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Abstract

We propose a new set of indices to capture the multidimensionality of a country's institutional quality. Our indices are obtained by employing a dimension reduction approach on the institutional variables provided by the Frazer Institute (2018). We estimate the impact that our measures of institutional quality have on the level and the growth rate of per capita GDP, using a large sample of countries over the period 1980-2015. To identify the causal effect of our measures of institutional quality on a country's GDP dynamics we employ the Generalized Propensity Score method. Institutions matter especially in low- and middle-income countries, and not all institutions are alike for economic development. For this group of countries, we find: i) a positive correlation between our main institutional index and the GDP growth and ii) that improvement in the reliability and fairness of the legal system leads to a higher long-run per capita GDP level. We also document non-linearities in the causal effects that different institutions have on growth, and the presence of threshold effects.

Keywords: Economic Development, Institutions, Threshold Effects, Mixture Model, High-income countries, Low- and middle-income countries.
JEL Classification: O43, O47.

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1 Introduction

In their influential essay, Acemoglu et al. (2005) provide convincing arguments in favor of the idea that institutions *cause* economic prosperity by providing "right" incentives and constraints to the economic agents. Along the path of economic development, Acemoglu and coauthors claim institutions emerge as outcomes of social decisions. Particularly, economic institutions encouraging economic growth may arise when "*political institutions allocate power to groups with interests in broad-based property rights enforcement when they create effective constraints on powerholders, and when there are relatively few rents to be captured by power-holders*". This view traces back to North (1990), who defines institutions as "*the rules of the game in a society or, more formally, [...] the humanly devised constraints that shape human interaction*". Consistently with this definition, the fundamental explanation of comparative growth can be found in the differences among institutions. This is the perspective we adopt in this paper, in which institutional differences across countries are used to explain differences in macroeconomic outcomes.

The attempt to understand cross-country differences in GDP dynamics through this lens is certainly not new.[1] We contribute to this strand of the literature in two ways. Since a country's institutional quality is a multidimensional phenomenon and that the array of connections between institutions and economic development is potentially extremely large, the first contribution of the paper is to propose a brand-new set of indices aimed at summarizing such multidimensionality. Building on the data provided by the Frazer Institute (2018) we focus on the following five measures: *i) the size of the public sector, ii) the reliability and fairness of the legal system, iii) the degree of liquidity in the financial markets, iv) the degree of openness to international trade and v) the strength of regulation.*[2] Our indices are obtained by employing a dimension reduction approach designed for panel data (Farcomeni et al., 2021) and rated on a 0–10 scale. As a second contribution, we use these indicators to assess the joint and separate role those different institutions and policies may have on GDP dynamics. We do this by explicitly taking into account the unobserved heterogeneity among countries, i.e. we split our

[1] See the literature review below.

[2] As noted in the literature, these sub-dimensions of institutions equally capture policy variables such as the size of the public sector in terms of government expenditure and taxes (see, for instance, De Haan et al., 2006). We will use these indices irrespective of whether they are institutional measures or policies aside from the overall index in our analysis.

sample of 80 countries, over the period 1980-2015, into two groups, namely "high-income" and "low- and middle-income" countries, resulting from the use of an optimal clustering method. To properly address the issue of endogeneity and omitted variable bias, which may generate biased and inconsistent estimates, and to identify the causal effect of (our measures of) institutional quality on GDP (levels and growth rate) we employ the Generalized Propensity Score method proposed by Hirano and Imbens (2004).

Our estimates show that the obtained measures of institutional quality vary across the two groups of countries. We show that improvements in some institutions (i.e. larger values of our institutional indices) may *cause* both higher levels and growth rates of the long-run per capita GDP. Such effects appear stronger for those countries which have been classified as "low- and middle-income", where comparatively markets are more dysfunctional and bureaucracies typically less efficient. Specifically, we document the important role played by the reliability and fairness of the legal system in determining the long-run level of GDP in "low- and middle-income" countries. Different from the large body of the literature on the topic, which focuses on the linear association between some measures of institutional quality and GDP (levels and growth rate), a final important feature of our analysis is that it looks at and finds non-linear (causal) effects. In particular, we show that improvements in institutional quality always determine a positive level effect on per capita GDP. Our estimates also show an interesting non-linear effect of (what we term) *Public sector size* on GDP: the positive impact of this indicator tends to increase up to some limit (being smaller in the group of "low- and middle-income" countries) and then starts to decline (more sharply in the group of "low- and middle-income" countries). Also, all our institutional and policy indicators have non-linear effects (despite not always statistically significant) on GDP growth. Finally, we document the presence of different institutional thresholds in the two groups of countries.

Related literature The body of literature empirically assessing the relationship between institutions and GDP dynamics has significantly increased over the last three decades. In general, a positive and direct relationship between institutions and GDP levels/growth rates is found. Estimates, however, substantially vary in terms of magnitude across different samples and/or specifications. Moreover, most of the papers rely only on few variables to capture institutional quality and/or do not provide any causal evidence on the relationship between institutions and GDP dynamics. In this brief review, we restrict our attention to those studies which, like ours, build upon Mankiw et al. (1992) (MRW, hereafter). For a more extensive review of the literature on the association between institutions and economic development, the reader can refer to Acemoglu et al. (2005).

Using a large sample of countries over the period 1975-1990, Dawson (1998) found that one standard deviation increase of an initial value of the "economic freedom" index above the mean provides a 3.78 percentage point higher growth rate in the subsequent 15-year sample period, holding the level of freedom fixed over the period. Taking data from 97 countries over the period 1974-89, Knach and Keefer (1995) introduced two institutional variables into an MRW regression, meant to capture the security of property rights and the enforcement of contracts, and found that an increase of one standard deviation in their "rule of law" index leads to an increase in the GDP growth rate by 0.504 of its standard deviation. In an earlier paper, Keefer and Knack (1997) also showed whenever good institutions are absent convergence tends to be slower.

Analyzing a sample of 127 countries over the period 1950-1994, Hall and Jones (1999) showed that differences in capital accumulation, productivity, and therefore output per worker are fundamentally related to differences in "social infrastructure" across countries. The positive impact of the "rule of law" on GDP growth has been found by Barro (1997), for a panel of 100 countries over the period 1960-90, while Rodrik et al. (2004), using the data set of Acemoglu et al. (2001), found institutions to be crucial in determining the long-run level of a country's income. Their estimates indicate that a one standard deviation increase in institutional quality produces a two log-points rise in per capita incomes. For a panel of 56 countries over the period 1981-2010, Nawaz (2015) found that the impact on GDP growth of various institutional variables is relatively larger in "high-income" countries as compared to the "low- and middle-income" ones.

Outline The rest of the paper is organized as follows. Section 2 outlines and discusses the methodology proposed to derive the set of institutional indices and the empirical model to assess the role of institutions in explaining GDP dynamics. Section 3 describes the data set. Section 4 presents the estimates, with some comments. Section 5 reports concluding remarks.

2 Model and Methodology

2.1 Institutional indices

Our first goal is to compute time-dependent summaries of indicators of interest. The main purpose of creating these institutional and policy indices is to identify unidimensional latent variables to summarize multidimensional indicators that, to some extent, are measuring similar characteristics from a different perspective. These latent variables can then be used for ranking and identifying different levels (*doses*) of the characteristics of interest (e.g., the reliability and fairness of the legal system). Notice that the resulting summaries are optimal from a specific mathematical perspective. However, they can only give a partial point of view on the information contained in the data.

There are different methods available for dimension reduction. The most widely used (e.g., principal component analysis) is anyway restricted to cross-sectional data and would not be appropriate for multidimensional measurements (in our case: a collection of indices that are deemed to measure different aspects of the same unidimensional latent trait) that are repeatedly measured over time (Hall et al., 2006). Among the different possible approaches proposed by the literature (e.g., Bai and Wang, 2015; Maruotti et al., 2017; Chen et al., 2020), we opt for a methodology based on the specification of a latent Markov model (Bartolucci et al., 2013) for the latent trait, as in e.g. Xia et al. (2016) or Vogelsmeier et al. (2019). Specifically, we employ the methodology proposed by Farcomeni et al. (2021), whose main advantage is that it allows us to explicitly consider dependence arising from measurements on the same agent that is repeated over time.

Formally, let X_{ith} denote the h-th indicator for country i at time t. Let also U_{it} denote an unobserved discrete latent variable. We assume $Z_{it} = \sum_{h=1}^{H} w_h X_{ith}$ follows a latent Markov model according to which Z_{it} is independent of Z_{is} conditionally on U_{it}, which follows a homogeneous first-order Markov chain. Additionally, conditional on $U_{it} = j$ we assume Z_{it} is Gaussian with mean $\xi_j(w)$. The optimal weights are found to optimize the latent class separation, that is, to maximize under the constraint $\sum_h w_h^2 = 1$,

$$\sum_{j=1}^{k} \sum_{t} \widehat{p_{tj}}(w)(\widehat{\xi_j}(w) - \bar{\xi}_t(w))^2, \tag{1}$$

where $p_{tj}(w) = \Pr(U_{it} = j)$ and $\bar{\xi}_t(w) = \sum_j p_{tj}(w)\hat{\xi}_j(w)$.

The resulting summary is a linear combination of the initial dimensions which optimizes the separation of a cluster of agents (e.g., countries that have a more or a less reliable legal system). Weights can be used for the interpretation and assessment of the importance of the original variables. A limitation is a Gaussian assumption for Z_{it}, which might not hold in practice if any X_{ith} is severely skewed, or if H is small.

Our methodology identifies five groups of indicators, which we summarize separately, creating treatment variables z_1 to z_5 (see Tables A1 and A2 in the Appendix for detailed descriptions) and jointly (treatment variable z). Finally, we normalize and scale the resulting indicators on a score of 0 (e.g., no reliability and fairness of the legal system) to 10 (e.g., highest reliability and fairness of the legal system).

2.2 The augmented Solow model

The rest of the paper is aimed at quantifying the *causal* effect of the institutional indices derived above on GDP levels and growth rates. To do this, we extend the canonical MRW's setting to account for institutions. For a country i at time t, we assume that the aggregate output is obtained through the following linearly homogeneous production function:

$$Y_{it} = K_{it}^{\alpha} H_{it}^{\beta} (A_{it} L_{it})^{1-\alpha-\beta} \qquad \text{with} \quad \alpha + \beta < 1 \tag{2}$$

where Y is the level of real GDP, K is the stock of physical capital, H is the stock of human capital, A is the Harrod-neutral technological progress and L is the labor force. We assume that the labor force and technology grow at the exogenously given rates n and g, respectively. For the sake of simplicity, we also assume that both forms of capital depreciate at the same constant rate δ. In the long run, the relation between the level of per capita GDP and the explanatory variables is given by:

$$\ln\left(\frac{Y_{it}}{L_{it}}\right)^{*} = \ln A_{i0} + g_{it} + \left(\frac{\alpha}{1-\alpha-\beta}\right)\ln(s_k)_{it} + \left(\frac{\beta}{1-\alpha-\beta}\right)\ln(s_h)_{it} - \left(\frac{\alpha+\beta}{1-\alpha-\beta}\right)\ln(n+g+\delta)_{it},$$

where s_k and s_h indicate the exogenous fractions of total income invested in physical capital and human capital, respectively. Notice that the term A is a reduced form to capture the large set of factors, other than inputs, that affect the steady-state level of GDP, such as resource endowments, climate, and institutions. Specifically, as in Dawson (1998), the notion that institutions affect productivity can be easily incorporated in the model by assuming A to be a function of institutions (z). Therefore, differently from MRW, in which $\ln(A)_{it} = \alpha + \epsilon_{it}$, with $\epsilon_i \sim N(0,1)$ representing a country-specific shock, in our set-up, we assume: $\ln(A)_{it} = f(z_{it}) + \epsilon_{it}$. Using this, we obtain the following empirical equation:

$$\ln\left(\frac{Y_t}{L_t}\right)^{*}_{it} = \psi_0 + \psi_1 z_{it} + \psi_2 \ln(s_{k,it}) + \psi_3 \ln(s_{h,it}) + \psi_4 \ln(n+g+\delta)_{it} + \epsilon_{it} \qquad (3)$$

, where ψ_0 is the Total Factor Productivity (TFP), ψ_1 captures the effect of institutions on per capita GDP, $\psi_2 \equiv \left(\frac{\alpha}{1-\alpha-\beta}\right)$, $\psi_3 \equiv \left(\frac{\beta}{1-\alpha-\beta}\right)$ and $\psi_4 \equiv -\left(\frac{\alpha+\beta}{1-\alpha-\beta}\right)$. This specification implies that differences in institutions have a homogenous effect on the level of productivity across countries (ψ_1). The growth of per capita income can be then expressed as a function of the determinants of the steady-state and the initial level of income, i.e

$$\ln\left(\frac{Y_t/L_t}{Y_0/L_0}\right) = \left(1-e^{-\lambda t}\right)\ln\left(\frac{Y_t}{L_t}\right)^{*} - \left(1-e^{-\lambda t}\right)\ln\left(\frac{Y_0}{L_0}\right) \qquad (\lambda > 0), \qquad (4)$$

where Y_0/L_0 is the per capita income at some initial time and λ indicates the speed of conditional convergence toward the steady-state. Plugging (3) into (4) we finally get the following empirical equation:

$$\ln\left(\frac{Y}{L}\right)_{it} - \ln\left(\frac{Y}{L}\right)_{i0} = \zeta_0 + \zeta_1 \ln(s_k)_{it} + \zeta_2 \ln(s_h)_{it} + \zeta_3 \ln(n+g+\delta)_{it} + \zeta_4 \ln\left(\frac{Y}{L}\right)_{i0} + \zeta_5 z_{it} + \epsilon_{it}, \qquad (5)$$

where $\zeta_0 = (1-e^{\lambda t})\psi_0$, $\zeta_1 \equiv (1-e^{-\lambda t})\frac{\alpha}{1-\alpha-\beta}$, $\zeta_2 \equiv (1-e^{-\lambda t})\frac{\beta}{1-\alpha-\beta}$, $\zeta_3 \equiv -(1-e^{-\lambda t})\frac{\alpha+\beta}{1-\alpha-\beta}$, $\zeta_4 \equiv -(1-e^{-\lambda t})$ and $\zeta_5 \equiv (1-e^{-\lambda t})\psi_1$.

2.3 Estimation Method

We first divide countries into groups according to a model-based clustering method. To do so, we restrict to the (log of) GDP in 1980 and compare twenty possible Gaussian mixture models, combining $k = 1, \ldots, 9$ groups with homogeneous or heterogeneous cluster-specific variance. The resulting optimal clustering is then used as a control, being a possible proxy for residual unobserved heterogeneity.

We then estimate a Gaussian mixed-effects model in which we include fixed effects for treatment (z, $z_1, \ldots, z_5$), its square, interactions with cluster indicators, and control variables as listed in the Appendix. We also include a random Gaussian country-specific intercept to consider dependence arising from repeated measurements.

Subsequently, we put forward a causal analysis using a Generalized Propensity Score (GPS) method (Hirano and Imbens, 2004). This is a generalization of the propensity score method for continuous treatments. Accordingly, we estimate a fixed-effect model to predict each treatment using controls and a country-specific intercept, as

$$E[z_{it}] = \alpha_i + t + \beta_1 \ln (y)_{i,t-1} + \beta_2 \ln(s_k)_{it} + \beta_1 \ln(s_h)_{it} + \beta_3 \ln(n + g + \delta)_{it}, \tag{6}$$

where y denotes the log of real per capita GDP, $\ln(Y/L)$. The resulting predicted treatment $\hat{z}_{it}$ and its square is then included in a regression model to predict the outcome x_{it}, which is either the log-GDP or its growth rate, as in

$$E[x_{it}] = \alpha + \omega_1 z_{it} + \omega_2 z_{it}^2 + \omega_3 \hat{z}_{it} + \omega_4 \hat{z}_{it}^2 + \omega_5 \hat{z}_{it} \times z_{it} + \omega_6 cluster_i \times z_{it} + \omega_7 cluster_i \times z_{it}^2, \tag{7}$$

together with the treatment, its square, and interactions of treatment and GPS with cluster indicators. The resulting predicted *dose-response* surface can be used to assess causal relationships between the treatment and endpoint, as discussed in Hirano and Imbens (2004) and references therein.

3 Data

To construct our sample, we merge information from three different sources. Our final sample contains country-level data for 80 countries from 1980 to 2015 taken over every fifth year. Our main dependent variable is the real per capita GDP (y) taken from The World Bank (2018). We used this variable to construct our second dependent variable, which is the 5 years average growth rate of the real per capita GDP ($\textit{Growth}$). This leaves us with seven data points for each country while at the same time controlling for initial income (y_{t-1}) which starts from 1980. Data on the total population used in constructing effective labor ($n + g + \delta$) and the investment share (I/GDP) that are seen to affect GDP dynamics were also taken from The World Bank (2018). The rate of human capital accumulation has been proxied by the Human Capital Index (HC) taken from the PWT (2018).

Finally, the variables used in the construction of our optimal institutional indices were taken from the Frazer Institute (2018) database.[3] The optimal summary index (z) and the optimal sub-indices (z_i, $i = 1, \ldots, 5$) have been obtained by applying the methodology proposed in Paragraph 2.1. Specifically, the summary index, z is constructed from sub-indices such as *Public sector size* (z_1), *Reliability and fairness of the legal system* (z_2), *Liquidity market openness* (z_3), *Degree of (trade) protectionism* (z_4), and *Regulation* (z_5). As part of our investigation, we will conduct several robustness analyses with the five optimal sub-indices of institutions (z_1 to z_5) as alternative treatments to the overall institutional variable. A detailed description of the Frazer Institute (2018) variables used to construct our treatment indices and the variables employed in our regressions can be found in Tables A1 and A2 in the Appendix.

Table 1 presents the summary statistics of key variables used in the analysis. Overall, there are 560 observations across 80 countries for 7-year periods taken every fifth year. On average, the natural logarithm of real per capita GDP is about 8.56, and countries' GDP growth rates are approximately 0.08. The average institutional index is approximately 7.1 (score out of 10). The analysis also includes the binary variable '*cluster*', which is 1 for "high-income" countries and zero otherwise.[4] Table 2 reports the correlation matrix amongst key variables.

[3]For a detailed description of the raw data, see Gwartney and Lawson (2003).
[4]See Paragraph 4.1 for details.

Table 1: Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
$\ln(y)$	560	8.562	1.586	5.391	11.583
Growth	560	0.077	0.121	-0.441	0.519
$\ln(n+g+\delta)$	560	0.135	0.053	0.023	0.383
$\ln(I/GDP)$	560	3.028	0.346	0.092	3.973
$\ln(HC)$	560	0.794	0.311	0.038	1.320
z	560	7.084	2.004	0	10
z_1	560	4.463	2.346	0	10
z_2	560	5.548	2.933	0	10
z_3	560	1.952	2.178	0	10
z_4	560	2.626	2.278	0	10
z_5	560	4.488	2.607	0	10
cluster	560	0.288	0.453	0	1

Table 2: Correlation matrix for key variables

	Growth	$\ln(y)$	$\ln(y_0)$	$\ln(n+g+\delta)$	$\ln(I/GDP)$	$\ln(HC)$	z	z_1	z_2	z_3	z_4	z_5
Growth	1.000											
$\ln(y)$	0.139	1										
$\ln(y_0)$	0.063	0.997	1.000									
$\ln(n+g+\delta)$	-0.253	-0.599	-0.584	1.000								
$\ln(I/GDP)$	0.489	0.285	0.251	-0.083	1.000							
$\ln(HC)$	0.182	0.853	0.843	-0.624	0.228	1.000						
z	0.157	0.288	0.275	-0.188	0.201	0.224	1.000					
z_1	-0.034	0.732	0.737	-0.521	0.165	0.569	0.451	1.000				
z_2	0.050	0.672	0.671	-0.455	0.145	0.542	0.273	0.650	1.000			
z_3	-0.244	-0.238	-0.218	0.168	-0.215	-0.222	-0.880	-0.286	-0.327	1.000		
z_4	-0.157	-0.523	-0.509	0.371	-0.116	-0.511	-0.305	-0.358	-0.468	0.317	1.000	
z_5	-0.014	0.132	0.128	0.008	0.081	0.182	-0.088	0.052	0.253	-0.073	-0.067	1.000

4 Results

4.1 Regime Membership

To group countries into various regimes, we cluster them according to their initial per capita GDP in 1980 (y_0). The optimal number of clusters is two following the Bayesian Information Criterion (BIC) and as suggested by the Classification Trimmed Likelihood (CTL) curves (Garcia-Escudero et al., 2011; Farcomeni and Greco, 2015) presented in Figure 1. The figure shows the objective function at convergence for the different number of clusters and increasing trimming levels α. The curves for $k = 2, 3, 4$ clusters almost overlap, while there is a gap for $k = 1$ vs $k = 2$, indicating that the optimal number of groups is $k = 2$.

We are then left with a predictable grouping reported in Table 3. This leads to the variable '*cluster*', the indicator of being a "high-income" country (Cluster 2). Overall, there are 23 "high-income" countries out of 80. Countries such as Chile, Cyprus, Uruguay, and Portugal, that were "high-income" countries by 2015 according to the World Bank list of economies (June 2017) are classified among "low- and middle-income" countries according to the above selection criteria.

Figure 1: CTL Curves

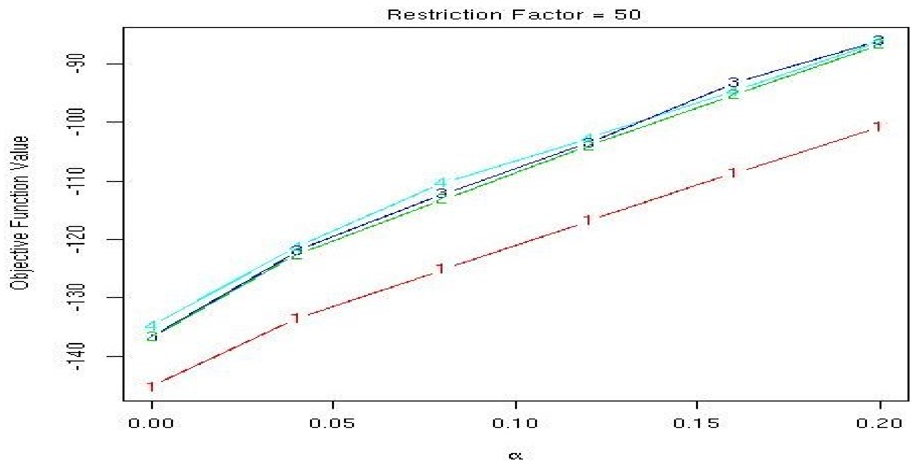


Table 3: Classification of countries based on initial income (1980)

Cluster 1 (Low- and middle-income)			**Cluster 2 (High-income)**	
1 Algeria	20 Fiji	39 Nicaragua	58 Australia	77 Sweden
2 Argentina	21 Gabon	40 Niger	59 Austria	78 Switzerland
3 Bangladesh	22 Ghana	41 Nigeria	60 Bahrain	79 UnitedKingdom
4 Benin	23 Guatemala	42 Pakistan	61 Belgium	80 United States
5 Bolivia	24 Honduras	43 Panama	62 Canada	
6 Botswana	25 India	44 Paraguay	63 Denmark	
7 Brazil	26 Indonesia	45 Peru	64 Finland	
8 Burundi	27 Iran	46 Philippines	65 France	
9 Cameroon	28 Jamaica	47 Portugal	66 Greece	
10 Chile	29 Jordan	48 Senegal	67 Ireland	
11 China	30 Kenya	49 Sierra Leone	68 Israel	
12 Colombia	31 Madagascar	50 South Africa	69 Italy	
13 Congo, Rep.	32 Malawi	51 Sri Lanka	70 Japan	
14 Costa Rica	33 Malaysia	52 Thailand	71 Luxembourg	
15 Cote d'Ivoire	34 Mali	53 Togo	72 Netherlands	
16 Cyprus	35 Mauritius	54 Tunisia	73 New Zealand	
17 Ecuador	36 Mexico	55 Turkey	74 Norway	
18 Egypt	37 Morocco	56 Uruguay	75 Singapore	
19 El Salvador	38 Nepal	57 Zimbabwe	76 Spain	

Note: Countries were clustered according to their initial income in the year 1980.

4.2 Estimates

4.2.1 Institutions and GDP level

Table 4 reports the results of the model for GDP level using the overall institutional index (model 1) and the five sub-indices (models 2 - 6). In the analysis conducted on the whole sample, we find

Table 4: Mixed-Effect Estimates: Institutions and GDP level

	Overall	Sub-indices				
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable: Log of Real per capita GDP						
z	0.001	-0.042	0.058***	-0.035**	-0.018	0.015
	(0.020)	(0.028)	(0.018)	(0.018)	(0.017)	(0.016)
z^2	0.0001	0.008**	-0.004**	0.003*	0.002	-0.001
	(0.002)	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)
cluster	2.432***	2.206***	2.700***	2.426***	2.530***	2.477***
	(0.442)	(0.389)	(0.397)	(0.221)	(0.222)	(0.231)
$z \times cluster$	0.046	0.111	-0.094	0.070	-0.056	0.012
	(0.114)	(0.097)	(0.095)	(0.050)	(0.056)	(0.029)
$z^2 \times cluster$	-0.005	-0.012*	0.008	-0.008	0.016	-0.001
	(0.008)	(0.008)	(0.007)	(0.005)	(0.015)	(0.003)
Year	0.011***	0.011***	0.012***	0.011***	0.011***	0.011***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$\ln(n+g+\delta)$	-0.412	-0.332	-0.420	-0.379	-0.325	-0.376
	(0.325)	(0.321)	(0.315)	(0.322)	(0.324)	(0.324)
$\ln(I/GDP)$	0.102***	0.100***	0.093***	0.100***	0.101***	0.104***
	(0.030)	(0.031)	(0.030)	(0.030)	(0.030)	(0.030)
$\ln(HC)$	0.587***	0.603***	0.535***	0.600***	0.574***	0.580***
	(0.156)	(0.154)	(0.153)	(0.154)	(0.156)	(0.157)
Intercept	6.945***	6.965***	6.856***	7.001***	6.977***	6.914***
	(0.176)	(0.174)	(0.175)	(0.175)	(0.178)	(0.177)

Note: In model 1, we have estimates with the overall institution index (z). The sub-index ($z_i; i = 1, ..., 5$) used in the various specification (models 2 – 6) are as follows: 2 – Public sector size (z_1), 3 — Reliability and fairness of the legal system (z_2), 4 – Liquidity market openness (z_3), 5 – Degree of (trade) protectionism (z_4), 6 – Regulation (z_5). Standard errors are in parentheses and * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ represent levels of significance.

that the effect on the long-run level of income of our aggregate measure for institutional quality (z) is essentially null in "low- and middle- income" countries (0.001) while it is positive (despite not statistically significant) in "high-income" countries (0.047). Parameter estimates for physical capital (0.102) and human capital (0.587), which are both statistically significant, are in line with the recent empirical literature based on MRW.[5]

[5]See e.g., Bucci et al. (2019a), for a study on non-OECD countries, and Bucci et al. (2019b), for a study on OECD countries.

The results presented in the remaining five alternative specifications (models 2 - 6) employ a set of covariates including one sub-index in each estimation. For "low- and middle-income" countries, the sub-index *Reliability and fairness of the legal system* (model 3) positively (0.058) and significantly (p-value<0.001) affects the level of income in the long-run while we find a negative impact of the *Liquidity market openness* (model 4) sub-index (-0.035, with a p-value<0.005).[6]

4.2.2 Institutions and GDP growth

The analysis conducted on the whole sample shows that improvements in the overall institutional quality (z) foster economic development in "low- and middle-income" countries. Table 5 reports the

Table 5: Mixed-Effect Estimates: Institutions and GDP growth

	Overall	Sub-indices				
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable: Real per capita GDP growth						
z	0.030***	-0.025**	0.009	-0.002	0.004	0.014*
	(0.009)	(0.012)	(0.008)	(0.008)	(0.008)	(0.007)
z^2	-0.002**	0.003*	-0.001	-0.001	-0.001	-0.001
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
cluster	0.159	0.199**	0.234	0.016	0.081***	0.064*
	(0.173)	(0.095)	(0.159)	(0.030)	(0.028)	(0.039)
$z \times cluster$	-0.030	-0.035	-0.069	-0.001	-0.070***	-0.006
	(0.048)	(0.031)	(0.045)	(0.022)	(0.026)	(0.014)
$z^2 \times cluster$	0.002	0.001	0.005*	0.001	0.012*	0.000
	(0.003)	(0.003)	(0.003)	(0.002)	(0.007)	(0.001)
Year	-0.0001	0.0001	0.0003	-0.0003	0.0002	0.0001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\ln(y)_{-1}$	-0.061***	-0.061***	-0.063***	-0.058***	-0.056***	-0.061***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.008)	(0.009)
$\ln(n+g+\delta)$	-0.724***	-0.770***	-0.700***	-0.700***	-0.643***	-0.688***
	(0.125)	(0.126)	(0.126)	(0.123)	(0.120)	(0.12)5
$\ln(I/GDP)$	0.159***	0.176***	0.171***	0.158***	0.166***	0.171***
	(0.013)	(0.014)	(0.013)	(0.013)	(0.013)	(0.013)
$\ln(HC)$	0.182***	0.186***	0.176***	0.183***	0.151***	0.175***
	(0.039)	(0.039)	(0.039)	(0.039)	(0.038)	(0.039)
Intercept	-0.057	0.047	0.009	0.056	0.011	-0.022
	(0.072)	(0.072)	(0.070)	(0.069)	(0.070)	(0.071)

Note: See notes under Table 4.

estimates of the growth regression model. The index z is found to have a positive impact (0.030 with a p-value <0.01) on the 5-year average real per capita GDP growth rate (model 1). The effect is not conclusive for "high-income" countries since the parameter for the interaction $z \times cluster$ is not

[6]This index is meant to capture the relative tightness (low values of the index) or ease of monetary policy (high values of the index). See Table A1 in the Appendix for further details.

statistically significant. The coefficients for physical capital (0.159) and human capital (0.182) are in line with the literature based on MRW while the coefficient for the lagged value of GDP (-0.061) indicates that there is a slight tendency toward convergence in our sample.

The results for the baseline growth regression when using the five alternative synthetic sub-indices taken in isolation are reported in models 2 - 6 of the table. There is evidence of *Public sector size* (z_1) being harmful for growth for "low- and middle-income" countries (-0.025, p-value<0.05) while the GDP growth effect of the *Degree of (trade) protectionism* (z_4) is negative in "high-income" countries (-0.070, p-value<0.01).

4.2.3 Estimates with all five sub-indices of institutions

Results in Table 6 present estimates for using all the five sub-indices of institutions ($z_i : i = 1, ..., 5$)

Table 6: Mixed-Effect Model, Institutions and GDP -level / -growth

	(1)		(2)	
z_1	-0.034	(0.028)	-0.027**	(0.012)
z_2	0.056***	(0.018)	0.005	(0.008)
z_3	-0.030*	(0.018)	-0.004	(0.008)
z_4	-0.012	(0.017)	0.006	(0.008)
z_5	0.006	(0.016)	0.011	(0.007)
z_1^2	0.007*	(0.004)	0.003*	(0.002)
z_2^2	-0.004*	(0.002)	-0.001	(0.001)
z_3^2	0.003	(0.002)	-0.001	(0.001)
z_4^2	0.002	(0.002)	-0.001	(0.001)
z_5^2	0.000	(0.002)	-0.001	(0.001)
cluster	2.080***	(0.547)	0.356*	(0.203)
$z_1 \times cluster$	0.116	(0.099)	-0.019	(0.032)
$z_2 \times cluster$	-0.056	(0.108)	-0.061	(0.047)
$z_3 \times cluster$	0.074	(0.053)	-0.001	(0.024)
$z_4 \times cluster$	-0.074	(0.059)	-0.054**	(0.027)
$z_5 \times cluster$	0.007	(0.030)	-0.004	(0.014)
$z_1^2 \times cluster$	-0.012	(0.008)	0.000	(0.003)
$z_2^2 \times cluster$	0.006	(0.008)	0.005	(0.003)
$z_3^2 \times cluster$	-0.009	(0.006)	0.002	(0.003)
$z_4^2 \times cluster$	0.021	(0.015)	0.008	(0.007)
$z_5^2 \times cluster$	0.0003	(0.003)	-0.00001	(0.001)
Year	0.011***	(0.002)	-0.0001	(0.001)
$\ln(y)_{-1}$			-0.053***	(0.010)
$\ln(n + g + \delta)$	-0.476	(0.331)	-0.718***	(0.129)
$\ln(I/GDP)$	0.097***	(0.031)	0.158***	(0.013)
$\ln(HC)$	0.685***	(0.159)	0.167***	(0.040)
Intercept	6.838***	(0.183)	0.037	(0.079)

Note: Models (1) and (2) uses the log of real per capita GDP and GDP growth rates as dependent variables. See notes under Table 4.

as regressors together with the other covariates. From model 1 of the table, we find a positive and statistically significant impact on GDP (0.056, p-value<0.01) of the sub-index *Reliability and fairness of the legal system* in "low- and middle-income" countries.

In the growth specification (model 2), the sub-indices that have statistically significant effects are *Public sector size* for "low- and middle-income" countries (-0.027, p-value<0.05) and the *Degree of (trade) protectionism* (z_4) for "high-income" countries (-0.054, p-value<0.05).

4.3 Generalized Propensity Score Analysis

We use the Generalized Propensity Score (GPS) estimator to evaluate the causal effect of each treatment on GDP dynamics. Tables 7 and 8 report the estimates while Figures 2 and 3 present dose-response curves for "high-income" (solid line) and "low- and middle-income" (dotted line) countries in models 1 - 6.

Table 7: GPS Estimates: Institutions and GDP level

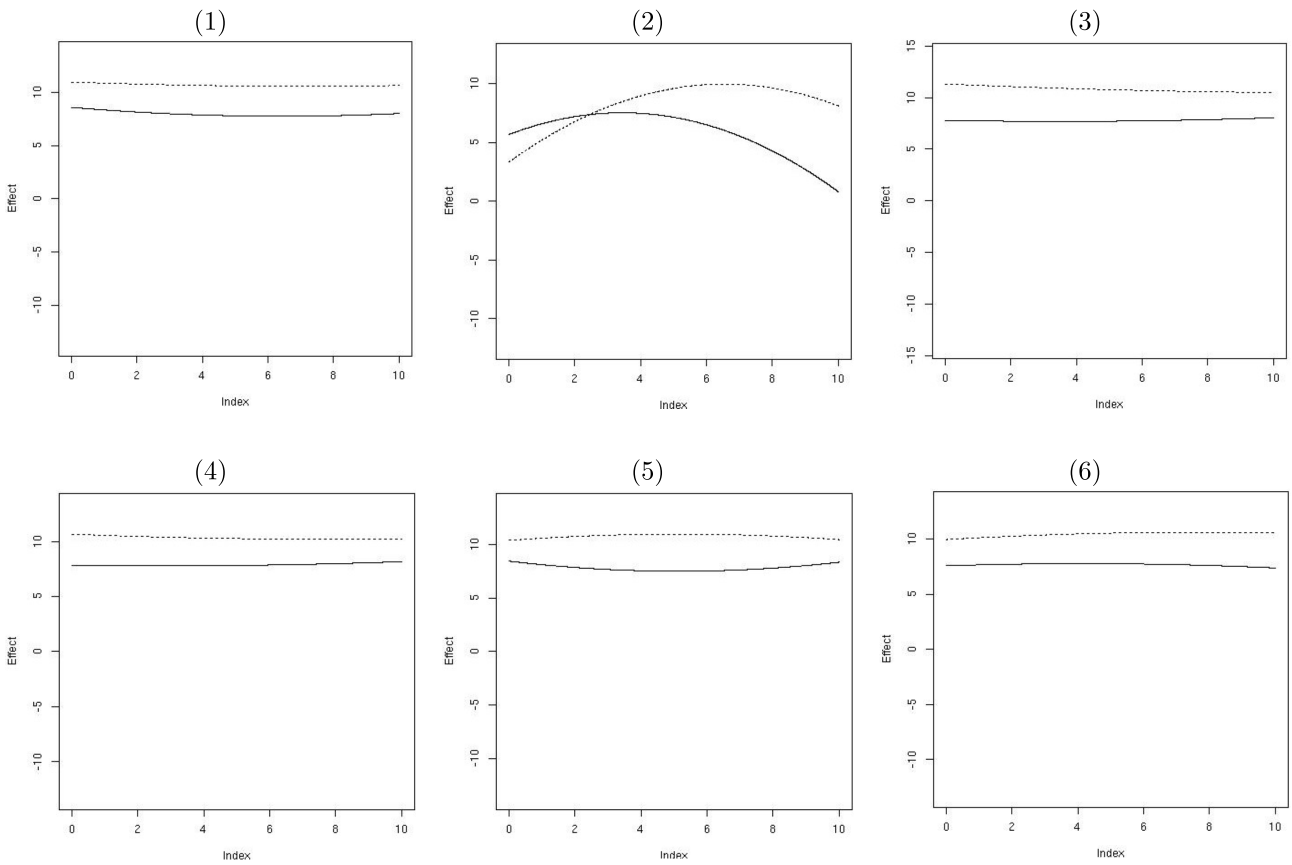
	Overall	Sub-indices				
	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: Log of Real per capita GDP					
z	0.068	-0.152	-0.057	0.015	-0.281***	0.017
	(0.118)	(0.111)	(0.087)	(0.090)	(0.076)	(0.086)
z^2	0.020	-0.156***	0.008	0.007	0.036***	-0.012
	(0.012)	(0.032)	(0.015)	(0.012)	(0.010)	(0.008)
$\hat{z}$	0.254	0.701***	0.069	-0.128	-0.678***	0.250**
	(0.242)	(0.120)	(0.117)	(0.119)	(0.103)	(0.127)
$\hat{z}^2$	0.006	-0.214***	0.011	0.039	0.070***	-0.037**
	(0.026)	(0.039)	(0.021)	(0.024)	(0.020)	(0.018)
cluster	1.857	3.563***	2.625*	2.928***	1.189***	2.557***
	(1.839)	(0.553)	(1.357)	(0.187)	(0.202)	(0.309)
$z \times \hat{z}$	-0.049*	0.359***	0.000	-0.022	-0.026	0.019
	(0.029)	(0.068)	(0.029)	(0.029)	(0.022)	(0.016)
$z \times cluster$	0.225	-0.342*	-0.080	-0.116	0.531**	0.059
	(0.497)	(0.195)	(0.388)	(0.205)	(0.230)	(0.140)
$z^2\hat{c}luster$	-0.012	0.001	-0.003	0.001	-0.058	0.000
	(0.034)	(0.018)	(0.027)	(0.024)	(0.063)	(0.014)
Intercept	6.622***	6.142***	7.259***	7.802***	9.759***	7.273***
	(0.707)	(0.203)	(0.213)	(0.129)	(0.175)	(0.256)

Note: Models 1 to 6 uses the Main Institutional Index and the sub-indices in the various estimations. See notes under Table 4.

From Table 7 and Figure 2, we see that with the partial exception of *Public sector size* (z_1) (see the second plot of Figure 2 in which the dotted lines do not always lie above the solid ones), an improvement in institutional quality causes a more pronounced level effect on GDP in "high-income" countries.

Moreover, an interesting non-linear relationship emerges in the causal effect of *Public sector size* (z_1), where the intensity tends to decline for larger values of the sub-index.

Figure 2: Dose-response: Causal effect of institutions on GDP level



Note: The treatments used in the various panels are (1) – Main Institutional Index (z), (2) – Public sector size (z_1), (3) – Reliability and fairness of the legal system (z_2), (4) – Liquidity market openness (z_3), (5) – Degree of (trade) protectionism (z_4), (6) – Regulation (z_5).

Also, estimates in Table 8 and the dose-response curves in Figure 3 exhibit some form of non-linearity in the causal effect of institutions on growth. The overall index (z) and sub-indices such as *Public sector size* (z_1), *Reliability and fairness of the legal system* (z_3), and *Regulation* (z_4) display a concave pattern. Focusing only on the statistically significant effects, we find that institutional improvements to legal structure and security of property rights are an important source of growth in "low- and middle-income" countries. Moreover, a lax monetary policy, that is, higher values of the sub-index *Liquidity market openness* (z_3), appears to be detrimental for the economic development of less advanced economies.

Table 8: GPS Estimates: Institutions and GDP growth

	Overall	Sub-indices				
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable: Real per capita GDP growth						
z	0.046***	0.008	0.011	0.004	0.019*	0.017
	(0.015)	(0.017)	(0.012)	(0.011)	(0.011)	(0.011)
z^2	-0.005***	-0.014***	-0.003	-0.005***	-0.002	-0.003***
	(0.002)	(0.005)	(0.002)	(0.002)	(0.001)	(0.001)
$\hat{z}$	-0.066**	0.000	-0.023	-0.042***	-0.044***	0.026
	(0.030)	(0.019)	(0.016)	(0.014)	(0.014)	(0.016)
$\hat{z}^2$	0.004	-0.011*	0.000	0.004	0.005*	-0.005**
	(0.003)	(0.006)	(0.003)	(0.003)	(0.003)	(0.002)
cluster	0.036	0.076	0.034	-0.011	0.015	0.043
	(0.227)	(0.086)	(0.186)	(0.023)	(0.028)	(0.039)
$z \times \hat{z}$	0.004	0.024**	0.004	0.005	-0.002	0.003
	(0.004)	(0.011)	(0.004)	(0.004)	(0.003)	(0.002)
$z \times cluster$	0.004	-0.028	-0.019	-0.025	-0.085***	-0.018
	(0.061)	(0.030)	(0.053)	(0.025)	(0.032)	(0.018)
$z^2 \times cluster$	-0.001	0.003	0.001	0.006*	0.014	0.002
	(0.004)	(0.003)	(0.004)	(0.003)	(0.009)	(0.002)
Intercept	0.111	0.075**	0.098***	0.138***	0.151***	-0.011
	(0.087)	(0.032)	(0.029)	(0.016)	(0.024)	(0.033)

Note: Models 1 to 6 uses the Main Institutional Index and the sub-indices in the various estimations. See notes under Table 4.

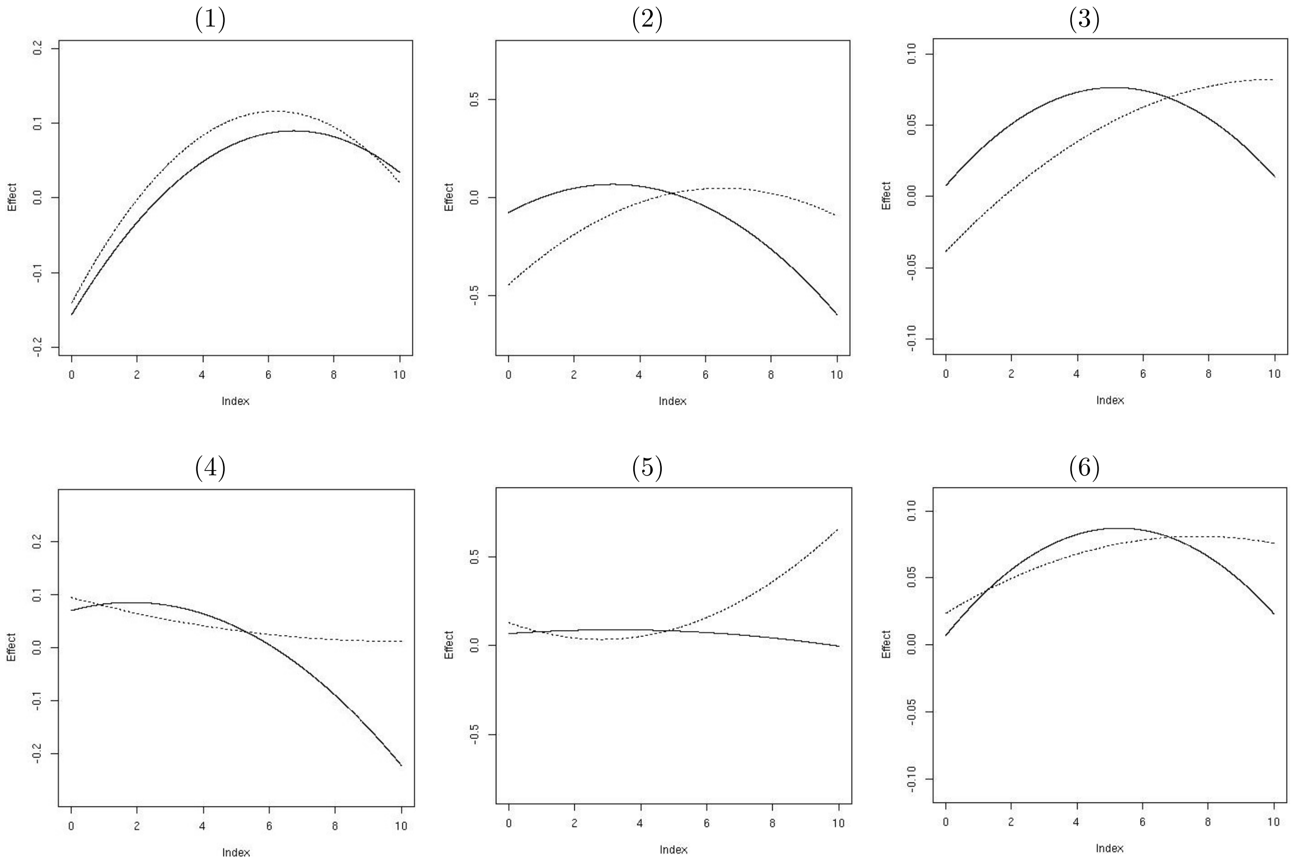
4.4 Sub-sample Analysis

With the copious number of studies revealing institutional lapses in developing countries, Tables B1, B2, and B3 as well as Tables B4 and B5 (all of them in the Appendix), report results of the analysis conducted on a restricted sub-sample of "low- and middle-income" countries when using the mixed effect and GPS approaches, respectively.[7] Notice that in this sub-sample analysis, we do not include the interaction $z - cluster$, since it is not identifiable in the sub-sample. The reason is that we stratified by cluster and this variable is a constant in each sub-sample.

From the results presented in Tables B1 and B2, we find no significant effect of institutions on GDP level but a positive linear effect (0.027, p-value<0.01) on its growth rate. In terms of the sub-indices, we observe a non-linear relationship between GDP dynamics and *Public sector size* (z_1) as well as *Degree of (trade) protectionism* (z_6), such that increases in the sub-indices causes higher income and faster growth only if they do not exceed values around 4. There is also a significant non-linear

[7] More estimates within the sample can be found in the online appendix especially when we exclude countries such as Chile, Malaysia, Portugal, and Uruguay from the sample. These four countries were in the high-income group according to the World Bank income classification as of the year 2015. This leaves us with 53 instead of 57 "low- and middle-income" countries.

Figure 3: Dose-response: Causal effect of institutions on GDP growth



Note: See notes under Figure (2).

relationship between GDP growth and *Liquidity market openness* (z_4) but the effect is weak and decreases at higher values (-0.001, p-value<0.10) of (z_4).

Such non-linearities appear even clearer from the dose-response curves shown in Figures B4 and B5. The beneficial effect on GDP due to improvements in institutions (z) emerges only for higher values of the index ($z > 5$), as shown in Panel (1) of Figure B4. Almost the opposite instead occurs when we assess the causal impact of z on GDP growth, with a dose-response plot showing a concave pattern, as illustrated in Panel (1) of Figure B5.

4.5 Threshold Effects

We have documented that advances in a country's institutional indices produce different (and potentially non-linear) effects on GDP (levels and growth rates), depending on whether the country belongs to the "high-income" or the "low- and middle-income" cluster. As an additional sensitivity check, in this paragraph, we briefly assess the existence of non-linearities between institutions and economic growth, according to the classifications in Table 3. To do this, we employ a dynamic panel threshold strategy, which allows for non-linear asymmetric dynamics, unobserved heterogeneity, and treats economic institutions as an endogenous variable.[8] For the sake of space, we restrict our attention to the relationship between our optimal institutional index and the GDP growth rate.

The model considered is of the form:

$$\triangle y_{it} = \lambda \triangle y_{it-1} + \triangle x'_{it}\beta + (1, x'_{it})\delta 1\{\hat{z}_{it} > \gamma\} - (1, x'_{it-1})\delta 1\{\hat{z}_{it-1} > \gamma\} + \triangle \epsilon_{it}, \tag{8}$$

where y_{it} is the natural logarithms of real per capita GDP, z_{it} is our optimal measure of institutions (transition variable) and x_{it} is a set of covariates including natural logarithms of total population, human and physical capital. Also, γ is the threshold parameter and the error term, ϵ_{it}. We used lagged values of political institutions as one of the instruments that lead to the selection of economic institutions together with the other exogenous regressors in an attempt to address endogeneity.[9]. From the equation, the hypothesis of interest is the null, $H_0 : \delta = 0$ as against the alternative $H_1 : \delta \neq 0$. Using the first difference generalized method of moments estimator (FD-GMM), models 1, 2, and 3 of Table 9 presents the results with the full, "high-income", and "low- and middle-income" samples, respectively. To have comparable results, we report the long-run estimates, where, $\hat{\phi} = (1 - \hat{\lambda})^{-1}\hat{\beta}$ and $\hat{\tau} = (1 - \hat{\lambda})^{-1}\hat{\delta}$ are estimates for countries below and above the estimated threshold effects in each cluster, respectively.

The F-statistic to test the strength of the excluded instrumental variable is above the critical value of 10 for "high-income" countries and close to the 10 for "low- and middle-income" countries and the overall sample. In general, the estimated threshold effects ($\hat{\gamma}$) are statistically significantly different from zero and similar to those reported in Acquah (2021). Particularly, for economic institutions to influence GDP growth, it must on average develop to a point of 6, 8, and 7 (out of a score of 10) for the full sample of 80, "high-income" and "low- and middle-income" countries, respectively. Since the threshold variable is unit-free, we interpret the estimated long-run effect of institutions towards GDP growth in reference to the estimated threshold parameter ($\hat{\gamma}$) as a way of providing some understanding into the gains or losses of institutions for countries whose institutional developments are below ($\hat{\phi}_{\triangle q}$) and above ($\hat{\tau}_{\triangle q}$) the estimated threshold effect in what follows. Below the threshold, improvements in the institutional index are associated in the long-run with an increase of the GDP growth rate by 0.21% for the "low- and middle-income" countries. Above the threshold instead, changes in the institutional index leads to a decline of the growth rate by 0.015% in the full sample and an increase in the growth rate for the "high-income" countries by 0.4%.

[8]Acquah (2021) follows a similar exercise (refer for further details on the methodology).
[9]See Acquah (2021) for a detailed discussion of this point.

Table 9: Institutional Threshold Effects

	(1)	(2)	(3)
$\hat{\gamma}$	6.146***	8.213***	7.003***
	(0.162)	(0.276)	(0.560)
$\phi_{\triangle z}$	0.022	0.029	0.208***
	(0.015)	(0.030)	(0.064)
$\phi_{\triangle hc}$	4.867***	3.079***	4.008***
	(0.421)	(1.159)	(0.890)
$\phi_{\triangle pop}$	-0.229	-0.148	0.524
	(0.149)	(0.343)	(0.433)
$\phi_{\triangle pc}$	0.094**	-0.265	0.456***
	(0.043)	(0.376)	(0.151)
$\tau_{\triangle z}$	-0.015***	0.400***	0.003
	(0.004)	(0.100)	(0.013)
$\tau_{\triangle hc}$	-0.356***	-0.034	-0.133**
	(0.034)	(0.654)	(0.054)
$\tau_{\triangle pop}$	-0.005*	-0.136	-0.038***
	(0.003)	(0.106)	(0.006)
$\tau_{\triangle pc}$	0.200***	0.636*	0.168***
	(0.008)	(0.330)	(0.026)
$\tau_{intercept}$	-0.028	-2.653	0.653***
	(0.080)	(2.314)	(0.149)
F-statistics	9.41	21.02	8.95
P-value	[0.002]	[0.000]	[0.003]
N	80	23	57

Note: Estimates follow equation (4) of Acquah (2021) when using the FD-GMM estimator. Results in models 1, 2, and 3 uses the full (80 countries), Clusters 2 (23 high -) and 1 (57 low- and middle-) income countries as reported in Table 3. The F-statistic to test the strength of the instrumental variable (lagged values of political institutions) is the Cragg-Donald Wald F statistic. Standard errors in parentheses and * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ represent levels of significance.

5 Concluding remarks

Building on Frazer Institute (2018), we have proposed a dimension reduction approach to obtain a new set of indices to summarize the multidimensionality of a country's institutional quality. To identify the causal effect of these brand-new measures of institutional quality on GDP (levels and growth rate) we have employed the Generalized Propensity Score estimation approach. Using a large sample of countries over the period 1980-2015, our analysis has documented the positive and statistically significant impact that improvements in institutional quality have on the growth rate of per capita GDP, in the economies that, according to our classification, belong to the cluster of "low- and middle-income".

Our causal analysis has also shown non-linearities in the effects that different institutions have on income and growth. The sub-index that captures the extent of public intervention into an economy, which we term *Public sector size* (z_1), has displayed a concave pattern in both regression models. Improvements of this policy index produce gains in terms of higher income and faster growth especially in less advanced economies, provided that the value of the sub-index is not too high. Despite often not statistically significant, improvements in all the other considered institutions cause a positive level effect that is larger for "low- and middle-income" countries.

The Mixed-Effect Model has also stressed on the role of the reliability and fairness of the legal system as a crucial driver for economic development. This result is reminiscent of La Porta et al. (2008) and has several policy implications. Specifically, our analysis reveals that the design and the implementation of legal reforms appear to be particularly important in "low- and middle-income" countries. Policy interventions aimed at improving this institution are complex. Such interventions pertain to i) drafting and enacting of laws and regulations, ii) enforcing laws and regulations, and iii) resolving and settling disputes. Like many economists, political scientists, and legal scholars have pointed out, however, legal reforms in society emerge as an equilibrium outcome, thus reflecting the balance between different interests of different social groups.[10] Moreover, the so-called "legal transplant" has rarely turned out to be successful (Aldashev (2009)).

Finally, we have documented the presence of interesting threshold effects: again, the advances in institutional quality are particularly important for those countries which are below the estimated threshold and belong to the cluster of "low- and middle-income" countries.

[10]See e.g., Besley and Ghatak (2009).

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Appendix A Variable Description

Table A1: Variables used in the construction of the optimal institutional indices

Public sector size (z_1)	Liquidity market openness (z_3)
1A. Government consumption	3A. Money growth
1B. Transfers and subsidies	3B. Standard deviation of inflation
1C. Government investment	3C. Inflation: Most recent year
1D. Top marginal tax rate	3D. Freedom to own foreign currency bank accounts
1E. State ownership of assets	
	Degree of (trade) protectionism (z_4)
Reliability and fairness of the legal system (z_2)	4A. Tariffs
2A. Judicial independence	4B. Regulatory trade barriers
2B. Impartial courts	4C. Black market exchange rates
2C. Protection of property rights	4D. Controls of the movement of capital and people
2D. Military interference in rule of law and politics	
2E. Integrity of the legal system	Regulation (z_5)
2F. Legal enforcement of contracts	5A. Credit market regulations
2G. Regulatory restrictions on the sale of real property	5B. Labor market regulations
2H. Reliability of police	5C. Business regulations
Overall institutional index (z)	
z_1, z_2, z_3, z_4, and z_5	

Note: Authors' construct compiled from Frazer Institute (2018). See the Appendix Explanatory Notes and Data Sources from Frazer Institute (2018) for the detailed definition of variables.

Table A2: *Data Description and Source*

Variable	Description	Source
Dependent Variable		
y	Real per capita GDP based on constant 2010 international U.S. dollars.	The World Bank (2018)
Growth	Percentage growth rate of per capita GDP (constant 2010 international U.S. dollars) based on the difference between the natural logarithms of current real per capita GDP and their past values ($(\ln)\frac{y_t}{y_{t-1}}$).	The World Bank (2018)
Overall Institutional Index		
z	Main institutional index. It measures the extent to which the institutions and policies of a country are consistent with the protective function and the freedom of individuals in making their own economic decisions	Our elaboration on Frazer Institute (2018)

Continued on next page

Data Description and Source (continued from previous page)

Variable	Description	Source
Sub-indices		
z_1	Public sector size in terms of expenditures, taxes, and public enterprises.	Our elaboration on Frazer Institute (2018)
z_2	Reliability and fairness of the legal system. It measures the reliability of legal structure and the security of property rights.	Our elaboration on Frazer Institute (2018)
z_3	Liquidity market openness. It captures the consistency of monetary policies with long-term price stability and the ease with which foreign currencies can be used in both domestic and foreign banks.	Our elaboration on Frazer Institute (2018)
z_4	Degree of (trade) protectionism. It measures the freedom of exchange across national boundaries.	Our elaboration on Frazer Institute (2018)
z_5	Regulation. It measures the strength of regulation in credit, labor, and goods and service markets.	Our elaboration on Frazer Institute (2018)
Controls		
y_{-1}	Initial level of income measured as the lagged values of natural logarithms of per capita GDP (constant 2010 international U.S. dollars).	The World Bank (2018)
I/GDP	Investment rate. Physical capital measured as gross fixed capital formation (% of GDP).	The World Bank (2018)
$n + g + \delta$	Population growth + 0.05 (imposing a 3% technological growth + 2% depreciation). The population growth is the difference between current and past natural logarithms of total population based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.	The World Bank (2018)
HC	Human capital index measured as the years of schooling and returns to education	PWT (2018)
cluster	Binary variable equals to 1 if a country is classified as "high-income" based on their initial income as at 1985 and zero others	Authors' construct from The World Bank (2018).

Sources: Authors' construct compiled from The World Bank (2018), PWT (2018), Frazer Institute (2018).

Appendix B Sub-sample analysis

B.1 Sub-sample Estimates

The following results are estimates when using the sub-sample of 57 "low- and middle- income " countries.

Table B1: Mixed-Effect Model, Sub-sample analysis, Institutions and GDP level

	Overall	Sub-indices				
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable: Log of Real per capita GDP						
z	0.013	-0.038	0.058***	-0.033	-0.022	0.017
	(0.023)	(0.031)	(0.020)	(0.020)	(0.020)	(0.018)
z^2	-0.001	0.007*	-0.004*	0.003	0.002	-0.001
	(0.002)	(0.005)	(0.002)	(0.002)	(0.002)	(0.002)
Year	0.008***	0.008***	0.009***	0.008***	0.008***	0.008***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
$\ln(n+g+\delta)$	-1.127**	-1.052**	-1.165***	-1.081**	-1.070**	-1.074**
	(0.463)	(0.460)	(0.451)	(0.460)	(0.464)	(0.460)
$\ln(I/GDP)$	0.121***	0.121***	0.115***	0.120***	0.127***	0.124***
	(0.037)	(0.037)	(0.036)	(0.036)	(0.037)	(0.036)
$\ln(HC)$	0.633***	0.682***	0.603***	0.678***	0.683***	0.624***
	(0.222)	(0.221)	(0.218)	(0.221)	(0.224)	(0.221)
Intercept	6.984***	7.004***	6.908***	7.044***	7.006***	6.969***
	(0.220)	(0.217)	(0.216)	(0.218)	(0.220)	(0.220)

Note: Models 1 to 6 uses the Main Institutional Index and the sub-indices in the various estimations where: 1 – Main Institutional Index (z), 2 – Public sector size (z_1), 3 — Reliability and fairness of the legal system (z_2), 4 – Liquidity market openness (z_3), 5 – Degree of (trade) protectionism (z_4), 6 – Regulation (z_5). Standard errors are in parentheses and * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ represent levels of significance.

Table B2: Mixed-Effect Model, Sub-sample analysis, Institutions and GDP growth

	Overall	Sub-indices				
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable: Real per capita GDP growth						
z	0.027***	-0.024*	0.009	-0.003	0.006	0.012
	(0.010)	(0.013)	(0.009)	(0.008)	(0.009)	(0.008)
z^2	-0.002	0.003*	-0.001	-0.001	-0.001*	-0.001
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Year	0.0001	0.001	0.001	0.0001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$ln(y)_{-1}$	-0.056***	-0.055***	-0.057***	-0.054***	-0.053***	-0.055***
	(0.009)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
$\ln(n+g+\delta)$	-0.841***	-0.811***	-0.826***	-0.834***	-0.803***	-0.808***
	(0.159)	(0.160)	(0.160)	(0.157)	(0.157)	(0.161)
$\ln(I/GDP)$	0.152***	0.171***	0.165***	0.152***	0.163***	0.166***
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
$\ln(HC)$	0.176***	0.168***	0.166***	0.177***	0.147***	0.160***
	(0.042)	(0.043)	(0.042)	(0.042)	(0.041)	(0.042)
Intercept	-0.050	0.023	-0.003	0.061	0.013	-0.025
	(0.077)	(0.079)	(0.076)	(0.075)	(0.078)	(0.078)

Note: See notes under B1.

Table B3: Mixed-Effect Model: institutions and GDP -level/ - growth

	(1)		(2)	
z_1	-0.029	(0.032)	-0.027**	(0.013)
z_2	0.056***	(0.021)	0.006	(0.009)
z_3	-0.028	(0.020)	-0.005	(0.008)
z_4	-0.014	(0.020)	0.007	(0.009)
z_5	0.008	(0.018)	0.010	(0.008)
z_1^2	0.006	(0.005)	0.003*	(0.002)
z_2^2	-0.004*	(0.002)	-0.001	(0.001)
z_3^2	0.002	(0.002)	-0.001	(0.001)
z_4^2	0.002	(0.002)	-0.001	(0.001)
z_5^2	-0.0004	(0.002)	-0.001	(0.001)
Year	0.008***	(0.003)	0.000	(0.001)
$\ln(y)_{-1}$			-0.049***	(0.010)
$\ln(n+g+\delta)$	-1.156**	(0.463)	-0.809***	(0.161)
$\ln(I/GDP)$	0.116***	(0.037)	0.155***	(0.015)
$\ln(HC)$	0.742***	(0.222)	0.165***	(0.044)
Intercept	6.888***	(0.224)	0.027	(0.086)

Note: Models (1) and (2) uses (ln) real per capita GDP and real per capita GDP growth as dependent variable while controlling for all 5 sub-dimensions of institution where, z_1 – Public sector size, z_2 — Reliability and fairness of the legal system, z_3 – Liquidity market openness, z_4 – Degree of (trade) protectionism, z_5 – Regulation. Standard errors are in parentheses and * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ represent levels of significance.

Table B4: GPS Estimates, Sub-sample analysis: Institutions and GDP level

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: Log of Real per capita GDP					
	Overall	Sub-indices				
z	0.053	0.030	-0.040	-0.038	-0.188**	0.013
	(0.139)	(0.159)	(0.107)	(0.108)	(0.089)	(0.107)
z^2	0.025*	-0.156***	0.008	0.007	0.034***	-0.006
	(0.015)	(0.039)	(0.018)	(0.014)	(0.012)	(0.010)
$\hat{z}$	0.513	0.386*	0.036	-0.002	-0.935***	0.423**
	(0.318)	(0.211)	(0.154)	(0.146)	(0.136)	(0.200)
$\hat{z}^2$	-0.012	-0.132**	0.019	0.016	0.108***	-0.056**
	(0.034)	(0.064)	(0.027)	(0.030)	(0.025)	(0.027)
$z \times \hat{z}$	-0.056	0.295***	-0.005	-0.011	-0.042	0.010
	(0.034)	(0.090)	(0.034)	(0.034)	(0.026)	(0.021)
Intercept	5.921***	6.340***	7.281***	7.724***	10.040***	6.986***
	(0.878)	(0.252)	(0.257)	(0.152)	(0.212)	(0.360)

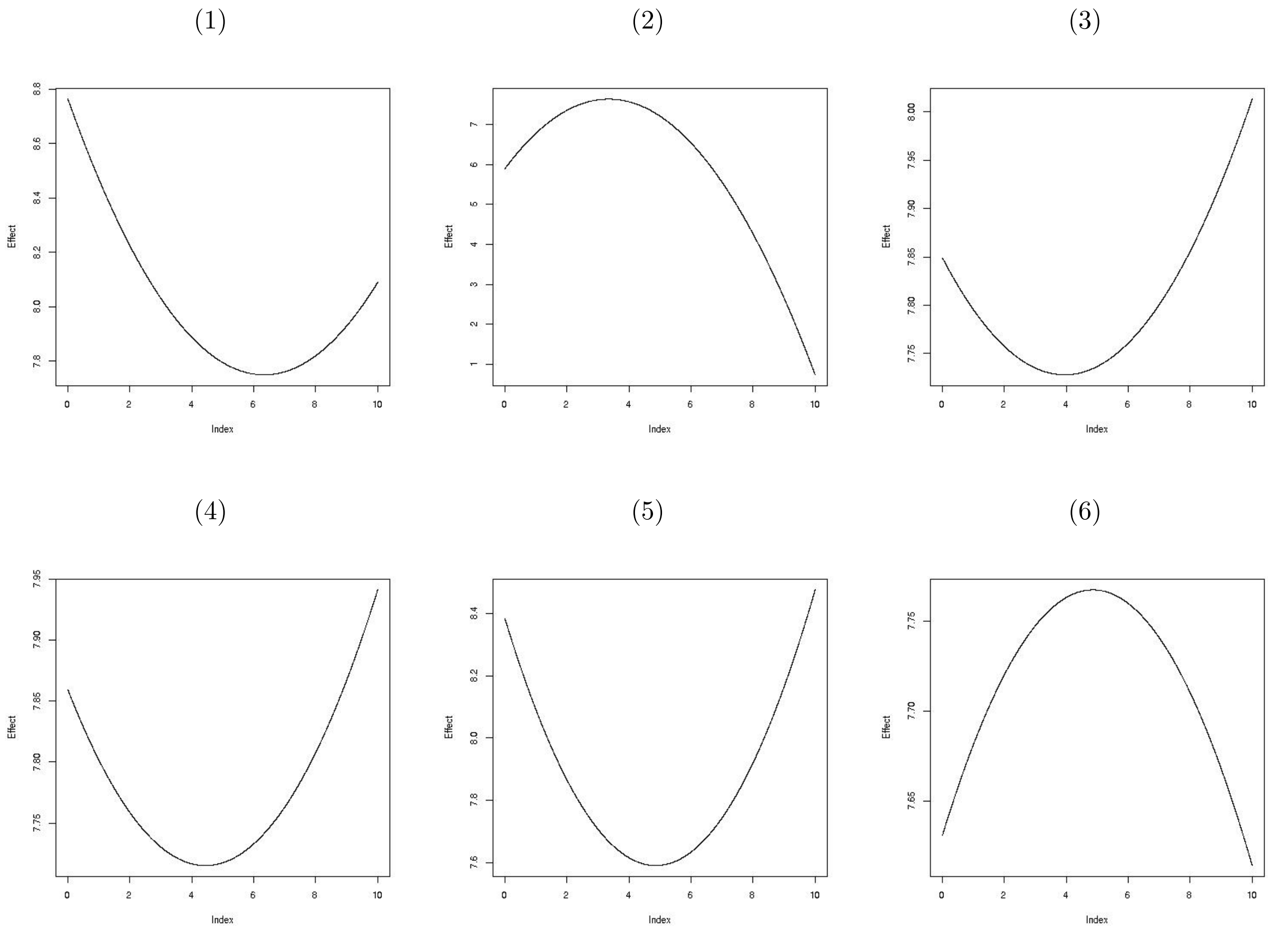
Note: See notes under B1.

Table B5: GPS Estimates, Sub-sample analysis: Institutions and GDP growth

	Overall	Sub-indices				
	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: Real per capita GDP growth					
z	0.048***	0.005	0.020	0.007	0.021*	0.013
	0.016	0.024	0.014	0.012	0.012	0.013
z^2	-0.005***	-0.017***	-0.003	-0.005***	-0.002	-0.003**
	0.002	0.006	0.002	0.002	0.002	0.001
$\hat{z}$	-0.077**	0.000	-0.042**	-0.047***	-0.051***	0.046*
	0.037	0.032	0.020	0.017	0.019	0.024
$\hat{z}^2$	0.005	-0.014	0.004	0.005	0.006*	-0.008**
	0.004	0.010	0.004	0.003	0.003	0.003
$z \times \hat{z}$	0.004	0.030**	0.002	0.005	-0.002	0.004
	0.004	0.014	0.004	0.004	0.004	0.003
Intercept	0.131	0.079**	0.117***	0.141***	0.158***	-0.034
	0.103	0.038	0.033	0.017	0.029	0.044

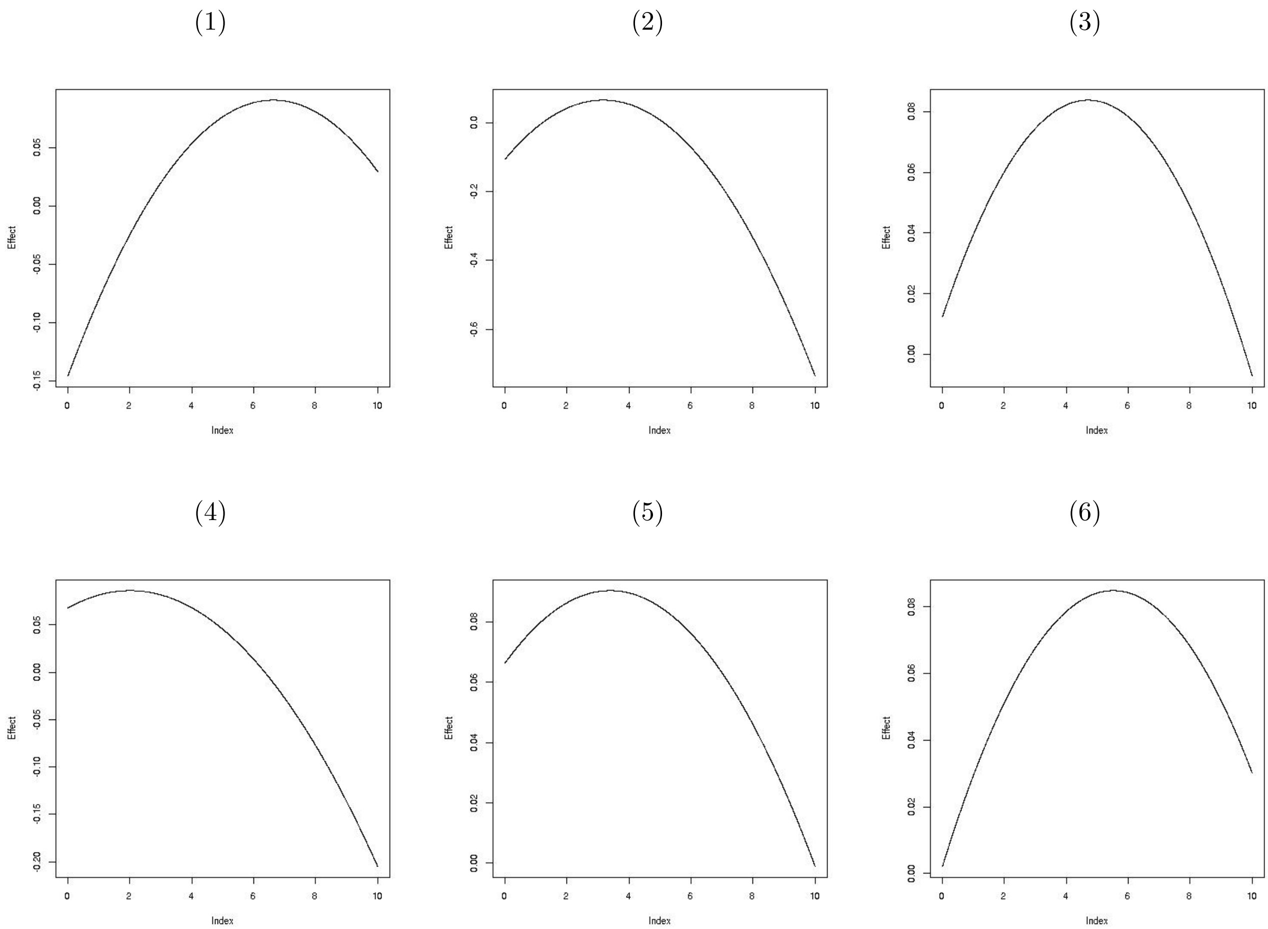
Note: See notes under B1.

Figure B4: Dose-response, Sub-sample analysis: Causal effect of institutions on GDP level



Note: The various plots are the dose-response curves when using the generalized propensity score estimator to evaluate the causal effect of each treatment on GDP level for low-/ middle-income from models 1 – 6. The various treatment are (1) – Main Institutional Index (z), (2) – Public sector size (z_1), (3) – Reliability and fairness of the legal system (z_2), (4) – Liquidity market openness (z_3), (45) – Degree of (trade) protectionism (z_4), (6) – Regulation (z_5).

Figure B5: Dose-response, Sub-sample analysis: Causal effect of institutions on GDP growth



Note: The various plots are the dose-response curves when using a generalized propensity score estimator to evaluate the causal effect of each treatment on GDP growth for low-/ middle-income from models 1 – 6. See notes under B4.