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# The Effect of Government Purchases on Economic Growth in Japan

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## Abstract

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## 1. Introduction

Other than China's emergence as a major engine of economic growth, one of the most stunning turnarounds in modern economic history is the lost generation of Japanese growth. Japan was not only the largest economy in Asia, it was also a model for other regional economies. In trying to restore growth after the asset bubble collapse of 1989, Japan's Liberal Democratic Party (LDP) used fiscal policy, especially through construction projects, to keep its hold on the popular vote. However, such government spending does not appear to have led to a fast-growing economy, at least not to the casual observer, even though central government debt has now risen to 170 percent of GDP.

A common methodological pitfall in the literature that tries to uncover the causal links between government spending and long-term economic growth is that they regularly conduct Granger causality tests outside the cointegration framework.[1] As is now well-known, this problem may render many of their conclusions invalid (Granger, 1988). Furthermore, the papers

[1] Ghali (1998) and Islam (2001) are among the exceptions.

that do place their Granger causality analyses within the cointegration framework do not tend to implement a Vector Error Correction (VEC) model, which is the natural follow up in the case in which the variables are cointegrated, given that the definitive test of causality lies with the error correction term (Engle and Granger, 1987; Granger, 1988).[2]

In this paper, we examine the statistical evidence for the relationship between government spending and GDP growth in Japan, using quarterly data from 1955 to 2009. Our findings are in line with an evolving new consensus in the economics profession (see Christiano, Eichenbaum, & Rebelo, 2009) that the fiscal multiplier for government purchases is larger when interest rates are near the zero bound, and follow on similar work applied to the United States (Guerrero & Parker, 2007). Our empirical exercises show a positive but modest effect of government spending on real GDP in Japan. Thus, expansionary fiscal policy may have played the role of avoiding a deeper economic depression than the one observed during Japan's lost decades.

## 2. Fiscal Policy and Economic Growth in Japan

From the early days of the Meiji restoration, Japan had a strong interventionist government, but the relationship between government and big business was much more collaborative than adversarial. Japanese postwar government policy helped transform the huge Zaibatsus into bank-centered Keiretsu firms, with an "iron triangle" of firm leaders, LDP politicians, and government technocrats setting most government trade, banking and finance

[2] The only exception we could find is Ghali (1998), who implements VEC models in a setup with multiple cross-sections (ten advanced countries), but short time spans (quarterly data for the period 1970-94). Islam (2001) implements Johansen-Juselius' weak exogeneity tests, but reports no VEC model.

policies. From 1955 to 1973, Japan’s real per-capita GDP quadrupled, with an average annual growth rate of 8.4 percent that was largely driven by a high savings rate and a successful export orientation. The nominal size of government remained relatively small for a developed economy, in part because Japan had to keep its military expenditures low, and because most pensions were managed through the big firms and private savings, not through government transfers.

After the worldwide recession in the mid-1970s hit Japan harder due to its exclusive dependence on imported oil, Japan was never able to achieve its prior rapid growth rates, but nonetheless Japanese growth rates were still impressive. From 1973 through the peak of the bubble economy in 1990, Japanese real per-capita growth averaged 3.8 percent per year, and its trade surplus helped it build large reserves of foreign assets in spite of an appreciating currency. These growth rates are shown in Figure 1.

When the bubble burst, however, severe problems began. According to Chakraborty (2009), the slowdown resulted from increased inefficiency in both labor and capital allocation. Nadenichek (2007) argues that pessimistic consumer expectations was a key factor in the continued slow growth, while Horioka (2006) found that stagnant private fixed investment reduced household disposable income and overall wealth, increasing consumer uncertainty.

Caballero, Hoshi, and Kashyap (2008) argue that lax regulation created an incentive for banks to continue lending to “zombie” firms, keeping them alive when they should have shed their claim on the economy’s capital and labor resources, and these banks in turn were propped up by the government. In what Koo (2003) called a balance sheet recession, both banks and firms in the real sector became averse to debt, while savings were redirected toward liquid assets with less risk.

For several years following the burst of the bubble, the newly-independent Bank of Japan refused to relent on a tight money policy which had helped to pop the bubble, in part because it hoped to force the Finance Ministry to reform the financial system; once it did relent, it did so half-heartedly, with a zero-interest rate policy that did not account for the effect of deflation on the real interest rate. Cargill and Parker (2004) demonstrated how deflation reduced Japanese consumption while increasing money demand faster than the Bank of Japan was willing to increase the supply.

If monetary policy was ineffectively used, then what about fiscal policy? When the bubble burst, Japanese government purchases totaled about 20 percent of GDP, significantly less than most other OECD countries. As Figure 1 shows, this ratio rose to 24 percent by 1999, and then fell back to 22 percent before the recession of 2007-2009. In the first five years, the growth was primarily in public investment. By 2007 this investment share had declined to postwar lows, while public consumption rose from 13 percent of GDP in 1990 to 18 percent in 2007.

Cargill and Sakamoto (2008) argue that the LDP had traditionally used Keynesian fiscal policy to respond to prior recessions, and that this approach was again used after 1990, particularly with the Fiscal Investment and Loan Program (FILP), as an alternative to real reforms that might have addressed underlying problems in firm behavior. As the stagnation of the Japanese economy continued, the government became less and less fiscally conservative, at least until the East Asian financial crisis of 1997, when there was an effort to increase taxes and tighten spending.

Was fiscal policy ineffective? Perri (2001) used a general equilibrium simulation to argue that the expansionary effects of fiscal policy in Japan were mostly canceled out by the crowding-out effects. However, Kuttner and Posen (2001) examined the hypothesis that fiscal policy was ineffective in Japan in the decade after the bubble collapsed, using a vector autoregression approach. What they concluded was that fiscal policy was actually effective, as savers appeared to passively accommodate it, but inadequate. Rising debt levels were not so much caused by increases in expenditures, but rather by falling revenues to the continued slowdown. Leightner and Inoue (2009) found that the effects of fiscal policy in Japan were asymmetric, in that the multiplier for reductions in spending were larger than for increases.

Ono (2008) used a Granger-causality framework to examine the link between government expenditures and government revenue, and found that the variables were linked prior to the 1990s, while they became independent afterwards. As the economy slowed, there was much less emphasis on constraining debt, and expenditures were no longer bound by the taxes collected. As Tamada (2009) demonstrated, government spending in Japan had a significant effect on voting patterns. This would suggest that government investment purchases was less likely to have as significant of an economic return. But the ratio of these government investments declined over the past decade, while overall government purchases remained relatively steady, at least until the Great Recession of 2008-2009 led to a 7 percent decline in Japan’s per-capita GDP.

**3. The Effect of Government Spending on Growth**

How should government spending in Japan have affected its growth? Poot (2000) argued that there are at least seven separate effects of government spending on growth. These include, among other factors, the provision of pure and quasi public goods, the distortionary effect of taxes on resource allocation, and the comparative inefficiency of government control over resources and production. The public choice literature focuses on the theoretical reasons for inefficient provision of goods and services by the state, for reasons of inappropriate incentives, insufficient information, and inadequate competition. The private sector, however, has its own share of inefficiencies, and government spending may help to offset the effects of these market failures.

In addition to the microeconomic affects, government expenditures may have a real fiscal effect on aggregate demand in an economy with excess capacity, especially when monetary policy is limited by deflation, fiscal crises, and the zero lower bound on interest rates. On the other hand, increased government spending near full employment may crowd out the private sector, especially when exchange rates float and monetary policy does not have to accommodate fiscal expansion.

Christiano, Eichenbaum, and Rebelo (2009) have argued that the fiscal effects of government spending can be large when interest rates are near the zero bound, as monetary policy no longer follows a Taylor rule response. This argument is also consistent with that of Leijonhufvud (2009) who, citing Minsky (1977), examined the leveraging and deleveraging phases of the financial cycle to support the argument that private finance was the source of the worldwide Great Recession.

Minsky (1986, ch. 2) explains why recessions accompanied by financial crises are especially severe, and why fiscal policy becomes particularly important in stabilizing balance sheets by augmenting low-quality assets with government bonds, by creating deficits in the public sector to offset sudden, undesired surpluses in the private sector. An interventionist fiscal policy may thus not create positive growth as much as it prevents a more significant recession.

Barro (1990) posited that the aggregate relationship between the size of government and economic growth may be shaped like an inverted-U, with low growth resulting from both too little and too much government, and the effect of government spending depends on the type of spending. Defense spending, or investment in public infrastructure and education, may have significantly different effects than transfers and public consumption.

On the empirical front, Landau (1983, 1986) found a negative effect of government consumption on growth, while Ram (1986) found a positive effect. The international evidence uncovered over the last two decades since these studies has remained decidedly mixed. In his survey, Slemrod (1995) argues that the aggregate effect of government involvement is negligible, though some types of taxes affect some behaviors significantly. Engen and Skinner (1996) focus on the effect of taxes, and they find mildly negative effects for some taxes and positive effects for others, but like much of the rest of the literature, the effects of larger government are contradictory, ambiguous, and in the aggregate rather minimal.

Poot (2000) cited 41 studies in his survey, with seven finding a positive effect, twelve finding a negative effect, and 23 inconclusive. Even more recently, Lee and Lin (2007) found a negative effect of government that became insignificant once demographic factors were taken into account. Plümper and Martin (2003) found a negative effect of government on growth primarily in non-democratic countries, a result generally consistent with the findings of Guseh (1997) and Scully (2001), which suggests that governments in democratic societies are more likely to spend money on public investments, and less likely to divert public resources for personal purposes.

## 4. The Time-Series Properties of Japanese Government Purchases and Growth

We start by defining *Y* as Japan's real GDP, *G* as the real value of central and local government purchases, *Gc* as the real value of government consumption, and *Gi* as the real value of government investment (where $G \neq Gc + Gi$ precisely, due to discrepancies). The first differences in these variables are defined as d*Y*, d*G*, d*Gc*, and d*Gi*, and the growth rates are defined as $y$, $g$, $g_c$, and $g_i$. These seasonally-adjusted, quarterly data were collected from the Statistics Bureau of the Japanese Ministry of Internal Affairs and Communications. The sample spans the period 1955:1-2009:3.

Figure 1.1 shows the time profile of the variables *Y*, *G*, *Gc*, and *Gi* in their levels, and it is not obvious from this graph whether these variables can be regarded as trend stationary. Similarly, Figure 1.2 displays the rates of growth *y* and *g*, and it is also not clear if these rates of growth are either trend-stationary or difference-stationary.

As is well-known, running regressions involving I(1) variables may give rise to spurious results and multiple inference and interpretations problems, given that the *F*-statistic does not follow the tabulated values of Fisher's *F* distribution (Granger & Newbold, 1974). Furthermore, as Sims, Stock, and Watson (1990) make clear, the issue is not whether the data are integrated per se, but rather whether the estimated coefficients or *t*-statistics of interest have a non-standard distribution in the case when the regressors are in fact integrated.

Table 1 contains the results for a battery of unit root tests including the Augmented Dickey-Fuller (ADF) test, the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test, and the Elliott, Rothenberg, and Stock (ERS) test. The ADF test was specified to use a maximum number of lags equal to 14 and the optimal number of lags was decided for each test using the Schwartz Information Criterion. The KPSS test uses a spectral estimation method (in this case, the Bartlett kernel) and the optimal number of lags used was chosen case-by-case using the Newey-West bandwith, and the results were similar when we fixed the number of lags at 4 for all tests. The ERS test also uses a spectral estimation procedure (AR spectral OLS, in this case), the maximum number of lags allowed in the regressions was set equal to 14, and the optimal number of lags was chosen in each test using the Schwartz Information Criterion.

Both the ADF and KPSS tests provide clear evidence that *Y* contains a unit root in its level (i.e., it is an I(1) process), but apparently not in its first-difference (i.e., *Y* is first-difference stationary).[3] The ERS tests show the opposite result, suggesting that *Y* is trend-stationary in its level, but displays a unit root in its first difference (we found some evidence that this last result may be driven by a structural break in the year 1973, but the evidence is not conclusive). Using tests that allowed for structural breaks in the real GDP series level, Cheung and Chinn (1986) also rejected the unit root hypothesis (at the 10 percent significance level and using a different dataset) for the level of Japan's real GDP, and were among the first to show that Japan's real GDP can equally plausibly be thought of as trend-stationary.

[3] For a more detailed discussion on different procedures to test for unit roots in the real GDP series the reader is referred to Cheung and Chinn (1986).

Similar conclusions arise in regards to the government expenditure variables. The ADF and KPSS tests both reject the hypothesis of trend-stationarity in the variables' levels, while not rejecting the hypothesis of first difference-stationarity. The ERS tests arrive at the opposite conclusion, namely the ERS tests find the government expenditure variables' levels to be trend-stationary whereas the first differences display unit roots.

Table 2 provides a summary of the variables' stationarity and unit roots, and illustrates two major points. First, a common specification in the literature is to regress real GDP growth on the share of government purchases *G/Y*, and these shares are shown in Figure 2. But in this case, these variables are not integrated of the same order as *y*, the growth rate of GDP. Regressing a stationary dependent variable on independent variables which are not stationary is an approach that Granger (1986: 216) argues "makes no sense as the independent and dependent variables have such vastly different temporal properties." Indeed, the expected coefficient(s) from such a regression would be zero in such a case. Thus, we should not run regressions combining these variables.

Second, real GDP and real government spending variables are not stationary in their levels (i.e., not trend-stationary), according to both the ADF and the KPSS tests, but they are stationary in their first differences. However, the opposite is true according to the ERS test, that real GDP and real government spending are trend-stationary but their first differences display unit roots (i.e., first differences are not stationary). This difficulty is not new; see, for example, the pioneering work of Cheung and Chinn (1986) for the comparison of results between the ADF and KPSS tests. Disentangling this ambiguity in tests results exceeds the scope of this paper. Instead, we follow a pragmatic strategy in order to focus on the main goal of this paper, which is to study the effectiveness of government spending to affect real GDP.

We thus take an agnostic approach regarding unit roots and proceed in two steps. First, we run unrestricted VAR models in the variables' levels. Second, we run the unrestricted VAR models in the variables' first differences. Finally, we conduct a cointegration analysis and estimate a Vector Error Correction (VEC) model to extract causality implications from it.

## 5. An Unrestricted VAR Approach

As a first approach to analyzing the effect of the levels of *G* on *Y*, and of the growth rates *g* on *y*, we estimated unrestricted Vector Auto-Regression (VAR) models from which we extracted impulse-response results. An advantage of using an unrestricted VAR model is that it implies a non-committal approach to the data in which issues of causation, timing, and appropriate structural restrictions are temporarily left on hold, awaiting further analysis.

Since the impulse-response results are sensitive to the Cholesky-ordering of the variables in the VAR, we first conduct Granger block-exogeneity tests on the variables' levels and first differences to gain some intuition on the most appropriate order of the variables. As shown in Table 3 for 8, 9, and 10 lags, all the tests strongly suggest ordering the purchases variables first and real GDP second.[4]

[4] Eight, nine and ten lags are used in the Granger tests of Table 3, since using four lags created a significant number of inconclusive tests in the case of the variables in their rates of growth.

*Unrestricted VAR models in the variables' levels:*

For the real levels of the variables, we follow the Final Prediction Error, the Akaike Information Criterion, and the Hanna-Quinn Information Criterion, all of which suggest the use of 4 lags as the optimal lag structure. Other, longer lag structures were also tried (again, 8 and 9 lags) and results were still generally in line with the ones reported.

In the first rows of Figures 3.1, 3.2, and 3.3, we show the impulse-response diagrams from the VAR(4) model. For the levels of *G*, *Gc*, and *Gi*, government purchases, consumption, and investment all have a significant effect on the level of GDP, while GDP does not appear to increase government purchases, contrary to what we would expect from Wagner (1893).

On average, a one standard-deviation increase in real government spending leads, over a period of two and a half years, to an approximately 40 point increase in real GDP, relative to an index where 1955:1 GDP = 100. This is equivalent to an increase of 3.3 percent in Japan's real GDP of Japan at the end of the sample (2009:3). Interestingly, the smallest effect (10 points accumulated over a period of 10 quarters) occurs for government consumption. Fiscal policy shows some of its strongest effects in the form of government investment. This evidence is in line with Koo (2008), who presented complementary evidence on the effectiveness of Japan's fiscal policy.

*Unrestricted VAR models in the variables' growth rates:*

In considering the growth rates $y$, $g$, $g_c$, and $g_i$, we find that four of the five information criteria used to determine the optimal lag structure still suggest the use of four lags, and we follow this again. Granger tests of block exogeneity, shown in the bottom of Table 3, suggest ordering the variables with *g* entering first, and *y* second.

The impulse-response diagrams are displayed in the bottom panels of Figures 3.1, 3.2, and 3.3. A one standard deviation to the growth of real government purchases has a strongly positive compounded effect on the growth of real GDP, adding one and a half percentage points over a 10-quarter period. A similar shock to the rate of growth of real government consumption increases real GDP growth by one full percentage point over a 10 quarter period, while a one-standard-deviation shock to government investment has a slightly larger effect. These results again support the argument that government purchases have had a positive effect on real GDP in Japan during the postwar period.

The unrestricted VAR approach is not free of problems, however. Problems with this approach include the potential for inefficient estimation due to over-parameterization (Zellner, 1988), and misspecification when the data are first-differenced and the variables are cointegrated (Engle & Granger, 1987), as is potentially the case here. Hence, more analysis is needed.

## 6. Cointegration Analysis

If the variables *Y* and *G* are cointegrated, causality tests conducted outside the cointegration analysis framework may lead to incorrect causal inferences, since the error correction term is omitted in the specifications used to test for Granger causality (see Granger, 1988, for additional discussion). Hence, to account for that difficulty we follow a two step procedure in what follows. First, we check if the variables for GDP and government purchases are cointegrated. Second, if the hypothesis that the series are not cointegrated is rejected, we implement a Vector Error Correction (VEC) model in order to double check the results on block exogeneity reported in Table 3. If cointegration test results show the presence of only one cointegrating equation, the one in which *G* is the dependent variable and *Y* the explanatory one, and the VEC model contains only one statistically significant error correction term in the dynamic equations then, and only then, the block exogeneity test results reported below in Table 3 are valid (Granger, 1988).

In general, if two variables such as *G* and *Y* are both I(1), any combination of these variables, such as $Z = G - aY$, will also be I(1), where *Z* is called the equilibrium error term. However, there may exist a singularity $a^*$, such that $G - a^*Y$ is I(0). If such a singularity exists, *G* and *Y* are said to be cointegrated. This implies that in the long-run, although *G* and *Y* can be arbitrarily high or low, they must be proportional to each other, with a factor of proportionality $a^*$. It is clearly possible for more than one equilibrium relation to govern the joint behavior of the variables.

Johansen's cointegration tests statistics are shown in Tables 4.1, with the results for the variables in levels, and in Table 4.2, with the results for variables in growth rates. In general, the variables in the levels contain only one cointegrating relation, with the exception being the case of the pair of (*Gi*, *Y*), for which there tends to be a lack of cointegration (except for the case in which the data are allowed no trend and the test includes only an intercept, but no trend). In the growth rates, there tends to be two cointegrating relations (i.e., bi-directional causation) for the growth variables in the overwhelming majority of the cases considered in the different cointegration tests. The prevalence of a single cointegrating relationship in the case of the levels raises the question of the direction of causation, which is addressed in the next section.

**7. The Vector Error Correction Models**

Engle and Granger (1987) have shown that if two variables are cointegrated, then there must exist a VEC model linking these variables. Furthermore, the VEC model representation of the bivariate system of cointegrated variables sheds light on the direction of causation between those variables (Granger, 1988). Our VEC models for the variables in their levels is formulated as follows:

$$\begin{aligned}(1-L)g_t = c(1) + b(1)E(1)_{t-1} + \sum_{j=1}^{T} c_{1,j}(1-L)\,g_{t-j} \\ + \sum_{j=1}^{T} d_{1,j}(1-L)\,y_{t-j} + u_{1,t}\end{aligned} \tag{1}$$

$$\begin{aligned}(1-L)y_t = c(2) + b(2)E(2)_{t-1} + \sum_{j=1}^{T} c_{2,j}(1-L)\,y_{t-j} \\ + \sum_{j=1}^{T} d_{2,j}(1-L)\,g_{t-j} + u_{2,t}\end{aligned} \tag{2}$$

where $L$ is the lag operator, $T$ is the number of lags to be included, and the error correction terms are given by $E(j)_{t-1}$ for $j = 1, 2$, which are the residuals from the OLS static regressions of $G$ on $Y$ and vice versa, respectively. In equations (1) and (2), the VEC model allows for the finding that $G$ Granger-causes $Y$, or vice versa, so long as the corresponding error correction term carries a statistically significant coefficient, even if the estimated $d_j$ coefficients are not jointly statistically significant (Granger, 1988). If $G$ and $Y$ are cointegrated, then the error correction terms are stationary I(0) processes. Conversely, if the residuals from the static regressions involving *G* and *Y* are I(0), then G and *Y* are cointegrated (Engle & Granger, 1987).

The estimates of the VEC model contain important information regarding the long-run relationship and the short-run dynamics involved in the relationship between G and *Y*. We chose Johansen's (1992) estimation procedure,[5] and Table 5 displays the estimates. The error correction terms leave no room for doubt: causation runs unidirectionally from real GDP to government purchasing variables, and not the reverse. The impulse-response diagrams from these VEC models clearly show that an increase in real government purchases still produces positive effects on real GDP, as shown in Figures 4.1, 4.2, and 4.3.

One way to reconcile the causality results from the error correction terms of Table 5 with the ones displayed in the impulse-response diagrams in Figure 4 is by means of the hypothesis that Japanese government officials have tended to react immediately to increases in real GDP by contracting government spending, as displayed in the right-hand charts. This introduces a systematic pattern of causation from real GDP to government spending, as suggested by the error correction terms of Table 5 because a positive innovation to real GDP is immediately followed by a reduction in government spending. Indeed, Koo (2008) has used a similar explanation to account for the premature fiscal consolidations of 1997 and 2001 that aborted strong economic recoveries that had been fueled by an activist fiscal policy in a context of a zero lower bound constraint for short-term interest rates.

[5] . See Guerrero and Parker (2007) for an illustration of Engle-Granger's procedure for the case of the United States.

## 8. Conclusion

Our study examines whether government purchases in Japan helped or hurt GDP. This is a very important issue for Japan after two lost decades of growth, in which Japan has failed to return to a consistent growth path while debt has grown substantially.

Our dataset included quarterly data on GDP, government consumption, and government investment from 1955 to 2009. This dataset permits a careful study of the time-series properties of these variables for stationarity, cointegration, and Granger causality. Our results support other evidence that government purchases had positive effects on growth. Government investment was not that much more effective than consumption, which suggests that the fiscal impact was at least as important as the effect of public infrastructure on potential GDP.

These results are consistent with the argument that fiscal policy may have worked in Japan, but its observed effects, though consistently positive, were generally modest. The financial crisis in Japan was severe, and the balance sheet troubles it created were long-lasting. It was accompanied by a monetary policy that was tighter than it should have been in the context, with deflation an unpleasant result. Expansionary fiscal policy may only have helped ease the downturn. But that, as remarked by Koo (2008) and Leijonhufvud (2009), for example, may be no small accomplishment.

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**Table 1: ADF, KPSS, and ERS Test Statistics**

| | | *Y* | *G* | *Gc* | *Gi* |
|---|---|---|---|---|---|
| **Augmented Dickey-Fuller Unit Root Tests** | | | | | |
| *Null Hypothesis: Level is not stationary* | | -0.725 | -1.425 | -3.173 | -0.168 |
| *Null Hypothesis: Difference is not stationary* | | -5.514 | -17.762 | -21.708 | -15.036 |
| Test critical values: | 1% level | -4.001 | | | |
| | 5% level | -3.431 | | | |
| | 10% level | -3.139 | | | |
| **KPSS* Unit Root Tests (LM Statistics)** | | | | | |
| *Null Hypothesis: Level is stationary* | | 1.914 | 1.91 | 1.516 | 1.453 |
| *Null Hypothesis: Difference is stationary* | | 0.318 | 0.167 | 0.588 | 0.581 |
| Asymptotic critical values*: | 1% level | 0.739 | | | |
| | 5% level | 0.463 | | | |
| | 10% level | 0.347 | | | |
| **Elliott-Rothenberg-Stock Test Statistics** | | | | | |
| *Null Hypothesis: Level is not stationary* | | 14.765 | 26.275 | 184.339 | 44.314 |
| *Null Hypothesis: Difference is not stationary* | | 2.899 | 0.917 | 1.146 | 0.843 |
| Test critical values: | 1% level | 4.041 | | | |
| | 5% level | 5.656 | | | |
| | 10% level | 6.863 | | | |

* See Kwiatkowski, Phillips, Schmidt, & Shin (1992, Table 1).

**Table 2: Summary of Stationarity Results**

*Stationarity Results at 5% level*

| | ADF | KPSS | ERS |
|---|---|---|---|
| *Y* | NS | NS | S |
| *G* | NS | NS (1) | S |
| *Gc* | NS (1) | NS | S |
| *Gi* | NS | NS | S |
| | | | |
| *G/Y* | NS | NS (1) | S |
| *Gc/Y* | NS | NS | S |
| *Gi/Y* | NS | NS | S |
| | | | |
| $y$ | S | S | NS |
| $g$ | S | NS (1) | NS |
| $g_c$ | S | S | NS |
| $g_i$ | S | S | NS |

*S = Stationary at 5%*

*NS = Non-Stationary*

*NS (1) = S at 10%*

**Table 3: Block Exogeneity and Granger tests**

| **Variables in Levels** | *Null Hypothesis:* | | *Lags of Y are* *not* *block-exogenous* | | *Lags of G are* *not* *block-exogenous* | |
|---|---|---|---|---|---|---|
| Variable | | Obs | F-stat | p-value | F-stat | p-value |
| $G$ | 8 lags | 211 | 4.16 | 0.000 | 0.68 | 0.710 |
| | 9 lags | 210 | 3.98 | 0.000 | 0.73 | 0.685 |
| | 10 lags | 209 | 3.87 | 0.000 | 0.74 | 0.684 |
| $G_c$ | 8 lags | 211 | 2.16 | 0.032 | 1.34 | 0.227 |
| | 9 lags | 210 | 2.03 | 0.039 | 1.71 | 0.089 |
| | 10 lags | 209 | 1.75 | 0.072 | 2.25 | 0.017 |
| $G_i$ | 8 lags | 211 | 1.57 | 0.136 | 1.29 | 0.248 |
| | 9 lags | 210 | 2.04 | 0.037 | 1.49 | 0.154 |
| | 10 lags | 209 | 2.23 | 0.018 | 1.38 | 0.193 |
| **Variables in Growth rates** | *Null Hypothesis:* | | *Lags of y are* *not* *block-exogenous* | | *Lags of g are* *not* *block-exogenous* | |
| | | Obs | F-stat | p-value | F-stat | p-value |
| $g$ | 8 lags | 210 | 4.99 | 0.000 | 1.20 | 0.296 |
| | 9 lags | 209 | 5.40 | 0.000 | 1.11 | 0.355 |
| | 10 lags | 208 | 1.47 | 0.115 | 1.11 | 0.354 |
| $g_c$ | 8 lags | 210 | 4.48 | 0.000 | 2.02 | 0.046 |
| | 9 lags | 209 | 5.07 | 0.000 | 1.73 | 0.084 |
| | 10 lags | 208 | 4.13 | 0.000 | 1.47 | 0.155 |
| $g_i$ | 8 lags | 210 | 2.81 | 0.006 | 1.77 | 0.085 |
| | 9 lags | 209 | 2.92 | 0.003 | 1.71 | 0.090 |
| | 10 lags | 208 | 2.56 | 0.006 | 1.70 | 0.083 |

**Table 4.1: Bilateral Johansen's Cointegration Tests for Variables in Levels**

Lags interval: 1 to 4

Selected (0.05 level*)

Series: *G* and *Y*

| | Number of Cointegrating Relations by Model | | | | |
|---|---|---|---|---|---|
| Data Trend: | None | None | Linear | Linear | Quadratic |
| Test Type | No Intercept | Intercept | Intercept | Intercept | Intercept |
| | No Trend | No Trend | No Trend | Trend | Trend |
| Trace | 1 | 1 | 1 | 0 | 1 |
| Max-Eig | 1 | 1 | 1 | 1 | 1 |

Series: *Gc* and *Y*

| | Number of Cointegrating Relations by Model | | | | |
|---|---|---|---|---|---|
| Data Trend: | None | None | Linear | Linear | Quadratic |
| Test Type | No Intercept | Intercept | Intercept | Intercept | Intercept |
| | No Trend | No Trend | No Trend | Trend | Trend |
| Trace | 1 | 1 | 2 | 1 | 1 |
| Max-Eig | 1 | 1 | 2 | 1 | 1 |

Series: *Gi* and *Y*

| | Number of Cointegrating Relations by Model | | | | |
|---|---|---|---|---|---|
| Data Trend: | None | None | Linear | Linear | Quadratic |
| Test Type | No Intercept | Intercept | Intercept | Intercept | Intercept |
| | No Trend | No Trend | No Trend | Trend | Trend |
| Trace | 0 | 1 | 0 | 0 | 0 |
| Max-Eig | 0 | 1 | 0 | 0 | 0 |

*Critical values based on MacKinnon, Haug, & Michelis (1999).

**Table 4.2: Bilateral Johansen's Cointegration Tests for Variables in Growth Rates**

Lags interval: 1 to 4

Selected (0.05 level*)

| Series: $g$ and $y$ | | | | | |
|---|---|---|---|---|---|
| | Number of Cointegrating Relations by Model | | | | |
| Data Trend: | None | None | Linear | Linear | Quadratic |
| Test Type | No Intercept | Intercept | Intercept | Intercept | Intercept |
| | No Trend | No Trend | No Trend | Trend | Trend |
| Trace | 2 | 2 | 2 | 2 | 2 |
| Max-Eig | 2 | 2 | 2 | 2 | 2 |
| Series: $g_c$ and $y$ | | | | | |
| | Number of Cointegrating Relations by Model | | | | |
| Data Trend: | None | None | Linear | Linear | Quadratic |
| Test Type | No Intercept | Intercept | Intercept | Intercept | Intercept |
| | No Trend | No Trend | No Trend | Trend | Trend |
| Trace | 1 | 1 | 2 | 2 | 2 |
| Max-Eig | 1 | 1 | 2 | 2 | 2 |
| Series: $g_i$ and $y$ | | | | | |
| | Number of Cointegrating Relations by Model | | | | |
| Data Trend: | None | None | Linear | Linear | Quadratic |
| Test Type | No Intercept | Intercept | Intercept | Intercept | Intercept |
| | No Trend | No Trend | No Trend | Trend | Trend |
| Trace | 2 | 2 | 2 | 2 | 2 |
| Max-Eig | 2 | 2 | 2 | 2 | 2 |

*Critical values based on MacKinnon, Haug, & Michelis (1999).

## Table 5: VEC between Measures of Government and GDP in Levels

| | Gov't Purchases | | Gov't Consumption | | Gov't Investment | |
|---|---|---|---|---|---|---|
| **Cointegrating Equation:** | | | | | | |
| *G*(-1) | 1 | | 1 | | 1 | |
| *Y*(-1) | -1.045 | | -1.560 | | -3.021 | |
| | -0.025 | | -0.093 | | -0.966 | |
| | [-41.00] | | [-16.75] | | [-3.13] | |
| Constant | 25.753 | | 406.861 | | 1399.554 | |
| **Error Correction Model:** | | | | | | |
| | d*G* | d*Y* | d*Gc* | d*Y* | d*Gi* | d*Y* |
| CointEq1 | -0.097 | -0.009 | -0.022 | 0.000 | 0.006 | 0.001 |
| | -0.021 | -0.013 | -0.005 | -0.004 | -0.003 | -0.001 |
| | [-4.51] | [-0.71] | [-4.73] | [-0.07] | [ 2.14] | [ 1.36] |
| d*G*(-1) | -0.195 | -0.050 | -0.449 | -0.097 | 0.022 | -0.035 |
| | -0.070 | -0.042 | -0.070 | -0.057 | -0.071 | -0.016 |
| | [-2.78] | [-1.20] | [-6.38] | [-1.71] | [ 0.31] | [-2.20] |
| d*Y*(-1) | 0.044 | 0.198 | -0.180 | 0.026 | 0.028 | 0.174 |
| | -0.124 | -0.074 | -0.075 | -0.060 | -0.314 | -0.072 |
| | [ 0.35] | [ 2.69] | [-2.40] | [ 0.43] | [ 0.09] | [ 2.44] |
| d*Y*(-2) | -0.066 | 0.126 | -0.122 | 0.029 | -0.088 | 0.143 |
| | -0.122 | -0.072 | -0.076 | -0.061 | -0.308 | -0.070 |
| | [-0.54] | [ 1.73] | [-1.61] | [ 0.48] | [-0.29] | [ 2.04] |
| d*Y*(-3) | -0.487 | 0.199 | 0.046 | 0.217 | -0.530 | 0.215 |
| | -0.130 | -0.077 | -0.089 | -0.071 | -0.321 | -0.073 |
| | [-3.76] | [ 2.58] | [ 0.52] | [ 3.04] | [-1.65] | [ 2.95] |
| d*Y*(-4) | -0.164 | -0.165 | -0.207 | 0.222 | 0.229 | -0.137 |
| | -0.145 | -0.086 | -0.093 | -0.075 | -0.349 | -0.080 |
| | [-1.13] | [-1.92] | [-2.23] | [ 2.98] | [ 0.66] | [-1.73] |
| Constant | 9.725 | 3.330 | 12.264 | 3.643 | 5.146 | 3.063 |
| | -1.562 | -0.929 | -1.616 | -1.298 | -3.428 | -0.780 |
| | [ 6.23] | [ 3.58] | [ 7.59] | [ 2.81] | [ 1.50] | [ 3.93] |
| R-squared | 0.159 | 0.135 | 0.259 | 0.142 | 0.043 | 0.155 |
| Adj. R-squared | 0.121 | 0.097 | 0.226 | 0.105 | 0.001 | 0.118 |
| F-statistic | 4.273 | 3.550 | 7.909 | 3.766 | 1.031 | 4.165 |
| Akaike AIC | 8.117 | 7.077 | 7.507 | 7.069 | 10.014 | 7.054 |
| Schwarz SC | 8.274 | 7.234 | 7.665 | 7.226 | 10.171 | 7.211 |

Included observations: 214 after adjustments
Standard errors in (parentheses) and *t*-statistics in [brackets]
Note: Insignificant lags are not shown

**Figure 1.1: Real GDP and Government Purchases**

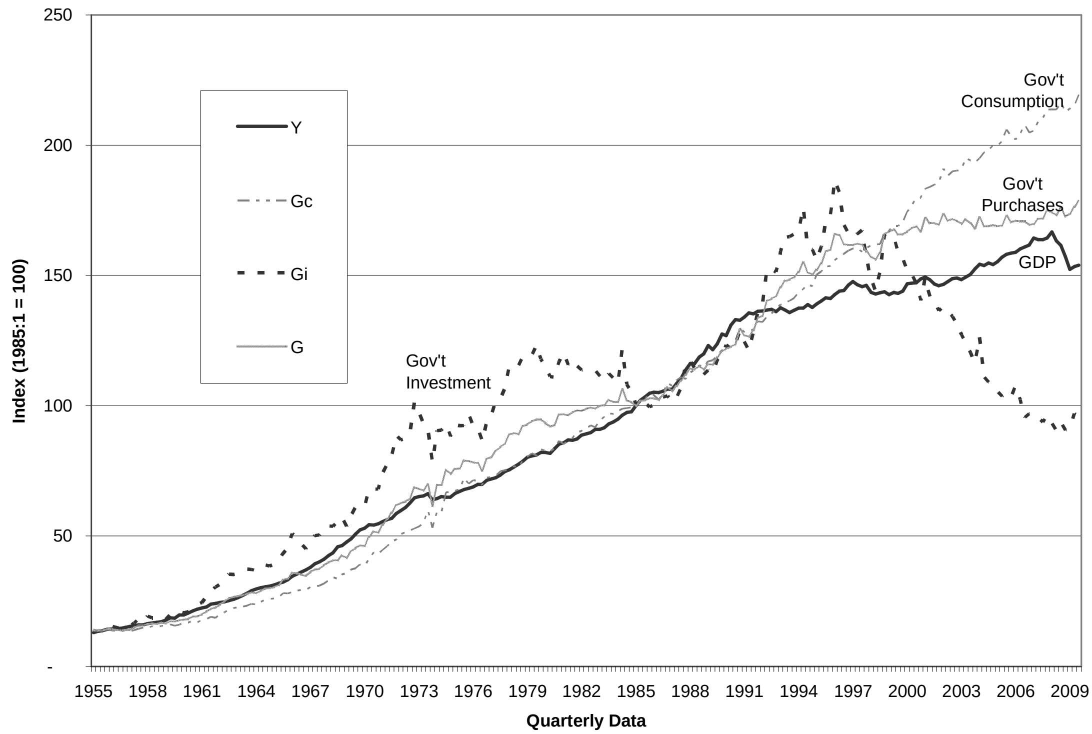



**Figure 1.2: Real Growth of GDP and Government Purchases**

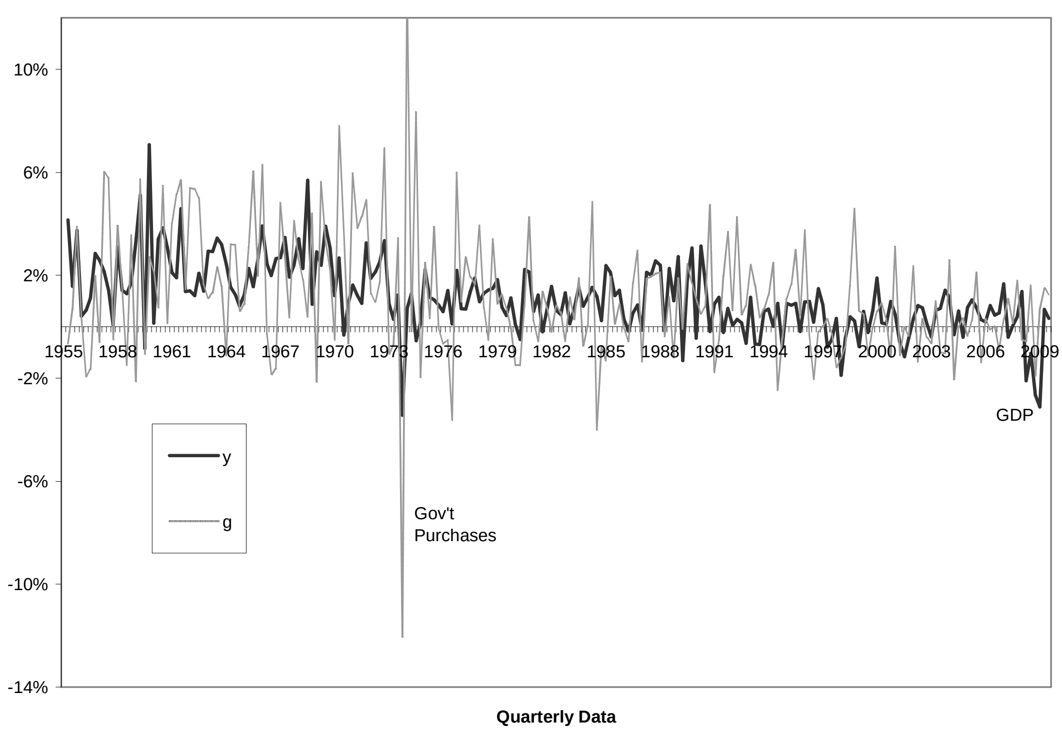


**Figure 2: Government Shares of GDP**

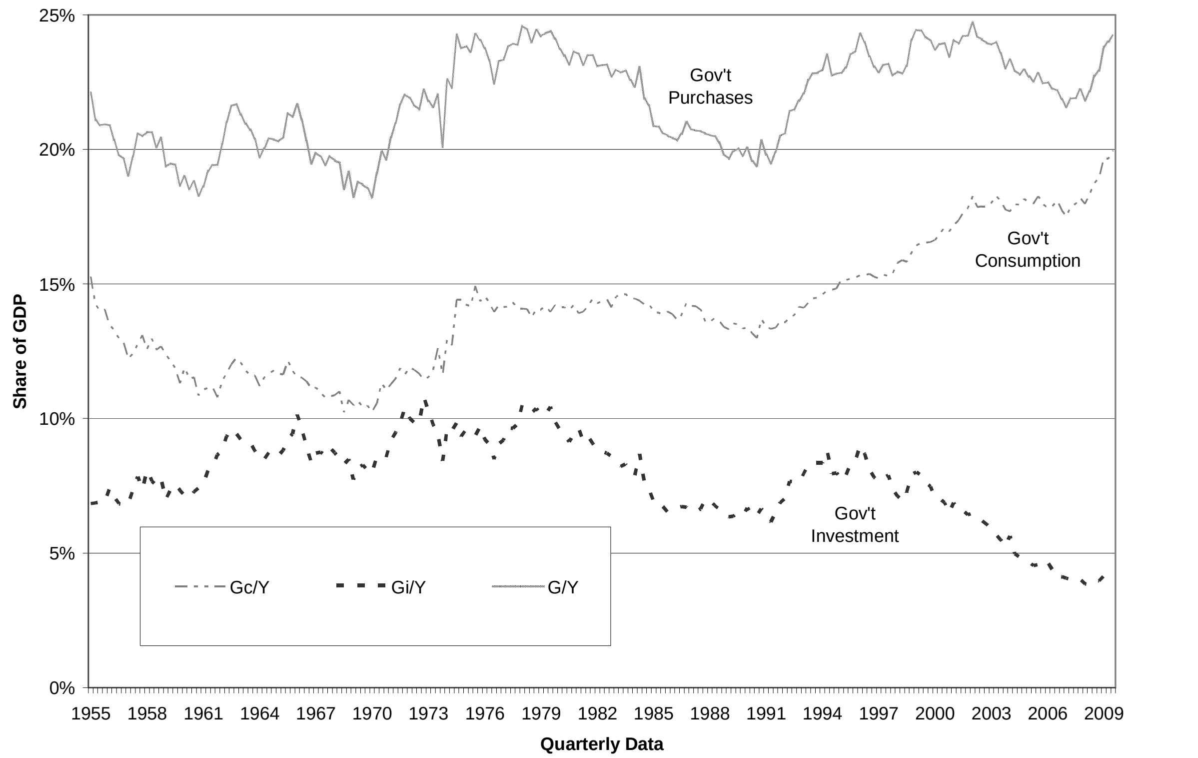
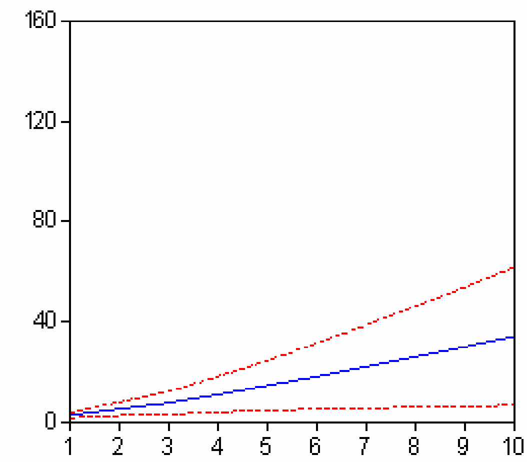
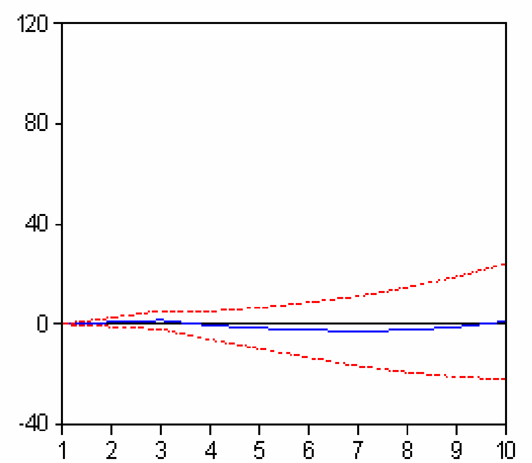


**Figure 3.1: Accumulated Response for Government Purchases**
Cholesky One-Standard Deviations +/- Two Standard Errors

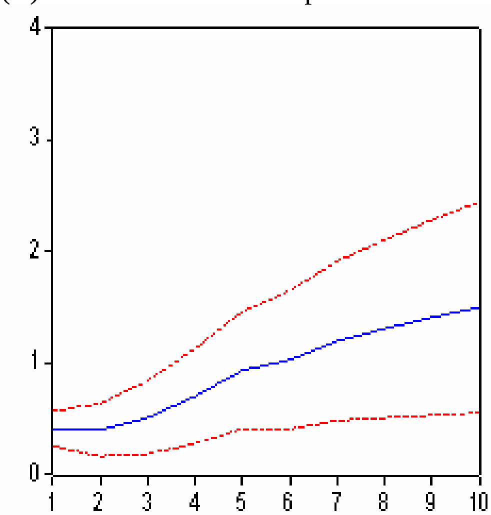
(A) Accumulated Response of *Y* to *G*




Accumulated Response of *G* to *Y*




(B) Accumulated Response of d*Y* to d*G*




Accumulated Response of d*G* to d*Y*

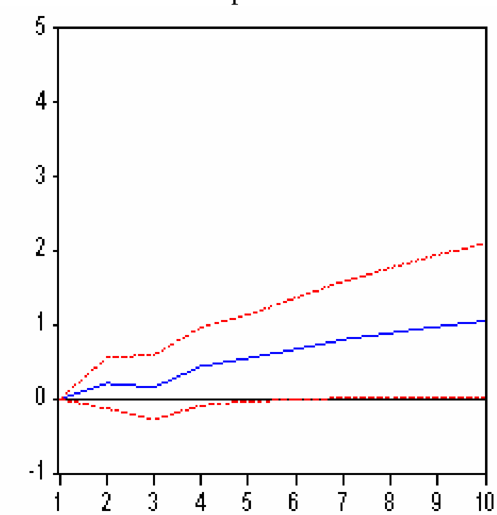
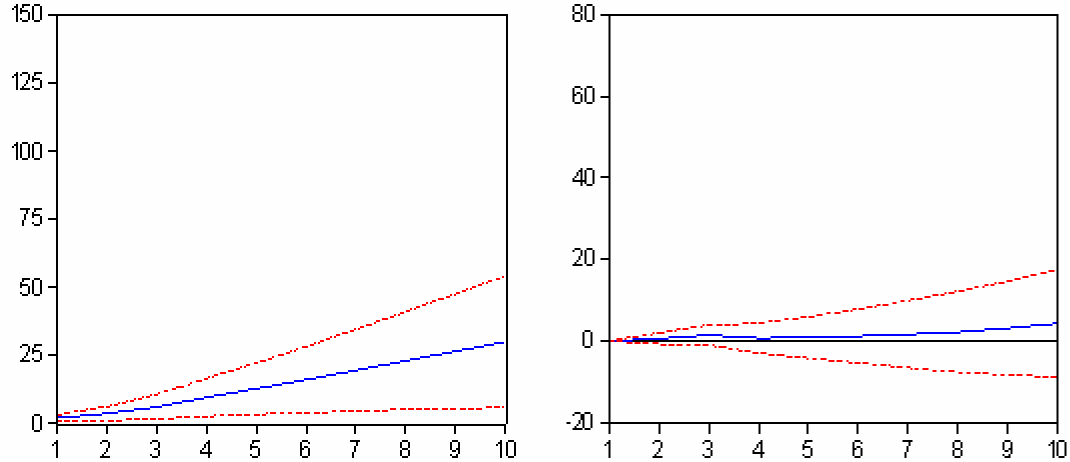


**Figure 3.2: Accumulated Response for Government Consumption**
Cholesky One-Standard Deviation Shocks +/- Two Standard Errors

(A) Accumulated Response of *Y* to *Gc* — Accumulated Response of *Gc* to *Y*




(B) Accumulated Response of d*Y* to d*Gc* — Accumulated Response of d*Gc* to d*Y*

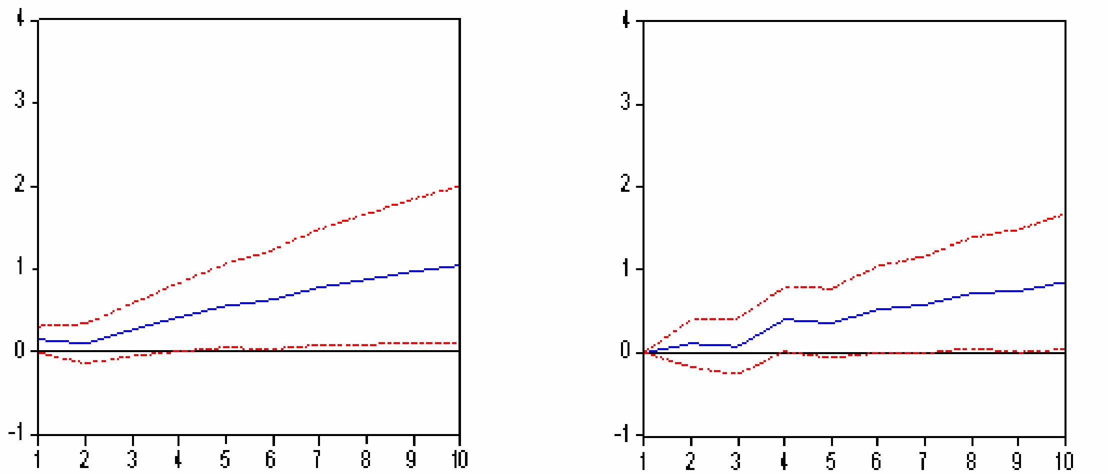
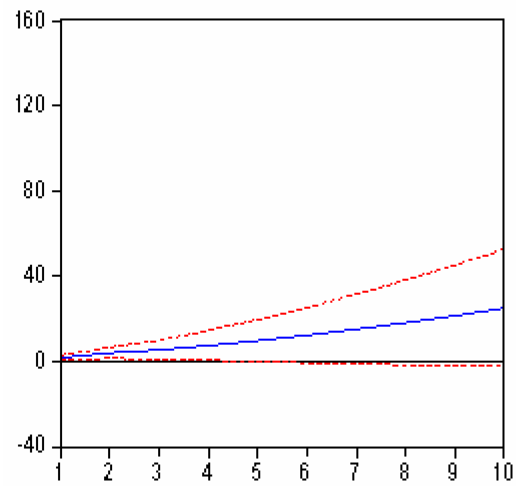
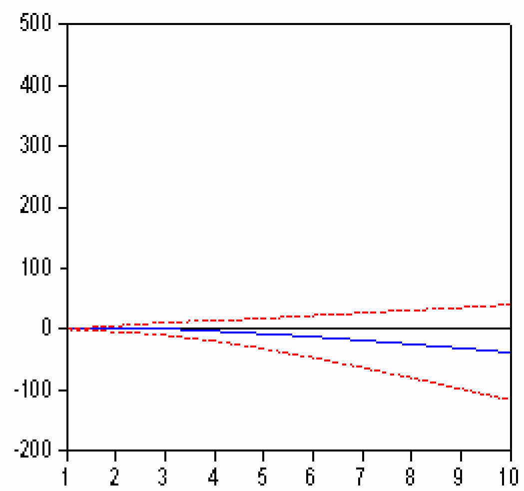


**Figure 3.3: Accumulated Response for Government Investment**
Cholesky One-Standard Deviations +/- Two Standard Errors

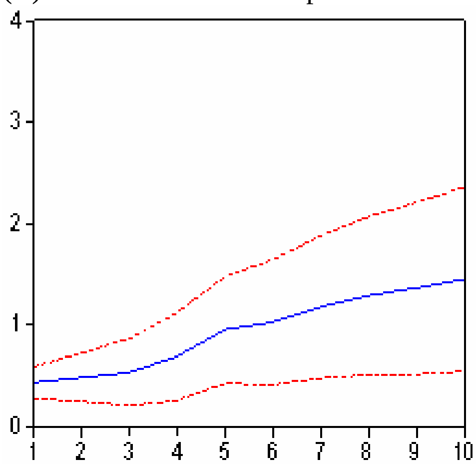
(A) Accumulated Response of *Y* to *Gi*




Accumulated Response of *Gi* to *Y*




(B) Accumulated Response of d*Y* to d*Gi*




Accumulated Response of d*Gi* to d*Y*

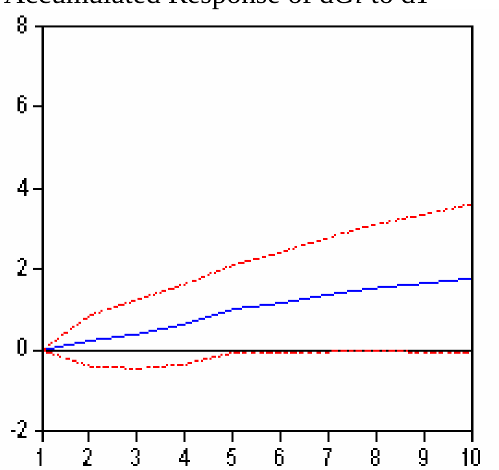


**Figure 4: Accumulated Response for Government Purchases**