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## Does it Make a Difference? Comparing Growth Effects of European and North American FDI in Latin America

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# Does it Make a Difference? Comparing Growth Effects of European and North American FDI in Latin America

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## Abstract

FDI from the European Union (EU) ranks before FDI from North America (NA) in some of the Latin American countries. We investigate the impact of EU- versus NA-FDI on the growth rate including about 50 controls. Country specific effects and parameter heterogeneity are incorporated in our estimation. We use Bayesian Model Averaging to address model uncertainty and to select the best models and most robust parameters. Our results indicate that positive effects of FDI are dependent on the functioning of legal frameworks and the quality of infrastructure. EU-FDI is an important, robust growth determinant whereas NA-FDI is not.

*JEL Classification:* C52, F21, F43, O54

*Keywords:* Growth determinants, FDI, model uncertainty, Bayesian Model Averaging, Latin America

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# 1 Introduction

The EU has become the largest direct investor ahead of North America (NA) in some of the Latin American (LA) countries, especially in South America.<sup>1</sup> Due to the negative experiences with their earlier import substitution development strategies, LA countries consider the attraction of foreign direct investment (FDI) as a key strategy to promote growth and development since the 1990s. At the end of this decade more than 80 per cent of the net private capital flows into the region have been FDI.<sup>2</sup> This raises several questions: To what extent can FDI flows into LA actually contribute to growth? Which conditions must be met for FDI to be beneficial for growth? Are growth effects different if source countries differ, in particular, does it make a difference if FDI comes from the EU compared to NA?

The theoretical literature proposes a number of arguments for FDI having a positive impact on growth. The starting point is commonly an endogenous growth model in which FDI receives a special role in raising technology levels. First, FDI is considered to act as main channel for international technology transfers increasing the productivity of the host country. Second, foreign firms are supposed to increase competition and, thus, inducing local firms to become more productive. Third, foreign firms are assumed to invest in training of the work force thereby improving qualifications in the country.<sup>3</sup>

Contrary to the extensive literature on FDI effects in other developing and transition countries, there are only few studies having investigated the FDI-growth nexus for LA. In our opinion, two major drawbacks are related to these studies. First, it is not possible to draw clear conclusions from them due to the varying methods, model specifications and country samples used. Second, these studies neither consider different source countries in general nor EU- versus NA-FDI in particular. First evidence, however, suggests that the pattern and motivation of EU-FDI – hence, most likely also its impact on the host country – differ from those of NA. While EU companies heavily invested in public utilities and the service sector through acquisitions, NA investment focused on greenfield investment in the manufacturing sector.

Several studies analyzed the connection of GDP growth and FDI inflows. A positive relation was early established in studies for Mexico (e.g. Blomström and Wolf 1994). Cuadros et al. (2004) performed Granger causality tests between FDI and growth for Argentina, Brazil and Mexico 1975-1997. Looking at 1970-1990 and performing a time series analysis and vector autoregressions (VAR), De Mello and Fukasaku (2000) also find a positive

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<sup>1</sup>See, for example, UNCTAD 2004; Vodusek 2004.

<sup>2</sup>Levy Yegati et al. 2007.

<sup>3</sup>Borensztein et al. 1998.

effect of FDI on GDP growth for Mexico and Venezuela but have to reject such an effect for Chile and Brazil. Nor do find Heo and De Rouen (2002) clear evidence for a positive growth impact of US-FDI in LA in a similar VAR analysis for 1950-1998. In contrast, Bengoa and Sanchez-Robles (2003) estimate the impact of FDI on growth in a panel data model and propose a positive effect of FDI on growth in their study on 18 LA countries. This paper analyzes the growth effects of FDI in 17 LA countries in the period 1985-2003. In contrast to earlier studies that only investigated fairly general conditional factors, we look at specific indicators capturing infrastructure and human capital conditions as well as the institutional, structural and macroeconomic environment for FDI in LA. We first analyze total FDI inflows but then distinguish between NA- and EU-FDI allowing also for parameter heterogeneity between different groups of LA countries (the rich, the big and the South American economies as opposed to the rest).

A problem inherent in empirical growth research is model and parameter uncertainty, that is, uncertainty about the correct model and about which explanatory variables to include exactly in the growth regression. It roots in lacking theoretical guidance due to the ‘openedness’ of growth theory and necessitates a framework being capable of incorporating these uncertainties in a statistically rigorous way. Therefore, we use BMA which was first proposed in the growth context by Fernández, Ley and Steel (henceforth FLS) (2001a). It draws inference based on a weighted average of all available models instead of on the basis of one *a priori* chosen model that is supposed to be the ‘true’ one.<sup>4</sup>

This paper extends the seminal work of FLS (2001a) to a panel framework. BMA endogenously determines a ranking in terms of explanatory power of all our variables and models which is why our results are highly reliable as they are not derived conditional on a special model but based only on very robust regressors. We find a strong and positive growth impact of total FDI when it interacts with rule of law and tertiary education. Distinguishing between source countries we find only EU-FDI to be an important growth factor in LA if it meets low political risk and a sound legal framework. In contrast, we cannot find a robust impact of NA-FDI. Generally, institutions, infrastructure and human capital, especially tertiary education, play an important role in our growth regressions.

The paper is organized as follows: Section 2 presents our hypotheses and specifies the model. Section 3 describes the large set of variables and their sources. Section 4 describes the methodology and discusses econometric issues. Section 5 presents the results while section 6 concludes.

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<sup>4</sup>See Hoeting et al. (1999) for a general overview on the methodology. For a recent survey on the econometric problems of standard cross-country growth regressions see, for example, Durlauf et al. (2005). The need for Bayesian approaches is emphasized, among others, in Brock and Durlauf (2001), Brock et al. (2003), Masanjala and Papageorgiou (2004) or Sala-i-Martin et al. (2004).

## 2 Hypotheses and Model Specification

While growth was high in LA in the 1960 and 1970s, it faded after the debt crisis of the early 1980s. The period entered as Latin America's lost decade in economic history. Then economic reforms were initiated aiming at less government intervention, more liberalization and macroeconomic stabilization in line with the Washington consensus. Finally, growth gained momentum since the first half of the 1990s. Nevertheless, the region suffered a number of crises, such as Mexico in 1994/95, Brazil in 1999 and Argentina in 2001.<sup>5</sup>

Economic liberalization also entailed an opening towards FDI. LA countries and their representative international institutions like the UN commission for LA and the Caribbean (ECLAC) and the Inter-American Development Bank (IDB) increasingly considered the attraction of FDI as key strategy to promote growth and development. Therefore, the total stock of FDI in LA rose steeply with a growth rate of around 30 per cent per year since the mid 1990s.<sup>6</sup> In countries like Bolivia and Chile FDI reached more than 50 per cent of GDP from the end of the 90's onwards and steeply increasing up to 70 per cent or more. In countries like Ecuador, Nicaragua or Venezuela the FDI/GDP share is approaching 50 per cent and, generally speaking, it is still steadily increasing in all LA countries (see Figure 1 in the appendix). While NA investment traditionally played an important role in LA, EU-FDI surpassed NA-FDI stocks in South America in the 1990s. Since then it dominates in Argentina, Brazil, Columbia, Ecuador, Paraguay and Peru whereas NA-FDI is still most important in Mexico and Central America (see Figures 2-5 in the Appendix). Why should FDI stimulate growth and development? The starting point is commonly the notion that FDI receives a special role in raising the technology level. First, FDI is considered to act as a main channel for international technology transfer. Multinationals operate with superior technologies and managerial practices, which increase productivity in the industry of the host country. Second, the entry of foreign firms increases the competition level in the branch that should lead to an increase of productivity of local firms. Third, foreign firms establish linkages with upstream and downstream firms and will thereby transfer technological know-how to them as well. Another channel of spillover effects of foreign firms will act through the labor market (Aitken et al. 1997, Blomström and Kokko 1997, Borensztein et al. 1998).

Empirical studies testing the growth impact of the level of FDI stocks per se largely remain inconclusive. However, some literature appeared which proposed the growth effect is subject to certain conditions in the country of destination. Borensztein et al. (1998) show that FDI only has a positive impact on growth if a country possesses a sufficient

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<sup>5</sup>Corbo et al. 2005.

<sup>6</sup>Levy Yegati et al. 2007, p. 105

level of human capital. Carkovic and Levine (2002) test whether human capital and the income level of an economy determine the growth impact of FDI while Castejón and Wörz, (2006) look at the openness of an economy as a condition for the growth effect of FDI. We consider that there are many more factors that may be critical for the growth impact of FDI. Therefore, in contrast to earlier studies looking at fairly rough general indicators as conditional factors for FDI, we shall investigate the impact of FDI conditioned on a variety of very specific factors, which will be described below.

This study also distinguishes between different source countries of FDI as the impact of EU-FDI may differ from that of NA-FDI since the motives for FDI, its nature and type as well as the investment sectors differ between EU and NA investors. Starting from these first insights on FDI provided by European and North American investors to what extent could the source region then make a difference for growth effects of FDI to arise?

Note that the aggregate productivity effect on the macro level is the sum of several effects, namely productivity increases within the firm, horizontal productivity effects through increased competition and labor mobility to competing firms and, finally, productivity spillovers through forward and backward linkages (Rodriguez Clare 1996, Markusen and Venables 1999). The extent of these productivity effects depends (i) on the way in which foreign investment is provided (greenfield FDI versus mergers and acquisitions), (ii) the type of FDI (market seeking/horizontal FDI versus vertical FDI) which often is related to the distance of the source country and the applicability of free trade regimes and (iii) and the sector of investment. Obviously it makes a difference whether FDI takes place as greenfield investment or through mergers and acquisitions. While greenfield investment usually introduces more advanced technologies in the new production site and thus provides a substantial direct productivity effect, it is less likely to source locally and thus produces less spillover effects to backward industries. These spillovers are more provided in the case of mergers and acquisitions where the supplier relations of the acquired firm are kept (Javorcik 2004, Javorcik and Spatareanu 2006). Second, vertical FDI, where just a stage in the production is transferred to the host country to benefit from cost advantages and where commonly the supplies are imported from the source country, will not generate spillover effects on the local industry. The benefit of this FDI remains limited to a direct productivity effect and the provision of additional production capacity offering employment. In contrast, with horizontal FDI, the entire production process of a product is placed in the host country. This not only provides for a direct productivity effect through advanced technologies and the upgrading of a multitude of skills, but it also provides for large productivity spillovers since a large number of intermediary products need to be purchased, mostly locally. Geographically close partner countries and labor costs differ-

entials promote vertical FDI. The existence of a free trade regime between the partners will further boost vertical FDI. Examples are found in the Eastern European transition countries and in Mexico, which are both close to a rich neighbor and linked by a free trade arrangement. Javorcik et al. (2004) have shown that distance to the source country and the applicability of free trade results in different types of investment and spillovers in Eastern Europe. While close EU investors, subject to free trade, did not provide for local spillovers when investing in Rumania because they did not source locally, US-FDI which did not benefit of free trade for home supplies and were home imports would also involve high transport costs, generated productivity spillovers. Similarly, we may expect that EU-FDI in Latin America should in general be market seeking because home markets are too distant for vertical FDI and the extent of free trade between the EU and Latin American countries is very limited. In contrast, for North American investors Latin American countries are close production sites and free trade regimes are partly well established, e.g. with Mexico and Central America. We would therefore expect that vertical FDI dominates with NA-FDI. Third, investment in the manufacturing sector is likely to generate more spillover effects to the local economy through linkages than investment in the primary sector such as mining which uses imported capital goods and operates rather isolated (Alfaro and Rodriguez Clare 2003). Furthermore, FDI in the in the service sector subject to privatization processes improves the efficiency of local infrastructure such as telecommunication and financial services and consequently enables more productivity gains from FDI in manufacturing (Arnold et al. 2006). Consequently, the important participation of European investors in service markets liberalization in Latin American countries would have a high potential to generate productivity effects. In summary, there is good reason to suppose EU- and NA-FDI would yield different productivity effects in LA.

The lack of robust results on the growth impact of FDI in previous studies is also likely to be attributed to different indicators for FDI, econometric problems and unreliable data. First, using FDI data one needs to be aware of potential problems arising in the data. According to the IMF's Balance of Payments Manual, which is the principal framework for collecting FDI data, FDI data should include the components equity capital, reinvested earning and intra-firm loans. However, particularly the latter two categories may not be reported properly. Furthermore, while the IMF recommends indication of FDI stocks on a market value basis, in practice, firms report FDI stocks from firm balance sheets that are often measured at historical costs (Duce 2003). Our principal source of FDI stock data is UNCTAD. FDI stocks from the EU and the NA were compiled from several additional sources as explained in Table A.2.2 in the appendix. Although data for our FDI variables was compiled with much care, one needs to be aware of remaining data uncertainties.

Second, there is a debate of whether to use FDI stocks or FDI flows. It is argued that working with stocks can avoid endogeneity problems and that it is the total stock of FDI which constitutes the basis to generate technology spillovers. Furthermore, stock data are more stable than FDI flows where a major investment in one year can lead to extreme values. However, particularly in transition countries and developing countries FDI stock data may contain unit roots. This is also the case with EU- and NA-FDI in LA. Therefore, we have to use FDI flows being aware that there may be endogeneity problems. In an economic sense it can be argued that the FDI growth nexus can work via FDI flows since it is the latest capital which is responsible for generating productivity gains. Third, FDI growth regressions are likely to be haunted by a number of econometric problems. One of these is certainly the endogeneity bias caused by the use of FDI flows. As a remedy, Carkovic and Levine (2002) employ a GMM framework and Stehrer and Wörz (2005) estimate a system of simultaneous equations.

In our BMA model, we investigate a number of potential growth factors and conditional variables for FDI. We use a panel data growth regression model with country specific fixed effects as the starting point for our BMA. In this model productivity growth  $\Delta y_{it}$  is explained by gross fixed capital formation  $inv_{it}$ , a number of human capital variables contained in matrix  $HC_{it}$ , some macroeconomic variables in matrix  $MACRO_{it}$ , a few infrastructure variables in matrix  $INFRA_{it}$ , different institutional variables in matrix  $INST_{it}$ , some structural variables in matrix  $STRUC_{it}$  and many interaction terms of FDI with human capital, infrastructure and institutional variables.

$$\Delta y_{it} = \alpha_i + \beta_1 INV_{it} + \beta_2 HC_{it} + \beta_3 FDI_{it} + \beta_4 MACRO_{it} + \beta_5 INFRA_{it} + \beta_6 INST_{it} + \beta_7 STRUC_{it} + \beta_8 FDI_{it} HC_{it} + \beta_9 FDI_{it} INFRA_{it} + \beta_{10} FDI_{it} INST_{it} + \varepsilon_{it} \quad (1)$$

We include 17 LA countries in our analysis, i.e. Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Peru, Paraguay, Uruguay and Venezuela. The time period considered ranges from 1985 to 2003.

As endogenous growth theory suggests, we should assume that the availability of human capital in LA plays an important role for growth. Therefore, we test the impact of the literacy rate and of educational attainment in primary, secondary and tertiary education. In all countries the literacy rate and the tertiary education attainment rate in the population increased over the whole period considered. As argued in the human capital literature (for a survey, see Temple 2001), we use attainment rates and not enrolment rates since our data confirms that enrolment rates are too volatile and therefore likely to yield unreliable estimation results. Nevertheless, since our data comes from the Barro/Lee (2000) data



set, which reports figures in 5-year intervals, we have to consider that the data do not represent the exact development of attainment rates but rather their rough development path.

One by one the LA countries started a reform process after the debt crisis. Policies to foster macroeconomic stability formed the core. Countries started to combat their fiscal deficits without, however, achieving sustainable advance in that field (e.g. Brazil, Argentina and Mexico faced fiscal policy problems repeatedly in the past decade; Corbo et al. 2005). The accumulation of debt was accompanied by high interest rates. The external debt ratio (in terms of exports) went down since the mid 1980s, but there is still a wide spread between countries like Argentina with a debt ratio amounting to 5 times of its exports by 2000, Brazil where the debt ratio accounts 3 times the export level and Chile and Mexico where it accounts for 200 per cent and 100 per cent of exports, respectively. The inability of countries to manage inflation constituted another serious macroeconomic problem. Several countries such as Argentina, Brazil, Bolivia and Peru suffered hyperinflation before or shortly after 1990 (Corbo et al. 2005). High inflation also means that inflation rates may become very volatile what can be observed in the LA hyperinflation countries. High inflation and high inflation volatility increase uncertainty and seriously worsen the business climate. A number of LA currencies drastically devalued during the 1980s and early 1990s (Argentina, Brazil, Bolivia, Peru, Nicaragua). Over the 1990s the exchange rate index became much more stable. Exchange rate volatility decreased in the 1990s. Decreasing exchange rate volatility reduces the risk premium for investments and leads to more stable terms of trade.

Consequently, the reduction of debt, the decrease in inflation volatility and the decrease in exchange rate volatility should lead to a more stable business environment and therefore higher growth rates. The importance of stable macroeconomic variables such as low inflation and low budget deficits was verified in previous growth studies (e.g. Dollar and Burnside 1999) for developing countries. To test the impact of improved macroeconomic stability we concentrate on the mentioned indicators debt to export ratio, inflation volatility and exchange rate volatility. We cannot consider budget deficits and interest rate differentials due to inconsistent definitions across countries and too short time series.

Recent empirical growth research, e.g. Barro (1996), Rodrik et al. (2002) and Easterly and Levine (2003), found that the quality of institutions is an important prerequisite for growth. Low political risk, absence of corruption, rule of law and bureaucratic efficiency build a safer business environment and guarantee better economic policies and, thus, enable higher growth rates. With respect to LA, Corbo et al. (2005) examine the institutional quality in the large LA countries using the Index of Economic Freedom pub-

lished by the Fraser Institute (Gwartney and Larson 2005). This index considers the size of government, security of property rights and legal situation. According to these authors, institutional quality partly improved in LA with Chile being the most advanced country in this respect. Bengoa and Sanchez-Robles (2003) estimate the impact of FDI on LA growth and consider as well the composite economic freedom index of the Fraser Institute. They find that growth is significantly positively related to the economic freedom index. Unfortunately, the single items of the freedom index, like corruption, property rights, etc. are not available for LA.

In our opinion it is important to distinguish between single aspects of institutional quality rather than to look at a composite index, though, we use institutional data from the International Country Risk Guide, which provides this detailed data. Hence we can consider government stability, democratic accountability, bureaucratic quality, corruption, law and order, military in politics and political risk in general as factors potentially affecting growth. Indeed, an exploratory correlation analysis showed that there is no high correlation between these different institutional subcategories in LA. Government stability largely improved in LA in the 1990s, but fell in the early 2000s. Political risk diminished as well in the 1990s but increased thereafter. The involvement of military in politics decreased in the second part of the 1980s, but increased again with some countries in the 1990s. The extent of internal conflicts (violence, civil disorder) largely improved until the mid 1990s, but deteriorated by the late 1990s and in the early 2000s. Democratic accountability and law and order improved in the first half of the 1990s. However, bureaucratic quality and corruption oscillated between improvement and deterioration. Despite a general trend of improvement there is, however, much variation across countries and numerous interruptions occurred. Therefore, we should expect that the development of various institutional variables in LA indeed explains differences in growth.

We do not only consider institutional variables per se in our regressions but will also test their significance as a complementary factor for FDI. Therefore, we build interaction terms of all institutional variables with FDI. Why should institutional factors be critical for the effect of FDI? If a foreign investor can rely on an efficient public administration (bureaucratic quality), low corruption and an enforceable legal system, he can implement projects faster and will save time and resources. Therefore, investment meeting good institutional factors will contribute more to productivity growth than investment meeting poor institutions. Moreover, FDI meeting high political risk and political instability will more often produce failed projects due to an uncertain environment and will therefore have lower productivity effects. Whether democracy or military in politics is important for the growth impact of FDI is questionable. Democracy as well as military governments may

improve the reliability of government decisions and would, thus, produce a safer business environment which can boost the growth impact of FDI. However, military governments may also produce less predictable business environments.

The effect of public investment in infrastructure on growth and development has received much attention since the work of Aschauer (1989). A number of papers proposed public infrastructure to play an important role for development. For example, in the context of the European Union's regional policy, where infrastructure investment is a key policy concern to improve the attractiveness and economic potential of a location, De la Fuente (2002) found that infrastructure made an important contribution to development in Spain. Calderón and Servén (2004b) investigated the growth impact of infrastructure in a sample of 121 countries in the period 1960-2000 and found that the stock of infrastructure as well as its quality and single items such as infrastructure in roads, telecommunication and electric power have a positive impact on growth. Calderón and Servén (2004a) show that infrastructure endowments of LA lag behind other middle-income countries and that their development suffered from the retrenchment of public budgets since the mid 1980s.

Looking at various infrastructure components we find that the road network and electricity generating capacity in LA has in general grown modestly, but stagnated in several countries. Telecommunication service, measured by the number of telephone mainlines per 1000 persons steeply increased since the late 1980s. Aircraft departures per 1000 persons declined in many LA countries in the second part of the 1980s, increased in the first half of the 1990s and declined again thereafter. The pattern is not likely to be caused by fluctuations of business cycles since it does not coincide with those and since we find a general increase or decline over the whole period in the rest of LA. Strikingly, we find a considerable variation in all infrastructure variables across countries. Therefore, we wonder whether different endowments in infrastructure matter for growth of LA.

In addition to contributing independently to growth, infrastructure is likely to be a conditional factor for FDI to produce growth effects. A good infrastructure can be considered as a complement for FDI. If FDI meets a poor telecommunication infrastructure, poor transport and unreliable electricity provision, it may not produce a high productivity impact. The effect of FDI conditioned on infrastructure variables is modeled with interaction terms. Finally, we consider a number of structural variables as growth factors such as GDP share of agriculture and manufacturing, composition of exports and level of urbanization. Consequently, we investigate novel hypotheses in several respects. We look at the effect of different institutional factors, rather than a composite institutional index. We distinguish between different origins of FDI considering that there might be a difference between FDI originating from Europe or NA. We investigate the effect of FDI not only under the con-

dition of different levels of human capital but also subject to infrastructure conditions and institutional factors.

### **3 Data Definitions and Sources**

Table A.2.1 in the appendix contains the list of included variables, their definition and a detailed description of sources and compilations. We start with FDI outward stock data because data series can be better extrapolated for stocks than for flows. UNCTAD and OECD serve as principal sources. To complete the series FDI outward stock data is also taken from US Bureau of Economic Analysis, Statistics Canada, Deutsche Bundesbank, Banque de France, Bank of England, Swedish Riksbank, Swiss National Bank and De Nederlands Bank. Additionally, we use FDI inward stock from LA central banks and statistical offices (Bolivia Instituto Nacional de Estadística, Chile Investment Committee, Banco de la Republica Colombia, Central Bank of Costa Rica, Central Reserve Bank El Salvador, Mexico Instituto Nacional de Estadística, Honduras Central Bank, Nicaragua Central Bank).

In many cases the level of FDI from different sources did not correspond. In this case the level of the principal source was maintained while using the fluctuations of the second source. Sometimes stock data had to be generated from flow data, which is legitimate considering that many central banks themselves compile stocks in this fashion. The total FDI stock for the EU was calculated from the sum of European countries and the one for NA from the sum of the US and Canada. Note that the respective European countries may vary from one LA country to another since not all European countries are present in all LA countries (e.g. Portugal invests practically only Brazil). EU investment is slightly underestimated since there is no data for small investors.

## **4 Methodology**

### **4.1 Motivation**

Since the seminal work of Barro (1991) empirical research on the determinants of economic growth has identified numerous variables as being correlated with the growth rate. Durlauf et al. (2005) list more than 140 potential right hand side variables for growth regressions in their appendix coming from 44 broader areas such as education, finance, government or trade. Taking into account the limited number of observations on a national level, growth regressions are exposed to severe criticism based on the inherent model uncertainty. Moreover, empirical work should address the crucial problem of variable selection in setting up

an empirical model for estimation as omitted variables can create spurious relations, while inclusion of irrelevant variables can bias the results of an estimate. Theory sometimes can support choices of some variables whereas the exact decision on inclusion or exclusion of variables mostly will be arbitrary. This fundamental model uncertainty results in a wide set of possible model specifications and, frequently, contradictory conclusions. Besides, the results are often not robust to (minor) changes in model specification yielding uncertainty in valid interpretations of the results.

The lacking theoretical guidance has led to the increasing use of Bayesian methods to deal with parameter and model uncertainty within a formal framework.<sup>7</sup> Bayesian econometrics is of particular benefit for model averaging since classical econometrics does not treat models as random variables and, thus, the concept of averaging over models cannot be given a rigorous statistical foundation. There are, however, various ad hoc classical methods of model averaging, for example, Levine and Renelt (1992) using Leamer's (1983, 1985) extreme-bounds analysis (EBA) or Sala-i-Martin (1997), who attenuated the extreme criteria for variables as being robust or non-robust regressors. EBA defines an *upper extreme bound* and a *lower extreme bound* based on the regression coefficient,  $\beta$ , and its standard deviation,  $\sigma$ . The *extreme bounds test* for a variable says that if the value of the lower extreme bound is negative and the upper one is positive, then the variable is not robust. So, if one finds a single regression for which the sign of the coefficient changes or becomes insignificant, then the variable is not robust. Sala-i-Martin (1997) assigns "some level of confidence to each of the variables" (p. 179) to avoid the strict zero-one labeling of variables as being robust or not. Both approaches are preferable to using only one model for a growth regression. Nevertheless, they do not address the uncertainty about the true model entirely as each of those methods keeps certain variables constant in every model and changes only part of the regressors.

On the contrary, BMA does not require selecting any subset of the regressors a priori or fixing any variables as 'base-line' regressors. All inference is averaged over all possible combinations of regressors, that is over all models, using the corresponding posterior model probabilities (PMPs) as weights. First, given a set of potential explanatory variables, BMA separately identifies models that are expedient to explain growth by allowing for any subset of the explanatory variables to combine in a regression and to estimate

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<sup>7</sup>Another slightly different approach than BMA is the Bayesian Averaging of Classical Estimates (BACE) framework proposed by Sala-i-Martin, Doppelhofer and Miller (2004). Due to the fact that this method combines Bayesian with classical estimation techniques, it abandons the 'truly Bayesian' framework of proper, informative priors. As we are highly aware of the caveats related to this abandonment (see discussion in section 4.2), we prefer using BMA. For more information on BACE, the interested reader is referred to that literature.

the posterior probability of any such combination of regressors. Second, conditional on the posterior model probabilities, the issue of model uncertainty concerning the most efficient means of stimulating economic growth can be resolved by estimating the posterior probabilities of all possible explanatory variables commonly used.

## 4.2 BMA

Within the Bayesian framework, one can handle model uncertainty automatically by not choosing a special model but simply averaging the results over all models using PMPs as weights. Alternative models  $M^j$ , with  $j = 1, \dots, J$ , will be defined through the set of  $K$  regressors they include. They are all linear regression models that differ in their explanatory variables and contain country-specific intercepts,  $\alpha_i \iota_T$ . It is assumed that the individual effects enter in all models and so the number of possible models is  $2^K$ . We have data for  $N$  countries and  $T$  periods. The dependent variables for all agents and all models are grouped in vector  $y$  of length  $NT$ , the explanatory variables and the  $N$  dummy variables for each country are stacked in a design matrix  $X$  of dimension  $NT \times K+N$  and  $\beta$  is defined as the full  $K+N$ -dimensional vector of regression coefficients and individual effects.

Any model  $M^j$  with  $T$  observations for agent  $i$  is represented by:

$$y_i = \alpha_i \iota_T + X_i^j \beta^j + \varepsilon_i \quad (2)$$

where  $X_i^j$  is the  $T \times k^j$  submatrix of regressors of model  $M^j$  and  $\beta^j$  is the  $k$  vector of slope coefficients common to all models,  $\beta^j \in \mathfrak{R}^{k^j}$  ( $0 \leq k^j \leq K$ ).  $\iota_T$  is a column vector of  $T$  ones and  $\varepsilon_i$  is the  $T \times 1$  error vector that is normal, with covariance matrix  $\sigma^2 I_T$ , not autocorrelated and independent of  $X_i^j$ ,  $\alpha_i$  and  $\beta^j$ . Thus  $X_i^j$  is strictly exogenous with respect to  $\varepsilon_i$  given  $\alpha_i$ . Although normality is not necessary for consistency, it guarantees good finite sample properties (FLS 2001b). The effect of variables not contained in  $X^j$  is assumed to be zero.

By averaging over all models the marginal posterior probability of including a certain variable is simply the sum of the posterior probabilities of all models containing this variable. Formally, the posterior distribution of any quantity of interest, say  $\theta^j (= \beta^j, \sigma, \alpha_i)$ , is an average of the posterior distributions of that quantity under each of the models with weights given by the PMPs:

$$p(\theta^j | y_i) = \sum_{j=1}^{2^K} p(\theta^j | y_i, M^j) p(M^j | y_i) \quad (3)$$

This procedure is typically referred to as BMA and it follows from direct application of Bayes' theorem (Leamer 1978).  $P(\theta^j | y_i, M^j)$ , the posterior distribution of  $\theta^j$  under

model  $M^j$ , is typically of standard form. However, we have to compute the PMPs due to model uncertainty. Using the standard way in this case and allocating equal prior model probabilities, this yields

$$p(M^j | y_i) = \frac{p(y_i | M^j)}{\sum_{i=1}^{2^K} p(y_i | M^i)} \quad (4)$$

where  $p(y_i | M^j)$  is the marginal likelihood of Model  $M^j$ . This is given by

$$p(y_i | M^j) = \int p(y_i | \alpha_i, \beta^j, \sigma, M^j) p(\alpha_i) p(\sigma) p(\beta^j | \alpha_i, \sigma, M^j) d\alpha_i d\beta^j d\sigma \quad (5)$$

with  $p(y_i | \alpha_i, \beta^j, \sigma, M^j)$  the sampling model corresponding to equation (1) and  $p(\alpha_i)$ ,  $p(\sigma)$  and  $p(\beta^j | \alpha_i, \sigma, M^j)$  the priors defined below in equations (6) and (7). Since marginal likelihoods can be derived analytically<sup>8</sup>, the same holds for the PMP given in (3) and the distribution given in (2).

In practice, however, computing the relevant posterior distributions is still subject to challenges as the number of models to be estimated increases with the number of regressors at the rate  $2^K$ . Furthermore, the derivation of the integrals implicit in (4) may be difficult because the integrals may not exist in closed form. As we have a minimum number of 51 possible regressors, we would need to calculate the posterior probabilities for each of the in this case  $2^{51}$  models and average the required distributions over all these models. Given these difficulties, we will approximate the posterior distribution on the model space  $\mathcal{M}$  by simulating a sample from it, applying the Markov Chain Monte Carlo Model Composition (MC<sup>3</sup>) methodology by Madigan and York (1995) described in section 5.3.

The Bayesian framework needs to be completed with prior distributions for the parameters in each model  $M^j$  which are  $\alpha_i, \beta^j$  and the scale parameter  $\sigma$ . While the inclusion of prior information is a particular feature of Bayesian inference, in the context of model uncertainty the choice of these distributions can have substantial impact on the PMPs. Furthermore, in a context where there are many potential explanatory variables, but one cannot be sure about which ones to include, this prior information is rare. Accordingly, non-informative priors would be preferable. However, PMPs cannot be meaningfully calculated with improper non-informative priors for parameters that are not common for all models. Thus, many researchers have attempted to develop proper priors which can be automatically used without requiring subjective input or fine tuning for each individual model. Therefore, we use *benchmark priors* developed in FLS (2001b) that have little influence on posterior inference as the incorporation of substantive prior information is not necessary. If we take the  $\{\alpha_i\}$  to be independently uniformly distributed on the real

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<sup>8</sup>For the cross-section case with demeaned regressors, FLS (2001a) derive it in their equation (8), on p. 566.

line and adopt a default uniform prior for the scale parameter common to all models, the prior is

$$p(\alpha, \sigma) \propto \sigma^{-1} \quad (6)$$

With this assumption our regression now resembles the Bayesian analysis of the simplest normal linear model with  $K + N$  regression parameters. This prior implies that all values of  $\alpha$  and of  $\sigma$  for  $\ln(\sigma)$  are given equal prior weight. Furthermore, this distribution is the only one that is invariant under scale transformations as for example a change in the measurement units.

For  $\beta^j$  we choose an informative g-prior structure according to FLS (2001b)<sup>9</sup>

$$p(\beta^j \mid \alpha, \sigma, M^j) \sim N(0, \sigma^2 [g_j X'^j X^j]^{-1}) \quad (7)$$

It is common practice to center priors over the hypothesis that explanatory variables have no effect on the dependent variable, especially when there are many regressors but it is suspected that many of them may be irrelevant. Therefore, we set the mean of  $\beta^j = 0$ . Hence, one only has to elicit the scalar hyperparameter  $g_j$  and, following FLS (2001), we choose

$$g_j = \min \left\{ \frac{1}{NT}, \frac{1}{(K + N)^2} \right\} \quad (8)$$

As we have to deal not only with parameter but as well with model uncertainty, we need to choose a prior distribution over the space  $\mathcal{M}$  of all  $2^K$  possible models. Following the standard practice for BMA in linear regression models, especially in the context of economic growth (FLS 2001a; Masanjala and Papageorgiou 2004; Leon-Gonzalez and Montolio 2004), we allocate equal prior model probability to each model and set

$$p(M_j) = 2^{-K} \quad (9)$$

This yields a uniform distribution on the model space which implies that the prior probability of including a regressor is  $\frac{1}{2}$ , independently of the combination of regressors included in the model.<sup>10</sup>

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<sup>9</sup>This prior is slightly unusual as it depends upon  $X_i^j$ , the regressor matrix. However, as we are later conditioning on  $X_i^j$  in likelihood function and posterior as well, we are not violating any rule of probability by conditioning on  $X_i^j$  in the prior already.

<sup>10</sup>Some authors recommend different choices for  $p(M_j)$ . For instance, many researchers prefer parsimony and feel that simpler models should be preferred to more complex ones, all else being equal. In contrast, Durlauf et al. (2005) argue against priors promoting parsimonious models that the underlying "presumption is unappealing as our own prior beliefs suggest that the true growth model is likely to contain many distinct factors" (p. 83). Moreover, regular posterior odds ratios already include a reward for parsimony and the



### 4.3 Implementation

In Bayesian econometrics, models are random variables (albeit discrete ones), just like parameters. Hence, posterior simulators drawing from model space (i.e. the posterior distributions of the models) can be derived for both, single regressors and complete models. These algorithms do not need to evaluate every model, but rather focus on the models of high PMP.

The most common  $MC^3$  algorithm is based on a Random Walk Chain Metropolis-Hastings algorithm which draws candidate models from regions of the model space in the neighborhood of the current draw and then accepts them with a certain probability. Posterior results based on the sequence of models generated from the  $MC^3$  algorithm can be calculated by averaging over the draws. As with other Markov Chain Monte Carlo algorithms, a starting value for the chain must be chosen and a reasonable number of burn-in replications should be discarded to eliminate the effects of this choice.

It is important to verify convergence of the algorithm and to estimate the accuracy of approximations such as the posterior mean. FLS (2001b) suggest a simple way of doing this: based on a reduced set of models, for example every model visited by the  $MC^3$  algorithm, they calculate the PMP first analytically and then using the algorithm. If the algorithm has converged, then these two ways should yield the same results. The relationship between the analytical and  $MC^3$  results give an idea of approximation error and simple diagnostics can be constructed to check for convergence. For instance, FLS (2001b) suggest calculating the correlation between the analytical and  $MC^3$  PMPs and taking enough replications to ensure this correlation lies above 0.99.

### 4.4 Econometric Issues and Specification Tests

Before performing the BMA we had to consider a number of econometric problems potentially arising in panel data growth regressions. Hence, we performed various tests and simple Least Squares Dummy Variable (LSDV) panel estimations before doing the actual BMA.

In the case of developing countries one has to face the fact that several growth factors like educational attainment rates, infrastructure variables and institutional factors are steadily

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Bayes factor obtained in (3) has a built-in mechanism to avoid overfitting. Brock and Durlauf (2001) and Brock et al. (2003) raise objections against uniform priors on the model space because of the assumption that the probability that one regressor should appear in a growth model is independent of the inclusion of others. Some regressors are similar to others whereas others are not and, therefore, they suggest a tree structure to organize model uncertainty in linear regression models. Hoeting et al. (1999), however, state that when there is little prior information about the relative plausibility of each model, the assumption that all models are equally likely a priori is a reasonable “neutral” choice.

increasing over time. Therefore, one has to consider the possibility that the data contains unit roots and has to perform unit root tests. First, we used the Levin/Lin/Chu panel unit root test that considers the ADF specification

$$\Delta y_{it} = \alpha y_{it-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{it-j} + X'_{it} \delta + \varepsilon_{it} \quad (10)$$

where  $\alpha$  is common, the lag order  $p_i$  of the difference term can vary across cross-sections and  $H_0 : \alpha = 0$ . Second, we used the Im/Pesaran/Shin unit root test that permits not only the  $p_i$  to vary across cross sections but to estimate the above equation for each cross section. The null hypothesis is  $H_0 : \alpha = 0$ . The average t-statistic of the individually estimated  $\alpha_i$  is taken.

According to these unit root tests all education variables contain unit roots. This also is manifested in bad Durbin Watson statistics when we took the level series in the LSDV panel estimates. Therefore, we do not take the level of educational attainment rates but their change. This turns out to remove the error autocorrelation and these series no longer contain unit roots. Further we find unit roots in the GDP shares of agriculture and industry reflecting the process of sectoral change. Taking the change of GDP shares, we find no unit roots. The share of agricultural and manufacturing exports in total merchandize exports contains unit roots but not the share of ores exports. Thus, we take the change in agricultural and manufacturing export shares. All infrastructure variables except for the electricity distribution and transmission output loss contain unit roots, which is why we take the change or growth of infrastructure, sometimes averaged over 3 years. As the stocks of FDI grew drastically in the 1990s, this variable proved to contain unit roots. Therefore, we take the change of FDI stocks. Finally, we see that all institutional variables contain unit roots.

Taking a number of differenced series in the estimations we need to be aware of the economic interpretation of the coefficients. For example, we test whether a higher or lower increase of the FDI share has a positive effect on growth or whether a more rapid increase of tertiary education is good for growth.

The use of interaction terms has recently appeared in empirical growth research. If the regression is

$$Y = \beta_0 + \beta_1 X + \beta_2 Z + \varepsilon \quad (11)$$

then the regression with an interaction term is

$$Y = \beta_0 + \beta_1 X + \beta_2 Z + \beta_3 XZ + \varepsilon \quad (12)$$

The idea is that the impact of a growth regressor is often depending on the simultaneous level of other economic indicators.  $\beta_3$  is interpreted as the amount of change in the slope

of the regression when  $Z$  changes by one unit. Equation (12) can be reformulated as

$$Y = (\beta_1 + \beta_3 Z)X + (\beta_0 + \beta_2 Z) + \varepsilon \quad (13)$$

For examining the interaction, one then has to choose particular values for  $Z$ , e.g. the mean, or the standard deviation below and above. One can then compute the reaction of  $Y$  to  $X$  for given values of  $Z$ .

In the context of analyzing the growth impact of FDI, Borensztein et al. (1998) use interaction with human capital and find that the effect of FDI depends on the availability of human capital. Calderón et al. (2004) examine the growth impact of openness conditioning with interaction terms on GDP p.c. levels and find that the impact is zero for low levels of income. Chang et al. (2005) use interaction terms to show that the impact of openness on growth depends on structural characteristics such as education, financial depth, inflation stabilization, public infrastructure, governance, etc.

When using interaction terms, one has also to include the main variables even if not significant. Friedrich (1982) points out that otherwise the interaction effect and the main effects get confounded. Furthermore, if the main effect is not included, changes in the zero point of the original variables can result in important changes in the effects of the interaction terms. Using the interaction terms and the main variables may result in multicollinearity. Therefore, some authors use quadratic interaction terms, e.g. Calderón et al. (2004). Since BMA is capable of handling highly collinear regressors, we use simple products as interaction terms. The algorithm appropriately weights the information added to a regression from two collinear variables: the Markov Chain will not visit models containing regressors that are collinear to those already included as there is no additional information provided in such a model. In fact, the algorithm avoids such models and assigns high PMPs only to models not characterized by this problem (Masanjala and Papageorgiou 2004, Milani 2003). Evidently, series containing unit roots enter the interaction terms in differences.

Another issue arising with a growth regression for a group of countries situated on the same continent is the possibility of spatial dependency. This issue has been increasingly raised in the context of growth econometrics. To settle this issue, we performed Moran's  $I$  tests on the dependent variable and the errors of a panel estimate of equation (1) containing all variables except the interaction terms. As spatial weighting matrix the contiguity matrix was used. The results indicate that there is no reason to assume spatial dependencies among Latin American countries. The reason may be that there are not strong enough trade and financial relations between the Latin American countries but that LA countries are more oriented towards the US economy.

Endogeneity of regressors, i.e. simultaneity or reverse causality, constitutes a serious problem of growth regressions. A number of regressors in growth regressions such as education

and investment and maybe political parameters are likely to be simultaneously determined with growth. This leads to biased estimates in normal OLS regressions. However, it is generally difficult to find suitable instruments, variables that are correlated with the explanatory variable  $X$  but not with the error term. One possibility that circumvents this problem is to use lagged values of the dependent variable as instruments. GMM estimators for dynamic panel data models use lagged differences or levels of the variable as instruments as proposed by Arellano/Bond (1991) (GMM difference estimator) and Blundell/Bond (1997) (GMM systems estimator). However, this approach does not permit full endogeneity, but assumes that the explanatory variable is not correlated with future error terms. A Sargan test for overidentifying restrictions is commonly used to test the validity of instruments (Chang et al. 2005). Consequently, the consistency of any instrumental variable estimation critically depends on the validity of instruments.

Among our regressors are several variables that are blamed to be endogenous in the literature. First, human capital is often considered to be simultaneously determined with growth (Temple 2001). However, this should apply rather to educational enrolment rates than to attainment rates which change only after the degree has been gained and when the person becomes part of the adult population (attainment rates refer to the adult population). It is debateable whether changes in infrastructure, the indicator we use, can cause endogeneity problems. However, as any investment, infrastructure investment will lag growth, being only realized when the economy has already experienced higher growth in the previous period. One can also argue that governments may raise infrastructure investment anti-cyclically to stimulate growth. Since the CPI has to be considered to be endogenous, we take the volatility of the consumer price index.

In the context of institutional factors one can also hypothesize that institutions may be endogenous to growth. It may be a favorable growth climate that leads to better institutions, so the causality may run in both directions from institutions to growth and from growth to institutions. But should we really believe that higher growth leads to better bureaucracy or less corruption? The example of China would suggest that this is not the case. Also, it seems more likely that the development of institutions has something to do with the income level and not with growth. Svensson (2005) found a strong negative relationship between income and corruption for a sample of some 80 countries using various measures of corruption. Dawson (2003) performed Granger causality test between the institutional variables of the Fraser Institute and growth on a large number of countries and found strong support that institutions actually cause growth. We follow this view and assume that our institutional variables are not endogenous.

Finally, applying panel data estimation it is also important to consider the possibility of

parameter heterogeneity as pointed out by Hsiao and Pesaran (2004). Having to consider the limited degrees of freedom given by the sample size ( $n=17$ ,  $t=19$ ) and the high number of variables, including the interaction terms ( $k_{max}=61$ ), we had to refrain from permitting full parameter heterogeneity. However, we consider the possibility of coefficient variation for different subgroups of LA and account for this with slope dummy variables. The considered subgroups are the large economies "D1", the rich economies "D2" and the South American economies "D3". Their likely contribution was tested in exploratory LSDV panel estimates since the number of heterogeneous coefficients had to be kept low in order to save degrees of freedom.

Evidently, one should also consider the possibility of structural breaks in time. However, since the full data set with all regressors starts only in 1985, it was not possible to consider a likely structural break around 1990.

## 5 Estimation Results

### 5.1 Posterior probabilities

All our results are based on taking 2 million draws and discarding the first 500,000 as burn-in replications. As a test for convergence of the algorithm and a diagnostic check that the model performance is satisfactory, we checked the correlation coefficient between visit frequencies and posterior probabilities which lies above the recommended threshold of 0.99 for the two BMAs.

Dealing firstly with the inherent model uncertainty and with the significance of combinations of regressors, we report the PMPs for the ten best models of the two BMAs and their respective regressors in Tables A.2.2 and A.2.4 in the appendix. The ten best models' posterior probabilities are quite spread between and within our two samples. Also the cumulative PMP, which is the numerical probability of the top 10 models out of the total number of models, varies a lot between our two samples. In the first sample with total FDI it accounts for 9.2 per cent of the total posterior mass, whereas it is as high as 25 per cent for our second BMA with distinguished EU- and NA-FDI. This can be seen as an indicator for the fact that disaggregated FDI reveals much more information in our growth regression than does total FDI. An indicator for that is also the high PMP of the most important model in the second BMA, which is 40.8 per cent, whereas the PMP of the most important model in the first BMA with total FDI is only 16.2 per cent. All our PMPs, however, are high compared to other BMA studies of economic growth in which the PMP of the most important model sometimes is only between 1 and 5 per cent, thus,

resembling the PMP of only our tenth best model or being even lower than that.<sup>11</sup> Looking secondly at the importance of single regressors in affecting growth, the second columns of Tables A.2.3 and A.2.5 in the appendix report the BMA posterior probability (or probability of inclusion) for each of the explanatory variables in our two BMAs. It can be interpreted as the probability that the respective regressor should be included in the evaluation as it exerts some influence on the dependent variable regardless of which other explanatory variables are included as well. We ranked the variables according to their probability of inclusion and will discuss their respective effects in the next section. As there is no theoretical justification for any threshold of posterior probabilities over which to call a regressor 'very important', we base our discussion on the number of regressors that has been identified as the mean number in each of our BMAs. In the second sample with disaggregated FDI the mean number was six whereas the mean number of regressors of 7.2 in the first BMA with total FDI reproduces exactly the suggested number of at least seven regressors in growth regressions (Sala-i-Martin 1997). Furthermore, we discuss the regressors used in one of the ten best models (but which do not exert a high posterior probability themselves).

## 5.2 Discussion and policy implications

When assessing the impact of total FDI (see Tables A.2.3 and A.2.4) in 17 LA countries in the period 1985-2003, our first BMA indicates that institutional and infrastructure factors show a high posterior probability. The mean coefficients signs indicate that countries with decreasing political risk and internal conflict and with more democratic accountability enjoyed higher growth. The sign of military involvement in politics is negative, indicating military involvement did not harm growth. Among infrastructure variables, the change of telephone mainlines, of electricity power capacity and of road density are variables with high posterior probability. This indicates that an improvement in infrastructure endowments, which is a critical point in LA, was important for growth. Among education variables, only tertiary level attainment rates show a high probability as regressors. The increase in tertiary level education attainment rates, however, was negatively related with growth. Nevertheless, in the big economies tertiary education attainment was positively associated with growth. FDI per se is negatively related to growth, but not if conditioned on tertiary education and the development of the legal system. Finally, in the rich economies a high level of external debt had a negative effect on growth.

As our intention was to investigate the likely different impact of NA-FDI compared to steeply growing EU-FDI, we ran a separate BMA in which we distinguish between the two

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<sup>11</sup>See, for example, FLS 2001a; Masanjala and Papageorgiou 2004.

sources of FDI. Due to data constraints the time span of this sample is only 1990-2003. We now find (see Tables A.2.5 and A.2.6) that the infrastructure variables ROAD and PHONE are among the regressors with high posterior probability. Our previous results are confirmed that tertiary education is an important regressor having unfortunately a negative coefficient. The coefficient becomes positive only in the large economies. In addition, the improvement of primary education attainment enters with a positive coefficient as a regressor in the 10 best models. EU-FDI enters at an important place with a positive coefficient if conditioned on an improvement of institutional features. The interaction terms with LAW, POLRI and DEMO have a high probability and positive sign. In addition, we can find EU-FDI in interaction with electricity capacity among the 10 best models with a positive coefficient. NA-FDI cannot be found among the regressors with a high probability or among the 10 best models.

How can we explain our regression results that European investment contributes to growth in LA while NA-FDI has no important influence? Let us recall our hypotheses on the likelihood of productivity effects in the host economy depending on the type of FDI, the distance of the source country, the trade regime and the sector of investment. To what extent can this help us to explain different the performance of NA versus EU-FDI? What is the respective situation in LA? First, statistical evidence suggests that NA-FDI largely has taken the form of greenfield investment while EU-FDI rests to a large extent on acquisitions (Javorcik and Spatareanu 2006). Therefore, EU-FDI would establish more linkages with local industries and produce more productivity spillovers. Second, we have to acknowledge that a large share of NA-FDI takes place in the context of the free trade agreements of NAFTA and CAFTA in Central America. These arrangements favor vertical FDI of NA firms where some stage in the production is located in Central America to benefit from cheap labor costs. All intermediaries are easily imported from the close NA firm under the free trade regime and final products are then exported again into NA. This type of maquila industry is widespread in NA-FDI in Mexico and other Central American countries in the machinery and electronics industry (Gomez Vega 2004; Lindegaard and Leiner 2003). Clearly, these firms do not establish any linkages with local firms and thus productivity spillovers will not arise. The literature on the maquila industry (Puyana Mutis et al. 2005; Gomez Vega 2004), concluding that its growth effect was disappointing, supports this reasoning. In contrast, the distance between EU-FDI in Latin America is too far and the free trade agreements between LA countries and the EU are still too limited to support vertical FDI. Hence EU-FDI contains a larger share of market seeking, horizontal FDI than NA-FDI. This implies that European firms locate entire productions in LA and establish linkages with local suppliers. As a result, we should expect that EU-FDI makes

a contribution to aggregate productivity growth.

In order to learn more about the structure of NA-FDI and EU-FDI, we compiled information on the largest foreign affiliates as provided by UNCTAD for each LA country. This source indicates the industries of investment and reports its source country, as well as the number of sales and employees in the affiliates in 2002. Compiling this information (see Figure 6 in the appendix) reveals some interesting facts on the structure of NA-FDI and EU-FDI. First, we see that the number of European affiliates in South America is almost twice as large as that of NA affiliates. Given that the size of EU-FDI does not drastically exceed NA-FDI European investments in South America evidently comprises a larger network of firms than North American ones. In Central America, on the contrary, where the level of NA-FDI is larger than that from Europe, the number of European affiliates accounts for 70 per cent of the number of NA-firms. Hence the network of European firms is not larger in Central America. Generally, the size of Europe affiliates is smaller than that of North American affiliates, with the exception of FDI in Argentina and Brazil where the average size of affiliates is equal and in Mexico, where just 2 large German car producers are operating.

Calculating the Theil index of sales/employment in diverse industries as a measure of sectoral concentration in manufacturing, we find that European affiliates mostly operate in a wider set of industries in South America than NA ones, except for Venezuela where a number of European firms operate only in the rubber sector. In Central America, however, the reverse is true. The concentration of NA-affiliates is less than the European. The much lower stock of EU-FDI than that of NA can explain the concentration in a few sectors. Compared to the concentration of EU-FDI in South America, the concentration of NA-FDI in Central America is still high. (Very interesting is the case of Guatemala where all brands of US cosmetics are produced. The EU produces pharmaceutical products there). Given the larger number of European firms in South America, their smaller size and their sectoral diversity it would be clear that they are more likely to establish local linkages and EU-FDI would consequently have a significant productivity effect. In contrast, we would expect that few companies in a narrow range of industries would provide fewer linkages with the productive fabric of a country. NA-FDI would, therefore, have less productivity effects in South America. In Central America, the relatively high concentration of a substantial FDI stock of NA companies would reduce productivity spillovers. Consequently, EU-FDI would make a larger growth contribution in LA than NA-FDI. Finally, as our compilation on foreign affiliates shows, it is striking that the share of FDI placed in the service sector is almost always larger with EU- than with NA-FDI. In some cases as in Chile, Venezuela and El Salvador the share of service sector FDI is significantly higher



with EU-FDI. This is largely the result of the activity of European firms in telecommunication networks, but also in the supply of gas, water and electricity. In banking the size of activity of European firms and the number of their affiliates is larger than with NA-FDI. As in Arnold et al. (2006) who stressed the importance of service sector FDI in the Czech economy for productivity growth, we should expect that EU-FDI in the LA service sector has modernized the infrastructure in the service sector and increased its capacity. Local industries should benefit from this improved infrastructure and become more productive as a consequence. Consequently, EU-FDI will also have a larger effect on productivity growth in LA than NA-FDI because of its larger activity in the service sector.

## 6 Conclusion

This paper investigates the growth effects of FDI in 17 LA countries conditional on macroeconomic, institutional, structural and infrastructure factors and on education. Examining the period 1985-2003, we first analyze the effects of aggregated FDI inflows and then distinguish between EU- and NA-FDI. In doing so we account for the major shifts in the regional composition of these inflows since the 1990s and for the varying types and motives of FDI coming from the EU as opposed to coming from NA. We allow for country specific effects in our panel data model and look at group specific coefficients addressing potential parameter heterogeneity within the LA countries.

The method we propose in this context is BMA as it is a suitable way to account for model uncertainty in growth regressions and to ascertain the most robust regressors given the myriad of possible model specifications.<sup>12</sup> From more than 50 potential growth determinants we identify not only the parameter combinations of the best models – which can be seen as the most relevant ‘policy packages’ for stimulating FDI-led growth in LA – but also a ranking of all included regressors according to their respective importance for growth.

Consequently, our findings entail new insights in the conflicting results on the growth impact of FDI in LA in two respects: We are in the position to suggest a growth model that is highly reliable to describe the growth effects and the impact of FDI in LA as it was selected ‘conditional on model uncertainty’. Furthermore, our paper provides a kind of ‘external robustness check’ for related studies. Concerning the latter, we can confirm the results of previous studies on the importance of certain institutional and infrastructure factors for growth but we have to reject the findings of other studies on the influence of macroeconomic factors, structural change and human capital in general in LA. The models

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<sup>12</sup>This is shown here and elsewhere; see, for example, the discussion in chapter 1 and 4.1.

selected in our two BMA provide robust conditions conjecturing that FDI in general as well as EU-FDI is good for productivity growth in LA but also that LA can mostly benefit from FDI if the political and institutional settings reduce political risk and improve law and order. Another prerequisite for positive effects of FDI is that these countries invest heavily in their infrastructure. Developing a qualified human capital base, in particular on the level of higher education, is another requirement for LA to benefit from FDI. As we find no robust influence of NA-FDI, we would suggest the region to focus more on horizontal, market-seeking FDI – possibly coming from European countries – instead of trying to attract efficiency seeking, vertical FDI which is the type usually focused on in North American countries.

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# A Appendix

## A.1 Figures

Figure 1: Total FDI as share of GDP

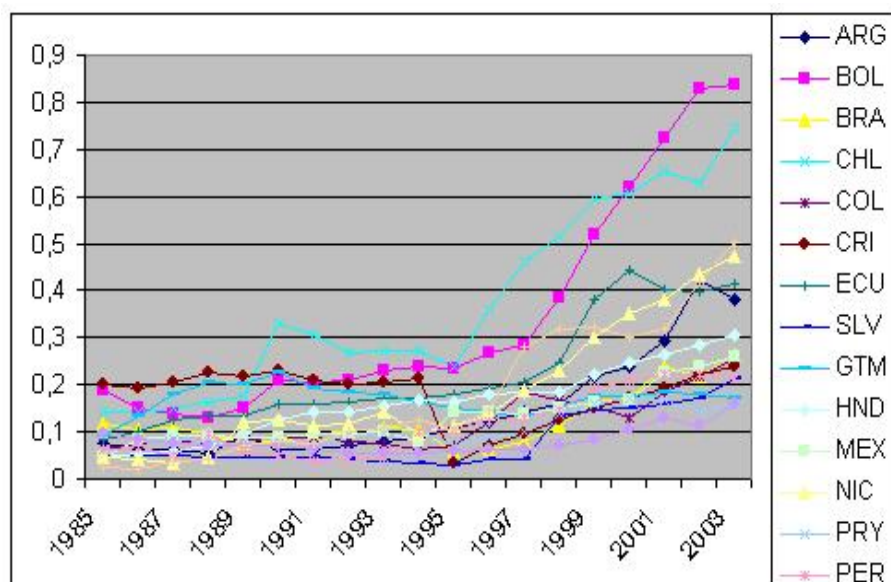




Figure 2: EU-FDI as share of GDP

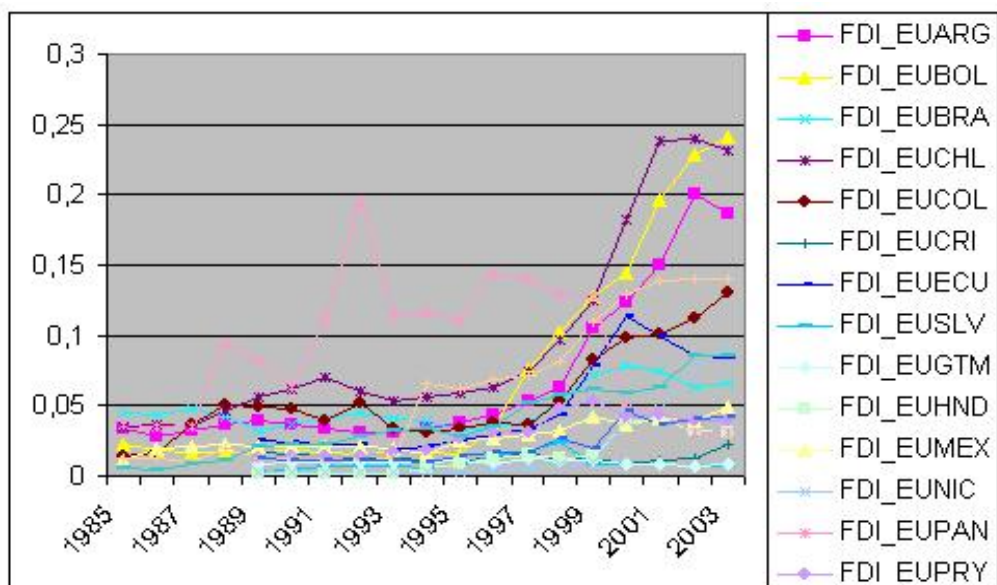


Figure 3: NA-FDI as share of GDP

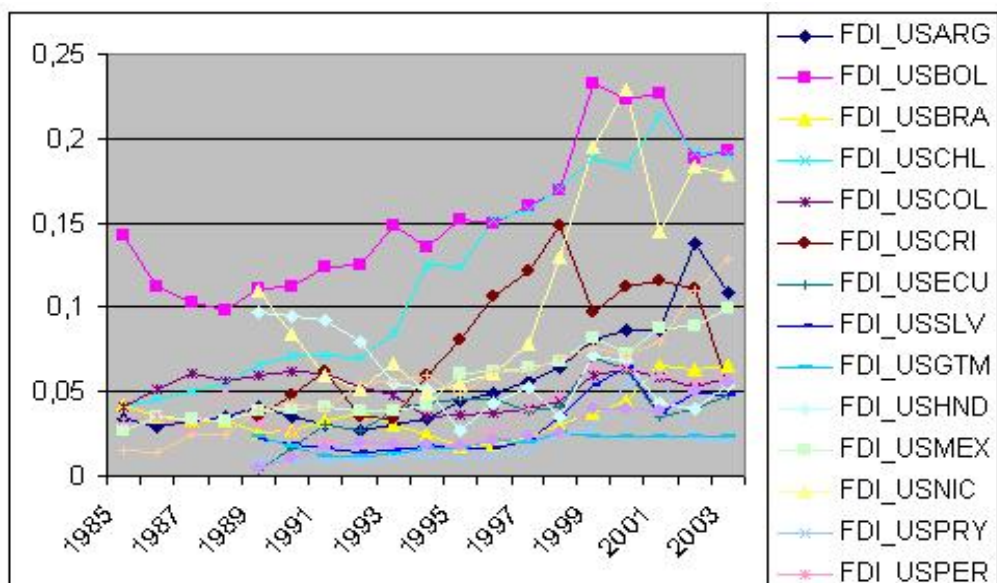


Figure 4: EU- vs. NA-FDI across period

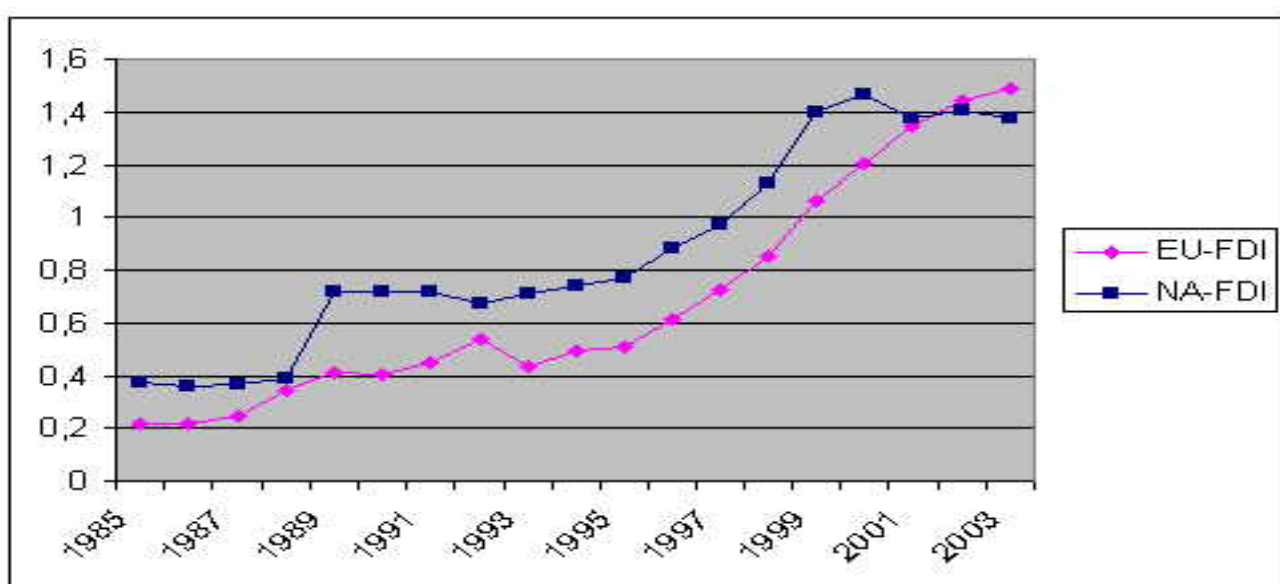


Figure 5: EU- vs. NA-FDI across countries

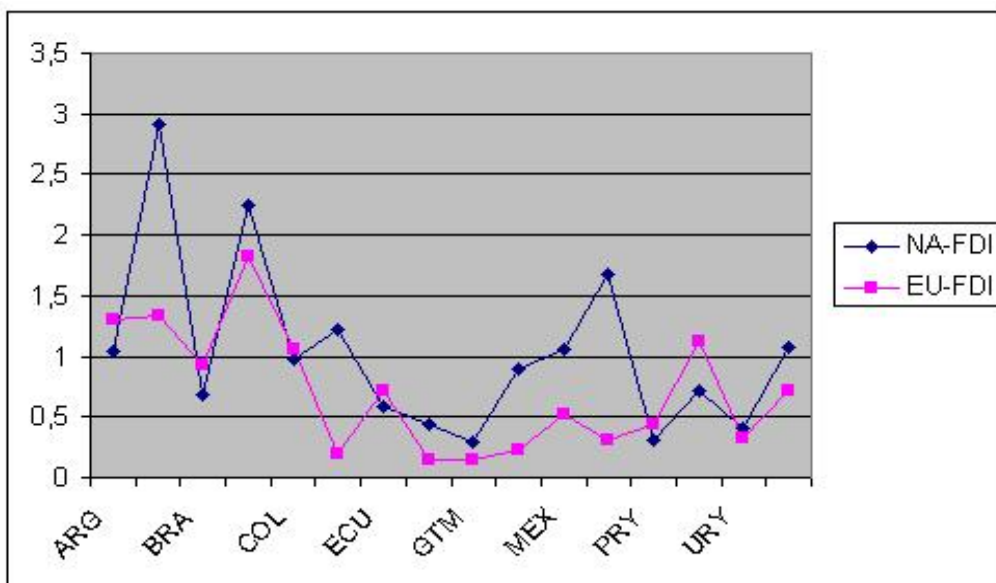


Figure 6: Structural characteristics of EU-FDI and NA-FDI in LA (based on largest foreign affiliates\*\*)

	number of firms in all sector		average size of firm in manufacturing		concentration manufacturing (Theil coeff.)		services in percent manufacturing		assets in banking	
									EU	NA
	EU	NA	EU	NA	EU	NA	EU	NA		
<i>South America</i>										
Arg	29	9	1144	1016	1.35	1.85	1.13	0.50	25200	434
Bol	12	8								
Bra	30	8	2120	2276	1.01	1.70	2.63	0.36	62474	6624
Chi	28	10	33	89	1.41	1.07	29.92	8.75	5961	2376
Col	9	15	195	477	1.36	1.65	0.35	0.51	-	182
Ecu*	15	9	430	200	1.42	1.24	0.48	1.33	-	107
Per	2	5	na	na	na	na	2.86	0.65	na	na
Ven	16	3	36	95	2.14	1.47	20.85	0.05	14227*	na
Par*	22	4	64	703	1.69	2.50	5.25	0.10	278*	-
Uru*	16	23	198	410	1.63	1.85	6.57	0.24	466*	-
<i>Central America</i>										
Mex	15	27	8150	4591	2.63	1.74	0.49	0.36	63307*	34603*
Costa*	8	17	559	800	2.35	1.13	1.35	0.10	-	2100*
El Sal*	18	6	176	205	1.80	1.47	17.70	0.48	-	-
Gua*	4	21	313	444	2.37	2.08	0.04	0.19	-	-
Hon*	6	12	290	1910	1.79	1.88	0.07	0.03	52*	65*

Source: Own calculation based on UNCTAD; \*\* all calculations are based on sales in Million US-Dollars of affiliates unless with \* where the number of employees are considered. The Theil index considers concentration in 14 industries of primary production and manufacturing. The Theil index runs from 0 (equal distribution on all industries) to 2.63 (concentration on one industry)

## A.2 Tables

### A.2.1 Variables and Data Sources

Variable	Definition	Source	Remarks
$GROWTH_{LF}$	Share of real GDP growth per labour force	WDI 2005	Constant US-Dollars in 2000
GFCF	Share of gross fixed capital formation in GDP	WDI 2005	Lagged value of t-1
$FDI_T$	Change share total FDI stock in GDP	UNCTAD	
$FDI_{EU}$	Change share FDI stock from EU in GDP	UNCTAD	Generated from inward stocks of LA data by country of origin. Data completed with data from OECD international investment directory for European countries, FDI stock data from EU, NA and LA central banks and statistical offices
$FDI_{US}$	Change share FDI stock from NA in GDP	UNCTAD	See $FDI_{EU}$
LIT	Change of literacy rate	WDI 2005	
PRIM	Change share of adult population with completed primary education	Barro/Lee	Missing years own calculations
SEC	Change share of adult population with completed secondary education	Barro/Lee	Missing years own calculations
TERT	Change share of adult population with completed tertiary education	Barro/Lee	Missing years own calculations
$CPI_{VOL}$	Consumer price volatility	IFS	Standard deviation of per cent changes, quarterly data of past 5 years
EXCH	Exchange rate volatility	IFS	Calculated from official exchange rate national currency per US-Dollar, quarterly data of past 5 years
DEBT	Share external debt to exports	WDI 2005	

Variable	Definition	Source	Remarks
URBAN	Urban population growth	WDI 2005	
AGRI	Change GDP share agriculture	WDI 2005	
IND	Change GDP share industry	WDI 2005	
$EX_{AGRI}$	Change share agricultural exports in merchandize exports	WDI 2005	
$EX_{ORES}$	Share ores and metals in merchandize exports	WDI 2005	
$EX_{MAN}$	Change share manufacturing in merchandize exports	WDI 2005	
PHONE	Growth telephone mainlines per 1000s	WDI 2005	
ELEC1	Growth electricity generating capacity per 1000 persons	WDI 2005	3 year moving averages
ELEC2	Electric power transmission and distribution loss, share of output	WDI 2005	
ROAD	Change paved road, km per square kilometer	International Road Fed.	3 year moving averages
AIR	Change of aircraft departures per 100s (in logs)	WDI 2005	
BURO	Change bureaucratic quality index (in logs)	ICRG	Improvement indicates better bureaucracy, index runs from 0 to 1.4
CORR	Change corruption index (in logs)	ICRG	Improvement indicates less corruption, index runs from 0 to 1.8
DEMO	Change index democratic accountability (in logs)	ICRG	Improvement indicates more democracy, index runs from 0 index runs from 0 to 1.8
GOV	Change index government stability (in logs)	ICRG	Improvement indicates more stability, index runs from 0 to 2.5
CONFL	Change index internal conflict (in logs)	ICRG	Improvement indicates less conflict, index runs from 0 to 2.5
LAW	Change index law and order (in logs)	ICRG	Improvement indicates better law, index runs from 0 to 1.8

<b>Variable</b>	<b>Definition</b>	<b>Source</b>	<b>Remarks</b>
MILI	Change index military in politics (in logs)	ICRG	Improvement indicates less military, index runs from 0 to 1.8
POLRI	Change index political risk (in logs)	ICRG	Improvement of index indicates less risk, index runs from 0 to 4.6
<i>FDI<sub>T</sub> * LIT</i>	Interaction term		
<i>FDI<sub>T</sub> * PRIM</i>	Interaction term		
<i>FDI<sub>T</sub> * SEC</i>	Interaction term		
<i>FDI<sub>T</sub> * TERT</i>	Interaction term		
<i>FDI<sub>T</sub> * PHONE</i>	Interaction term		
<i>FDI<sub>T</sub> * ELEC1</i>	Interaction term		
<i>FDI<sub>T</sub> * ELEC2</i>	Interaction term		
<i>FDI<sub>T</sub> * ROAD</i>	Interaction term		
<i>FDI<sub>T</sub> * EX<sub>AGRI</sub></i>	Interaction term		
<i>FDI<sub>T</sub> * EX<sub>ORES</sub></i>	Interaction term		
<i>FDI<sub>T</sub> * EX<sub>MAN</sub></i>	Interaction term		
<i>FDI<sub>T</sub> * BURO</i>	Interaction term		
<i>FDI<sub>T</sub> * DEMO</i>	Interaction term		
<i>FDI<sub>T</sub> * CORR</i>	Interaction term		
<i>FDI<sub>T</sub> * LAW</i>	Interaction term		
<i>FDI<sub>T</sub> * GOV</i>	Interaction term		
<i>FDI<sub>T</sub> * CONFL</i>	Interaction term		
<i>FDI<sub>T</sub> * MILI</i>	Interaction term		
<i>FDI<sub>T</sub> * POLRI</i>	Interaction term		
D1	Dummy for big economies obtained from ranking GDP in 2000 US-Dollars in 1980 and 1990		Arg, Bra, Chi , Col, Mex, Per, Uru, Ven (no change of group members between years)
D2	Dummy for high income countries obtained from ranking GDP p.c. in 2000 US-Dollars in 1980 and 1990		Arg, Bra, Chi, Costa, Mex, Pan, Uru, Ven (no change of group members between years)
D3	Dummy for South America		



**A.2.2 Total FDI-growth BMA in 17 LA countries 1985-2003: Regressors and PMP of ten best models**

Model	Regressors	PMP (in per cent)
1	$FDI_T$ , $FDI_T^*TERT$ , MILI, D2*DEBT, ROAD, $FDI_T^*LAW$	16.17
2	$FDI_T$ , $FDI_T^*TERT$ , PHONE, MILI, $FDI_T^*LAW$	15.56
3	$FDI_T$ , $FDI_T^*TERT$ , MILI, D2*DEBT, $FDI_T^*LAW$	15.23
4	$FDI_T$ , $FDI_T^*TERT$ , MILI, $FDI_T^*LAW$	10.91
5	$FDI_T$ , $FDI_T^*TERT$ , MILI, D2*DEBT, PHONE, ROAD, $FDI_T^*LAW$	8.44
6	$FDI_T$ , $FDI_T^*TERT$ , MILI, D2*DEBT, PHONE, $FDI_T^*LAW$	8.16
7	$FDI_T^*TERT$ , MILI, POLRI, $FDI_T^*LAW$	7.21
8	MILI, POLRI, $FDI_T^*LAW$	6.98
9	MILI, D2*DEBT, ROAD, $FDI_T^*LAW$	6.06
10	MILI, D2*DEBT, $FDI_T^*LAW$	5.27

**A.2.3 Total FDI-growth BMA 17 LAC 1985-2003: Regressors' posterior probabilities and posterior means**

Importance	Regressor	Posterior probability	Posterior Mean
1	$FDI_T^*LAW$	0.997	3.2171
2	MILI	0.8995	-0.0625
3	$FDI_T^*TERT$	0.7055	158.5842
4	$FDI_T$	0.5176	-0.2753
5	D2*DEBT	0.5067	-0.0068
6	ROAD	0.3899	1.7996
7	PHONE	0.3190	0.0314
8	POLRI	0.2217	0.0483
9	ELEC1	0.1705	0.0150
10	CONFL	0.1475	0.0061
11	TERT	0.1418	-1.643
12	DEMO	0.1389	0.0073
13	$FDI_T^*MILI$	0.087	0.0643
14	D1*TERT	0.076	1.2275
15	GFCF	0.0526	0.0065
16	$FDI_T^*PHONE$	0.051	0.0706
17	$FDI_T^*POLRI$	0.0457	0.1314
18	URBAN	0.0435	0.0493
19	$FDI_T^*LIT$	0.0386	-1.5704

Importance	Regressor	Posterior probability	Posterior Mean
20	LIT	0.0317	-0.2024
21	$FDI_T$ *ELEC2	0.0301	0.0010
22	D1*LIT	0.0298	0.2466
23	$FDI_T$ *GOV	0.0294	0.0152
24	D3*URBAN	0.0293	0.0345
25	EXCH	0.0291	0.000
26	$EX_{ORES}$	0.0283	0.0025
27	$FDI_T$ *ROAD	0.0277	-0.8102
28	$FDI_T$ *BURO	0.027	0.0178
29	BURO	0.0264	0.0005
30	PRIM	0.0262	0.0132
31	$FDI_T$ *CONFL	0.0254	0.0115
32	$FDI_T$ *SEC	0.0252	0.2376
33	AIR	0.0246	0.0002
34	$FDI_T$ *DEMO	0.0230	-0.0163
35	$EX_{AGRI}$	0.0207	0.0015
36	IND	0.0203	-0.0016
37	$FDI_T$ * $EX_{ORES}$	0.0201	0.0023
38	CORR	0.0196	-0.0003
39	GOV	0.0195	-0.0001
40	$FDI_T$ *PRIM	0.019	0.1575
41	$FDI_T$ *ELEC1	0.0183	-0.0142
42	LAW	0.0172	0.0003
43	DEBT	0.0168	0.0000
44	AGRI	0.0167	-0.0010
45	SEC	0.0166	-0.0028
46	$FDI_T$ *CORR	0.0164	0.0009
47	$FDI_T$	0.0160	-0.0001
48	$FDI_T$ * $FDI_T$	0.0155	0.0026
49	ELEC2	0.0149	-0.0002
50	$CPI_{VOL}$	0.0147	0.0000
51	$FDI_T$ * $EX_{ORES}$	0.0146	-0.0202

**A.2.4 Disaggregated FDI-growth BMA in 17 LA countries 1990-2003: Regressors and PMP of ten best models**

Model	Regressors	PMP (in per cent)
1	TERT, D1*TERT, PHONE, $FDI_{EU}$ *LAW	40.81
2	TERT, D1*TERT, $FDI_{EU}$ *LAW	21.54
3	TERT, D1*TERT, PHONE, ROAD, $FDI_{EU}$ *LAW	12.20
4	TERT, D1*TERT, ROAD, $FDI_{EU}$ *LAW	7.11
5	PHONE, $FDI_{EU}$ *LAW	4.38
6	$FDI_{EU}$ *LAW	3.21
7	TERT, D1*TERT, $EX_{AGRI}$ , PHONE, $FDI_{EU}$ *LAW	2.79
8	TERT, D1*TERT, PHONE, $FDI_{EU}$ *LAW, $FDI_{EU}$ *ELEC1	2.83
9	TERT, D1*TERT, PHONE, $FDI_{EU}$ *DEMO, $FDI_{EU}$ *LAW	2.65
10	PRIM, TERT, D1*TERT, PHONE, $FDI_{EU}$ *LAW	2.48

**A.2.5 Disaggregated FDI - growth BMA 17 LAC 1990-2003: Regressors' posterior probabilities and posterior means**

Importance	Regressor	Posterior probability	Posterior Mean
1	$FDI_{EU}$ *LAW	0.9341	7.3443
2	TERT	0.8264	-33.4809
3	D1*TERT	0.8060	32.4102
4	PHONE	0.6522	0.0689
5	ROAD	0.2301	0.9039
6	$FDI_{EU}$ *POLRI	0.1176	1.5728
7	MILI	0.1008	-0.0047
8	$FDI_{US}$ *MILI	0.085	0.0821
9	$FDI_{EU}$ *DEMO	0.0713	-0.5047
10	PRIM	0.0665	0.0882
11	$FDI_{EU}$ *ELEC1	0.0654	-0.5389
12	$EX_{AGRI}$	0.0599	0.0111
13	POLRI	0.0508	0.0065
14	$FDI_{US}$ *LAW	0.0466	0.0738
15	$FDI_{EU}$	0.0463	-0.019
16	LIT	0.0414	-0.3607
17	D2* $EX_{AGRI}$	0.0395	-0.0137
18	EXCH	0.0303	0.0001
19	$FDI_{US}$ *CONFL	0.0268	-0.0095

Importance	Regressor	Posterior probability	Posterior Mean
20	SEC	0.0257	0.0096
21	<i>FDI<sub>EU</sub></i> *SEC	0.0227	-0.6821
22	<i>FDI<sub>EU</sub></i> *MILI	0.0223	0.0346
23	<i>FDI<sub>EU</sub></i> *ELEC2	0.0211	-0.0175
24	<i>FDI<sub>EU</sub></i> *ROAD	0.0208	1.4167
25	GFCF	0.0207	-0.0015
26	CONFL	0.0197	0.0003
27	<i>FDI<sub>EU</sub></i> *TERT	0.0190	0.8342
28	<i>FDI<sub>US</sub></i> *DEMO	0.0189	0.0034
28	<i>FDI<sub>EU</sub></i> *PRIM	0.0184	0.4764
29	DEMO	0.0183	-0.0004
30	<i>FDI<sub>EU</sub></i> *BURO	0.0174	0.0296
31	<i>FDI<sub>US</sub></i> *SEC	0.0174	-0.0686
32	<i>FDI<sub>US</sub></i> *PRIM	0.0172	0.1074
33	<i>FDI<sub>US</sub></i> *GOV	0.0171	-0.0016
34	ELEC1	0.017	0.0009
35	<i>FDI<sub>US</sub></i>	0.0165	-0.0003
36	<i>CPI<sub>VOL</sub></i>	0.0165	0.0000
37	<i>FDI<sub>EU</sub></i> *PHONE	0.0164	-0.0193
38	<i>FDI<sub>US</sub></i> *BURO	0.0162	-0.001
39	<i>FDI<sub>US</sub></i> *PHONE	0.016	-0.001
40	ELEC2	0.0157	-0.0006
41	<i>FDI<sub>EU</sub></i> *CONFL	0.0156	0.0069
42	<i>FDI<sub>US</sub></i> *ELEC2	0.0156	0.0004
43	BURO	0.0155	0.0001
44	AIR	0.0152	0.0001
45	GOV	0.0152	0.0000
46	<i>FDI<sub>EU</sub></i> *GOV	0.0149	-0.0034
47	<i>FDI<sub>US</sub></i> *TERT	0.0148	0.1823
48	<i>EX<sub>ORES</sub></i>	0.0146	0.0005
49	<i>EX<sub>MANUF</sub></i>	0.0145	0.0002
50	<i>FDI<sub>US</sub></i> *ELEC1	0.0145	0.0033
51	URBAN	0.0142	-0.0027
52	<i>FDI<sub>EU</sub></i> *CORR	0.014	-0.0043
53	<i>FDI<sub>US</sub></i> *POLRI	0.0138	-0.0024

<b>Importance</b>	<b>Regressor</b>	<b>Posterior probability</b>	<b>Posterior Mean</b>
54	AGRI	0.0135	0.0004
55	CORR	0.0133	-0.0001
56	LAW	0.0130	0.0001
57	IND	0.0128	-0.0007
58	DEBT	0.0125	0.0000
59	$FDI_{US} * ROAD$	0.0125	-0.0285
60	$FDI_{US} * CORR$	0.0121	0.0008