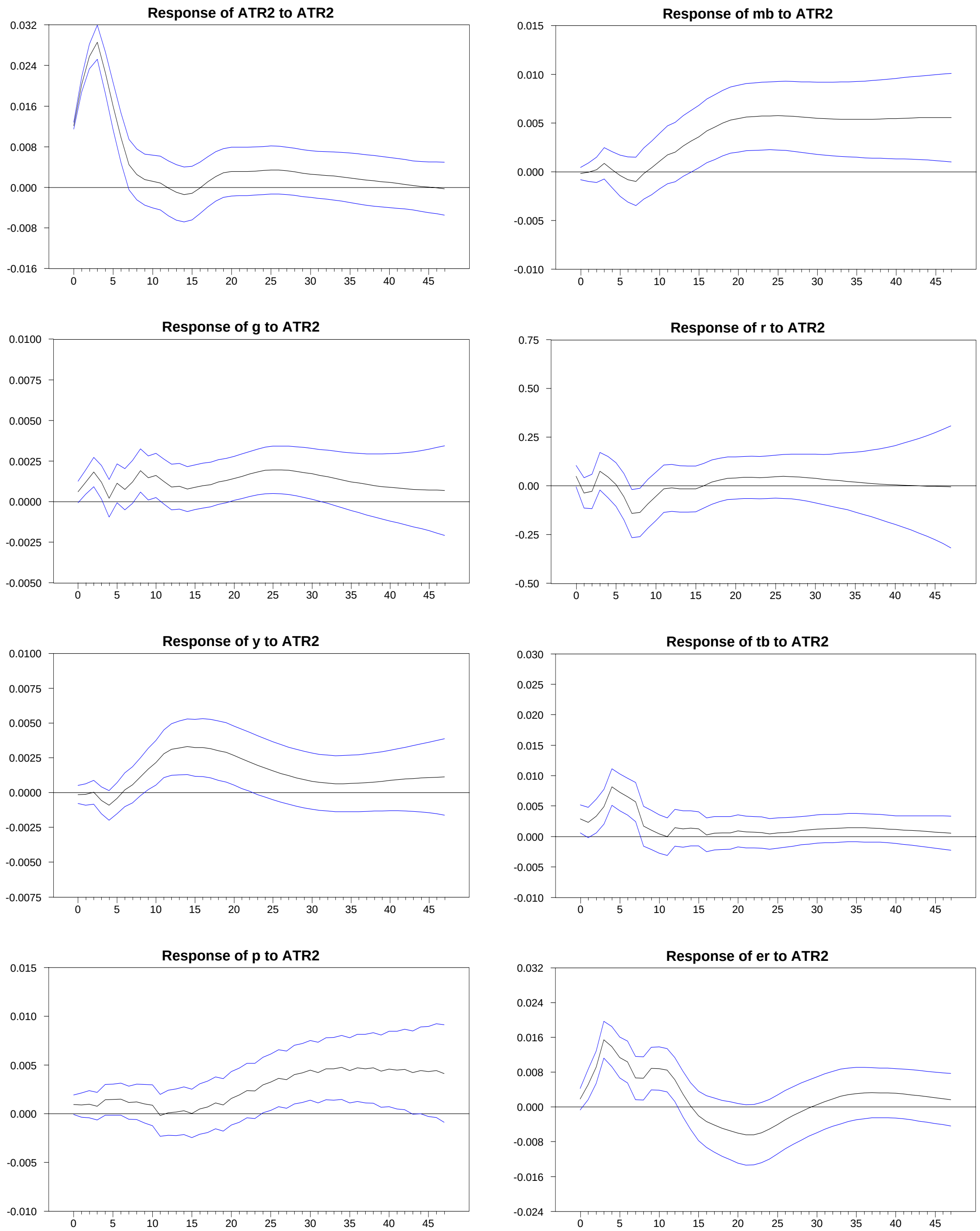
(APPENDIX H continued)

Panel A. Shock of ATR1: ATR1, g, y, p, mb, r, tb, er



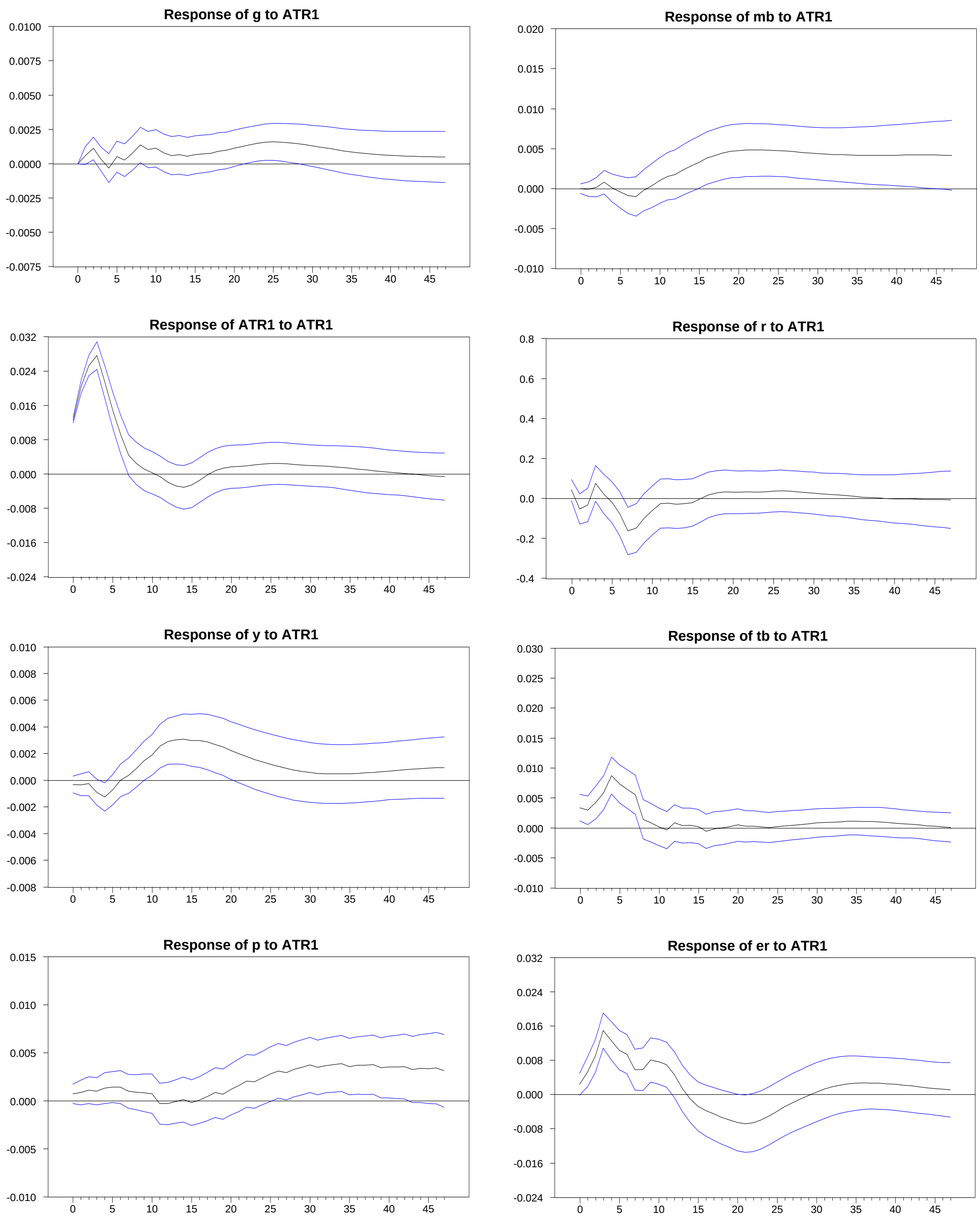
(APPENDIX H continued)

Panel B. Shock of ATR2: ATR2, g, y, p, mb, r, tb, er



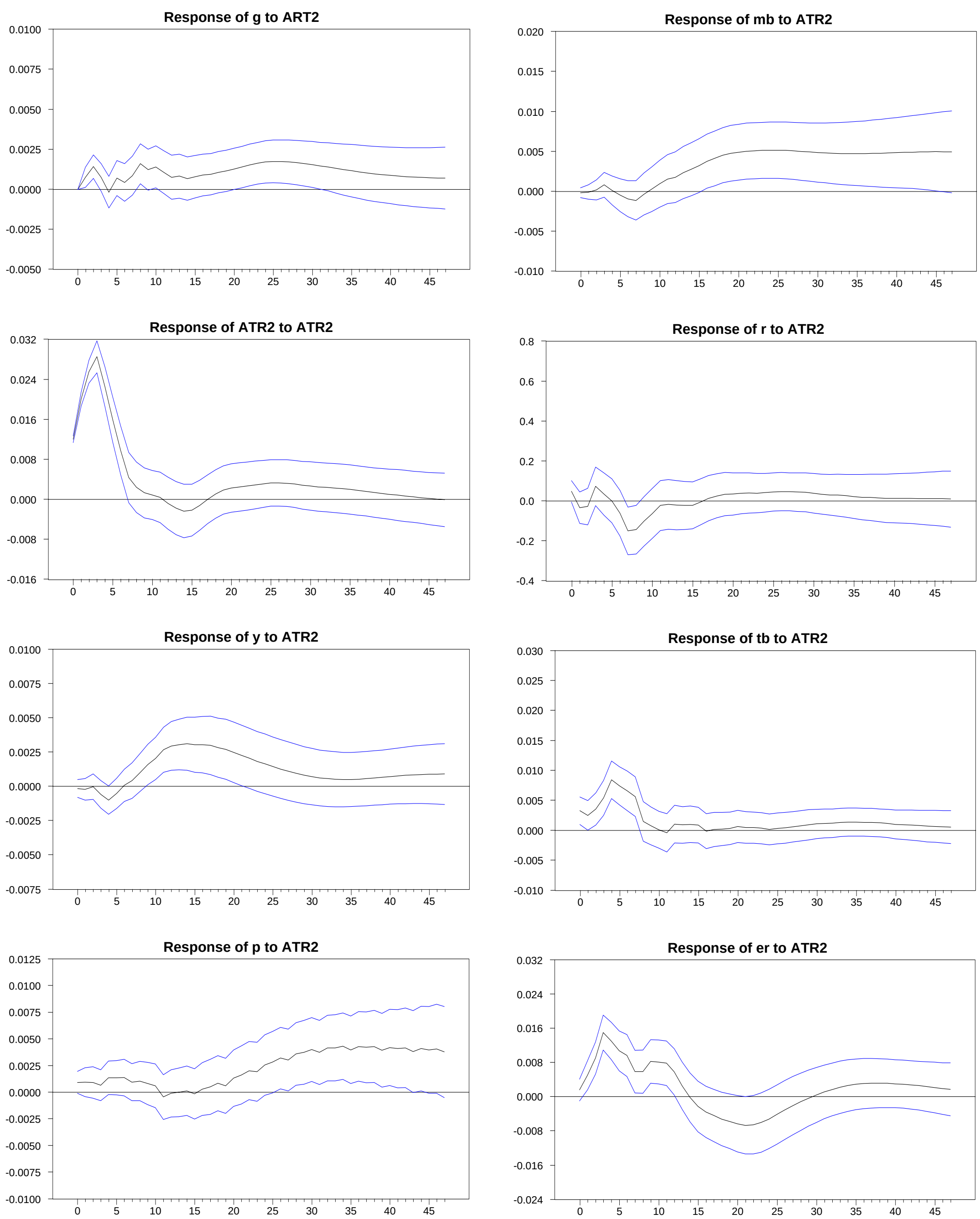
(APPENDIX H continued)

Panel C. Shock of ATR1: g, ATR1, y, p, mb, r, tb, er



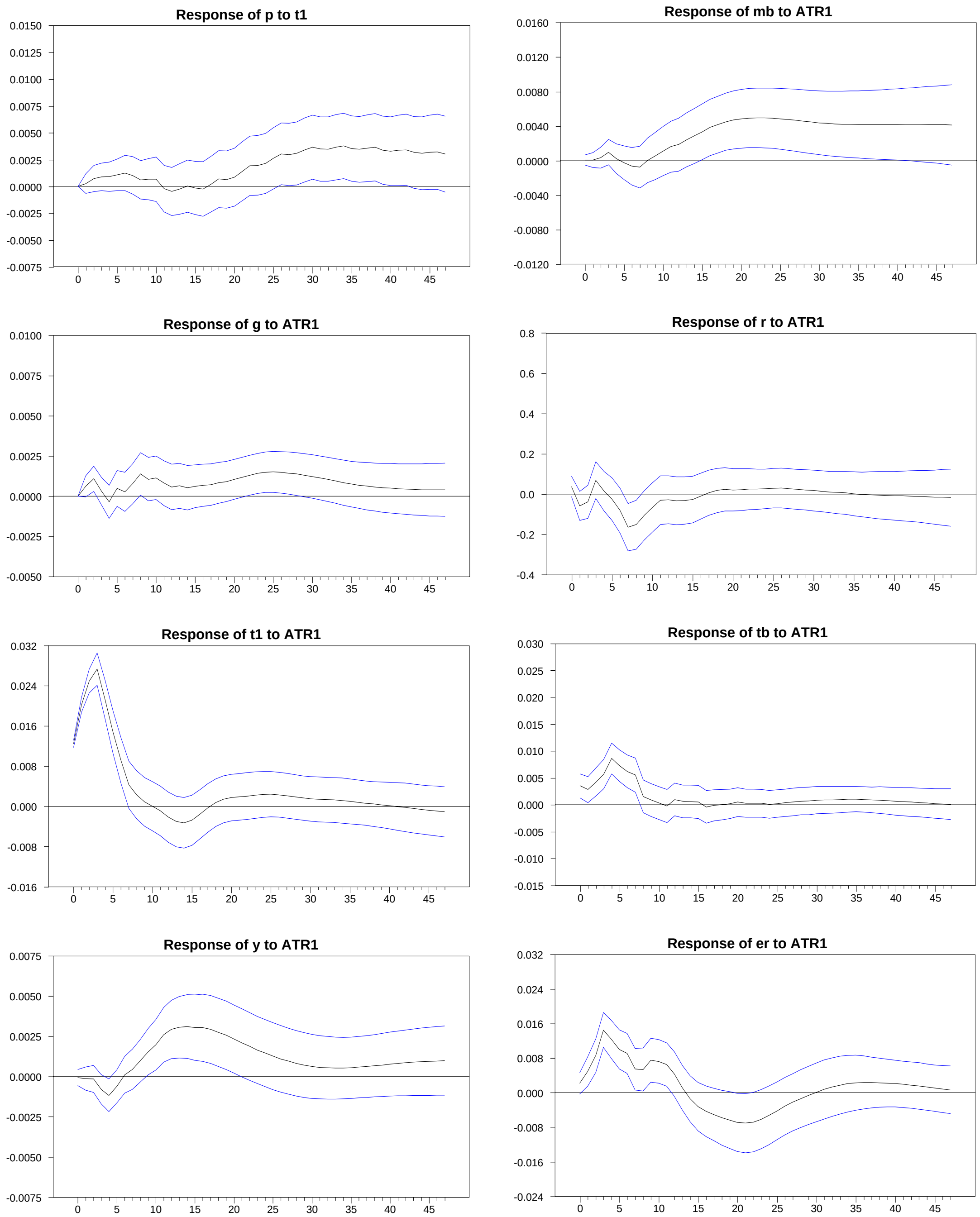
(APPENDIX H continued)

Panel D. Shock of ATR2: ATR2, g, y, p, mb, r, tb, er



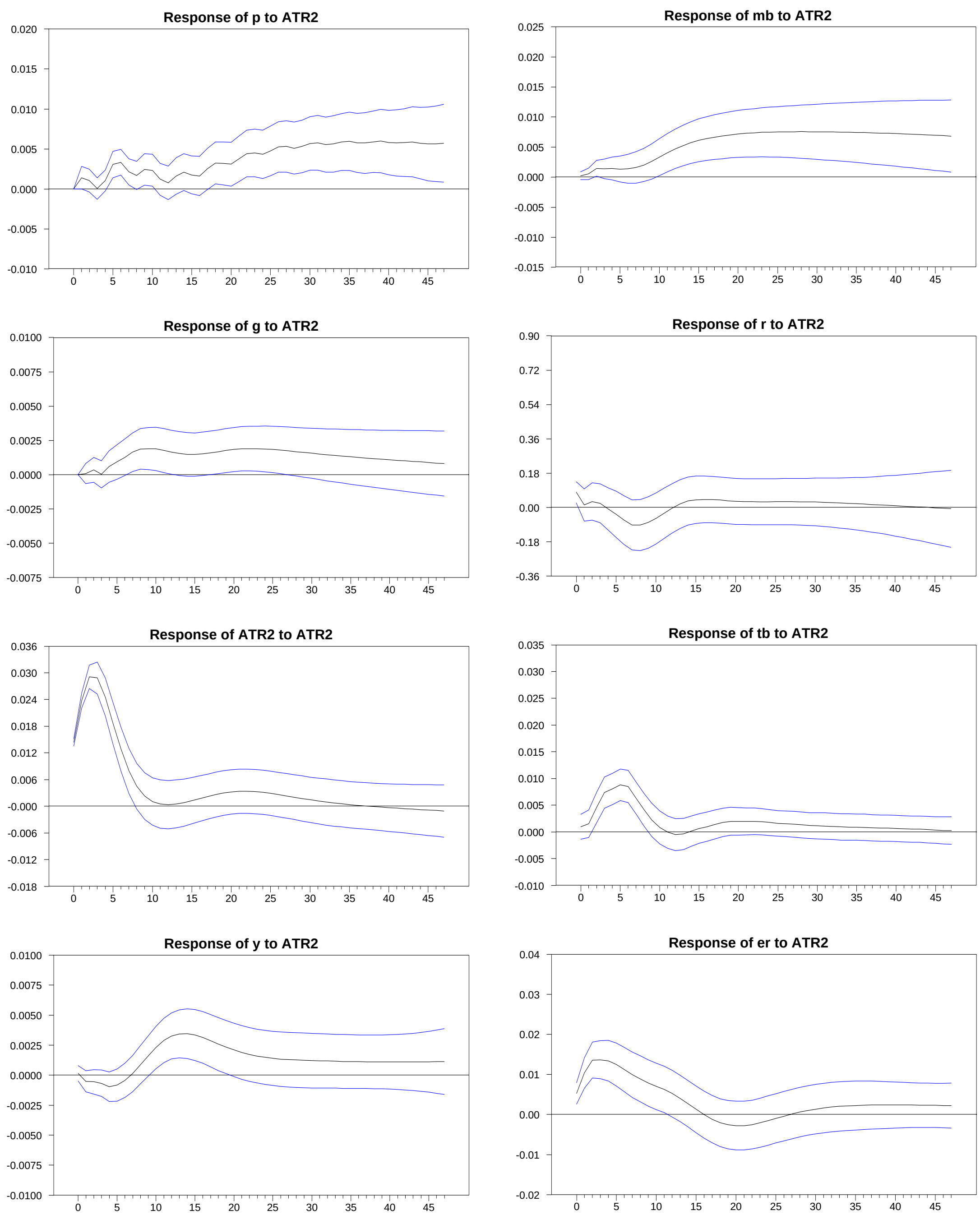
(APPENDIX H continued)

Panel E. Shock of ATR1: p, g, ATR1, y, mb, r, tb, er



(APPENDIX H continued)

Panel F. Shock of ATR2: p, g, ATR2, y, mb, r, tb, er



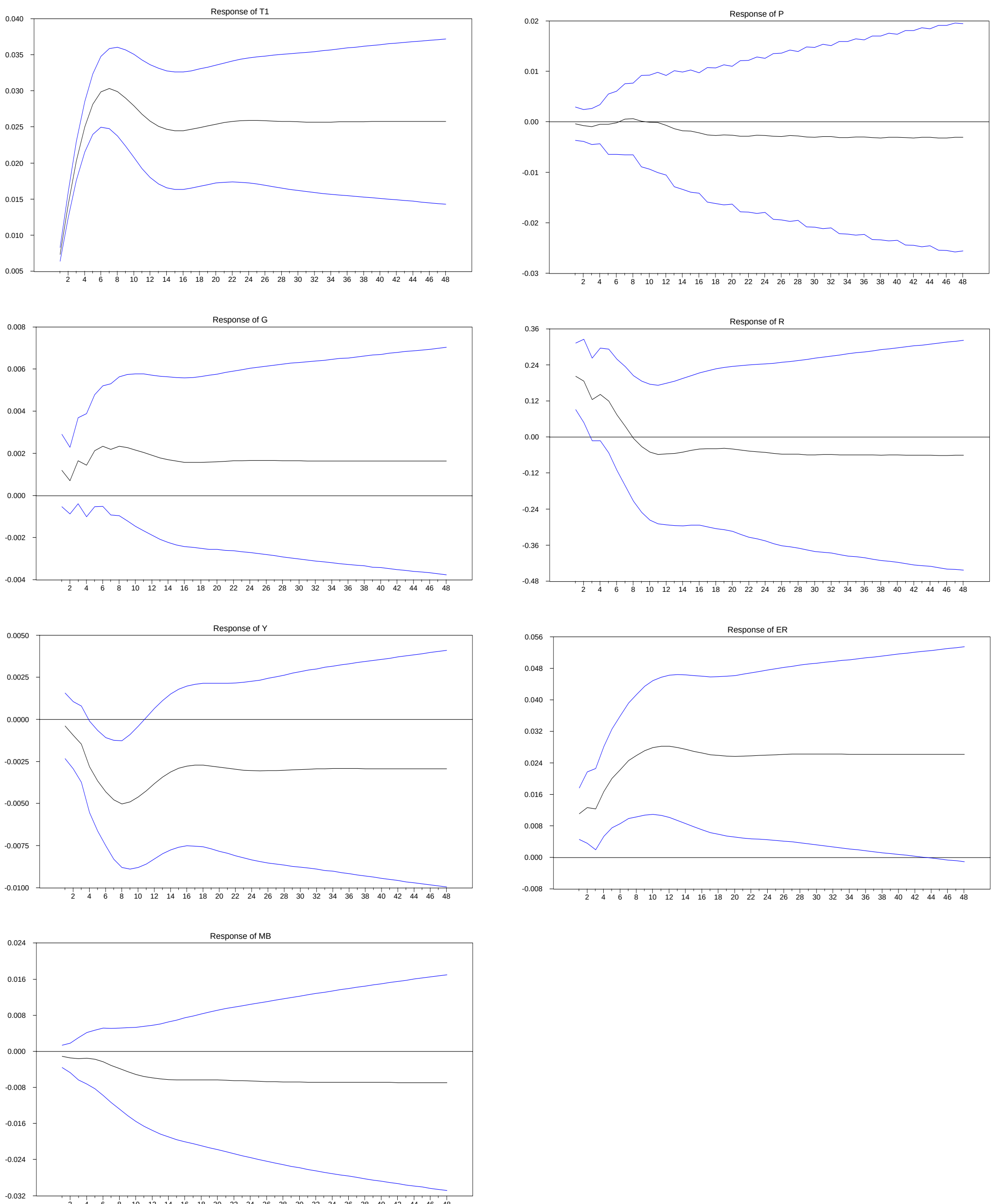
APPENDIX I. THE EFFECTS OF AMTR SHOCKS WHEN T IS ORDERED FIRST AND THE LAG LENGTH IS 4

Impulse response functions of the real government expenditures (G), the real gross domestic product (Y), the price level (P), the interest rate (R), the exchange rate (ER), and the monetary base (MB) to a one standard deviation shock to each of the average marginal tax rate (T) measures are presented. The appropriate lag length for the estimations has been determined as 4.

Tax	T	G	Y	MB	P	R	ER
T1	increase	not significant	decrease	not significant	not significant	increase	increase
T2	increase	not significant	decrease	not significant	decrease	increase	increase
T3	increase	increase	decrease	not significant	not significant	increase	increase
T4	increase	not significant	decrease	not significant	not significant	increase	increase
T5	increase	not significant	decrease	not significant	decrease	increase	increase
T6	increase	increase	decrease	not significant	not significant	increase	increase

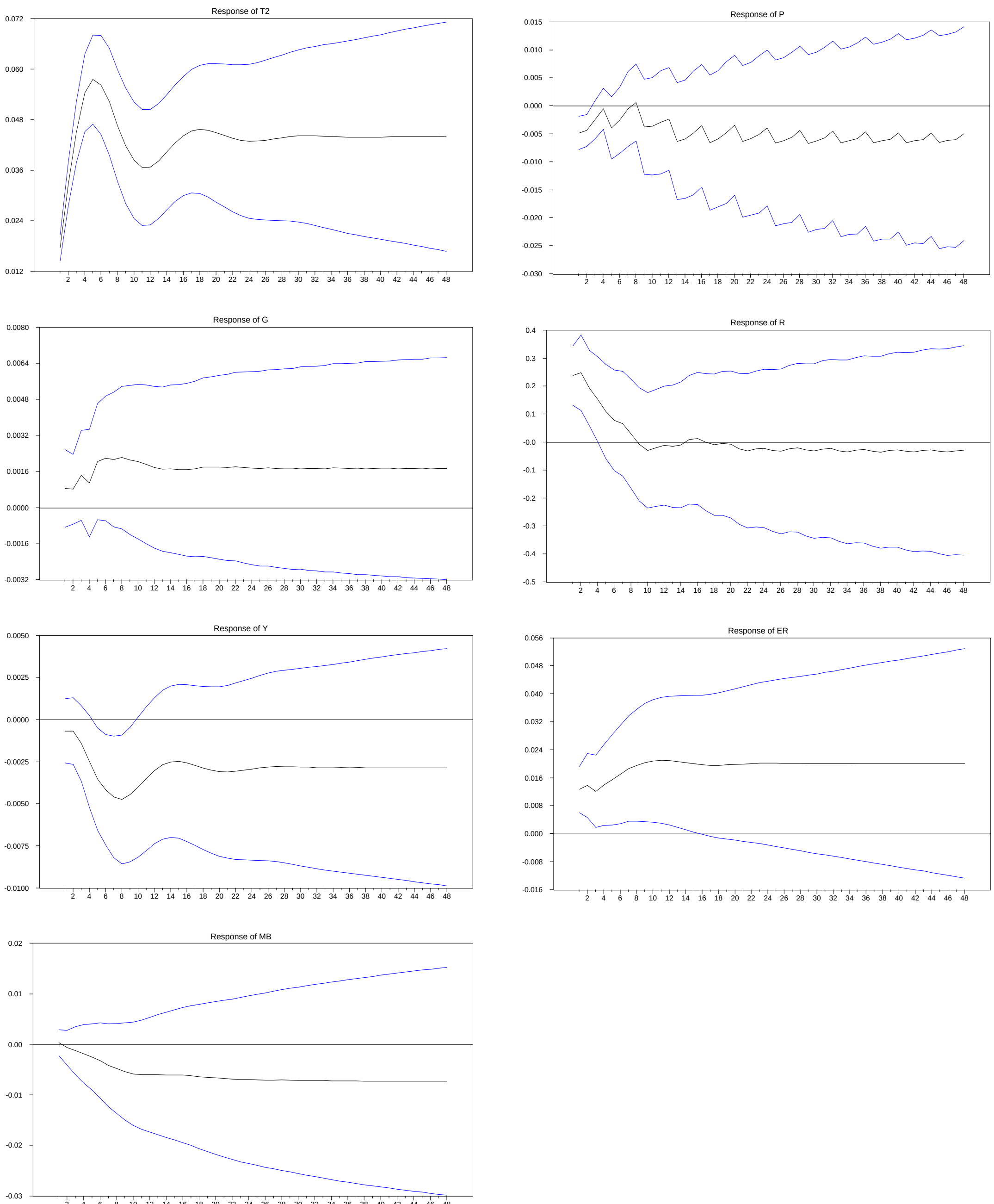
(APPENDIX I continued)

Panel A: Shock to T1: T1,G,Y,MB,P,R,ER



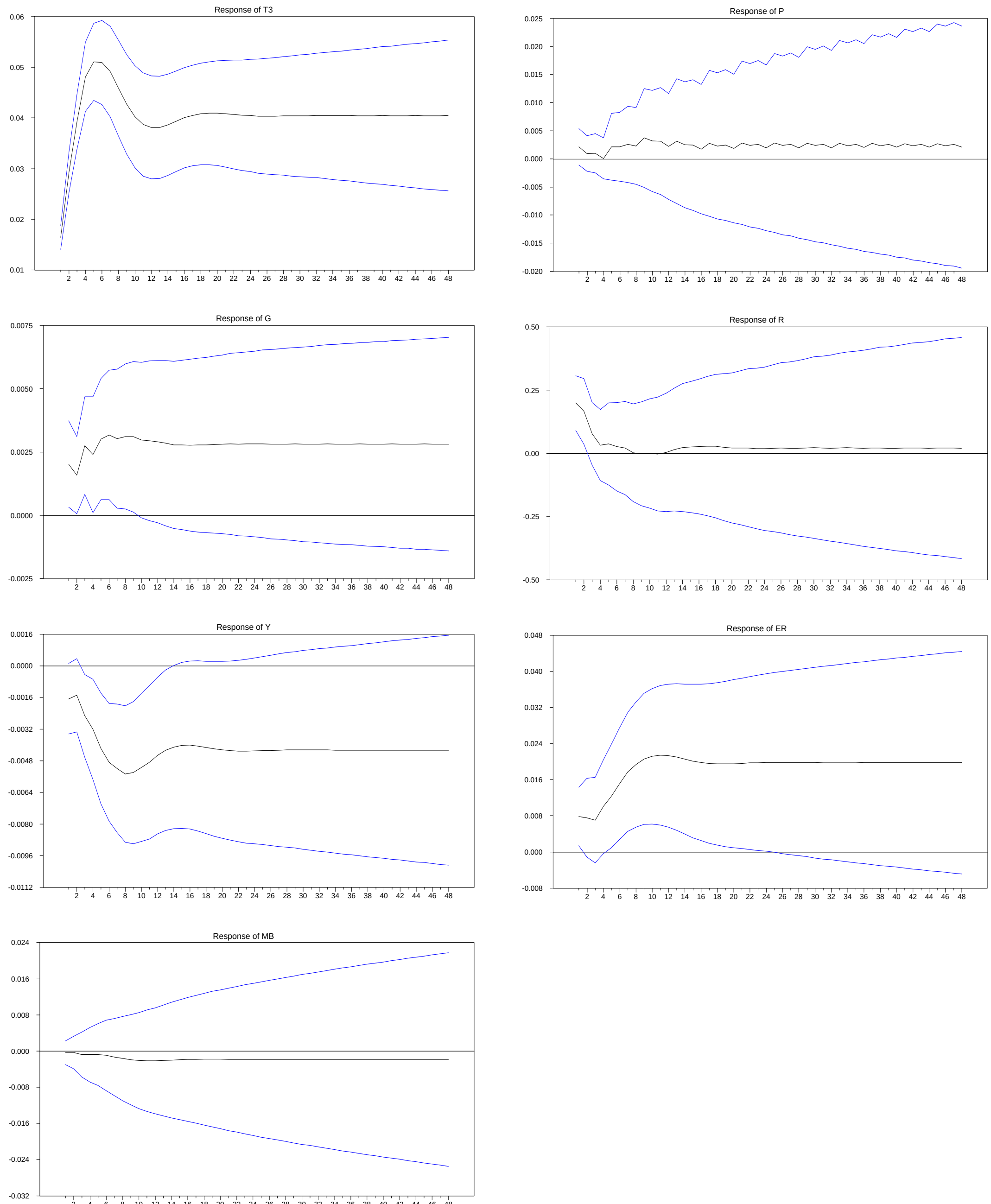
(APPENDIX I continued)

Panel B: Shock to T2: T2,G,Y,MB,P,R,ER



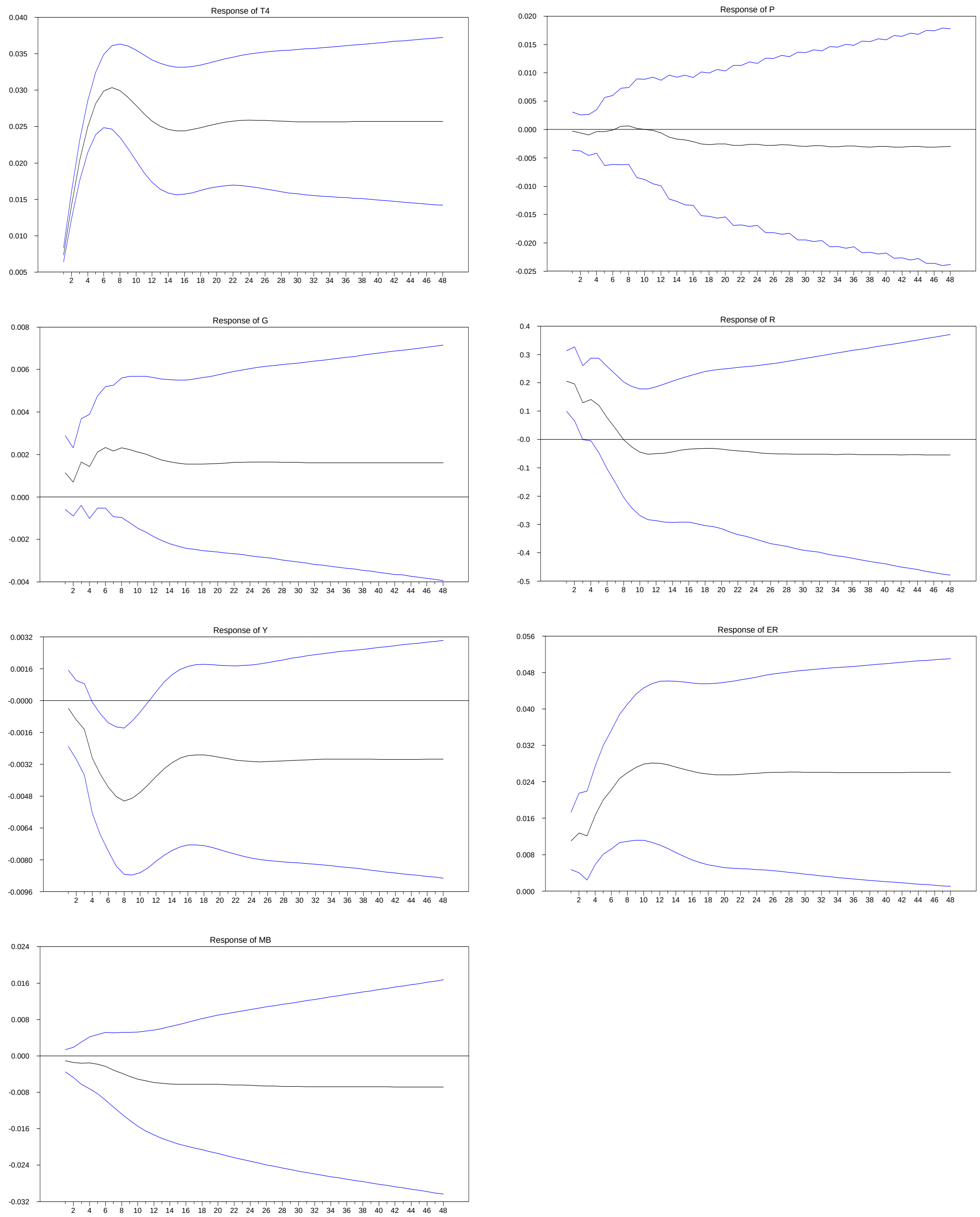
(APPENDIX I continued)

Panel C: Shock to T3: T3,G,Y,MB,P,R,ER



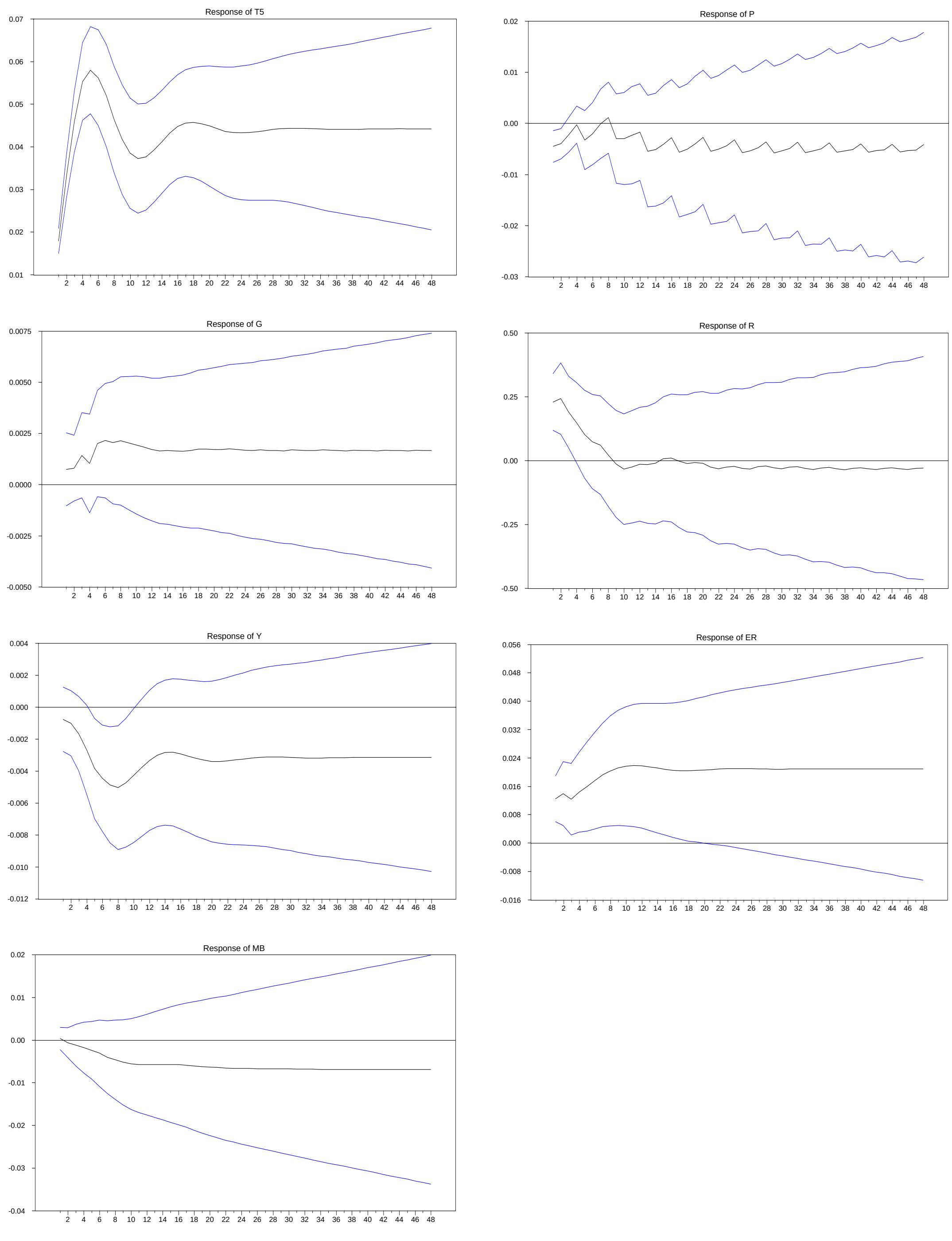
(APPENDIX I continued)

Panel D: Shock to T4: T4,G,Y,MB,P,R,ER



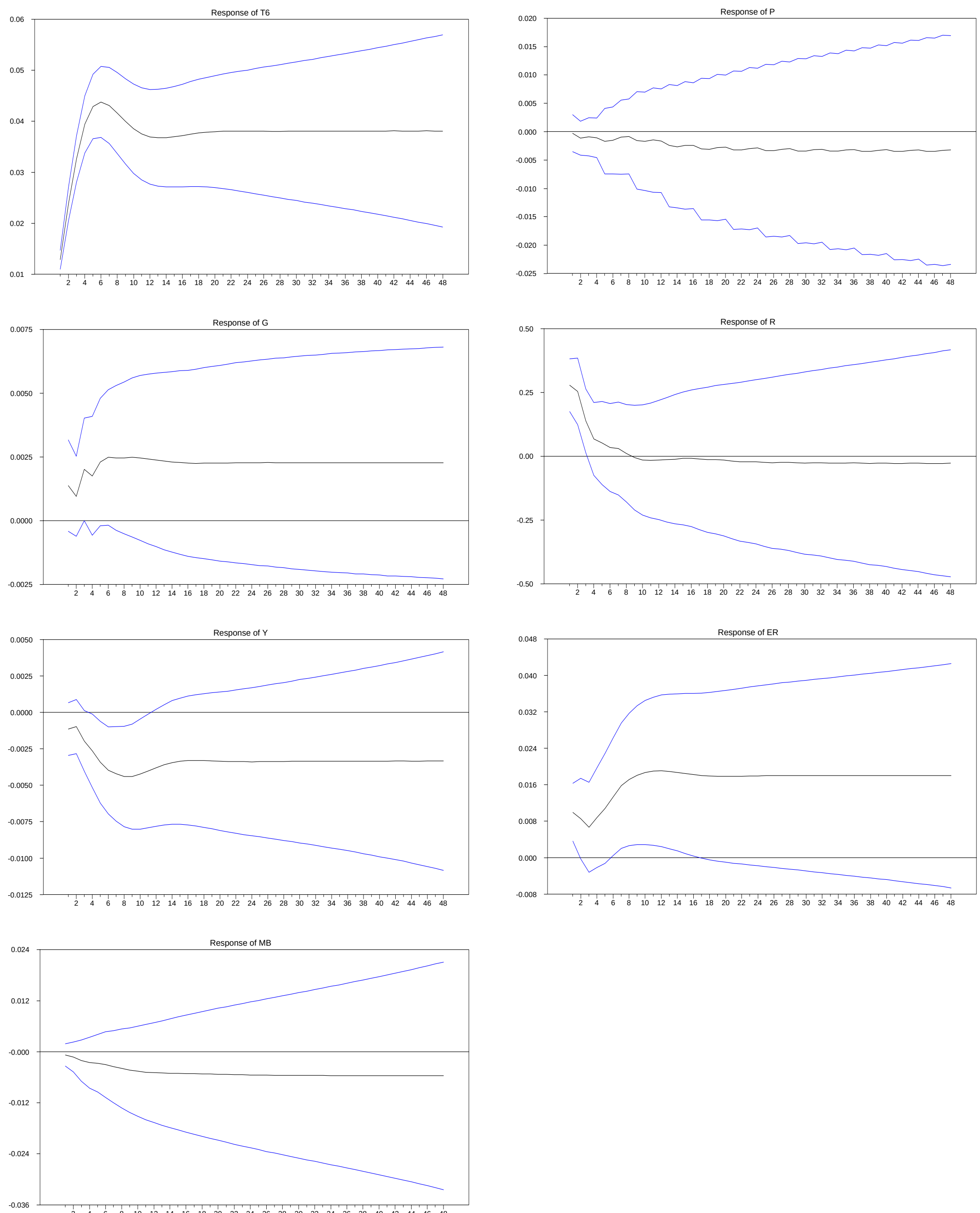
(APPENDIX I continued)

Panel E: Shock to T5: T5,G,Y,MB,P,R,ER



(APPENDIX I continued)

Panel F: Shock to T6: T6,G,Y,MB,P,R,ER



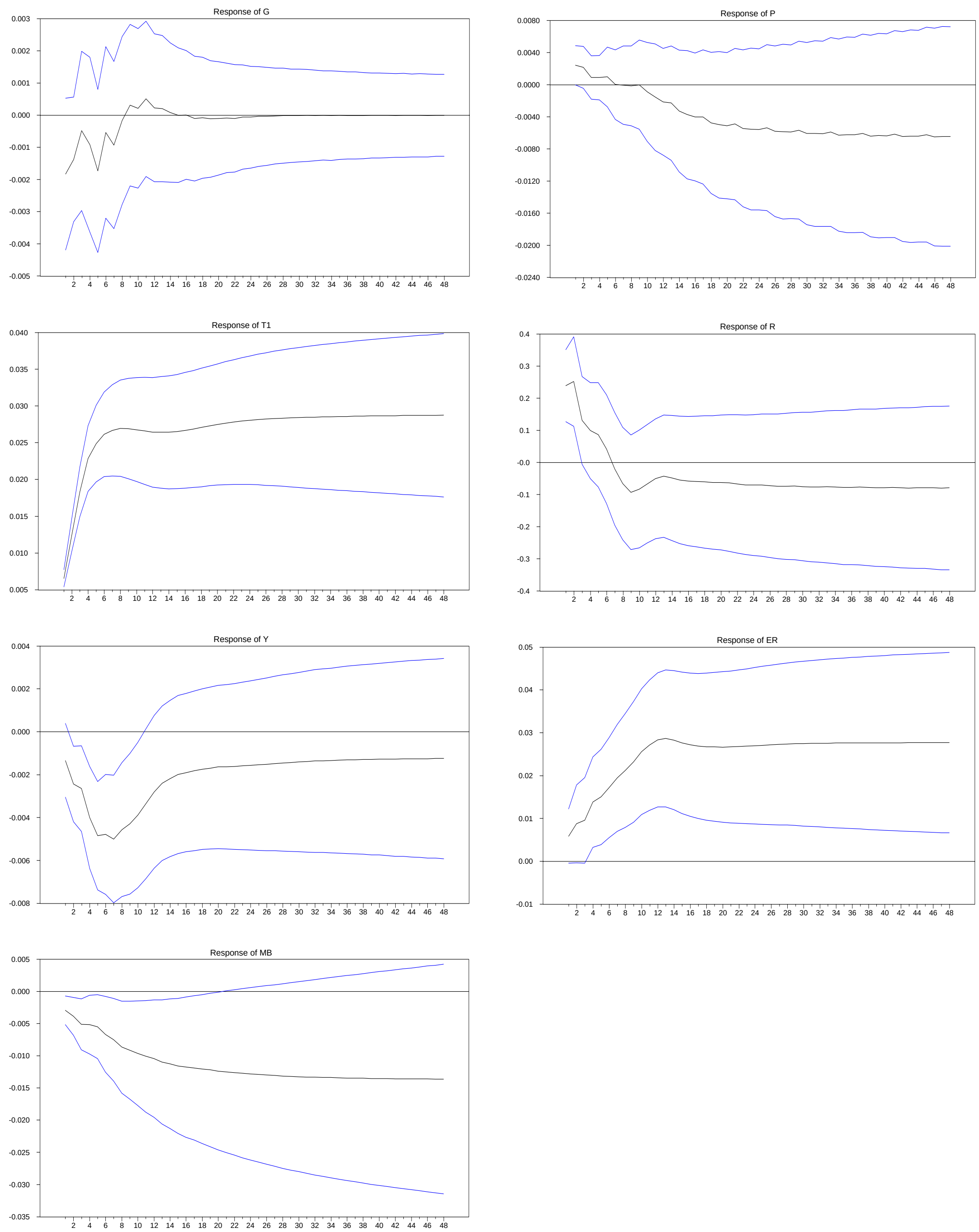
APPENDIX J. THE EFFECTS OF AMTR SHOCKS WHEN G IS ORDERED FIRST AND THE LAG LENGTH IS 5.

Impulse response functions of the real government expenditures (G), the real gross domestic product (Y), the price level (P), the interest rate (R), the exchange rate (ER), and the monetary base (MB) to a one standard deviation shock to each of the average marginal tax rate (T) measures are presented. The appropriate lag length for the estimations has been determined as 5 by using the AIC.

Tax	G	T	Y	MB	P	R	ER
T1	not significant	increase	decrease	decrease	not significant	increase	increase
T2	not significant	increase	decrease	not significant	not significant	increase	increase
T3	not significant	increase	decrease	decrease	increase	increase	increase
T4	not significant	increase	decrease	decrease	not significant	increase	increase
T5	not significant	increase	decrease	not significant	decrease	increase	increase
T6	not significant	increase	decrease	decrease	not significant	increase	increase

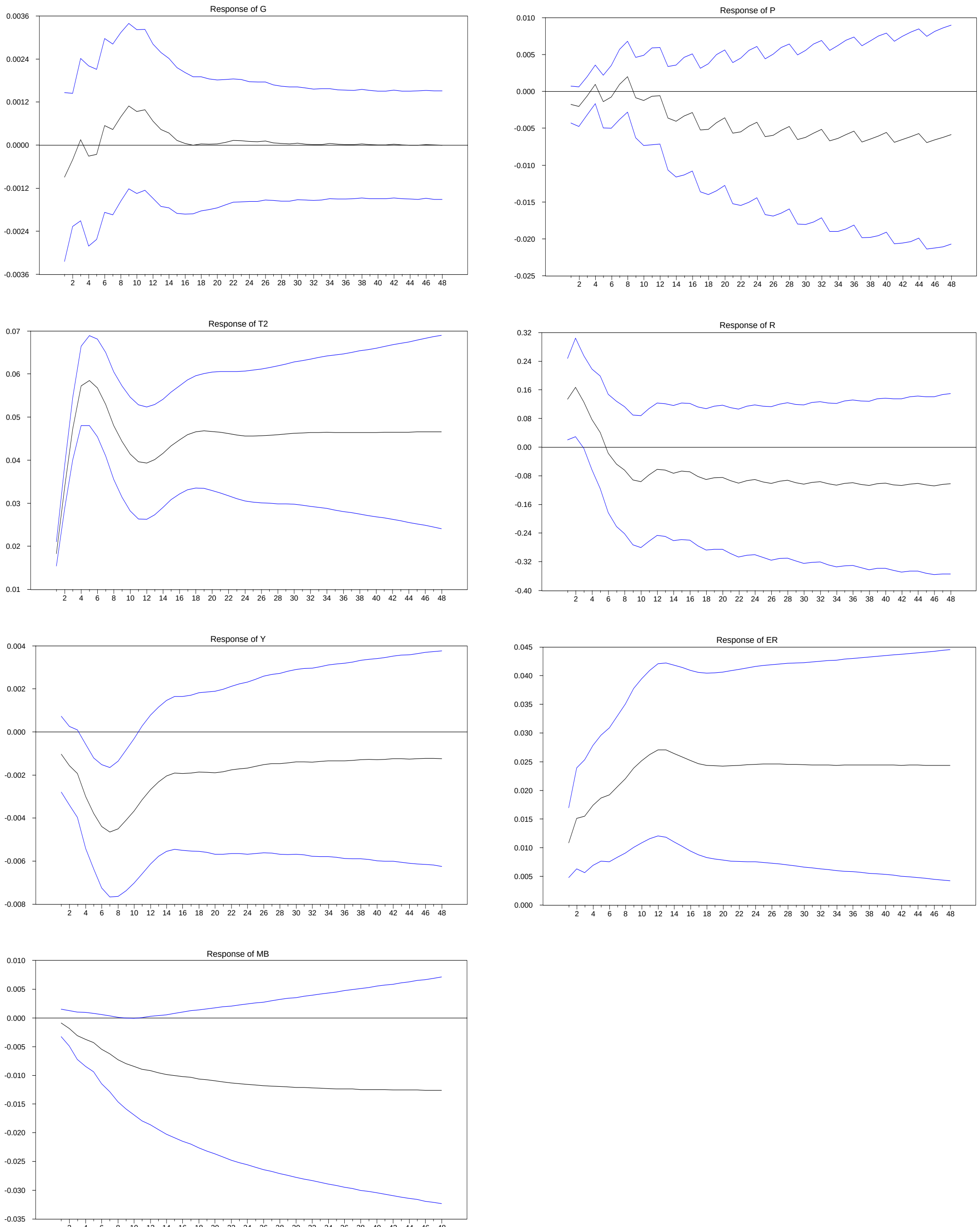
(APPENDIX J continued)

Panel A: Shock to T1: G,T1,Y,MB,P,R,ER



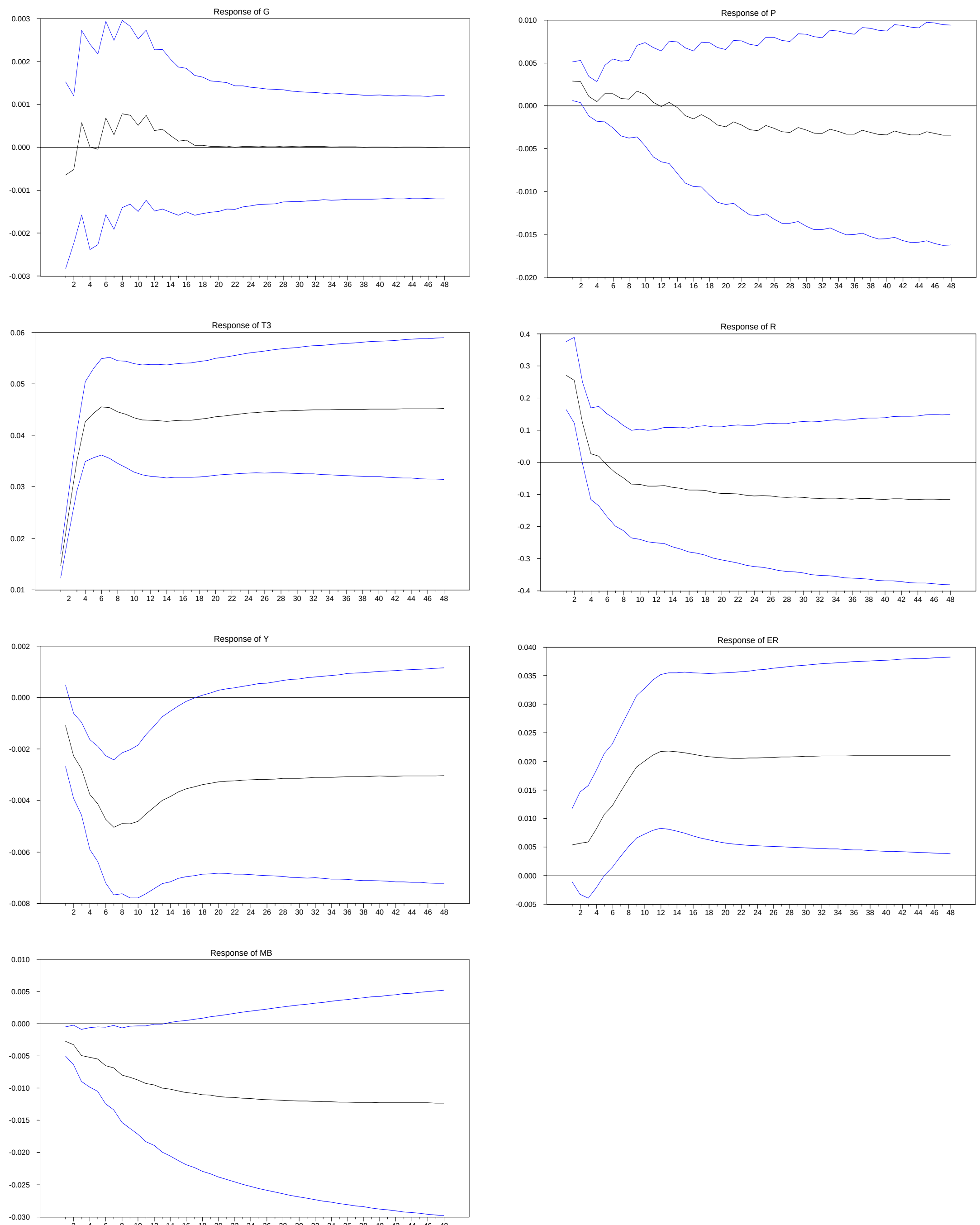
(APPENDIX J continued)

Panel B: Shock to T2: G,T2,Y,MB,P,R,ER



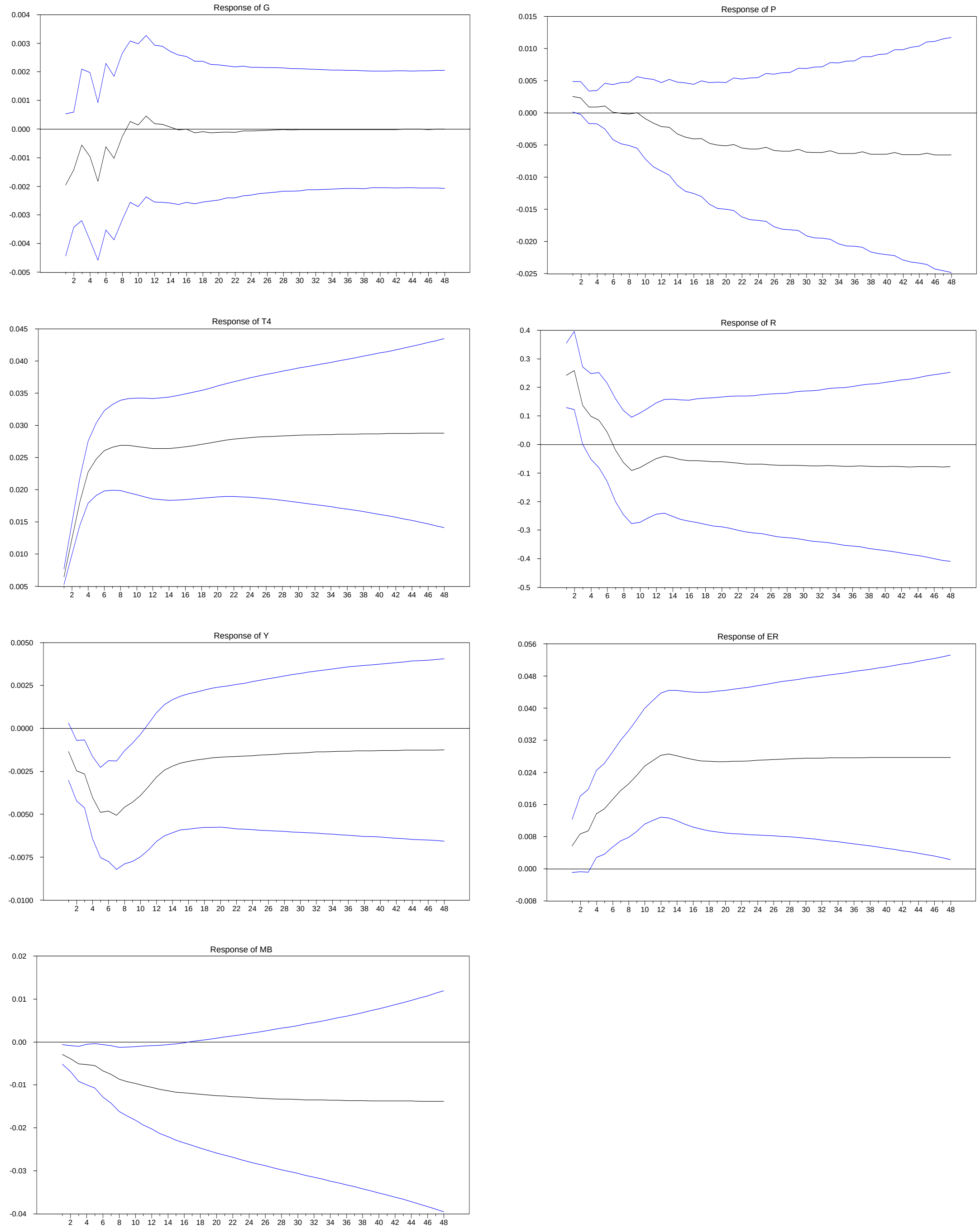
(APPENDIX J continued)

Panel C: Shock to T3: G,T3,Y,MB,P,R,ER



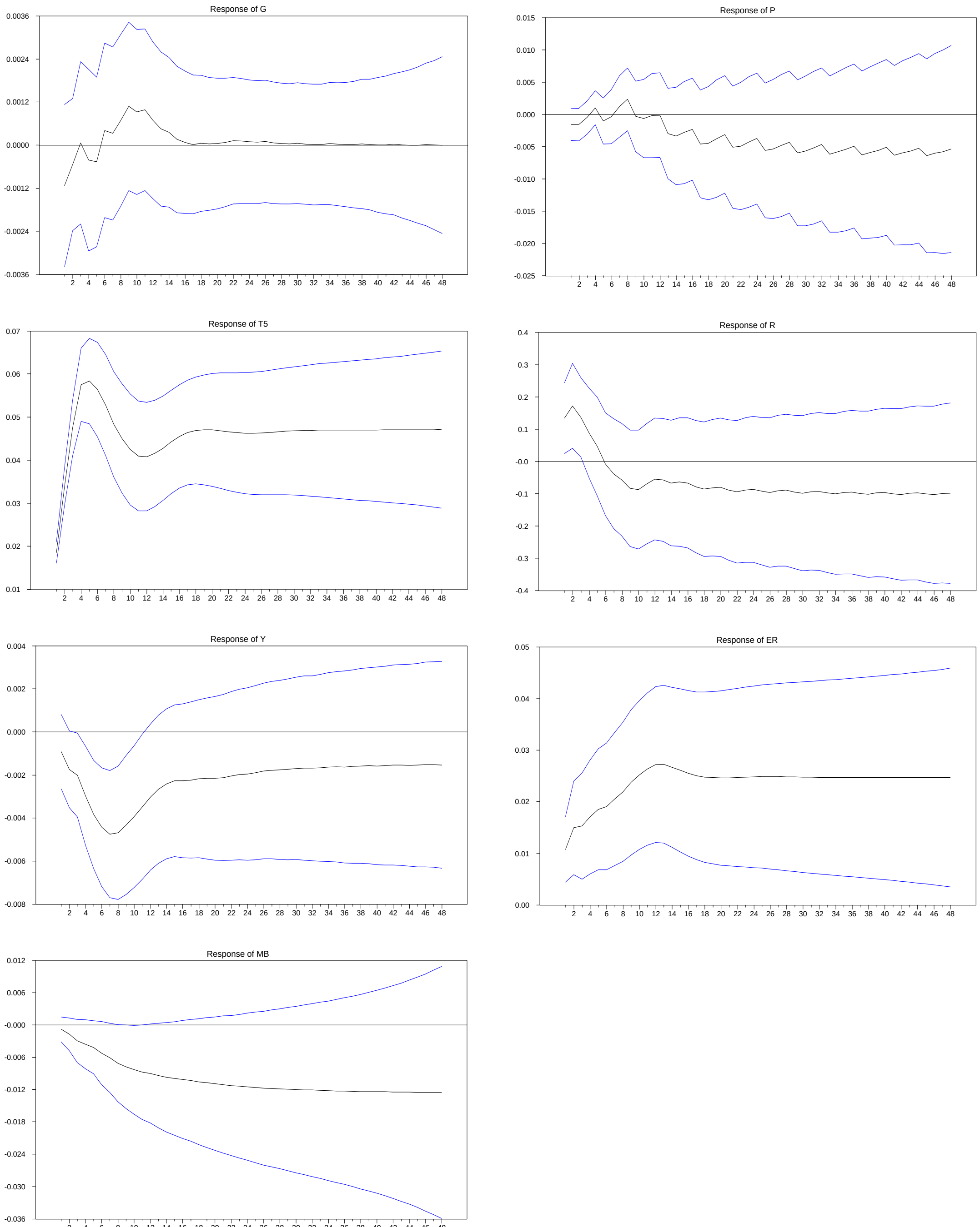
(APPENDIX J continued)

Panel D: Shock to T4: G,T4,Y,MB,P,R,ER



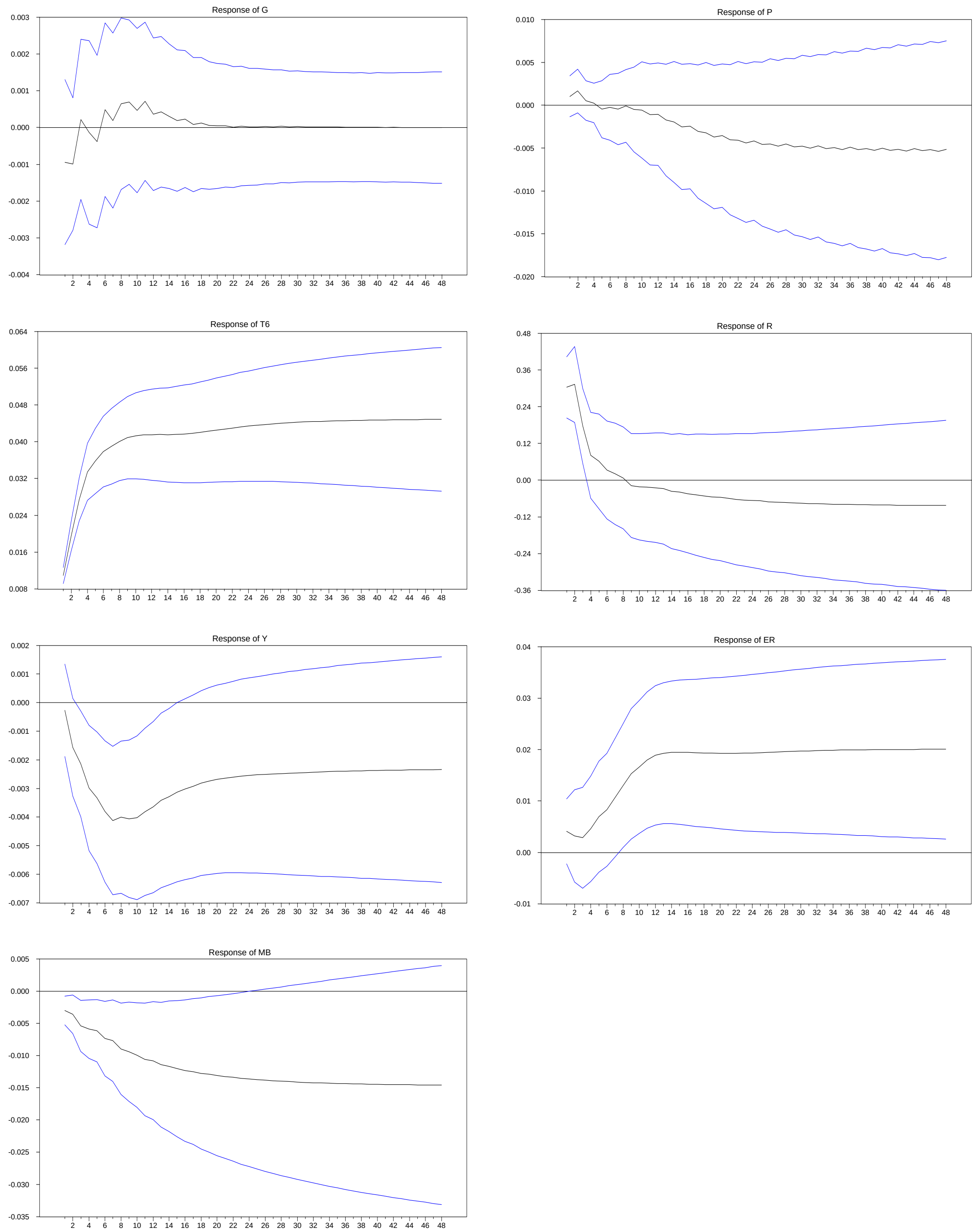
(APPENDIX J continued)

Panel E: Shock to T5: G,T5,Y,MB,P,R,ER



(APPENDIX J continued)

Panel F: Shock to T6: G,T6,Y,MB,P,R,ER



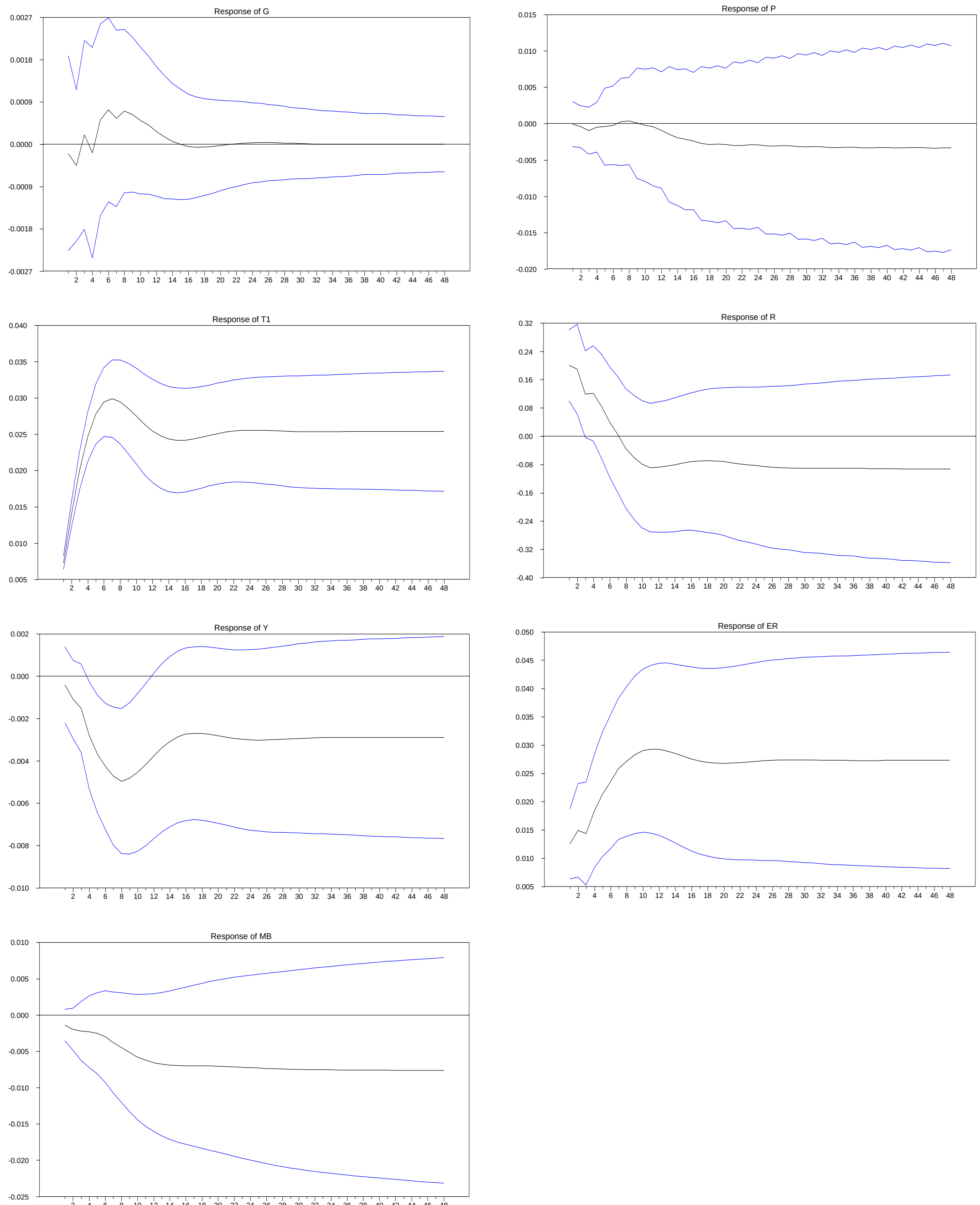
APPENDIX K. THE EFFECTS OF AMTR SHOCKS WHEN G IS ORDERED FIRST AND THE LAG LENGTH IS 4.

Impulse response functions of the real government expenditures (G), the real gross domestic product (Y), the price level (P), the interest rate (R), the exchange rate (ER), and the monetary base (MB) to a one standard deviation shock to each of the average marginal tax rate (T) measures are presented. The appropriate lag length for the estimations has been determined as 4.

Tax	G	T	Y	MB	P	R	ER
T1	not significant	increase	decrease	not significant	not significant	increase	increase
T2	not significant	increase	decrease	not significant	decrease	increase	increase
T3	not significant	increase	decrease	not significant	not significant	increase	increase
T4	not significant	increase	decrease	not significant	not significant	increase	increase
T5	not significant	increase	decrease	not significant	decrease	increase	increase
T6	not significant	increase	decrease	not significant	not significant	increase	increase

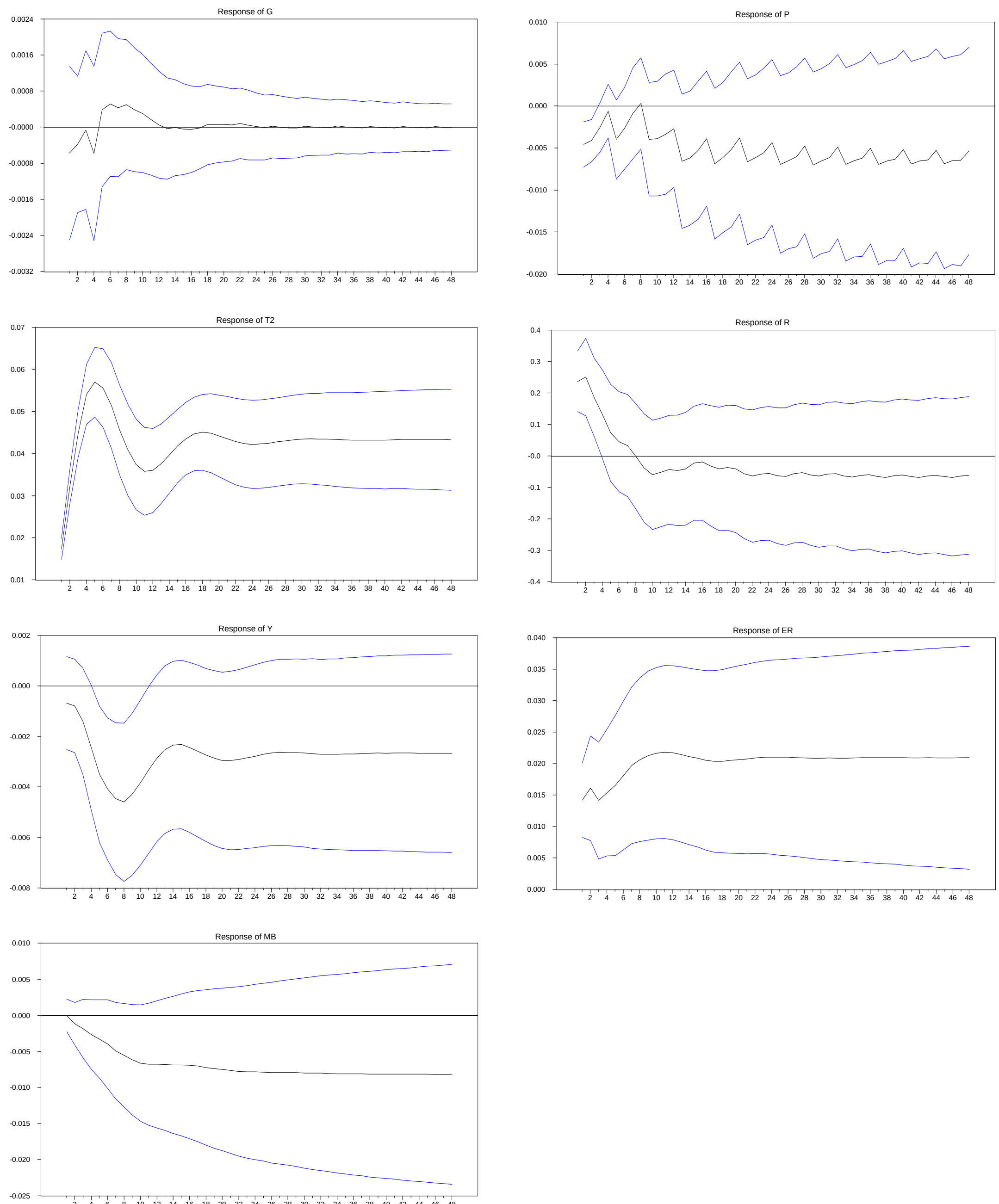
(APPENDIX K continued)

Panel A: Shock to T1: G,T1,Y,MB,P,R,ER



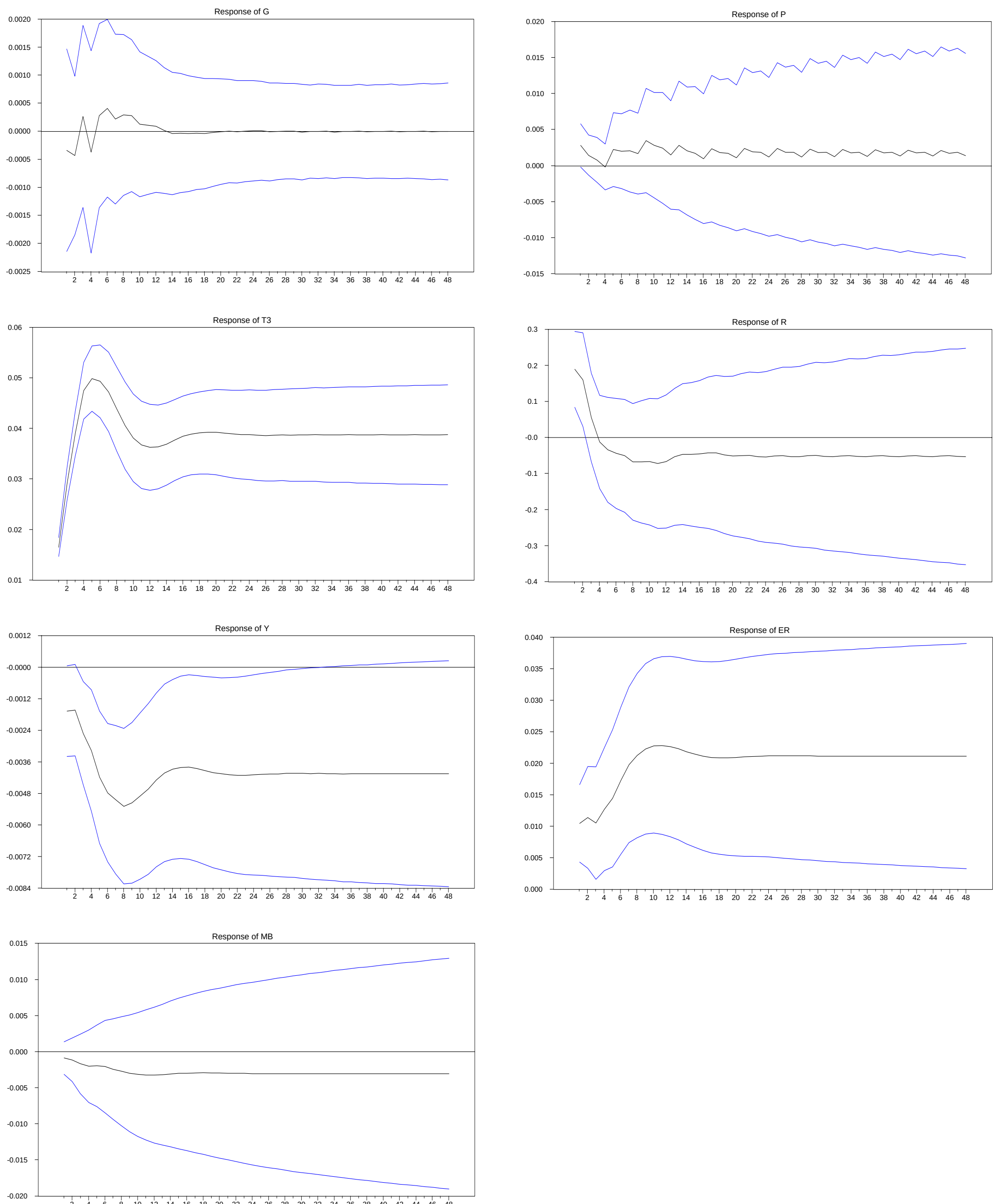
(APPENDIX K continued)

Panel B: Shock to T2: G,T2,Y,MB,P,R,ER



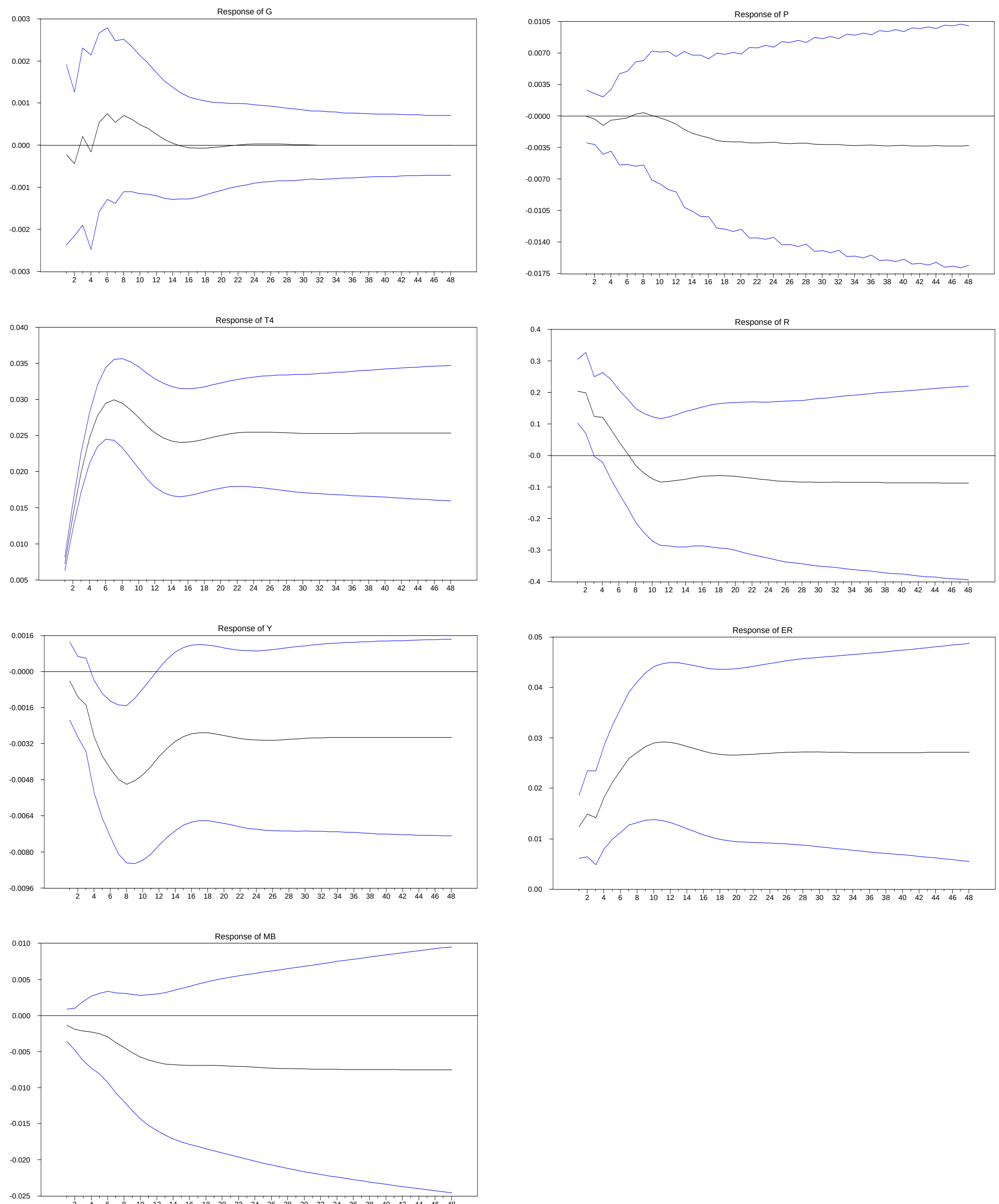
(APPENDIX K continued)

Panel C: Shock to T3: G,T3,Y,MB,P,R,ER



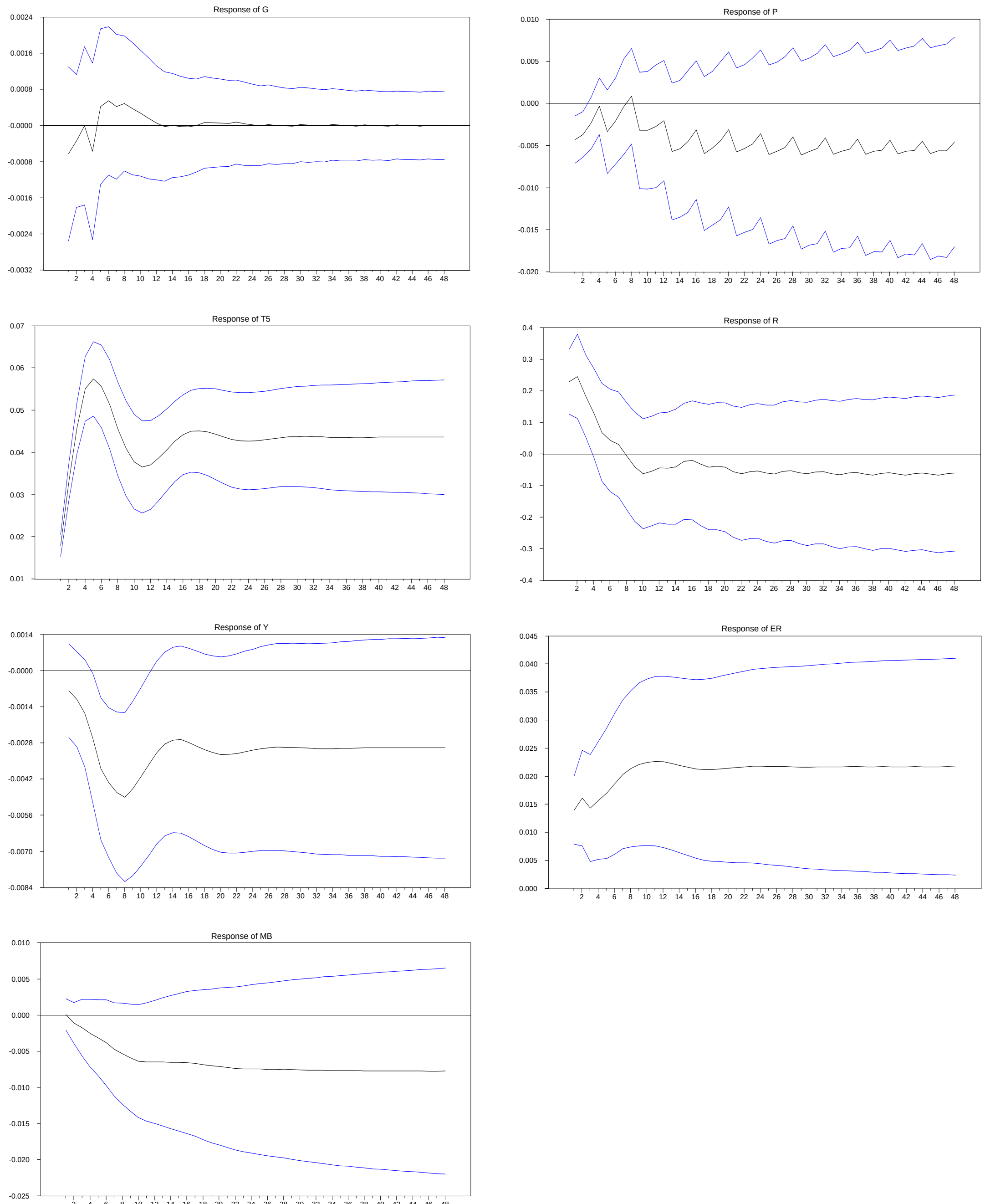
(APPENDIX K continued)

Panel D: Shock to T4: G,T4,Y,MB,P,R,ER



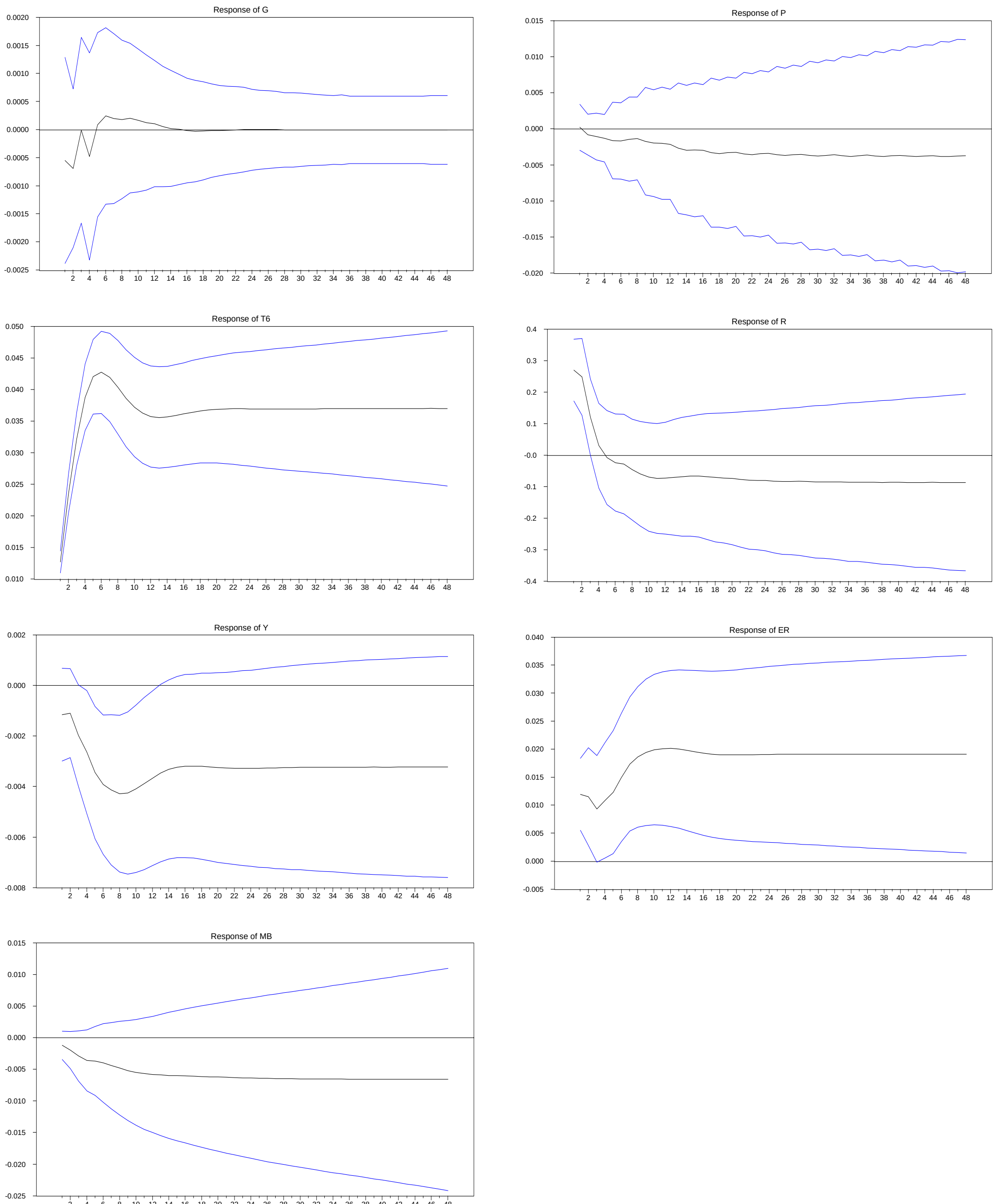
(APPENDIX K continued)

Panel E: Shock to T5: G,T5,Y,MB,P,R,ER



(APPENDIX K continued)

Panel F: Shock to T6: G,T6,Y,MB,P,R,ER



APPENDIX L. THE EFFECTS OF ATR SHOCKS ON SVAR (LAG LENGTH = 6)

Pannel A and B. The Effects of AMTR Shocks When AMTR is Ordered First

Impulse response functions of the real government expenditures (G), the real gross domestic product (Y), the price level (P), the interest rate (R), the exchange rate (ER), and the monetary base (MB) to a one standard deviation shock to each of the average marginal tax rate (T) measures are presented. The appropriate lag length for the estimations has been determined as 6 using the AIC.

Tax	ATR	G	Y	MB	P	R	ER
ATR1	increase	not significant	decrease	not significant	not significant	increase	not significant
ATR2	increase	not significant	decrease	not significant	not significant	increase	not significant

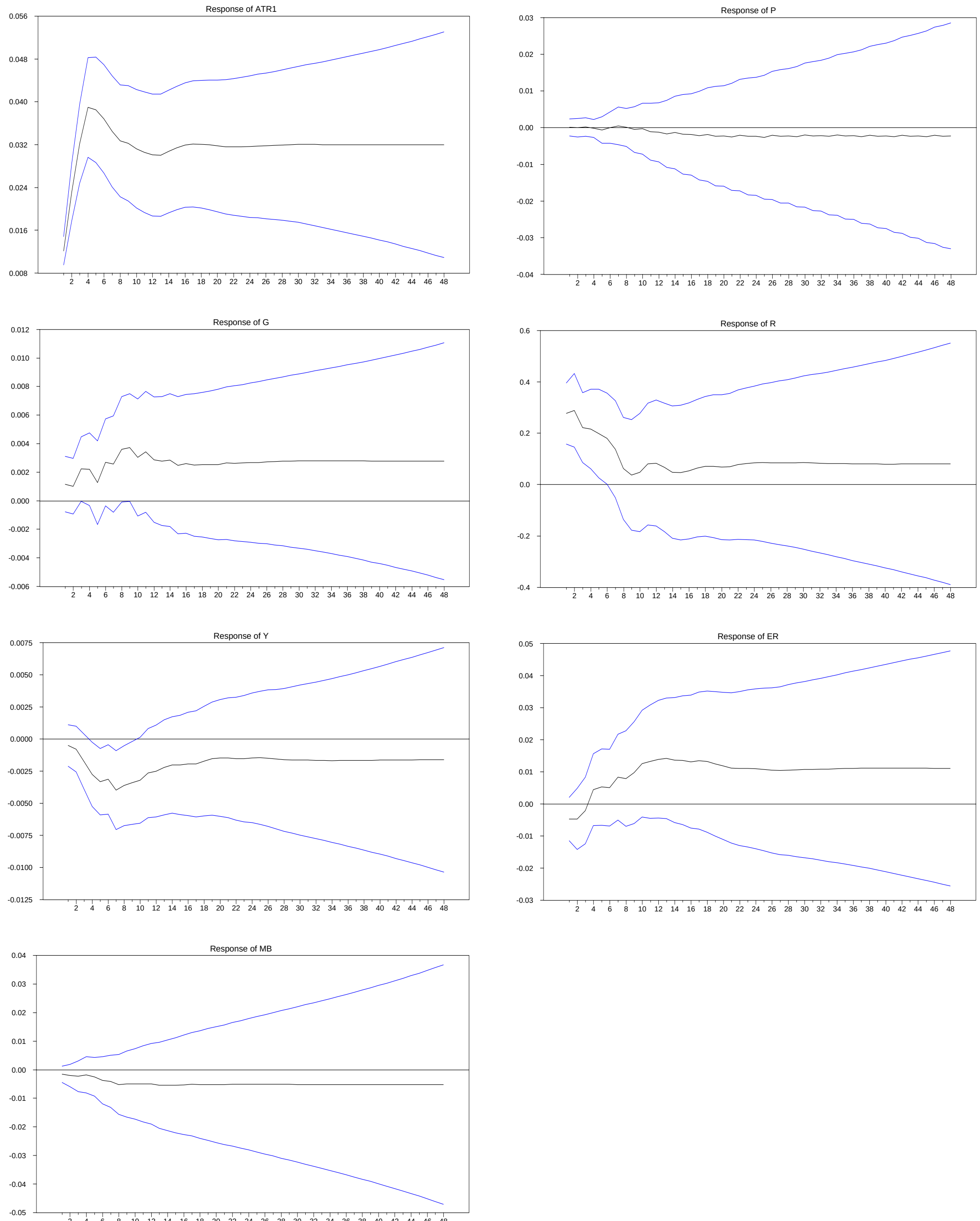
Pannel A and B. The Effects of AMTR Shocks When G is Ordered First

Impulse response functions of the real government expenditures (G), the real gross domestic product (Y), the price level (P), the interest rate (R), the exchange rate (ER), and the monetary base (MB) to a one standard deviation shock to each of the average marginal tax rate (T) measures are presented. The appropriate lag length for the estimations has been determined as 6 using the AIC.

Tax	G	ATR	Y	MB	P	R	ER
ATR1	not significant	increase	decrease	not significant	not significant	increase	not significant
ATR2	not significant	increase	decrease	not significant	not significant	increase	not significant

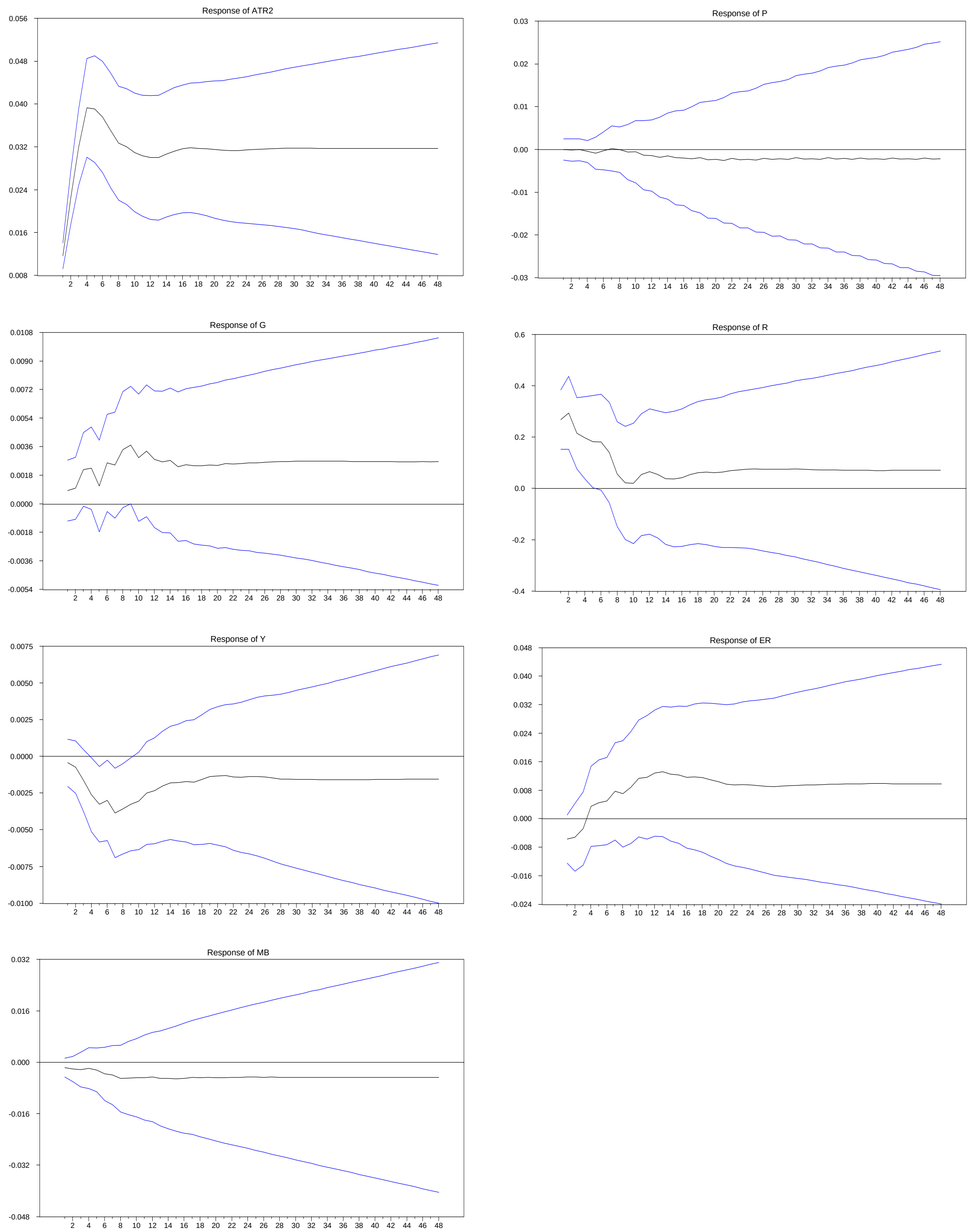
(APPENDIX L continued)

Panel A: Shock to ATR1: ATR1,G,Y,MB,P,R,ER



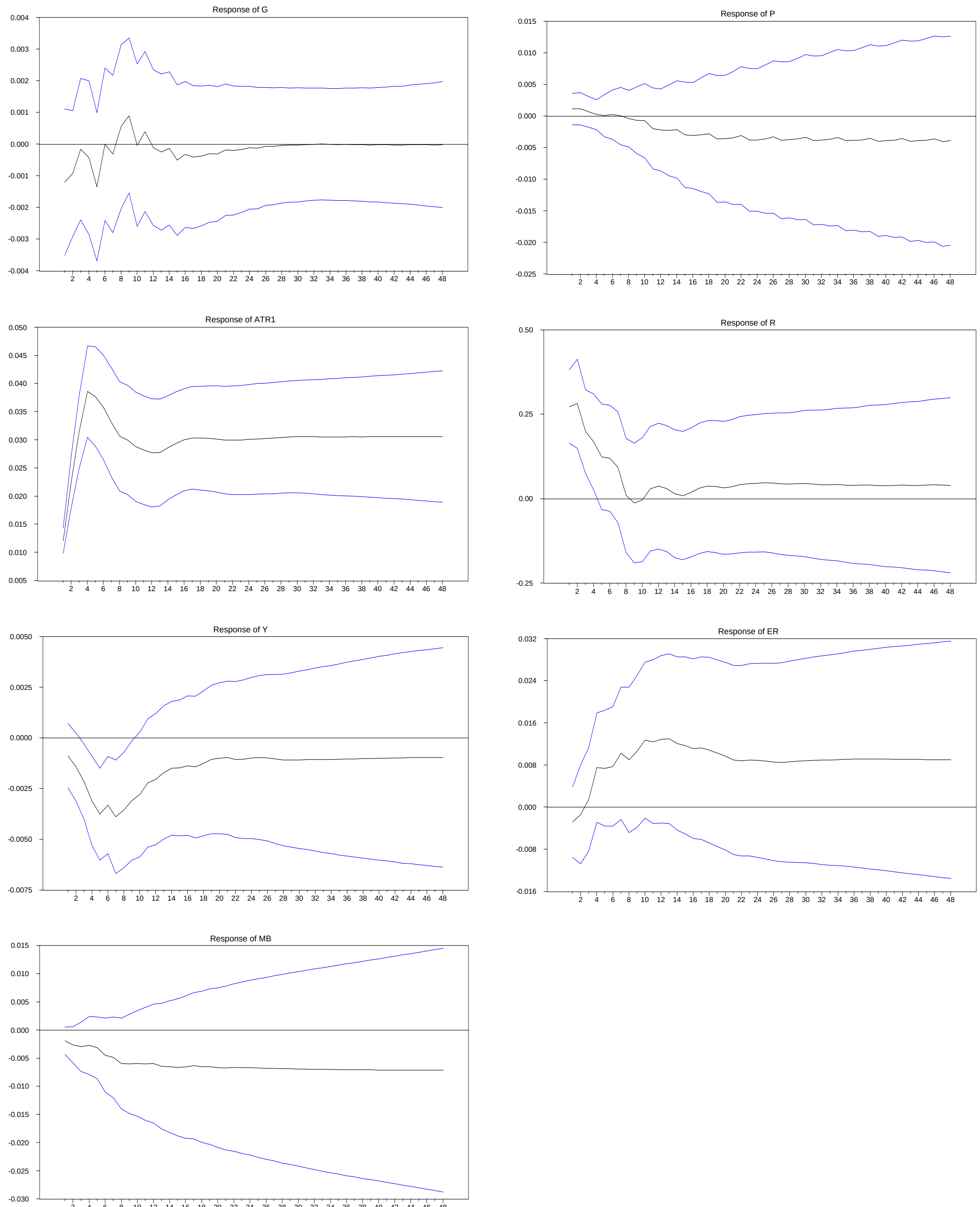
(APPENDIX L continued)

Panel B: Shock to ATR2: ATR2,G,Y,MB,P,R,ER



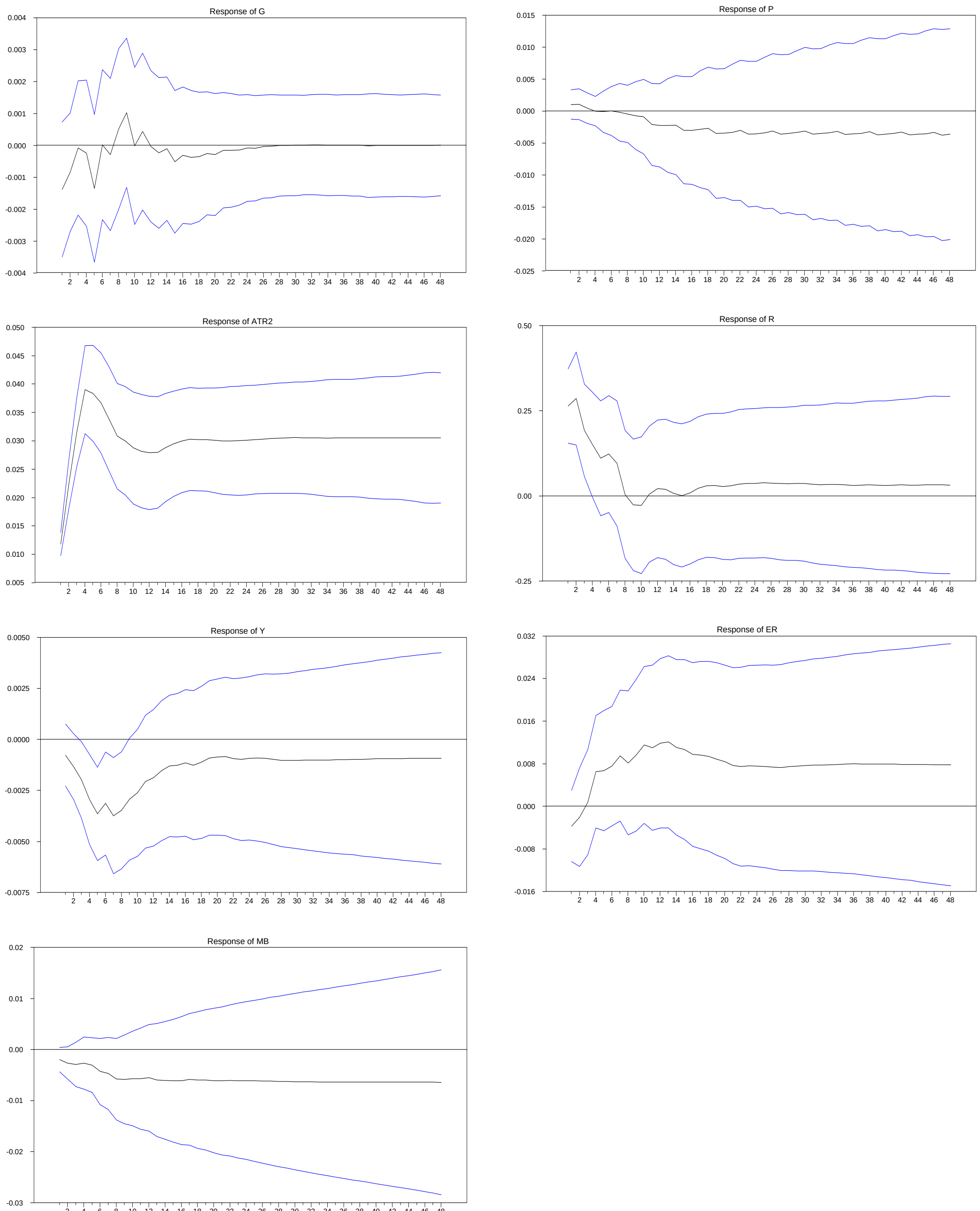
(APPENDIX L continued)

Panel A: Shock to ATR1: ATR1,G,Y,MB,P,R,ER



(APPENDIX L continued)

Panel B: Shock to ATR2: ATR2,G,Y,MB,P,R,ER



VITA

The author, Eon-Seon Rym, from Korea graduated with bachelor and master degrees of economics in Chun-Ang University in Seoul, Korea. After graduating, he worked on the Department of Economics in Chung-Ang University, and he organized the company, Financial Focus, with his friends. In 1996, he entered the Department of Economics at Louisiana State University. He earned the master degree of arts in economic in 1998. He expects to be awarded the degree of Doctor of Philosophy in economics in August 2003.