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Yang, Jue and Managi, Shunsuke and Sato, Masayuki

Tohouku University, Tohouku University, Kyoto University

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Jue Yang[1], Shunsuke Managi, Masayuki Sato

Jue Yang and Shunsuke Managi
Graduate School of Environmental Studies, Tohouku University; 6-6-20 Aramaki-Aza-Aoba, Sendai, 980-8579, Japan

Masayuki Sato
Graduate School of Human Development and Environment, Kobe University, Japan

[1] Graduate School of Environmental Studies, Tohouku University; 6-6-20 Aramaki-Aza-Aoba, Sendai, 980-8579, Japan.
e-mail: yangjue@m.tohoku.ac.jp

Abstract
Various indicators have been developed to assess the sustainability of countries. However, whether it is possible to include institutions as an element of the sustainability index remains theoretically and practically unclear. One of the main challenges is the substantial missing data problem. Recent studies has shed light on means of improving data collection and constructing better indicators for the quality of institutions and their use in sustainability theory. However, although a variety of imputation methods have been developed in this field, the special nature of institutions and the time trend effect make it difficult to develop an appropriate selection strategy. This study addresses this problem by including theoretically considerable variables in a multiple imputation framework. A panel dataset is constructed that covers approximately 190 countries for the period 1980-2010. Based on this complete imputed dataset, we investigate the effects of institutions on the change in comprehensive wealth, which is the adjusted net savings, using the instrument variable method. We also suggest a strategy for including institutional indicators in post-2015 sustainability index design.

Keywords: Multiple imputation, adjusted net savings, institutional quality

1. Introduction

Since Daly and Cobb developed the index of Sustainable Economic Welfare (ISEW) in their book "For the Common Good" in 1989, various indicators for assessing the achievement of sustainability have been developed. These newly developed indicators are more inclusive than the traditional Gross Domestic Production (GDP) in terms of environmental and social progress. Among them, the capital theory approach (CTA), which judges a country's sustainability as closely tied to its intergenerational wellbeing, is now becoming a dominant approach in the sustainability development field (Stern 1997). However, the move from theory to measurement in empirical economics entails some difficulties. One of these challenges is the question of whether it is necessary to include institutions as an element of the sustainability index.

As Dasgupta (2013) noted, capital assets are patently a part of the so-called "productive base," but there are other intangible objects such as institutions that also contribute to overall inclusive wealth growth. It is essential to include institutions in sustainability measures to develop better and comprehensive indicators. The literature reveals the improvements in data collection and the construction of better indicators for the quality of institutions and their use in economic growth theory. However, a serious problem in data collection is the substantial number of missing values. Most studies focus only on OECD countries or large countries such as China, India, or Brazil. But to arrive at a unified global development agenda for the Post-2015 Era that incorporates sustainable development, we must include all countries in a temporally and spatially complete database. A variety of imputation methods have been presented in the statistics literature as a means to solve the missing data problem. However, due to the special nature of institutions and the time trends in panel data, it is difficult to make good choices about methodologies.

This paper attempts to address the aforementioned challenge by including theoretically considerable variables in a multiple imputation framework and by demonstrating the influence of institutions on nations' sustainability using the instrument variable (IV) method. We begin by using data imputation to create a complete panel dataset using the multiple imputation (MI) method. Imputation by a single value has been critiqued for misrepresenting the uncertainty of estimates, whereas MI fills in missing data with a set of plausible values to represent this uncertainty. Recently, the advent of new computation methods has generated a rapid increase in the popularity of MI in the biomedical, behavioral, and social sciences. We use a MI package called Amelia II developed by Honaker et al. (1998-2013) in this paper. Honaker and King (2010) state that the enhancements to the newly developed algorithm of Amelia can work well with panel data structures in the macroeconomic and political fields. We review the literature that contains information on theoretical institution-related variables and collect those variables in our MI framework. In this paper, we construct a new database that includes data from 189 countries for the period 1980-2010 to facilitate cross-country comparisons of institutional impacts on sustainability.

Using the imputed dataset, this paper tests the impact of institutional quality, especially the quality of political institutions, on adjusted net savings (ANS) (% of Gross National Income, GNI) at the country level. As shown in Fig.1, positive relationship could be found between ANS and the quality of political institutions. A panel model is developed to test both the aggregated impacts and each indicator for political institutions. Our empirical analysis is closely related to the work of Stoever (2012), which also tested the relationship between the quality of institutions and sustainability. However, there are several significant differences between Stoever's and our research. First, his study covered the time period from 1996 to 2006, while our dataset is extended covering from 1980 to 2010. Second, because the instruments he used were not time various, and panel analysis was not applied. Third, he used one indicator, the average Worldwide Governance Indicators (WGI) score, to represent the quality of institutions. This paper conducts both panel estimation and cross-section estimation, and tests more institutional indicators collected from the International Country Risk Guide (ICRG 2009), World Bank institution database, Polity IV database and WGI.

This paper is organized into four main sections. The section 2 reviews the literature that examines the possible relationship between institutions and sustainability and the variables that can potentially be used for the imputation framework. Section 3 focuses on the methodology and data used in this paper. In this section, we present a detailed introduction to the multiple imputation methodology and information about our dataset. Section 4 and 5 reports the imputation results and the empirical results of the panel analysis. Section 6 is policy implication and conclusion.

2. Sustainability and institutions

Adjusted net savings (ANS), also called genuine savings, was developed by Pearce, Atkinson (1993). It was later extended by Hamiton and Clemens (1999) and published in the world development indicators database by the World Bank. As an indicator based on capital theory, ANS contains the elements of human capital, productive capital, and natural depletion. The method that the World Bank uses to calculate ANS is as follows:

$$ANS = NNS + EE - ED - MD - NFD - CO_2D - PMD \qquad (1)$$

where ANS is the adjusted net savings; NNS is the traditional net nation savings; EE is education expenditure; ED is energy depletion, which covers coal, crude oil, and natural gas; MD is mineral depletion; NFD is the net forest depletion; and CO_2D is carbon dioxide (CO_2) damages, with a conservative figure of $20 marginal global damages per ton of carbon emitted. PMD is a willingness to pay-based measure that indicates the particulate matter (PM) damages.

It is more common to use the adjusted net savings rate (ANS divided by GNI) to assess the sustainability of an economy. An annual average ANS (% of GNI) has been provided by the World Bank since 1970 for all countries for which data are available. The simple correlation coefficient between this newly developed measure of ANS (% of GNI) and the traditional GDP is only approximately 0.06. In growth theory and cross-country comparison studies, researchers have already acknowledged the importance of institutions (Acemoglu et al. 2001; Easterly and Levine 2003). It is interesting to examine whether the relationship between institutions and sustainability is different from the traditional GDP after resource use is included in the indicator.

Atkinson and Hamilton (2003) argued that institutions may still play a very important role in the sustainable development of a country. Dasgupta (2013) provided an example of the negative effect of corruption on the social wealth of capital assets. However, none of these researchers have translated their hypothesis into empirical studies. Stoever (2012) firstly provided the analysis by taking the average institutional scores and ANS (% of GNI) of 138 countries for 1996-2006 and found a significant and causal positive relationship between good institutions and sustainability. In this paper, we examine the influence of institutions on the adjusted net savings as an indicator of national sustainability using our imputed complete panel dataset.

Institutions have many dimensions, including economic freedom, political freedom, and social trust. How can we measure them? There are different ways to categorize institutions. Kuncic (2012) grouped the empirical proxies into three relatively homogenous groups of formal institutions: legal, political, and economic. He found all three dimensions of institutional factors are highly correlated with each other. For political institutions, he isolated 12 political institutional indicators from Freedom House, Polity IV, the World Bank DPI, the ICRG, the WB World Governance Indicators (WGI), Transparency International, and the Political Terror Scale. Most of these indicators are highly correlated with GDP per capita (constant 2000 US$). Glaeser et al. (2004) classified three types of political institutions in the economic growth literature based on the relative risk of expropriation by the government, government effectiveness, and constraints on the executive. The researchers used 4 institutional indicators to assess the quality of institutions, 2 constitutional measures of constraints, and 2 measures of judicial independence and constitutional review. They found a strong correlation between economic growth over a period and the average assessments of institutional quality over the same period but did not find the same correlation between economic growth and the constitutional constraints measures. Instead, they found that the initial levels of constraints on the executive do not predict subsequent economic growth, whereas average constraints continue to be strong predictors. In this paper, we follow Glaeser et al. (2004) in testing both institutional indicators and constitutional constraints measures.

The endogeneity problem is another topic that has been discussed widely in growth and institution studies. As Acemoglu et al. (2001) posited, the early pattern of institutions has persisted over time and influences the extent and nature of institutions in the modern world. One of the central strategies that researchers have adopted in the literature involves introducing instrumental variables, including colonial experimentation and the ethnolinguistic fractionalization of the population. Following the literature, we also apply these instruments in this paper.

3. Methods and Data

3.1 Constructing the dataset using multiple imputation

There are various methods of addressing missing data. The traditional method is to use list-wise deletion (or the complete-case approach), deleting the cases with one or several missing values. During the late 1990s, 94% of academic papers used the complete-case approach (King et al. 2001). However, it has been confirmed that the complete-case approach cannot provide valid standard errors and confidence intervals (Carlin et al. 2003) except for some situations (King et al. 2001).[2] Recently, the World Bank and Environmental Performance Index(EPI) group have used hot-deck imputation for missing values (Srebotnjak et al. 2012), which pick up data from similar observations but which may perform poorly when many rows of data have at least one missing value (Roystion 2004).

Unlike other imputation methods, MI fills in each missing value with a set of plausible values that reflect the uncertainty of the predictions of the missing values. MI was introduced nearly 30 years ago in the survey analysis setting (Rubin 1978). This method displays the sensitivity of the inferences to different mechanisms that could have

[2] King et al. (2001) discussed when list wise deletion is preferable compare to multiple imputation method. For instance, when the complete dataset is large, the sensitivity of results of the imputed model maybe low. When the function form is known to be correctly specified, or when there is no unobserved omitted variables that affect the variable with missing values exist, the cost of list wise deletion is lower compare to multiple imputation method.

created the non-response (van Buuren et al. 1999). However, MI has not been applied frequently because of the limits on computation capacity from the 1970s to the 1990s. Recently, with the development of computer science, MI has been implemented more frequently in empirical studies. We illustrate the increasing use of the MI method between 1990 and 2013 in Fig.2 by searching for papers with the keyword MI in the Web of Science database. The search results show that the frequency of application of the MI method in total (right axis) rises from nearly zero in 1990 to nearly 600 publications in 2013. Although most of the contributions are from the medical field, the increase in the use of MI in the social sciences has been marked and rapid.

Before imputing the dataset, we need to first identify the types of missing mechanisms. There are three types of mechanisms: those that are missing completely at random (MCAR), those that are missing at random (MAR), and those that are missing not at random (MNAR). (The original formal definitions were provided by Rubin (1976), Little and Rubin (1987) and Schafer (1997)). Because analysis techniques that rely on a sampling distribution are valid only when the data are MCAR (Rubin 1976), the complete-case approach can only be used when the missing mechanism is MCAR. However, the MI method can be used with both MCAR and MAR. In the case of MNAR, because the probability of the missing values depends on the unobserved data themselves, different types of treatment or methods are required (e.g., a pattern mixture model). To test the missing mechanism type, we create binary variables for each variable in the dataset and set each to 1 when the value is missing and 0 otherwise. We then correlate the binary variables with other variables. We find no high correlation among the variables, and thus, MI is suitable for our dataset.

The second step is to choose the model for multiple imputation and decide the times of imputations. Two important routes have been delineated in the development of MI. One route is named joint modeling through the multivariate normal, with approximation for non-normal variables (JM: MVN, log-linear and the general location model) (van Buuren 2007). Another route uses conditional unilabiate models without rigorous formal justification, as in Multiple Imputation by Chained Equations (MICE)[3]. In this paper, we decide to use Amelia II (version 1.7.2), a general-purpose multiple imputation package that is based on the MVN methodology. Amelia II integrates the Expectation-Maximization algorithm with Bootstrapping (EMB). We choose Amelia II because our dataset is a panel of a large number of countries, which is unique relative to

[3] Compared to MVN, MICE can handle different variable types, because in MICE, each variable is imputed using its own imputation model. However, the properties of MICE are not generally proven: the justification of the MICE procedure has thus far rested on empirical studies (Kenward and Carpenter 2007). Empirical studies on countries with missing information are rare.

traditional survey-based datasets. This type of dataset requires algorithms that can control for a time trend during imputation. Honaker and King (2010) suggested the newly developed algorithm can solve this problem and improve imputation efficiency.

Fig. 3 shows the structure of multiple imputation using Amelia. EMB algorithm is applied to construct a posterior distribution of the missing data, and draw a random sample from this distribution. The set of random draws is used for fill in the missing observations. The number of variables *n* in the dataset for imputation could be up to 30-40 (Honaker and King 2010). In this paper, we use 27 variables in our imputation model. Simulation studies have shown that the required number of repeated imputations *m* can be as low as three for data with 20 percent of the entries missing (Rubin 1987; Graham et al. 2007). The relative efficiency (RE) of an estimate of the parameter of interest is equal to $(1+\lambda/m)^{-1}$ (λ is missingness, %). The rate of missing values in our dataset is approximately 25%, and we repeat a total of *m*=5 times, which can generate sufficiently high efficiency for RE, approximately 0.95.

Then, in the third step, applying statistical model to the imputed dataset. MI inferences assume that the model for imputation is the same as the analysis model or at least contains all of the variables for the final analysis model. So the number of variables in the analysis model *k* should $\leq n$. The results of the *m* statistical analyses are used as follows to calculate a point estimate. The missing value can be combined as $\bar{\theta}$ in equation (2).

$$\bar{\theta} = \frac{1}{m}\sum_{m=1}^{m}\hat{\theta}_m \qquad (2)$$

The point estimate for θ from the MI inference is the average of the m datasets. The variance estimate is a value that combines the within-round variance and the adjusted between-round variance. The within-round variance (denoted by *V*) is the average of the *m* complete datasets (see equation 3).

$$\bar{V} = \frac{1}{m}\sum_{m=1}^{m}\hat{V}_m \qquad (3)$$

The between-round variance (denoted by *S*) is defined as follows:

$$S = \frac{1}{m-1}\sum_{m=1}^{m}(\hat{\theta}_m - \bar{\theta})^2 \qquad (4)$$

The total variance of θ is then equal to

$$T = \bar{V} + (1+\frac{1}{m})S \qquad (5)$$

3.2. Data and variables

Our research group has been working on conducting a database named World Resource Table using MI for a long time (Managi et al. 2009; Tsurumi and Managi 2012). In this paper, we developed the database by including approximately 27 variables and 5859 observations for 189 countries that cover the period from 1980 to 2010. We exclude 13 non-independent countries/areas and 8 countries with poor availability[4].

(1) Sustainability related variables

To impute ANS (% of GNI), the various countries' socio-economic variables were collected, such as population density, rural population (% of total population), the GDP per capital growth rate, the GDP growth rate, agricultural land (% of total land area), and cereal yield (kg per hectare). We also include elements that are not highly correlated with ANS, such as wages, adjusted savings based on carbon dioxide, electricity production from oil, and trained primary school teachers in primary. Data for all of these variables were collected from the World Development Indicators database (the World Bank 2013).

(2) Institutional variables

We collected institutional variables from the International Country Risk Guide (ICRG), Polity IV, WB World Governance Indicators (WGI) (Kaufmann et al. 2010), and World Bank DPI. In light of the arguments presented in Glaser et al. (2004), we collected two types of variables from the databases. The corruption variable from ICRG, an average score of 6 components from the WGI and the Polity2 variable from Polity IV (Marshall et al. 2013) were used to measure **the quality of institutions**. The ICRG provides a dataset that assesses government stability, socio-economic conditions, investment profile, internal conflict, external conflict, corruption, the influence of the military in politics, law and order, and 4 other indicators. This resource has been evaluated as a problematic database by Glaeser et al. (2004) because of several measurements cannot consistently reflect the political constraints; therefore, we use only *corruption* to test Dasgupta's example (Dasgupta 2013). The data on *corruption* are available for 1984 onward, with a maximum value of six. This is a measure that considers excessive patronage, nepotism, job reservations, secret party funding and suspiciously close ties between politics and business (ICRG 2012). The average WGI score has been used to examine the effect of institutions on ANS by Easterly and Levine (2003) and Stoever (2012). It is the average

[4] The thirteen countries/areas that are excluded from the dataset are: American Samoa, Aruba, Cayman Islands, French Polynesia, Greenland, Guam, Hong Kong, Isle of Man, Macao, New Caledonia, Northern Mariana Islands, Puerto Rico, Turks and Caicos Islands.
The eight countries are: Channel Islands, Kosovo, Montenegro, Palestine, Virgin Islands (U.S.), Bermuda, Faeroe Islands, and Monaco.

value of citizens' voices and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law and control of corruption. *Polity2* is the most popular measure of a country's political regime (Plümper and Neumayer 2010). It is a combined score that is computed by subtracting the autocracy score from the democracy score and has been revised to facilitate its use in time-series analyses (Marshall, Gurr, and Jaggers 2013). *Plurality and proportional representation* were collected to measure the **constitutional constraints**. We do not include judicial independence or constitutional review, which were used in the work of Glaeser et al.(2004) in the dataset because they are only available for one year. Plümper and Neumayer (2010) found that the freedom indicator from Freedom House is a good predictor of polity. We also included it in the imputation model.

(3) Other variables

We control for energy use, health, legal origin, geographic and cultural effects based on the existing empirical research (Algan and Cahuc 2010). Energy production and CO_2 emissions per capital were included as energy use variables. Culture may potentially affect the formation of institutions, and thus, we include legal origin, which may help to explain institutional development (Acemoglu et al. 2001, 2012; Glaster et al. 2004), as well as two dummy religion variables for countries with predominantly Christian and Muslim populations. Health is another factor that may affect the human capital accumulation and sustainability both historically and currently. We include the percentage of a country's land area that lies in the Koeppen-Geiger temperate zone (from the Center for International Development). Legal origin is the legal origin of the company law or commercial code of each country, has been tested by Glaeser et al. (2004) and La Porta et al. (2008). Missingness and a brief description of the statistics for all of the variables are reported in Table 1.

We plotted the histograms of all of the variables to determine whether the distributions were suitable for the MVN model. Log, square, square root and other transformations were used to normalize highly skewed variables. The data sources are provided in Appendix A.

3.3 Model specification

In this paper, we use the IV-two stage least squares (2SLS) panel data estimation methodology. The equation that we use to estimate the impact of institutions on sustainability is as follows:

$$y_{i,t} = \mu + log I'_{i,t}\beta + X'_{i,t}\gamma + \alpha_t + \alpha_c + \varepsilon_{i,t} \tag{6}$$

where $y_{i,t}$ is the ANS (% of GNI) of country i at time t, $I'_{i,t}$ is the set of institutional indicators of country i at time t, β is the parameter that measures the effect of the increase in the level of an institutional indicator on sustainability, X=(x_1, …,x_k)' denotes a vector of k exogenous variables (see control variables in section 3.2), γ is a column vector of coefficients, α_t is the vector of the year-fixed effect, α_c is the vector of the continent-fixed effect (for capturing regional heterogeneity bias), and $\varepsilon_{i,t}$ is the error term for country i at time t.

Higher levels of institution quality and constitution constraints are expected to positively affect the ANS rate. Although no empirical evidence showed the existence of an impact of constitutional constraints (Glaeser et al. 2004), we test their impacts on sustainability. We specify the following structural equation:

$$\log I'_{i,t} = \vartheta + \varphi \log Z'_{i,t} + X'_{i,t}\delta + \alpha_t + \alpha_c + v_{i,t} \quad (7)$$

Z' is a set of instruments. Instruments are selected based on findings in the literature. A popular instrument used in the literature is the mortality settler indicator, which was originally tested by Acemoglu et al. (2001). It has also been tested by Glaeser et al. (2005) and Stoever (2012). But because it only available for one year and 67 countries, we cannot include it in our panel model. The idea of using the mortality settler is the survival rate in the colonies may affect the formation of institution. We assume the life expectancy at birth in a given country which related to the health condition in that country can also affect the formation of institution. Other instruments include enrolment rate, cultural indicator and dummies. The mortality settler is used in the Robustness test for checking the differences between our imputed dataset and literature.

4. Results

4.1 Imputation results

The brief statistics for the variables after imputation are reported in Table 2. Comparing these results with those presented Table 1 illustrates the nature of the missing data. First, if we examine the variables related to sustainability, we see that most of the means decreased. For instance, the mean of ANS (% of GNI) is 1.234 higher than in the imputed dataset. In contrast, the means of the institutional variables increased in the case of corruption but decreased for the average WGI score, which indicates government effectiveness. These results indicate that the “good” news reported by the World Bank or other international organizations may overstate sustainability by excluding developing countries from the dataset. It is also possible that society globally may underestimate the diffusion of democracy and that the effectiveness of government may be worse than we had predicted.

A common method of assessing the results of the imputation is to use the density graph to compare the curves of the observed and imputed data. Fig. 4 shows the results of the density comparisons for the sustainability-related variables. In each figure, there are two curves. The red curve represents the density of the mean imputation over the *m* datasets, and the black curve is drawn with the density of the observed data. The black curve indicates that the curves for ANS (% of GNI) and educational attainment are reasonably similar; thus, we can conclude that the imputation model fits very well[5]. Fig.5 represents the imputation results for the institutional variables. Among the five institutional indicators, the average WGI score fits best. It is a continuous variable that changes smoothly over time, similar to the economic indicators, whereas the other four categorical variables are much more difficult to impute. Proportional representation fits worst, and we omit it from Fig.5. What happens if there is limited data available at all for a country? Fig.6 presents the imputed values for Chad as an example. Chad experienced civil war during the period 1969-1985 and remains plagued by political violence; 24% of its data were missing. Proportional representation and plurality suggest a lower level than in later periods. The imputed average WGI scores are lower compare to those real values in later 1990s and earlier 2000s. But it is unclear whether Chad's government even functioned worse after the civil war. For corruption, there are no data at all for Chad. The imputed score for corruption is approximately 3, which is nearly identical to the scores of some OECD countries. We will examine these findings in greater detail in the discussion section.

4.2 Panel analysis results of ANS

The panel analysis was estimated for both the list-wise dataset (dataset by list wise deletion method) and the imputed complete dataset. All of the variables were transformed except for the dummies and the institutional indicators. We started with baseline models for testing the correlation between institutional variables and ANS. The baseline models included exogenous variables and controlled for region and time fixed effect. The result of listwise models showed that four of the five institutional variables have significant relationships with ANS except for proportional representation.

Then we provided the Durbin-Wu-Hausman test to check for the endogeneity of the five institutional variables. The method we used here was suggested by Davidson and MacKinnon (1993), which includes the residuals of each institutional variable as a function of all the exogenous variables X in a regression of the original model, and then

[5] We also i) compared real data from some domestic survey databases (published in domestic language) with some of our imputed values; ii) generate randomly missing cells in our database, and impute them using MI. We compared the difference between the imputed values with real values. The results shows that the imputed values are quite close to reality.

check whether the OLS estimates are consistent or not. The results showed that we are able to reject the null for all 5 institutional indicators. It is therefore necessary to use the instruments.

Table 3 presents the results of IV models both the list-wise panel dataset and the imputed dataset. The institutional indicators that were significant for both the list-wise panel and imputed panel datasets were the average WGI score, Polity2 and corruption. The other 2 variables that represent constitutional constraints were not significant in either model. This finding is consistent with those of Glaeser et al. (2004) in the OLS analysis. However, the Hansen J-statistics of the IV models (lise-wise model) show that instruments for constitutional constraints does not work very well. Thus, we can hardly discuss more about the effects from constitutional constraints and the differences between the two types of institutional indicators: constitutional constraints and the quality of institutions. Better instruments are needed for these two variables. The tests for imputed models cannot be obtained because of the limitation of existing program. The solution we took here is testing the reliability of the MI dataset itself (see notes of Table 3).

The different results of control variables between list-wise models and imputed models occurred among Christian dummy, Islam dummy and GDP per capital growth rate. However, the significance of these three variables were not consistent in all the models. The only variable may need to be noted here is the Christian dummy. We found it has negative effects on the ANS (% of GNI) in three of the five imputed models. Barro and McCleary (2003) presented a precise analysis on the impacts of religion on economic growth. Instead of using dummy variables, they collected continuous variables such as church attendance, belief in hell, and belief in heaven to capture the characteristics of religion in a country. They found that increases in church attendance tend to reduce economic growth. They argued that higher church attendance may relate to a larger use of resources by the religion sector, and the main output of this sector held constant. In this paper, we only use a dummy variable which can hardly further discuss whether the Christian religion consumes more resources. But combined with what Barro and McCleary (2003) found in their paper, effects of religions could have strong consequences for sustainable development.

We perform three sets of additional robustness tests. First, we take the lagged ANS (% of GNI) as an independent variable and added it to the specifications. We add one period-lagged value and find that it was also significant, which indicates that potential effects of ANS itself existed in the panel models. Second, as Glaeser et al. (2004) noted, there are two ways to assess the impact of institutions on economic growth: using growth regressions or examining the differences among countries. We separate the dataset into higher-income countries (high-income countries and upper-middle-income countries) and lower-income countries to perform the analysis. The results show that the effects of institutions on ANS (% GNI) are same for different income groups. We then add CO_2 emissions (log) to the equations and find that this variable has a negative sign and is significant in most of the models. As a direct component of ANS (% GNI), this result is reasonable. The ANS may also needs to include other contributions from difference natural capital such as air and water pollution, bio-diversities.

5. Discussion

This paper evaluates the MI methodology in applying the institutional variables. The imputation results show that the newly developed MI methodology works well with the ANS index and socio-economic variables. Plümper and Neumayer (2010) advised that adding theoretically related variables into the imputation framework may reduce the bias of the results. Honaker and King (2010) also proposed incorporating expert knowledge in the form of new types of Bayesian priors. Thus, we include freedom, wage, and other variables that have been considered good instruments for institutional variables into the imputation model. We also introduce time trend and logic bounds into the algorithm. The results show that the average WGI score fits best, other institutional variables are also rendered reasonable.

Our results confirm that institutions also contribute to the ANS (% of GNI), an index for assessing sustainability, as Stoever (2012) found in his paper. We also prove evidences that not only the average WGI score, but also polity2 and corruption have significant effects on the ANS. Traditionally, institutions as an important factor of economic growth has been studied a lot, but in case of the newly designed ANS, we have less knowledge of their relationship. Our findings developed the literature that the quality of institutions has positive impacts on the sustainability.

There is some debate regarding whether the sustainability index should include institutions in sustainable development assessment. Dasgupta (2013) insists that to include institutions in the wealth of nations – for instance, financial capital – would interfere with economic evaluation because it is difficult to determine the value of institutions. However, the form of including institutions empirically could be various. For instance, the environmental sustainability index (ESI) developed by Esty et al. (2005) includes measures such as corruption and liberty that represent the capability of the government. Eicher and Rhn (2007) created an institutional climate index for OECD countries. Their index is an aggregated one that selected eight indicators and weighted them by GDP predictive power.

Here, we suggest developing a continuous variable as an indicator that can be used to assess the institutional situation for each country and even to design the post-2015 Sustainable Development Goals (SDGs).[6] First, according to the definition provided by North (1981), institutions are "a set of rules, compliance procedures, and moral and ethical behavioral norms designed to constrain the behavior of individuals in the interests of maximizing the wealth or utility of principals." Institution as an integrated product cannot be evaluated easily as a dummy variable but should include more information from various dimensions. Indicators that reflect the efficiency of government, political democracy, and corruption could be included. Second, if the aim is to guarantee the effectiveness of multiple imputation, our findings show that it is better to use a continuous indicator, which is easier to collect and impute and which appropriately represents the impact of institutions on sustainability. Third, constitutional constraints may not work well for sustainability assessment. According to our panel results, proportional representation and plurality were not significant. Similar results were also found in the empirical economic growth literature. Acemoglu et al. (2002) and Glaeser et al. (2004) found that the measures of constitutional constraints were not significant, whereas the measures of institutional quality were significant. Glaeser et al. (2004) argued that it is the average of constraints over time that contributes to economic growth. As we discussed in the previous section, better instruments needed for investigating the impacts of these two variables. But it may also because the voting rules can hardly reflect a single dimension of countries' political institutions. For instance, proportional electoral rules are costly because of extended negotiation times among parties which reduces the efficiency, but at the same time, the decisions made by the government precisely reflect citizens' preferences. Case studies may needed for further investigations.

The effects of other socio-economic variables are not stable, which likely results from a variety of developing structures in different countries. A single socio-economic indicator can hardly explain the whole implications of sustainable development. Rather, institutional indicators and socio-economic context may have mixed effects. However, our results do suggest that religion differences may have an impact on adjusted net savings. Religion effects can also reflect the extent to which colonization policies and institutional forms introduced by different client states in the history. Identifying the differences in country groups and the influence mechanisms of institutions is an issue that requires further studies.

[6] After the Rio+20 Conference, the development of a set of Sustainable Development Goals (SDGs) and indicators to improve global welfare became a hot topic. Whether and how to include institutions as a component of the sustainability index is also under discussion, as we state in the introduction.

6. Conclusions and policy implications

This paper makes two contributions. First, we have developed our dataset WRT for sustainable development studies using the MI method and find that introducing theoretically confirmed variables into the imputation model is a useful strategy for addressing panel data and political variables such as institutional indicators. Our second contribution is that we re-examined the role of institutions in the growth of ANS (% of GNI), also called genuine savings, using the complete imputed panel dataset. We confirmed the findings in the literature and further found polity2 and corruption, as indicators of the quality of institutions, exert a strong positive influence on sustainability.

Compared to category variables, measures such as average sentences could be a better indicator of the varying characteristics of institutions across countries and could also promote easier imputation. We also find that socio-economic variables such as the per capital GDP growth rate were not notably significant. It could because that the sustainability measurements are well designed for systematic and quantitative comparison among countries. This adjusted net savings index may successfully integrate elements from multiple dimensions that enhance sustainable development but that are very different from the traditional GDP measure. The imputed models also captured effects of religions which has been found in the literature but cannot be revealed by list wise approach. Basically, the results of list-wise dataset and imputed dataset are similar except for socio-economic variables. Therefore, we suggest that multiple imputation method could be a useful tool for conducting database for sustainability research. Especially for low income countries, this method can potentially reduce the costs of collecting data or setting a monitory system in their countries.

The ANS index itself does not include any indicators refer to institutional quality. However, based on our results it may be necessary to include institution quality as an element of the sustainability index because it contributes to the growth of ANS. The institutional quality used in this paper represents citizens' voices and accountability, political stability and absence of violence, government effectiveness, and regulatory quality, rule of law and control of corruption. Further investigation on which types of institutions influence nations' sustainability are needed to design a better sustainability index for the post-2015 SDGs. Moreover, indicators/instruments that can better capture the characteristics of institutional constraints require further research.

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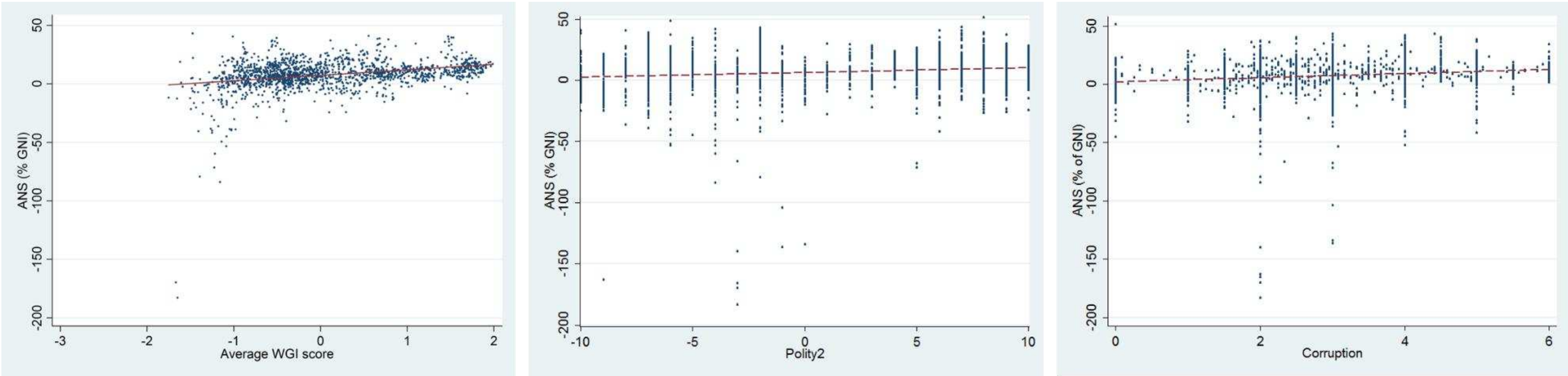

Fig.1 Relationship between ANS (% of GNI) and the quality of institutions

Notes: Average WGI score is the average value of citizens' voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law and control of corruption from the World Governance Indicators dataset. Polity2 is a measure of a country's political regime (Marshall, Gurr, and Jaggers 2013). Corruption is from the International Country Risk Guide.

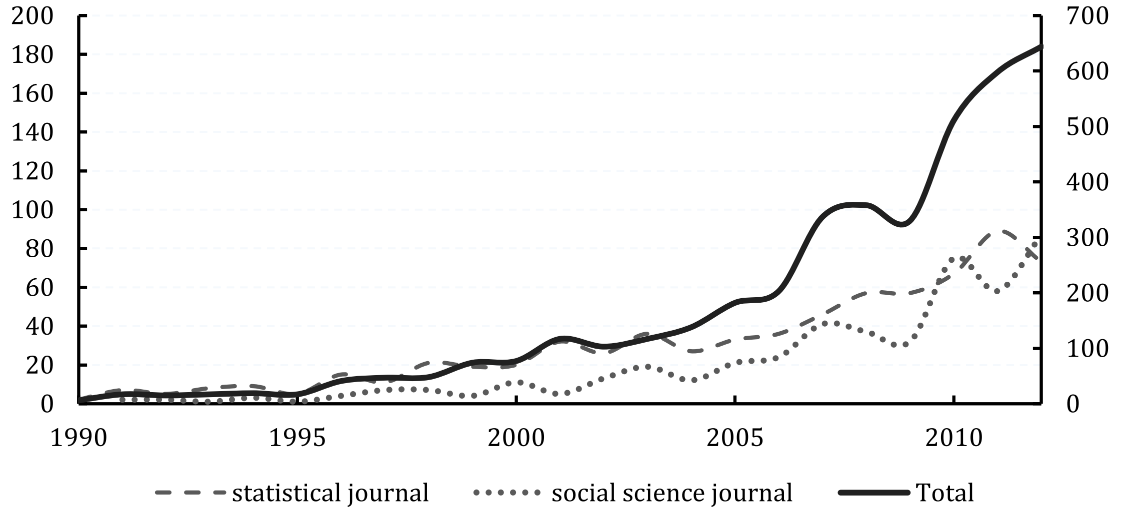

Fig.2 The increase of multiple imputation method applications in last 20 years

Notes: Data was collected from Web of Science by searching "multiple imputation". Left axis shows the number of multiple imputation related papers that published in statistical journal and social science journal. Right axis shows the total number of journals.

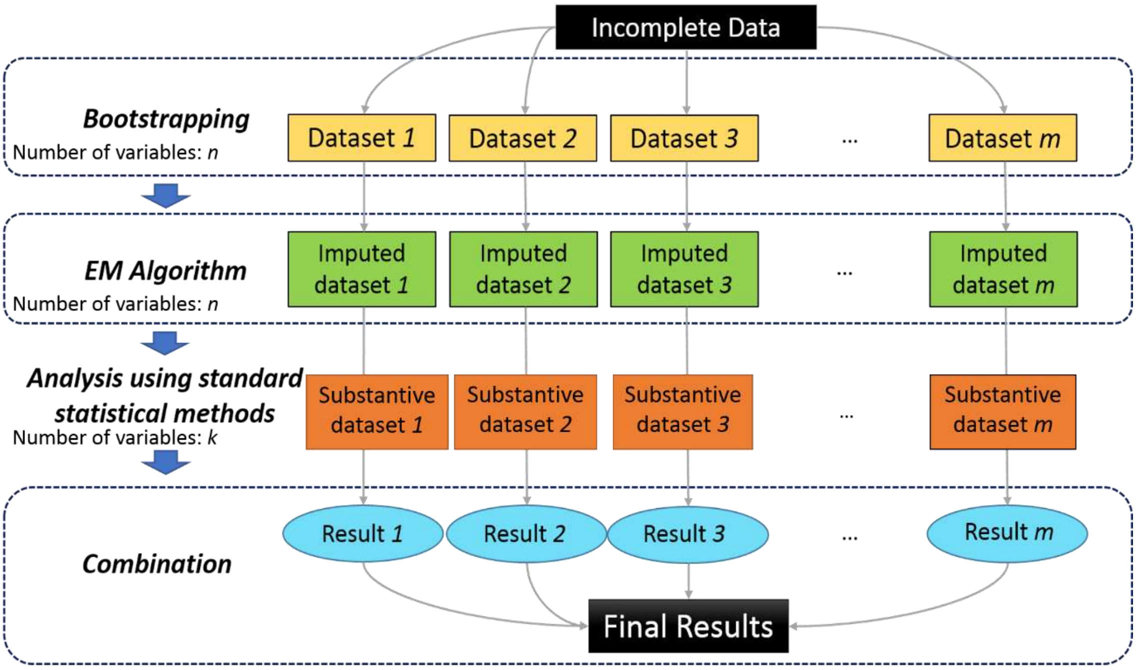

Fig. 3 Multiple Imputation via the EMB Algorithm

Notes: Refined based on Honaker, King, and Blackwell (2011, p4).

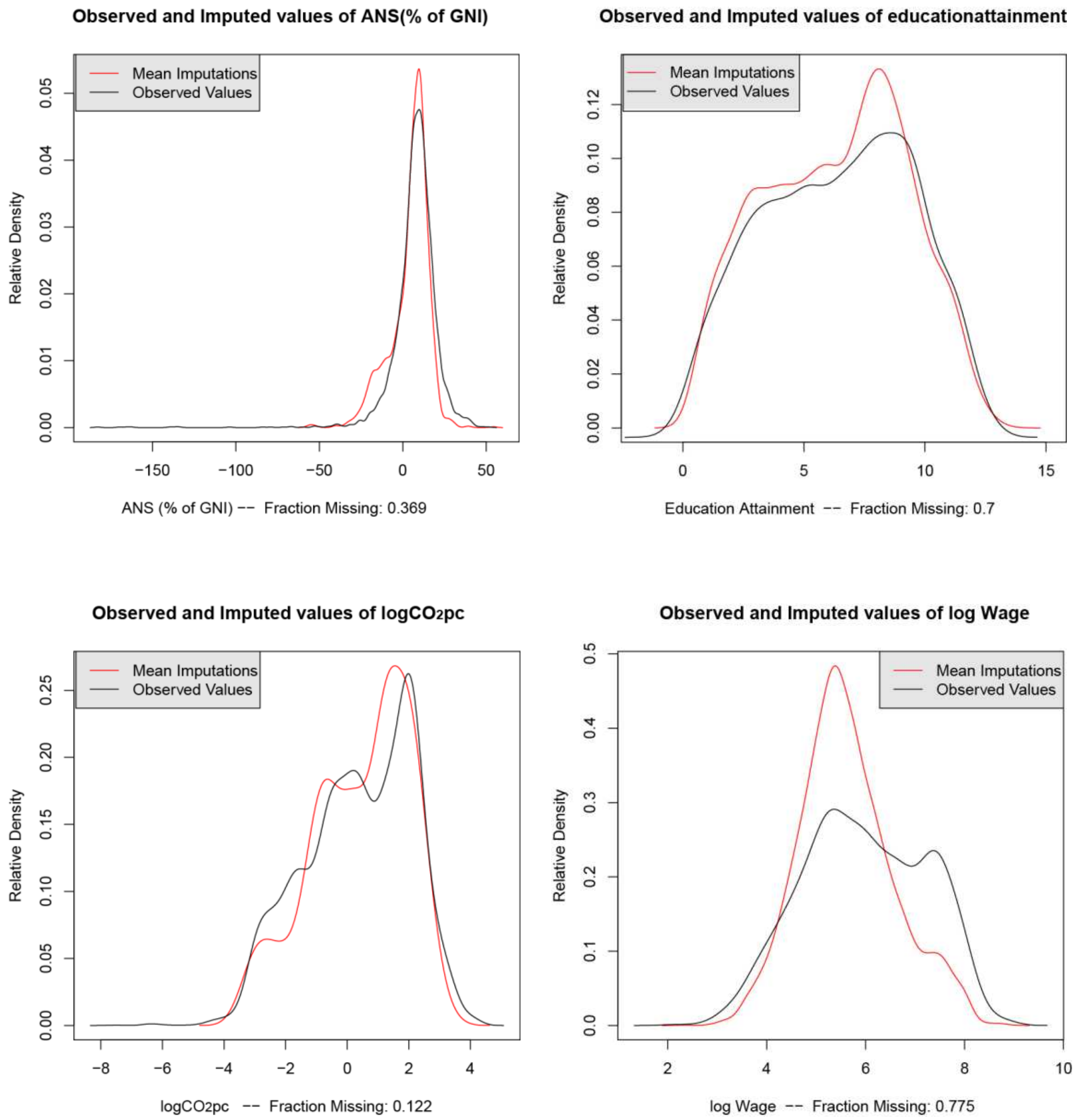

Fig.4 Density comparison

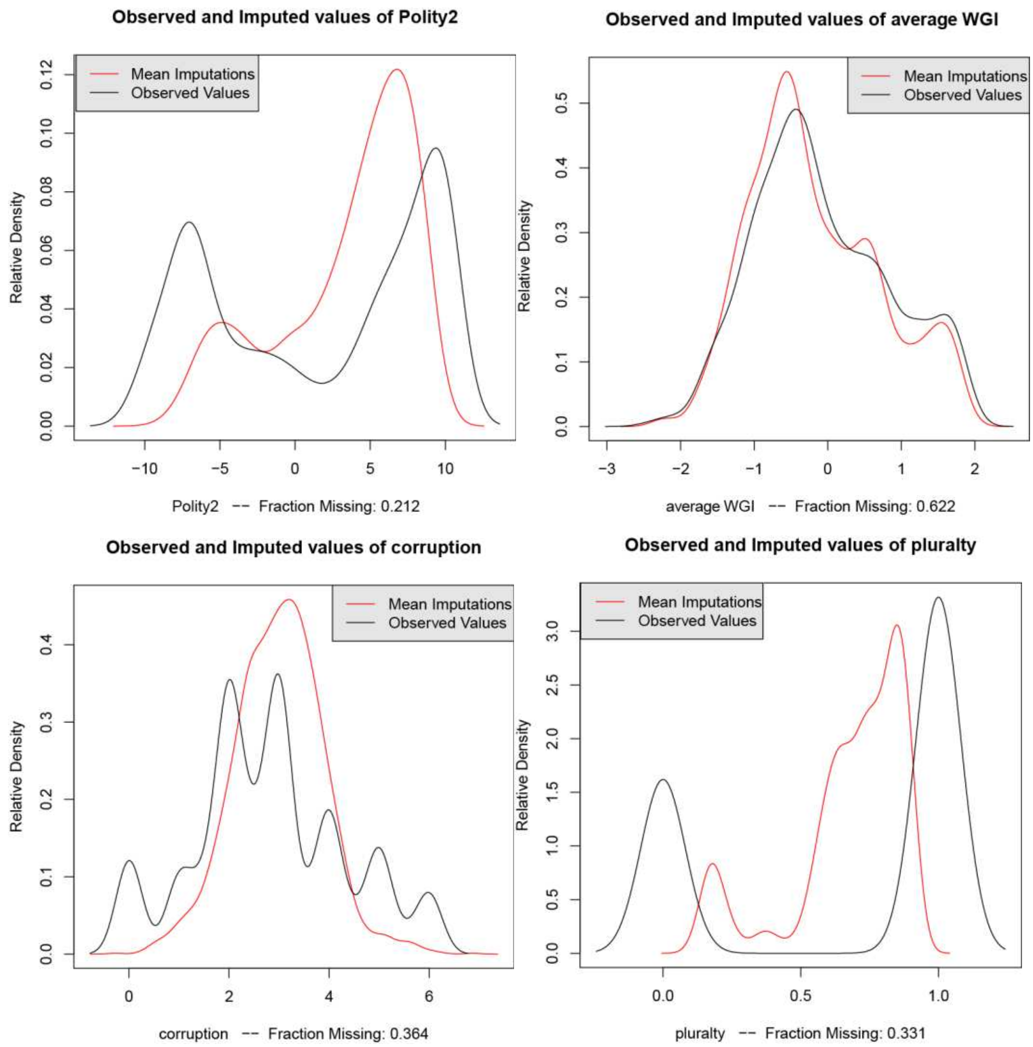

Fig.5 Density comparison for institutional indicators

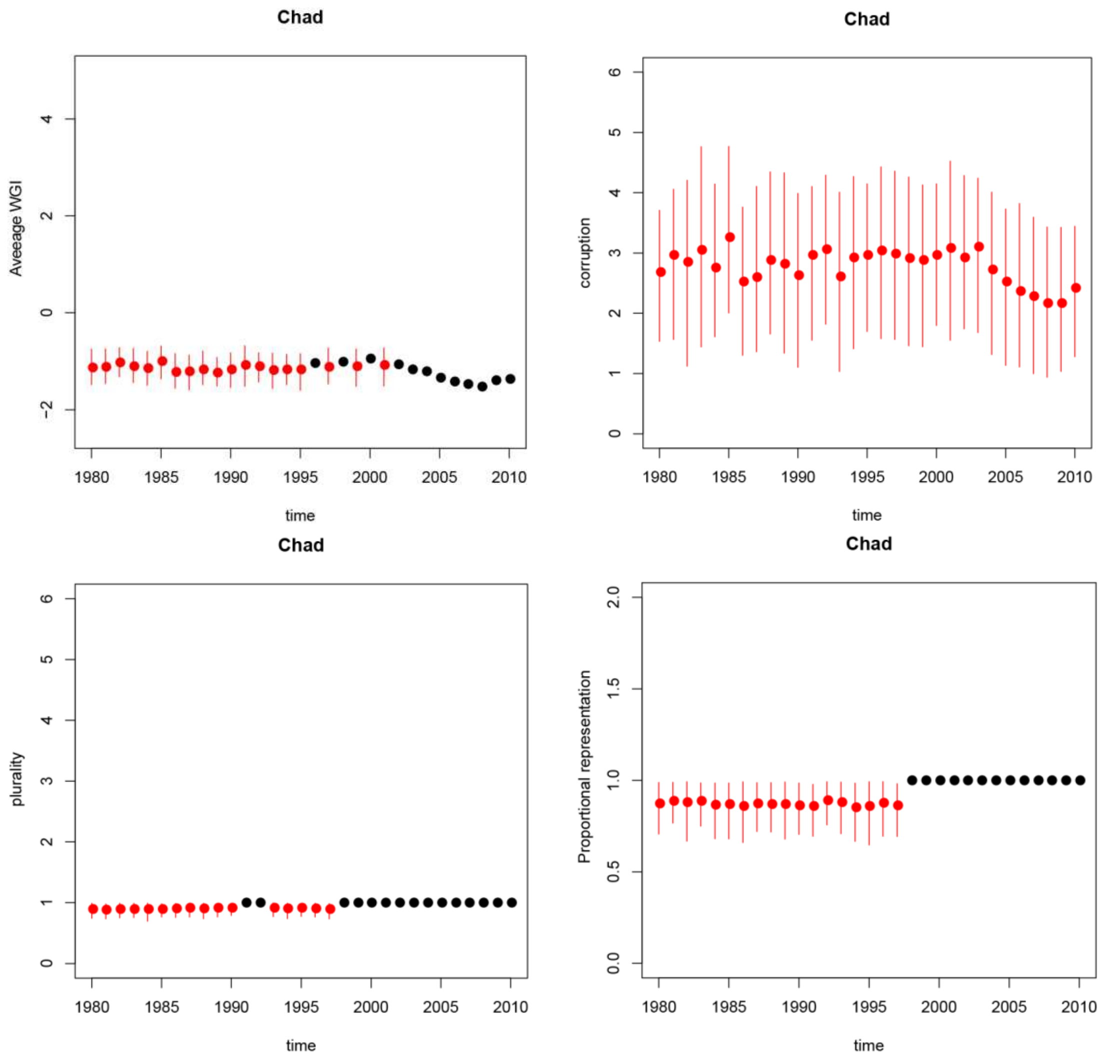

Fig.6 Imputed institutional indicators for Chad

Table 1 Variables description

Variables	N	Missingness (%)	Mean	Std. Dev.	Min	Max
Sustainability related variables						
ANS (% of GNI)	3696	37%	7.575	13.566	-182.857	51.663
Education attainment	1758	70%	6.931	3.076	0	13.3
Adjusted savings: education	4677	20%	1.974	0.439	0.564	3.738
Institutional variables						
Average WGI	2215	62%	-0.078	0.921	-2.490	1.987
Polity2 (revised polity score)	4620	21%	1.705	7.242	-10	10
Plurality	3918	33%	0.672	0.470	0	1
Proportional representation	3578	39%	0.586	0.493	0	1
Corruption	3725	36%	2.816	1.511	0	6
Control variables						
Rural population (%)	5849	0%	49.351	23.641	0	95.661
GDP per capital growth rate	5216	11%	1.633	6.136	-50.236	91.673
Population density (log)	5828	1%	1.745	0.591	0.234	4.364
Electricity production from oil (square root)	3879	34%	7.058	2.948	0	10
Legal origin	5797	1%	1.952	0.988	1	5
Energy depletion	5148	12%	1.093	1.811	0	13.887
CO_2 emission per capita (log)	5144	12%	0.367	1.739	-7.493	4.229
Islam dummy	5797	1%	0.251	0.434	0	1
Christian dummy	5797	1%	0.588	0.492	0	1
Life expectancy at birth	5607	4%	65.411	10.243	26.764	85.163
Variables for imputation only						
Trained teachers in primary school	5601	4%	59.544	6.913	45.287	85.806
Agricultural land share (%)	5496	6%	39.266	21.993	0.442	91.160
Cereal kg (log)	5045	14%	7.580	0.738	3.993	11.215
Wage (log)	1318	78%	5.970	1.238	2.116	8.872
% land area at temperate zones	4836	17%	0.300	0.419	0	1
Income class	5133	12%	2.321	1.102	1	4
Freedom (3 categories)	5421	7%	0.120	0.820	-1	1
Enrolment rate	3104	47%	68.005	19.378	7	115

Table 2 Descriptive statistics after multiple imputation

Variables	N	Mean	Std. Dev.	Min	Max
sustainability related variables					
ANS (% of GNI)	29290	6.339	14.018	-182.857	67.605
Education attainment	29290	6.481	3.114	0.000	14.126
Adjusted savings: education	29290	1.954	0.427	0.564	3.738
Institutional variables					
Average WGI	29290	-0.137	0.911	-2.499	2.406
Polity2 (revised polity score)	29290	2.062	6.878	-10	10
Plurality	29290	0.676	0.410	0	1
Proportional representation	29290	0.544	0.431	0	1
Corruption	29290	2.879	1.380	0	6
Control variables					
Rural population (%)	29290	49.350	23.620	0	95.661
GDP per capital growth rate	29290	1.583	6.240	-52.094	91.673
Population density (log)	29290	1.745	0.590	0.234	4.364
Electricity production from oil (square root)	29290	6.859	2.516	0	11.031
Legal origin	29290	1.954	0.983	1	5
Energy depletion	29290	1.176	1.839	0	13.887
CO_2 emission per capita (log)	29290	0.380	1.703	-7.493	4.573
Islam dummy	29290	0.253	0.432	0	1
Christian dummy	29290	0.587	0.490	0	1
Life expectancy at birth	29290	65.647	10.162	26.764	87.443
Variables for imputation only					
Trained teachers in primary school	29290	59.703	6.900	45.287	85.806
Agricultural land share (%)	29290	39.864	21.881	0.442	91.160
Cereal kg (log)	29290	7.607	0.714	3.993	11.215
Wage (log)	29290	5.701	1.089	1.780	9.052
% land area temperate zones	29290	0.297	0.383	0	1
Income class	29290	2.299	1.065	1	4
Freedom (3 categories)	29290	0.119	0.800	-1	1
Enrolment rate	29290	65.425	19.590	0.271	117.543

Table 3 2SLS estimation of the panel models

	List wise model					Imputed model				
average WGI	0.056					0.037				
	(0.021)**					(0.013)**				
Polity2 (revised polity score)		0.017					0.018			
		(0.008)*					(0.008)*			
Plurality			1.649					0.632		
			(0.082)					(0.652)		
Proportional representation				0.092					0.624	
				(0.099)					(0.661)	
Corruption					0.042					0.051
					(0.016)*					(0.020)*
Christian dummy	-0.029	-0.022	0.130	-0.012	-0.037	-0.032	-0.058	-0.127	-0.057	-0.033
	(0.022)	(0.021)	(0.239)	(0.019)	(0.023)	(0.013)*	(0.028) *	(0.162)	(0.066)	(0.015)*
Islam dummy	-0.007	0.057	0.011	0.001	-0.007	-0.030	0.016	-0.031	0.008	-0.025
	(0.015)	(0.038)	(0.082)	(0.025)	(0.017)	(0.012)*	(0.032)	(0.070)	(0.070)	(0.014)
Legal origin	-0.005	0.007	0.062	-0.011	-0.007	-0.006	0.003	-0.074	-0.102	-0.009
	(0.005)	(0.008)	(0.099)	(0.013)	(0.007)	(0.004)	(0.008)	(0.098)	(0.106)	(0.007)
% land area temperate zones	-0.043	-0.043	0.072	0.012	-0.029	-0.007	-0.038	-0.044	0.028	-0.034
	(0.023)#	(0.043)	(0.164)	(0.017)	(0.021)	(0.013)	(0.043)	(0.112)	(0.066)	(0.025)
GDP per capital growth rate	0.002	0.001	0.003	0.001	0.002	0.002	0.002	-0.0001	0.001	0.001
	(0.001)	(0.001)	(0.003)	(0.001)*	(0.001)*	(0.001)**	(0.001)	(0.004)	(0.001)	(0.001)

Constant	5.368	5.382	4.633	5.320	5.258	5.365	5.381	6.193	5.267	5.210
	(0.018)***	(0.034)***	(1.127)***	(0.038)***	(0.037)***	(0.014)***	(0.030)***	(1.148)***	(0.093)***	(0.055)***
Cragg-Donald Wald F statistic	234.674	41.475	2.631	10.202	131.513					
P-value (Chi-squared test)	0.254	0.472	0.948	0.001	0.106					
N	955	2138	1901	1769	1764	5859	5859	5859	5859	5859
number of countries	122	130	127	123	117	189	189	189	189	189

Notes: Robust SEs are denoted in the parentheses. *, ** and *** denote statistical significance of the estimated coefficients at the 10, 5, 1 % levels, respectively. Time trend results were omitted. Updated ivreg2 (3.2.07) and mim for STATA was used for estimation. Year dummies and continent dummies are included in all specifications. All variables except the dummy for institutions and time trend are in logarithm. P-values are reported for Hansen J statistics. The Cragg-Donald Wald F statistic and P-value for imputed model cannot be computed by the existing program. But we tested the reliability of MI (see footnote on page 10).

Appendix A Variables definitions and sources

Variable	Definition
Dependent variable	
ANS (% of GNI)	ANS rate excluding PM10 is used. Source: the World Bank(2013)
Measures of institutions	
Institutional quality	Average of six measures of governance effectiveness from WGI is used.
Polity2	An aggregate democracy variable runs from -10 to 10. Source: Marshall, Gurr and Jaggers (2013).
Plurality	It is a dummy variable, equal to 1 when legislators were elected using a winner-take-all rule; equals to 0 otherwise. The data available from 1975 to 2012. Source: Beck et al. (2001). (updated by the World Bank)
Proportional representation	It is a dummy variable, equals to 1 if candidates were elected using a proportional representation system, equals to 0 otherwise. Source: Beck et al. (2001). (updated by the World Bank)
Corruption	Source: International Country Risk Guide (2012).
Control variables	
Education attainment	Year of schooling of the total population aged over 15. Source: Barrro and Lee (2013). Data posted on http://www.barrolee.com/data/dataexp.htm
Legal Origin	The legal origin of the company law or commercial code of each country. Source: La Porta et al. (2008).
Share of land area in temperate zone	Percentage of land area in Koeppen-Geiger temperate zones (Cf+Cs+Df+DW). Source: Center for International Development (2001).
Religion dummy	Source: Central Intelligence Agency (2013)
Freedom	Aggregated index from political rights and civil rights. It equals to 1 if a given country is free, -1 if the country is not free, 0 if partial free. Freedom House (2012)

Appendix B Correlations among the variables used in list wise model (N is different for each coefficient)

No.	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	ANS (% of GNI)	1													
2	average WGI	0.308	1												
3	polity2	0.196	0.577	1											
4	plurality	0.032	-0.176	-0.306	1										
5	Proportional representation	-0.006	0.220	0.367	-0.616	1									
6	corruption	0.171	0.762	0.374	-0.212	0.197									
7	GDP per capital growth rate	0.163	-0.070	0.054	-0.045	0.049	1								
8	Legal origin	0.070	0.275	0.195	-0.293	0.452	0.046	1							
9	Energy depletion	-0.448	-0.310	-0.316	0.038	-0.109	0.051	-0.012	1						
10	CO_2 emission per capita (log)	0.138	0.604	0.289	-0.190	0.199	0.050	0.235	0.248	1					
11	Islam dummy	-0.094	-0.360	-0.435	0.205	-0.256	-0.054	-0.137	0.318	-0.099	1				
12	Christian dummy	-0.048	0.363	0.454	-0.252	0.243	-0.021	0.107	-0.215	0.176	-0.693	1			
13	Life expectancy at birth	0.299	0.658	0.451	-0.219	0.284	0.100	0.288	-0.007	0.751	-0.194	0.229	1		
14	Cereal kg (log)	0.188	0.488	0.367	-0.184	0.235	0.100	0.295	-0.001	0.533	-0.247	0.221	0.642	1	
15	Share of land area in temperate zone	0.190	0.624	0.450	-0.252	0.290	0.055	0.489	-0.232	0.523	-0.326	0.378	0.548	0.494	1