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Empirical Economics

DOI:
10.1007/s00181-021-02175-4

Published: 01/09/2022

Peer reviewed version

November 10, 2021

Does institutional quality foster economic complexity? The fundamental drivers of productive capabilities

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Abstract

This study investigates the extent to which the quality of institutions helps shape international differences in economic complexity – a novel measure of productive capabilities. More specifically, economic complexity, which is highly predictive of future patterns of growth and development, corresponds to an enhanced capacity to produce and export a diverse range of sophisticated (high-productivity) products. This paper hypothesizes that there exists a positive association between institutional quality and economic complexity across the globe. The underlying intuition is that well-functioning institutions fundamentally drive structural transformation towards productive activities *via* strengthening incentives for innovative entrepreneurship, fostering human capital accumulation, and deploying human resources in acquiring productive capabilities. Employing data for up to 115 countries, I consistently obtain precise estimates of the positive effect of institutional quality, measured by the Economic Freedom of the World Index, on economic complexity. The main findings advocate for establishing a pro-development institutional environment, which helps attenuating the persistence of underdevelopment by fostering the level of economic complexity.

Key words: Institutions, Economic freedom, Economic complexity, Productive capabilities.

JEL Classification: O43, O11, H11.

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Acknowledgement: I wish to thank Professor Dorian Owen for his generous support from immature ideas to the end of this research. I am also grateful to an Associate Editor (Professor Christopher O'Donnell) and two anonymous reviewers for many helpful suggestions. My gratitude extends to Professors Alfred Haug and David Flath for their constructive comments on an earlier version of this paper. This study benefits from financial support from the University of Otago provided in the form of a Doctoral scholarship. All errors remain my responsibility.

1. Introduction

One of the most intriguing and difficult questions in economics is "why are some countries more affluent than others?". Several influential contributions to this body of research postulate that economic complexity helps explain the worldwide distribution of income per capita (Hidalgo & Hausmann, 2009; Hausmann & Hidalgo, 2011; Hausmann et al., 2014; Hidalgo, 2021). Accordingly, complex economies producing (and exporting) a diverse range of sophisticated (high-productivity) products, including automobiles, electronics, and chemicals, are more likely to experience sustained growth (Felipe et al., 2012; Hidalgo, 2021). By contrast, countries whose economic structures comprise of less complex (low-productivity) products, such as raw materials, wood, and textiles, tend to suffer from persistent underdevelopment. More specifically, economic complexity provides an internationally comparable measure of productive capabilities based on the mix of products embedded in a country's economic structures (Hidalgo & Hausmann, 2009). The underlying intuition is that an enhanced ability to produce a variety of sophisticated products, typically characterized by high and increasing returns, reflects the amount of productive knowledge within an economy (Hidalgo & Hausmann, 2009; Felipe et al., 2012; Hidalgo, 2021).

Recent studies find suggestive evidence that economic complexity matters for many economic outcomes (Hidalgo, 2021). For example, Hartmann et al. (2017) and Lee and Vu (2020) reveal that economic complexity is associated with less income inequality. Using international and subnational data, several papers empirically establish a positive association between complexity and the rates of economic growth (Hidalgo & Hausmann, 2009; Zhu & Li, 2017; Gao & Zhou, 2018). Other scholars put forward that complex economies enjoy better health outcomes (Vu, 2020), higher workers' share of income (Arif, 2021), and lower levels of greenhouse gas emissions per capita (Romero & Gramkow, 2021). Overall, the existing literature reveals that economic complexity is a key determinant of cross-country comparative development. Therefore, a better understanding of the root causes of international differences in complexity plays an important role in formulating relevant policies that help alleviate the persistence of underdevelopment in many parts the world.

There exist several empirical attempts at establishing the driving forces of economic complexity, including, but not limited to, internet usage (Lapatinas, 2019), security of property rights (Sweet & Maggio, 2015), foreign direct investment (Zhu & Fu, 2013; Kannen, 2020), human capital accumulation (Hausmann et al., 2007), R&D investment (Zhu & Fu, 2013), and demographic characteristics (Vu, 2021c). However, previous studies have predominantly established a mere correlation between economic complexity and development outcomes (Hidalgo, 2021). Importantly, empirical estimation of the drivers of economic complexity requires attention to potential selection bias from unobservables, reverse causality, and measurement issues. It is noteworthy that the use of the aforementioned 'proximate' determinants of development to explain the worldwide distribution of economic complexity is unsatisfactory from a theoretical perspective. For example, foreign investment, income levels and economic complexity are interrelated with and jointly determined by each other, making it difficult to identify the root causes of complexity.

Considering these concerns, I draw on a parallel and well-established line of research positing that institutions are the fundamental determinants of long-run economic performance. The institutional theory of comparative development can be traced back to the seminal contribution of North (1990, p. 3) who views institutions as *'the rules of the game in a society, or, more formally, … the humanly devised constraints that shape human interaction'*. Good institutions, reflected in security of property rights or competitive markets, affect the relative returns to different productive and non-productive economic activities. Hence, the quality of institutions fundamentally drives investments in human and physical capital and innovative activities, leading to substantial and persistent variation in income per capita across the world. It is noteworthy that poor-quality economic or political institutions remain an enduring feature of many societies throughout the globe, widely attributed to a country's geographic or historical characteristics (Acemoglu et al., 2001; Spolaore & Wacziarg, 2013). Hence, deeply rooted institutional characteristics plausibly provide a more fundamental explanation for substantial and persistent differences in economic complexity across countries (Vu, 2021b).

Against this background, this study attempts to identify the effect of deeply rooted institutions on economic complexity. By doing so, the paper goes beyond previous studies by uncovering whether and through which mechanisms slowly evolving institutional characteristics transmit to worldwide differences in economic complexity. The existing literature establishes that countries with poor-quality (autocratic) institutions, on average, tend to suffer from the persistence of underdevelopment, captured by lower levels of GDP per capita (Acemoglu et al., 2001; Rodrik et al., 2004). While average income is a measure of existing comparative development, economic complexity is developed to elaborate predictions of future patterns of growth and development based on the availability of productive capabilities within an economy (Hidalgo & Hausmann, 2009; Hidalgo, 2021). In particular, countries endowed with greater productive capabilities can sustain growth over prolonged periods due to their abilities to produce a diverse range of sophisticated products (Hidalgo & Hausmann, 2009; Felipe et al., 2012). As put forward by Hidalgo et al. (2007), complex economies find it easier to diversify into many other related high-productivity activities, potentially ending up wealthier in the future. The basic intuition is that sophisticated products, located at the center of the product space, are densely connected to many other products with increasing returns due to similarities in productive capabilities required for production (Hidalgo et al., 2007).[1] Recent studies also suggest that economic complexity, relative to GDP per capita, provides a better understanding of comparative cross-country development. For example, Chile and Malaysia differ substantially in terms of economic complexity despite their comparable levels of income per capita. The divergence in economic complexity translates into significant disparities in economic growth and income distribution between these two economies (Hartmann et al., 2017). Vu (2020) argues that the variation in economic complexity between Bangladesh and Vietnam helps explain their considerable discrepancies in mortality rates and life expectancy, which is not captured by GDP per person or trade openness. These narratives motivate exploring the contribution of institutions to shaping the global pattern of economic complexity.

As articulated in Section 2, Hausmann and Rodrik (2003) and Hausmann et al. (2007) propose that a country's economic complexity depends on the number of entrepreneurs engaged in the cost discovery process, based on the so-called '*self-discovery*' theory. Building upon these studies, I hypothesize that well-functioning institutions help strengthen entrepreneurial investment in the cost discovery process by internalizing possible externalities associated with cost discoveries. I also contend that the quality of institutions is linked to higher levels of economic complexity through fostering human capital accumulation and direct human resources towards productive activities. Using data for up to 115 world economies, I consistently find evidence that the quality of institutions, captured by the Economic Freedom of the World index, is positively associated with economic complexity.

Section 2 discusses the conceptual framework and hypotheses. Section 3 describes data and the econometric specification. Sections 4 – 6, respectively, contain identification methods, main findings, and additional empirical evidence. Section 7 concludes.

[1] More specifically, the product space represents the degree of proximity/relatedness between products, captured by similarities in productive capabilities or knowledge (e.g., technologies, skills, infrastructure, legal systems and tacit knowledge). For instance, the overall affinity between apples and pears would be greater than that between apples and iPhones. The production of less sophisticated products, typically located at the periphery of the product space, is less connected to other high-productivity productive activities due to greater dissimilarities in required productive capabilities. See Hidalgo et al. (2007) for a more detailed discussion.

2. Conceptual framework and hypotheses

Conventional explanations for worldwide differences in economic complexity draw on the idea of cost uncertainties associated with the process of acquiring new productive capabilities. An influential study by Hausmann and Rodrik (2003) argues that economic development is a '*self-discovery*' process through which a country transforms itself from low-productivity activities to high-productivity ones. More specifically, the 'self-discovery' process involves uncovering the underlying cost structure of domestic activities by pioneering investors (Hausmann & Rodrik, 2003). This process facilitates structural transformation towards new productive activities by providing other entrepreneurs with useful information about certain products that can be produced profitably domestically (Hausmann & Rodrik, 2003). It follows from this line of reasoning that substantial and persistent variation in the path of structural transformation across the globe stems from the number of entrepreneurs engaged in the 'self-discovery' process within an economy (Hausmann et al., 2007). Therefore, achieving higher levels of economic complexity critically requires incentivizing entrepreneurial investments in cost discoveries (Hausmann & Rodrik, 2003).

Hausmann et al. (2007) highlight that an entrepreneur who participates in new economic activities, particularly in the developing world, incurs significant cost uncertainties prevailing in a poorly understood field. Nevertheless, attempts at uncovering the underlying cost structure of the economy typically create positive externalities when other entrepreneurs can benefit from knowledge spillovers (Hausmann & Rodrik, 2003). Well-functioning institutions, reflected in security of property rights and enforcement of contracts, laws and regulations, help internalize the externalities of cost discoveries, thus promoting investments in cost discoveries (Hausmann et al., 2007). More specifically, inclusive institutions secure private property and reward pioneering entrepreneurs (Baumol, 1990; North, 1990), thereby deploying entrepreneurial resources in the 'self-discovery' process. In contrast, poor-quality institutions provide greater returns to (existing) rent-seeking activities, thus hindering the accumulation of new productive capabilities (Baumol, 1990; North, 1990; Murphy et al., 1993). Building upon the aforementioned 'self-discovery' theory of comparative development, I argue that strong institutions contribute to achieving higher levels of economic complexity through fostering innovative entrepreneurship in acquiring new productive capabilities.

It is also plausible that institutions give rise to economic complexity through promoting human capital accumulation and the deployment of human resources in productive activities. Endogenous growth theory emphasizes the role of human capital in driving economic performance. Hence, improvements in economic complexity, achieved by acquiring new productive capabilities and resource transformation towards productive activities, are reinforced by the accumulation of better human capital skills (Hausmann et al., 2014; Zhu & Li, 2017; Lapatinas & Litina, 2019; Lee & Vu, 2020; Vu, 2020). The underlying idea is that countries endowed with a more educated workforce, on average, learn and acquire new productive knowledge faster (Costinot, 2009; Zhu & Li, 2017; Lapatinas & Litina, 2019). As argued by Hidalgo and Hausmann (2009), the production of sophisticated products requires numerous hard-to-find capabilities, and the accumulation of such productive capabilities is contingent on the pool of talents within an economy. This suggests that lack of a well-educated workforce is a major barrier to driving structural transformation towards high-productivity activities. Moreover, the quality of human capital affects the extent to which a country can exploit accumulated (existing) productive capabilities to diversify its economic structures towards the production of other (related) high-productivity activities (Zhu & Li, 2017).

Previous studies provide suggestive evidence that well-functioning institutions are key driving forces of human capital accumulation and the allocation of human resources between productive and non-productive activities (Baumol, 1990; North, 1990; Murphy et al., 1991; Acemoglu, 1995; Natkhov & Polishchuk, 2019). In particular, inclusive institutions strengthen incentives for acquiring better human capital skills by offering higher returns to accumulating knowledge and education (Dias & Tebaldi, 2012). Additionally, well-functioning institutions, by rewarding high-productivity activities, deploy human resources towards the production of sophisticated products (Baumol, 1990). Meanwhile, rent-seeking activities, which tend to proliferate in societies with poor-quality institutions, offer higher returns to human capital investment in non-productive activities (Murphy et al., 1991; Acemoglu, 1995; Natkhov & Polishchuk, 2019). These discussions reveal that the quality of institutions is of importance for acquiring better human capital skills and deploying human resources in productive activities, leading to higher levels of economic complexity.

Overall, the main hypothesis of this paper is that institutional quality is positively associated with the level of economic complexity across countries. Figure 1 depicts the proposed mechanisms underlying the proposed relationship between the quality of institutions and economic complexity.

3. Data description and econometric specification

3.1. The baseline model

I explore the effect of institutions on economic complexity by estimating the following cross-country model:

$$ECI_i = \alpha + \beta EFW_i + \rho X_i + \delta Continent_i + \varepsilon_i$$

in which the outcome variable is the economic complexity index (*ECI*). The quality of institutions is captured by the Economic Freedom of the World Index (EFW). The coefficient on EFW reflects the contribution of institutions to economic complexity, and is expected to be positive ($\beta > 0$). The model specification is augmented with several geographic controls (X), including mean levels of elevation, distance to nearest waterways, a binary variable for landlocked countries, average land suitability for agriculture and the fraction of arable land. $Continent$ represents binary variables for Africa, America, Europe and Asia (Oceania is excluded as the base group). ε is the country-specific disturbance term. The benchmark model is estimated using a sample of up to 115 countries ($i = 1,2, \dots ,115$), mainly dictated by the availability of data. Supplementary Information contains a detailed description of all variables and data sources (see Appendix Tables A1 to A3 for more details).

3.2. Economic complexity index

The outcome variable is an index of economic complexity developed by Hidalgo and Hausmann (2009). This indicator provides an internationally comparable measure of cross-country differences in productive knowledge or capabilities, based on the types of products embedded in a country's economic structures. The amount of productive capabilities is typically hard to measure in a consistent manner across the globe. This is because many non-tradeable capabilities are tacit and not codified (Hidalgo & Hausmann, 2009). In order to resolve this issue, Hidalgo and Hausmann (2009) propose the method of reflections to indirectly capture the availability of productive capabilities within an economy.

Accordingly, the types of products a country produces and exports with revealed comparative advantage (RCA) arguably provide important insights into the set of productive knowledge. More specifically, Hidalgo and Hausmann (2009) create an index of economic complexity for each economy based on *Diversity* and *Ubiquity* metrics. Higher levels of *Diversity* correspond to the capacity to produce and export a diverse range of products, measured by the number of products a country exports with RCA (Hidalgo & Hausmann, 2009). *Ubiquity* is constructed by the number of countries exporting a given product with RCA

(Hidalgo & Hausmann, 2009). The production of sophisticated (high-productivity) products typically requires a wide range of hard-to-find capabilities. Hence, a country's ability to produce and export less ubiquitous products indirectly reflects possession of greater productive knowledge. Taken altogether, complex economies, characterized by the ability to export a diverse range of sophisticated products, are those with high *Diversity* and low *Ubiquity*. By contrast, countries whose economic structures comprise of a limited range of ubiquitous products have low levels of economic complexity, which represent a lack of productive capabilities.[2] Data, obtained from the Observatory for Economic Complexity, are averaged between 2000 and 2010 to estimate the benchmark model. Figure 2 depicts the variation in economic complexity across countries.

3.3. The quality of institutions

Conventional proxies for the cross-country variation in institutional quality include security of property rights, risk of expropriation, rule of law and constraints on the executive, among others. Plausible concerns about using such unidimensional measures of institutions relate to the possibility that they may not properly capture a wide range of institutional factors, including country-level tax, regulatory, and trade policies (Glaeser et al., 2004; Gwartney et al., 2006). Against this backdrop, I attempt to capture international differences in institutional quality by using EFW, provided by the Canadian Fraser Institute and the Heritage Foundation.

This indicator reflects the extent to which a country's institutional environment provides support for the protection of property rights, voluntary exchange, personal choice and minimal regulation of markets (Gwartney et al., 2004). In particular, the construction of EFW exploits 38 sub-indicators, measured on a categorical scale from zero to ten, with higher values corresponding to greater well-functioning institutions. These components can be classified into five areas, including (1) size of government, (2) legal system and security of property rights, (3) freedom to trade internationally, (4) access to sound money, and (5) regulation of credit, labor and businesses. Therefore, EFW offers a comprehensive measure of numerous institutional factors, which helps capture the multidimensional facets of institutions (Gwartney

[2] It is worth noting that ECI is constructed using data on cross-border movements of goods rather than services. Therefore, it may not properly derive productive capabilities from certain products that a country produces but does not export. Moreover, this indicator does not account for the sophistication level of service products. This may underestimate the amount of productive knowledge of several service-based economies, such as Australia (Hidalgo, 2021). Nevertheless, as highlighted by Hidalgo (2021), constructing an internationally comparable index of economic complexity based on trade in services appears to be very difficult due to the scarcity of data. A more detailed description of ECI is provided by Hidalgo and Hausmann (2009) and Hidalgo (2021).

et al., 2006). As put forward by Gwartney et al. (2006), countries with inclusive institutions would secure privately owned property, contract enforcement, and provide access to sound money. Moreover, the government's minimal intervention into market entry, voluntary exchange and trade policies may foster an inclusive institutional environment, thus driving economic prosperity (Gwartney et al., 2006). The multidimensional nature of EFW helps address several concerns about using the aforementioned measures of institutions. In order to estimate the cross-sectional models, I calculate a simple average of EFW across the period 2000 – 2010. Figure 3 depicts the variation in institutional quality across the world.

3.4. Main control variables

It is widely established in the long-term development literature that fundamental (fixed) geographic attributes exert a persistent influence on economic performance (Sachs, 2003; Carstensen & Gundlach, 2006). However, Rodrik et al. (2004) find suggestive evidence that country-level geographic characteristics affect long-run comparative development through shaping the quality of institutions. This lends support to the important role of deeply rooted institutions in affecting the worldwide distribution of income per capita. Nevertheless, geographic factors may simultaneously affect both institutions and economic complexity. Therefore, the main analysis is augmented with several geographic controls, including mean elevation, distance to nearest waterways, a binary variable for being landlocked, mean land suitability for agriculture, and the fraction of arable land. This helps rule out the possibility that the long-term legacy of institutions for economic complexity is attributed to geographic endowments. Furthermore, continent dummies are incorporated in the benchmark model to account for unobserved time-invariant heterogeneity across world regions.

4. Identification strategy

Empirical attempts at identifying a causal relationship between the quality of institutions and economic complexity face several challenges. A major concern relates to the possibility that the results can be driven by possible selection bias from unobserved confounding characteristics. Additionally, reverse causation exists if higher levels of economic complexity are conducive to the establishment of inclusive institutions. The main variable of interest may also be subject to measurement errors, leading to biased and inconsistent estimates of the effect of institutional quality on ECI. As discussed below, there exists no perfect strategy of identification. Hence, I undertake a wide range of empirical analyses to alleviate these plausible concerns about causal inference.

4.1. Assessing potential selection bias from unobservables

As argued earlier, plausible concerns about omitted variables bias are partially addressed by allowing potential confounders to enter the benchmark model specification. Nevertheless, countries differ significantly in numerous characteristics that may absorb the effect of institutional quality on ECI, making it difficult to identify and account for all relevant confounding factors. To address this issue, I rely on the coefficient stability test developed by Oster (2019). This method helps assess the scale of bias attributed to selection on unobserved confounders. More specifically, Oster (2019) proposes that selection bias from unobservables can be derived by comparing the estimated coefficients and *R*-squared values of a model with full observed controls, relative to that with a restricted set of observed controls. On this basis, we can estimate how large the amount of selection bias from unobservables required to completely absorb the estimated effect of EFW on ECI. The underlying idea builds upon an earlier contribution by Altonji et al. (2005) who posit that selection bias attributed to unobservables can be inferred from the reduction in selection bias when the standard regression models are augmented with observed controls.

As articulated by Oster (2019), the data-generating process can be expressed in the following hypothetical model:

$$ECI_i = \alpha + \beta EFW_i + \varphi X_i^{observed} + \tau X_i^{unobserved} + \varepsilon_i$$

where $X_i^{observed}$ represents the set of observed control variables, including geographic characteristics and continent dummies. $X_i^{unobserved}$captures unobserved confounders. Accordingly, the outcome variable is determined by both observables and unobservables. Assume that $X^o = \varphi X_i^{observed}$ and $X^u = \tau X_i^{unobserved}$. The δ statistic of proportional selection bias can be computed as:

$$\delta \frac{cov(X^o, EFW)}{var(X^o)} = \frac{cov(X^u, EFW)}{var(X^u)}$$

The δ statistic captures how strong the correlation between institutions and unobservables, relative to that between institutions and observables, would need to be to attenuate the coefficient on EFW towards zero. Additionally, the bias-adjusted estimate of β can be calculated assuming that unobserved confounders are as strongly correlated with EFW as observables ($\delta = 1$).

$$\beta^* = \tilde{\beta} - [\ddot{\beta} - \tilde{\beta}] \frac{R_{max} - \tilde{R}}{\tilde{R} - \ddot{R}}$$

where β^* captures the contribution of institutions to economic complexity when $\delta = 1$. $\ddot{\beta}$ and $\ddot{R}$ denote, respectively, the coefficient and R-squared obtained from estimating models with a restricted set of observed controls. $\tilde{\beta}$ and $\tilde{R}$ are, respectively, the coefficient and R-squared derived from estimating models with a full set of observed controls. R_{max} is the R-squared statistic of a hypothetical model. Conventional wisdom is that the results are unlikely to be fully attributed to unobservables if the inclusion of observables does not alter the stability of the estimated coefficients. In addition to this, Oster (2019), by comparing changes in R-squared values, accounts for the empirical relevance of observed control variables. To the extent that the R-squared statistic remains largely unchanged when incorporating observed controls, there exists a higher probability that unobserved confounders are correlated with the main variable of interest. Following Oster (2019), I calculate the δ and β^* statistics to assess the relative importance of possible selection bias from unobserved confounding characteristics.

4.2. Isolating a plausibly exogenous source of variation in institutional quality

Plausible concerns about reverse causation and measurement errors in the EFW remain intact even when I rule out possible selection bias from unobserved confounders. Hence, I attempt to create a plausibly exogenous source of variation in institutional quality that helps explain international differences in economic complexity.

A commonly adopted approach to estimating the causal effects of institutions on development outcomes is based on the 'germ' theory of institutions proposed by Acemoglu et al. (2001). The basic idea is that European colonizers established different types of institutions in former colonies depending on the disease environment, leading to substantial and persistent variation in institutional quality across the globe. On this basis, Acemoglu et al. (2001) employ the settler morality rate as an exogenous instrument for institutions to explain the worldwide distribution of income per capita. However, this influential contribution is not free from criticism. Glaeser et al. (2004) demonstrate that the global pattern of growth and development is mainly attributed to the human capital brought by European colonizers to their former colonies, rather than the quality of institutions per se. In response to this critique, Acemoglu et al. (2014) document suggestive evidence of the primacy of institutions, relative to human capital, in shaping long-run comparative development. In addition, Albouy (2012) questions the validity of the identification strategy of Acemoglu et al. (2001) because it exploits unreliable data on the settler mortality rate inferred from neighboring countries. Regarding these concerns, Acemoglu et al. (2012) provide a detailed response arguing that the 'germ' theory of institutions remains highly predictive of cross-country differences in GDP per capita. Nevertheless, data on the settler mortality rate are available only for a restricted sample of 64 former colonies, of which 53 countries are included in the main sample of this paper. The scarcity of the data makes it difficult to obtain a generalized understanding of the relationship between institutions and economic complexity across the world, based on the IV strategy of Acemoglu et al. (2001). Therefore, I employ two different instrumental variables to generate the plausibly exogenous component of institutions, and they differ substantially in terms of country coverage.

First, motivated by Ang et al. (2018), this paper uses a measure of exposure to ultraviolet radiation (UV-R) as an instrument for EFW, which helps maximize the feasible sample size. The established relationship between UV-R exposure and worldwide differences in institutional quality draws on an influential contribution to the long-term comparative development research agenda by Andersen et al. (2016). More specifically, Andersen et al. (2016) provide suggestive evidence that countries with greater exposure to UV-R are more likely to suffer from lower levels of GDP per capita. As proposed by Andersen et al. (2016), an important mechanism underlying the extent to which UV-R intensity helps shape global income differences is the permanent threat of contracting eye diseases (e.g., cataracts), as widely established in the epidemiological literature. It is argued that loss of visual acuity is a major barrier to pursuing skill-intensive occupations that typically require literacy. The pervasiveness of impaired vision and blindness in societies with greater exposure to UV-R significantly reduces work-life expectancy as a skilled worker, thereby shaping the perceived return to investments in accumulating skills and human capital (Andersen et al., 2016). On this basis, the (historical) prevalence of eye diseases in high-UV-R countries affects the timing of the fertility transition by shaping the perceived return to human capital investment, thereby determining the worldwide distribution of income per head (Andersen et al., 2016).[3]

Several major contributions to identification of the deep roots of underdevelopment establish that the (historical) disease environment is of importance for driving the cross-country variation in institutional quality and economic performance. As mentioned previously, a highly cited paper by Acemoglu et al. (2001) reveals that Europeans adopted different colonization

[3] Using cross-country data, Andersen et al. (2016) document robust evidence of a reduced-form link between UV-R and worldwide income differences. The level of UV-R exposure is highly predictive of the cross-country variation in the timing of the fertility transition, which is consistent with a mechanism of transmission proposed by Andersen et al. (2016). In addition, the intensity of UV-R also helps explain subnational comparative development in the United States and China.

strategies depending on the disease environment of former colonies. In places where Europeans could healthily settle, they established inclusive institutions. In contrast, where the disease environment was unfavorable for Europeans to settle permanently, they set up extractive institutions. The early institutions persist until today, thus affecting economic development (Acemoglu et al., 2001; Rodrik et al., 2004; Acemoglu et al., 2014).

It is plausible that the (historical) prevalence of eye disease in countries with greater exposure to UV-R transmits to long-run economic development through shaping the quality of institutions. In this regard, Ang et al. (2018), by estimating several cross-country models, demonstrate that countries with greater UV-R intensity tend to suffer from the emergence and persistence of poor-quality institutions. The underlying intuition is that the prevalence of eye diseases, by shortening work-life expectancy as a skilled worker, impedes the motivation for investment in cooperation via establishing inclusive institutions (Ang et al., 2018). More specifically, shortened work-life expectancy is associated with lower expected return from institutional building, leading to the persistence of (early) autocratic institutions in high UV-R countries (Ang et al., 2018; Vu, 2021a). These findings indicate that UV-R intensity is a potential fundamental driver of cross-country differences in the quality of institutions. Therefore, I employ exposure to UV-R as an instrumental variable for institutions that helps explain international variation in economic complexity. This empirical exercise potentially improves our understanding of the important role of UV-R in shaping comparative development across the world. As discussed earlier, Andersen et al. (2016) suggest that exposure to UV-R is a key determinant of global income differences by shaping the incentive for skill accumulation. The results of the current paper complement the findings of Andersen et al. (2016) by documenting that institutional quality is an additional mechanism underlying the relationship between UV-R and long-run development.

The validity of this instrument requires that exposure to UV-R exerts no direct influence on economic complexity except through shaping the evolution of institutions. However, the exogeneity assumption cannot be verified empirically due to the unobserved nature of the disturbance terms. Admittedly, the intensity of UV-R may not transmit to long-term development exclusively by driving worldwide differences in institutions. The aforementioned discussion is suggestive that exposure to UV-R may impart a persistent impact on economic complexity by affecting human capital accumulation. Furthermore, the intensity of UV-R can be highly correlated with other geographic attributes, including absolute latitude or the fraction of the population at risk of contracting malaria, which can be relevant for long-term development. In this regard, isolating the exogenous component of institutions based on variation in UV-R intensity critically requires some attention to potential deviations from the exclusion restriction. Therefore, I follow the empirical procedure developed by Conley et al. (2012) to formally bound the estimated coefficient on EFW allowing for deviations from the orthogonality condition. As discussed in Section 5, the inclusion of several mechanisms that may invalidate the validity of the instrument may further address this concern.

Second, I replicate the IV analysis using the settler mortality rate as an instrument with a highly restricted sample of 53 countries. The IV regression for this substantially reduced sample is also estimated using two different instruments to perform a test of over-identifying restrictions. This provides some support for the exogeneity requirements. If I obtain broadly similar estimates of the impacts of the exogenous component of institutions on economic complexity, the IV results for the reduced sample are unlikely to be exclusively driven by variation in the feasible sample size. Furthermore, using this alternative instrumental variable provides a valid basis for statistical inference because the IV strategy proposed by Acemoglu et al. (2001) has been widely used in the long-term development literature.

5. Empirical results

5.1. Ordinary least squares estimates

Figure 4 illustrates an unconditional correlation between institutional quality and economic complexity across countries. Consistent with the central hypothesis, there exists a positive association between institutions and economic complexity. However, these results may not necessarily carry a causal interpretation due to the aforementioned threats to identification.

To explore the contribution of institutions to economic complexity, I regress ECI on EFW, the main measure of institutional quality. Table 1 contains OLS estimates of the impacts of EFW on the worldwide distribution of productive capabilities. EFW enters the regression with a statistically significant and positive coefficient in all cases. The statistical significance of the estimated coefficients of EFW remains intact after accounting for several country-level geographic attributes and unobserved continent-specific factors. This provides evidence that the results are not driven by conventional explanations for long-term development across the world. In contrast to the main variable of interest, the coefficients on most geographic controls turn out to be imprecisely estimated at conventional thresholds of statistical significance. These findings are consistent with several studies documenting evidence of the primacy of institutions, rather than geography, in driving the global pattern of growth and development

(Easterly & Levine, 2003; Rodrik et al., 2004). Overall, the baseline OLS estimates reveal that countries endowed with inclusive institutions tend to accumulate greater productive capabilities, captured by higher levels of economic complexity.

It is important to re-emphasize that the OLS estimates can be biased and inconsistent if relevant unobserved confounders are excluded from the model specification. For this reason, I report the δ and β^* statistics derived from the coefficient stability test of Oster (2019) in Table 1. Following Oster (2019), the construction of these statistics relies on an assumption that R_{max} is 30% greater than $\tilde{R}$ (see Section 4.1). Oster (2019) proposes that a value of the δ statistic exceeding one implies that selection on unobservables would need to be considerably stronger than selection on observables in order to explain away the main results. As demonstrated in column (2) of Table 1, the value of Oster's δ statistic is 1.932. This reveals that the association between possibly unobserved confounders and institutions needs to be approximately twice as strong as that between observed control variables and institutions to attenuate the coefficient on EFW towards zero. Conditional on proportional selection ($\delta = 1$), the estimated coefficient on EFW, if I were to account for all unobserved confounders, would equal to $\beta^* = 0.110$ (Column 3, Table 1). This positive lower bound estimate captures the bias-adjusted effects of institutions on economic complexity. As demonstrated in Table 1, zero is safely excluded from the intervals bounded by the β^* statistic and the baseline coefficient on EFW (β). As put forward by Oster (2019), the results of the coefficient stability test indicate that the OLS estimates of the effects of institutions on economic complexity is unlikely to be explained away by potential selection bias from unobservables. This provides some support for causal inference although I cannot incorporate all possibly confounding factors in the regression.

5.2. *Instrumental variables estimates*

Table 2 reports empirical estimates of the effects of the plausibly exogenous component of institutions, created by exposure to UV-R, on economic complexity. The first-stage results presented in Panel B of Table 2 reveal that the estimated coefficients of UV-R are negative and statistically significant at the 1% level in all cases. These results are consistent with recent studies documenting the negative effects of UV-R on the quality of institutions (Ang et al., 2018; Vu, 2021a). Furthermore, the *F*-statistic of excluded instrument developed by Olea and Pflueger (2013) is much larger than the rule-of-thumb value of 10 in all cases (Table 2). This helps rule out concerns about using an instrument that is weakly correlated with the potential endogenous regressor. The *F*-statistic of Olea and Pflueger (2013) offers reliable inference on weak instruments even when using clustered, autocorrelated and non-homoscedastic data

(Andrews et al., 2019). Following Andrews et al. (2019), I also report identification-robust Anderson-Rubin confidence intervals in Table 2. Given that none of these bound estimates contains zero, the effects of the exogenous component of EFW on ECI retain their statistical precision regardless of the strength of the instrument in the first-stage regression (Andrews et al., 2019). Overall, the first-stage estimates and several diagnostic tests lend support to the relevance of the instrument for institutions (Table 2).

Turning to the second-stage results reported in Panel A of Table 2, the estimated coefficients of EFW have a positive sign in all cases, indicating that institutions exert a positive influence on economic complexity. The estimated effects are also precise at the 1% level of statistical significance. Moreover, the sign and statistical precision of the coefficients on EFW withstand the inclusion of the geographic control variables and continent dummies. As demonstrated in Table 2, I also find evidence that institutions play a more important role in shaping long-run economic performance compared with geographic endowments. Consistent with the benchmark OLS estimates, the IV findings imply that countries with better institutional quality are likely to enjoy higher levels of economic complexity. On this basis, establishing an inclusive institutional environment is conductive to the ability to produce and export a wide range of sophisticated products, possibly sustaining long-term economic development. As discussed above, the positive relationship between institutions and economic complexity draws upon the premise that good institutions act as a catalyst for innovative entrepreneurship in the 'cost-discovery' process, resulting in higher levels of economic complexity (Hausmann & Rodrik, 2003; Hausmann et al., 2007; Hidalgo & Hausmann, 2009). It is also widely established that market-supporting institutions guarantee greater payoffs to human capital accumulation, and foster an optimal allocation of human resources between productive and non-productive activities (Natkhov & Polishchuk, 2019). This contributes to growing economic complexity via increasing the quality of human capital and directing human resources towards acquiring productive capabilities.

The magnitude of the estimated coefficients of EFW reveals that institutions exert sizeable effects on ECI. For example, the EFW index values of Thailand and Japan are 6.71 and 7.72, respectively. The difference in institutional quality between these two countries equals 1.01, which is approximately one standard deviation of the EFW index in the sample. According to the estimated coefficients in column (3) of Table 2, a one-unit increase in the plausibly exogenous component of institutions, generated by UV-R, implies a 1.146-unit increase in ECI. Thus, if Thailand instead experienced a level of the EFW index similar to

Japan, the expected increase in the ECI of Thailand would be 1.157 units, which is approximately 2.5 times its initial ECI value (0.482), a substantial increase. Overall, this paper documents evidence of the economic and statistical significance of the long-term legacy of institutions for international variation in economic complexity.

Furthermore, I adopt alternative instrument sets, and report the empirical results in Table 3. As illustrated in the first column of Table 3, I employ the log of settler mortality rate to generate an exogenous source of variation in institutions across 53 European former colonies. In column (2) of Table 3, I regress ECI on the exogenous component of EFW created by exposure to UV-R using a comparable sample of former colonies. In the last column of Table 3, both instruments are exploited to generate the plausibly exogenous variation in institutions. The first-stage estimates presented in Panel B of Table 3 are consistent with the 'germ' theory of institutions of Acemoglu et al. (2001). The coefficient on EFW reported in Panel A of Table 3 is positive and statistically significant at the 1% level. The statistical significance and sign of the effects of institutions on economic complexity remain insensitive to using different instrument sets and a highly restricted sample of countries. The *p*-value obtained from a test of over-identifying restrictions provides some additional support for the plausibility of my IV approach.

Using alternative methods of identification, I consistently obtain precise estimates of the long-term effects of deeply rooted institutions on economic complexity. This is in line with the central hypothesis that establishing inclusive institutions contributes to structural transformation towards productive activities that can help sustain future prosperity.

5.3. Using alternative measures of institutions

As argued earlier, EFW is adopted as a comprehensive (multidimensional) measure of institutional quality and policies, following Gwartney et al. (2006). One may well argue that this measure of institutions fails to capture other aspects of a country's institutional environment, such as control of corruption or the quality of legal systems. It is noteworthy that the quality of institutions encompasses different aspects, making it difficult to obtain an internationally comparable proxy for this multidimensional concept.

To alleviate the above concern, I replicate the baseline analysis using alternative measures of institutions. To this end, I use various sub-indicators of the World Bank's World Governance Indicators to capture the cross-country variation in institutional quality. Higher values of these variables represent better institutions. I reproduce both the OLS and IV regressions, as reported in Table 4. As shown in column (1) of Table 4, the quality of institutions is measured by the rule of law index, which reflects perceptions of the extent to which agents have confidence in and abide by the rules of society. I also adopt a measure of control of corruption that is based on perceptions of the degree to which public power is misappropriated for private gain (Column 2, Table 4). Moreover, institutions, reflected in the quality of public services, policies, and its independence from political pressure, are measured by an index of government effectiveness (Column 3, Table 4). In the last column of Table 4, institutional quality is proxied by the voice & accountability index, which reflects perceptions on freedom to select the government, and freedom of media, association, and expression. The results presented in Table 4 indicate that alternative measures of institutions still impart a statistically significant and positive influence on economic complexity. Hence, it is plausible that the established relationship between institutions and economic complexity is not exclusively attributed to using EFW as a proxy for the main variable of interest.

5.4. Potential violation of the exclusion restriction

Obtaining consistent inference of the IV estimates presented in Table 2 critically requires justification of the validity of the exclusion restriction. The aforementioned argument suggests that the orthogonality requirement can be violated if exposure to UV-R transmits to economic complexity through shaping the quality of human capital. Therefore, this mechanism of transmission appears to be a key threat to my identification strategy. To circumvent this concern, I rely on the approach developed by Conley et al. (2012) to investigate whether the main IV estimates are robust to allowing for potential deviations from the exogeneity condition.

Assuming that exposure to UV-R may have a direct influence on the outcome variable, the benchmark model can be re-written as: $ECI_i = \alpha + \beta EFW_i + \gamma Log(UV - R)_i + \rho X_i + \delta Continent_i + \varepsilon_i$, in which the log of UV-R is used to isolate the plausibly exogenous component of institutions in the main IV analysis. The exogeneity requirement is satisfied when $\gamma = 0$, but this assumption is largely untestable. Given challenges with justification of the exclusion restriction, Conley et al. (2012) develop an intuitive approach that provides reliable inference even when the exogeneity condition is slightly violated ($\gamma \neq 0$). The underlying idea is that it would be possible to estimate the above model using exposure to UV-R as an IV for institutions if one were to calculate the true value of γ. As such, the IV regression could be performed by first removing $\gamma Log(UV - R)_i$ from both sides of the model. However, the magnitude of the direct influence of UV-R on economic complexity is unknown. Therefore, the methodology developed by Conley et al. (2012) relies on an assumption about the size of

γ, which follows a normal distribution with mean zero and variance δ^2 ($\gamma \sim N(0, \delta^2)$).The IV regression can be estimated by varying the values of the standard deviation δ. On this basis, it is possible to construct 95% confidence intervals for the coefficient on EFW (β).

Table 5 reports the 95% confidence intervals of β allowing for possible deviations from the orthogonality condition, based on making different assumptions about the magnitude of the effects of UV-R on ECI. More specifically, the size of γ is assumed to equate up to 20% – 80% of the marginal impact of institutions on economic complexity derived from the benchmark IV regression (Column 3, Table 2). Table 5 should be read as the partial effect of institutions on economic complexity when I assume, for example, that the direct influence of the instrument on ECI corresponds to 20% of the size of the effects of institution on ECI in the main IV estimates (2δ = 20%). For the purpose of comparison, I also replicate this empirical exercise using alternative measures of institutions, discussed in Section 5.3. The bounds of β do not encompass zero in most specifications. Even when making an implausibly strong assumption about possible violation of the exclusion restriction (CI 2δ = 80%), the main findings retain their statistical significance, except in Columns (1) and (5) of Table 5. This implies that the effect of institutions on economic complexity remain precisely estimated at the 5% level of statistical significance even if I allow for possible deviations from the exogeneity condition. Moreover, the findings retain their statistical significance, except in columns (1) and (5). Admittedly, I may not completely rule out plausible concerns about the reliability of the exclusion restriction. Nevertheless, this widely used approach helps provide some further evidence of the plausibility of my identification approach.[4]

5.5. Sensitivity analyses

This sub-section contains the results of numerous robustness checks. In particular, I replicate both the main OLS and IV regressions by controlling for alternative explanations for cross-country differences in economic complexity. The benchmark findings also withstand accounting for unobserved time-invariant factors by estimating dynamic panel data models, notwithstanding several caveats below. I also rule out the possibility of a non-linear

[4] A recent study by Casey and Klemp (2021) revisits the validity of historical instruments, commonly adopted in the long-run development literature. It empirically establishes that using historical or slowly evolving variables to create plausibly exogenous sources of variation in contemporary variables, including institutions, may provide inconsistent estimates due to potential deviations from the exclusion restriction. Based on replicating influential studies examining the deep origins of long-term economic performance, Casey and Klemp (2021) highlights the relevance of applying the framework of Conley et al. (2012) to formally bound the main coefficient of interest.

relationship between institutions and economic complexity, and investigate the effects of potential outliers. The detailed results are presented in the Supplementary Information.

Robustness to accounting for early development

A conventional explanation for comparative cross-country development highlights the persistent influence of early development and/or historically determined variables. For example, accumulated experience with state-like polities spanning thousands of years plays a key role in shaping global differences in income per capita (Bockstette et al., 2002; Borcan et al., 2018), institutions (Ang, 2013), and income inequality (Vu, 2021d). It is also widely acknowledged that civil-law countries, compared with their common-law counterparts, are more (financially) underdeveloped (La Porta et al., 2008), and tend to suffer from the persistence of poor governance (La Porta et al., 1999). Moreover, several scholars posit that having experienced an early transition to sedentary agriculture, dating back to 10,000 years ago, is conducive to contemporary economic development (Hibbs & Olsson, 2004; Ang, 2013). An influential contribution to this line of inquiry by Ashraf and Galor (2013) suggests that the current level of genetic diversity, as determined over the prehistoric course of the exodus of *Homo sapiens* from East Africa tens of thousands of years ago, imparts an inverted U-shaped effect on income per capita.[5] Spolaore and Wacziarg (2009) contend that cultural barriers to the world frontiers of technologies, captured by an index of genetic relatedness between populations, hinder economic performance by imposing greater costs on the cross-border diffusion of technological innovation. To the extent that these factors simultaneously affect both institutions and economic complexity, my findings could be biased and inconsistent. However, the inclusion of possible historical confounders in the benchmark model fails to alter the results (Appendix Table A4).

Robustness to incorporating the 'proximate' determinants of economic complexity

An additional concern is that the established relationship between institutions and economic complexity is driven by failure to account for the 'proximate' determinants of productive capabilities. Indeed, previous studies have predominantly exploited several macroeconomic variables to explain why countries differ in the types of products embedded in

[5] According to Ashraf and Galor (2013), genetic diversity corresponds to the likelihood that two people randomly selected from a relevant population are genetically dissimilar to each other, with regard to a given spectrum of genetic traits. The degree of genetic heterogeneity within a country is negatively linked to migratory distance to East Africa. A medium length of genetic diversity is conductive to economic prosperity. In contrast, underdevelopment tends to persist in highly diverse and homogenous societies.

their economic structures. These factors include trade openness, financial development and the size of government (Hausmann et al., 2007; Zhu & Fu, 2013; Sweet & Maggio, 2015). The aforementioned argument suggests that these variables are jointly determined along with ECI, which necessitates investigating the fundamental drivers of complexity. Moreover, obtaining a valid basis for statistical inference on the contribution of these variables to economic complexity requires addressing endogeneity concerns. However, empirical attempts at isolating plausibly exogenous causes of numerous endogenous regressors appear to be challenging. If institutions affect economic complexity through these 'proximate' factors, incorporating them in the baseline model may capture part of the relationship between deeply rooted institutions and today's productive capabilities. However, my findings withstand augmenting the main analysis with several 'proximate' causes of economic complexity even though I cannot rule out plausible endogeneity concerns relating to these 'proximate' determinants (Appendix Table A5).

Robustness to controlling for other effects

To attenuate omitted variables bias, I allow additional variables to enter the baseline model specification. Specifically, I control for other geographic covariates, including mean precipitation and the fraction of the population at risk of contracting malaria. It is also well established that population diversity may affect long-term development through shaping the quality of institutions or productivity (La Porta et al., 1999; Alesina et al., 2003). Hence, I attempt to address this problem by augmenting the main analysis with an index of ethnolinguistic fractionalization (La Porta et al., 1999; Alesina et al., 2003). Another concern relates to the likelihood that the benchmark findings are purely driven by cross-country differences in natural resource endowments (Acemoglu et al., 2001). This motivates controlling for the legacy of natural resources for long-run economic development, following Acemoglu et al. (2001). As represented in Appendix Table A6, incorporating these additional controls in the regression fails to explain away the observed relationship between institutions and economic complexity.

Robustness to estimating dynamic panel data models

The system Generalized Methods of Moments (GMM) estimator of Blundell and Bond (1998) has been popularly adopted to address endogeneity concerns in the growth-development literature (see, e.g., Bazzi & Clemens, 2013; Kraay, 2016). The system GMM estimator, in particular, exploits lagged levels and lagged differences of the potentially endogenous regressors as internal instruments for the contemporaneous model specification in differences and levels, respectively. A key advantage of estimating dynamic panel data models lies in the ability to account for unobserved time-invariant factors, which possibly bias empirical estimates derived from a cross-sectional framework. One could argue that the main findings of this paper are confounded by unobserved time-invariant heterogeneity across nations. This paper demonstrates, by estimating dynamic panel data models using the system GMM estimator, that this argument is largely implausible. The results reported in Appendix Table A7 indicate that institutions exert positive and statistically significant effects on economic complexity when holding unobserved country-specific factors constant. The system GMM estimates, largely driven by the within-country variation in the data, are suggestive of a substantial reduction in the magnitude of the effects of institutions on complexity, relative to the cross-sectional estimates. However, the main interest of this paper lies in understanding the long-term legacy of institutions for persistent and substantial differences in economic complexity across the world. To this end, the benchmark model specification is more relevant.

Importantly, violations of the exogeneity condition, as rigorously explored throughout this research, are more likely to arise using internal instruments. This concern primarily stems from the persistent nature of the worldwide distribution of institutions, growth and development (Acemoglu et al., 2001). Against the background of the persistence of (under)development, the moment conditions within a system GMM framework are invalidated, which undermines consistent inference. As argued by Bazzi and Clemens (2013), this problem is regularly ignored in many empirical studies using the system GMM estimator to explore the driving forces of growth and development across countries. In a broadly similar context, Carter et al. (2021), through undertaking a wide range of simulations, reveal that the slowly evolving feature of endogenous variables invalidates statistical inference based on the use of internal instruments. Moreover, the issue of weak instrument bias tends to proliferate in system GMM, but it has received little attention in the empirical growth literature (Bazzi & Clemens, 2013; Kraay, 2016). Indeed, the first-stage estimates are commonly hidden, and identification-robust confidence bounds remain hard to find in studies applying the system GMM estimator (Bazzi & Clemens, 2013; Kraay, 2016; Andrews et al., 2019). These concerns have been thoroughly explored through a series of empirical analyses on the validity of the exclusion restriction and the strength of the instrument. Hence, I maintain using the benchmark estimates to draw consistent inference on the contribution of institutions to economic complexity.

Additional robustness checks

I explore the presence of a non-linear relationship between institutions and economic complexity. To this end, I rely on Ramsey's *RESET* test of functional form misspecification to test whether the baseline model is appropriately specified. Appendix Table A8 contains the results, which provide evidence against functional form misspecification. Moreover, I undertake a non-parametric estimation based on kernel-weighted local polynomial smoothing. Accordingly, there exists no evidence of a non-linear correlation between institutions and complexity, except for a few outliers at the upper and lower bounds of EFW (Appendix Figure A1). Even when the model specification is augmented with a quadratic term of EFW, the results are not supportive of a higher-order relationship (Appendix Table A9). Additionally, the presence of possible outliers could account for the established association between institutions and economic complexity. To address this issue, I replicate the main analysis by excluding potential outliers, identified by estimating Cook's distance, standardized residuals, and robust regression weights. The results provided in Appendix Table A10 indicate that the benchmark findings are not sensitive to removing outliers.

6. Extensions

6.1. Institutions, human capital, and economic complexity

A high-profile contribution to the long-term development literature by Acemoglu et al. (2001) emphasizes the important role of institutions, rather than other 'proximate' determinants of growth, including human capital. Their main argument is that substantial variation in contemporary institutions across countries has its deep historical roots from the patterns of European colonization, as articulated above (Acemoglu et al., 2001). Nonetheless, Glaeser et al. (2004) challenge this viewpoint by documenting that human capital accumulation plays a more critical role than institutions in shaping the worldwide distribution of income per head. Glaeser et al. (2004) empirically establish that the persistence of underdevelopment is attributed to the human capital, rather than the types of institutions, brought by European colonizers to their former colonies. A detailed response to this critique is provided by Acemoglu et al. (2014). Against this background, the relative importance of institutions and human capital in driving long-run growth and development remains controversial.

The central hypothesis of this paper rests upon the premise that institutions transmit to growing economic complexity partially through fostering the quality of human capital. It is argued that the accumulation of human capital is interrelated with and reinforced by a country's productive capabilities, thus offering an inadequate explanation as a fundamental driver of economic complexity. By contrast, deeply rooted institutions arguably provide a deeper understanding of the evolution of economic complexity. On this basis, I propose that human capital is a mechanism underlying the relationship between institutions and complexity. Motivated by Glaeser et al. (2004) and Acemoglu et al. (2014), I further examine the primacy of institutions versus human capital in driving international differences in complexity. To this end, the benchmark model specification is augmented with the World Bank's index of human capital (Kraay, 2019). Moreover, this empirical exercise helps address a key concern relating to the validity of the IV approach. As discussed previously, Andersen et al. (2016) propose that UV-R affects long-run development through shaping the incentive for accumulating better human capital skills. In this regards, controlling for worldwide differences in the quality of human capital helps isolate the plausibly exogenous component of institutions based on exposure to UV-R. The validity of this empirical approach critically requires attention to the endogenous nature of both institutions and human capital. Following Acemoglu et al. (2014), I employ the number of Protestant missionaries per 10,000 people in the 1920s as a plausibly exogenous instrument for human capital accumulation. In line with the main analysis, institutional quality is instrumented by UV-R intensity.[6]

Table 6 reports the IV estimates of the effects of institutions and human capital on economic complexity. Accordingly, EFW enters the regression with a positive and statistically significant coefficient. By contrast, the impact of human capital on economic complexity is imprecisely estimated at conventional levels of statistical significance. I also report identification-robust Anderson-Rubin confidence intervals, which are efficient regardless of the relevance of the instruments in the first-stage regression (Andrews et al., 2019). These results are consistent with the argument that institutional quality is a deep determinant of economic complexity, which lends support to the findings of Acemoglu et al. (2014). A misinterpretation of the results in Table 6 is that the quality of human capital does not matter for accumulating greater productive knowledge. Instead, the results are consistent with the central hypothesis that human capital accumulation is an important mechanism underlying the relationship between institutions and complexity. This helps disentangle the roles of institutions versus human capital in shaping long-term development. Importantly, the IV estimates in Table 6 further attenuate concerns about the plausibility of the main IV results by controlling for a potential mechanism that may invalidate the exclusion restriction.

[6] The IV estimates, not reported for brevity, remain unchanged when I use the log of settlers' mortality rate as an alternative instrument for institutions. Consistent with the results in Table 3, the adoption of two instruments for institutions does not affect the magnitude and statistical precision of the estimated coefficient on EFW.

6.2. Mechanisms underlying the effect of institutions on economic complexity

As articulated in Section 2, institutions exert a positive influence on economic complexity via boosting incentives for innovative entrepreneurship, improving the quality of human capital, and increasing deployment of human resources in productive activities. Exploring the relative importance of institutions versus human capital in driving the cross-country variation in economic complexity, I provide suggestive evidence for one of these proposed mechanisms. Specifically, a conventional approach to establishing the underlying channels of influence is to augment the regression model with proposed mediating variables. However, this widely adopted method yields inconsistent estimates due to intermediate variables bias (Acharya et al., 2016).[7] To provide a more valid basis for statistical inference, I undertake a mediation analysis for different proposed mechanisms underlying the relationship between institutions and complexity, based on the methodology developed by Acharya et al. (2016).

In order to perform the empirical strategy of Acharya et al. (2016), I capture cross-country differences in key pathways through which institutions translate into higher degrees of economic complexity. For this purpose, I employ two sub-indicators of the global innovation index as proxies for innovative entrepreneurship, including knowledge and technology outputs, and creative outputs (Dutta et al., 2020). The dataset provided by Dutta et al. (2020) offers comprehensive measures of international variation in innovative entrepreneurship undertaken by scientists, manufacturing and service firms, and public entities, among others. The data also have a wide coverage of up to 131 world economies. To be more specific, I use an index of knowledge and technology outputs, which reflects knowledge creation, knowledge impact and knowledge diffusion (Dutta et al., 2020).[8] I also employ a measure of creative outputs to measure the creation of intangible assets and creative goods and services (Dutta et al., 2020).

In line with the analysis in Section 6.1, I use the World Bank's human capital index to capture investments in human capital (Kraay, 2019). It reflects the expected level of human

[7] As highlighted by an Associate Editor, the results would not imply causal inference if I were to incorporated potentially mediating channels in the regression without addressing endogeneity concerns of these variables. It is noteworthy that isolating plausibly exogenous sources of variation of different mechanisms depicted in Figure 1 is challenging.

[8] According to Dutta et al. (2020), knowledge creation is measured by registered patents, utility model applications, peer-reviewed articles, while knowledge impact is captured by, for example, improvements in labour productivity, entry density of new firms, and firms' utilization of science and technologies. Moreover, knowledge diffusion is reflected in the international exchange of intellectual properties, ICT services, and high-tech products, among others (Dutta et al., 2020). These factors capture a country's efforts to acquire productive knowledge. See also Dutta et al. (2020) for a more detailed description.

capital that a child born today may obtain by the age of 18, given the threats to health and education improvements prevailing within a society (Kraay, 2019). Following Murphy et al. (1991) and Natkhov and Polishchuk (2019), I attempt to capture the deployment of human resources in productive activities, rather than non-productive activities, by using the share of tertiary education graduates in sciences. This measure of the allocation of talent, compiled by the UNESCO Institute of Statistics, encompasses the fraction of graduates majoring in life and physical sciences, mathematics, technology and engineering.

Overall, this section is devoted to understanding the roles of (1) knowledge and technology outputs, (2) creative outputs, (3) human capital accumulation and (4) the allocation of talent in mediating the established effects of institutions on economic complexity (Figure 1). Before discussing the mediation method developed by Acharya et al. (2016), I replicate the main analysis by using the aforementioned mediating factors as alternative outcome variables. Consistent with numerous studies cited in Section 2, I find evidence that institutions have positive impacts on innovative entrepreneurship, human capital accumulation and the allocation of talent towards productive activities (Figure 1).[9] Moreover, previous studies also suggest that these proposed pathways play a key role in shaping the worldwide distribution of economic complexity (Hausmann & Rodrik, 2003; Hausmann et al., 2007; Costinot, 2009; Zhu & Fu, 2013; Zhu & Li, 2017; Lapatinas & Litina, 2019). Therefore, the mediating variables plausibly play an important role in explaining the relationship between institutional quality and economic complexity across countries.

In order to investigate the size of the total effects of institutions on economic complexity attributed to these mechanisms, I rely on a simple two-stage regression procedure of Acharya et al. (2016). The first step involves regressing ECI on the treatment variable (EFW) and the mediators (e.g., human capital), controlling for the main geographic attributes and continent dummies. Using these empirical estimates, I construct a demediated outcome variable by subtracting the effects of the mediators from the fitted values of ECI. In the second-step regression, the average controlled direct effects (ACDE) of institutions on economic complexity are estimated by regressing the demediated dependent variable on EFW, geographic controls and continent dummies.[10] According to Acharya et al. (2016), the unbiased

[9] These estimates are not reported for brevity, but are available upon request.

[10] More specifically, the first-step regression model can be expressed as $ECI_i = \alpha + \beta EFW_i + \varphi M_i + \rho X_i + \delta Continent_i + \varepsilon_i$, in which M_i stands for possible mediating variables (see also the benchmark model for a description of other variables). Next, the demediated outcome variable is calculated as $\widetilde{ECI_i} = ECI_i - \hat{\varphi} M_i$. The second-stage regression is represented by $\widetilde{ECI_i} = \alpha_2 + \beta_2 EFW_i + \rho_2 X_i + \delta_2 Continent_i + \omega_i$. The estimated

ACDE estimates offer valid inference on the impacts of institutions on economic complexity holding the effects of the mediating variables fixed at a particular level. Meanwhile, the baseline results reflect the total effects of institutions on ECI when I do not account for the underlying mechanisms. The difference between the ACDE estimates and the benchmark findings in terms of their statistical precision and magnitude captures the role of the mediating variables in explaining the established relationship between institutions and economic complexity (Acharya et al., 2016).

Figure 5 plots the estimated coefficients and 95% confidence intervals of the ACDE estimates of EFW on ECI when partialling out the effects of the proposed mechanisms. More specifically, the results capture the ACDE estimates of institutions on economic complexity once I account for (1) knowledge and technology outputs (ACDE (*Know_tech outputs*)), (2) creative outputs (ACDE (*Creative outputs*)), (3) human capital accumulation (ACDE (*Human capital*)), and (4) the deployment of human resources in productive activities (ACDE (*Allocation of talent*)). Furthermore, I undertake an additional mediation analysis by accounting for all mediating variables (ACDE (*All mechanisms*)). In all cases, the model specification is augmented with the set of main geographic controls and continent dummies, and the bootstrapped standard errors based on 1000 replications are adopted to obtain reliable inference.

As illustrated in Figure 5, the magnitude of the ACDE of institutions on ECI, except for ACDE (*Creative outputs*), is significantly smaller than that of the total effects, reported in Column (3) of Tables 1 and 2. The results depicted in Panel A of Figure 5 suggest that the OLS estimates of the ACDE of institutions remain precisely estimated at conventionally accepted levels of statistical significance, except for ACDE (*Know_tech outputs*) and ACDE (*All mechanisms*). However, the ACDE estimates of the plausibly exogenous component of institutions turn out to be highly imprecisely estimates at commonly accepted thresholds of significance (Panel B, Figure 5). Moreover, there exists substantial reduction in the statistical precision and magnitude of the effects of institutions on ECI when accounting for all possibly mediating variables (see ACDE (*All mechanisms*)).

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coefficient on EFW ($\widehat{\beta_2}$) reflects the estimated effects of institutions on economic complexity accounting for potentially mediating variables. However, Acharya et al. (2016) emphasize that the standard errors obtained from the second-stage regression can be biased given that the first-stage estimates of $\hat{\varphi}$ are not accounted for. To address this concern, I derive the standard errors from a bootstrapped procedure using 1000 replications.

The findings indicate that institutions have no statistical significant effect on economic complexity when partialling out the effects of mediating factors. In other words, the established positive association between institutions and complexity is mainly mediated by innovative entrepreneurship, human capital accumulation and the deployment of human resources in productive activities. This is consistent with the arguments outlined in Section 2 and Figure 1. Overall, these estimates suggest that the proposed mechanisms play a key role in shaping the extent to which institutions translate into cross-country differences in economic complexity.

7. Concluding remarks

This study empirically establishes that institutions are the fundamental drivers of economic complexity – a measure of the amount of productive capabilities. The basic intuition is that complex economies producing and exporting a diverse range of sophisticated (high-productivity) products tend to accumulate greater productive knowledge. In contrast, countries characterized by specialization in a limited range of simple (low-productivity) products are likely to suffer from lack of productive capabilities, thus impeding long-run economic growth driven by structural transformation. On this basis, economic complexity is highly predictive of future growth and development. A key distinguishing feature of this paper is to demonstrate that the availability of productive capabilities, captured by higher economic complexity, tends to proliferate in countries with well-functioning institutions.

The main hypothesis of this paper draws upon the 'self-discovery' theory of Hausmann and Rodrik (2003) and Hausmann et al. (2007). Accordingly, the extent of productive capabilities within a country critically depends on the number of entrepreneurs who pioneer in discovering the underlying cost structure of an economy. This process creates positive externalities by providing important information on the types of (new) products that can be profitably produced domestically. I propose that well-functioning institutions, by reducing cost uncertainties associated with the 'self-discovery' process, contribute to a higher degree of economic complexity. In other words, inclusive institutions, including security of property rights and enforcement of laws, contracts and regulations, reward productive activities, thus directing innovative entrepreneurship in the 'self-discovery' process. By contrast, countries with weak institutions may fail to internalize the externalities of cost discoveries, thereby reducing economic complexity. Furthermore, the quality of institutions is linked to growing economic complexity through enhancing human capital accumulation and deploying human resources in productive activities (Figure 1).

Based on a series of empirical analyses, this paper consistently documents evidence supporting the hypothesized positive relationship between institutional quality and economic complexity. Specifically, the OLS estimates are suggestive of the important role of institutions in shaping the variation in complexity across the world. To alleviate plausible concerns about omitted variables bias, I assess the scale of bias from selection on unobservables using the coefficient stability test of Oster (2019). The results indicate that the contribution of institutions to productive capabilities is not easily explained away by possibly unobserved confounders. Moreover, the plausibly exogenous component of institutions, generated by exposure to UV-R and the settlers' mortality rate, has a positive impact on the accumulation of productive knowledge. I also rely on the 'plausibly exogenous' instruments framework of Conley et al. (2012) to formally bound the estimates of institutions permitting possible deviations from the exclusion restriction. The bound estimates, together with a thorough analysis of weak instrument bias, demonstrate that my IV findings can provide a causal interpretation.

This paper also attempts to resolve inconclusive findings on the relative importance of institutions versus human capital in driving long-term development (Glaeser et al., 2004; Acemoglu et al., 2014). In line with Acemoglu et al. (2014), I find suggestive evidence of the primacy of institutions in shaping the global pattern of economic complexity. This stands in contrast to the findings of Glaeser et al. (2004). As argued above, human capital accumulation is a 'proximate' driver of economic complexity, whereas slowly evolving institutions provide a more fundamental explanation for the deep causes of productive capabilities. Hence, deeply rooted institutions may translate into economic complexity through strengthening incentives for accumulating knowledge and education. A final empirical analysis is to estimate the extent of the long-term legacy of institutions for economic complexity attributed to several mediating variables, depicted in Figure 1. The mediation results support the main hypothesis that strong institutions affect economic complexity primarily through promoting innovative entrepreneurship, human capital accumulation, and the allocation of human resources towards productive activities.

It is worth re-emphasizing that structural transformation towards producing and exporting a diverse range of sophisticated products plays a key role in fostering future economic prosperity (Hausmann & Rodrik, 2003; Hausmann et al., 2007; Hidalgo & Hausmann, 2009; Hausmann et al., 2014). The miracle growths of several East Asian economies, driven by technological innovation and imitation, are suggestive of the importance of acquiring productive capabilities in sustaining long-run growth (Liang, 2010; Ang &

Madsen, 2011). Nevertheless, many less-developed economies, characterized by the persistence of poor-quality institutions, find it hard to transform themselves from technologically backward to technologically advanced economies. Therefore, the main findings of this paper help generate a policy prescription by demonstrating that inclusive institutions help foster structural change of a country's economic structures. In other words, persistent weak institutions appear to be a major impediment to acquiring productive capabilities. The results, therefore, advocate for establishing inclusive institutions in order to strengthen economic complexity and long-term development. Policymakers should recognize the contribution of institutional improvements to structural transformation, particularly in developing economies where considerable resistance to building pro-development economic and political institutions typically persists.

Declarations

Conflict of interest: I have no conflict of interest to declare.

Ethical approval: This article does not contain any studies with human or animal subjects performed by the author.

Availability of data and material: Replication files are available on request.

References

Acemoglu, D. (1995). Reward Structures and the Allocation of Talent. *European Economic Review, 39*(1), 17-33.

Acemoglu, D., Gallego, F. A., & Robinson, J. A. (2014). Institutions, Human Capital, and Development. *Annual Review of Economics, 6*(1), 875-912.

Acemoglu, D., Johnson, S., & Robinson, J. A. (2001). The Colonial Origins of Comparative Development: An Empirical Investigation. *American Economic Review, 91*(5), 1369-1401.

Acemoglu, D., Johnson, S., & Robinson, J. A. (2012). The Colonial Origins of Comparative Development: An Empirical Investigation: Reply. *American Economic Review, 102*(6), 3077-3110.

Acharya, A., Blackwell, M., & Sen, M. (2016). Explaining Causal Findings without Bias: Detecting and Assessing Direct Effects. *American Political Science Review, 110*(3), 512-529.

Albouy, D. Y. (2012). The Colonial Origins of Comparative Development: An Empirical Investigation: Comment. *American Economic Review, 102*(6), 3059-3076.

Alesina, A., Devleeschauwer, A., Easterly, W., Kurlat, S., & Wacziarg, R. (2003). Fractionalization. *Journal of Economic Growth, 8*(2), 155-194.

Altonji, J. G., Elder, T. E., & Taber, C. R. (2005). An Evaluation of Instrumental Variable Strategies for Estimating the Effects of Catholic Schooling. *Journal of Human Resources, 40*(4), 791-821.

Andersen, T. B., Dalgaard, C.-J., & Selaya, P. (2016). Climate and the Emergence of Global Income Differences. *Review of Economic Studies, 83*(4), 1334-1363.

Andrews, I., Stock, J. H., & Sun, L. (2019). Weak Instruments in Instrumental Variables Regression: Theory and Practice. *Annual Review of Economics, 11*(1), 727-753.

Ang, J. B. (2013). Institutions and the Long-Run Impact of Early Development. *Journal of Development Economics*, *105*, 1-18.

Ang, J. B., Fredriksson, P. G., Nurhakim, A. L. B., & Tay, E. H. (2018). Sunlight, Disease, and Institutions. *Kyklos, 71*(3), 374-401.

Ang, J. B., & Madsen, J. B. (2011). Can Second-Generation Endogenous Growth Models Explain the Productivity Trends and Knowledge Production in the Asian Miracle Economies? *Review of Economics and Statistics, 93*(4), 1360-1373.

Arif, I. (2021). Productive Knowledge, Economic Sophistication, and Labor Share. *World Development, 139*, 105303.

Ashraf, Q. H., & Galor, O. (2013). The 'out of Africa' Hypothesis, Human Genetic Diversity, and Comparative Economic Development. *American Economic Review, 103*(1), 1-46.

Baumol, W. J. (1990). Entrepreneurship: Productive, Unproductive, and Destructive. *Journal of Political Economy*, *98*(5), 893-921.

Bazzi, S., & Clemens, M. A. (2013). Blunt Instruments: Avoiding Common Pitfalls in Identifying the Causes of Economic Growth. *American Economic Journal: Macroeconomics, 5*(2), 152-186.

Blundell, R., & Bond, S. (1998). Initial Conditions and Moment Restrictions in Dynamic Panel Data Models. *Journal of Econometrics, 87*(1), 115-143.

Bockstette, V., Chanda, A., & Putterman, L. (2002). States and Markets: The Advantage of an Early Start. *Journal of Economic Growth*, *7*(4), 347-369.

Borcan, O., Olsson, O., & Putterman, L. (2018). State History and Economic Development: Evidence from Six Millennia. *Journal of Economic Growth, 23*(1), 1-40.

Carstensen, K., & Gundlach, E. (2006). The Primacy of Institutions Reconsidered: Direct Income Effects of Malaria Prevalence. *World Bank Economic Review, 20*(3), 309-339.

Carter, P., Van de Sijpe, N., & Calel, R. (2021). The Elusive Quest for Additionality. *World Development, 141*, 105393.

Casey, G., & Klemp, M. (2021). Historical Instruments and Contemporary Endogenous Regressors. *Journal of Development Economics, 149*, 102586.

Conley, T. G., Hansen, C. B., & Rossi, P. E. (2012). Plausibly Exogenous. *Review of Economics and Statistics, 94*(1), 260-272.

Costinot, A. (2009). On the Origins of Comparative Advantage. *Journal of International Economics, 77*(2), 255-264.

Dias, J., & Tebaldi, E. (2012). Institutions, Human Capital, and Growth: The Institutional Mechanism. *Structural Change and Economic Dynamics, 23*(3), 300-312.

Dutta, S., Lanvin, B., & Wunsch-Vincent, S. (2020). Global Innovation Index 2020: Who Will Finance Innovation? (13th Edition). Cornell University, INSEAD, and WIPO.

Easterly, W., & Levine, R. (2003). Tropics, Germs, and Crops: How Endowments Influence Economic Development. *Journal of Monetary Economics, 50*(1), 3-39.

Felipe, J., Kumar, U., Abdon, A., & Bacate, M. (2012). Product Complexity and Economic Development. *Structural Change and Economic Dynamics, 23*(1), 36-68.

Gao, J., & Zhou, T. (2018). Quantifying China's Regional Economic Complexity. *Physica A: Statistical Mechanics and its Applications, 492*, 1591-1603.

Glaeser, E. L., La Porta, R., Lopez-de-Silanes, F., & Shleifer, A. (2004). Do Institutions Cause Growth? *Journal of Economic Growth, 9*(3), 271-303.

Gwartney, J. D., Holcombe, R. G., & Lawson, R. A. (2004). Economic Freedom, Insitutional Quality, and Cross-Country Differences in Income and Growth. *Cato Journal, 24*, 205-233.

Gwartney, J. D., Holcombe, R. G., & Lawson, R. A. (2006). Institutions and the Impact of Investment on Growth. *Kyklos, 59*(2), 255-273.

Hartmann, D., Guevara, M. R., Jara-Figueroa, C., Aristarán, M., & Hidalgo, C. A. (2017). Linking Economic Complexity, Institutions, and Income Inequality. *World Development, 93*, 75-93.

Hausmann, R., & Hidalgo, C. A. (2011). The Network Structure of Economic Output. *Journal of Economic Growth, 16*(4), 309-342.

Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., Simoes, A., & Yildirim, M. A. (2014). *The Atlas of Economic Complexity: Mapping Paths to Prosperity*. Cambridge, MA: The MIT Press.

Hausmann, R., Hwang, J., & Rodrik, D. (2007). What You Export Matters. *Journal of Economic Growth, 12*(1), 1-25.

Hausmann, R., & Rodrik, D. (2003). Economic Development as Self-Discovery. *Journal of Development Economics, 72*(2), 603-633.

Hibbs, D. A., & Olsson, O. (2004). Geography, Biogeography, and Why Some Countries Are Rich and Others Are Poor. *Proceedings of the National Academy of Sciences, 101*(10), 3715.

Hidalgo, C. A. (2021). Economic Complexity Theory and Applications. *Nature Reviews Physics, 3*(2), 92-113.

Hidalgo, C. A., & Hausmann, R. (2009). The Building Blocks of Economic Complexity. *Proceedings of the National Academy of Sciences, 106*(26), 10570-10575.

Hidalgo, C. A., Klinger, B., Barabasi, A. L., & Hausmann, R. (2007). The Product Space Conditions the Development of Nations. *Science, 317*(5837), 482-487.

Kannen, P. (2020). Does Foreign Direct Investment Expand the Capability Set in the Host Economy? A Sectoral Analysis. *World Economy, 43*(2), 428-457.

Kraay, A. (2016). Weak Instruments in Growth Regressions: Implications for Recent Cross-Country Evidence on Inequality and Growth. World Bank Policy Research Working Paper No. 7494.

Kraay, A. (2019). The World Bank Human Capital Index: A Guide. *World Bank Research Observer, 34*(1), 1-33.

La Porta, R., Lopez-de-Silanes, F., & Shleifer, A. (2008). The Economic Consequences of Legal Origins. *Journal of Economic Literature*, *46*(2), 285-332.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. (1999). The Quality of Government. *Journal of Law, Economics and Organization, 15*(1), 222-279.

Lapatinas, A. (2019). The Effect of the Internet on Economic Sophistication: An Empirical Analysis. *Economics Letters, 174,* 35-38.

Lapatinas, A., & Litina, A. (2019). Intelligence and Economic Sophistication. *Empirical Economics, 57*(5), 1731-1750.

Lee, K.-K., & Vu, T. V. (2020). Economic Complexity, Human Capital and Income Inequality: A Cross-Country Analysis. *Japanese Economic Review*, *71*(4), 695-718.

Liang, M.-Y. (2010). Confucianism and the East Asian Miracle. *American Economic Journal: Macroeconomics*, *2*(3), 206-234.

Murphy, K. M., Shleifer, A., & Vishny, R. W. (1991). The Allocation of Talent: Implications for Growth. *Quarterly Journal of Economics, 106*(2), 503-530.

Murphy, K. M., Shleifer, A., & Vishny, R. W. (1993). Why Is Rent-Seeking So Costly to Growth? *American Economic Review, 83*(2), 409-414.

Natkhov, T., & Polishchuk, L. (2019). Quality of Institutions and the Allocation of Talent: Cross-National Evidence. *Kyklos, 72*(4), 527-569.

North, D. C. (1990). *Institution, Institutional Change and Economic Performance*. Cambridge: Cambridge University Press.

Olea, J. L. M., & Pflueger, C. (2013). A Robust Test for Weak Instruments. *Journal of Business & Economic Statistics*, *31*(3), 358-369.

Oster, E. (2019). Unobservable Selection and Coefficient Stability: Theory and Evidence. *Journal of Business & Economic Statistics*, *37*(2), 187-204.

Rodrik, D., Subramanian, A., & Trebbi, F. (2004). Institutions Rule: The Primacy of Institutions over Geography and Integration in Economic Development. *Journal of Economic Growth, 9*(2), 131-165.

Romero, J. P., & Gramkow, C. (2021). Economic Complexity and Greenhouse Gas Emissions. *World Development*, *139*, 105317.

Sachs, J. (2003). Institutions Don't Rule: Direct Effects of Geography on Per Capita Income. NBER Working Paper 9490.

Spolaore, E., & Wacziarg, R. (2009). The Diffusion of Development. *Quarterly Journal of Economics*, *124*(2), 469-529.

Spolaore, E., & Wacziarg, R. (2013). How Deep Are the Roots of Economic Development? *Journal of Economic Literature, 51*(2), 325-369.

Sweet, C. M., & Maggio, D. S. E. (2015). Do Stronger Intellectual Property Rights Increase Innovation? *World Development, 66,* 665-677.

Vu, T. V. (2020). Economic Complexity and Health Outcomes: A Global Perspective. *Social Science & Medicine*, *265*, 113480.

Vu, T. V. (2021a). Climate, Diseases, and the Origins of Corruption. *Economics of Transition and Institutional Change, 29*(4), 621-649.

Vu, T. V. (2021b). Does Institutional Quality Foster Economic Complexity? The Fundamental Drivers of Productive Capabilities. ZBW - Leibniz Information Centre for Economics, Kiel, Hamburg.

Vu, T. V. (2021c). Linking LGBT Inclusion and National Innovative Capacity. *Social Indicators Research*, https://doi.org/10.1007/s11205-11021-02743-11202.

Vu, T. V. (2021d). Statehood Experience and Income Inequality: A Historical Perspective. *Economic Modelling*, *94*, 415-429.

Zhu, S., & Fu, X. (2013). Drivers of Export Upgrading. *World Development, 51*, 221-233.

Zhu, S., & Li, R. (2017). Economic Complexity, Human Capital and Economic Growth: Empirical Research Based on Cross-Country Panel Data. *Applied Economics, 49*(38), 3815-3828.

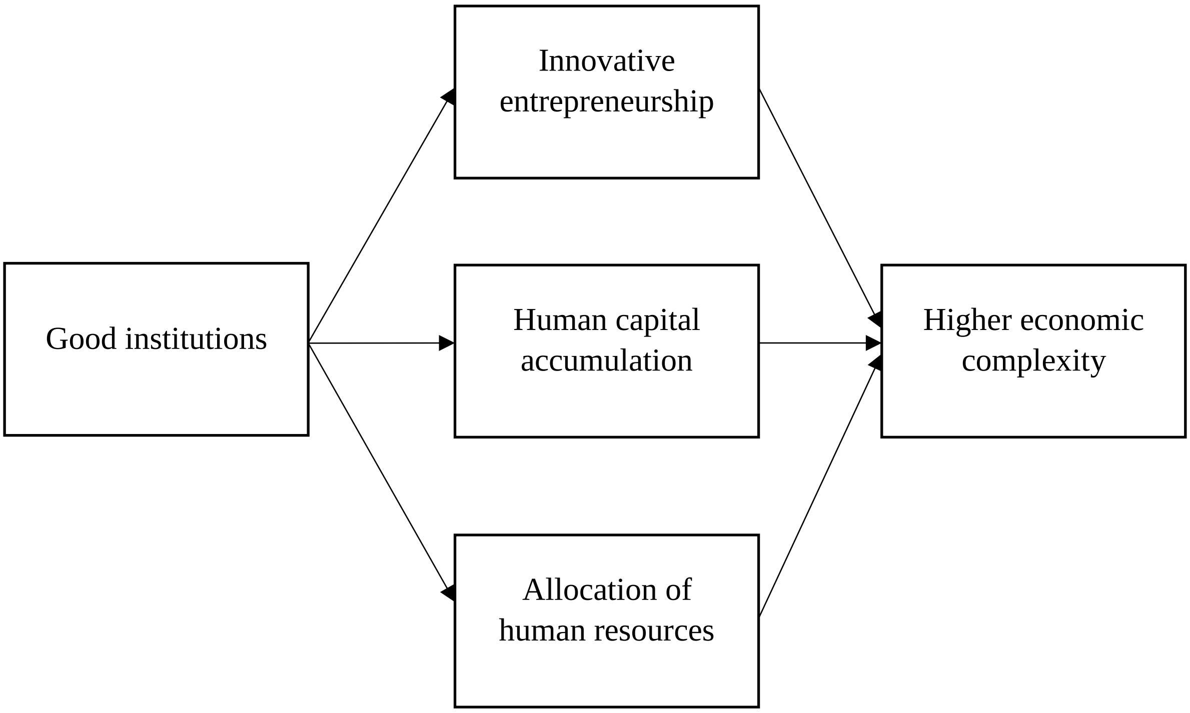

Figure 1. The relationship between institutional quality and economic complexity

Notes: This figure depicts the proposed mechanisms explaining the extent to which the quality of institutions affects economic complexity. Section 2 contains a more detailed discussion.

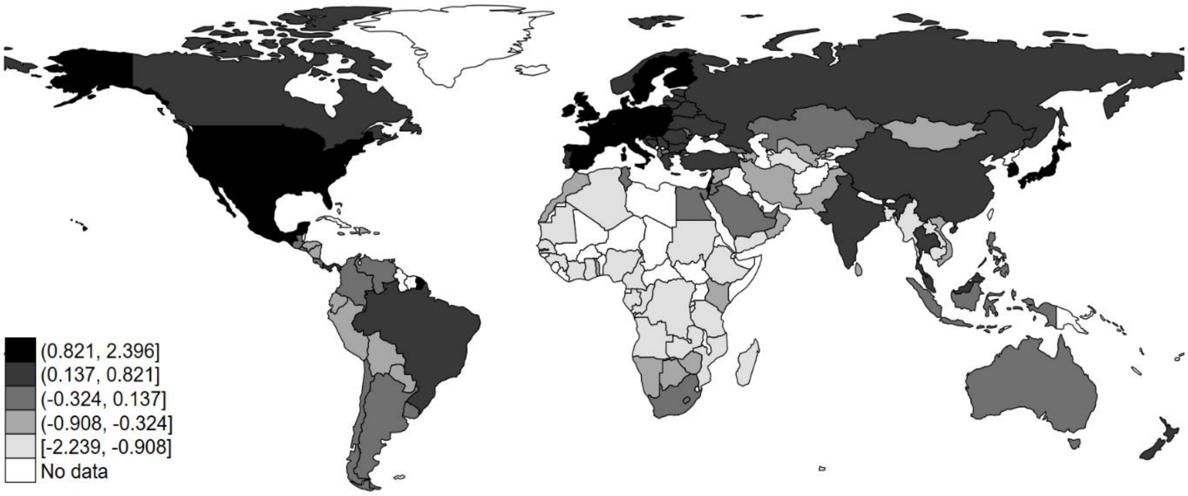

Figure 2. Cross-country differences in economic complexity

Notes: This figure depicts the cross-country variation in economic complexity. Darker areas correspond to more complex economies, characterized by the ability to produce (and export) a diverse range of sophisticated (high-productivity) products. Data, obtained from the Observatory of Economic Complexity, are averaged across the period 2000 – 2010.

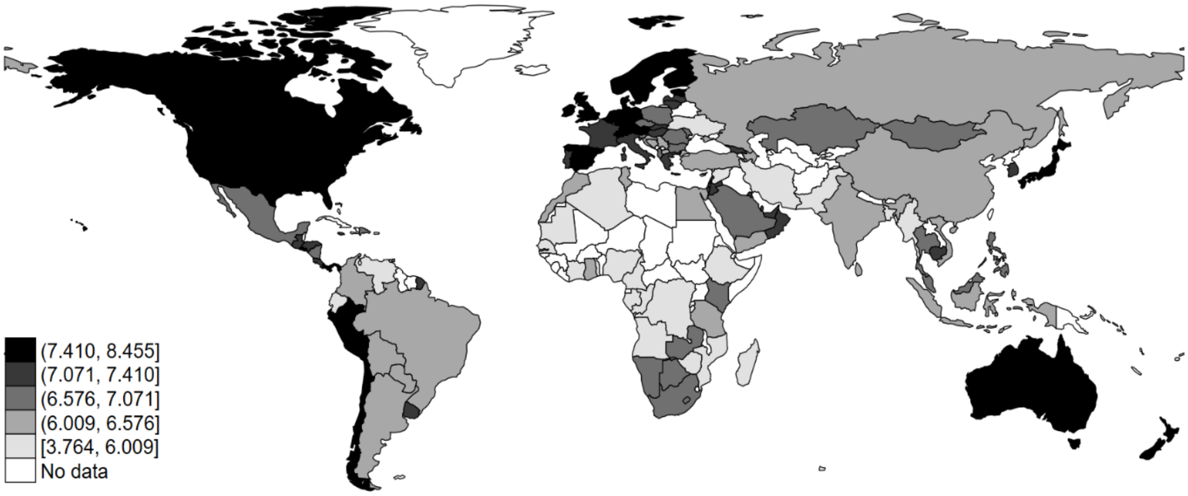

Figure 3. Cross-country differences in the quality of institutions

Notes: This figure depicts the cross-country in the quality of institutions, captured by the Economic Freedom of the World index. Darker areas correspond to societies with greater well-functioning institutions. Data, obtained from the Canadian Fraser Institute and the Heritage Foundation, are averaged across the period 2000 – 2010.

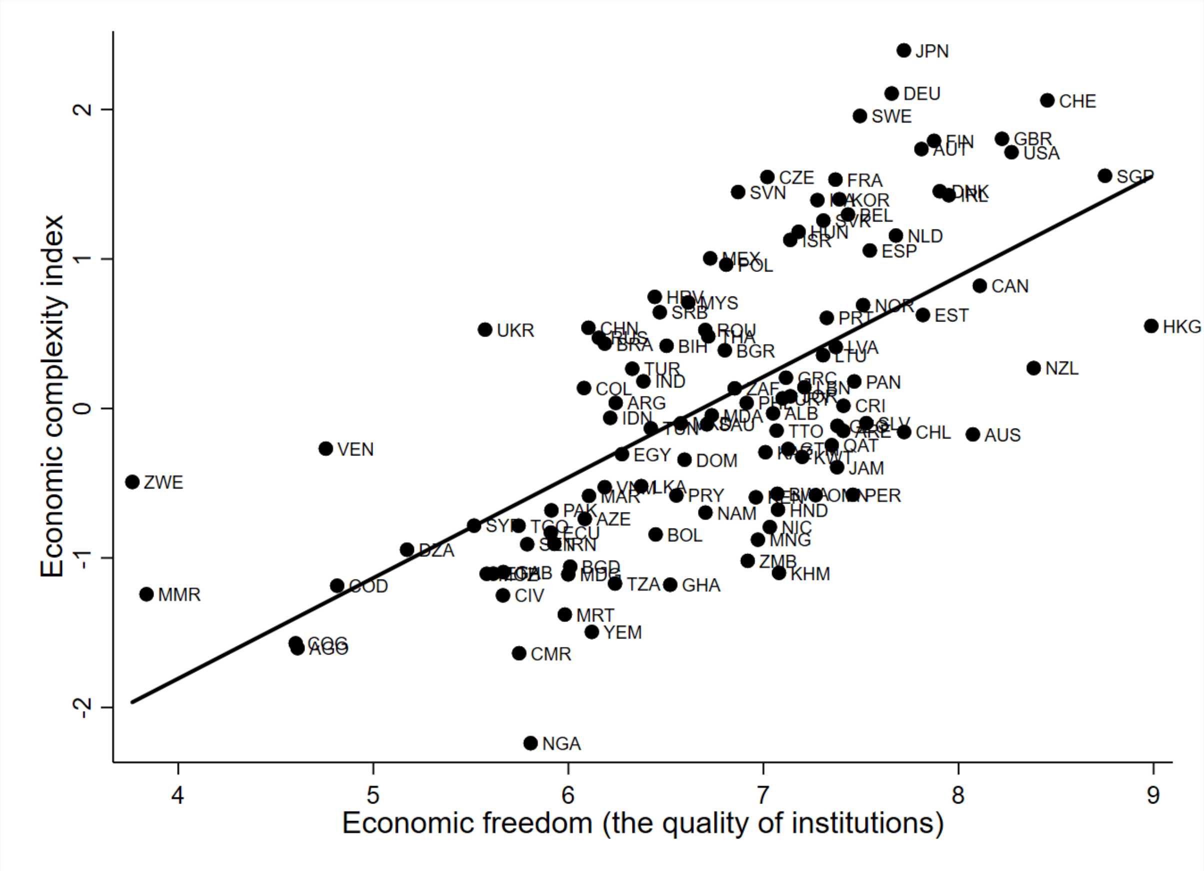

Figure 4. The relationship between institutional quality and economic complexity

Notes: This figure depicts an unconditional correlation between the quality of institutions and economic complexity across the world. Countries' abbreviations are obtained from the World Bank's World Development Indicators. See also the notes to Figures 2 and 3.

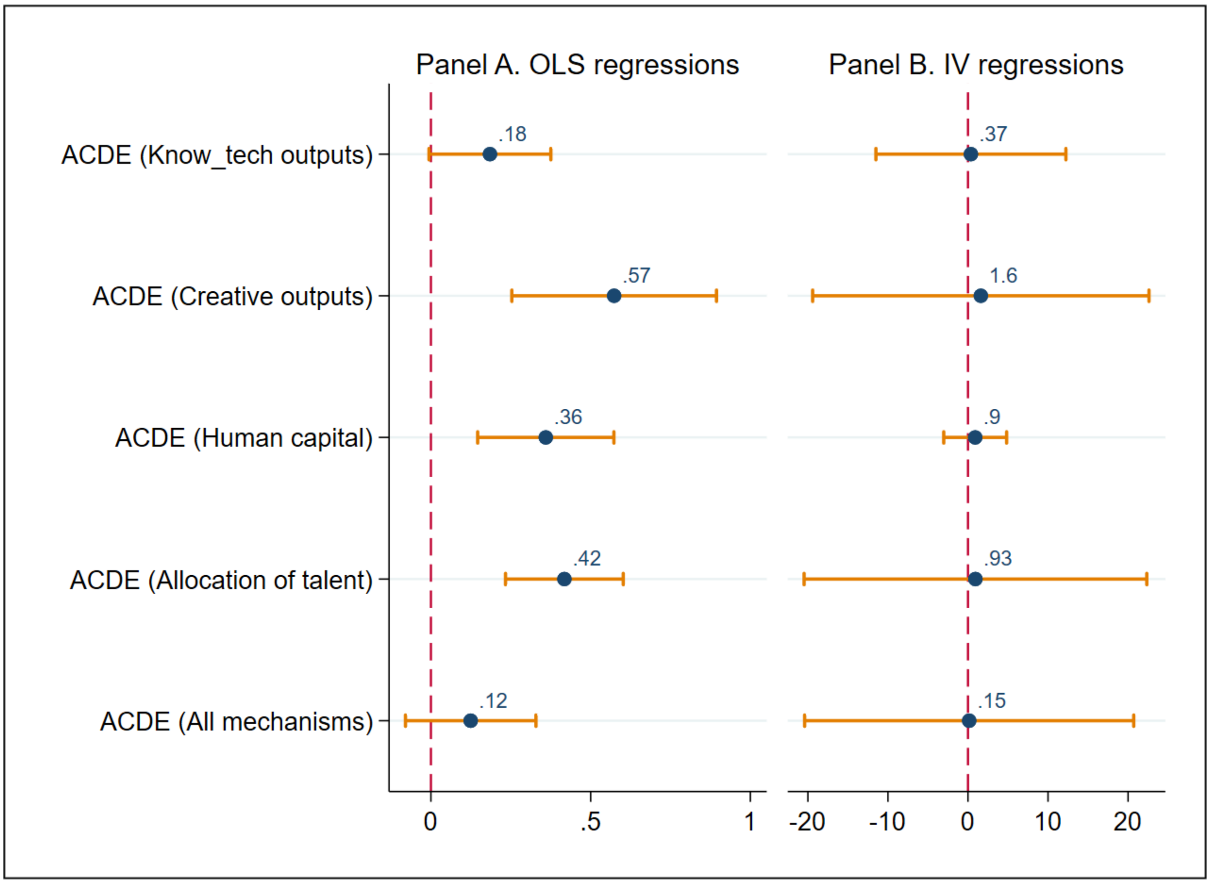

Figure 5. Average controlled direct effects of institutions on economic complexity

Notes: This figure depicts the point estimates and 95% confidence intervals of the average controlled direct effects of institutions on economic complexity. The results capture the contribution of institutions to economic complexity accounting for the impacts of potentially mediating variables, including innovative entrepreneurship (*Know_tech outputs* & *Creative outputs*), human capital accumulation (*Human capital*) and the deployment of human resources in productive activities (*Allocation of talent*).

Table 1. OLS estimates of the effect of institutions on economic complexity

Dependent variable is *ECI*	(1)	(2)	(3)
EFW	0.673***	0.669***	0.449***
	(0.081)	(0.095)	(0.101)
Mean elevation		-0.146	-0.092
		(0.199)	(0.186)
Distance to the nearest waterways		-0.174	-0.181
		(0.241)	(0.142)
Landlocked dummy		0.074	-0.007
		(0.251)	(0.213)
Land suitability for agriculture		-0.129	-0.149
		(0.325)	(0.390)
The fraction of arable land		0.014**	-0.003
		(0.006)	(0.007)
Continent dummies	No	No	Yes
Observations (# of countries)	115	100	100
R-squared	0.419	0.510	0.657
Oster's δ statistic for $\beta = 0$		1.932	1.184
Oster's lower bound estimates (β^*)		0.535	0.110

Notes: This table reports OLS estimates of the effects of institutions on economic complexity. Continent dummies are binary variables for Africa, America, Europe and Asia (Oceania is the base group). The δ statistic captures how large the amount of selection on unobservables, relative to that on observables, needs to be in order to attenuate the coefficients on institutions towards zero. Conditional on proportional selection ($\delta = 1$), β^* would equate to the bias-adjusted impact of institutions on ECI if I were to account for all unobserved confounders. An intercept, omitted for brevity, is included in all the regressions. Robust standard errors in parentheses. ***, **, and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 2. IV estimates of the effect of institutions on economic complexity

	(1)	(2)	(3)
Panel A. Second-stage estimates. Dependent variable is *ECI*			
EFW	1.593***	1.351***	1.146***
	(0.209)	(0.165)	(0.262)
Mean elevation		-0.042	-0.087
		(0.269)	(0.232)
Distance to the nearest waterways		0.021	-0.067
		(0.287)	(0.227)
Landlocked dummy		-0.004	-0.030
		(0.344)	(0.293)
Land suitability for agriculture		-0.513	-0.266
		(0.344)	(0.351)
Arable land		0.014**	0.005
		(0.007)	(0.007)
Panel B. First-stage estimates. Dependent variable is *EFW*			
Log (UV-R)	-0.815***	-1.069***	-1.158***
	(0.117)	(0.130)	(0.235)
Panel C. Additional information			
Continent dummies	No	No	Yes
Observations	108	99	99
First-stage *F*-statistic of excluded instrument	48.42	67.43	24.10
First-stage *R*-squared	0.257	0.384	0.496
Anderson-Rubin Wald test	116.46	80.67	19.10
Cragg-Donald weak identification test	36.77	47.18	18.21
Anderson-Rubin confidence intervals	[1.28, 2.11]	[1.07, 1.72]	[0.70, 1.79]

Notes: This table reports IV estimates of the effects of institutions on economic complexity. The first-stage *F*-statistic of Olea and Pflueger (2013) is suggestive of the relevance of the instrument. Anderson-Rubin identification-robust confidence intervals are the bound estimates of the effects of institutions on economic complexity, regardless of the strength of the instrument (Andrews et al., 2019). Robust standard errors in parentheses. ***, **, and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 3. Using alternative instrumental variables

	(1)	(2)	(3)
Panel A. Second-stage estimates. Dep_var: *ECI*			
EFW	1.592***	1.048***	1.148***
	(0.547)	(0.274)	(0.262)
Panel B. First-stage estimates. Dep_var: *EFW*			
Log of settlers' mortality	-0.239**		-0.177*
	(0.113)		(0.093)
Log (UV-R)		-1.414***	-1.166**
		(0.417)	(0.434)
Panel C. Additional information			
Geographic controls	Yes	Yes	Yes
Continent dummies	Yes	Yes	Yes
Observations	53	52	52
First-stage *F*-statistic of excluded instrument	4.47	11.48	7.87
First-stage *R*-squared	0.457	0.567	0.586
Anderson-Rubin Wald test	17.08	18.38	20.34
Cragg-Donald weak identification test	2.85	10.82	6.47
Anderson-Rubin confidence intervals	[0.52, 2.66]	[0.64, 1.94]	[0.82, 2.35]
Over-id [*p*-value]			0.316

Notes: This table replicates the baseline IV regressions using alternative instrument sets. Over-id is the test for the validity of over-identifying restrictions, and failure to reject the null hypothesis provides some support for the exclusion restriction. Geographic controls stand for all geographic characteristics included in the main regression, as shown in Tables 1 and 2. Robust standard errors in parentheses. ***, **, and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 4. Using alternative measures of institutions

	(1)	(2)	(3)	(4)
Panel A. OLS estimates. Dep_var: *ECI*				
Rule of Law	0.597*** (0.078)			
Control of Corruption		0.601*** (0.074)		
Government Effectiveness			0.672*** (0.075)	
Voice & Accountability				0.551*** (0.099)
Panel B. Second-stage (IV) estimates. Dep_var: *ECI*				
Rule of Law	0.749*** (0.127)			
Control of Corruption		0.739*** (0.127)		
Government Effectiveness			0.808*** (0.124)	
Voice & Accountability				1.115*** (0.266)
Panel C. First-stage (IV estimates). Dep_var: alternative measures of institutions				
Log(UV-R)	-1.784*** (0.276)	-1.809*** (0.277)	-1.655*** (0.267)	-1.198*** (0.263)
Panel D. Additional information				
Geographic controls	Yes	Yes	Yes	Yes
Continent dummies	Yes	Yes	Yes	Yes
Observations	106	106	106	106
First-stage *F*-statistic	41.71	42.52	38.26	20.80
First-stage *R*-squared	0.591	0.611	0.579	0.586
Anderson-Rubin Wald test	19.91	19.91	19.91	19.91
Cragg-Donald weak identification test	41.56	43.31	37.92	19.48
Anderson-Rubin confidence intervals	[0.51, 1.01]	[0.50, 1.00]	[0.57, 1.06]	[0.72, 1.82]

Notes: This table replicates the main analysis using alternative measures of institutions, obtained from the World Bank's World Governance Indicators. Higher values of these variables correspond to better institutions. The World Bank's indices of rule of law, control of corruption, government effectiveness, and voice & accountability are adopted in Columns (1) to (4), respectively. Robust standard errors in parentheses. ***, **, and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5. Plausibly exogenous IV estimates of the effect of institutions on economic complexity

Measures of institutions	(1)	(2)	(3)	(4)	(5)
	EFW	Rule of Law	Control of Corruption	Government Effectiveness	Voice & Accountability
Panel A. IV estimates. Dependent variable is *ECI*					
Institutions	1.146***	0.749***	0.739***	0.808***	1.115***
	(0.262)	(0.127)	(0.127)	(0.124)	(0.266)
Panel B. 95% confidence intervals for institutions under $\boldsymbol{\gamma \sim N(0, \delta^2)}$					
CI (2δ = 20%)	[0.467, 1.897]	[0.417, 1.086]	[0.410, 1.072]	[0.467, 1.151]	[0.446, 1.867]
CI (2δ = 40%)	[0.291, 2.141]	[0.332, 1.176]	[0.328, 1.160]	[0.365, 1.255]	[0.289, 2.105]
CI (2δ = 60%)	[0.102, 2.391]	[0.246, 1.268]	[0.244, 1.249]	[0.260, 1.362]	[0.119, 2.347]
CI (2δ = 80%)	**[-0.097, 2.645]**	[0.156, 1.362]	[0.157, 1.340]	[0.152, 1.472]	**[-0.062, 2.592]**
Geographic controls	Yes	Yes	Yes	Yes	Yes
Continent dummies	Yes	Yes	Yes	Yes	Yes
Observations	108	114	114	114	114

Notes: This table reports lower bound and upper bound estimates of the effects of the exogenous component of institutions, created by exposure to UV-R, on economic complexity allowing for different degrees of deviations from the exogeneity condition, following Conley et al. (2012). More specifically, *CI (2δ = p%)* corresponds to the 95% confidence intervals of the estimated coefficient on institutions allowing for the direct contribution of the instrument (UV-R) to the outcome variable to be up to *p%* of the marginal effects of institutions on complexity in the main IV analysis. These intervals are constructed using the main IV estimates reported in Tables 2 and 4, and they are reproduced in Panel A of this table for ease of comparison. Robust standard errors in parentheses. ***, **, and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 6. The roles of institutions and human capital in driving economic complexity

	Second-stage estimates	First-stage estimates	
	(1)	(3)	(4)
Dep_var	**ECI**	**EFW**	**Human capital**
EFW	0.949**		
	(0.472)		
	[0.177, 4.421]		
Human capital	-0.578		
	(2.931)		
	[-22.117, 4.209]		
Log (UV-R)		-1.466***	-0.191***
		(0.515)	(0.037)
Protestant missionaries in the early twentieth century		0.135	0.035**
		(0.218)	(0.015)
			(0.011)
Geographic controls	Yes	Yes	Yes
Continent dummies	Yes	Yes	Yes
Observations	44	44	44
First-stage *F*-statistic		4.86	13.13
First-stage *R*-squared		0.622	0.802

Notes: This table reports IV estimates of the effects of institutions and human capital on economic complexity. The quality of human capital is the World Bank's index of human capital accumulation (Kraay, 2019). I account for endogeneity concerns by instrumenting both EFW and human capital by exposure to UV-R and the number of Protestant missionaries in the early twentieth century. Robust standard errors in parentheses. Identification-robust Anderson-Rubin confidence intervals are reported in squared brackets. ***, **, and * denote statistical significance at the 1%, 5% and 10% levels, respectively.