On the Measurement of the Government Spending Multiplier in the United States An ARDL Cointegration Approach

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Abstract

This paper applies annual data from 1962 to 2011 to investigate the long run relationship between government spending and Gross Domestic Product (GDP) based on Barro's (1990) government spending model. The common approach only considers defense government spending to estimate the multiplier to overcome the identification problem and endogeneity in isolating the effect of changes in government spending on GDP. I use the Autoregressive Distributed Lag (ARDL) approach to cointegration, which works despite having endogenous regressors to estimate the spending multiplier. The results confirm that government spending can be treated as a 'long-run forcing' variable for the explanation of real GDP and the long-run multiplier is found to be 1.94.

Key Words: Government Spending, Spending Multiplier, Cointegration, ARDL Approach

JEL Classification: E62

1. Introduction

At the onset of a recession the first macroeconomic policy which comes to a Keynesian economist's mind is to increase the purchasing power of consumers through demand management policies like greater government spending. This idea is based upon the assumption that the spending multiplier is greater than one (Barro and Redlick 2011). In other words, if government spending increases by one dollar, Gross Domestic Product (GDP) will increase by more than one dollar.

Assuming that the multiplier is greater than one, government spending on public goods is free. When assuming a multiplier of approximately 1.5, not only is the spending of that one dollar on public goods free, but it can also produce more than one dollar in economic activity. The idea of classical economists (crowding-out effect) implies that given a multiplier of approximately 1.5, we should not consider reductions in the consumption of others or investment spending.

The argument about the overall effect of government spending on GDP remains unsettled as there is no consensus among economists about the sign and size of it. Some argue that increasing government spending will boost total output through the crowding-in effect; however, opponents to this idea insist that government spending reduces overall economic activity through the crowding-out effect. These critics assert that Keynesian theory ignores the source of government spending (Mitchell 2005). If an increase in government expenditure is financed through borrowing, the consequence will be an increase in taxes to repay the debt in the future, thereby negating any stimulative effects on the economy (Ricardian Equivalence).

Despite a lack of general consensus among economists about the size of the multiplier, there is a general understanding about the positive impacts of government spending on GDP growth.

Ramey (2011) assesses the likely range of the multiplier from 0.8 to 1.5 according to aggregate time series evidence. The range of the multiplier could be different based on different models and the assumed parameters.

For example, Evans (1969) estimates the spending multiplier to be slightly above 2.0 based on the equations in the Wharton, Klein-Goldberger, and Brookings models. However, Barro (1981) illustrates the positive effect of defense purchases and he believes the effects of nondefense purchases are imprecisely determined. In fact, an endogeneity problem and lack of proper instruments for non-defense purchase make controlling its impact on GDP much too difficult to estimate. Therefore, he assumes defense purchases increase as an exogenous shock to overcome the endogeneity problem of non-defense purchases.

Following Barro (1981), Hall (1986) focuses on non-defense purchases using military purchases as an instrument for government spending. He finds that an increase in Gross National Product (GNP) results in an increase in government spending. Rotemberg and Woodford (1992) take a similar view and focus on shocks as the residuals of a regression of military spending and conclude that the spending multiplier is 1.25. Including government purchases in a vector-auto-regression (VAR) system and making identification assumptions concerning exogeneity and timing becomes a common approach in the literature. To overcome estimation bias due to omitted variables, Romer and Romer (2009) assume that omitted variables are orthogonal to the fiscal variables. The other assumption in conducting a VAR system is the variable ordering assumption. Typically, it is assumed that government spending moves first. Based on this assumption, a VAR model is sensitive to the ordering of variables in the system. However, this approach is not satisfactory for non-defense purchases (Barro, Redlick 2011). To exemplify, Hall (2009) applied a VAR model and he finds that the multiplier may be in the range of 0.7 to 1.0.

Likewise, Barro and Redlick (2011) illustrate that all estimates of the multiplier are significantly less than one, which implies a crowding-out effect. To correct the lack of timing in investigating the government spending effect, Ramey and Shapiro (1998) propose narrative evidence of anticipated military buildups in applying a VAR model. However, based on the findings of Edelberg, Eichenbaum, and Fisher (1999), Einchenaum and Fisher (2005), and Callavo (2005), there is no considerable difference between the reported spending multiplier considering timing indicators within a range 0.6 to 1.2. Also, we can consider the status of an economy by investigating the effect of government spending instead of estimating the average multiplier for a time horizon without considering recession or expansion. For example, Auerbach and Gorodnichenko (2012) apply a structural VAR (SVAR) model and estimate multiplier ranges of -0.3 to 0.8 in expansion and a range of 1.0 to 3.6 in recession. Regardless of the different identification assumptions and different variables, the drawback of using VAR models occurs when there is more than one cointegration relationship and the "statistical approach to identification" is not reliable (Pesaran and Shin 1999).Therefore a different approach is needed to overcome the identification problem and endogeneity of government spending that is "particularly troubling in the existing literature" to isolate the effect of changes in government purchases on economic activity (Barro and Redlick 2011).

This paper attempts to solve the identification problem associated with government spending and also the endogeneity problem by using the Autoregressive Distributed Lag (ARDL) model proposed by Pesaran and Shin (1999), which works even in the presence of endogenous regressors. The ARDL procedure achieves an empirical advantage over other asymptotically efficient estimators such as DOLS, FMLS, and MLE because it is an optimal estimator

(Panopoulou and Pittis, 2004). I apply the ARDL approach to estimate the spending multiplier using a production function extracted from Barro's spending model (1990).

The remainder of the paper is organized in the following way: Section II discusses data and an estimation strategy. Section III provides empirical results. Finally, section IV summarizes the conclusions of the study.

2. Data and Estimation Strategy

I use annual real GDP data from 1962 to 2011, real capital stock, and real government spending, which are obtained from the Federal Reserve Economic Data (FRED) database. Following Barro's government spending model (1990), I assume that the production function consists of private sector (capital) and public sector (government spending) in the Cobb-Douglas production format:

$$Y = AK^{\alpha}G^{\beta} \qquad (1)$$

However, I do not make the assumption of constant returns to scale for the production function. Modifying the Cobb-Douglas production function by transforming the relationship to logarithmic form, I specify the regression as:

$$\ln RGDP_t = c + \alpha \ln RK_t + \beta \ln RGE_t + \varepsilon_t \qquad (2)$$

Where $\ln RGDP$ is the logarithm of real GDP, $\ln RK$ is the logarithm of real capital stock, $\ln RGE$ is the logarithm of real government spending, c is the constant term, and ε is the error term. I use the ARDL approach to investigate the long-run relationship among the variables. The main advantage of this testing and estimation strategy is that it can be applied regardless of having I(0) or I(1) regressors (Pesaran et al. 2001). To avoid having variables that are I(2), I use the Augmented Dickey-Fuller (ADF) test and find that all variables are I(1). I proceed with ARDL as:

$$\Delta \ln RGDP_t = \alpha + \sum_{i=1}^{n} \beta_i \Delta \ln RGDP_{t-i} + \sum_{i=0}^{n} \gamma_i \Delta \ln RK_{t-i} + \sum_{i=0}^{n} \eta_i \Delta \ln RGE_{t-i} + \lambda_1 \ln RGDP_{t-1} + \lambda_2 \ln RK_{t-1} + \lambda_3 \ln RGE_{t-1} + \mu_t \qquad (3)$$

The first part of the equation with parameters β_i , γ_i , and η_i the shows short-run dynamics of the model. The second part illustrates the long-run relationship with parameters λ_1, λ_2, and λ_3. The null hypothesis of existing cointegration is:

H_0: $\lambda_1 = \lambda_2 = \lambda_3 = 0$

H_1: $\lambda_1 \neq 0, \lambda_2 \neq 0, \lambda_3 \neq 0$

Pesaran and Shin (1999) propose a two-stage procedure, which works even when having endogenous regressors. The first stage is selecting the ARDL order using Schwartz Bayesian criterion (SBC) or Akaike Information Criterion (AIC), however, SBC performs slightly better. Then the ARDL model is estimated based on the optimum number of lags.

The existence of cointegration can be investigated by conducting the bounds test. The F-test critical value tabulated by Pesaran (1997) and Pesaran et al. (2001) allows us to see if there is a long-run relationship among the variables. Estimating λ_3 as the elasticity of real GDP with respect to government spending allows us to calculate the spending multiplier. I use the arc elasticity formula to find the size of the fiscal multiplier as follows:

$$\frac{d \ln RGDP}{d \ln RGE} = \frac{dRGDP}{dRGE} * \frac{RGE_{Ave}}{RGDP_{Ave}}$$

Having long-run elasticity and the ratio of the average real government spending and real GDP enables us to calculate the government spending multiplier ($\frac{dRGDP}{dRGE}$).

The error correction model (ECM) can be estimated to see the speed of adjustment to long-run equilibrium due to short-run disturbance. I estimate the standard ECM as follows:

$$\Delta \ln RGDP_t = \alpha' + \sum_{i=1}^{n} \beta'_i \Delta \ln RGDP_{t-i} + \sum_{i=0}^{n} \gamma'_i \Delta \ln RK_{t-i} + \sum_{i=0}^{n} \eta'_i \Delta \ln RGE_{t-i} + \omega_1 ECM_{t-1} + \nu_t \qquad (4)$$

3. Empirical Results

I use the ADF test to check that the variables are not I(2). The test confirms that the variables I have in the ARDL model are I(1). The ARDL bounds test approach for equilibrium long-run relationship among the variables is conducted by using the F-test. For two regressors the relevant critical value bounds at the 95 per cent level are 3.79 and 4.85. Since F ($\ln RGDP | \ln RK$, $\ln RGE$)= 6.24, which is greater than the upper bound critical level, I reject the null hypothesis of no long-run relationship between $\ln RGDP$, $\ln RK$, and $\ln RGE$ regardless of the order of their integration. The challenging issue of causality from GDP to government spending could be addressed here clearly. Since F ($\ln RGE | \ln RGDP$,$\ln RK$)= 0.07 and F ($\ln RK | \ln RGDP$, $\ln RGE$)= 0.06 both fall well below the lower bound of the critical value band, the variables $\ln RGE$ (government spending) and $\ln RK$ (Capital Stock) can be treated as the 'long-run forcing' variables for the explanation of $\ln RGDP$ (real GDP) (Pesaran and Pesaran 1997). Using long-run coefficient estimates, I replace lagged level variables with ECM_{t-1} and re-estimate the model at the same optimum lags. The negative and significant ECM_{t-1} coefficient supports

Table 1: Full-Information Estimate of Equation (3)

Panel A: Short-Run Coefficient Estimates

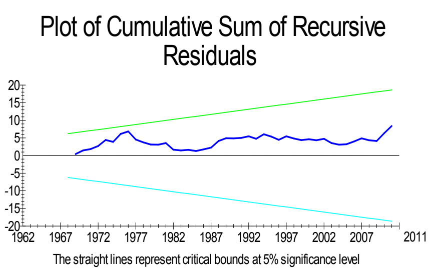
	Lag Order				
	0	1	2	3	4
$\Delta \ln RGE$	5.37	-5.01	0.87		
	(26.52)	(14.42)	(4.15)		
$\Delta \ln RK$	0.22				
	(6.38)				

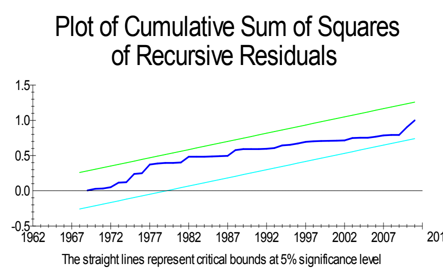
Panel B: Long-Run Coefficient Estimates

Constant	$\ln RK$	$\ln RGE$
-9.00	0.85	0.45
(16.23)	(12.10)	(4.47)

Panel C: Diagnostic Statistics

F	ECM_{t-1}	LM	RESET	Normality	Adj. R^2
6.24	-0.15	0.95	1.40	1.27	0.94
	(3.51)				





Notes:

a. Numbers inside parentheses are absolute value of t-ratio

b. The upper bound critical value of the F test at the usual 5% level of significance is 4.85. This comes from Pesaran *et al*. (2001, Table CI-Case III, p. 300)

c. LM is the Lagrange multiplier test for serial correlation. It has a χ^2 distribution with one degree of freedom. The critical value at 5% level of significance is 3.84.

d. RESET is Ramsey's specification test. It has a χ^2 distribution with only one degree of freedom. The critical value at the 5% level of significance is 3.84.

e. The normality test is based on test of skewness and kurtosis of residuals. It has the χ^2 distribution with only two degrees of freedom. The critical value at the 5% level of significance is 5.99.

adjustment toward equilibrium. The negative and significant coefficient of lagged error-correction term is another way of establishing cointegration. Also, I conduct three diagnostic tests. The Lagrange Multiplier (LM) confirms no serial correlation among the error terms, which means there is no omitted variable bias in the model (Pesaran et al, 2001, p.308). Ramsey's RESET test rejects the functional misspecification. Furthermore, normality holds for residuals. I apply CUSUM and CUSUMQ tests to the residuals of the estimated error-correction model to investigate the stability of estimated coefficients. Stability of the coefficients is confirmed by both the CUSUM and the CUSUMQ tests.

The estimated error correction model has a very high goodness of fit, as reflected by 94% adjusted R^2. As can be seen from Table 1, the long-run elasticity of real GDP (RGDP) with respect to real government spending (RGE) is 0.45, which is significant. If I use this elasticity by considering the arc elasticity formula ($\frac{RGE_{Ave}}{RGDP_{Ave}} = 0.23$), the long run multiplier is found to be 1.94. Although Ramey (2011) assesses the likely range of the multiplier is probably between 0.8 and 1.5 using common approaches, this estimation confirms his idea that the range of multiplier could be different based on different model construction and the assumed parameters. However, we should apply the optimal estimator to have a more accurate estimation of the multiplier as I did using the ARDL procedure.

4. Conclusion

The paper contributes to the debate on the size of the spending multiplier. The main drawbacks of using the common approach in the literature, a VAR model, are the identification problem and the endogeneity troubling isolation of the effect of government spending changes on economic activity. In previous studies the focus was on defense purchases to overcome the endogeneity problem. However, I consider the aggregate government spending (defense and nondefense) using Barro's (1990) government spending model. I apply the ARDL approach, which works despite having endogenous regressors to investigate the long run relationship between government spending and GDP. The results suggests that there exist a long-run relationship between Real GDP ($\ln RGDP$), Real Government Spending ($\ln RGE$), and Real Capital Stock (LnRK) and the variables $\ln RGE$ and LRK can be treated as the 'long-run forcing' variables for the explanation of $\ln RGDP$. After estimating the elasticity of real GDP with respect to real government spending I apply arc elasticity definition to find the multiplier, which is 1.94. This means that in the long run every one dollar increase in real government spending results in an increase of 1.94 dollars in real GDP. This estimation confirms that the range of the multiplier could be different based on different model construction and the assumed parameters (Ramey 2011). The main contribution of this paper is using the ARDL approach to overcome endogeneity problem. I show that there is just one causality direction from government spending to real GDP in the long-run by using an optimal estimator (ARDL). However, previous studies have not applied an optimal estimator and they focused on exogenous military spending to overcome endogeneity problem by using the VAR and SVAR models, which are not reliable (Pesaran and Shin, 1997). Therefore, I believe my estimation is more accurate and reliable than other time series approaches.

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