Different Growth for Different Folks? Reexamining East Asian Growth Determinants through Iterative Bayesian Model Averaging (IBMA)*

Jeffrey Begun
Department of Economics
University of Washington

March, 2009

Abstract: This paper applies Iterative Bayesian Model Averaging (IBMA) to a broad cross-country dataset to see if East Asia grew differently than the rest of the world. Unlike prior studies which merely include an East Asia dummy variable, this study allows for parameter heterogeneity in several oft-cited factors that have been tied to East Asian growth. The IBMA analysis finds evidence that primary schooling and labor market rigidity played a much larger role in East Asian growth than for growth in other regions. Specifically, greater labor market flexibility and higher levels of primary schooling appear to be strongly linked to greater East Asian growth.

***** I would like to thank Theo Eicher for his helpful comments and continued support throughout this project.

I. Introduction

Since the early 1960's most East Asian countries have enjoyed spectacular rates of economic growth while many countries in other developed and developing regions grew at a much slower pace. Between 1960 and 1996 the eight fastest growing East Asian economies grew at a yearly average of more than 5.5 percent on a per capita basis. Income per capita in South Asia, however, only grew around 2.5 percent per year during the same time frame, and average per capita growth worldwide was less than 2 percent per year.

What accounts for the anomalously high growth rates in East Asia during this time period? This is a highly contentious subject and many factors have been proffered as the root cause. These include initial conditions such as high levels of education and investment, macroeconomic stability, and outward orientation. Other factors such as institutional quality and government intervention have also been cited though their contributions to East Asian growth have often been disputed (see the World Bank, 1993; ADB, 1997; and Quibria, 2002 for excellent summaries).

Several studies such as Rodrik (1994) and the World Bank (1993) have run basic cross-country growth regressions on a global sample using factors widely agreed upon as being important for economic growth (such as initial GDP, schooling, investment). They then calculate predicted growth in East Asian countries using growth accounting methods. Although Rodrik was able to predict more than 80 percent of growth in several East Asian countries, the oft-cited and more inclusive World Bank study was only able to predict about two-thirds of actual growth.

Later studies such as Sala-i-Martin *et al.* (2004) did much broader cross-country growth analyses. These studies used Bayesian techniques to weigh the importance of 41 and 67 potential regressors, respectively. These regressors covered a wide range of macroeconomic, geographical, socioeconomic, institutional, and religious measures in an attempt to filter out the determinants of economic growth. Sala-i-Martin *et al.* (2004) find that one of those geographical dummies, East Asia, is a very important determinant of growth.[1] The significance of the East Asia dummy provides further evidence that East Asian countries may have somehow grown differently than countries in other regions of the world since much of their growth is left unexplained as in the previously mentioned growth accounting exercises. In the spirit of Masanjala and Papageorgiou (2007) who show that African countries followed a unique growth path, this study uses Bayesian Model Averaging (BMA) to see if East Asia somehow grew differently.

This paper uses a similar dataset to the one used by Sala-i-Martin *et al.* (2004). It begins with their dataset and adds three variables which have frequently been cited as important for East Asian growth: equipment investment, foreign direct investment (FDI), and labor market rigidity. Due to the large number of regressors in the dataset traditional Bayesian Model Averaging is not possible, so Iterative Bayesian Model Averaging (IBMA) is employed in the analysis.[2] Heterogeneous slope coefficients for East Asian countries are tested for in areas often cited as especially important for rapid growth in the region: equipment investment, FDI, primary schooling, inflation, real exchange rate distortions, labor market rigidity, and trade (World Bank, 1993; ADB, 1997; and Quibria, 2002).[3]

Of the seven variables tested for heterogeneity, equipment investment, primary schooling, and labor market rigidity are found to be important for East Asian growth but,

[1] Other authors, such as Fernández, Ley, and Steel (2001a) have found that the fraction of a country's population that is Confucian is a strong determinant of growth. Fraction Confucian and East Asia are generally highly correlated (the correlation is 0.58 in the present study).
[2] IBMA, which was developed by Yeung, Baumgarner, and Raftery (2005) for use in genomics applications, runs traditional BMA iteratively on a reduced set of variables. See the Estimation section for an in-depth discussion.
[3] Due to the small number of East Asian countries in the dataset only seven variables can be tested for heterogeneous slope coefficients using BMA without producing matrices of less than full column rank. The East Asian countries in this study are Hong Kong, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, Indonesia, and Thailand.

interestingly, labor market rigidity is not found to be an important growth determinant outside East Asia. Primary schooling also appears to be much more important for East Asian growth than for growth outside the region. Specifically, an increase in equipment investment, primary schooling, or labor market flexibility is found to raise economic growth in East Asian countries, while FDI, inflation, real exchange rate distortions, and trade have no discernible effects over the sample period.

II. Data

The dataset used in this study is a modified version of Sala-i-Martin *et al.*'s (2004) dataset which covers 88 developed and developing countries. Their dataset contains the average growth rate of GDP per capita between 1960 and 1996 as well as 67 potential determinants of GDP including various macroeconomic, geographic, religious, and socioeconomic measures. Since causation between average GDP growth and their potential regressors is far from obvious (e.g., GDP growth may lead to an increase in exports, or vice-versa), time-dependent variables other than average GDP growth are measured as close to 1960 as possible.

Since the present study focuses on East Asian growth, some modification of the Sala-i-Martin *et al.* dataset was necessary.[4] A high level of investment has often been cited as one of the keys to the East Asian growth "miracle" (World Bank, 1993; ADB, 1997; and Quibria, 2002). Somewhat surprisingly, the Sala-i-Martin *et al*. dataset does not contain a measure of private investment besides investment price, and thus average equipment investment for 1960-1985 as a

[4] 22 countries, mostly in Africa, were dropped due to missing data. See the Appendix for the list of countries employed in this study as well as descriptive statistics for all variables included in this paper.

share of GDP from Fernández *et al.* (2001a) was added for the present study.[5] Two other variables oft mentioned as important for growth in some East Asian countries, labor market rigidity (Mazumdar, 1993; World Bank, 1993; and Quibria, 2002) and foreign direct investment (World Bank, 1993) are also added to the dataset. Data for labor market rigidity come from Forteza and Rama (2001) in the form of zero to one index (zero is maximum flexibility). The index is based on information on trade unions, minimum wages, mandated benefits, and government employment averaged over 1970-1999. Data for foreign direct investment in 1970 are taken from Lane and Miseli-Ferretti (2006).[6] These data show accumulated FDI inflows as a percent of GDP.

III. Estimation

A. Motivation

Beginning with important works such as Kormendi and Meguire (1985) and Barro (1991), macroeconomists have identified a large number of variables that may have an effect on economic growth. In fact, Durlauf, Johnson, and Temple (2005) point out that hundreds of potential determinants of economic growth have been identified in the literature, more variables than there are countries in the world. Since running OLS with all of these variables on the right-hand side is not feasible (nor advisable), many authors have chosen a subset of these variables to include in their cross-country growth regressions. Given that there is often little theoretical guidance for including certain variables while leaving others out, different studies may come to

[5] Fernández *et al.* (2001a) find that this measure of equipment investment is an important determinant of economic growth in their Bayesian analysis. Equipment investment data for Indonesia was taken directly from De Long and Summers (1991) since Indonesia is not included in their study.
[6] A few countries in this study lack FDI data for 1970. The data for these countries was interpolated using available data from later years.

vastly different conclusions concerning the significance of a particular regressor depending on which other covariates are included in their specification.

Leamer (1978) was among the first to recognize this problem and stressed that model uncertainty should be incorporated into empirical work. He provided a specific mechanism for testing for model uncertainty in his 1983 paper on Extreme Bounds Analysis (EBA). In EBA each regressor is included in all possible models in order to test for robustness. If a variable is found to change signs in any of the specifications then it is deemed not to be robust. Critics have pointed out two major flaws with EBA: it is not based on well-developed statistical theory and it is biased towards finding "too few" robust variables (Sala-i-Martin, 1997, and Sala-i-Martin *et al.*, 2004). In addition, when analyzing a large number of variables (as is the case with cross-country growth regressions) it is not practical to analyze all possible models. Levine and Renelt (1992), in an oft-cited empirical application of EBA to cross-country growth, include certain "key" variables in all of their models and then only allow for four variables to be added at a time.

In light of these shortcomings researchers have increasingly focused on Bayesian Model Averaging (BMA) as a better way to address model uncertainty. BMA was first introduced into economics by Multon (1991) and Palm and Zellner (1992), but was initially limited by a lack of computing power. Recent years have seen a large expansion of BMA in empirical economics as processing power has steadily increased (see, for example, Fernández *et al.*, 2001a; Leon-Gonzalez and Montolio, 2003; Masanjala and Papageorgiou, 2007; and Eicher, Papageorgiou, and Roehn, 2007).

Unlike Extreme Bounds Analysis, BMA is based on solid statistical foundations.[7] BMA has the additional advantage of allowing for any subset of regressors to be tested for in order to

[7] See Raftery, 1995; Draper, 1995; and Hoeting, Madigan, Raftery, and Volinsky, 1999 for excellent introductions to BMA.

find the "best" model. Many authors such as Raftery (1995) and Raftery, Madigan, and Hoeting (1997) have shown that BMA yields superior out-of-sample predictive performance to predictions which are only based on a single model.

B. Bayesian Model Averaging

BMA has the potential to average over all possible models, where the posterior model probability of each model is used to weigh each model. The posterior model probability of any given model is the conditional probability of that model being the true model once all relevant data has been accounted for. Prior probabilities selected by the researcher and the likelihood function are incorporated into Bayes' theorem in order to calculate these posterior probabilities. The rest of this subsection provides a more formal presentation of BMA as utilized in this study.

The model presented here is based on Fernández *et al.* (2001a) and Begun and Eicher (2007). Consider a linear regression with n independent observations, a dependent variable y (per capita GDP growth), and potential regressors $x_1, x_2, ..., x_p$. The Bayesian problem is to find the "best" models of the form

$$y = \alpha + \sum_{i=1}^{h} \beta_i x_i + \varepsilon \tag{1}$$

where β_i represents a vector of regression coefficients and $x_1, x_2, ..., x_h$ is a subset of $x_1, x_2, ..., x_p$. Given a set of possible models $M = \{M_1, M_2, ..., M_k\}$ where $k = 2^p$, and data D, BMA ranks each model by its posterior probability, $p(M_i \mid D)$, which represents the model's share of the total posterior mass. Thus,

$$p(M_i \mid D) = \frac{p(D \mid M_i) p(M_i)}{\sum_{j=1}^{k} p(D \mid M_j) p(M_j)} \tag{2}$$

where

$$p(D \mid M_i) = \int p(D \mid \delta_i, M_i)\, p(\delta_i \mid M_i)\, d\delta_i \tag{3}$$

and δ_i is a vector of parameters in model M_i where $\delta_i \sim [\beta_i, \sigma^2]$. Any parameter of interest Θ can now be ranked according to a weighted sum of the posterior probabilities of all models which contain that parameter. Therefore,

$$p(\Theta \mid D) = \sum_{i=1}^{2^p} p(\Theta \mid D, M_i)\, p(M_i \mid D) \tag{4}$$

gives the posterior inclusion probability of any chosen parameter. Following Raftery (1993), the posterior model probabilities can also be used to determine the posterior means and variances

$$E[\beta \mid D] = \sum_{i=0}^{k} \hat{\beta}_i\, pr(M_i \mid D), \tag{5}$$

$$Var[\beta \mid D] = \sum_{i=0}^{k} \left(Var[\beta \mid D, M_i] + \hat{\beta}_i^2\right) pr(M_i \mid D) - E[\beta \mid D]^2. \tag{6}$$

There are several practical difficulties in employing this framework. First of all, prior distributions need to be specified for all potential models as well as for the parameters in M_i. It is generally accepted in the literature that when meaningful information on prior model probabilities is not available it is reasonable to assume a uniform distribution over the model space (see, e.g., Raftery *et al.*, 1997; Hoeting *et al.*, 1999; and Fernández *et al.*, 2001a,b). Therefore, the prior probability of each model is 2^{-p} and each regressor considered in this study has an equal chance of 0.5 of being included.

Unlike prior model probabilities, the choice of prior parameter distributions can be a somewhat difficult and controversial task. The software used for this paper utilizes the unit information prior (UIP), a relatively uncontroversial and diffuse prior with roots in frequentist statistics.[8] The UIP, a special case of the prior preferred by Fernández *et al.* (2001b), is a multivariate normal prior whose mean lies at the maximum likelihood estimate and whose variance is given by the expected information matrix for a single observation (Kass and Wasserman, 1995, and Raftery, 1999). The main advantage of the UIP is its ability to yield a straightforward approximation to the marginal likelihood through use of the Bayesian Information Criterion (BIC).

The other practical difficulties of implementing BMA involve the vast size of the model space to be considered (2^p, or 2^{77} in this study), and the difficulty of calculating the integral in equation (3) since a closed-form solution may not exist. The BIC, developed by Raftery (1995), allows for an approximate value of this integral without compromising the BMA results. In fact, the BIC is slightly biased towards not finding that a given regressor is "significant," and thus is generally seen as reasonable approximation given the intractability of the equation (3) in most circumstances.

In order to help search the model space, this study uses the "leaps and bounds" algorithm introduced by Raftery (1995) to limit the computational burden. The algorithm yields a user specified number of best models for each model size by finding the best subsets of variables for predicting the dependent variable. Leaps and bounds is the most efficient sampler computationally, and thus is the most appropriate sampler for this study given the vast number of potential regressors.

C. Iterative Bayesian Model Averaging

[8] The software used in this study is available at http://www.research.att.com/~vollinsky/software/bicreg.

After adding three variables and seven interaction terms to the Sala-i-Martin et al. (2004) dataset there are 77 candidate regressors in this study (which implies more than 150 billion trillion potential models). Since the *bicreg* algorithm often used in BMA analysis can only process a maximum of 54 regressors, this paper utilizes Iterative Bayesian Model Averaging (IBMA) as its model averaging devise. IBMA was developed by Yeung, Baumgarner, and Raftery (2005) for a genome application and introduced into empirical economics by Eicher *et al.* (2007).

IBMA is able to handle a larger number of regressors than traditional Bayesian Model Averaging since it performs BMA iteratively on a smaller set of variables. IBMA selects the first *v* regressors with the highest correlation to the dependent variable (*v* is set to 41 in this study) for the initial BMA run. Regressors with a very low posterior inclusion probability (less than one percent by default) are then replaced by variables which have yet to be considered, and the process repeats until all the variables have been included in at least one BMA run.

IV. East Asian Heterogeneity

Ideally, this study would follow Eicher *et al.* (2007) and test for heterogeneous slope coefficients for all the potential regressors. Due to the limited number of East Asian countries, however, allowing heterogeneous coefficients for all 70 variables is not feasible since many of the matrices utilized by BMA would not be of full column rank. Thus, this paper limits itself to searching for parameter heterogeneity in seven variables which have been theoretical and empirically linked to East Asian growth. These are equipment investment, trade, labor market flexibility, inflation, real exchange rate distortions, foreign direct investment, and primary schooling. Each of these variables is discussed in detail below.

Investment may have played a key role in rapid East Asian growth. Since most East Asian countries were relatively poor in the 1960's, according to the neoclassical Solow-Swan model high investment levels in these countries should have led to more rapid economic growth as they transition to the steady-state. Endogenous growth theory also allows for an increase in the growth rate due to high investment levels through economies of scale regardless of the level of economic development. In addition, many countries in East Asia have had open economies for some time, and Quibria (2002) notes that investment is usually highly correlated with growth in open economies since investment often spurs technological progress. Many authors have argued that high levels of investment were crucial to East Asian growth (World Bank, 1993, and ADB, 1997), but others have stressed that most investment may have been endogenous (Rodrick, 1994, for example). Endogeneity concerns aside, due to the explosive growth of investment in East Asia over the sample period and the central role of investment in the East Asian growth literature, this study tests for heterogeneity using average equipment investment from 1960-1985.

Openness/trade is another factor cited in almost every broad-based study of the causes of East Asian growth (World Bank, 1993; ADB, 1997; Yusuf, 2001; and Quibria, 2002). Exports and imports make up a relatively large percentage of GDP in many East Asian countries and have grow rapidly over time. In fact, Quibria calls trade "the most critical factor" in their long-lived economic expansion. Many authors such as Balassa (1991) and Hughes (1992) have found empirical evidence for the importance of trade for growth.

There are many theoretical reasons why (openness to) trade, and specifically exports, may lead to robust economic expansion. These include 1) access to new technologies (Urata, 2001); 2) compensation for inadequate domestic demand (Ades and Glaeser, 1999); 3) amassing foreign exchange (Findlay, 1971); 4) positive spillover effects in local markets due to competitive pressures (Caves, 1999); 5) increase pressure for local learning (Pack, 2001); 6) stimulated local investment (Nam and Kim, 2000); 7) learning international best practices (World Bank, 1993); and 8) stimulated domestic research and development (World Bank, 1993). In order to see if trade was particularly important for East Asian development, this paper tests for heterogeneity using exports plus imports as a percentage of GDP, averaged from 1965 to 1974.

Macroeconomic stability was also vital to East Asian growth according to many authors (World Bank, 1993; ADB, 1997; Quibria, 2002). The vast majority of East Asian countries were fiscally sound and enjoyed relatively low inflation, stable exchange rates, and manageable budget deficits. Quibria argues that low inflation and realistic exchange rates are essential for promoting an environment where high savings rates, efficient investment, and strong growth can be achieved. There are several reasons why high inflation can put a damper on growth. Inflation can cause relative price distortions, it can discourage investment due to uncertainties about future inflation, and it can impose high institutional costs as many qualified professionals, who would otherwise work in more "productive" areas of the economy, are drawn to financial sector management (World Bank, 1993). Several authors such as Fischer (1993) have examined cross-country data and found evidence that inflation lowers growth. In order to see if inflation played a special role in East Asia, this study tests for a heterogeneous inflation parameter. Real exchange rate distortions are also examined separately for East Asia as another proxy for macroeconomic stability.

With the rise of endogenous growth theory there has been a newfound emphasis on the role of human capital in economic growth. Although physical capital formation is essential to any modern economy, it is very difficult for a country to experience a prolonged period of economic growth without a well-educated workforce. Can education help explain the East Asian "miracle?" Although illiteracy was still 77% in Malaysia and 32% in Thailand in the 1960's, Behrman and Schneider (1994) note that after controlling for income per capita East Asian countries had relatively high rates of primary and secondary schooling in 1965. Rodrick (1994) finds evidence for the importance of schooling for East Asian growth, and the World Bank (1993) stressed that "emphasis on universal, high-quality primary education had important payoffs both for economic efficiency and equity" in East Asia.

Although the theoretical links between schooling and economic growth are strong, cross-country empirical support for this relationship is sometimes lacking. One reason for this may be that education can have a heterogeneous impact on growth based on the quality of a country's policies and institutions, such as openness to trade (Quibria, 2002). Stern (2001) emphasizes this same point when explaining the paradox of strong physical and human capital investments in the Middle East during the 1980's and 1990's which yielded relatively little economic growth. Since East Asian countries often had high quality institutions and were open to the world economy, this seems like an ideal area to test for heterogeneity. Therefore, a separate slope coefficient for primary schooling in East Asia is tested for.

Another potentially important factor for the meteoric rise of most East Asian economies is labor market flexibility. As noted by Hasan (2001) and the ADB (1997), East Asian countries have some of the most flexible labor markets in the world. While OECD countries had ratified 71 International Labor Organization (ILO) conventions as of 1997 and Latin American countries had ratified 50, East Asian countries had only ratified 14. There are several theoretical reasons why having a flexible labor market may fuel economic growth. First of all, having an overly protective labor market may reduce the demand for labor and thus act as a brake on growth.

Further, a plethora of labor market regulations can lead to rent-seeking by protected groups and thus decrease firms' investment rates. Finally, countries with inflexible labor markets often have a tough time rebounding from macroeconomic shocks since firms can't easily fire workers even during severe downturns. In order to gauge the importance of labor market flexibility in East Asian growth this paper employs Forteza and Rama's (2001) labor market rigidity index.

Foreign direct investment is sometimes cited as another key ingredient in the East Asian growth recipe. There are several reasons why FDI may lead to economic expansion in developing countries: 1) FDI brings access to advanced foreign technology 2) foreign physical and human capital allows for production on the world's best-practice production function; and 3) FDI yields crucial marketing and production knowledge that is often spread by labor mobility and informal contacts between managers. The World Bank (1993) argues that FDI has allowed for more rapid technology acquisition in Hong Kong, Malaysia, Singapore, Indonesia, and Thailand. Also, it is possible that FDI had particularly virtues effects in East Asia due to the relatively open nature of their economies (i.e. relatively large amounts of technology transfer due to FDI for manufactured exports). FDI may be endogenous to economic growth if FDI follows growth or if they tend to increase simultaneously. In order to help control for this, this study uses FDI in 1970 to search for a heterogeneous impact in East Asia.

V. Results

The main results are presented in Tables 1 and 2 and summarized in Table 3. Table 1 displays the posterior mean, standard deviation, and ratio of posterior mean to standard deviation for the full global specification for all regressors with a posterior inclusion probability greater than zero. Table 2 also reports posterior means, standard deviations, and the ratio of posterior mean to standard deviation for the specification which includes East Asian interaction terms for selected variables as discussed above. Table 3 summarizes the results by displaying posterior means and standard deviations for the global sample, non-East Asian sample, and East-Asian sample. It is important to note that only variables which are considered “effective” are presented in Table 3. Raftery (1995) argues that for a regressor to be effective its posterior inclusion probability must be greater than 50 percent. This roughly equates to a posterior mean to standard deviation ratio greater than 1 in absolute value, and thus that is the threshold that is used in this study.

Table 3 shows that there are 13 effective variables in the global sample 11 in both the non-East-Asian and East-Asian samples. The posterior means and standard deviations for effective variables such as mining which were not tested for a separate East Asian intercept are presented in both the non-East-Asian and East-Asian columns. There are several variables which are effective in the global sample but not in either of the two subsamples. These include life expectancy as well as religion dummy variables for Catholicism and Protestantism. Interestingly, the East Asia dummy variable is no longer effective when heterogeneous slope coefficients are permitted. This suggests that allowing for a different growth process in East Asia resolves Sala-i-Martin *et al.*’s (2004) finding that East Asian growth cannot be fully explained even when 67 potential regressors are considered.

Of the seven variables tested for heterogeneity, the biggest differences between East Asia and the rest of the world appear in the roles of primary schooling and labor market rigidity. Labor market rigidity is not found to be an effective growth determinant in the global or non-East-Asian samples, but more flexible labor markets appear to have had a strong positive effect on growth in East Asia. Higher levels of primary schooling are found to be effective in raising growth in both the East Asian and non-East-Asian samples, but the magnitude of the coefficient on primary schooling is more than four times higher in East Asia. Finally, equipment investment is found to be a key determinant of East Asian growth, but it also appears to have had a very similar effect in the rest of the world.

VI. Conclusion

Using Iterative Bayesian Model Averaging on a large cross-country dataset and allowing for partial parameter heterogeneity, this paper finds evidence that East Asia grew differently than the rest of the world between 1960 and 1996. Specifically, primary schooling and labor market rigidity appear to have played a much larger role in economic growth in East Asia than in other areas of the world. These findings are not too surprising considering the fact that a year of schooling is not an identical commodity in all places at all times. Schooling has an important qualitative aspect, and good governance and institutions in East Asia may have led to higher quality in this area than in other regions. In addition, labor markets do not operate in a vacuum, and economic openness in East Asia may have combined with flexible labor markets to help fuel growth.

Due to the limited number of East Asian countries in the cross-sectional data and thus only partial parameter heterogeneity examined in this work, the results should be seen as suggestive only. Further research involving time-series data would allow for a greater number of observations and a fully-specified search for East Asian parameter heterogeneity. By focusing on a well-known cross-country dataset and the most celebrated drivers of East Asian growth, this study hopes to open the door to a fruitful area for further research.

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Table 1
Growth Determinants in the Global Model

Regressor	Posterior Mean	Posterior S.D.	Posterior Mean / Posterior S.D.
Log of GDP per capita in 1960	-0.0133	0.0025	-5.2338
Equipment investment	0.1422	0.0389	3.6546
Sub-Saharan African dummy	-0.0180	0.0045	-4.0376
Life expectancy in 1960	0.0007	0.0002	3.1407
Fraction Confucius	0.0342	0.0128	2.6776
Mining	0.0423	0.0155	2.7326
Real exchange rate distortions	-0.0001	0.00003	-2.7147
Fraction Catholic	-0.0311	0.0101	-3.0621
Fraction Protestant	-0.0342	0.0111	-3.0765
Europe dummy	0.0320	0.0111	2.8871
Latin America dummy	0.0220	0.0093	2.3760
East Asia dummy	0.0114	0.0052	2.2042
Public investment share of GDP	-0.0642	0.0330	-1.9470
Spanish colony	-0.0025	0.0042	-0.5889
Fraction Orthodox	-0.0042	0.0078	-0.5386
Civil liberties	-0.0017	0.0037	-0.4583
Date of independence index	-0.0005	0.0014	-0.3986
Primary schooling in 1960	0.0019	0.0053	0.3546
Absolute latitude	0.00002	0.0001	0.3283
Fraction of land near navigable water	-0.0006	0.0019	-0.2941
Capitalism index	0.0002	0.0006	0.2739
Fraction speaking a foreign language	0.0004	0.0016	0.2669
Higher education in 1960	-0.0031	0.0125	-0.2500
Interior population density*	0.0011	0.0047	-0.2424
Investment price*	0.0069	0.0274	-0.2517
Government share of nominal GDP in the 1960's	-0.0017	0.0089	-0.1975
British colony	-0.0002	0.0011	-0.1865
Coastal population density*	0.0002	0.0008	0.1842
Fraction Buddhist	0.0006	0.0033	0.1764
Fraction of area in geographical tropics	-0.0001	0.0008	-0.0805
Malaria prevalence	0.0001	0.0012	0.0834
Log of aggregate GDP in 1960	0.00001	0.0002	0.0813
Oil-producing country dummy	0.00004	0.0006	-0.0634
Fertility in the 1960's	0.00003	0.0008	0.0370
Percentage speaking English	0.00004	0.0007	0.0661
Fraction Muslim	0.00004	0.0008	-0.0515
Public education share of GDP in the 1960's	0.0002	0.0061	0.0251
Population in 1960**	0.00004	0.0019	0.0232
Fraction Hindu	0.00003	0.0012	-0.0236

Note: *, ** indicate that a variable was multiplied by 1,000 and 1,000,000, respectively.

Table 2
Growth Determinants in the Interacted Model

Regressor	Posterior Mean	Posterior S.D.	Posterior Mean / Posterior S.D.
Equipment investment	0.1671	0.0435	3.8396
Log of GDP per capita in 1960	-0.0110	0.0027	-4.0073
Fraction of area in geographical tropics	-0.0113	0.0044	-2.5858
Labor market rigidity (East Asia)	-0.2005	0.0401	-4.9975
Sub-Saharan Africa dummy	-0.0125	0.0065	-1.9252
Mining	0.0312	0.0193	1.6130
Public investment as a fraction of GDP	-0.0601	0.0375	-1.6037
Civil liberties	-0.0084	0.0055	-1.5159
Primary schooling in 1960	0.0152	0.0108	1.4154
Fraction of population less than 15 years old	0.1124	0.0825	1.3629
Primary schooling in 1960 (East Asia)	0.0459	0.0286	1.6076
Real exchange rate distortions	0.00005	0.00004	-1.2062
Fraction of population more than 65 years old	0.1799	0.1558	1.1547
Fertility in the 1960's	-0.0104	0.0109	-0.9567
Spanish colony	-0.0033	0.0042	-0.7768
Government share of nominal GDP in the 1960's	-0.0212	0.0279	-0.7605
Life expectancy in 1960	0.0002	0.0003	0.6342
Higher education in 1960	-0.0149	0.0282	-0.5294
Investment price*	0.0182	0.0351	-0.5182
Oil-producing country dummy	-0.0023	0.0046	-0.5023
Fraction Orthodox	-0.0025	0.0059	-0.4186
Log of aggregate GDP in 1960	0.0004	0.0009	0.3901
East Asia dummy	0.0072	0.0176	0.4069
(Exports + Imports) / GDP (East Asia)	0.0024	0.0065	0.3622
Real exchange rate distortions (East Asia)	0.0001	0.0001	0.3628
Coastal population density*	0.0008	0.0028	-0.2863
Population growth rate (1960-1990)	-0.0708	0.2171	-0.3259
Population in 1960**	0.0034	0.0109	0.3098
Fraction Muslim	-0.0009	0.0031	-0.3047
Absolute Latitude	0.0003	0.0001	-0.2706
British colony	-0.0005	0.0017	-0.2660
Fraction Hindu	0.0010	0.0043	0.2353
Fraction tropical climate	0.0004	0.0020	0.2155
(Exports + Imports) / GDP	0.0002	0.0013	0.1662
Fraction speaking a foreign language	0.0001	0.0006	0.1368
Terms of trade growth in the 1960's	-0.0011	0.0107	-0.0991
Defense share of GDP	0.0016	0.0133	0.1171
Capitalism index	0.00002	0.0002	0.1076
Europe dummy	0.0001	0.0008	0.0888
Air distance to big cities**	0.0029	0.0525	-0.0551
Labor market rigidity	0.00004	0.0009	-0.0448

Note: *, ** indicate that a variable was multiplied by 1,000 and 1,000,000, respectively.

Table 3
Summary of Effective Growth Determinants

	Global Sample		Non-East-Asia		East Asia	
	Posterior Mean	**Posterior S.D.**	**Posterior Mean**	**Posterior S.D.**	**Posterior Mean**	**Posterior S.D.**
Log of GDP p.c. in 1960	-0.0133	0.0025	-0.0110	0.0027	-0.0110	0.0027
Equipment investment	0.1422	0.0389	0.1671	0.0435	0.1671	0.0435
Sub-Saharan Africa	-0.0180	0.0045	-0.0125	0.0065		
Life expectancy in 1960	0.0007	0.0002				
Fraction Confucius	0.0342	0.0128				
Mining	0.0423	0.0155	0.0312	0.0193	0.0312	0.0193
Exchange rate distortions	-0.0001	0.0000	-0.00005	0.00004	-0.00005	0.00004
Fraction Catholic	-0.0311	0.0101				
Fraction Protestant	-0.0342	0.0111				
Europe dummy	0.0320	0.0111				
Latin America dummy	0.0220	0.0093				
East Asia dummy	0.0114	0.0052				
Public investment	-0.0642	0.0330	-0.0601	0.0375	-0.0601	0.0375
Fraction tropical climate			-0.0113	0.0044	-0.0113	0.0044
Civil liberties			-0.0084	0.0055	-0.0084	0.0055
Primary schooling in 1960			0.0152	0.0108	0.0612	0.0437
Population under 15			0.1124	0.0825	0.1124	0.0825
Population over 65			0.1799	0.1558	0.1799	0.1558
Labor market rigidity					-0.2005	0.0411

Note: A variable is considered effective in this table if the ratio of its posterior mean to its posterior standard deviation is greater than one in absolute value.

APPENDIX

Table A-1: Descriptive Statistics

Variable	Mean	Standard Deviation
(Exports + Imports) / GDP	0.514	0.359
Absolute latitude	26.141	17.315
Aggregate GDP in 1960 (log)	16.664	1.664
Air distance to big cities	3,866.470	2,677.229
Average inflation (1960 - 1990)	14.658	16.680
British colony after 1776 dummy	0.333	0.475
Capitalism index	3.500	1.231
Civil liberties in 1972	0.581	0.310
Coastal population density	186.103	584.059
Date of independence index	0.848	0.965
Defense share of GDP (1960 - 1965)	0.028	0.026
East Asia dummy	0.136	0.346
Equipment investment (1960 -1985 average)	0.046	0.035
Ethnolinguistic fractionalization	0.292	0.273
Europe dummy	0.273	0.449
Fertility (1960's)	1.484	0.444
Foreign direct investment share of GDP (1970)	0.118	0.178
Former colony dummy	0.697	0.463
Fraction Buddhist	0.061	0.192
Fraction Catholic	0.416	0.431
Fraction Confucian	0.021	0.091
Fraction Hindu	0.025	0.110
Fraction in geographical tropics	0.518	0.474
Fraction Muslim	0.137	0.282
Fraction of land near navigable water	0.541	0.366
Fraction of population less than 15 years old in 1960	0.387	0.084
Fraction of population over 65 years old in 1960	0.052	0.032
Fraction of time spent in war (1960 - 1990)	0.072	0.160
Fraction Orthodox	0.023	0.113
Fraction population living in tropics	0.227	0.333
Fraction Protestant	0.155	0.309
Fraction speaking a foreign language	0.385	0.426
Fraction speaking English	0.096	0.270
Fraction tropical climate	0.173	0.259
GDP per capita in 1960 (log)	7.563	0.865
GDP per capita growth (1960-1996 average)	0.023	0.018
Government consumption share of GDP (1961)	0.098	0.054
Government spending share of GDP (1960-1964)	0.151	0.054
Higher education in 1960	0.046	0.053
Hydrocarbon deposits (log)	0.677	4.276
Interior population density	49.209	98.976
Investment price	81.252	31.487
Labor market rigidity	0.304	0.127
Land area in km^2	1,005,067.879	2,055,294.962
Landlocked country dummy	0.121	0.329
Latin America dummy	0.288	0.456
Life expectancy in 1960	57.253	11.152

Malaria prevalence	0.235	0.370
Mining share of GDP	0.046	0.080
Nominal government spending share of nominal GDP (1960-1964)	0.145	0.050
Oil-producing country dummy	0.061	0.240
Outward orientation	0.364	0.485
Political rights	3.253	1.772
Population density	86.886	180.927
Population growth rate (1960-1990)	0.020	0.010
Population in 1960	2,5437.333	59,782.915
Primary exports share of total exports	0.671	0.301
Primary schooling 1960	0.803	0.248
Public education share of GDP (1960's)	0.025	0.009
Public investment share of GDP (1960 - 1965)	0.054	0.040
Real exchange rate distortions	118.576	39.852
Religious intensity index	0.765	0.203
Revolutions and coups	0.186	0.246
Socialist dummy	0.045	0.210
Spanish colony dummy	0.227	0.422
Square of inflation (1960 - 1990)	488.865	1272.738
Sub-Saharan African dummy	0.167	0.376
Terms of trade growth in the 1960's	0.00001	0.035
Terms of trade ranking	0.314	0.202
War participation dummy (1960 - 1990)	0.409	0.495
Years open 1950-1994	0.450	0.344

Table A-2: List of Countries Included in This Study

Algeria	Guatemala	Paraguay
Argentina	Honduras	Peru
Australia	Hong Kong	Philippines
Austria	India	Portugal
Belgium	Indonesia	Senegal
Bolivia	Ireland	Singapore
Botswana	Israel	Spain
Brazil	Italy	Sri Lanka
Canada	Jamaica	Sweden
Chile	Japan	Taiwan
Colombia	Jordan	Tanzania
Costa Rica	Kenya	Thailand
Denmark	Korea	Trinidad & Tobago
Dominican Rep.	Madagascar	Tunisia
Ecuador	Malaysia	Turkey
El Salvador	Mexico	Uganda
Ethiopia	Morocco	United Kingdom
Finland	Netherlands	United States
France	Nigeria	Uruguay
Germany	Norway	Venezuela
Ghana	Pakistan	Zambia
Greece	Panama	Zimbabwe