Explaining the Cross-Country Variation in Fiscal Multipliers: A Bayesian Approach

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Abstract

The effectiveness of fiscal policy is subject to crowding out. For nearly thirty years of annual economic data, we find that the crowding out of fiscal policy occurs through interest rate and exchange rate channels. The three most important determinants affecting the size and sign of fiscal multipliers during recessions worldwide are: (i) exchange rate regime, (ii) monetary policy, and (iii) current account balance. We find statistically significant results that these accompanying policies are the most influential sources of the cross-country variation in fiscal multipliers. Similarly, using an OECD dataset examining both economic expansions and recessions, we find that the three most statistically significant variables affecting fiscal multipliers in this case are: (i) exchange rate stance, (ii) private investment, and (iii) monetary policy. We find that the coefficient of the private investment variable is significantly negative, which is in line with the theoretical predictions. This finding is consistent with the hypothesis that expansionary government spending financed by debt crowds out private investment through rising interest rates.

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(1) Introduction

There is a lack of consensus in the literature regarding the effectiveness of fiscal policy. Theory and empirics are often at odds with one another and we do not yet have a full understanding of the transmission mechanisms of fiscal policy.[1] We have seen that over the last decade, several political and economic developments turned the spotlight on research towards fiscal policy. In Europe, the introduction of the European Monetary Union (EMU) made fiscal adjustments extremely crucial for the member countries. Since 1995, many of these European countries have implemented extensive fiscal reforms. This, along with other recent developments in the U.S. has led to more attention directed towards understanding the implications of such fiscal adjustments. Many other contemporary discussions also focus on the potential for discretionary government policy to stimulate economic activity.[2] These studies particularly document the widespread cross country variation in fiscal multipliers and the difficulty in explaining them. According to Baldacci and others (2001, p. 36), "a simple framework may not capture all the country-specific factors that are likely to play a role in accounting for the complex relationship between fiscal policy and economic activity…there is wide variety, which results in large variance and insignificant results in the econometric analysis". To the best of our knowledge, we are yet to find a study that clearly identifies the root cause(s) of the cross-country variation in the fiscal multiplier.

This study investigates the determinants of the cross-country variation in fiscal multipliers documented in the previous literature. Using two comparable datasets, our first sample is restricted to recession episodes for sixty-five advanced and developing economies worldwide. Our second sample, on the other hand, is an unrestricted sample of 17 OECD countries that includes both economic expansions and recessions. Using these two datasets enable us to accomplish two things: (i) ascertain the key factors that influence the effectiveness of fiscal policy, and (ii) compare the results of our study to the results of previous empirical and theoretical work.

[1] See Giavazzi and Pagano (1990), Perotti (2002), Arin and Koray (2006) for non-Keynesian effects.
[2] Baldacci, Cangiano, Mahfouz, and Schimmelpfennig (2001) examine fiscal policy during recessions, and Ardagna (2001) investigates the composition of fiscal policy and the role of debt on economic activity.

By using Bayesian Model Averaging (BMA) methodology, we are able to account for the vast differences in the sign and magnitude of fiscal multipliers. We find that the effectiveness of fiscal policy is subject to 'crowding out' effects – particularly through the interest rate and exchange rate channels.[3] During recessions, the three most significant variables chosen from a wide array of thirty-four potential explanatory variables are the exchange rate regime, monetary policy, and the current account balance.[4] We find statistically significant results that these accompanying policies are the most influential sources of the cross-country variation in fiscal multipliers. The selection of these most significant variables also features heavily in our top ranked model specifications obtained through the model averaging process. These results have strong economic significance, which promote supporting accompanying policies (monetary and exchange rate policies) along with fiscal initiatives during recessions. One theoretical explanation provided by Pilbeam (2006), is the problem of multiple and often competing economic objectives facing policymakers, and the inability of a single policy tool to achieve these objectives. As a result, accompanying policies used to support fiscal policy are likely to be more effective in successfully stimulating economic activity. This is also supported empirically by Hemming, Mahfouz, and Schimmelpfennig (2002) who argue that accompanying monetary and exchange rate policies, among other things, improve the effectiveness of a fiscal expansion during recessions.

Similarly, we find that the three most statistically significant variables affecting fiscal multipliers in our unrestricted OECD sample are the exchange rate policy, private investment, and monetary policy.[5] We find that the accompanying policies (exchange rate and monetary policies) are once again prominent, however, the most striking result here is the effect of private investment on the fiscal multiplier. The coefficient estimate is not only statistically significant but also negative in sign, which is in line with the theoretical

[3] Crowding out can occur through the interest rate channel that affects private investment; or in open economies with flexible regimes, exchange rates can typically affect domestic exports.

[4] Bayesian Model Averaging (BMA) methodology essentially ranks statistical significance according to posterior probabilities. The derivation of the methodology is discussed in section (4), Estimation Methodology.

[5] This OECD sample consists of both economic expansions and recessions.

predictions. This is consistent with the hypothesis that expansionary government spending financed by debt crowds out private investment through rising interest rates.

We feel that our study makes two important contributions to the literature. First, we implement a strategy using Bayesian Model Averaging (BMA) methods influenced by Fernandez, Ley, and Steel (2001). This method has not been previously employed in such a study of fiscal policy. This methodology overcomes the problem of model uncertainty that inherently plagues the literature in this area, and also provides a framework that enables us to identify the root cause(s) of the cross-country variation in fiscal multipliers. These are selected from a vast set of potentially important explanatory variables indicated by previous empirical and theoretical work. The methodology is also grounded in strong statistical theory and is unique to normal procedures of inference. Given a set of explanatory variables, Bayesian Model Averaging provides a robust procedure to recognize the models that are most significant in explaining this well documented variation. Essentially, the process facilitates any particular subset of regressors to unite within a given regression and thus, approximates the posterior probability of such a combination.

Our second contribution fills a gap in the literature by documenting clear evidence of the effects of crowding out on fiscal policy. We find that the most significant determinants of fiscal multipliers during recessions (particularly the method of crowding out) have subtle differences in comparison to the unrestricted OECD sample. Specifically, the role of private investment is not significant in the worldwide recession sample. However, by studying recessions, we can assess the effectiveness of fiscal policy which is often questioned under such circumstances; for example, Kandil (2006), and Lane and others (1999) comment on the recession in the U.S. in the early nineties, and on more recent prolonged recessions in Japan and other Asian crisis countries. They explicitly focus on the inability of fiscal stimulus to support economic activity during such episodes. Our study enables us to answer the question of whether and when fiscal policy and other accompanying policies are important in supporting economic activity. The results highlight the importance of the accompanying policies (in the form of the interest rate and exchange rate) as well as the degree of financing constraints facing the government (in the form of the current account balance) during recessions.

In another study of fiscal policy during recessions, Baldacci *et al.* (2001) take an important first step in answering similar questions. When there is a lot of slack in the economy and the priority lies in reviving the economy, they suggest that the accompanying monetary policy and the exchange rate regime in action are one of a number of important factors influencing the effectiveness of fiscal policy. Yet their analysis is somewhat constrained statistically – they examine only recessions and therefore lose many observations.

We feel that if our study is restricted to recessions only, it may face a similar constraint and we therefore supplement it with an unrestricted study of economic expansions and recessions in OECD countries. This also provides a sort of comparative base to gauge the effectiveness of fiscal policy in different economic conditions, and distinguish the channels that affect it. While the importance of underlying accompanying policies is similar in the OECD sample, the key difference in this case is the role of private investment. The negative response substantiates the notion of crowding out and meets the result presented by economic theory. We are the first to provide statistically and economically significant evidence of the crowding out of private investment.[6]

In relation to other empirical studies, there is considerable cross-country variation in fiscal multipliers documented by Perotti (2002) and Van Aarle, Garretsen, Gobbin (2002). Using a different approach to ours, they show through Vector Auto-Regressive (VAR) models that individual countries have a tendency to react to similar fiscal policy actions differently. In fact, Giavazzi and Pagano (1990) even suggest that some fiscal contractions may be expansionary. Citing specific episodes of fiscal contractions in Denmark (1983-86) and Ireland (1987-89), they challenge the Keynesian ideal and the general consensus that fiscal multipliers, although varying in degree, are nonetheless positive.

[6] This is based on the assumption of a negative relationship between investment and interest rates.

The wide variation documented in the literature should not be at all surprising, since economic theory itself suggests that different tax groups may have different effects on the economy. Atkinson and Stiglitz (1980) develop a basic inter-temporal model, which shows that income taxes and consumption taxes have different effects on household saving decisions. There is also direct empirical support for the differential effects of the various tax groups. For instance, using a panel of 22 OECD countries, Kneller, Bleaney, Gemmell (1999) contend that distortionary taxation reduces growth, whereas non-distortionary taxation does not. Moreover, productive government expenditure enhances growth, while nonproductive government expenditure does not.[7] Hence, the composition of the fiscal response may be another important factor in explaining the cross-country variation in fiscal multipliers.

The current state of empirical research on the effects of fiscal policy actions is still not adequate as the transmission channels of fiscal policy are unresolved. There are studies that show the impact of fiscal policy on interest rates.[8] However, the extent of crowding out through interest rates still depends on the relationship between investment and interest rates. Hemming, Kell, and Mahfouz (2002) survey the empirical literature in this area and conclude that there is little evidence of the crowding out of investment through interest rates; moreover, the literature suggests that investment tends to be influenced more by output and other key macroeconomic variables rather than interest rates. However, Zarnowitz (1999) is an exception – he finds a negative and significant effect between investment and the user cost of capital, although the magnitude is very small. Our approach differs to all these studies in a number of ways. We focus on the explicit relationship between fiscal policy and investment. This allows us to determine whether private investment specifically responds to a fiscal induced action, as opposed to a general interest rate (or monetary policy) induced action.[9] We also consider the U.S. along with a panel of

[7] For example, they define distortionary taxation as taxes on income, profit, payroll, property and social security taxes. Non-distortionary taxation includes taxes on domestic goods and services (indirect taxes), among other things.

[8] For example, Barro (1992) finds that a 1 percent of GDP increase in U.S. debt increases interest rates by 12 basis points.

[9] This is common in many studies that do not consider fiscal policy; for example, Zarnowitz (1999) concentrates specifically on the investment response to a change in interest rates. We also distinguish between private and public investment as opposed to an aggregate investment variable.

other OECD countries with a much greater variety of regressors that characterize interest sensitive items (including investment) along with the initial economic conditions, characteristics of the fiscal response, accompanying policies, and political factors.[10]

Given the wide variety and variance in fiscal multipliers, this has led Baldacci *et al.* (2001) to explore unconventional techniques to attempt to solve the problem. They focus on recessions as they try to explain the cross-country variation for a large set of countries in a number of ways; including descriptive analysis, multidimensional statistical analysis, as well as standard regression analysis. They highlight the fact that economic theory indicates many plausible avenues of fiscal transmission, however, there is a considerable absence of empirical evidence to support these claims.

The Bayesian approach distinguishes itself from other methods when prior information regarding a variable or even a model specification is vague.[11] Such is the complexity of fiscal analysis that it may be difficult to choose exactly relevant explanatory variables using traditional regression methods. There is a wide range of possible economic/political factors inducing the cross-country variation in fiscal multipliers that are unresolved. Model specification thus becomes a very subjective exercise, using predetermined beliefs and possibly producing some analytical bias.[12] The usual procedures of inference attempt to be purely empirical in the sense that data driven information is favored to either prove, or disprove a certain hypothesis. However, an objection is that in various instances, scholars well versed in the 'frequentist' paradigm may unknowingly allow their assumptions and prior beliefs to influence their results.[13] As such, we favor a method that mechanically limits the input required from the researcher and solves the problem of model uncertainty.

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[10] Much of the reviewed literature in Hemming, Kell, and Mahfouz (2002) on this topic investigates only the U.S. with a limited range of variables, many of which act as proxy variables for one another. The lack of evidence is not surprising since it is well documented in Perotti (2002) that fiscal multipliers for the U.S., post 1980, generally become smaller and with more variance.

[11] The term *prior* is part of the vocabulary in Bayesian theory. It is generally interpreted as a description of what is known about a variable in the absence of some evidence; see Koop (2003).

[12] For example, Sala-i-Martin, Doppelhofer, and Miller (2004) indicate that 'artistic' economic theory can often suggest an enormous number of potential explanatory variables in any economic field.

[13] The term 'frequentist' refers to the usual method of statistical hypothesis testing.

The crucial difference between the 'Frequentist' approach and our present 'Bayesian' edition is the process of extracting and treating information. According to Bayesian Model Averaging methodology, prior probabilities are assigned to the various possible models. The model itself, therefore, becomes a random variable. As a result, both parameter and model uncertainty are accounted for. The next step utilizes the sample evidence and the posterior probabilities are then estimated for each model. These posterior results essentially give the probability that a particular model is the best model given the data. This 'inference' is then averaged over all models, with the posterior probabilities used appropriately as weights. During this process, the marginal posterior probabilities are also computed for each potential regressor. These are simply the sum of the posterior probabilities of all those models that include a particular regressor.

No matter what approach is favored to explain the cross country variation in fiscal multipliers, no single method is more suited to, or more capable of extracting all the relevant information from the data better than the Bayesian one. This is due to the vast difference in size and composition of fiscal balances, variety in initial economic conditions, accompanying policies and developments, together with the complexity of fiscal transmission channels documented in Baldacci *et al.* (2001). The merit of this Bayesian approach lies in its practical application, and a strong grounding in statistical theory to complement its use. Quite simply, it is capable of effortlessly placing all the information contained in the data and carefully process this through intensive computation.[14] Using this approach, topics such as policy evaluation under uncertain economic conditions are discussed in Brock, Durlauf, and West (2003). A key intuition behind their study is that model selection (by itself), which is a foremost endeavor in empirical research, is actually redundant in policy evaluation. More specifically, they state that conditioning policy evaluation on a single model ignores model uncertainty, since the usual methods of statistical analyses pay no attention to evaluate the robustness of policies across different model specifications.[15]

[14] There is no need to rely on any type of 'pre-test estimator' or tests of significance to distinguish significant variables and eliminate the insignificant ones, which is a common technique in standard regression analysis.
[15] The application of this Bayesian approach and its use in other contemporary economic research is discussed in section (4.2), Bayesian Model Averaging.

So far, we have discussed reasons why BMA provides an intuitively appealing framework, especially overcoming model uncertainty. However, it has only recently gained some popularity as a complementary tool for the researcher. This reflects some of the challenges in executing BMA. Hoeting and others (1999) summarize three primary issues. First, the number of models/terms to consider can be extremely large (i.e. given K, the number of regressors, the average of the posterior distributions under each of the models weighted by their posterior model probability comes from a possible 2^K sampling models). As a result, computation may be quite difficult. Second, certain technical issues remain, especially when it comes to computing and finding solutions to integrals inherent in the model averaging process.[16] Third, choice of prior distributions (a commonly cited defect) still remains a looming problem, and only until recently has there been some progress in this area.[17]

We provide further insight on the Bayesian approach and overcoming its various challenges at a later point. However, the rest of the paper is organized as follows. Section (2) provides a literature survey of empirical and theoretical literature that forms the basis of our study. Several findings are presented that allude to the varying nature of fiscal multipliers. Section (3) presents a description of the data used in BMA process, including the composition of each respective sample and justification behind the inclusion of variables. Section (4) concerns itself with the estimation methodology beginning with a review of general Bayesian theory, and then full details of the setup and implementation of the BMA process itself. Section (5) reports full results with the analysis via posterior inference of individual regressors and models. We also conduct a series of panel estimations to assess the effects of our most significant variables on fiscal multipliers. Robustness checks are implemented in section (6), and finally, section (7) concludes our investigation along with some suggestions for future research opportunities.

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[16] These issues are considered in sections (4.2 and 4.2), in the derivation of the methodology.

[17] Fernandez, Ley, and Steel (2001) provide a valid and appealing framework to mitigate this problem.

(2) Previous Literature

This section provides a review of previous fiscal policy studies starting with the notion of Ricardian Equivalence, and followed by a selection of contemporary VAR based literature. The results of the VAR based literature are explored in the context of Non-Keynesian Effects, Positive Tax Multipliers, and the Financial Markets. Finally, we provide an overview of various contemporary applications of Bayesian Model Averaging.

(2.1) Ricardian Equivalence

Early studies on fiscal policy focus on the Ricardian Equivalence Theorem, first suggested by Barro (1974). Ricardian equivalence states that a switch from lump-sum tax finance to deficit finance has no effect on the macro-economy; which means that the price level, income, consumption and interest rates will not be affected. The logic behind the Ricardian equivalence is that there is an inter-temporal budget constraint facing the government. The present value of the government revenues should be equal to the present value of government expenditures. Ricardian equivalence therefore implies that economic agents are not myopic and they know that cutting taxes today merely pushes these taxes in the future.

Empirical evidence is scant and mixed in support of this Ricardian equivalence theorem.[18] However, the framework is appealing and is often referred to in more general fiscal policy studies such as Baldacci *et al.* (2001). It specifically considers the financing constraints facing the government and the actions of the private sector that respond by changing consumption patterns. Furthermore, this theorem nicely links with the notion of crowding out. Following an increase in government spending, Ricardian consumers would anticipate increased future tax liability and decrease their consumption accordingly. The increase in government spending places greater pressure on the limited pool of available credit and raises interest rates. As a result, private investment declines and this either offsets or partially moderates the intended government stimulus.

[18] See Seater (1993) and Kormendi (1993) below.

There are reasons suggested by Seater (1993) that may lead to the failure of the Ricardian equivalence; including finite horizons, non-altruistic motives, liquidity constraints and uncertainty. On the other hand, Kormendi (1993) tests the Ricardian equivalence theorem, and his results provide direct support for this theorem. To explain private sector behavior, Kormendi utilizes a consolidated approach that is based on the permanent income hypothesis. In his specification of private sector consumption, Kormendi finds that government spending and the government stock of bonds affects private consumption negatively. These results suggest that government debt depresses private sector wealth when the present value of future taxes is greater than the present value of expenditures.

Nevertheless, we must admit that whether one is in favor or not of this Ricardian proposition, the method of financing government activity undoubtedly has a significant impact on the economy.

(2.2) VAR Based Literature

Economic theory suggests that fiscal policy might also have supply-side effects. It is only comparatively recently that much attention has been directed towards estimating the effects of fiscal policy within Vector Auto-regressive (VAR) models.

Edelberg, Eichenbaum, and Fisher (1999) examine the effects of exogenous shocks to U.S. real government defense purchases within VAR models. These exogenous shocks are measured by narrative based dummy variables created by Ramey and Shapiro that consist of four historical events: World War 2, Korean War, Vietnam War and the Carter-Reagan build-up. However, World War 2 was omitted because patriotism then seemed to induce large supply shifts. They use a 5 variable VAR specification: log level of GDP, 3-month T-bill rate, log of producer price index of crude fuel, log level of real defense spending and log level of another variable (among a list of variables of which one is added at a time, including employment, investment, CPI, etc). Their results suggest that a shock to government defense spending has a temporary "hump-shaped" effect on output, while real wages and consumption expenditures fall. They also make a distinction between residential and non-residential investment and find that residential investment falls, whereas non-residential investment increases.

Similarly, Fatas and Mihov (2002) examine the effects of exogenous shocks to real government purchases in a semi-structural VAR model by using U.S. data. They on the other hand, contrast the findings of Edelberg *et al.* (2001) and suggest that government expenditure has a pronounced and positive effect on output, lasting for a greater period of time. Most studies including VAR and non-VAR based literature find that output responds in a positive manner to an unanticipated increase in government spending. However, the interesting point is that the size of the estimated multiplier depends on the specification of the model and its parameters. This is the main issue that affects many empirical studies. For example, Baxter and King (1993) find fiscal multipliers on output are larger in the long run than in the short run, while Ramey and Shapiro (1998) find that output peaks within a relatively short time frame. While many studies indicate very plausible transmission channels for fiscal shocks, none of the studies directly identify the determinants of the variation in the fiscal multiplier.

By using a structural VAR approach, Blanchard and Perotti (2002) estimate the effects of exogenous shocks to real government purchases as well as real net taxes. They make a significant contribution to the economic literature by producing the first study to incorporate taxes. They use institutional information about tax and transfer systems and timing of tax collections to identify the automatic stabilizing aspects of fiscal policy, and use that information in deriving fiscal shocks. Their results show that positive government spending shocks tend to have a transitory effect on output, while positive tax shocks consistently have a negative effect. In relation to other studies, Edelberg *et al.* (1999) also find that an increase in government spending has a temporary hump shaped effect on output, unlike Fatas and Mihov (2002) who find a persistent positive effect on output. These differences in the response of output may be characterized by the response of investment. The response of investment is crucial as it not only affects long term growth, but also gives an indication of any crowding out that may occur.[19] While Edelberg *et al.* (1999) discover a positive but temporary effect on non-residential investment and a negative but temporary effect on residential investment, Fatas and Mihov (2002) find that investment does not respond significantly at all to government spending increases.

(2.3) Non-Keynesian Effects

There are a number of empirical studies that follow Giavazzi and Pagano (1990), who suggest that certain episodes of fiscal contraction are actually expansionary in the short term. Alesina, Ardagna, Perotti, and Schiantarelli (2002) investigate how different components of expenditure and revenue sides of the government budget influence profits and investment. Utilizing a data set of 18 OECD countries from 1960-96, they define a fiscal contraction according to the primary structural balance, if it improves by at least two percentage points of GDP in one year or one and a quarter percentage points of GDP in two consecutive years. A major component of their model incorporates the labor market channel as a means of transmission for fiscal policy, which in turn affects profits and investment. They find that a reduction in primary spending or an increase in labor taxes increases investment, which has an expansionary effect. However, the results suggest that the magnitude of the effects from the revenue side is less that the expenditure side. This is most interesting, since it provides an alternative explanation of the interaction between fiscal policy, profits, and investment.

In addition, Perotti (2002) estimates the effects of fiscal policy in five OECD countries within a structural VAR framework. One of the first studies to incorporate non-U.S. data, Perotti contends that over the whole sample, the effect of spending multipliers on output is positive. However, he provides evidence of positive tax multipliers on output for Australia, the UK and West Germany. Furthermore, the empirical results show that fiscal multipliers became smaller in the post-1980 period, and the U.S. response to fiscal shocks is often inconsistent when compared to the rest of the sample.

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[19] We investigate the role of both public and private investment instead of an aggregated investment variable. Private investment is most likely to respond to any change in the interest rate.

(2.4) Positive Tax Multipliers

Arin and Koray (2006) provide an alternative explanation to understand the positive tax multipliers suggested by the previous literature. They investigate the response of major macroeconomic variables to four different types of tax policy innovations (income, corporate, indirect and social security tax shocks) in Canada within a semi-structural VAR framework. The positive tax multipliers documented in the previous literature are found only for corporate tax innovations. Results indicate that different taxes affect output differently, and imply that the composition of the total tax response may be a major factor behind the cross-country variation in the sign and magnitude of total tax multipliers.

(2.5) The Financial Markets

Many studies attempt to explain the variation in multipliers by establishing various channels of transmission for fiscal policy. For example, Van Aarle, Garretsen, Gobbin (2003) study the transmission of fiscal policy within the European Monetary Union (EMU) and the relationship between government revenue and spending. Utilizing Blanchard-Quah (1989) type long run restrictions, the EMU is estimated as an aggregate entity and the results are compared to estimates for the US and Japan. Individual country estimates are also made to examine cross-country differences. Van Aarle *et al.* state that financial markets may play an important role in the transmission of macroeconomic shocks. They investigate this by adding stock market returns to an adjusted SVAR model. They also find that in the short run, fiscal deficit shocks increase real output in the Euro region and Japan, whereas the effects on the U.S. tend to be smaller – this is consistent with Perotti (2002). They conclude that examining policy based on an aggregated entity such as the EMU may be misleading, as individual countries within the region are also heterogeneous.

Tavares and Valkanov (2001) also utilize a VAR based approach and find that fiscal policy shocks account for 3-4 percent of the variation in unexpected excess stock returns, while the results for unexpected excess bond returns are slightly greater. Similarly, Ardagna

(2005) states that financial markets are an alternative channel of transmission for fiscal policy shocks. The behavior of financial markets around episodes of large changes in the fiscal stance is examined through a set of OECD countries. Using OLS regression of a specific financial variable on a set of dummy variables, the time distance and response of financial markets/variables are measured according to a 'fiscal episode'. She contends that the degree of response of the financial markets depends on a number of factors that include a country's initial fiscal position as well as the nature of the fiscal consolidation implemented. The results suggest that longer-term government bonds rates along with real short-term rates decrease around periods of tight fiscal policy – the reverse happens during expansionary episodes. While this is a notable finding, Ardagna does not identify if investment responds to this fiscal policy action. In contrast to interest rates, share price indices and growth rates tend to increase around fiscal contractions. This result is potentially one explanation of the positive tax multipliers documented by Perotti (2002).

(2.6) Bayesian Model Averaging

To date, we are unaware of any fiscal policy studies utilizing the Bayesian approach. However, recent empirical applications of Bayesian Model Averaging are found to be popular in examining economic growth. This is due to the inherent problem of model and parameter uncertainty and the failure of other methods to resolve these issues. In an investigation of cross country growth regressions, Levine and Renelt (1992) first try to evaluate the robustness of the results produced from standard regression analysis by using a variant of the 'extreme-bounds analysis' pioneered by Leamer (1985); this is essentially a series of customized tests that look into the validity of the regression variables. However, rather than providing solutions, the outcome actually raises even more doubt. Very few explanatory variables are deemed to be robust and certain key variables are rejected. Next, Sala-i-Martin (1997) develops a different approach by denoting some predetermined level of confidence to each potential regressor. This is defined by the maximum of the probability mass for a normal distribution centered at the estimate of the regression coefficient and its related variance. It is a less severe test than the one used in Levine and Renelt (1992) with more variables deemed to be significant for growth analysis. He also considers model uncertainty in two ways. One method conducts a series of regressions to compute some level of confidence (derived from averages of estimated means and variances). The other method defines the level of confidence as the average of all other levels of confidence obtained from various regressions. In both methods, averaging over models is conducted uniformly or with weighting schemes proportional to the likelihoods.

From these developments, Fernandez, Ley, and Steel (2001) earmark the problem of model uncertainty in cross-country growth regressions within the Bayesian paradigm. They use a method that employs 'benchmark' priors in the model averaging process. Their results highlight the sufficient care required in choosing the appropriate methodology, and the superiority of using Bayesian Model Averaging (BMA), which is grounded in a robust statistical foundation. We adopt a very similar approach in our own investigation and describe the methodology in section (4).

On the subject of model uncertainty and growth, Masanjala and Papageorgiou (2005) estimate the posterior probabilities for a large set of potentially important variables in examining Africa's dismal growth performance. Using the methodology provides them the necessary confidence to claim that the determinants of growth in Africa significantly vary in comparison to the rest of the world. Moreover, they subject their study to several stringent robustness checks such as the Bayesian Averaging of Classical Estimates (BACE) developed by Sala-i-Martin, Doppelhofer, and Miller (2004). This explicitly addresses the issue of whether the reported results may have been derived from the specific technique chosen. Unsurprisingly, comparison of the Averaging techniques developed by Fernandez *et al.* (2001) and Sala-i-Martin *et al.* (2004) show very small differences in evaluating posterior probabilities, and they conclude that the two methods are essentially identical. They also remark that the strategy proposed by Fernandez *et al.* (2001) has the benefit of a partly non-informative prior structure related to the natural *g*-prior specification; therefore, the amount of the subjective information required by the researcher is limited to the choice of a single hyperparameter g_{oj}.[20]

[20] This allows a benchmark prior specification within the linear regression framework with model uncertainty. Information on the different types of priors is described in section (4.1), Bayesian Theory.

The use of Bayesian Model Averaging is flexible and has uses other than examining economic growth alone. Avramov (2002) adopts this approach to illustrate a practical exercise in stock return predictability. He eagerly proposes this method, which attempts to answer empirical concerns over predictive regression specifications and the inability of various other studies to demonstrate 'out of sample' predictive performance. Avramov clearly emphasizes the issue of model uncertainty, which is often neglected in empirical applications, and also relates this effect on asset allocation decisions. He concludes by highlighting the superiority of the Bayesian approach over standard methods of model selection.

The versatile nature of BMA can also be used to assess predictive performance. Wright (2003) undertakes the arguably difficult task of forecasting exchange rates. He notes that although various other forecasting models have been constructed in the past to approximate exchange rates, none have superseded the 'driftless random walk' for prediction purposes. Like Avramov (2002), Wright finds the suitability of BMA in out of sample prediction. He asserts that this method tends to compare more favorably than the well known driftless random walk. Results indicate that forecasts via BMA at times have a higher propensity to outperform the random walk benchmark with respect to the mean square prediction error. In terms of the actual forecasts themselves, they are often quite close to the random walk forecast. This suggests that one need not fear any potential loss in efficiency when it comes to adopting the Bayesian framework over the standard method of inference.

(3) Data

This study aims to explain the cross-country variation in fiscal multipliers. Our investigation requires two separate data sets to examine fiscal policy under different economic circumstances – the fiscal response during a recession naturally differs to the response during an economic expansion. We think it is worthwhile to compare the results obtained from using a restricted 'World sample' comprised of only recessions, to results obtained from an unrestricted 'OECD sample' with expansions and recessions.[21] This we hope provides useful information on what influences the effectiveness of fiscal policy under different economic conditions.

The 'World sample' aims to represent extensive coverage of countries of all categories. This includes countries classified as Advanced Economies (also including recently industrialized Asian economies), and four groups of developing economies from Africa, Asia, the Middle East, and the Western Hemisphere.[22]

The data is derived from various sources such as the IMF and World Bank databases, and Penn World tables. We must also pay thanks to Baldacci, Cangiano, Mahfouz, and Schimmelpfennig (2001) who have contributed to part of the data set. Our annual data for 65 countries covers the period from 1970 to 1999. This results in a restricted data set comprised of 118 separate observations or recession episodes. Table (A1) in the Appendix displays the set of variables, definitions, and data sources. Table (A2) displays the full set of recession episodes according to region, country, and date.

This restricted 'World sample' is similar to the approach used in Baldacci *et al.* (2001). A recession episode is defined as a single year (or consecutive years) where real GDP growth is less than trend growth by at least one standard deviation. Trend growth is basically the average rate of growth for any given country during the sample period (1970 – 1999). In addition, the severity of the recession can be measured by taking the total difference

[21] This complements the work of Baldacci *et al.* (2001) who examine the effectiveness of fiscal policy during recessions.

[22] Based on World Economic Outlook (WEO) country classification scheme.

between real GDP growth and trend growth over the recession episode. As noted in Baldacci *et al.* (2001), this definition of a recession does not follow the standard definition. However, by using this definition, we are better able to identify any significant reduction in economic activity lasting more than a few months.[23, 24]

Next, the 'OECD sample' is a full and unrestricted sample that constitutes both expansions and recessions.[25] Sourced primarily from OECD Economic Outlook, we cover a total of 17 countries on an annual basis from 1970 to 1999, resulting in 341 observations. The obvious advantage of this sample is the considerably greater number of observations we have to work with. It also provides the capacity to establish how/if the determinants affecting recessions over a wide sample range remain true in a well defined OECD sample group. In addition, it can differentiate the factors most influential to fiscal multipliers over the longer-term business cycle – including both economic expansions and recessions.

Economic data for each sample is designed to closely resemble one another to provide comparative analysis. The choices of variables are carefully selected on the basis of previous empirical evidence and guidance through theoretical predictions. However, we must note that in certain cases the selection is limited by data constraints when examining such a large number of countries.[26] We are confident the most essential components are included, and consideration is given to the following factors with equal prior probabilities:

A. Initial Economic Conditions:

- *Slack in the economy* – measured by real GDP growth and real domestic product per capita.
- *Openness* – measured by the ratio of imports to GDP or openness as a proportion of real domestic product per capita.[27] A measure of openness is required as this can

[23] The alternative is to identify a recession by two consecutive quarters of negative growth.
[24] The fiscal multiplier in our case is the change in real GDP (relative to trend) during the recession over the fiscal response.
[25] Since we consider expansions and recessions, the fiscal multiplier in this case is the period-by-period change in real GDP over the period-by-period change in the fiscal balance.
[26] Following Baldacci *et al.* (2001), we use the change in the actual fiscal balance to measure the stance of fiscal policy as opposed to the structural balance due to a lack data for a large number of countries.
[27] Other measures for openness are often used, such as (Imports + Exports)/GDP ratio.

often affect the current budget deficits in the economy. It is also another plausible avenue for the transmission of fiscal shocks.

- *Exchange rate regime* – measured by a dummy variable representing flexible or fixed regimes. This has influence over the size of fiscal multipliers in an open economy; see Baldacci *et al.* (2001). The effects of the exchange rate regime also have direct implications on monetary policy flexibility.
- *Debt sustainability* – measured by the public debt to GDP ratio. It is a necessary variable that often affects current and/or future levels of government spending.
- *Financing constraints facing the government* – measured by the fiscal deficit, and current account deficit (both as a percentage of GDP). Surrounding circumstances and/or constraints are often influential factors in policy implementation.
- *Interest sensitive items* – include investment, consumption, and levels of current savings. From a theoretical viewpoint, crowding out tends to be amplified when investment is sensitive to interest rates. A private investment variable and its associated change specifically examine the viability of such crowding out effects on fiscal multipliers. In addition, a savings variable may possibly account for consumption smoothing effects. Standard Ricardian behavior suggests this consumption smoothing to equalize lifetime and intergenerational redistribution due to government debt policy.

B. Characteristics of the Fiscal Response:

- *Fiscal composition* – measured by changes in the revenue to expenditure ratio. This acts as a control variable when assessing the effects of economic and/or political variables on fiscal policy.
- *Leading fiscal indicator* – measured by either a government spending variable or a dummy variable signifying an expenditure led fiscal response.

C. Accompanying Policies:

- *Stance of monetary policy* – measured by changes in interest rates, M2 in relation to GDP, or the Consumer Price Index. Crowding out due to government expenditure (depending on the method of financing) often occurs through the interest rate channel.

- *Exchange rate policy* – measured by change in exchange rate. Crowding out can also occur through this channel (in an open economy with flexible exchange rates). High interest rates induce capital inflows which appreciate the exchange rate. It is thought that this deteriorates the current account and actually counteracts the positive effect of a fiscal expansion on aggregate demand.

D. Political Factors:

- *Institutional Aspects* – proxied by bureaucratic quality and party fractionalization (HHI index in the parliament). Alesina and Perotti (1995) are one of a number of studies to point out the effects of various political factors leading to a so-called 'deficit bias'. This effect causes a substantial budget deficit that prolongs over a period of years.

Table (1) below displays descriptive statistics for our 20 primary variables. The world recession sample and the unrestricted OECD sample are shown in columns 2 and 3 respectively.

The statistics in Table (1) illustrate some interesting facts. As expected, certain key variables reflect directly on the composition of each respective sample. Initial economic conditions such as GDP growth, the Current Account, and Government Debt, among others in the OECD sample tend to be much more favourable. These variables tend to describe the economic setting of each country, and it would seem that they are also more conducive to ensure effective fiscal policy in comparison to the recession sample. We also observe significant differences in terms of the standard deviation of variables between the samples. While this directly reflects the much larger number of countries in the World recession sample, it also shows less variation among OECD countries. Most notably, the differences between the standard deviations of government expenditure and revenue variables in each sample are quite large.

Table (1): Descriptive Statistics

	Variable	Restricted 'World' Recession Sample		Full 'OECD' Sample	
		Mean	Std.Dev	Mean	Std.Dev
1	Fiscal Multiplier	0.24	2.66	0.82	6.45
2	Real GDP growth	-5.97	3.16	2.93	2.45
3	Real Domestic Product per Capita	6599.84	6085.00	18185.32	7555.00
4	Openness	59.22	41.34	67.51	29.67
5	Central Government Debt	49.58	29.04	16.20	39.62
6	Current Account Balance	-2.95	4.86	0.81	3.84
7	Investment Share	19.03	10.05	25.50	4.52
8	Consumption Share	66.01	11.10	54.76	6.39
9	Government Share	18.29	8.48	17.51	3.81
10	Current Savings	10.19	15.88	8.24	5.49
11	Money Supply (M2)	43.43	21.42	64.19	20.43
12	Interest Rate	16.46	24.36	7.44	4.02
13	Consumer Price Index	41.23	29.65	78.95	22.34
14	Exchange Rate	95.75	247.80	0.70	0.49
15	Party fractionalisation Index	0.44	0.29	0.37	0.21
16	Public Investment	5.56	2.82	4.71	2.99
17	Private Investment	22.72	23.34	24.09	10.24
18	Government Crisis Dummy	0.21	0.52	0.08	10.11
19	Government Revenue	48.26	246.53	44.09	9.99
20	Government Expenditure	58.41	296.26	45.92	9.73

Notes: The variables presented here are primary variables only. Secondary variables such as policy change variables and policy dummy variables are derived from these. A brief description of variables and their source is presented in Table (A1) in the appendix. A full list of recession episodes for the 'World' sample is presented in Table (A2) in the appendix.

(4) Estimation Methodology

The lack of consensus in the literature, and the wide array of factors thought to provoke the cross-country variation in fiscal multipliers are very troublesome for the researcher. Surveying the empirical literature on this subject highlights the need for an alternative – a method that resolves to overcome these issues. Though various macroeconomic model simulations, reduced-form equations, or other statistical techniques are frequently employed to investigate theoretical predictions, or provide evidence in explaining fiscal adjustments, there ultimately lies doubt under the condition of model uncertainty.

Claims made on a theoretical basis or on empirical evidence offer very sound reasoning. However, there are many instances where both sides of the literature provide different indications on model specification and the parameters of interest. The next question then develops. What results from the incongruity that arises when even economic theory fails to provide satisfactory guidance? One clear cut example is the somewhat counter intuitive notion that fiscal contractions may indeed be expansionary. Empirical studies such as Giavazzi and Pagano (1990) explicitly challenge the theoretical validity of the traditional Keynesian view.[28] This is simply one of a number of empirical examinations to find non-Keynesian effects. In fact, Arin and Koray (2006) even find substantial evidence to suggest that the usually depressing corporate tax multipliers are positive in certain cases.

Given the myriad of 'potentially important' explanatory variables, one may like to include all of these into the estimation process. The downside though, is the deterioration in accuracy and statistical inference. The inclusion of statistically 'irrelevant' variables comes at a cost. In traditionally regression analysis one would observe an increase in standard errors and may find it tricky to delineate significant results. Following this, the next stage involves a variety of statistical procedures aimed at uncovering a singly optimal model.[29] Koop (2003) refers to numerous statistical discussions touching on the topic of 'pre-test estimators'. In 'frequestist' econometrics, the researcher faces doubt in the following two

[28] Refer to Hemming, Kell, and Mahfouz (2001) for a review of contemporary empirical literature.
[29] Techniques such as the 'Hendry method of elimination' are frequently utilised to exclude irrelevant variables.

areas; (i) there exists parameter uncertainty (are all viable parameters are established?), and (ii), there exists model uncertainty (are all relevant variables included and irrelevant ones omitted?).

Koop (2003) points out that by chance alone, the probability of making a mistake increases exponentially as the sequence of tests increase.[30] Poirer (1995) further states another problem with these so called pre-test estimators; if in fact the 'true' model is selected, the very fact of ignoring the so-called 'less explanatory' models explicitly overlooks the model uncertainty problem.

To overcome such limitations, especially dealing with model and parameter uncertainty, we can look to Bayesian Model Averaging to examine competing models. In our empirical investigation, we use this technique to effectively identify the most significant regressors (based on statistical inference only) and also sequentially rank our finest models in explaining the cross-country variation evident in fiscal multipliers.

(4.1) Bayesian Theory

Let us first consider general Bayesian theory as a prelude to the notion of model averaging. The central themes inherent in this theory shall provide the foundation to motivate the Bayesian approach, and also prove its versatility in using data to study a phenomenon. We proceed to highlight the main concepts.

The beauty of the Bayesian approach lies in its simplicity that can be demonstrated through a few simple rules of probability. One may derive the *Bayes Theorem* through the definition of conditional probability.[31] Letting A and B denote two events, we have the following;

The probability of event A given event B is

[30] A mistake is defined as rejecting the 'true' for one that is inferior.
[31] Conditional probability is the probability of some random variable/event occurring, say A, given some other B.

$$\Pr(A|B) = \frac{\Pr(A \cap B)}{\Pr(B)}. \tag{1}$$

In a similar fashion, the probability of event *B* given event *A* is

$$\Pr(B|A) = \frac{\Pr(A \cap B)}{\Pr(A)}. \tag{2}$$

Note: $\Pr(A \cap B)$ indicates the joint probability of *A* and *B* occurring, while Pr(*B*) and Pr(*A*) indicate marginal probabilities.

The probability of event *A* given event *B* is different to its inverse – *B* conditional on *A*. There is however, a distinct relationship. Combining these two rules yields

$$\Pr(A|B)\ \Pr(B) = \Pr(A \cap B) = \Pr(B|A)\ \Pr(A). \tag{3}$$

Now extracting the *Bayes Theorem*, assuming $\Pr(B) \neq 0$, we obtain

$$\Pr(A|B) = \frac{\Pr(B|A)\ \Pr(A)}{\Pr(B)}. \tag{4}$$

So far, we have considered the above formulations in the context of two events, *A* and *B*. The same inference also holds for two random variables, *A* and *B* with probability or probability density functions. This is shown below in equation (5) where we replace Pr(x) with *p*(x).

Bayesian econometrics uses the *Bayes Rule* to characterize the standard regression model. Typically one attempts to estimate the coefficients from the regression as the parameters of interest. In matrix form we can show *y* to be a vector or matrix of data, and also Θ to be a vector or matrix that represents the parameters in a model empowered with explaining *y*. Now by using the *Bayes Rule* and substituting *A* with Θ, and *B* with *y* yields

$$p(\Theta | y) = \frac{p(y | \Theta)\ p(\Theta)}{p(y)} \tag{5}$$

Each component of this *Bayes Theorem* signifies a particular convention. The component $p(\theta \mid y)$ characterizes the *'posterior density'*, which is essentially the probability density function for the data given the parameters of the model. This is a principal component of interest since it is derived from or depends on the data, y. As its name suggests, the posterior provides information by summarizing our knowledge of θ only after examining the data. Koop (2003) nicely states that the process can be thought of as an updating rule, where the data allows us to update our prior views about θ, resulting in the posterior that incorporates data as well as non-data information. In other words, using this approach easily facilitates the conditioning of probabilities wherein the possibility of new information may be accounted for.

The other two terms that form the numerator are $p(y \mid \theta)$, which represents the *'likelihood function'*, and $p(\theta)$, which represents the *'prior density'*.

Turning to the likelihood function first, $p(y \mid \theta)$, refers to the conditional nature of y (or density of data) given θ (or model parameters). 'Likelihood' can be interpreted as 'probability' in non-technical terms. Loosely speaking, since probability theory enables one to forecast unknown outcomes based on known parameters, likelihood therefore enables one to identify the unknown parameters based on predetermined outcomes. Often when we consider the typical linear regression, it is quite reasonable to presume that the characteristics of errors and even various statistical tests are based on normality, or a normal distribution. Here, Carlin and Louis (2000) describe the likelihood function as a data generating process, and from this we can infer that $p(y \mid \theta)$ has the properties of normality given the parameters of interest (regression coefficients and error variance).

On the other hand, the representation of $p(\theta)$ is suitably named as the prior density – its derivation refers to the fact that it is not subject to any pre-conditioned information regarding *y*, the data. This prior has the propensity to include information that is external to the specified data, with regard to θ. Koop (2003) mentions that it summarizes our beliefs about θ prior to seeing the data. For example, any fundamental assumptions that underlie a particular application or theory may be appropriately considered.[32] Thus, its properties can describe what is known about θ even in the absence of some 'hard' evidence.

This prior density component of *Bayes Theorem* is at times a subjective exercise depending on the inclinations of the researcher. One preference is using the conjugate prior that results in an easier calculation of the posterior results. This conjugate prior provides algebraic simplicity which would otherwise require exhaustive numerical integration.[33] In a nutshell, the choice of prior influences the algebraic form of the product $p(y \mid \theta) * p(\theta)$. So for particular classes of priors or conjugate priors, the posterior may acquire a similar algebraic form as the prior.

As a result, the treatment of prior information is a contentious issue in the Bayesian approach. Its somewhat subjective use leaves it open to criticism. In addition, there are classes of priors that belong to so-called 'informative' and 'non-informative' priors for different models.

Informative priors represent explicit information about a variable of interest. The prior is often interpreted with a normal distribution, with an expected value and variance appropriately defined. Gelman *et al.* (2003) state that both the prior and posterior generally relate to some pre-specified data or observation. So we can see that the posterior from the present becomes the prior for the future – existential evidence heavily influences the prior (rather than any predisposed assumption).

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[32] Suppose θ is a parameter that represents the returns to scale in the production process – it may be reasonable to assume constant returns to scale, or in other words, prior information (before analyzing the data) regarding θ that it is close to one.
[33] See Gelman, Carlin, Stern, and Rubin (2003) for more information.

On the other hand, uninformative priors refer to information that is generally vague about a variable. Carlin *et al.* (2000) suggest that it can relate to information such as the variable's algebraic sign or the value of the variable being more or less than some pre-determined limit. So in this case, finding a probability distribution to describe the data becomes more challenging.[34] It is worthwhile to note here that the approach considered by Fernandez *et al.* (2001) utilizes an improper noninformative prior for the parameters that are common to all models (α and σ), and a partly noninformative '*g*-prior' specification related to the natural conjugate class for β. We explore this approach in greater detail in the following section (4.2), Bayesian Model Averaging.

Finally, the treatment of probability and its associated distribution functions change slightly when considering discrete and continuous random variables. The probability function is lucidly defined with discrete random variables; it becomes the probability of each event occurring within the given sample space. On the other hand, the distribution function of a continuous random variable is more complex. Probabilities cannot be simply assigned to each point or event as there are an infinite number of such points/events (even within a seemingly small interval). Since we often consider continuous random variables, and their probabilities that are described by intervals, we integrate the given function to derive the area under the probability density function.

To apply *Bayes Theorem*, one simply multiplies the likelihood function by the prior density and then dividing (or normalizing) by a constant. This is shown in equation (6) below.

$$\text{posterior} = \frac{\text{likelihood} \times \text{prior}}{\text{normalizing constant}} \tag{6}$$

This theorem gives us the opportunity to learn about the models and compare them accordingly. Section (4.2) uses the same *Bayes* framework in which a model is identified by its associated likelihood function and prior.

[34] A useful survey of the noninformative prior is considered by Poirer (1995) and Zellner (1971).

(4.2) Bayesian Model Averaging

> The number of separate variables which in any particular social phenomenon will determine the result of a given change will as a rule be far too large for any human mind to master and manipulate them effectively. In consequence, our knowledge of the principle by which these phenomena are produced will rarely if ever enable us to predict the precise result of any concrete situation. While we can explain the principle on which certain phenomena are produced and can from this knowledge exclude the possibility of certain results...our knowledge will in a sense only be negative, i.e. it... will not enable us to narrow the range of possibilities sufficiently so that only one remains.

Friedrich von Hayek[35]

In this exercise, we aim to characterize the normal linear regression in a Bayesian manner. The use of Bayesian econometrics is an exciting and promising field that is quickly gaining prestige in applied economics analysis.[36] Recent empirical examinations in economics literature with specific regard to economic growth include (Doppelhoffer, Miller and Sala-i-Martin (2000), Brock and Durlauf (2001), Fernandez, Ley, and Steel (2001), Brock, Durlauf and West (2003), Masanjala and Papageorgiou (2005)). Other areas of application also include finance and forecasting (Avramov (2002), Garratt, Lee, Pesaran and Shin (2003) and Wright (2003)), and monetary policy work is covered by (Brock, Durlauf and West (2003), (2004)). At this point in time, research on fiscal policy is comparatively thin. To our knowledge, there currently exists no work on fiscal policy, and no work on explaining the cross-country variation in fiscal multipliers.

We examine linear regression models in a similar way to standard regression analysis. Our dependent variable, an estimated fiscal multiplier for n countries that is grouped in a vector y, is regressed on an intercept symbolized by α, and a variety of explanatory variables selected from a set of k variables. This set of k variables resemble a design matrix Z, with its dimension equaling $n * k$. This is shown algebraically as

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[35] von Hayek (1942, p.290).

[36] Useful references for the interested reader on this topic are Hoeting, Madigan, Raftery, and Volinsky (1999), and the BMA website, http://www.research.att.com/~volinsky/bma.html

$$y = \alpha\iota_n + Z_j\beta_j + \sigma\varepsilon \tag{7}$$

whereby rank is assumed to be $(\iota_n : Z) = k + 1$.
Note that ι_n indicates an $n * 1$ dimensional vector of ones, and β represents the full complement of a k dimensional vector of regression coefficients.

In a similar vein to the strategy proposed in Fernandez *et al.* (2001), we facilitate an unrestricted set of regressors – in other words, this allows for any subset of the variables in Z to appear in the model. Referring to equation (7), suppose there is an $n * k_j$ sub-matrix of variables in Z described by Z_j. A model now represented by M_j will contain the regressors grouped in Z_j. In addition, we also denote the following properties:

$\beta_j \in \Re^{k_j} (0 \le k_j \le k)$ is associated with the regression coefficients in relation to the sub-matrix Z_j, and $\sigma \in \Re_+$ is a scale parameter. Also following the usual convention, ε is subject to an n dimensional Normal distribution consisting of zero mean and an identity covariance matrix.

There are 2^k possible subsets of Z with this framework. This means there are also 2^k possible choices for Z_j, and the total number of models under our consideration is in fact 2^k. This is one of the challenges in implementing Bayesian Model Averaging described earlier. Depending on the number of regressors we wish to account for, the computation inherent in Bayesian Model Averaging can be extremely difficult. For example, allowing for any subset of up to 34 regressors in our model estimation results in a set of $2^{34} = 1.72 \times 10^{10}$ various models to observe. Attempting to directly calculate every term implicit in the averaging process would render the task impossible. However, algorithms such as the 'Markov Chain Monte Carlo Model Composition' or simply 'MC^3' have been developed to solve such numerically intensive headaches. This is an important aspect of utilizing Bayesian methodology as it enables one to consider a vast set of 'potential regressors' to include in the model. Finally, we must note that although conditioning on the complete set of regressors in *Z*, omitting any particular regressor essentially means that the corresponding element of matrix β takes the value of zero.

Now we can appropriately deal with the model uncertainty problem through BMA. Fernandez *et al.* (2001) show that the posterior distribution of any quantity (or parameter of interest), say Δ, which has common interpretation across models, is an average (or weighted value) of the posterior distributions of that quantity under each of the models, with weights given by the posterior model probabilities. As a result, we have

$$P_{\Delta|y} = \sum_{j=1}^{2^k} P_{\Delta|y,M_j} P(M_j|y) \tag{8}$$

The equation outlined above describes the model averaging process. We can see that the marginal posterior probability of inclusion of any given variable/regressor becomes the weighted sum of the posterior probabilities of all models that involve this parameter of interest. The end term $P(M_j \mid y)$, is the posterior model probability which is described by

$$P(M_j|y) = \frac{l_y(M_j)p_j}{\sum_{h=1}^{2^k} l_y(M_h)p_h} \tag{9}$$

The process of BMA makes use of the underlying principles set out in section (4.1), Bayesian theory, to utilize the *Bayes* rule to make a probability statement about whether a particular model is the right one or not, conditional on our observed data. The posterior is effectively used to observe the level of statistical confidence for a model M_j.

Note that $l_y(M_j)$ is actually the marginal likelihood of model M_j shown as

$$l_y(M_j) = \int p(y|\alpha, \beta_j, \sigma, M_j)\, p(\alpha, \sigma)\, p(\beta_j|\alpha, \sigma, M_j)\, d\alpha\, d\beta_j\, d\sigma \tag{10}$$

where $p(y|\alpha, \beta_j, \sigma, M_j)$ is representative of the sampling model to our linear model in equation (7) and $p(\alpha, \sigma)$ and $p(\beta_j|\alpha, \sigma, M_j)$ relate to the priors described in the following section (4.3), equations (11) and (12), respectively.

(4.3) Bayesian Computation

The Bayesian approach has always been acknowledged for its strong statistical decree. However, two common objections to Bayesian methodology are issues over the choice of prior structure and the method of computation. We describe the specification of our prior and the computation of the methodology as follows.

Keeping in mind the linear regression model in equation (7), section (4.2), our Bayesian setup requires the specification of a prior distribution for the parameters in M_j which are α, β_j, and σ. In addition, there is a need to specify prior distributions for all models within the model space. Given a particular sampling model, Fernandez *et al.* (2001) show that posterior model probabilities in the context of model uncertainty are typically rather sensitive to the specification of the prior – some arbitrarily chosen priors can result in surprising consequences. Furthermore, in many empirical exercises the researcher knows of numerous potential regressors but is unsure of their viability. Usually there is no freely available prior information, and even if there were, attempting to calculate priors for 2^k different models would undeniably be an exhaustive task.

As a result, much debate exists in the choice and specification of the prior. Some propose the use of a 'diffuse' prior on the model specific coefficients/parameters, which draws parallel to OLS estimation. This is clearly discussed in Brock *et al.* (2003). They acknowledge that the main disadvantage of this selection is that the resulting *Bayes* factors can be sensitive to choice of prior distributions; moreover, the influence of this prior distribution does not diminish, even asymptotically.

In an attempt to derive meaningful posterior model probabilities, many contemporary researchers aim to develop proper priors that can be automatically used without requiring subjective input or fine tuning for each individual model.[37] There are numerous methods that exist. Raftery, Madigan, and Hoeting (1997) choose to utilize a 'weakly-informative'

[37] Proper priors are preferred as it is sometimes difficult to calculate meaningful posterior probabilities with improper noninformative priors as mentioned in Koop (2003).

prior which is largely data dependent, whereas Fernandez *et al.* (2001) propose the use of a so-called 'improper noninformative' prior. In addition, they utilize a 'g-prior' specification shown in equation (12). They focus on pertinent cases where a large number of sampling models are entertained and also when they have (or wish to use) little or no subjective prior information. They provide a benchmark structure to be used when considering the standard linear regression model with ambiguity over the choice of regressors. Although it is always preferable to use prior information (if substantial prior information exists), the attractive feature of this benchmark prior specification is its ability to facilitate the computation when including such information is not easily available or possible.

In our case, we certainly know that there are a multitude of potential explanatory variables. Prior information about these parameters and fiscal multipliers are highly variable, and in some instances there is a lack of information altogether. Masanjala and Papageorgiou (2005) contend that when prior knowledge about a parameter is vague, conducting the Bayesian analysis with a noninformative prior is favored. There is also a general rule of thumb mentioned in Koop (2003), which states that when comparing models using the posterior odds ratios, it is viable to use noninformative priors over parameters that are common to all models.[38] We therefore aim for a benchmark solution that has little influence over posterior odds, and also one that does not require meticulous input from the researcher.

Influenced by Fernandez *et al.* (2001), we carry on with a partly noninformative prior structure related to a natural conjugate g-prior specification. This essentially limits the subjective information input from the user to a simple choice of one scalar hyperparameter. Using an improper noninformative prior for the parameters that are common to all models (α and σ), and a g-prior structure for β_j corresponds to the product of

$$p(\alpha, \sigma) \propto \sigma^{-1} \tag{11}$$

and

[38] The posterior odds ratio is simply a ratio of posterior probabilities used to compare models, which is related to the Bayes factor.

$$p(\beta_j|\alpha, \sigma, M_j) = f_N^{k_j}(\beta_j|0, \sigma^2(gZ'_jZ_j)^{-1}) \tag{12}$$

Where $f_N^q(w|m, V)$ indicates the density function of a q-dimensional normal distribution on w with mean m and covariance matrix V. The g-prior is set within matrix V and is the benchmark prior first introduced by Zellner (1986). Note that the prior is multiplied with Z_j which is actually the matrix of regressors in the linear model. None of the rules of conditional probability are violated as conditioning on Z_j also takes place in the likelihood function and posterior. Fernandez *et al.* (2001) also outline a convention to follow to determine the value of g, where they recommend

$$g = \begin{cases} 1/K^2 & \text{if } N \leq K^2 \\ 1/N & \text{if } N > K^2 \end{cases} \tag{13}$$

where N represents the number of observations, and K, the number of regressors.

Values for g typically range from 0 to 1. When g equals 1, the prior and data based information is equally weighted in the posterior covariance matrix (of similar form to matrix V in equation (12)). Conversely, when g equals 0, this implies an absolute noninformative prior. A frequently used strategy suggested in Koop (2003) is to select g based on some measure such as an information criterion. However, we directly test the sensitivity of our results to a range of prior distributions. This is illustrated as a robustness check in section (6).

The next step is to specify the prior distribution for the entire model space. By doing so, we can confront the inherent problem of model uncertainty. This takes the form of

$$P(M_j) = p_j, \quad j = 1, \ldots, 2^k, \quad \text{with } p_j > 0 \text{ and } \sum_{j=1}^{2^k} p_j = 1 \tag{14}$$

Following Fernandez *et al.* (2001), we set $p_j = 2^{-k}$ which satisfies the condition of uniform distribution on the model space. With independence of regressors, this means that the prior probability of including any regressor is precisely ½. This assumption is fair consensus especially when prior information on the model probability distribution is absent.

The second problem Bayesians face is the rigorous computation sometimes required when carrying out simulations. For example, calculating the posterior distribution in equations (8 and 9), in the earlier section (4.2) involves an extremely large number of terms when considering $k = 34$ regressors. There is a lot of number crunching involved and this would have been computationally impossible in the past. The development of the MC^3 algorithm and efficient programming allows for such large scale simulations. As noted in Fernandez *et al.* (2001), the objective of sampling methods is not to simply create a perfect replica of the posterior model distribution, but to examine the model space in the context of identifying the models with higher posterior probability. Their methodology is sound enough to guarantee that a high proportion of the posterior mass is accounted for and also able to distinguish the variability in the posterior distribution.[39]

[39] Fernandez *et al.* (2001) prove this through extensive testing of artificial data.

(5) Results

The results reported here are motivated by the sampling methods described in the methodology. We capture individual regressor posterior probabilities and model posterior probabilities, whilst covering a high proportion of the posterior mass and accounting for variability in the posterior distribution.

With our two sets of data, equations (7) to (10) in section (4.2) describe the model averaging process with uniform prior on model probabilities. Since $n < k^2$, we shall adopt $g = 1/k^2$ as the *g*-prior recommended by Fernandez *et al.* (2001). We run with 1 million recorded drawings after a 'burn-in' of 100,000 discarded drawings. While this slightly differs to Fernandez *et al.*, the sampler is robust enough to provide identical results from runs beginning from randomly drawn points in the model space.[40] The general model performance is encouraging, and is seen by the correlation coefficient between model visit frequencies and posterior probabilities which is greater than 0.99.

For our first BMA exercise, we use the restricted 'World' sample composed of recession episodes only. A total of 11,769 best models are visited and this describes 100 percent of the posterior mass. The corresponding prior probability for any single model is 0.4768E-04 percent. The posterior mass is spread out with the best 1,574 models covering 90 percent of the total posterior mass. Finally, the top 58 models resemble 46 percent of the posterior mass and have posterior model probabilities greater than 0.25 percent.

Next, we move on to the unrestricted 'OECD' only sample. A total of 17,400 best models are visited here, which resembles 100 percent of the posterior mass. The prior probability for a single model in this case is 0.2910E-06 percent. The best 2,258 models account for 90 percent of the posterior mass, and the top 57 models whose posterior model probabilities are larger than 0.25 percent, account for 49 percent of the posterior mass. In both cases, models with posterior probabilities larger than 0.25 percent typically do not have any more than 5 regressors. The averaging process acutely points out the determinant factors while

[40] Fernandez *et al.* (2001) provide a detailed discussion on this matter.

attempting to replicate the entire posterior mass. As this mass is widespread, we can see how BMA becomes a necessity to derive meaningful results. Moreover, the *Bayes* factor shown by equation (8), section (4.2), has an important property – a built-in mechanism to avoid overfitting when calculating posterior model probabilities. Having discussed several technical aspects of BMA, we now turn to the individual regressor and model posterior probabilities.

(5.1) Regressor Posterior Probabilities

This sub-section focuses on the results of individual regressor posterior probabilities. BMA analysis provides a useful feature of reporting the importance of explanatory variables as probabilities, which can be subsequently ranked according to significance. Parallel to standard model selection criteria, we are able to identify the variables with high explanatory power and thus determine if they ought to be considered for inclusion.

Individual regressor posterior probabilities are shown in Table (2) below. The full set of 34 regressors used in our investigation is listed sequentially in the first column. Columns 2 and 3 on the other hand, compare the marginal significance of each regressor from the restricted 'World' sample (comprised of recessions only) and the unrestricted 'OECD' only sample (comprised of both expansions and recessions).

Table (2): Individual Regressor Posterior Probabilities

	Regressor	Restricted 'World' Sample - recessions only (%)	Unrestricted 'OECD' Sample (%)
1	Real Domestic Product per Capita	5.20	2.36
2	*Change Real Dom Product p/Capita*	2.11	4.13
3	Openness	4.28	2.85
4	*Change Openness*	8.58	2.12
5	Central Government Debt	6.51	2.40
6	*Change Central Govt Debt*	21.37	2.73
7	Current Account Balance	6.70	3.91
8	*Change CA Balance*	**62.38**	2.52
9	Public Investment	8.09	3.40
10	*Change Pub Inv*	3.31	3.20
11	Private Investment	7.54	2.65
12	*Change Priv Inv*	10.11	**68.23**
13	Investment Share	8.96	4.03
14	*Change Inv Share*	5.00	4.78
15	Consumption Share	17.23	2.23
16	*Change Cons Share*	4.86	13.40
17	Government Share	12.63	2.10
18	*Change Govt Share*	9.23	3.15
19	Current Savings	4.76	2.87
20	*Change Current Sav*	1.88	2.31
21	Change in Govt Rev relative to Govt Exp	5.87	10.32
22	Expenditure-led Fiscal Response (Dummy)	1.20	5.22
23	Money Supply (M2)	25.27	2.66
24	*Change Money Supply (M2)*	13.75	2.23
25	Interest Rate	4.98	4.73
26	*Change Int Rate*	9.44	3.61
27	Monetary Expansion (Dummy)	**93.82**	**49.32**
28	Consumer Price Index	12.21	3.04
29	Exchange Rate	25.31	2.11
30	*Change Exchange Rate*	16.42	**76.94**
31	Depreciation (Dummy)	28.96	22.63
32	Exchange Rate Regime (Dummy)	**95.87**	6.73
33	Government Crisis (Dummy)	2.04	14.11
34	Party fractionalisation Index	10.56	5.79

Comparing both samples provides interesting reading. It appears that the marginal importance and relative rank of the explanatory variables in both samples differ. This is not at all surprising since one sample is concerned with capturing effects under recession, while the other examines advanced OECD economies only. Most notably, the effects of a Change in Private Investment are drastically different. This variable has relatively little or no influence given by its posterior value of (10.11%) in the World recession sample, compared to its significance as one of the most influential factors with a posterior probability of (68.23%) in the OECD only sample. Other differences also exist with the significance of a Change in Exchange rate (16.42% v 76.94%), and Change in CA Balance (62.38% v 2.52%) among others. The core factors (interest rate and exchange rate variables) from the recession sample also feature in the OECD sample, which suggests that these variables are extremely important in any case and are also consistent between samples.

The three variables of greatest significance in each respective sample are highlighted in bold font in Table (2). The factors that are most influential under conditions of economic recession ranked by posterior probability are: (i) Exchange Rate Regime (95.87%), (ii) Expansionary Monetary Policy (93.82%), and (iii) Current Account Balance (62.38%). While in advanced OECD economies (including economic expansions and recessions), the three foremost explanatory variables are ranked as follows: (i) Exchange Rate Stance (76.94%), (ii) Private Investment (68.23%), and (iii) Expansionary Monetary Policy (49.32%). In the 'World' recession only sample, the top two variables are accompanying policies – given by the supporting exchange rate regime and monetary expansion. The third variable, given by the current account balance, resembles an important facet of the initial economic conditions of a country as well as the financing constraints facing the government. Correspondingly, the unrestricted 'OECD' only sample ranks two of the three leading variables also as accompanying policies – given by the exchange rate stance and monetary expansion. The other supporting factor is the stimulus provided through the private investment channel – an interest sensitive variable that is also an indicator of a type of productive expenditure.

The interpretation of these posterior results does not necessarily follow suit to standard procedures of inference. It is important to note that in this BMA methodology, the marginal importance of any particular explanatory variable does not inevitably connote any meaning about size or sign of regression coefficients in a set of models. Rather, it purely suggests the importance based on probabilities (in posteriori) of models containing that particular explanatory variable. Consider the top ranked regressor in each sample; Exchange Rate Regime with a probability of (95.87%) in the recession only sample and Exchange Rate Stance with a probability of (76.94%) in the OECD only sample. Obviously the regressor with the high posterior probability suggests a greater level of 'importance' so to speak. However, to date, there is no exact rule or theoretical rationale to justify relevant thresholds of significance in posterior probabilities. Of course we can always look to previous literature for an inkling of guidance. Fernandez *et al.* (2001) who develop the system of benchmark priors for BMA, consider a regressor with a posterior probability of 90 percent or over as "highly effective". Similarly, Masanjala and Papageorgiou (2005) also adopt this threshold. Certainly in the case when we examine the recession only sample, two of our most important regressors Exchange Rate Regime and Expansionary Monetary Policy meet this threshold level with probabilities greater than 90 percent. However, in the full OECD sample, only the variable Exchange Rate Stance comes close with probability of (76.94%). Does such a conditional threshold imply that these so-called 'inferior' results must be disregarded or can they be of some use to derive other conclusions?

While posterior probabilities of 90 percent and over are ideal, the reality may be that one should interpret the results on a case-by-case basis. A probability below a generic threshold may in fact be just as meaningful as a probability above it – on a relative basis. It clearly depends on a number of factors such as the sample composition (particularly the economic state in question), topic of investigation (highly variant nature of cross country multipliers), choice of prior structure, and so on.

The common theme between the samples is the role of accompanying policies influencing fiscal multipliers. Factually, this is not unheard of. There are certainly numerous cases that are supported by theory and empirics.[41] Some of the most contentious issues arise in utilizing policies to support fiscal policy in stabilizing economic conditions. In recessionary conditions, it is plausible to stimulate economic activity by expansionary fiscal policies. This fiscal induced increase in aggregate demand acts to stimulate price inflation and output growth. Keynesians also propose that it is possible to moderate economic activity during a boom through the use of contractionary type fiscal initiatives. This is designed to target a reduction in demand with corresponding effects on inflation and also growth. Of course, the effectiveness of such initiatives is highly influenced by various conditions and policies that may act to support or moderate the intended fiscal stimulus.

One would have to closely monitor various demand and supply conditions (which we have done in our analysis of a vast variety of potential regressors). Empirical literature also generalizes fiscal multipliers as being positive and smaller than expected.[42] Kandil (2006) also refers to the method of government financing as a commonly touted determinant influencing the effectiveness of fiscal policy. While the financing of government activity may include taxation and borrowing, there is a significant alternative in the form of monetization. This has proved popular and is favored in many cases. Assuming a cohesive relationship between government and central banking authorities, monetization sassily evades political disorder over raising taxes and concerns over mounting debt. The end result of accommodating government spending through this method is an increase in the monetary base.

In what is to follow, we explain our findings in light of certain insightful and highly applicable theoretical frameworks that advocate the importance of accompanying policies in achieving economic policy objectives.

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[41] We have discussed Baldacci *et al.* (2001), Perry and Schultze (1993), and now, Kandil (2006).

[42] One exception is closed economies. It is also thought that fiscal expansions tend to be more effective when there is some slack in productive capacity in an economy; see Hemming *et al.* (2002).

The problem of multiple economic objectives

Our postulated BMA results regarding monetary policy and exchange rate policy during a recession are consistent on two accounts. First, place yourself in the position of the policymaker when facing conditions of economic recession. Given a predetermined stance in government taxation and expenditure simultaneously, one of the initial and most intuitive actions is to look toward alternative, yet supporting measures. While monetary and fiscal policy is frequently used to achieve policy objectives, they will result in significant implications for the balance of payments and the exchange rate in an open economy, especially with a floating exchange rate regime. Second, policymakers naturally have a multitude of competing economic objectives. For example, some common policy objectives are achieving internal and external balance. Internal balance is a primary aim, which refers to eradicating unemployment whilst maintaining stable prices. External balance on the other hand refers to the balance of payments and thus, the supply and demand for currency.

These objectives have both theoretical and practical importance. Much of the discussion during the 1950s and 1960s concerned these objectives where the international monetary system was generally one of fixed exchange rates. Although external balance tends to be more important for economies under fixed exchange rate regimes, it is still worthwhile to extend this same framework to those under floating rate regimes, since excessive imbalances in the balance of payments have a considerable impact on the domestic economy. The tools at hand to policymakers are fiscal and monetary policies that influence aggregate demand and are subsequently termed expenditure changing policies. Policies that act to devalue or revalue the exchange rate influence the mix of spending on domestic and foreign goods and are termed expenditure switching policies; for these policies, the type of exchange rate regime ultimately affects the ability to devalue/revalue a currency.

The problem of achieving multiple policy objectives is nicely conceptualized by Tinbergen's instruments-targets rule.[43] The basic idea is that an economy essentially requires as many instruments as its targets. For example, if an economy finds itself in

[43] This concept was originally developed by Nobel laureate Jan Tinbergen.

recession with a current account deficit, utilizing expansionary fiscal stimulus (expenditure changing) to reduce unemployment in combination with devaluing the exchange rate (expenditure switching) to tackle the deficit is deemed to be more effective in achieving both these objectives. The major point of this simplistic derivation is that the use of only one tool to reach multiple objectives will most likely be unsuccessful – hence the importance of accompanying policies (expansionary monetary policy and the supporting exchange rate regime) that act to support the change in government activity during a recession.

In addition, the degree of openness and the type of exchange rate regime influence the size of fiscal multipliers. In an open economy, theoretical implications state that high domestic interest rates in an economy with a flexible regime induce capital inflows, which appreciate the exchange rate. However, if there is perfect capital mobility, any given fiscal policy has no influence as there is complete crowding out through the exchange rate channel (the resulting appreciation in exchange rate deteriorates the current account and offsets the intended fiscal stimulus on domestic activity). However, under a fixed exchange rate regime, a rise in interest rates caused by a fiscal expansion can have different effects in open and closed economies. The effectiveness of fiscal policy in this case varies with the degree of capital mobility; fiscal policy tends to be more effective under fixed exchange rates and perfect capital mobility. There is also a subsequent loss in monetary control as the money supply adjusts to maintain interest rate autonomy.[44] So we can see that within these frameworks, the intended policy action may not be fruitful unless there is some form of support from interest rate and exchange rate policies.

The method of financing government activity

In theory, the method of financing government activity also has resulting implications on economic activity. There is a considerable segment of economic literature assessing the effectiveness of fiscal policy that is subject to various crowding out effects.[45] Theoretically speaking, the balanced budget multiplier is positive. That is, when an increase in

[44] Domestic and foreign interest rates remain unchanged.
[45] Kandil (2006) provides a good reference.

government spending is financed by an equally matched increase in taxes, there is a resulting increase in aggregate demand. The complication arises when government activity is not matched by equal taxation, which runs the budget into deficit. This deficit financing is a major influence on the economy and various explanations are put forward to assess the degree of influence.

Government spending financed by domestic borrowing is expected to result in a smaller multiplier effect than the balanced budget multiplier. The channel through which this occurs is through interest rates. As an increase in debt increases the demand for the available pool of domestic credit, a rise in interest rates is expected. Or in another case, financing government activity by borrowing from domestic financial institutions reduces the pool of credit available to the private sector and interest rates are bound to increase according to the level of debt. The higher premia on interest rates crowds out private investment and according to the degree of crowding out, the effects of government spending are somewhat moderated. This crowding out also varies in relation to the degree of sensitivity between investment and interest rates. However, a supporting monetary policy is very plausible in negating this upward pressure on interest rates caused by fiscal expansion. There is documented evidence to support the use of an accommodating monetary policy to lower the possibility of crowding out (see Perry and Schultze (1993) with U.S. evidence and the fiscal multiplier).

In addition, the stimulatory effects of government spending tend to be more pronounced according to the degree of dependency on monetization as opposed to debt. The Ricardian proposition theorizes that consumers anticipate future tax increases to offset the current government spending activity financed by debt. The resulting effect is a decline in private consumption that counteracts the intended stimulus to aggregate demand from increased government spending activity.

A key result of our OECD sample is the significance of the response of private investment, along with the exchange rate stance and expansionary monetary policy as accompanying policies. The data driven model averaging process has carefully delineated a fiscal policy transmission channel that has its roots grounded in theory. The role of private investment (posterior probability of 68.23%) provides empirical support for the various crowding out effects as stated above. Furthermore, Kandil (2006) suggests that the variation in the fiscal multiplier along with the method of financing tends to increase under a flexible exchange rate regime. For such reasons, our OECD results here reflect certain differences to the World recession sample. Although the OECD sample period corresponds to the World recession sample period (1970 – 1999), a key difference lies in the composition of each respective sample. Almost all of the observations in the OECD sample consist of data under flexible exchange rate regimes. The importance of exchange rate regime naturally declines after the collapse of the Bretton Woods system. This is shown by a low posterior probability of (6.73%) for the exchange rate regime variable. In place of this, the exchange rate stance becomes a more pertinent factor with a probability of (76.94%). The data driven results here reflect the greater variation under flexible exchange rate schemes as well as expected differences in the structural composition of each sample.

(5.2) Model Posterior Probabilities

Turning to model posterior results, the Bayesian approach is capable of guiding us on the optimal model specification, or at the very least, identify probable combinations of regressors that best describe the cross country variation in fiscal multipliers. Table (3) below presents a similar ranking scheme as the one described in section (5.1), with an ordered ranking of the top three models obtained through posterior inference of our two samples.

From the full set of 34 potential regressors, the top three models that best describe fiscal multipliers during world recessions contain 3 to 4 key variables. In OECD countries, the top three models consist of 2 to 3 key variables. The optimal model for the 'World' sample has a posterior probability of (4.45%), while the best model for the 'OECD' sample has a probability of (3.74%). As we discussed earlier in section (5.1), there are no appropriately justified thresholds to adhere to. It is once again open to some subjective interpretation. As an example, Masanjala and Papageorgiou (2005) observe top model posterior probabilities in empirical growth exercises ranging from 1.66 percent to 4.82 percent as quite acceptable, while Fernandez *et al.* (2001) observe probabilities around 1 to 2 percent in other empirical exercises.

Table (3): Model Posterior Probabilities

Model	Regressors	Posterior Probability (%)
	World recession sample	
First	Ex. Rate Regime, Monetary Expansion, Chg. In Current Account Balance	4.45
Second	Ex. Rate Regime, Monetary Expansion, Ex. Rate Depreciation, Chg. In Current Account Balance	3.44
Third	Ex. Rate Regime, Monetary Expansion, Exchange Rate, Chg. In Current Account Balance	2.16
	OECD sample	
First	Chg. in Private Investment, Monetary Expansion, Exchange Rate Stance	3.74
Second	Chg. in Private Investment, Exchange Rate Stance	2.09
Third	Chg. in Private Investment, Monetary Expansion, Ex. Rate Depreciation	1.50

A point to note is that the relative overall posterior model probabilities for the world recession sample are generally higher than those of the OECD sample. This suggests that sample composition and specification has some slight influence on the explanatory power of models in explaining the cross-country variation in fiscal multipliers; however, this is certainly not surprising. These effects have plagued empirical analysis of fiscal policy under conditions of model uncertainty. In fact, Perotti (2002) has indicated that the effects of fiscal policy (especially in OECD economies) have become considerably harder to distinguish post Bretton Woods.

The composition of these best models reflects the importance of certain theoretically justified regressors. From a wide variety of possible regressors, model averaging has identified the most common aspects that are pertinent to the worldwide recession sample and the OECD sample. The dual inclusion of accompanying policies in one form or the other signifies the importance of such policies that influence fiscal multipliers. We can be sure that the top ranked models recognize the most important transmission channels that are likely to convey the information regarding the effectiveness of fiscal policy.

On the other hand, certain variables previously thought to have some weight in explaining the cross-country variation in fiscal multipliers have little or no influence in the analysis of both our samples. This simply confirms a statement by Hemming *et al.* (2001) who describe the implications of theoretical and empirical literature for fiscal policy – "The proper fiscal policy response…will depend on a range of factors, and only a country-by-country approach, and indeed an episode-by-episode approach, can reveal whether a fiscal expansion or a fiscal contraction is appropriate".[46]

Through the application of BMA in fiscal policy analysis, our results confirm certain theoretical predictions. The most appealing aspect of this empirical exercise is the discovery of evidence indicating some crowding out through interest rates and exchange rates, and the significant role of accompanying policies. We now consider the direct effects of these variables through a series of panel regression estimations.

(5.3) Panel Regression Estimation

So far, the BMA methodology nicely alludes to the key determinants explaining the cross-country variation in fiscal multipliers. It also indicates certain aspects with regard to model specification. This has given substantial evidence indicating that the variation in cross-country fiscal multipliers is mostly determined by accompanying monetary and exchange rate policies.

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[46] See Hemming *et al.* (2001), pg 36.

With this information at hand, we are naturally curious to discern the actual impact of such policies, and subsequently quantify them in a meaningful way. This provides the benefits of establishing a benchmark to gauge such relationships and also provides practitioners useful inference. We must point out that the averaging process in itself is not purely concerned with estimating coefficients as in standard regression analysis. Although employing the linear regression model in a Bayesian manner, it primarily acts to resolve model and parameter uncertainty within this framework.

As a result, this sub-section acts to apply and evaluate the evidence presented by the BMA process through analytical panel estimation techniques. We are purely concerned with obtaining coefficient estimates here in a robust manner, and controlling for country heterogeneity. Utilizing both the data sets described earlier, which consist of observations on various phenomena over multiple time periods, we conduct a series of regressions that include panel estimation techniques (fixed effects and random effects). These models are variants of the standard linear regression model, however, the models tend to differ in their assumptions on the nature of the disturbance term. This treatment of the disturbance term and its connection with the explanatory variables is essential, given the nature of our topic and its intricacy.

There are numerous advantages of panel data over cross-section or time series discussed in Gujarati (2003). The main points that directly relate to our study and composition of our data are as follows. First, the structure of panel data implicitly relates to individual countries over time, and given the cross-country variation in fiscal multipliers, there is considerable heterogeneity within the data. The benefit in panel estimation lies in its ability to account for this heterogeneity by accommodating such individual country-specific effects. In one sentence, Gujarati (2003) describes the benefits as "more informative data, more variability, less collinearity among variables, more degrees of freedom and more efficiency".[47] Second, panel data is more viable to analyze the 'dynamics of change'. Moreover, it has increased efficiency in detecting and measuring effects that go beyond the

[47] Baltagi, op. cit., pp. 3-6.

range of either time series or cross-section data. We are confident that these panel estimation techniques confirm the usefulness of BMA and act as to instill confidence in those well versed in conventional econometric methods.

We now proceed with our panel estimation techniques – fixed effects and random effects. These are the two primary methods that essentially account for the panel structure of the data. Although based on the linear regression model, these methods have certain advantages in panel estimation over the normal OLS method or pooled estimator. As already mentioned, the structure of panel data itself adds intricacies to the estimation procedure. The pooled estimator is subject to certain limitations that are not appropriate for our study. Automatically assuming that the error term is independent and identically distributed (i.i.d.) may be over-imposing and does not conveniently consider the panel structure of the data.[48] While it is a simple estimation procedure, it is not the most optimal one in explaining the cross-country variation in fiscal multipliers. The empirical literature highlights the variation in fiscal multipliers that considerably varies in sign and magnitude over time period and country. By using the fixed and random effects approaches, we are able to account for time and country specific effects.

Fixed effects estimation

To investigate the factors affecting fiscal policy, we consider two-way fixed effects estimation in order to be able to control for both country specific and time specific effects. The regression results are presented in Table (4) below.

There are three sets of separate regressions for each of our top three models indicated by the BMA methodology. This tackles the model uncertainty problem and we are able to specify appropriate models based on this inference for analyzing the world recession and the OECD samples. The first column lists the relevant variables for each model along with the model R^2 values and the number of observations for each sample under consideration. Columns 2, 3, and 4 present the first, second, and third ranked models respectively. These

[48] $\varepsilon_{it} \sim$ iid $(0, \sigma^2)$ for all i and t; this essentially means that for a given country i, the observations exhibit no serial correlation, and across countries and time, the errors are homoscedastic.

columns are further subdivided according to each of our two samples that we utilize. For the models that do not contain certain regressors, a semi dashed line fills the appropriate space.

Table (4): Two-way Fixed effects for the top three models using Recession and OECD samples

Model Regressors	*First Ranked Model*		*Second Ranked Model*		*Third Ranked Model*	
	Recessions	OECD	Recessions	OECD	Recessions	OECD
Constant	-8.083**	-11.123*	-8.072**	-7.775**	-17.592**	-12.088*
	(3.352)	(6.266)	(3.452)	(6.345)	(7.304)	(6.247)
Exchange Rate	---	---	---	---	0.011*	---
					(0.007)	
Exchange Rate Depreciation	---	---	0.065*	---	---	2.406**
			(0.925)			(1.179)
Exchange Rate Regime	3.770**	---	3.746**	---	3.744**	---
	(1.952)		(2.037)		(1.894)	
Exchange Rate Stance	---	2.857*	---	3.782***	---	---
		(1.081)		(1.524)		
Monetary Expansion	1.683***	3.432***	1.694***	---	1.819***	3.519***
	(0.595)	(1.189)	(0.630)		(0.585)	(1.183)
Change in Current Account Balance	0.230**	---	0.229*	---	0.261**	---
	(0.110)		(0.114)		(0.108)	
Change in Private Investment	---	-0.207**	---	-0.221**	---	-0.232**
		(0.099)		(0.102)		(0.103)
R^2	0.191	0.354	0.190	0.299	0.030	0.362
Obs.	118	341	118	341	118	341

Notes: The dependent variable in these regressions is the fiscal multiplier, which is broadly described as the change in output over the change in the fiscal balance. The time period covered is between 1970 and 1999. Standard errors are in parentheses. *** Significantly different from zero at the 1% level. ** Significantly different from zero at the 5% level. * Significantly different from zero at the 10% level.

First, we observe that all our variables here are statistically significant either at the 1%, 5%, or 10% levels. This is not at all surprising as we rely on the model averaging process to unearth the most pertinent regressors. The results, consistent with our earlier statements as well as the previous theoretical predictions covered in Baldacci *et al.* (2001), suggest that once again, the accompanying monetary policy and the exchange rate regime/policy in action are the most important factors in explaining the cross-country variation in fiscal multipliers. Furthermore, other literature such as Taylor (1998) emphasizes these channels in relation to business cycle considerations, and inflation and unemployment. These studies inadvertently argue that failing to properly account for these channels leads to improper specification of the estimated equation.

As expected, we observe that the resulting monetary expansion during a recession has a positive impact on fiscal multipliers. This is one of the most immediate tools at hand to policy makers and is very often utilized to provide economic stimulus. In all the three models, the estimated coefficient of the monetary expansion variable is positive and significant at the 1% level. This is a similar case for the OECD sample that is unrestricted and consists of both expansions and recessions. The monetary expansion variable is statistically significant at the 1% level in the first and third models for OECD economies, but it is not included in the second model. However, we observe that the exchange rate stance becomes a very significant factor in place of this omission. This variable in our second model is significant at the 1% level, and it is interesting to point out that the positive sign and size of the estimated coefficient is very similar to the coefficients of the monetary expansion variable in the first and third OECD sample models. Not only are these monetary/exchange rate variables interlinked, they seem to assert similar effects based on these regression results.

On a similar note, an exchange rate depreciation features on a lesser level. The second recession model includes this variable and is significant at the 10% level, however, its estimated effect is comparatively smaller to the other variables measuring the effects of exchange rate policy. It also features in the third ranked model in the OECD sample with an estimated effect that is more in tune with those found for the exchange rate stance variable. The value of the exchange rate itself also becomes significant during recessions in our third model. This is a little unique, since the actual value of the exchange rate should generally have no effect. Although this estimated value is minute, it is significant at the 10% level, and perhaps gives some indication of the disparity in exchange rate parity that has been documented in the literature such as Alba and Papell (2007).

In all three recession sample models, we observe the significance of the exchange rate regime at the 5% level. This variable is not even included in any of the OECD sample models, and is very much consistent with various political and economic developments during the period (1970 – 1999) for each respective sample. The OECD models clearly illustrate the collapse of the Bretton Woods system where flexible exchange rate regimes were subsequently preferred. This resembles the low posterior probability of (6.73%) that was earlier reported in our BMA results for the exchange rate regime variable in the OECD sample. However, in the world recession sample, this variable is significant and resembles the fact that some of the countries in this sample still implement fixed exchange rate regimes, which we can see, impacts on the effectiveness of fiscal policy.

The current account balance also plays a part to a lesser degree during recessions. The point estimates presented in columns 1 and 3 (first and third ranked models) for this variable is significant at the 5% level, and significant at the 10% level in column 2 (second ranked model). The estimated coefficient values in these three models are positive and range from 0.229 to 0.261. This suggests that if an economy is in recession, but has a current account surplus (or is a net exporter) during that period, an increase by one percentage point enhances the effectiveness of fiscal policy by 0.23 percentage points.[49]

The effects of private investment on fiscal multipliers become very prominent in the OECD analysis. We observe that all three OECD models exhibit the significance of this variable at the 5% level. However, the most striking feature is the sign of these estimated coefficients; all have a negative effect on fiscal multipliers, which range from -0.207 to -0.232. In our

[49] This coefficient estimate is for the first ranked model only.

first ranked model, the coefficient estimate suggests that a one percent increase actually depresses fiscal multipliers by 0.207 percent. This result is somewhat counter intuitive that private investment reduces the effectiveness of fiscal policy on output. However, it provides evidence for the effects of crowding out that are predicted in theoretical work.[50] In addition, we observe that this variable does not feature at all in any of the three recession sample models. This is consistent with the fact that private investment becomes naturally less prominent during episodes of recession.

Random effects estimation

There is considerable debate over which method of estimation, whether fixed effects or random effects, is more suitable. One can easily argue that given the composition of both our samples, the fixed effects estimator should be preferred as both samples are in well-defined groups. On the other hand, the commonly touted Hausman test is recommended to examine the appropriateness of the random effects estimator under various conditions. If one believes the model is correctly specified and the test returns significant results, this will provide evidence that the regressors are correlated with random effects.

Given the challenging nature of our topic, there is no perfectly right or wrong answer in this case. The empirical literature in this area is already riddled with difficulty in explaining the cross-country variation in fiscal multipliers, so we aim to utilize both these methods to assess the accuracy of our estimated results. Two-way random effects estimation is therefore employed and the results are presented in Table (5). The table follows the same format as described earlier for the fixed effects estimation.

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[50] This was previously discussed in detail in sections (5.1) and (5.2).

Table (5): Two-way Random effects for the top three models using Recession and OECD samples

Model Regressors	*First Ranked Model*		*Second Ranked Model*		*Third Ranked Model*	
	Recessions	OECD	Recessions	OECD	Recessions	OECD
Constant	-0.882*	-13.609**	-1.119*	-9.882	-0.872*	-13.681**
	(2.759)	(5.948)	(2.735)	(6.053)	(2.757)	(5.913)
Exchange Rate	---	---	---	---	-0.020**	---
					(0.013)	
Exchange Rate Depreciation	---	---	-0.581**	---	---	2.550**
			(0.599)			(1.061)
Exchange Rate Regime	3.858***	---	4.146***	---	3.861***	---
	(0.865)		(0.909)		(0.863)	
Exchange Rate Stance	---	3.989**	---	5.502**	---	---
		(1.210)		(2.445)		
Monetary Expansion	1.793***	3.715***	1.768***	---	1.765***	3.815***
	(0.459)	(1.133)	(0.472)		(0.456)	(1.124)
Change in Current Account Balance	0.154***	---	0.158***	---	0.151***	---
	(0.054)		(0.054)		(0.054)	
Change in Private Investment	---	-0.172**	---	-0.178**	---	-0.185*
		(0.092)		(0.095)		(0.092)
R^2	0.376	0.361	0.387	0.307	0.411	0.368
Obs.	118	341	118	341	118	341

Notes: The dependent variable in these regressions is the fiscal multiplier, which is broadly described as the change in output over the change in the fiscal balance. The time period covered is between 1970 and 1999. Standard errors are in parentheses. *** Significantly different from zero at the 1% level. ** Significantly different from zero at the 5% level. * Significantly different from zero at the 10% level.

The first and foremost observation is that a comparison of these results is very similar to the fixed effects estimation results. Most notably, the estimated coefficient signs are the same in both respects, and all variables are once again significant. We observe that the actual significance levels of each of the variables tend to be quite similar. In addition, the estimated values themselves resemble one another in a fairly close manner. There are of course one or two results that exhibit some discrepancy. For example, the estimated coefficient value of the exchange rate depreciation variable in the fixed effects estimation of the recession sample does not closely correspond to the random effects estimation. However, on the whole, the random effects regression results are excellent result since they indicate that the Bayesian approach is also robust to different panel estimation techniques.

(6) Robustness

For any given empirical examination there are certain questions that arise from the selection of the particular methodology used, and the sensitivity and robustness of the results. This is a genuine concern, since Bayesian Model Averaging methodology has not been previously utilized in traditional fiscal policy analysis.

Up to this point, we have attempted to convey as much relevant information in previous sections, including methodological derivations that promote the viability and appeal of adopting BMA. Therefore, this section will first summarize a competing strategy of equivalent nature to address robustness – known as Bayesian Averaging of Classical Estimates (BACE). We highlight the main differences between these two methods and cite an empirical exercise that compares both methods. Second, we implement a type of 'sensitivity analysis' that intuitively follows to address the sensitivity of individual regressor rankings to the choice of various prior distributions.

BACE is developed by Sala-i-Martin, Doppelhofer and Miller (2004) and is essentially a variant of BMA. Key differences include the use of diffuse priors, whereas our approach as explained by Fernandez *et al.* (2001), adopts the use of a prior selection inherent within the model. There is also a different weighting scheme. Our approach adopts a uniform model prior distribution and this automatically assumes that the prior value is ½. On the other hand, Sala-i-Martin *et al.* (2004) propose that a more appropriate prior probability is ¼ that a particular variable appears in the true model. BACE also utilizes a tool called the stratifying sampler instead of the MC^3 sampler. Given these slight technical differences, a robust BMA procedure should yield results that are similar to BACE.

This is exactly what Masanjala and Papageorgiou (2005) infer, and they implement BACE as a comparative method to BMA. They find that the two methodologies provide results that are essentially the same. Their top ranked regressors and models are identical, and they confer that the choice of model priors between the two methods has indifferent effects on their main findings. In fact, their tests suggest that simply using BACE as a robustness check only reconfirms the similarity between the two approaches. We conclude that this is also the case in our investigation, since we, like Masanjala and Papageorgiou (2005), also use the approach set out by Fernandez *et al.* (2001).

The real issue at heart is the degree to which our results may vary according to the choice of prior distribution. We implicitly rely on a data-driven process that ensures the prior has little influence over posterior model probabilities. However, to illustrate the robustness across various choices of prior distributions, we present a range of results obtained from three randomly selected *g*-prior scalar parameters below and compare them to the main findings. In Tables (6a) and (6b), column 1 below displays the top five ranked variables and their probabilities derived from both samples. In a similar fashion, columns 2, 3, and 4 illustrate the top five ranked variables and their associated probabilities obtained from the three randomly selected prior structures. In a way, this is a type of sensitivity analysis to assess the degree to which the results may vary due to the choice of *g*-prior.

Tables (6a) & (6b): Sensitivity of Individual Regressor Posterior Probabilities

(6a): Sample 1: 'World' Recession only sample - top 5 variables

	Estimated Result (Default Prior)	**Prior 1**	**Prior 2**	**Prior 3**
1	Exchange Rate Regime (96%)	99%	88%	91%
2	Monetary Expansion (94%)	98%	79%	90%
3	Chg in CA Balance (62%)	56%	43%	60%
4	Ex. Rate Depreciation (29%)	48%	22%	25%
5	Chg in Govt. Debt (26%)	37%	20%	22%

(6b): Sample 2: 'OECD' only sample - top 5 variables

	Estimated Result (Default Prior)	**Prior 1**	**Prior 2**	**Prior 3**
1	Chg in Ex. Rate (77%)	69%	81%	77%
2	Chg in Priv. Inv (68%)	62%	76%	71%
3	Monetary Expansion (49%)	41%	66%	54%
4	Ex. Rate Depreciation (23%)	18%	35%	26%
5	Govt. Crisis (14%)	15%	23%	18%

Notes: The relative rankings of these top five variables in either sample do not change even after extensive testing of many alternative priors. Only the posterior probabilities experience slight changes as shown above.

We can see from the tables above that the use of these different *g*-priors influence the marginal posterior probabilities, however, the rankings of the explanatory variables based on relative importance or significance remains unchanged. These results indicate that although the choice of prior distribution is somewhat important, the data-driven nature of this BMA algorithm consistently distinguishes variables that are most relevant. It produces essentially the same results over a variety of prior distributions and leads us to believe in this very robust procedure.[51]

In addition, the methodology of BMA is statistically robust enough to overcome any effects of collinearity. That is, when a pair or more of regressors may be in some way connected to constrict the usual methods of inference in regression analysis. There is a strong chance of collinearity within our full set of regressors. For example, Money Supply, Interest Rate, CPI, among others, all relate to monetary policy and tend to be highly correlated. Moreover, many primary variables in Table (1), section (3, Data) are represented in a slightly different format, in which they are converted to measure period-by-period changes.[52] The inclusion of all these variables would lead to obviously flawed results in standard regression analysis, and may run the risk of incorrectly excluding statistically important variables.

One of the advantages of this Bayesian approach is its capacity to negate such effects simply by its handling of data. The weighting scheme discussed in the methodology section carefully computes the information given by any pair(s) of regressors in a regression. So if a pair of variables is indeed correlated, one is likely to be excluded in a model since its counterpart captures more or less the same information. For example, note that in the OECD sample, the variables 'Exchange Rate Stance' and 'Exchange Rate Depreciation' are both significant and would undoubtedly exhibit characteristics of collinearity. However, they are both mutually exclusive. The model posterior results in Table (3), section (5.2) shows that BMA tends to visit the more significant variable 'Exchange Rate Stance' more

[51] Additional robustness checks include extensively analyzing the effects of priors on our top overall ranked models and also constricting the number of independent variables. The use of various *g*-priors has no real effect on the models, nor do the number of regressors have any significant impact on the regressor rankings, besides some small differences in posterior probabilities.

[52] For example, given two data points over two periods, we calculate the change between the time periods.

frequently in the first and second ranked models. However, in the third ranked model, 'Exchange Rate Depreciation' is included as a proxy. Such variables with pairwise correlation have no real chance of harming the regression outcome by using this methodology.

(7) Conclusions and Suggestions for Future research

Given the lack of consensus in the literature, this investigation seeks to explain the cross-country variation in fiscal multipliers through the use of Bayesian Model Averaging (BMA) methods. The analysis covers two facets that are inherently plagued by problems of parameter and model uncertainty; (i) what determines the effectiveness of fiscal policy? Are these factors different during recessions or exclusively in advanced economies; (ii) is there empirical support for any of the theoretical predictions?

Generally speaking, there is considerable variance under conditions of recession. This often leads to results that are seemingly insignificant. The application of Bayesian Model Averaging effectively estimates the posterior probability of a vast array of regressors, and in different combinations, and is therefore better able to capture the specific effects that tend to influence the relationship between fiscal policy and economic activity. Our results suggest that from a wide range of potential explanatory variables, accompanying policies (monetary policy and exchange rate regime) tend to have the greatest impact on fiscal multipliers during recessions, while the current account features to a lesser extent.

Next, we find that in a well defined unrestricted OECD sample group (consisting of expansions and recessions), there are some intriguing discoveries on the effectiveness of fiscal policy that confirm certain theoretical predictions. The importance of accompanying policies is once again confirmed, however, there is a noteworthy addition to be considered. The significance of private investment provides evidence of crowding out, particularly through the interest rate channel. This effect is confirmed through a series of panel regression estimations. We find the effect of private investment on the fiscal multiplier is not only statistically significant but also negative in sign. The economic implications are very significant. Given the fact that essentially all OECD economies during the sample period are open economies with flexible exchange rate regimes, crowding out directly influences the size and sign of fiscal multipliers through the interest rate and exchange rate channels.

Some opportunities for future research exist. As BMA is relatively fresh in econometric analysis, and even untested in the analysis of fiscal policy, there is considerable scope for the development of various methodological issues described within this study. For example, BMA analysis fails to tackle the endogeneity problem that many VAR fiscal policy studies look into. Another consideration is to include a measure for certain variables that relate directly to country and region specific effects, which due to data limitations and difficulty in quantifying for a large number of countries, were not considered in this analysis.[53] This may provide a clearer picture on the complexity of fiscal policy and economic activity, especially when it comes to accounting for some extreme variance covering a large number of countries during recessions.

While one of the main lessons of this investigation is the importance of accompanying policies, it would be most useful to undertake a study to estimate the extent to which fiscal multipliers vary according to monetary and exchange rate policy. The process of BMA in this instance has identified the significance of certain variables, and some indications of model specification. Similarly, the panel study has given us some estimates of the impact of such variables on the fiscal multiplier. However, there are certain other questions that would be useful to know. We have identified the effects of the crowding out of private investment on the fiscal multiplier. The other side of the coin is to determine the relationship between interest rates and investment and the extent to which this relationship varies. We have also used the change in the actual fiscal balance to determine the stance of fiscal policy instead of the structural balance due to data limitations. While using the actual balance has the advantage of not having to distinguish between the discretionary and automatic components of fiscal policy during recessions, it may be influenced by real GDP growth, and may therefore be subject to certain limitations. Finally, some consideration should be given to the composition of a fiscal expansion or contraction. It would be extremely useful to calculate separate multipliers for the different tax and expenditure components of fiscal policy and then determine the factors that influence the effectiveness

[53] For example, we were unable to consider factors such as financial uncertainty and the sensitivity of consumption and investment to interest rates. Such variables influence the degree of crowding out, and may in fact vary considerably across different regions.

of these individual fiscal tools. There is strong evidence in the empirical literature that the different components of fiscal policy induce different effects, and using an aggregated approach may conceal the true impact of the intended fiscal policy action.

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Appendix

Table (A1): Variables, Definitions, and Data Source

Variable	Definition	Source
Growth	Real GDP growth (relative to trend) during the recession	From Baldacci et.al
FISRES	Average overall fiscal balance during recession minus overall fiscal balance before recession, % of GDP	From Baldacci et.al
Interest Rate	Deposit Rate	IFS
M2 to GDP	Money and quasi money, % of GDP	IFS and WEO
Exchange Rate	National currency per USD	WEO
Inflation	Consumer Price Index	WEO
Public Debt	General government net debt, % of GDP	WEO
CA Balance	Current Account Balance, % of GDP	WEO
Pub. Inv	Public Investment, % of GDP	WB
Priv. Inv	Private Investment, % ofGDP	WB
Party	Party fractionalization index	WB
RealOV	Real Overvaluation	WB
GRev	Government Revenue, % of GDP	WB
GExp	Government Expenditure, % of GDP	WB
CGDP	Real Domestic Product per Capita	Penn World Tables
CONSHARE	Consumption Share of CGDP	Penn World Tables
INVSHARE	Investment Share of CGDP	Penn World Tables
OPENC	Imports+Exports/CGDP	Penn World Tables
CURSAVE	% of Current Savings to GDP	Penn World Tables

Notes: WEO = IMF World Economic Outlook, WB = World Bank Global Development Finance, IFS = IMF International Financial Statistics.

Variable	Definition
Multiplier (Dependant variable)	Growth/FISRES
Fiscal Size	Revenue/GDP ratio
Proportion of Revenue to Expenditure	GRev/GExp
Expenditure-led Fiscal Response	Change in expenditure to GDP is larger than change in revenue to GDP, absolute values (Dummy)
Exchange Rate Regime	Flexible or Fixed Regime (Dummy)
Expansionary Monetary Policy	Negative interest rates response, decline in rates (Dummy)
Exchange Rate Depreciation (During)	Positive exchange rate response during recession (Dummy)

Notes: The variables in this table are derived from the primary variables above, and are also used in Bayesian Model Averaging.

Given the vast coverage and highly variable nature of some data, we treat certain observations as outliers and exclude them from the analysis. The conditions set forth below are designed to exclude extremely rare and obscure events. Treatment of outliers occurs when:

- Growth is over 15 percent in absolute value
- Fiscal balance is over 15 percent of GDP in absolute value
- Government debt to GDP is over 300 percent
- Inflation is over 100 percent
- Interest rate is over 100 percent in absolute value
- Change in revenue to GDP or expenditure to GDP is over 20 percent in absolute value
- Current account balance to GDP is over 20 percent in absolute value
- Openness is over 100 percent
- Exchange rate change is above 100 percent in absolute value

Note: Baldacci *et al.* (2001) use a similar definition in the treatment of outliers.

Table (A2): Collection of Recession Episodes

Region: **ADVANCED ECONOMIES**

Country	*Year of Recession*
Australia	1982, 1990
Austria	1978, 1981, 1984, 1993
Belgium	1983, 1993
Canada	1982, 1990
Denmark	1974, 1980, 1989, 1993
Finland	1991
France	1975, 1991, 1993
Germany	1993
Greece	1982, 1987, 1993
Iceland	1983, 1988, 1992
Ireland	1983
Italy	1982, 1993
Japan	1974, 1993
Korea	1980, 1998
Netherlands	1993
New Zealand	1991
Norway	1978, 1982, 1988
Portugal	1983, 1993
Singapore	1975, 1985
Spain	1981, 1992
United Kingdom	1974, 1980, 1991
United States	1974, 1980, 1982
Total No. of Episodes	49

Region: **AFRICA**

Country	*Year of Recession*
Burkina Faso	1987
Cameroon	1988
CÂte d'Ivoire	1983, 1987
Central African Republic	1982, 1987
Ethiopia	1984
Gabon	1981
Gambia, The	1984
Madagascar	1981
Malawi	1981
Mali	1983
Mauritius	1981, 1984
Morocco	1981, 1987
Mozambique, Rep. of	1982
Nigeria	1987
Rwanda	1982
Senegal	1984
Sierra Leone	1985
South Africa	1982, 1985
Togo	1983
Tunisia	1986, 1988
Uganda	1984
Total No. of Episodes	27

Region: **ASIA**

Country	*Year of Recession*
Fiji	1977, 1980, 1983, 1985, 1987
India	1972, 1974, 1976, 1979
Nepal	1971, 1973, 1980, 1983, 1985
Pakistan	1971
Philippines	1984
Sri Lanka	1987
Total No. of Episodes	17

Region: **MIDDLE EAST**

Country	*Year of Recession*
Iran, Islamic Republic of	1986, 1988
Syrian Arab Republic	1986
Total No. of Episodes	3

Region: **WESTERN HEMISPHERE**

Country	*Year of Recession*
Barbados	1981
Brazil	1981, 1983
Chile	1982
Costa Rica	1980, 1985
Dominican Republic	1984
Ecuador	1983, 1987
Haiti	1982
Honduras	1974, 1982
Jamaica	1974, 1988
Mexico	1982
Panama	1983, 1987
Paraguay	1982, 1986
Peru	1983, 1988
Trinidad and Tobago	1983
Total No. of Episodes	22