



# Endogeneity and panel data in growth regressions: A Bayesian model averaging approach



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## ARTICLE INFO

### Article history:

Received 12 May 2014

Accepted 12 July 2015

Available online 14 August 2015

### JEL Classification:

O1  
O2  
O4  
C30  
C11

### Keywords:

Bayesian model averaging  
Instrumental variables  
Panel data  
Empirics of growth  
Effectiveness of aid

## ABSTRACT

Bayesian model averaging (BMA) has been successfully applied in the empirical growth literature as a way to overcome the sensitivity of results to different model specifications. In this paper, we develop a BMA technique to analyze panel data models with fixed effects that differ in the set of instruments, exogeneity restrictions, or the set of explanatory variables in the regression. The large model space that typically arises can be effectively analyzed using a Markov Chain Monte Carlo algorithm. We apply our technique to investigate the effect of foreign aid on per capita GDP growth. We show that BMA is an effective tool for the analysis of panel data growth regressions in cases where the number of models is large and results are sensitive to model assumptions.

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## 1. Introduction

The technique of Bayesian model averaging (BMA) was popularized as a method to overcome model uncertainty in growth regressions by [Fernández et al. \(2001a,b\)](#) and [Sala-i Martin et al. \(2004\)](#). It was proposed as a method to overcome the sensitivity of results with respect to the set of explanatory variables that is included in a regression. Since then, BMA has been applied widely in the empirical growth literature (e.g., [Cicccone and Jarocinski, 2010](#); [Crespo-Cuaresma et al., 2011](#); [Durlauf et al., 2008](#); [Prüfer and Tondl, 2008](#); [Winford and Papageorgiou, 2008](#)) and in other areas of economics (e.g., [Koop and Toole, 2003](#); [Tobias and Li, 2004](#)). Recent papers have contributed towards the development of summary measures of the output ([Doppelhofer and Weeks, 2009](#); [Ley and Steel, 2007](#)); led to greater understanding of prior assumptions (e.g., [Ley and Steel, 2009, 2012](#)); and extended the technique in ways that are relevant to growth regressions such as threshold models ([Crespo-Cuaresma and Doppelhofer, 2007](#)), heteroscedasticity ([Doppelhofer and Weeks, 2008](#)), endogeneity ([Cohen-Cole et al., 2009](#); [Karl and Lenkoski, 2012](#); [Koop et al., 2012](#); [Lenkoski et al., 2014](#)), and panel data models ([Chen et al., 2009, 2011](#); [León-González and Montolio, 2004](#); [Moral-Benito, 2012, 2014](#)).

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As has been well documented, some of the regressors in growth regressions may be endogenous. This problem is particularly relevant in empirical studies looking at the impact of foreign aid on the economic growth of developing countries. The importance of the policy implications that can be derived from such studies makes the issue of properly addressing causality between aid and growth the cornerstone of this literature. Only robust and reliable results can be transferred into effective foreign aid policies that ultimately contribute towards the development of countries and their citizens.

However, while most previous research in growth regressions has dealt with uncertainty regarding the set of explanatory variables in the regression, little attention has been given to the uncertainty regarding the choice of instruments and exogeneity restrictions. In this sense it is also noteworthy that empirical results can be greatly affected by the choice and number of instruments that are used to tackle the endogeneity problem, as we further illustrate in [Section 5](#). Moreover, although in a panel data context instruments can be easily constructed using lags, it has been argued that it is not good practice to use the whole set of available instruments (e.g., see [Roodman, 2009a](#)). As a consequence, there are no clear guidelines to choose among models with different sets of identifying restrictions.

In this paper we develop a new BMA strategy to deal with a model space that includes models that differ in the set of regressors, instruments, and exogeneity restrictions in a panel data context. To deal with the large number of models that arise in a typical application (in our application, we deal with approximately  $2^{46}$  models) we use the reversible jump algorithm developed by [Koop et al. \(2012, KLS henceforth\)](#) for BMA in the instrumental variable regression model. We show how this framework can be adapted to deal with dynamic panel data models with endogenous (or predetermined) regressors and the large instrument set that is typically available in a panel data context (e.g., [Arellano and Bond, 1991](#)). Our work differs from other BMA analyses of dynamic panel data models with endogenous regressors (i.e. [Chen et al., 2009, 2011](#); [Moral-Benito, 2014](#)) in that we allow uncertainty regarding not only the set of controlling variables but also in other dimensions such as the set of instruments and exogeneity restrictions of regressors. Although [Moral-Benito \(2014\)](#) does not explicitly use instruments, the reduced form for endogenous regressors is written as an autoregressive process with the maximum number of lags. Because the likelihood could also be specified with a smaller number of lags, the problem of choosing the number of lags arises and this problem is analogous to choosing the set of instruments. Similarly, [Chen et al. \(2009, 2011\)](#) use GMM style moment restrictions and choosing the set of moment restrictions is also analogous to choosing the set of instruments.

We make use of the original dataset of [Burnside and Dollar \(2000, BD henceforth\)](#), as extended by [Easterly et al. \(2004, ELR henceforth\)](#), who used instrumental variable regression to analyze the impact of foreign aid (an endogenous regressor) on the per capita GDP growth of developing countries. The work of BD generated a lot of interest and was followed by a large number of papers that (using different estimation methods, set of control variables/instruments, definition of variables, slightly different datasets, etc.) found similar (e.g., [Collier and Dollar, 2002](#)) and sometimes different results (e.g., [Hansen and Tarp, 2001](#)). Furthermore, it still generates open debate in the aid effectiveness literature today.<sup>1</sup>

Our novel methodology provides a useful diagnostic tool to study whether foreign aid increases the growth rate of per capita GDP, thereby contributing substantially to the aid effectiveness debate. Furthermore, we show what we can learn from the approach adopted in BD if we appropriately consider the problem of model uncertainty in the set of regressors, in the exogeneity restrictions, and in the choice of instruments typically used in panel data growth regressions with fixed effects. We find that there is no strong evidence that foreign aid increases the growth rate of per capita GDP, not even when interacted with an index of good policies. Instead we find that good policies such as low inflation and openness have a clear role in improving the economic growth of recipient countries.

The paper is organized as follows. [Section 2](#) describes the context of our empirical contribution in reference to previous literature. [Section 3](#) describes the model space in the context of panel data growth regressions with endogenous regressors. [Section 4](#) briefly presents the main concepts regarding prior/posterior probabilities and computation. [Section 5](#) presents the results of applying our new BMA strategy. Finally, [Section 6](#) concludes.

## 2. Aid, policies, and economic growth

The impact of foreign aid and macroeconomic policies on economic growth is still an interesting and open debate, in both developing countries (recipients) and developed countries (donors). The seminal work by BD became influential because of the policy implications of their results, which could be summarized as follows: donor countries should direct aid to developing countries with “good” macroeconomic (i.e. fiscal, monetary, and trade) policies. The “policy selectivity” result in BD has been questioned by various authors and for different reasons: (i) data issues; (ii) selection of regressors and of instrumental variables (when endogeneity of aid is accounted for); and (iii) the econometric technique chosen. As [Roodman \(2007\)](#) states, “*The diversity of conclusions within this literature, arising from roughly similar specifications applied within the same data universe, alone suggests that many of the results in question are fragile. That should concern policymakers and researchers alike. Yet among research papers favoring one story or another, robustness testing is rare.*”

Because of the high relevance of this topic, and the controversy of some of the results found, the literature dealing with the effectiveness of foreign aid is vast and shows often contradictory results, which is a sign that the debate is still open and demands further research. The literature is so extensive that it is already the focus of meta-analysis techniques (e.g. [Doucouliagos and Paldam, 2009, 2010, 2015](#); [Mekasha and Tarp, 2013](#)). In a recent meta-analysis exercise [Doucouliagos and Paldam \(2015\)](#) report

<sup>1</sup> For a broad review of this literature, see for example, the meta-analysis produced by [Doucouliagos and Paldam \(2009; 2010\)](#).

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