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An empirical analysis of economic growth in countries exposed to coastal risks - Implications for their ecosystems*

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Abstract

Using a novel database on countries exposed to coastal risks (CR), this paper estimates an augmented neoclassical growth model that nests eight other new growth models. To account for uncertainty related to model multiplicity and choice of growth determinant proxies, we use a Bayesian model averaging (BMA) approach. A preliminary examination of the data shows that a country exposed to coastal risks is likely to be a former British colony characterized by a common law legal framework, a parliamentary political system, a high degree of international trade openness, a small language and ethnic fractionalization, weak public sector corruption, and a high fertility rate. The BMA-based model selection procedure shows that growth determinant proxies typically used in the neoclassical, macroeconomic policy, natural capital, and institutions theories are significantly correlated to growth in CR countries. These results suggest a dual implication as far as these countries' coastal ecosystems are concerned. On the one hand, because they are heavily dependent on natural capital and have high fertility rates, these countries may potentially seek short-term economic gains at the expense of deteriorating their ecosystems. On the other hand, these countries' good institutions and low levels of ethnic splitting may be conducive to sustainable management of these ecosystems.

Keywords: Economic growth, coastal risks, ecosystems, Bayesian model averaging.
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1. Introduction

Human economic activity has major impacts on coastal environments through its effect on climate change, agriculture, aquaculture, urbanization, and tourism, among other factors. Concerning climate change these impacts include aquifer and agricultural soil contamination, flooding of wetlands, destructive erosion, loss of marine habitats and biodiversity, bleaching of coral reefs, and changes in the oceanographic processes that affect marine productivity (Patterson and Glavovic, 2008). Moreover, sea level rise exercises a significant impact on coastal ecosystems by contaminating drinking and farming water, changing coastal vegetation with the new chemistry of soil, and threatening wildlife populations (Darwin and Tol, 2001).

Overall, these coastal ecosystem losses associated with natural disasters are steadily raising, but, along with climate change, the occurrence of natural hazards has been multiplied by more than four across the world since 1975 (Loayza et al., 2012). Beyond climate change, there are other economic drivers that affect coastal ecosystems. Over two billion people and about half of the largest cities in the world are found within 50 km of coastlines (Brown et al., 2008; MEA, 2005). There is a momentum in coastal agglomeration growth, with economic growth and geographical concentration being mutually reinforcing processes (Martin and Ottaviano, 2001).

The global economy has expanded sixfold during the 1950-2000 period, with coastal tourism, fishing, energy, minerals and agriculture, having had a disproportionate impact on coastal ecosystems (Patterson and Glavovic, 2008). In the same period, tourism has been one of the world's fastest growing industries with a number of tourists that has been multiplied by a factor of 65. (CBD-UNEP, 2005; Rekacewicz and UNEP/GRID-Arendal, 2001). Tourism infrastructure has been considered as a major cause of habitat loss in Mediterranean coastal ecosystems (WWF GMP, 2006).

A key policy question then is how to strike a balance between economic development and ecosystem conservation in coastal areas in the context of climate change. Economic growth and ecosystem conservation should clearly be integrated within the basic infrastructure that is required to provide essential services to the population in these areas (Emerton, 2014). A lens through which this issue may be examined is the nexus between the development pathway of a country and the anthropogenic pressures exercised on coastal ecosystems that are already exposed to climate change effects. This is the perspective we adopt in this paper. In a nutshell, we attempt to assess how, for a country, the fact that it is particularly exposed to coastal risks affects the relationship between human activity and economic growth through the influence exerted by these risks on the likelihood of occurrence of natural hazards.

We seek to identify the determinants of economic growth in countries exposed to significant coastal risks and, viewing those risks as additional sources of anthropogenic pressures on (coastal) ecosystems to those already imposed by natural disasters, we focus on the potential consequences of these pressures on these countries' coastal ecosystems. Technically, Our empirical strategy consists in comparing growth regressions for countries exposed to coastal risks, referred to as "CR countries" hereafter, to those for generic worldwide countries, referred to as "WW countries" hereafter.[1]

While the literature on the economic impact of natural disasters finds that it could be significant, there is no consensus on its sign (Cavallo et al., 2013).[2] Some authors have argued that climatic disasters may have a positive impact on growth through the acceleration of capital replacement (Skidmore and Toya, 2002; Cuaresma et al., 2008) while some others have argued that in developing countries extreme weather events may have a negative impact when their frequency is high (Mechler, 2004; Hallegate et al., 2007; Loayza et al., 2012), and may even put the population in a poverty trap (Carter et al., 2006; Hallegate and Dumas, 2009).

Still some authors have found that climatic events may not event be robust determinants of economic growth once the uncertainty about the appropriate growth theory and the specification of proxies for the theory is taking into account (Durlauf et al., 2008a). This paper seeks to contribute to this ongoing debate by analyzing a novel database on 54 CR countries for the 1960-2009 period that we constructed relying on country-level geospatial information. To investigate the existence of a CR-specific effect, we analyze the determinants of growth using both this CR data and data on 83 WW countries.

[1] There exists a stream of the literature that uses microeconomic tools to analyze the impact of natural hazards (Barbier and Cox, 2004). In this paper we rather rely on techniques that are typically used in macroeconomic analyses.
[2] For recent reviews on the relationship between natural disasters and economic growth, see Shabnam (2014) and Panwar and Sen (2019).

This paper is organized as follow. In the next section, we review nine candidate theories we use to analyze growth in CR countries, discuss the extent to which these theories apply to these countries, and describe the way we estimate and evaluate their relative empirical performance using a Bayesian Model Averaging (BMA).[3] Section 3 presents the data and discusses the results of their preliminary examination. In section 4, we discuss the results obtained with the BMA methodology applied to the CR and WW samples of countries. Section 5 gives some concluding remarks. The appendix provides a detailed description of the data, some descriptive statistics, and some estimation results that are discussed in the main text.

2. Theories and corresponding regressions for analyzing growth in countries exposed to coastal risks

An empirical implication of the neoclassical growth theory (Solow, 1956) is that labor productivity should converge worldwide as higher returns on capital in less developed countries should attract more capital leading to their economies catch-up with those of the more advanced ones. However, these exists a large empirical evidence showing discrepancies between rich and poor countries as to productivity growth suggesting that there has been little worldwide unconditional convergence and that most capital investment has occurred in developed countries. The concept of conditional convergence has thus been developed to account for some other factors that are determinants of growth and incorporate them in the standard framework.

To improve the empirical explanatory power of the neoclassical-type growth models, in particular, to explain how and why growth rates differ across time and countries, a large number of new factors have been introduced in the original neoclassical framework with the aim of capturing the part of growth that remained unexplained. This extension of the original framework has given birth to what is referred to as "new growth theories." Durlauf et al. (2008a) have identified 43 growth theories and 145 regressors used as proxies for the determinants of growth in the empirical literature on economic growth. Overall, this enriched growth literature has produced empirical evidence in favor of conditional convergence

[3] The BMA approach explicitly recognizes uncertainty related to both growth modelling and growth determinants proxying. For an introduction to BMA, see, e.g., Hinne et al. (2020) and for a recent survey of its use in economics, see Steel (2020).

suggesting that poorer countries should grow at faster rates until they reach a steady state under the hypothesis of decreasing returns to scale.

Besides the large size of the set of candidate growth theories, and additional difficulty in empirical analysis of economic growth is the possibility that a given country might experience multiple economic growth regimes (Durlauf and Johnson, 1995). Under such circumstances, the data sample analyzed is typically split based on a cut-off point of the level of a relevant variable either relying on the results of a methodology or making an ad-hoc choice. A great variety of statistical methods have been used to identify multiple economic growth regimes (Durlauf et al., 2005). Owen et al. (2007) and Konte (2013) give an overview of how the presence of multiple economic growth regimes has been addressed by dividing the sample according to different theories besides the neoclassical one, in particular, theories based on geographical, demographical, and institutional factors.

Given this potentially large number of new growth theories, model uncertainty is clearly an issue when empirically analyzing the determinants of economic growth. Regressions have shown that a large number of variables are correlated with economic growth without necessarily implying a direction of causation. The lack of consensus on a structural growth model and subsequently on a reduced form to apply in empirical analyses has led some researchers to admit model uncertainty and let the data show which variables perform well as economic growth predictors (Capolupo, 2009). To test the growth models corresponding to the new theories, in particular, those that incorporate natural capital, Durlauf et al. (2005; 2008a) and Sala-i-Martin et al. (2004) have proposed a BMA approach that explicitly accounts for model uncertainty.[4] This is the approach that we adopt in this paper.

Following Rodrik (2003) and Durlauf et al. (2008b), we classify growth theories as "proximate" theories and "fundamental" or "deep" theories. Proximate theories are those that are associated with the human and physical capital inputs and their productivity in the production of goods and services (Neoclassical theory, Demography), those that consider the determinants of growth that can be relatively rapidly influenced by macroeconomic policy

[4] More specifically, Sal-i-Martin et al. (2004) build on the work of Sala-i-Martin (1997) to propose a Bayesian averaging of classical estimates (BACE) approach that consists in taking weighting averages of estimates of mean and standard deviations for variables across regressions using weights proportional to the likelihoods of the models. As a measure of significance of the correlation of a variable with growth, Sala-i-Martin calculates a likelihood-weighted sum of normal distributions. Fernandez et al. (2001) argue about the superiority of the BMA method over other techniques in selecting regressors to explain cross-country economic growth.

measures (Macroeconomic policy), and those that emphasize countries' specific characteristics (Regional heterogeneity). Fundamental theories emphasize natural capital (Natural capital), geographical (Geography), institutional (Institutions), and cultural (Religion, Fractionalization) determinants of growth. Table 1 below shows the classification of these theories, gives typical proxies that are used to capture the determinants of growth that are emphasized by each of these theories, and directs to some important references concerning each theory.[5]

To what extent these theories of growth are appropriate to capture the role of exposure to coastal risks though? In his seminal work, Smith (1776) has already highlighted the relationship between geographical location, international trade, and economic growth in coastal countries. More recently, economic historians have argued that the sea-based trade in the Mediterranean basin has significantly facilitated the fast growth in settlements in this region (Braudel, 1972; McNeill, 1974; Jones, 1981; Crosby, 1986). Also, the regions that are easily accessible by the sea are typically more urbanized and have lower transport costs (Gallup et al., 1999) while countries with longer coastlines are likely to have more ports, a higher percentage of the population leaving close to the sea, and a larger share of economic activity associated with international trade (Bloom and Sachs, 1998; Masters and Sachs, 2001; Masters and McMillan, 2001; Bloom et al., 2003).

Table 1. Growth theories, proxies for determinants of growth, and main references

Proximate theories	Proxies used and references
Neoclassical	Initial income, Population growth rates, Investment in physical capital, Investment in schooling (Solow, 1956)
Demography	Life expectancy, Fertility rate (Shastry and Weil, 2003; Weil, 2007)
Macroeconomic policy	Openness, Government expenditure, Inflation (Barro, 1997)
Regional heterogeneity	Latin America and Caribbean, Sub-Saharan Africa, East Asia and the Pacific, South-East Asia (Brock and Durlauf, 2001)
Fundamental theories	**Proxies and references**
Religion	Catholicism, Protestantism, Orthodoxy, Judaism, Islam, Buddhism, Hinduism, Eastern religion, Other religion (Barro and McCleary, 2003; Durlauf et al., 2012)
Natural capital	Natural capital, Natural capital per capita (Sachs and Warner, 1995; Gylfason, 2011)
Geography	Coastline, Landlocked (Sachs, 2003)

[5] Also qualified as "deep" sources of economic growth theories, fundamental theories pay special attention to variables that have a significant influence on a country's ability to accumulate production factors and knowledge (Acemoglu et al., 2005). In contrast with the growth determinants highlighted by proximate theories, those emphasized by fundamental theories tend to depend on slow-moving parameters (Durlauf et al., 2008b).

Fractionalization	Language, Ethnic group (Alesina et al., 2003; Easterly and Levine, 1997)
Institutions	Liberal democracy, Public sector corruption, Legal formalism, Governance, Executive constraints (Djankov et al., 2002; 2003)

Policy choices also depend upon geography. For instance, a coastal economy may have a higher elasticity of output with respect to trade taxes than a landlocked economy (Gallup et al., 1999) and coastal countries are generally prone to liberalize their economies earlier than landlocked countries. Moreover, there is evidence that natural capital exports in coastal countries, mainly non-renewable resources, often have a negative impact on economic growth (Sachs and Warner, 2001). Between 1981 and 2006, resource-scarce coastal countries in Africa have experienced an average growth rate of 4.1% whereas it was only 2.3% in resource-rich coastal countries (Ndulu et al., 2007).[6]

These streams of literature suggest that theories that emphasize demography, macroeconomic policy, geography, natural capital, and institutions as determinants of economic growth are appropriate for analyzing the economic development process of coastal countries. Yet, an open question is the extent to which these theories apply to countries particularly exposed to coastal risks, that is to say, does the precise topography of coastal countries play any significant role in growth? This is the question we address in this paper by analyzing two datasets covering the 1960-2009 period.[7] The first dataset contains information on a sample of 54 countries that are considered as particularly exposed to coastal risks while the second concerns 83 countries worldwide. Our very purpose in running such a comparative empirical experiment is to attempt to highlight the determinants of economic growth while emphasizing exposure to natural risks in coastal countries and the potential additional anthropogenic pressure that these risks impose on these countries' ecosystems.

[6] The causes of the negative relationship between resource dependence, in particular non-renewable, and economic growth has been largely debated although no universally accepted theory of the so-called "resource curse" has emerged. Many potential explanations have been suggested including the crowding-out of manufacturing activities, the political capture of rents, unsustainable government policies, poor investment in human resources, economic shocks, low institutional quality, armed conflicts, lack of effective property rights and high transaction costs, and volatility of world resource prices. See Frankel (2012) and Torres et al. (2013) for surveys of the literature that addresses this important issue.

[7] Since 2013, the United Nations Statistical Commission has endorsed the System of Environmental-Economic Accounting Experimental Ecosystem Accounting (SEEA EEA) that contains indicators of natural capital that integrate newly available information (UNSC, 2021). However, despite the fact that the data went over 2009, due to compatibility issues, we decided to not use this new information in this paper.

To account for uncertainty pertaining to the growth models and growth determinants proxies discussed above, we apply the BMA methodology. Moreover, to avoid misleading information about the long-term economic growth process conveyed by annually varying growth rates we work with 5-year averages of the data (Durlauf and Quah, 1999). We specify the following generic augmented Solow neoclassical regression that nests the eight new growth theories (Durlauf et al., 2005 and 2008a):[8]

$$\bar{g}_{i,t} = \gamma_0\, log\left(g_{i,t-5}\right) + \gamma_1\, log\left(s_{i,t}^{k}\right) + \gamma_2\, log\left(s_{i,t}^{h}\right) + \gamma_3\, log\left(\tau_{i,t} + \psi + \delta\right) + \beta' z_{i,t} + \mu_i + \nu_t + \varepsilon_{i,t} \qquad (1)$$

where the subscripts $i = 1,2,\cdots,N$ and $t = 1,2,\cdots,T$ indicate the country and the year respectively, $\bar{g}_{i,t}$ is the average growth rate of real Gross Domestic Product (GDP) per capita over the periods $t, t+1, t+2, \cdots, t+5$, $g_{i,t-5}$ is the real GDP per capita at the beginning of the 5-year period, and $s_{i,t}^{k}$, $s_{i,r}^{h}$, and $log\left(n_{i,t} + \psi + \delta\right)$ are neoclassical growth theory measures of the net accumulation of factors, more specifically, $s_{i,t}^{k}$ is the saving rate of physical capital accumulation that captures or the investment in physical capital, $s_{i,t}^{h}$ is the saving rate of human capital accumulation or the investment in schooling, $\tau_{i,t}$ is the population growth rate, ψ is the augmenting technical progress parameter, and δ is the physical capital depreciation rate, $z_{i,t}$ is a vector of independent variables that allows us to extend the standard neoclassical theory by incorporating growth determinants proxies associated with the growth theories (see Table 1), μ_i and ν_t are respectively country- and year-specific factors, γ_0, γ_1, γ_2, and γ_3 are unknown scalar parameters, β is an unknown vector parameter, and $\varepsilon_{i,t}$ is an error term.[9] The parameters γ_i, $i = 1,2,3$ satisfy:

$$\gamma_1 = e^{5\lambda}, \gamma_2 = \left(1 - e^{5\lambda}\right)\left(\frac{\alpha_k}{1-\alpha_k-\alpha_h}\right), \gamma_3 = \left(1 - e^{5\lambda}\right)\left(\frac{\alpha_h}{1-\alpha_k-\alpha_h}\right), \gamma_4 = -\left(1 - e^{5\lambda}\right)\left(\frac{\alpha_k+\alpha_h}{1-\alpha_k-\alpha_h}\right) \qquad (2)$$

[8] We should indicate that even though averaging enables us to deal more adequately with business cycle effects, the sample size and the presence of heteroscedasticity and serial correlation impose constraints on the time horizon over which this averaging is performed. Indeed, the longer the averaging time span, the smaller the number of degrees of freedom, and hence the less accurate the estimates and the less explanatory power the regressors have (Durlauf et al. 2008b).

[9] Following Mankiw et al. (1992), we assume that the rate of technical progress and the physical capital depreciation rate add up to 5%, i.e., $\psi + \delta = 0.05$.

where $\lambda < 0$ is the rate of growth convergence and $\alpha_k, \alpha_h > 0$ are the elasticities of output with respect to, respectively, physical capital and human capital in a Cobb-Douglas production function assumed to exhibit decreasing returns to scale, i.e., $\alpha_k + \alpha_h < 1$.

The growth determinants associated with the theories that we consider are proxied by several variables incorporated in the vector of independent variables $z_{i,t}$. Table 1 below describes these theories and proxies. A proxy is used to represent an unobserved metric, that is, in our case, a factor that identifies a given growth theory. For instance, life expectancy and fertility rate are very good candidate for proxying growth determinants in the framework of Demography growth theory. When several proxies are used to represent a given growth theory, it is possible to disentangle the effects of each proxy. Thus, for instance, while examining whether or not the Religion theory is relevant to explain economic growth, it is possible to investigate the relative impact of each of the religions on economic growth.

As indicated, the regressions include proxies for determinants of growth used in proximate and fundamental theories. We will say that a given growth theory is satisfactory if the coefficient of at least one variable that proxies a growth determinant within this theory is "significant."[10] By definition, proximate theory proxy variables can only have direct effects on growth whereas fundamental theory proxy variables can have direct and/or indirect effects. Consequently, to make sure that a direct effect on growth be uncovered, a regression should include both proximate and fundamental theories' proxy variables referred to as, respectively, "proximate variables" and "fundamental variables." Now, if the parameter estimates of proximate variables or fundamental variables happen to be significant, this would say that the corresponding theories are satisfactory to explain a direct effect on economic growth.

To uncover indirect impacts of fundamental theories' proxy variables on growth, the regressions should only include fundamental theories' proxy variables. When fundamental variables are significant while they were not when both proximate and fundamental variables are included, one concludes that the corresponding fundamental theories are satisfactory only

[10] The term significant is in quotes here because, strictly speaking, in the context of BMA, this means that the variable is "significantly related to growth," i.e., the value of its weighted cumulative distribution (see footnote 4) is sufficiently large, i.e., larger than 0.95 (see, Sala-i-Martin, 1997 and Sala-i-Martin et al., 2004). In the sequel of the paper, the term significant will be used alone.

to explain indirect effects on growth that passes through the proximate theories channel. Incidentally, we also examine correlations between proximate and fundamental variables for the purpose of obtaining some alternative evidence on the relationships between these two sets of explanatory theories.

We handle growth model and determinant proxy uncertainties as follows. Following Brock and Durlauf (2001) and Brock et al. (2003), let m designate an economic growth model in the model space M given available data D. Then, the posterior probability of this model is given by:

$$\mu(m|D) = \mu(D|m)\mu(m) \quad (3)$$

where $\mu(D|m)$ is the conditional likelihood of the model m, i.e., the probability that this model is the data generating process and $\mu(m)$ is the prior probability of the model m. In the empirical analysis, we set the prior probability that a particular theory is the true model to 0.5 so as not to discriminate across models (Durlauf et al. 2008a).[11] Given $\mu(m|D)$, we then estimate the probability, P_{ξ}, that a given theory, ξ, is the true model, as the aggregate posterior probability:

$$P_{\xi} = \sum_{m \in \mathrm{M}} \mu(m|D, m \in A) \quad (4)$$

where A is the event that "At least one proxy variable associated with the theory ξ is in the true model," i.e., empirically, the coefficient associated with this proxy variable is significant.

3. Data and preliminary examination

[11] At this point, we must indicate that this paper is part of a project that seeks to empirically analyze anthropogenic pressure on various environmental assets through the lens of economic growth. Both the fundamental data constructed for, and the econometric approach (BMA) used in, the various papers produced in the context of this project (Gasmi et al., 2020 and 2022) are features that are common to these papers. So are the *Matlab* software and its specifications that closely follow the empirical literature on growth of the recent two decades or so, including the contributions of Barro, Durlauf, and Sala-i-Martin and their coauthors, in particular, Durlauf (see, e.g., the model equiprobability prior assumption of 0.5 used in Durlauf et al., 2008a) who kindly shared with us some econometric programs. In other words, explaining the details of these technical specifications, which have been tested and are rather standard in this literature, would only add length to the paper. An exception is jointness analysis based on a recent contribution by Hofmacher et al. (2018) to check the degree of dependency between pairs of growth determinants that, given the advances that we already made in the project, we decided to leave for further research.

The dataset that we constructed consists in an unbalanced panel dataset on 54 countries subject to significant exposure to coastal risks (CR) and 83 worldwide (WW) countries during 10 five-year periods from 1960 to 2009. To proxy the vulnerability of coastal zones to climate change, we use an available index of coasts at risk exposure that is admittedly imperfect. This index describes the share of a country's population exposed to coastal hazards (Beck, 2014) and takes into account two types of natural hazards, namely, sudden onset hazards including storms, floods, storm surges and tsunamis, slow onset hazards, including sea level rise based on the exposed people to sea level rise by one meter.[12] As to the choice of the eight new growth theories and the associated proxy variables used for growth determinants we follow Durlauf et al. (2008a). The definition of the variables, the data sources, and some descriptive statistics are given in the appendix.

Compared to the countries included in the WW dataset, we see from Table A.5 in the appendix that the ones in the CR dataset tend to have a higher degree of openness to international trade, a greater percentage of protestants in the population, and more likely prevalence of an English legal code inherited from UK colonization. When we equally split the CR sample according to the median value of this exposure and create a sample of 27 countries above the median (upper-half) and a sample of 27 countries below the median value (lower-half), it turns out that the latter subsample shows no significant differences with the WW sample. In contrast, we note several differences between the upper-half CR subsample, i.e., the one that contains countries with even higher exposure to coastal risks and the WW countries. Table 2 below shows these differences.

Table 2. CR versus WW countries - Main differences in representative variables' median values

Theories & variables	Variable names	CR countries: Average	CR countries: Lower-half	CR countries: Upper-half	WW countries
Demography					
Fertility rate	$fert$	1.38	1.31	1.44	1.32
Macroeconomic policy					
Openness	$open$	0.71	0.53	0.88	0.51
Government consumption	gov	0.09	0.07	0.15	0.08
Religion					

[12] There is insufficient data on the vulnerability of coastal zones to storm surges and sea-level rise at the global scale (Füssel, 2010). Moreover, there are divergences when seeking to identify the most vulnerable countries based on data on the population below one meter above sea level (Buys et al., 2009; Dasgupta et al., 2009) and on the percentage change in population annually flooded (Hinkel, 2008; Klein and Hinkel, 2009). While acknowledging these data limitations, knowledge of adaptation costs and benefits associated with coastal protection at the global scale has made significant progress (Agrawala and Fankhauser, 2008).

Protestantism	*protestantism*	0.01	0.00	0.11	0.00
Other	*other*	0.04	0.06	0.09	0.23
Fractionalization					
Ethnic group	*eth*	0.32	0.42	0.23	0.42
Institutions					
Public sector corruption	*corr*	0.42	0.46	0.29	0.40
Others (controls)					
English legal origin	*english*	1.00	0.00	1.00	0.00
System	*sys*	1.12	0.34	2.00	0.55

We see from Table 2 that, compared to the WW countries, the countries in the upper-half of the CR dataset are characterized by a higher degree of openness (about 30% higher), fewer ethnic fractionalization (about 50% less), less public sector corruption, higher fertility rates, a higher percentage of protestants, an English legal origin, and a parliamentary system rather than a presidential or an assembly-elected president. In fact, concerning this last point, there is a broad empirical evidence that former British colonies are characterized by better political and economic institutions than former French, Portuguese, and Spanish colonies (Landes, 1998; La Porta et al., 1998, 1999). According to Acemoglu et al. (2002), these results showing a positive impact of British colonies on growth were mainly due to the fact that Britain colonized areas where settlements were possible, that is, where the settlers' mortality rates and the expropriation risks were low.

In this preliminary analysis we also checked some other properties of the data. We found that heteroskedasticity and serial correlation needed to be taken into account in the analysis. As to the correlations (see Table A.6 and A.7), they conveyed some useful information on the explanatory power of fundamental theories in the economic growth regression. More specifically, we found that some of the fundamental theories, namely, religion, natural capital, fractionalization, and institutions, may exert an influence on economic growth through proximate theories. These preliminary results hold both for the CR and WW samples.

4. BMA Results

Tables A.8 and A.9 in the appendix present the results obtained by applying the BMA estimation methodology to Equation (1), incorporating the augmented Solow growth model and the eight new growth theories, to respectively the CR and WW datasets. These tables show in their columns 1 through 3 BMA results for the case where both proximate and fundamental theories are included in the set of theories and in their columns 4 through 6 the case where only fundamental theories are included. Also, for both the proximate and fundamental theories, these tables in their columns 1 and 4 the posterior probability that each theory is the true model/data generating process according to the BMA method. Table 3 below extracts some results that we discuss next.[13] The results on the upper-half and the lower-half of the CR dataset are presented in Table 4 below. We discuss in turn the results that differ for CR and WW countries, those that are common, and finally those related to the upper-half and lower-half of the CR dataset.

4.1. CR versus WW countries: Differing results

Tables A.8 and A.9 in the appendix show that, compared to the WW countries', the CR countries' analysis validates two additional new growth theories, namely, the macroeconomic policy and natural capital models. Indeed, as is reported in Table 3 below, for each of these two theories, the posterior inclusion probability is close to one both for the estimations with proximate and fundamental theories and for the estimations with fundamental theories alone. These results are consistent with the literature. The results on macroeconomic policy may be grounded on the role of international trade in coastal countries (Gallup et al., 1999) and economic institutions in former British colonies (Acemoglu et al., 2002) which are present in the CR sample (28 out of 54 countries).

As to the natural capital theory, the results are in line with the empirical literature that provides evidence of a robust natural resources-economic growth relationship (Ding and Field, 2005; Cerny and Filer, 2007; Gylfason, 2011).[14] As suggested by Gylfason (2011), we used natural capital in wealth and per capita (World Bank, 2006) to proxy respectively natural capital dependence and natural capital abundance. The literature has shown that too strong dependence on natural resource extraction is typically correlated with low economic growth while high ecological abundance in per capita terms contributes positively to wealth

[13] Following Bartlett et al. (2001), we made sure that the ratio of the number of observations to that of the independent variables does not fall below five. Moreover, as in Durlauf et al. (2005), the variables that have weak explanatory power in the regressions are excluded from the BMA regressions. Those are the religion variables Buddhism, Catholicism, Judaism, and Orthodoxy. We also checked for multicollinearity and this led us to exclude from the BMA regressions the regional heterogeneity variables East Asia and the Pacific the institutional variables Liberal democracy, Public sector corruption, Legal formalism: Check (1), Legal formalism: Check (2), and Complexity.

[14] The natural capital variable is composed of renewable (timber, non-timber forest resources, protected areas, cropland and pastureland) and non-renewable (oil, natural gas, hard coal, soft coal and minerals) resources.

(Gylfason, 2011). We find (see Table A.8) evidence that natural capital dependence plays a negative role in growth in countries with a significant exposure to coastal risks.

Otherwise, with respect to the neoclassical theory, investment in physical capital appears to be a robust determinant of economic growth in countries exposed to coastal risks, while it is not relevant in the worldwide sample of countries. In particular, there is evidence that the impact of investment in physical capital has a positive and significant impact on economic growth in countries exposed to coastal risks, which is consistent with previous findings in the empirical literature (Barro, 1991, 1996, and 1997; Barro and Lee, 1994; Sachs and Warner, 1995; Caselli et al., 1996).

4.2. CR versus WW countries: Common results

The demography, religion, fractionalization, institutions, and neoclassical (initial income) growth theories were found to be relevant through some indirect or direct impact of representative proxies on economic growth when using both the CR and WW samples of countries.[15] With regards to demographic variables, higher fertility rates appear to be significantly detrimental to economic growth as in Barro (1991, 1996, and 1997) and Barro and Lee (1994). The variables that proxy the religion theory matter for economic growth since the posterior probability of inclusion is higher than the prior of 0.5 when accounting for proximate and fundamental theories (close to 1) and again these results are consistent with the empirical literature (Barro and McCleary, 2003). More specifically, we see from Tables A.8 and A.9 that the eastern religion has a positive and significant impact on economic growth.

When using the CR sample, we see from Table A.8 in the appendix that religion matters for economic growth only when fundamental growth theories are considered (see also Table 3 below). This says that the impact of religion is indirectly exerted through proximate theories proxies, a result that is consistent with the findings of the preliminary analysis performed in the previous section. When the demographic variables are included only in the fundamentals theories, the religion variables that were found to be robust determinants as shown in column 3 of Table 3 become non-robust as the posterior inclusion probability becomes equal to

[15] Regional heterogeneity and geography theories were not found to be robust to explain growth in both CR and WW countries.

0,3611.[16] This is consistent with the fact that religion is significantly correlated with neoclassical, demography, and regional heterogeneity variables in the CR sample as can be seen from Table A.6 in the appendix. As in Durlauf et al. (2008a), these results indicate that previous findings on the direct importance of religion for economic growth are fragile.

Concerning the fractionalization theory, our results are also consistent with previous findings in the empirical literature that fractionalization is a significant determinant of economic growth (Easterly and Levine, 1997; Alesina et al., 2003). The variables that identify the language and ethnic groups are both negative and significant as can be seen from Tables A.8 and A.9.[17] As reported in Table 3, when using the WW sample, fractionalization matters for economic growth only when fundamental growth theories are considered (see Table A.10). The impact of fractionalization is thus exerted indirectly through proximate theories which is consistent with the preliminary analysis. In fact, if the demography variables are included in the set of models only with fundamental theories, the fractionalization variables that were found to be robust determinants (see Table 3) become no longer relevant with a posterior probability that drops to 0.06.[18] This is consistent with the fact fractionalization is significantly correlated with neoclassical (population growth rates), demography (fertility rate), and regional heterogeneity (Sub-Saharan Africa) variables (see Table A.8). Again, these results indicate that previous findings on the importance of fractionalization for economic growth worldwide are fragile.

The results point to a role of institutions on economic growth in line with the findings of the empirical literature (Acemoglu et al., 2002). We find a negative impact of institutions on economic growth, both directly and indirectly when considering only fundamental theories (see Tables A.8, A.9, and 3). A possible interpretation of these findings is that weaker checks and balances may enhance economic growth by enabling policy decisions (Barro, 1994). Another reason could be that our measure of institutional quality is positively correlated with political instability, a variable for which there is significant evidence in the empirical

[16] Results available from the authors upon request.
[17] This suggests that more language and ethnic diversity may lead to more conflict and less communication.
[18] Results available from the authors upon request.

literature of a negative relationship with economic growth (Barro, 1991; Barro and Lee, 1994; Sachs and Warner, 1995; Alesina et al., 1996; Caselli et al., 1996).[19]

The results related to the neoclassical theory obtained with the CR sample coincide with those obtained with the WW sample except for the physical investment variable. The findings are overall consistent with those in the conditional convergence literature as well as previous studies that have used BMA methods. We see from Tables A.8 and A.9 that there is robust evidence of conditional convergence with a negative and significant coefficient on initial income as found in many previous studies (Barro, 1991; Sachs and Warner, 1995; Barro, 1997; Easterly and Levine, 1997).

The variables schooling and population growth turn out not to be significant using both CR and WW samples. The results for schooling are largely consistent with the findings of the empirical literature (Durlauf et al., 2008a). Moreover, in exercises where the demography theory is excluded from the set of possible models, population growth has a negative and significant impact on economic growth when using the CR sample and has a negative but not significant impact when using the WW sample.[20] In fact, there exists empirical evidence on this negative relationship between population growth and economic growth (Mankiw et al., 1992; Kelley and Schmidt, 1995; Bloom and Sachs, 1998).

Table 3. BMA posterior inclusion probabilities of new growth theories - CR vs. WW countries[+]

	Proximate and fundamental theories		Fundamental theories	
Theories	CR countries	WW countries	CR countries	WW countries
Demography	**1.000**	**1.000**		
Macroeconomic policy	**1.000**	0.028		
Regional heterogeneity	0.320	0.085		
Religion	0.062	**0.981**	**1.000**	**1.000**
Natural capital	**0.964**	0.250	**1.000**	0.227
Geography	0.048	0.056	0.053	0.035
Fractionalization	**1.000**	0.056	**0.999**	**0.964**
Institutions	**1.000**	**1.000**	**1.000**	**1.000**

[+] The posterior inclusion probability of a theory is market in bold to indicate that such a theory is relatively robust in explaining economic growth. Robustness increases with this probability.

4.3. Upper-half versus lower-half CC countries

[19] The executive constraints variable we use reflects the outcomes of the most recent elections (Glaeser et al., 2004). Cox and Weingast (2017) find that the quality of legislature measured by the executive's horizontal accountability is more important than the existence of free and fair elections for economic growth.

[20] Results available upon request.

When splitting the CR sample in two, we see from Table 4 below that the natural capital and institutions theories are robust determinants of economic growth only when the upper-half of the dataset is used. Indeed, for these two new growth theories, the posterior inclusion probability is equal to one both for the estimations with proximate and fundamental theories and those with the fundamental theories alone. In addition, regional heterogeneity is also a robust determinant of economic growth only in the upper-half of the CR dataset with a posterior probability of inclusion equal to 0.771. In contrast, the fractionalization theory is found to have a significant explanatory power of economic growth only when using the lower-half of the dataset.

Table 4. BMA posterior inclusion probabilities of new growth theories - CR countries[+]

	Proximate and fundamental theories		Fundamental theories	
Theories	Lower-half	Upper-half	Lower-half	Upper-half
Demography	**0.998**	**1.000**		
Macroeconomic policy	**1.000**	**1.000**		
Regional heterogeneity	0.111	**0.771**		
Religion	0.636	0.341	**1.000**	**0.923**
Natural capital	0.220	**1.000**	0.139	**1.000**
Geography	0.085	0.176	0.167	0.319
Fractionalization	**0.998**	0.427	**1.000**	0.228
Institutions	0.364	**1.000**	0.056	**1.000**

[+] The posterior inclusion probability of a theory is market in bold to indicate that such a theory is relatively robust in explaining economic growth. Robustness increases with this probability.

These findings are consistent with the fact that, as mentioned, the upper-half of the CR dataset is composed of countries that are characterized by a high degree of economic openness (about 30% higher), less public sector corruption, a parliamentary system rather than a system with an elected president and assembly, and fewer ethnic fractionalization (about 50% less). Finally, as in the full CR dataset, the demography, macroeconomic policy, religion, and neoclassical (initial income) theories' proxy variables have a (direct or indirect) impact on economic growth both in the upper-half and in the lower-half of the dataset. The geography theory is not found to be robust to explain growth independently of the sub-sample used for the estimation.

5. Conclusion

This paper has sought to contribute to the literature on the determinants of economic growth by focusing on countries exposed to coastal risks and highlighting the impact of anthropogenic pressure on their coastal ecosystems. Using a Bayesian Model Averaging methodology to evaluate the performance of the regressions associated with a set of growth theories, we find evidence that investment in physical capital, macroeconomic policy, natural capital, and institutional factors are significant determinants of economic growth in these countries. In contrast to worldwide countries, in countries significantly exposed to coastal risks, factors that relate to language and ethnic fractionalization of society turn out not to be relevant to explain economic growth.

These results are consistent with the empirical evidence on the determinants of economic growth in coastal countries that are former British colonies. Indeed, compared to the average country worldwide, coastal countries that are significantly exposed to coastal risks have typically a great degree of international trade openness and are of an English legal origin. On the one hand, there is broad evidence in the literature on the role of trade and natural capital on economic growth in coastal countries (Ndulu et al., 2007; Gallup et al., 1999). On the other hand, former British colonies are considered as having better political and economic institutions than French, Portuguese, and Spanish colonies basically because Britain colonized regions where settlements were possible, that is, where the settler mortality rates and the expropriation risks were low (Landes, 1998; La Porta et al., 1998, 1999; Acemoglu et al., 2002).

Our findings on the negative impact of the natural capital weight in the economy on growth are also largely consistent with the empirical evidence (Gylfason, 2011). In particular, a strong dependence on the export of non-renewable natural resources is found to hinder economic growth (van der Ploeg, 2010; Ross, 2015). These findings also highlight the potential additional anthropogenic pressures that coastal areas that are significantly exposed to coastal risks can be subject to such as land conversion for agriculture or aquaculture, farming and other run-offs, coastal construction, and public works that natural capital exports call for.

Our results also show the importance for growth of high fertility rates associated with countries significantly exposed to coastal risks and this is particularly worrisome as they suggest that the degradation of coastal ecosystems should accelerate (Bond Estes et al., 2012). The role of demography is particularly relevant since many of the world's coasts are becoming increasingly urbanized and populated, which typically damages coastal ecosystems (Cinner et al., 2009a). High fertility rates increase anthropogenic pressures on coastal ecosystems through direct overexploitation impacts such as the "Malthusian overfishing" and indirect impacts such as uncontrolled sewage or farming runoffs (McClanahan et al., 2008). In countries significantly exposed to coastal risks, i.e., those included in the upper-half of the CR sample, there is a strong dependence on natural capital and high fertility rates and coastal ecosystems can be wasted to obtain some short-term gains rather than used in a more sustainable way to achieve long-term benefits (Larrère and Larrère, 1997).

While, in terms of policy, short-term gains are often preferred to ecosystem services management the reverse is true when institutions are of good quality. This is the case in countries with a significant exposure to coastal risks that typically have low levels of public corruption and parliamentary systems that contrast with more authoritarian regimes (MEA, 2005). There is evidence that stable and legitimate institutions have enabled countries to improve the state of coral ecosystems, especially through well-respected fishing regulation and Marine Protected Areas (McClanahan et al., 2007; Babcock et al., 2010). Also, it has been argued that management of coastal ecosystems by means of authoritarian top-down norms is less efficient than bottom-up measures and community-based co-management, especially in poor countries (Cinner et al., 2009b; Cinner et al., 2012; Sundström, 2012).

Countries with a significant exposure to coastal risks are also characterized by less language and ethnic fractionalization, which can play a positive role with regards to coastal ecosystems. An extensive stream of literature has examined the relationship between ethnic diversity and environmental conservation (Serra Maggi, 2013). Lower ethnic fractionalization may result in better environmental performance since it can lead to greater cohesion and better communication (Das and DiRienzo, 2010). In fact, the negative interactions between the ethnic and religious identities and the access to resources characterize to a great extent politics in Africa (Cilliers, 2009). Also, the interests of local communities and the oversight of the socially and culturally different local structures has often resulted in the failure of marine conservation projects (Serra Maggi, 2013).

Our empirical findings and the above observations highlight the important role that central governments of countries that are significantly exposed to coastal risks may play in providing local policy makers and communities with incentives to protect their coastal ecosystems (Naumann et al., 2011). These countries have already much to do with protecting their coastal cities against storms and flooding caused by changing climate conditions (Nicholls et al., 2008; Hallegatte et al., 2013). Their strong dependence on natural capital and high fertility rates to grow economically may exacerbate the degradation of these coastal ecosystems. Nevertheless, their good institutions and low levels of ethnic fractionalization should be conducive to a sustainable management of these ecosystems.

Appendix

Data description, sources, and descriptive statistics

The data set constructed for this study contains observations from 1960 to 2009 on a sample of 54 countries considered as particularly exposed to coastal risks, referred to as CR countries, and another of 83 worldwide countries, referred to as WW countries, for which there is sufficient data on the growth determinants proxy variables listed in Table 1 given in the main text. Tables A.1 and A.2 below lists respectively the upper-half and lower-half of the sample of 54 CR countries according their coastal risk (probability) in a decreasing order.

Table A.1 CR countries - Upper-half of the sample*

Country	Coastal risk exposure
Saint Kitts and Nevis	0.5955
Antigua and Barbuda	0.5893
Tonga	0.5108
Brunei Darussalam	0.2818
Fiji	0.2568
Vanuatu	0.2392
Philippines	0.2095
Japan	0.2080
Netherlands	0.2036
Bangladesh	0.1878
Seychelles	0.1776
Bahamas	0.1717
Belize	0.1685
Kiribati	0.1558
Mauritius	0.1548
Vietnam	0.1445
Samoa	0.1409
Guyana	0.1352
Cambodia	0.1333
Suriname	0.1146
Jamaica	0.1135
Djibouti	0.0869
Grenada	0.0832
Saint Vincent and the Grenadines	0.0820
Solomon Islands	0.0799
Saint Lucia	0.0768
Cuba	0.0739

* Data constructed by authors based on Beck (2014). These countries are considered as being exposed to significant coastal risks.

Table A.2 CR countries - Lower-half of the sample*

Country	Coastal risk exposure
Barbados	0.0704
Australia	0.0676
Cape Verde	0.0629
Bahrain	0.0604
Dominican Republic	0.0585
Madagascar	0.0558
Cameroon	0.0541
Ireland	0.0523
Republic of Korea	0.0522
Indonesia	0.0520
New Zealand	0.0484
Haiti	0.0478
Chile	0.0452
Malaysia	0.0422
Sri Lanka	0.0413
Peru	0.0399
Gabon	0.0393
Myanmar**	0.0393
Ecuador	0.0342
Maldives	0.0323
Denmark	0.0298
Canada	0.0271
Egypt	0.0258
United States	0.0240
Singapore	0.0239
Congo	0.0233
United Kingdom	0.0233

* Data constructed by authors based on Beck (2014). These countries are considered as being exposed to moderate coastal risks.
** Country excluded from the analysis due to lack of sufficient data.

The sample of 83 WW countries includes:

- 20 countries from Latin America and the Caribbean region: Argentina, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Peru, Trinidad and Tobago, Uruguay, and Venezuela.
- 10 countries from Middle East and North Africa: Bahrain, Brunei, Egypt, Iran, Israel, Jordan, Kuwait, Saudi Arabia, Tunisia, and United Arab Emirates.
- 15 countries from Sub-Saharan Africa: Cameroun, Congo, Gabon, Ghana, Kenya, Malawi, Mauritius, Mozambique, Senegal, Sierra Leone, South Africa, Sudan, Uganda, Zambia, and Zimbabwe.
- 13 countries from East Asia and Pacific: Australia, China, Fiji, Indonesia, Japan, Malaysia, New Zealand, Papua New Guinea, Philippines, Republic of Korea, Singapore, Thailand, and Tonga.
- 5 countries from South Asia: Bangladesh, India, Maldives, Pakistan, and Sri Lanka.
- 2 countries from North America: Canada and United States and 18 countries from Europe and Central Asia: Austria, Belgium, Canada, Denmark, Finland, France, Greece, Hungary, Italy, Ireland, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, and United Kingdom.

As to the proxies for the determinants of growth, we collected data on variables regrouped in ten categories corresponding to nine theories and controls, namely, Neoclassical, Demography, Macroeconomic policy, Regional heterogeneity, Religion, Natural capital, Geography, Fractionalization, Institutions, and Others (controls). The definition, the content of these variables, and the source(s) of raw data are given in Table A.3 below. Tables A.4 through A.9 present some summary statistics and the results that are discussed in the text.

Table A.3 Variables, contents, and sources

Theories & variables	Contents and sources
Neoclassical	
Growth of GDP per capita	Average growth rates of Gross National Product per capita (in 2005 USD) for the 10 five-year time segments 1960-1964, 1965-1969, 1970-1974, 1975-1979, 1980-1984, 1985-1989, 1990-1994, 1995-1999, 2000-2004, and 2005-2009. Source: Penn World Table 7.1.
Initial income	Natural logarithm of GDP per capita (in 2005 USD) in the beginning of each of the above 10 five-year time segments, i.e., in 1960, 1965, 1970, 1975, 1980, 1985, 1990, 1995, 2000, and 2005. Instruments used to account for endogeneity of initial income its fifth lag, i.e., its values in 1955, 1960, 1965, 1970, 1975, 1980, 1985, 1990, 1995, and 2000. Source: Idem.
Population growth rate	Natural logarithm of average population growth rates plus 0.05 for each of the above 10 five-year time segments. Instruments used for population growth rates for each of the above 10 five-period time segments are their average values over the time segments 1955-1959, 1960-1964, 1965-1969, 1970-1974, 1975-1979, 1980-1984, 1985-1989, 1990-1995, and 2000-2004. Source: Idem.
Investment in physical capital	Natural logarithm of average ratios of investment in physical capital to GDP for each of the above 10 five-year time segments. Instruments used for investment are their average values over the time segments 1955-1959, 1960-1964, 1965-1969, 1970-1974, 1975-1979, 1980-1984, 1985-1989, 1990-1994, 1995-1999, and 2000-2004. Source: Idem.
Schooling	Natural logarithm of the ratio of male population enrolled in secondary school to total population in years 1960, 1965, 1970, 1975, 1980, 1985, 1990, 1995, 2000, and 2005. Source: Barro and Lee (2014).
Demography	
Life Expectancy	Reciprocal of life expectancy at age 1 in years 1960, 1965, 1970, 1975, 1980, 1985, 1990, 1995, 2000, and 2005. Source: The World Bank.
Fertility rate	The natural logarithm of the total fertility rate for each of the above 10 years. Source: Idem.
Macroeconomic policy	
Openness	Average ratio of exports plus imports to GDP for each of the above 10 five-year time segments. Instruments are average values over the time segments 1955-1959, 1960-1964, 1965-1969, 1970-1974, 1975-1979, 1980-1984, 1985-1989, 1990-1994, 1995-1999, and 2000-2004. Source: Pen World Table 7.1.
Government consumption	Average ratio of government consumption to GDP for each of the above 10 five-year time segments. Source: Idem.
Inflation	Consumer price inflation rate calculated as average for the 5 ten-year time segments 1960-1969, 1970-1979, 1980-1989, 1990-1999, and 2000-2009. Source: The World Bank.
Regional heterogeneity	
Latin America and Caribbean	Dummy variable. Source: The World Bank.
Sub-Saharan Africa	Idem.
South- & East- Asia	Idem.
Religion	
Catholicism	Catholicism share in 1970 expressed as a fraction of the population that expressed adherence to some religion. Instruments include the Catholicism share in 1900 expressed as a fraction of the population who expressed adherence to some religion. Source: Barrett et al. (2001).
Protestantism	Idem, but for Protestantism. Source: Idem.
Judaism	Idem, but for Judaism. Source: Idem.
Orthodoxy	Idem, but for Orthodoxy. Source: Idem.
Islam	Idem, but for Islam. Source: Idem.
Buddhism	Idem, but for Buddhism. Source: Idem.
Hinduism	Idem, but for Hinduism. Source: Idem.
Eastern religion	Idem, but for Eastern religion other than Buddhism and Hinduism. Source: Idem.
Other religion	Idem, but for some religion other than Catholicism, Protestantism, Judaism, Orthodoxy, Islam, Buddhism, Hinduism, and Eastern religion. Source: Idem.
Natural capital	
Natural capital in wealth	Time-invariant variable measuring the weight of natural capital in total wealth in 2000.

	Source: World Bank (2006).
Natural capital per capita	Time-invariant variable measuring natural capital per capita in 2000. The variable is scaled to take values between 0 and 1. Source: Idem.
<u>Geography</u>	
Coastline	Coastline length in km scaled to take values between 0 and 1. Source: UNEP (2015).
Landlocked	Binary variable equal to 1 if the country is landlocked and to 0 otherwise. Source: CIA (2009).
<u>Fractionalization</u>	
Language group	Time-invariant measure of linguistic fractionalization that reflects the probability that two randomly selected individuals from a population belong to different language groups. The measure takes values between 0 to 1. Source: Alesina et al. (2003).
Ethnic group	Idem, but with ethnic instead of language groups. The measure takes values between 0 and 1. Source: Idem.
<u>Institutions</u>	
Liberal democracy	Time variant-index that emphasizes the importance of protecting individual and minority rights against the tyranny of the state and the tyranny of the majority. This is achieved by constitutionally protected civil liberties, strong rule of law, an independent judiciary system, and effective checks and balances that, together, limit the exercise of executive power. To make this a measure of liberal democracy, the index also takes the level of electoral democracy into account. This variable is calculated as the average of the aggregate index for each of the time segments 1960-1965, 1965-1970, 1970-1980, 1980-1985, 1985-1990, 1990-1995, 1995-2000, 2000-2005, and 2005-2009. It values range from 0 to 1 with higher scores meaning a more liberal democracy. Source: The QOG Standard Dataset.
Public sector corruption	Time-variant index that measures the extent to which public sector employees grant favors in exchange for bribes, kickbacks, or other material inducements, and how often they steal, embezzle, or misappropriate public funds or other state resources for personal or family use. This variable is calculated in the same manner as the Liberal democracy variable and its values range from 0 to 1 with higher scores meaning more corruption. Source: Idem.
Legal formalism: Check (1)	Time-invariant index including professionals vs. laymen, written vs. oral elements, legal justification, statutory regulation of evidence, control of superior review, and engagement formalities indices, and the normalized number of independent procedural actions for the case of collection of a check. The values of this index range from 0 to 7 where higher values meaning a higher level of control or intervention in the judicial process. Source: Djankov et al. (2003).
Legal formalism: Check (2)	Time-invariant index of formality in the number of legal procedures for collecting on a bounced check. This index is rescaled to lie between 0 and 1 for 2003. Lower values mean less legal formality. Source: Doing Business-The World Bank.
Complexity	Time-invariant index of complexity in collecting a commercial debt valued at 50% of annual GDP per capita. This index is rescaled to lie between 0 and 1 for 2003. Lower scores imply less complexity. Source: Idem.
KKZ96	Time-invariant composite governance index calculated as the average of six indices that capture voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption in 1996. Its values range from -2 to 2 and higher values imply better governance. Source: Kaufmann et al. (2005).
Executive constraints	Time-varying index variable that measures the extent of institutionalized constraints on the decision-making power of chief executives. This variable is calculated as the average for the time-segments 1960-1965, 1965-1970, 1970-1980, 1980-1985, 1985-1990, 1990-1995, 1995-2000, 2000-2005, and 2005-2009. Its values range from 0 to 7 and higher values mean greater institutionalized constraints on the power of chief executives. Source: Polity IV Project, 1946-2013.
<u>Others (controls)</u>	
Time dummy variables	Dummy variables for period segments 1960-1965, 1965-1970, 1970-1980, 1980-1985, 1985-1990, 1990-1995, 1995-2000, 2000-2005, and 2005-2009. Source: Authors.
Colonial (Spain or Portugal)	Binary dummy variable equal to 1 if a country was colonized by Spain or Portugal and 0 otherwise. Source: Barro and Lee (1994).
English legal origin	Binary dummy variable where a value of 1 indicates that a country was colonized by the UK and English legal code was transferred. Source: Easterly (2001).
French legal origin	Binary dummy variable where a value of 1 indicates that a country was colonized by France, Spain, Belgium, Portugal, or Germany and French legal code was transferred. Source: La Porta et al. (1999), Djankov et al. (2003).
Latitude	The absolute value of the latitude of a country's capital scaled to take values between 0 and 1. Source: Djankov et al. (2003).
Stock of minerals	Time-invariant variable equal to the logarithm of fuel and 35 other non-fossil fuel stocks estimated for 1970 at market prices in USD per capita. Source: Moral-Benito (2012), Norman (2009), van der Ploeg and Poelhekke (2010).
System	Time-invariant variable that takes the value of 0 if the country has a presidential system, 1 if it has an assembly-elected president, and 2 if it has a parliamentary system. The mean value is between 1975 and 2010. Source: Beck et al. (2001).

Table A.4 Summary statistics for CR countries*

Theories & variables	Variable names	Obs	Median	Mean	Std dev	Min	Max
Neoclassical							
Growth of GDP per capita	gdp	498	0.02	0,02	0,03	-0,08	0,13
Initial income	inc	498	8.56	8,60	1,14	6,28	11,37
Population growth rate	pop	540	-2.77	-2,76	0,15	-3,15	-2,19
Investment	inv	498	3.11	3,04	0,55	0,69	4,39
Schooling	sch	390	3.53	3,39	1,13	6,28	11,37
Demography							
Life expectancy	$life$	521	0.01	0,01	0,00	0,01	0,04
Fertility rate	$fert$	521	1.38	1,31	0,47	0,07	2,03
Macroeconomic policy							
Openness	$open$	498	0.71	0,77	0,49	0,04	4,20
Government consumption	gov	519	0.09	0,12	0,09	0,00	0,65
Inflation	$infl$	408	0.05	0,20	1,12	-0,01	16,67
Regional heterogeneity							
Latin America and the Caribbean	lac	540	0.00	0,33	0,47	0,00	1,00
Sub-Saharan Africa	ssa	540	0.00	0,14	0,35	0,00	1,00
South-East Asia	sea	540	0.00	0,05	0,22	0,00	1,00
Religion							
Buddhism	$buddhism$	540	0.00	0,05	0,17	0,00	0,87
Catholicism	$catholicism$	540	0.19	0,31	0,32	0,00	0,97
Eastern religion	$eastern$	540	0.00	0,03	0,08	0,00	0,45
Hinduism	$hinduism$	540	0.00	0,03	0,09	0,00	0,45
Judaism	$judaism$	540	0.00	0,00	0,00	0,00	0,03
Islam	$islam$	540	0.00	0,13	0,27	0,00	0,99
Orthodoxy	$orthodox$	540	0.00	0,00	0,02	0,00	0,14
Other religion	$other$	540	0.01	0,03	0,08	-0,16	0,49
Protestantism	$protestantism$	540	0.13	0,23	0,25	0,00	0,90
Natural capital							
Natural capital in wealth	nat_w	420	0.14	0,27	0,40	0,00	2,21
Natural capital per capita	nat_pc	420	0.06	0,10	0,14	0,00	0,78
Geography							
Coastline	$coast$	530	0.00	0,06	0,16	0,00	1,00
Fractionalization							
Language group	$lang$	480	0.24	0,30	0,25	0,00	0,88
Ethnic group	eth	530	0.32	0,36	0,25	0,00	0,87
Institutions							
Liberal democracy	$demo$	376	0.37	0,42	0,30	0,02	0,95
Public sector corruption	$corr$	376	0.42	0,42	0,31	0,00	0,95
Legal formalism: Check (1)	$check(1)$	220	0.33	0,37	0,17	0,09	0,76
Legal formalism: Check (2)	$check(2)$	280	3.01	3,15	1,04	1,41	5,60
Complexity	$comp$	280	0.49	0,53	0,15	0,29	0,82
KKZ96	$kkz96$	540	0.08	0,23	0,84	-1,35	1,92
Executive constraints	exe	365	5.00	4,64	2,23	0,75	7,00
Others (controls)							
Time dummy variables	$period$						
Colonial (Spain or Portugal)	$colo$	420	0.00	0,11	0,32	0,00	1,00
English legal origin	$engl$	530	1.00	0,52	0,49	0,00	1,00
French legal origin	fr	420	0.00	0,14	0,35	0,00	1,00
Latitude	lat	540	0.17	0,21	0,16	0,01	0,66
Stock of minerals	min	380	-6.15	-6,28	3,18	-14,51	-1,35
System	sys	480	1.12	1,10	0,86	0,00	2,00

* A set of preliminary tests have been performed on the raw data. First, we did a Fisher unit-root test and found that the dependent variable (see equation (1)) is stationary in levels. Second, we checked whether or not data could be pooled by testing the random and fixed-effects panel data model against a pooled Ordinary Least Square (OLS) model through goodness-of-fit criteria. The panel data framework was preferred to pooled data suggesting that the parameters of the equation are time-variant over the ten periods of available data. Third, we found evidence that there exists heteroskedasticity across panels through the Erlat Lagrange Multiplier (LM)-test as well as serial correlation through the Baltagi LM-test. OLS and fixed-effects methods adjust standard errors for intragroup correlation, which should therefore be robust to heteroskedasticity and serial correlation. The General Method of Moments (GMM) also allows us to control for heteroskedasticity and we test for the presence of serial correlation of order one and two. To apply Two-Stage Least Square (2SLS) for the economic growth regressions, we use Driscoll and Kraay (1998)'s approach that guarantees that the covariance matrix estimator is consistent, independently of the cross-sectional dimension, in contrast to the Parks (1967) - Kmenta (1986) and the Panel-Corrected Standard Errors (PCSE) approaches, which typically become inappropriate when the cross-sectional dimension of a panel gets large (Driscoll and Kraay, 1998).

Table A.5 Summary statistics - Median values of CR versus WW countries

Theories & variables	Variable names	Average	CR countries Lower-half	CR countries Upper-half	WW countries
Neoclassical					
Growth of GDP per capita	gdp	0.02	0.02	0.02	0.02
Initial income	inc	8.56	8.55	8.58	8.61
Population growth rate	pop	-2.77	-2.74	-2.80	-2.73
Investment	inv	3.11	3.11	3.11	3.11
Schooling	sch	3.53	3.52	3.54	3.40
Demography					
Life expectancy	$life$	0.01	0.01	0.01	0.01
Fertility rate	$fert$	1.38	1.31	1.44	1.32
Macroeconomic policy					
Openness	$open$	0.71	0.53	0.88	0.51
Government consumption	gov	0.09	0.07	0.15	0.08
Inflation	$infl$	0.05	0.05	0.05	0.06
Regional heterogeneity					
Latin America and the Caribbean	lac	0.00	0.00	0.00	0.00
Sub-Saharan Africa	ssa	0.00	0.00	0.00	0.00
South-East Asia	sea	0.00	0.00	0.00	0.00
Religion					
Buddhism	$buddhism$	0.00	0.00	0.00	0.00
Catholicism	$catholicism$	0.19	0.22	0.17	0.17
Eastern religion	$eastern$	0.00	0.00	0.00	0.00
Hinduism	$hinduism$	0.00	0.00	0.00	0.00
Judaism	$judaism$	0.00	0.00	0.00	0.00
Islam	$islam$	0.00	0.01	0.00	0.01
Orthodoxy	$orthodox$	0.00	0.00	0.00	0.00
Other religion	$other$	0.01	0.00	0.11	0.00
Protestantism	$protestantism$	0.13	0.05	0.25	0.04
Natural capital					
Natural capital in wealth	nat_w	0.14	0.14	0.19	0.17
Natural capital per capita	nat_pc	0.06	0.05	0.08	0.09
Geography					
Coastline	$coast$	0.00	0.02	0.00	0.01
Fractionalization					
Language group	$lang$	0.24	0.21	0.27	0.33
Ethnic group	eth	0.32	0.42	0.23	0.42
Institutions					
Liberal democracy	$demo$	0.37	0.32	0.40	0.38
Public sector corruption	$corr$	0.42	0.46	0.29	0.40
Legal formalism: Check (1)	$check(1)$	3.01	2.62	3.06	3.39
Legal formalism: Check (2)	$check(2)$	0.33	0.27	0.34	0.38
Complexity	$comp$	0.49	0.50	0.46	0.53
KKZ96	$kkz96$	0.08	-0.04	0.10	0.08
Executive constraints	exe	5.00	5.00	5.25	5.00
Others (controls)					
Time dummy variables	$period$				
Colonial (Spain or Portugal)	$colo$	0.00	0.00	0.00	0.00
English legal origin	$engl$	1.00	0.00	1.00	0.00
French legal origin	fr	0.00	0.00	0.00	0.00
Latitude	lat	0.17	0.21	0.17	0.22
Mineral stocks	min	-6.15	-6.07	-7.22	-6.25
System	sys	1.12	0.34	2.00	0.55

Table A.6 Correlations between proximate and fundamental theories' proxy variables - CR countries+

Fundamental theories' proxies	Proximate theories' proxies									
	pop	inv	sch	$life$	$fert$	$open$	gov	$infl$	lac	sea
Religion										
$buddhism$	-0.30	0.32	0.19	-0.11	-0.15	-0.01	-0.09	-0.06	-0.23	**0.74**
$catholisism$	0.38	-0.01	-0.24	0.26	0.36	-0.18	-0.26	0.23	**0.65**	-0.18
$hinduism$	0.05	0.22	0.12	0.04	0.08	0.37	-0.00	-0.06	-0.22	**0.90**
$islam$	**0.44**	-0.24	-0.31	**0.43**	0.33	0.40	0.17	-0.04	-0.29	-0.04
$protestantism$	**-0.50**	-0.10	0.36	**-0.47**	**-0.51**	-0.15	0.09	-0.11	-0.30	-0.20
Natural capital										
nat_w	**0.48**	0.16	-0.37	0.38	**0.44**	0.05	-0.08	0.03	0.32	-0.00
Fractionalization										
eth	0.38	0.01	-0.27	0.33	0.36	0.05	-0.08	0.16	**0.40**	0.03
Institutions										
$demo$	**-0.69**	0.05	**0.59**	**-0.74**	**-0.79**	-0.36	-0.02	-0.05	-0.32	-0.11
$corr$	**0.64**	-0.14	**-0.59**	**0.65**	**0.65**	0.33	0.06	0.10	**0.40**	-0.03
$check(1)$	**0.45**	-0.01	-0.39	**0.58**	**0.57**	0.02	-0.22	0.16	**0.44**	0.11
$check(2)$	**0.42**	-0.00	-0.31	**0.49**	**0.54**	0.02	-0.24	0.16	**0.48**	0.13
$comp$	**0.48**	-0.02	**-0.42**	**0.60**	**0.61**	0.03	-0.21	0.16	**0.46**	0.13
$kkz96$	**-0.58**	-0.00	**0.56**	**-0.66**	**-0.71**	-0.21	-0.05	-0.16	**-0.56**	-0.26
exe	**-0.62**	0.12	**0.57**	**-0.72**	**-0.66**	-0.16	-0.04	-0.06	-0.19	0.01

+ The proxy variables associated with the four fundamental theories, namely, religion, natural capital, fractionalization, and institutions, are found to be significantly correlated with variables from every proximate theory except for the macroeconomic policy theory. Values of correlation greater than or equal to 0.40 are considered as significant and indicated in bold. The complete correlation matrix is available from the authors upon request.

Table A.7 Correlations between proximate and fundamental theories' proxy variables - WW countries+

Fundamental theories' proxies	Proximate theories' proxies										
	pop	inv	sch	$life$	$fert$	$open$	gov	$infl$	lac	ssa	sea
Religion											
$catholicism$	-0.16	-0.07	-0.00	0.05	-0.07	-0.09	-0.23	0.13	**0.54**	-0.22	-0.22
$hinduism$	0.06	0.00	-0.06	-0.00	0.11	-0.09	0.14	-0.02	-0.10	-0.06	**0.70**
$islam$	**0.44**	-0.11	-0.24	-0.01	0.35	0.21	0.03	-0.03	-0.23	0.07	0.17
$other$	**0.41**	-0.14	-0.28	-0.01	**0.42**	0.03	0.12	-0.01	-0.10	**0.73**	-0.00
Natural capital											
nat_w	**0.53**	-0.18	-0.34	-0.02	**0.59**	-0.03	0.17	0.06	0.13	**0.48**	0.19
nat_pc	0.27	-0.23	-0.26	-0.01	**0.50**	0.01	0.38	0.03	0.06	**0.40**	0.09
Fractionalization											
$lang$	**0.43**	-0.15	-0.20	-0.02	**0.41**	0.11	0.10	-0.03	-0.32	**0.57**	0.27
eth	**0.60**	-0.23	-0.30	-0.04	**0.61**	0.13	0.06	0.11	0.26	**0.50**	0.09
Institutions											
$demo$	**-0.60**	0.08	**0.50**	0.04	**-0.72**	-0.11	-0.08	-0.03	-0.22	-0.28	-0.08
$corr$	**0.55**	-0.20	-0.42	-0.02	**0.65**	0.12	0.08	0.08	0.28	0.32	0.02
$check(1)$	0.11	-0.09	-0.22	-0.08	0.21	0.07	-0.01	0.13	**0.50**	-0.16	0.08
$check(2)$	0.11	-0.09	-0.23	-0.08	0.22	0.08	-0.02	0.13	**0.50**	-0.17	0.02
$kkz96$	**-0.63**	0.24	**0.45**	0.03	**-0.73**	-0.06	-0.14	-0.11	-0.36	-0.38	-0.27
exe	**-0.48**	0.04	**0.47**	0.00	**-0.57**	-0.09	-0.09	-0.00	-0.11	-0.24	0.04

+ The proxy variables associated with the four fundamental theories, namely, religion, natural capital, fractionalization, and institutions, are found to be significantly correlated with variables from every proximate theory except for the macroeconomic policy theory. Values of correlation greater than or equal to 0.40 are considered as significant and indicated in bold. The complete correlation matrix is available from the authors upon request.

Table A.8 BMA estimation results for average growth rate of GDP per capita regression: CR countries[+]

	Proximate and fundamental theories			Fundamental theories		
Theories & variables	Posterior inclusion probability	Posterior mean	Posterior standard deviation	Posterior inclusion probability	Posterior mean	Posterior standard deviation
Neoclassical						
inc		-0.077*	0.013		-0.019*	0.008
pop		0.055	0.076			
inv		0.069*	0.023			
sch		-0.003	0.016			
Demography	**1.000**					
$life$		0.039	1.805			
$fert$		-0.252*	0.036			
Macroeconomic policy	**1.000**					
$open$		0.001	0.007			
gov		-0.173	0.304			
$infl$		-0.007	0.004			
Regional heterogeneity	0.320					
lac		-0.000	0.004			
ssa		0.000	0.004			
sea		-0.025	0.042			
Religion	0.062			**1.000**		
$buddhism$		-0.002	0.016		0.002	0.015
$eastern$		0.003	0.023		0.391*	0.069
$islam$		-0.000	0.007		-0.007	0.022
$protestantism$		-0.000	0.006		-0.002	0.013
Natural capital	**0.964**			**1.000**		
nat_w		-0.041	0.028		-0.041*	0.020
nat_pc		-0.011	0.045		-0.000	0.029
Geography	0.048			0.053		
$coast$		-0.000	0.008		0.000	0.009
Fractionalization	**1.000**			**0.999**		
$lang$		-0.072*	0.030		-0.066*	0.028
eth		0.002	0.014		-0.004	0.017
Institutions	**1.000**			**1.000**		
$kkz96$		0.000	0.003		0.000	0.002
exe		-0.017*	0.005		0.002	0.004
Others (controls)						
$period$		Yes			Yes	
Obs		403			403	

[+] A "*" indicates statistical significance of the coefficient associated with the corresponding proxy variable. The posterior inclusion probability of a theory, given in column 2 or 5, is market in bold to indicate that such a theory is relatively robust in explaining economic growth and robustness increases with this probability.

Table A.9 BMA estimation results for average growth rates of GDP per capita regression: WW countries[+]

	Proximate and fundamental theories			Fundamental theories		
Theories & variables	Posterior inclusion probability	Posterior mean	Posterior standard deviation	Posterior inclusion probability	Posterior mean	Posterior standard deviation
Neoclassical						
inc		-0.051*	0.008		-0.014*	0.006
pop		-0.016	0.050			
inv		0.018	0.012			
sch		-0.012	0.010			
Demography	**1.000**					
$life$		-0.006	0.024			
$fert$		-0.159*	0.025			
Macroeconomic policy	0.028					
$open$		-0.000	0.001			
gov_c		-0.000	0.013			
$infl$		-0.001	0.000			
Regional heterogeneity	0.085					
lac		0.000	0.001			
ssa		-0.002	0.010			
sea		0.000	0.002			
Religion	**0.981**			**1.000**		
$eastern$		0.288*	0.076		0.433*	0.062
$hinduism$		0.001	0.012		0.017	0.039
$islam$		0.000	0.004		-0.001	0.007
$protestantism$		-0.003	0.012		-0.003	0.012
$other$		0.001	0.013		0.000	0.011
Natural capital	0.250			0.227		
nat_w		-0.006	0.018		-0.012	0.026
nat_pc		0.000	0.000		0.000	0.000
Geography	0.056			0.035		
$coast$		-0.000	0.004		0.000	0.005
$land$		-0.001	0.006		-0.000	0.003
Fractionalization	0.056			**0.964**		
$lang$		-0.001	0.006		-0.002	0.010
eth		-0.000	0.004		-0.089*	0.031
Institutions	**1.000**			**1.000**		
$kkz96$		-0.000	0.002		0.000	0.003
exe		-0.006*	0.003		0.000	0.003
Others (controls)						
$period$		Yes			Yes	
Obs		640			640	

[+] A "*" indicates statistical significance of the coefficient associated with the corresponding proxy variable. The posterior inclusion probability of a theory, given in column 2 or 5, is market in bold to indicate that such a theory is relatively robust in explaining economic growth and robustness increases with this probability.

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