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Macroeconomic Analysis of the Impact of Economic Complexity on Income Inequality: Does Institutional Quality Matter?[1]

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This paper sheds light on the relationship between economic complexity and income inequality considering the role of institutions based on data over the period 1996–2020 across 52 developed and developing countries from Europe and Central Asia, and the Middle East and North Africa. Our contribution to the existing literature is twofold. First, we analyse the relationship between economic complexity and income inequality considering the institutional dimension and studying various components of institutions. Second, we take into account the non-linear form of relationship between economic complexity and income inequality, as well as heterogeneity of this relationship across groups of countries. We address endogeneity by employing a fixed effect two stage least squares model with instrumental variables. Our results demonstrate that for the overall sample of countries, an increase in a country's economic complexity results in higher level of income inequality. However, the impact of economic complexity on income inequality is heterogene-

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ous across groups of countries, with a U-inverted relationship in countries of Europe and Central Asia. Moreover, economic complexity combined with the high level of institutional quality can reduce income inequality. Therefore, we conclude that the improvement of all components of institutional structure will facilitate a decrease in income disparities. Our analysis shows that better educational level leads to lower income inequality. Besides, our findings emphasise the need for policy ensuring more equal gains from economic development and international trade.

***Key words*:** economic complexity; income inequality; institutional quality; economic development; instrumental variables (IV) estimation; economic policy.

JEL Classification: E02, O15, O33.

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1. Introduction

Nowadays the major challenges to global and national socio-economic development pivot on achieving sustainable economic growth and reducing income inequality, but inequalities within most countries have been significantly deepening and widening [Chancel et al., 2022]. Economic growth is still perceived as the fundamental determinant of inequality reduction, as enshrined by Kuznets (1955), who suggested that economic growth initially causes increasing inequality, which eventually evens out into lower income inequality. However, questioning the conclusions of Kuznets and subsequent works, Piketty (2014) proposed another view on the link between economic growth and inequality, claiming that when an economy reaches higher income levels, inequality tends to continue to increase, and the latter paradigm is supported by trends in income inequality dynamics. In fact, inequalities have increased consistently in advanced economies over the last decades [Nolan et al., 2019; Malla, Pathranarakul, 2022]. Such outcomes also run contrary to the view that advanced economies tend to have a higher *economic complexity* (i.e., economic diversification and sophistication of productive capabilities), which can potentially improve the standard of living for all social strata [Hidalgo, Hausman, 2009].

Therefore, the aim of this paper is to shed light on the relationship between economic complexity and income inequality considering the role of *institutions* (i.e., institutional quality measured as an average of the World Governance Indicators which include Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law, Control of Corruption. The Institutional quality variable ranges from –2 to 2, with 2 indicating strong governance performance.

The issue of rising income inequality is important for several reasons, including that it can undermine socio-economic gains that form the political and ontological basis for economic growth at the societal level. Persistently high inequality is related to lower and less durable economic growth in the long run, as well as to potential food insecurity and political instability [Alesina, Rodrik, 1994; Lakner, Milanović, 2016]. Evidence suggests that inequality can dampen economic growth by restraining investments and consumption [Acemoglu et al., 2012; Carvalho, Rezai, 2014;

Kumhof et al., 2015]. Countries with high inequality levels are vulnerable to economic, financial and political instability, and are less resistant to crises [Rajan, 2010; Cingano, 2014; Berg, Ostry, 2017]. Moreover, rising inequality is also fraught with fall in human capital investment and decrease in innovative activities [Topuz, 2022].

High inequality is also associated with unbalanced redistribution of economic gains among individuals, rent-seeking behaviour, and excessive concentration of resources [Mihályi, Szelényi, 2019]. Therefore, while shifting to a sustainable and inclusive economic growth paradigm [Zhu, 2022], it is essential to analyse factors determining inequality as well as develop policies to handle the increasing rates of income disparities and ensure prosperity of societies. In this framework, the concept of *economic complexity*, as a novel perspective on socio-economic development, gave rise to a burgeoning line of income inequality studies. However, literature on *the link between economic complexity and inequality* is currently limited to a dozen works with contradictory results. There are four scenarios documented in the existing literature: a negative relationship [Hartmann et al., 2017; Lee, Vu, 2019], a positive relationship [Lee, Vu, 2019; Chu, Hoang, 2020; Sepehrdoust et al., 2021]; a non-linear U-inverted relationship [Sbardella et al., 2017; Chu, Hoang, 2020; Zhu et al., 2020; Morais et al., 2021; Amarante et al., 2023; Nguyen et al., 2023]; and a non-linear U-shaped relationship [Nguyen et al., 2023; Pham et al., 2023].

The relationship between economic complexity and income inequality was found to be non-homogenous across countries with different income and development levels by many recent investigations [Lee, Vu, 2019; Chu, Hoang, 2020; Amarante et al., 2023; Nguyen et al., 2023]. Moreover, using interaction terms, authors explored factors that can mediate the impact of economic complexity on inequality, among which they cited education, government spending, institutions, and trade openness [Lee, Vu, 2019; Chu, Hoang, 2020]. Specifically, there is evidence that government policies and institutions can affect the nature of the economic complexity and inequality nexus [Chu, Hoang, 2020].

Institutions tend to co-evolve with the sophistication of an economic system [Hidalgo, Hausmann, 2009; Hartmann et al., 2017; Vu, 2022], as transformation and improvement of institutions is essential to ensure the functioning of the economic system in general and the redistribution of income in particular. Gaps in governance, weakness, or a lack of inclusive institutions can exacerbate inequalities while a country experiences economic growth. This is a consequence of the accumulation and use by a few corporations (and even individuals) of new productive capabilities, diversification, and sophistication of production, growing competitiveness, and strengthening of the country's position in the world market [Acemoglu et al., 2005; Balland et al., 2022].

Overall, theoretical predictions suggest a potentially powerful role for institutions, but in praxis their instrumentality in the relationship between economic complexity and income inequality has not received commensurate attention. Our work is aimed at filling this gap by considering the role of institutions in the nexus of economic complexity and income inequality. Our contribution to the existing literature is twofold. First, we analyse the relationship between economic complexity and income inequality considering the institutional dimension and studying various components of institutions. Second, we address the non-linear form of relationship between economic complexity and income inequality, as well as heterogeneity of this relationship across groups of countries. Besides, we account for economic development and human capital levels, and countries' participation in international trade. In addition, we address the issue of endogeneity by employing a fixed effect two stage least squares (2SLS) model with instrumental variables (IVs).

This paper is structured as follows. Section 2 reviews previous findings on the relationship between economic complexity and income inequality. Section 3 describes the empirical modelling, economic complexity measurement, econometric methods, and data used in this paper. Section 4 presents the results of our analysis and discusses the main findings. Section 5 finalises our work and provides policy implications.

2. Literature Review

2.1. Economic complexity: theoretical and empirical background

Economic complexity refers to the diversity and sophistication of a country's productive capabilities, i.e., all inputs available to the country, such as technologies, unique productive know-how and ideas that allow an economy to produce a wide range of goods [Hidalgo, Hausman, 2009]. The more inputs a country has, the more diversified and sophisticated its production structure. Therefore, economic complexity can be conceptualized as a measure of the *knowledge accumulated in a society* expressed in the products it makes [Hausmann et al., 2011]. Moreover, knowledge, local and non-local, is essential for innovation, which, in turn, creates opportunities for economic diversification and complexity [Gao, Rai, 2023].

Economic complexity is an accurate predictor of economic growth [Hidalgo, Hausmann, 2009; Chávez et al., 2017; Tacchella et al., 2018; Bustos, Yıldırım, 2022]. The sophistication of the economy (i.e., increasing economic complexity) was traditionally assumed to be associated with a commensurate decrease in income inequality, as proclaimed by the pioneering study in this field by Hartmann et al. (2017). However, there is extensive empirical evidence questioning the supposed role of economic complexity in improved income distribution and reduced inequality problems, as mentioned previously. Nevertheless, studies have highlighted several mechanisms through which economic complexity can potentially improve the distribution of income in a country.

Firstly, complex economic systems are associated with better quality institutions and higher unionization, which tend to reduce income inequality. In fact, appropriate institutions can prevent increasing inequalities in the individuals' capabilities and skills, while strong unionization provides workers with more bargaining power enabling them to earn higher wages [Hartmann, 2014; Le Caous, Huarng, 2020].

Secondly, economic diversification broadens employment opportunities, because a complex economy, due to its specific demands, requires more labour with different skill levels, resulting in lower inequality [Hartmann, 2014].

Finally, individuals living in a complex economy possess an access to a greater diversity of skills and knowledge, and, more importantly, to a larger pool of social capital (social contacts, communities, and networks); while social capital is not captured by aggregate measures of human capital, it is assumed to intrinsically reduce income inequality [Caldarelli et al., 2012; Hartmann 2014]. Besides, a complex economy creates incentives for firms to search for new knowledge, and, therefore, to look for collaborations, which also enhances social links and provides more opportunities for employees [Bernal et al., 2022].

Therefore, this theoretical paradigm posits that structural changes in the economy, accompanied by sophistication and diversification, are not only able to foster economic growth *per se*,

but also facilitate a reduction of inequality. However, recent studies of the link between economic complexity and inequality present contradictory or ambiguous results, and there is a need for more research exploring the relationships between associated variables in various socio-economic contexts worldwide.

2.2. The link between economic complexity and income inequality

The exploration of the link between economic complexity and income inequality resulted in the findings suggesting that increasing economic complexity can lead to lower inequality, as reported by Hartmann et al. (2017). Their study based on panel regression with country fixed effects revealed that countries with higher levels of economic complexity have lower levels of income inequality and tend to be more inclusive. Meanwhile, a country's productive structure is affected by the interaction of various factors, from the education level to the institutional quality, which co-evolve along with the country's mix of exported goods and the economy's inclusiveness.

However, subsequent research by Lee and Vu (2019) employing dynamic panel data analysis, namely a system GMM estimator, demonstrated a positive relationship between economic complexity and inequality that contradicts the results obtained by Hartmann et al. (2017). Lee and Vu (2019) argued that an increase in economic complexity (i.e., sophistication and diversification of production and export) is associated with higher income inequality in both the short and long term. Furthermore, the presence of a positive link was evidenced by more recent research [Chu, Hoang, 2020; Sepehrdoust et al., 2021].

Several studies point out non-linear relationships between economic complexity and income inequality and underscore several determinants of income inequality along with economic complexity. Chu and Hoang (2020), exploring a positive link between economic complexity and inequality, mentioned that this relationship is far more complicated than suggested by the binary of negative or positive. They observed that economic complexity can facilitate a decrease in inequality in countries endowed with better human capital, higher institutional quality, efficient public spending, and economic freedom. Conversely, in less favourable environments, it fails to reduce income inequality.

This controversial effect of economic complexity on income inequality implies the possibility of a non-linear relationship, which can be interpreted in the framework of the Kuznets (1955) curve hypothesis. This concept implies the adverse effects of structural changes on income distribution in the initial period of economic growth and, after a certain point, the levelling of income inequality by public finance investments, including public education, the social safety net, and health care. Specifically, economic complexity initially can increase income inequality, but once a country reaches a certain level of development or complexity, income inequality starts reducing [Chu, Hoang, 2020]. In line with this framework, current empirical studies reveal a U-inverted relationship between economic complexity and inequality [Sbardella et al., 2017; Chu, Hoang, 2020; Zhu et al., 2020; Morais et al., 2021; Amarante et al., 2023; Nguyen et al., 2023]. Although the existence of a threshold of economic complexity has been addressed in most recent studies, the specific characteristics of this threshold have not yet been extensively researched.

However, there is also evidence of a U-shaped relationship between economic complexity and inequality [Nguyen et al., 2023; Pham et al., 2023]. The U-inverted effect of economic com-

plexity on inequality was discovered in non-high-income countries, whereas in high income countries an opposite effect was revealed (i.e., the latter exhibited a U-shaped curve); the U-shaped relationship was also reported for most countries in such regions as the Middle East and North Africa (MENA) and South Asia [Nguyen et al., 2023].

Overall, there is evidence that the economic complexity effect on inequality is not homgenous across countries [Sbardella et al., 2017; Lee, Vu, 2019; Amarante et al., 2023], which, in combination with mixed results, suggests the existence of a non-linear relationship.

Moreover, some studies using interaction terms revealed factors that can moderate the impact of increased economic complexity. For instance, better education and (*ipso facto*) developed human capital have the potential to enhance the negative correlation between economic complexity and inequality [Lee, Vu, 2019; Chu, Hoang, 2020]; effective government spending and trade openness have moderating impacts on the effect of economic complexity [Chu, Hoang, 2020].

Thus, we assume that the sophistication of the economic system, along with its positive effects, can bring the aggravation of inequality. However, these adverse effects could be mediated by institutional factors. For instance, when national institutions are inclusive, they ensure a fair distribution across society of wealth and gains from increasing economic complexity and consequent economic growth. Moreover, strong institutions along with factors like human capital can enhance positive impacts of economic sophistication thus decreasing inequality, and, at the same time, mitigate negative ones, preventing further exacerbation of income disparities and the existing socio-economic problems.

2.3. Determinants of income inequality on the regional and country level

Along with research based on the country-level data, a number of studies consider the nexus between economic complexity and income inequality on the regional level. For instance, Sbardella et al. (2017) found that wage inequality increases in US counties with growing economic complexity; however, the relation between economic complexity and income inequality has an inverted U-shaped pattern consistent with the Kuznets hypothesis. Morais et al. (2021) analysed Brazilian states and also documented the U-inverted shape of this relationship, having displayed that growing levels of economic complexity first worsen and then improve income distribution in Brazil, with a more distinct pattern in highly urbanized and developed states. Hence, a certain level of economic development must be achieved before the regional production structure begins to reduce income inequality.

The abovementioned relation between a higher economic complexity and urbanization level as well as overall regional development was supported by recent research on inequality in diverse economies, including China [Zhu et al., 2020] and Romania [Le Caous, Huarng, 2020]. In urban areas, a more sophisticated industrial structure provides a wider range of occupational opportunities and greater resilience to shocks. Besides, in urban areas, workers are more skilled and have more complex networks, which increases their bargaining power on the labour market and eventually reduces inequality. At the same time, rural areas suffer from higher income inequality, which is partly explained by inequalities in opportunities for education, training, and working, less developed infrastructure, and limited social networks.

The results of regional level studies are comparable to those of national-level research [Chu, Hoang, 2020; Sepehrdoust et al., 2021]: countries that are generally wealthier and endowed

with more developed human capital, institutions, and economic freedom may be likely to exhibit a reduction in inequality when their economies become more complex and diversified, while countries with the opposite characteristics may not exhibit such trends. Such non-homogenous and uneven development is difficult to control due to the self-reinforcing nature of complexity [Balland et al., 2022].

2.4. Summary of economic complexity-income inequality relationships and research hypotheses

To summarize, during recent years four types of relationships were found in empirical research: positive and negative relationships, «U-inverted», and conversely «U-shaped» non-linear relationships.

The hypothesis of economic complexity as a negative predictor of income inequality [Hartmann et al., 2017] is supported by the difference in the knowledge diversification levels typical for high- and low-complexity economies. Developing highly sophisticated industries is impossible without a proper level of knowledge diversification. This, in turn, leads to a relatively flat occupational structure, broadly distributed knowledge, and a wide range of demanded skills, thus decreasing income inequality [Constantine, Khemraj, 2019].

In contrast, low-complexity economies producing simpler and more widespread products usually depend mainly on low-skilled labour. This happens because a low value-added production requires much less advanced technology, competence, or product knowledge [Sepehrdoust et al., 2021]; as a result, the range of available occupational opportunities is constrained. Consequently, only a limited group of people benefits economically from such a production structure. This leads to a significant income discrepancy when a small number of individuals receives the largest portion of generated income, while the most numerous middle- and low- income classes have low salaries and very few opportunities for moving up the social ladder [Chu, Hoang, 2020].

At the same time, the evidence about the positive link between economic complexity and income inequality is often explained by technological changes, for instance, by the skills-based technological change theory [Violante, 2008]. The shift in production technologies required for an economy to become more complex results in an increasing demand for skilled labour over unskilled labour; the demand for highly qualified personnel grows further with the emergence of new technologies, widening the skills and income gap.

Inequality seems to be associated with growth and concentration of economic complexity, since more complex systems, by their nature, tend to be more unequal. This happens since complex adaptive systems are characterized by the preferential attachment, self-reinforcing feedback loops, and other multiplicative processes that lead to increasing inequality [Balland et al., 2022]. The example of urban areas demonstrates that inequality also rises when some individuals, corporations, and even locations occupy privileged positions, accumulate benefits from the growing diversification and sophistication of an economy, and therefore have access to a more significant share of income redistribution associated with growing economic complexity [Sbardella et al., 2017; Zhu et al., 2020; Morais et al., 2021]. Others are less fortunate due to many factors, from being in the «wrong» place to having an unsuitable skill set or level.

In turn, technological gaps, and the monopolization of advanced knowledge by technological giants [Rikap, Lundvall, 2020; Feldman et al., 2021] can potentially explain why the in-

creasing complexity of productive capabilities and economic diversification do not reduce inequality [Balland et al., 2022].

Based on the reviewed theoretical and empirical literature on economic complexity and income inequality, we propose the following hypotheses:

H1: *The effect of economic complexity on income inequality is non-linear.*

The rationale for this hypothesis is that income inequality behaves differently at various stages of economic diversification [Sbardella et al., 2017; Chu, Hoang, 2020; Zhu et al., 2020; Morais et al., 2021; Amarante et al., 2023; Nguyen et al., 2023; Pham et al., 2023].

H2: *Institutional quality has a mediating role in the relationship between economic complexity and income inequality.*

The basis for this hypothesis is that well-functioning institutions can strengthen positive effects of economic complexity and level out its negative consequences [Lee, Vu, 2019; Chu, Hoang, 2020].

3. Methodology and Data

3.1. Measurement of economic complexity

Firstly, the interpretation of the economic complexity index (ECI) is the following. The intuition behind the concept of economic complexity proposed by Hidalgo and Hausmann (2009) is that the productive capabilities of each economy can be characterized by the range of productive knowledge that it possesses and by the number of ways in which individual knowledge can be combined to produce various goods. In other words, every good produced by a country contains information about the knowledge used for its production. Therefore, by combining data on all the products created by the economy, we can assess its level of knowledge advancement and productive capabilities. Hidalgo and Hausmann (2009) emphasize that countries' productivity depends on the diversity of non-tradable capabilities, such as institutional and human capital characteristics, as well as their interactions, that determine economic complexity.

The ECI is calculated using export data that connects countries to the products in which they have revealed comparative advantages (RCA) [Hidalgo, Hausmann, 2009; Hausmann et al., 2011; Caldarelli et al., 2012; Kemp-Benedict, 2014; Hartmann et al., 2017; Lee, Vu, 2019]. Thus, it goes beyond the idea of production diversity associated with the range of productive knowledge described above. ECI reflects not only the *diversity* of a country's economy (the number of products it produces and exports) but also the *ubiquity* of products (other countries' ability to produce and export a particular type of a product). Hence, *complex economies* are diverse and can export products with low ubiquity, meaning knowledge-intensive (sophisticated) products that only a few diverse countries are able to export [Hartmann et al., 2017; Balland et al., 2022].

Secondly, the construction of ECI implies the following concepts and stages. Hidalgo and Hausmann (2009) proposed the Method of Reflections to reveal production capabilities of countries based on trade data by calculating ECI. The title of the method is due to a symmetric set of variables for countries and products (two types of nodes in the network) that it generates. This method brings information about the capabilities available in a country based on knowledge of the measurable capabilities required for producing a specific product.

This method was further elaborated and applied in numerous papers, including Hausmann et al. (2011) and Hartmann et al. (2017). The method involves the concept of revealed com-

parative advantage (RCA); RCA of a country *c* in a product *p* is the share of product *p* in the export of country c to the share of product p in world export [Hidalgo, Hausmann, 2009; Hartmann et al., 2017]. An RCA greater than 1 indicates that a country has a comparative advantage in a particular product, which means that the export of a product from a country is larger than what would be expected based on the size of the country's exports and the global market for the product.

The RCA is used to determine elements of a discrete matrix M_{cp}, equal to 1 if country *c* has a revealed comparative advantage in product *p* and 0 if it does not, as shown in Eq. 1:

$$M_{cp} = \begin{cases} 1 \text{ if } RCA_{cp} \geq 1 \\ 0 \text{ if } RCA_{cp} < 1. \end{cases} \quad (1)$$

where M_{cp} is a matrix in which rows represent different countries and columns represent different products.

A country *c* is considered to be a significant exporter of a product *p* in world trade if its RCA is greater than 1. The matrix M_{cp} allows to define the diversity of a country (Eq. 2) and the ubiquity of a product (Eq. 3), respectively. The number of products exported by a country with comparative advantage, and the number of countries exporting a product with comparative advantage are described by the following equations:

$$Diversity = k_{c,0} = \sum_p M_{cp}. \quad (2)$$

$$Ubiquity = k_{p,0} = \sum_c M_{cp}. \quad (3)$$

where $k_{c,0}$ and $k_{p,0}$ stand for diversity and ubiquity (respectively), measured by summing the rows and columns of the matrix M_{cp}.

Furthermore, to generate a more accurate measure of economic complexity, these indicators are jointly corrected for each other. This adjustment is needed as a country may export a wide variety of goods because of its economic size, whereby the information on a country's capabilities contained in the diversity indicator could be biased [Lee, Vu, 2019]. The Method of Reflection iteratively calculates the mean value of the previous-level diversity and ubiquity [Hidalgo, Hausmann, 2009; Kemp-Benedict, 2014; Lee, Vu, 2019].

Therefore, the adjusted matrix connects countries exporting similar products, weighted by the inverse of the ubiquity of a product, discounting common products, and normalized by the diversity of a country (Eq. 4):

$$\tilde{M}_{CC'} = \frac{1}{k_{c,0}} \sum_p \frac{M_{cp} M_{c'p}}{k_{p,0}}. \quad (4)$$

Lastly, the ECI is formulated as shown below (Eq. 5):

$$ECI_c = \frac{\vec{K}_c - \langle \vec{K} \rangle}{std(\vec{K})}. \quad (5)$$

where $\left\langle \vec{K} \right\rangle$ represents an average, and $std\left(\vec{K}\right)$ stands for a standard deviation of a K_c – the eigenvector of $\tilde{M}_{CC'}$, associated with the second largest eigenvalue [Hausmann et al., 2011; Caldarelli et. al., 2012; Kemp-Benedict, 2014; Hartmann et al., 2017].

Thus, the Method of Reflections breaks down a country's trade into separate industries and products, making it possible to analyse the relationships between individual units in the system and ultimately draw a conclusion about the overall complexity level of an economy [Kemp-Benedict, 2014].

The limitations of ECI are the following. First, product classification is quite detailed [Hidalgo, Hausmann, 2009], however, it might not cover all firms' activities limiting itself by the main activity specified by a firm. Secondly, not all economic activities are correctly registered, especially in developing countries, including some of the ECA and MENA countries in our sample. Third, although RCA index is quite informative, its classical version used by Hidalgo and Hausmann (2009), mentioned above, does not include countries' imports, unlike, for example, Lafay index, limiting the overall understanding of a country's role in international trade. Besides, Hidalgo and Hausmann (2009) point out that the method does not capture differences among countries in capabilities utilized in production, although it is able to capture the correspondence between variety of capabilities in a country (such as employment categories), and diversity and ubiquity of products. Finally, Kemp-Benedict (2014) points out that ECI measure suggested by Hidalgo and Hausmann (2009) provides more information on export basket of a country than on a country's diversity of export.

3.2. Data

This work employs data over the period 1996-2020 across 52 developed and developing countries from Europe and Central Asia (ECA), the Middle East and North Africa (MENA). The list of countries in the sample is presented in Appendix A. The data on income inequality is obtained from the Standardized World Income Inequality Database (SWIID) [Solt, 2020]. The ECI is obtained from the Atlas of Economic Complexity, provided by the Growth Lab at Harvard University. We also include in our analysis a set of control variables established in the literature, using data from the World Development Indicators (WDI) database. Table 1 describes the variables and data sources.

Most previous studies analysed the relationship between economic complexity and inequality in large samples of countries [Hartman et al., 2017; Sbardella et al., 2017; Lee, Vu, 2019; Chu, Hoang, 2020; Amarante et al., 2023; Nguyen et al., 2023], but Lee and Wang (2021) focused on small groups of developed and developing countries. Most researchers emphasize the heterogeneity in results for countries with various income and development levels as well as for countries in different regions [Lee, Vu, 2019; Chu, Hoang, 2020; Amarante et al., 2023; Nguyen et al., 2023], but extensive sub-group and regional analyses are lacking. Moreover, recent works have questioned previous results such as those reported by Hartman et al. (2017), suggesting that they may be influenced either by the patterns typical for countries with high income levels and above average economic complexity [Amarante et al., 2023], or by patterns of development in lower-income countries [Lee, Vu, 2019].

Table 1.

Variables and data sources

Variable	Description	Source
GINI	The Gini index is a measure of inequality in equivalized (square root scale) disposable (post-tax, post-transfer) household income. GINI ranges from approximately 23.0 (more equal income distribution) to 46.0 (more unequal income distribution)	The Standardized World Income Inequality Database (SWIID) by Solt (2020)
ECI	The Economic Complexity Index measures the amount of productive knowledge belonging to each country. ECI ranges from approximately –2.0 (low complexity) to 2.0 (high complexity)	The Atlas of Economic Complexity provided by the Growth Lab at Harvard University
GDP pc	Estimate of Gross Domestic Product per capita using the WB data on GDP (constant 2015 US$) and population, total	World Development Indicators (WDI)
Gov	General government final consumption expenditure (% of GDP), which includes all government current expenditures for purchases of services and goods. It includes most national defence and security expenditures but excludes government military expenditures (they are part of government capital formation)	
Trade	Trade (% of GDP) presents the sum of exports and imports of goods and services measured as a share of gross domestic product	
Schooling	School enrolment, tertiary (% gross) is the ratio of total enrolment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. *Note: tertiary education, whether or not it is an advanced research qualification, normally requires, as a minimum condition of admission, the successful completion of education at the secondary level*	
Institute	Institutional quality is an average of the World Governance Indicators which include Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law, Control of Corruption. The Institutional quality variable ranges from –2 to 2, with 2 indicating strong governance performance	The Worldwide Governance Indicators, 2022

These contradictory findings lead us to the idea of estimating the inequality effects of economic complexity by groups of countries. Therefore, we propose two *classifications of countries*, based on (1) their income levels, and (alternatively) (2) based on geography. According to income level, countries can be subdivided into high, upper-middle, and lower-middle income groups. Concerning classification based on geography, the first group of countries includes ECA, and the second group consists of MENA countries.

The descriptive statistics for the main variables are displayed in Table 2. The GDP per capita, government expenditure, trade and school enrolment rate are transformed into the natural logarithmic form. The Gini coefficient takes values from 22.0 to 47.0, meaning that our sample contains countries with relatively more equal income distributions, which are mostly located in Europe; and countries with relatively high levels of inequality, mainly located in MENA and Central Asia. The economic complexity values are in the interval ranging from –1.9 to 2.5, which includes countries with various levels of complexity.

Table 2.

Variable descriptive statistics (N = 1352)

Variable	Mean	Std. Dev.	Min	Max
ECI	0.63	0.86	–1.85	2.45
GINI	32.59	5.65	21.90	47.00
lnGDPpc	9.24	1.22	5.92	11.38
lnSchooling	3.81	0.54	2.08	5.02
Institute	0.36	0.92	–1.66	1.95
lnGov	2.87	0.26	2.04	3.50
lnTrade	4.42	0.39	2.59	5.53

3.3. Empirical model

Several studies mentioned endogeneity concerns pertaining to the relation between economic complexity and inequality [Lee, Vu, 2019; Chu, Hoang, 2020; Amarante et al., 2023; Nguyen et al., 2023]. In particular, Lee and Vu (2019) questioned the pioneering influential research in the field by Hartmann et al. (2017). Lee and Vu (2019) argued that the results on the negative relationship between economic complexity and inequality may be biased due to the potential endogeneity of ECI, since there is a significant difference in coefficients of economic complexity under linear pooled OLS and system GMM estimations. Chu and Hoang (2020) also addressed the potential endogeneity issue by using pooled 2SLS and system-GMM; however, they found no differences between the estimation results. Similarly, Amarante et al. (2023) incorporated lagged regressors into the fixed effect estimation to control for endogeneity, but also found no difference between these results and those obtained from simple fixed effect estimation. Since the endogeneity problem is not sufficiently covered in the existing literature on the ECI – inequality relationship, with only a few papers employing instrumental variables, there is a need to further explore this issue [Lee, Vu, 2019; Amarante et al., 2023].

We address the potential endogeneity issue by employing a fixed-effect two stage least squares (2SLS) model with instrumental variables (IVs), which provides more consistent results in comparison with simple OLS estimation [Bollen, 1989; Foster, McLanahan, 1996; Maydeu-Olivares et al., 2020]. Moreover, this allows for comparability of results with previous studies.

At the first stage of 2SLS model we use lagged ECI as IVs and assess the impact of lagged ECI on current ECI, as we assume that ECI is an endogenous variable. For robustness check we also assume endogeneity of GDP pc and include lagged GDP pc as IVs in addition to lagged ECI. The results prove to be robust (Appendix B: Table 7).

At the second stage of 2SLS model we assess the impact of economic complexity on income inequality based on the following model (Eq. 6):

$$(6)\quad \begin{aligned} GINI_{it} = {} & \beta_0 + \beta_1 ECI_{it} + \beta_2 \ln GDP_{it} + \beta_3 \ln GDP_{it}^2 + \beta_4 \ln Schooling_{it} + \beta_5 Institute_{it} + \\ & + \beta_6 \ln Gov_{it} + \beta_7 \ln Trade_{it} + \nu_i + \gamma_t + \varepsilon_{it}. \end{aligned}$$

where *i* stands for a country and *t* stands for a time period; *ECI* and *Institute* are the economic complexity and institutions indexes; *lnGDP*, *lnSchooling*, *lnGov*, *lnTrade* are the natural logarithms of the GDP per capita, school enrolment (tertiary), government expenditures, and trade, respectively; ν_i is an unobserved effect that does not change over time (country fixed effect); γ_t – time fixed effect; and ε_{it} stands for the error term.

To check the validity of the results obtained from the instrumental regression, we use the Sargan-Hansen J-statistic (since the conventional R-squared is no longer valid in the 2SLS model). This statistic is used to test whether the instruments are uncorrelated with the error term [Baum, 2003]. The acceptance of the null hypothesis suggests that instruments are generally valid, and hence the results are reliable. The model was estimated using xtivreg2 command developed for Stata by Schaffer (2010).

Additionally, to consider a scenario of non-linear relationships between GDP per capita and income inequality [Kuznets, 1955], as well as that of *economic complexity* and income inequality [Sbardella et al., 2017; Chu, Hoang, 2020; Zhu et al., 2020; Morais et al., 2021; Amarante et al., 2023; Nguyen et al., 2023; Pham et al., 2023], we introduce quadratic terms for GDP per capita and ECI in the model. Both the baseline model and the models with quadratic terms are estimated using 2SLS with country and time fixed effects.

4. Results

4.1. Economic complexity impacts on inequality: regional features

Table 3 presents the estimation results of the impact of ECI on income inequality for all countries in our sample based on 2SLS method with country and time fixed effects. Columns 1 and 5 in Table 3 demonstrate the estimation results of the baseline model. Columns 2–4 and 6–8 provide estimation results of the models with quadratic terms of ECI and institutions that were added to the baseline model to test for non-linear relationships between variables and the robustness of the results. Models 1–4 are estimated with country fixed effects, and Models 5–8 are estimated with country and time fixed effects (FE). Heteroskedasticity-robust standard errors are applied.

Table 3.

Estimation results for all countries in the sample

Dependent variable: Gini coefficient

	1	2	3	4	5	6	7	8
ECI	1.134***	1.212***	1.370***	1.398***	1.270***	1.311***	1.504***	1.514***
	(0.355)	(0.369)	(0.363)	(0.374)	(0.369)	(0.381)	(0.376)	(0.385)
lnGDP	4.510**	4.775**	3.444	3.589	4.197*	4.315**	2.796	2.841
	(2.138)	(2.170)	(2.218)	(2.258)	(2.151)	(2.176)	(2.259)	(2.290)
lnGDP2	−0.261**	−0.274**	−0.203	−0.210	−0.278**	−0.281**	−0.192	−0.193
	(0.125)	(0.126)	(0.129)	(0.131)	(0.127)	(0.128)	(0.134)	(0.135)
lnSchooling	−0.620***	−0.643***	−0.666***	−0.676***	−0.794***	−0.797***	−0.785***	−0.785***
	(0.184)	(0.187)	(0.185)	(0.186)	(0.206)	(0.207)	(0.204)	(0.205)
Institut	−0.540*	−0.542*	−0.480*	−0.482*	−0.358	−0.367	−0.330	−0.334
	(0.282)	(0.284)	(0.278)	(0.279)	(0.275)	(0.278)	(0.274)	(0.276)
lnGov	−0.026	−0.055	0.009	−0.006	−0.168	−0.180	−0.083	−0.088
	(0.320)	(0.323)	(0.321)	(0.322)	(0.318)	(0.321)	(0.321)	(0.323)
lnTrade	0.982***	0.978***	0.893***	0.893***	0.799***	0.802***	0.704***	0.706***
	(0.247)	(0.248)	(0.251)	(0.252)	(0.259)	(0.260)	(0.265)	(0.266)
ECI2		−0.102		−0.047		−0.060		−0.019
		(0.111)		(0.115)		(0.115)		(0.120)
Institut2			−0.622***	−0.608***			−0.651***	−0.646***
			(0.199)	(0.202)			(0.205)	(0.208)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	No	No	No	No	Yes	Yes	Yes	Yes
Observations	1040	1040	1040	1040	1040	1040	1040	1040
S-H test (p-value)	0.9041	0.8923	0.7475	0.7382	0.9008	0.8932	0.7249	0.7218
Countries	52	52	52	52	52	52	52	52

Notes: *, ** and *** denote a significance level at 10%, 5%, and 1%, respectively; heteroskedasticity-robust standard errors are in parentheses; IVs: lagged ECI.

The results with country fixed effects and with both country and time fixed effects proved to be consistent. Moreover, adding quadratic terms also confirmed robustness of the results. For models in Tables 3–8 the Sargan-Hansen test (S-H test) of overidentifying restrictions demonstrates that the instruments are valid (uncorrelated with the error term) and that the excluded instruments are correctly excluded from the estimated equation (p-values are in Tables 3–8). Besides, Underidentification test (LM statistic) showed that the model is identified (the null hypothesis of underidentification was rejected). Instruments were checked for redundancy, and the null hypothesis of redundancy was rejected.

Our findings reveal a positive and statistically significant effect of economic complexity on income inequality, meaning that an increase in a country's economic complexity results in a higher level of income inequality. This is consistent with previous works, which also found that rising complexity enhances income inequality [Lee, Vu, 2019; Chu, Hoang, 2020; Amarante et al., 2023]. However, in contrast to previous studies [Sbardella et al., 2017; Chu, Hoang, 2020; Zhu et al., 2020; Morais et al., 2021; Amarante et al., 2023; Nguyen et al., 2023], we observe that the quadratic term of economic complexity is insignificant. Hence, we cannot confirm the presence of a nonlinear relationship in an overall sample of ECA and MENA countries.

Meanwhile, the results demonstrate that higher education significantly contributes to the reduction of inequality, consistent with previous findings [Lessmann, Seidel, 2017; Chu, Hoang, 2020]. This observation is reinforced by the fact that income inequality is directly related to educational inequality [Lee et al., 2018]. Therefore, when higher education becomes more accessible, and its attainment rate consequently increases, income inequality tends to decrease.

At the same time, we revealed that the overall quality of institutions has a significant role in reduction of inequality, corroborating recent studies featuring the overall quality of institutions or specific aspect of institutions such as democracy [Hartmann et al., 2017; Ouechtati, 2022; Oyèkọ́lá, 2023]. Thus, development of inclusive institutions can promote equal access to gains from economic growth thus decreasing income disparities.

An opposite effect is observed for trade. Particularly, specific features of a country's international trade may be associated with increasing inequalities, in line with previous research [Bergh, Nilsson, 2010; Dorn et al., 2021; Adão et al., 2022]. This effect also coincides with the ambiguous theoretical predictions of the neoclassical trade theory on the effect of trade openness on income inequality for developing and developed countries. Namely, this theory implies that trade openness has a potential to decrease inequality in developing countries due to narrowing the income gap between skilled and unskilled labour, and providing the poorest people with larger gains; simultaneously, it tends to increase inequality in developed countries, by providing upper middle class with disproportionately more gains [Stolper, Samuelson, 1941].

At the second stage, driven by the fact that previous works reported heterogeneous results for various groups of countries and different regions [Lee, Vu, 2019; Chu, Hoang, 2020; Amarante et al., 2023; Nguyen et al., 2023], we divided our sample of 52 countries into two subsamples based on their regional belonging, as described previously (ECA and MENA). The model estimation by regions is shown in Table 4.

After dividing the sample into subgroups of ECA (Models 1–3 and 7–9) and MENA (Models 4–6 and 10–12) countries, the results with country fixed effects and with both country and time fixed effects are consistent. Adding quadratic terms also confirmed robustness of the results. For the ECA group, the sign of ECI remains statistically significant and positive. Moreover, the coefficient of its quadratic term becomes significantly negative. Hence, we conclude that the U-inverted relationship between economic complexity and income inequality is typical for ECA. This implies that the increased sophistication of the economy and diversification of production initially lead to rising disparities in the region; however, after reaching a certain level of development, ECA countries start to experience a decrease in income inequality, with the further increase in the complexity of their economies. In contrast, in MENA countries, both the ECI and its square have no significant impact on income inequality dynamics.

Table 4.

Estimation results by regions

Dependent variable: Gini coefficient

	ECA	ECA	ECA	MENA	MENA	MENA	ECA	ECA	ECA	MENA	MENA	MENA
	1	2	3	4	5	6	7	8	9	10	11	12
ECI	1.470*** (0.380)	1.998*** (0.509)	2.174*** (0.521)	−0.302 (0.657)	−0.678 (1.104)	−0.827 (1.120)	1.688*** (0.425)	2.096*** (0.568)	2.273*** (0.576)	−0.163 (0.637)	−0.413 (0.965)	−0.538 (1.014)
lnGDP	4.593** (2.055)	6.129*** (2.209)	5.150** (2.241)	16.90*** (4.566)	17.97*** (5.238)	15.20*** (5.033)	3.887 (2.485)	5.101* (2.632)	3.960 (2.718)	16.11*** (4.815)	16.91*** (5.199)	13.75** (5.337)
lnGDP2	−0.268** (0.119)	−0.344*** (0.126)	−0.293** (0.127)	−1.013*** (0.258)	−1.069*** (0.292)	−0.88*** (0.282)	−0.274* (0.146)	−0.320** (0.151)	−0.249 (0.157)	−0.929*** (0.276)	−0.966*** (0.290)	−0.751** (0.313)
lnSchoo-ling	−0.0260 (0.227)	−0.0768 (0.229)	−0.116 (0.230)	−1.237*** (0.270)	−1.248*** (0.261)	−1.30*** (0.259)	−0.272 (0.245)	−0.247 (0.248)	−0.231 (0.247)	−1.047*** (0.339)	−1.051*** (0.331)	−1.08*** (0.321)
Institut	−0.737** (0.311)	−0.779** (0.314)	−0.645** (0.319)	0.796 (0.534)	0.755 (0.538)	−0.179 (0.795)	−0.491 (0.315)	−0.597* (0.328)	−0.504 (0.325)	0.716 (0.585)	0.709 (0.593)	−0.259 (0.844)
lnGov	0.962** (0.422)	0.886** (0.422)	0.976** (0.425)	−1.192** (0.471)	−1.066* (0.558)	−0.958* (0.573)	0.795* (0.430)	0.816* (0.448)	0.993** (0.453)	−1.330*** (0.460)	−1.193** (0.598)	−1.056* (0.633)
lnTrade	0.852*** (0.281)	0.793*** (0.283)	0.739*** (0.285)	−0.169 (0.383)	−0.200 (0.392)	−0.353 (0.415)	0.474 (0.331)	0.505 (0.335)	0.485 (0.335)	−0.441 (0.570)	−0.539 (0.622)	−0.740 (0.637)
ECI2		−0.450** (0.176)	−0.423** (0.176)		−0.281 (0.473)	−0.325 (0.474)		−0.394* (0.205)	−0.389* (0.209)		−0.185 (0.396)	−0.227 (0.408)
Institut2			−0.483** (0.215)			−0.956 (0.585)			−0.511** (0.223)			−0.972 (0.626)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Observa-tions	860	860	860	180	180	180	860	860	860	180	180	180
S-H test (p-value)	0.7043	0.7132	0.7837	0.8714	0.9102	0.9967	0.8916	0.8851	0.9026	0.9531	0.9713	0.9754
Countries	43	43	43	9	9	9	43	43	43	9	9	9

Notes: *, ** and *** denote a significance level at 10%, 5%, and 1%, respectively; heteroskedasticity-robust standard errors are in parentheses; IVs: lagged ECI.

The effects of the control variables are consistent with the baseline model (Table 3), except for a significantly positive effect of government expenditures in ECA, and, at the same time, a significantly negative effect of this variable in the MENA countries. In other words, an effective general government expenditure demonstrates a potential to reduce inequality in MENA, while in the ECA it is associated with higher inequality. Therefore, for the ECA, we can confirm an existence of the inverted-U-shaped pattern of relations between economic complexity and inequality, in line with previous studies [Sbardella et al., 2017; Chu, Hoang, 2020; Zhu et al., 2020; Morais et al., 2021; Amarante et al., 2023; Nguyen et al., 2023]. At the same time, an absence of any

significant effect of economic complexity on inequality in the MENA countries does not allow us to draw final conclusions. Meanwhile, it partly corresponds to the study by Nguyen et al. (2023), who did not find a U-inverted relationship in MENA and South Asian countries.

These results reiterate that the impact of economic complexity differs across regions of the world. ECA economies are mainly dominated by developed upper middle- and high-income countries, wherein increasing economic complexity can potentially reduce inequality after reaching a certain level of development. Conversely, the nature of this relationship in MENA is not clear and requires further investigation.

Our results also support the opinion that the results for all countries may be driven by the patterns established for countries with high income or, instead, with non-high income [Lee, Vu, 2019; Amarante et al., 2023]. Consequently, all four relationships between economic complexity and inequality discovered in previous studies are possible, although they may be specific to different groups of countries.

In our case, for the overall sample of countries we found only the dominant patterns of relation between economic complexity and income inequality, probably affected by the patterns prevailing in the developed countries. Overall, ***H1*** is partly supported, as the effect of economic complexity on income inequality turned out to be non-linear, taking a U-inverted shape, in ECA countries.

We perform the following robustness check. First, we check the robustness of the results by including the IVs for GDP p.c. for the overall sample, for ECA and MENA countries, and for estimation with interaction terms. We provide the estimation results with IVs for GDP p.c. only for the overall sample (initial estimation results are presented in Table 3) due to the size limit and format of the paper (Appendix B: Table 7). Second, we check the robustness of the results by excluding GDP p.c. and GDP p.c. squared from the model (Appendix B: Table 8). The results proved to be robust.

4.2. Institutional quality mediating effect

Addressing ***H2***, we delved into the study of the role that institutional factors play in reducing inequality. Previous works on the nexus between economic complexity and income inequality employed an aggregate measure of the institutional quality across countries. This is usually estimated as the average of the Worldwide Governance Indicators (WGIs), which aim to measure the quality of governance and institutions in a country across six dimensions: voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption [World Bank, 2022].

There are suggestions in the literature that institutions can play the mediating role in the relationship between economic complexity and income inequality by alleviating an increase in inequality that arises due to growing complexity, but the indirect impacts of institutions on income inequality have not been studied extensively [Lee, Vu, 2019; Chu, Hoang, 2020]. Seeking to close this research gap in the literature, we consider the interaction of ECI with the institutional indicator and its components (Table 5) while analysing an impact of economic complexity on income inequality. This approach enables us to capture an effect of economic complexity conditional on the quality of institutions.

The model in this case has undergone some changes; in our base-line equation (Eq. 6), we alternately add WGI governance components and their interaction terms with the economic

complexity index. We also considered the interaction term of an aggregate measure of institutions as in the above models (Tables 3 and 4). The estimation results are displayed in Table 5 and indicate that institutional quality and all its components are vital for decreasing income inequality when economic complexity grows.

For instance, among other institutional indicators, we included in the model the variable «control of corruption» (*Corrupt*), which captures the extent to which public power is exercised for private gains, and state administration is subordinated to the private interests of the elites. Corruption has a number of consequences, including poor tax administration, tax evasion, reduced spending on education and healthcare, and a decline in the bargaining power of workers and trade unions. Besides, corruption diminishes the quality of public services and hinders people's access to them, leading to a lower standard of living in a country; hence, the control of corruption is an important leverage for the decrease in inequality. Moreover, corruption was found to have an adverse impact on a country's development by limiting economic growth through numerous channels, among which are discouraging investments and altering the composition of public spending.

Table 5.

Estimation results with interaction terms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ECI	1.142***	1.291***	1.117***	1.639***	1.279***	1.323***	1.173***
	(0.355)	(0.356)	(0.352)	(0.393)	(0.358)	(0.377)	(0.351)
lnGDP	4.072*	4.973**	4.211**	5.153**	4.669**	4.378**	3.796*
	(2.098)	(2.097)	(2.138)	(2.126)	(2.026)	(2.017)	(2.165)
lnGDP2	–0.234*	–0.284**	–0.245**	–0.307**	–0.281**	–0.269**	–0.232*
	(0.123)	(0.123)	(0.125)	(0.124)	(0.119)	(0.119)	(0.127)
lnSchooling	–0.640***	–0.661***	–0.554***	–0.658***	–0.656***	–0.619***	–0.538***
	(0.178)	(0.180)	(0.178)	(0.182)	(0.181)	(0.180)	(0.179)
lnGov	0.0547	–0.0357	–0.0650	–0.282	0.0749	0.126	–0.0382
	(0.325)	(0.329)	(0.318)	(0.325)	(0.318)	(0.319)	(0.317)
lnTrade	0.982***	0.872***	0.914***	0.948***	1.069***	1.108***	0.964***
	(0.248)	(0.249)	(0.244)	(0.250)	(0.245)	(0.244)	(0.248)
Corrupt	–0.503***	–0.229					
	(0.193)	(0.203)					
ECI_Corrupt		–0.600***					
		(0.148)					
Gov_Effect			–0.376*	0.0549			
			(0.199)	(0.211)			
ECI_Gov_Effect				–0.774***			
				(0.162)			

Continuation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Accountability					−0.690***	−0.727***	
					(0.176)	(0.180)	
ECI_Accountability						0.203	
						(0.160)	
Polit_Stability							0.0499
							(0.118)
ECI_Polit_Stability							
Rule_of_Law							
ECI_Rule_of_Law							
Reg_Quality							
ECI_Reg_Quality							
Institut							
ECI_Institut							
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	No	No	No	No	No	No	No
Observations	1040	1040	1040	1040	1040	1040	1040
S-H test (p)	0.8914	0.8659	0.8727	0.5913	0.8927	0.8982	0.8335
Countries	52	52	52	52	52	52	52

Continuation

	(8)	(9)	(10)	(11)	(12)	(13)	(14)
ECI	1.223***	1.165***	1.317***	1.176***	1.245***	1.134***	1.260***
	(0.350)	(0.354)	(0.364)	(0.353)	(0.359)	(0.355)	(0.356)
lnGDP	3.947*	3.930*	4.516**	3.848*	3.628*	4.510**	4.904**
	(2.141)	(2.116)	(2.134)	(2.098)	(2.108)	(2.138)	(2.136)
lnGDP2	–0.243*	–0.232*	–0.262**	–0.238*	–0.224*	–0.261**	–0.282**
	(0.125)	(0.124)	(0.125)	(0.123)	(0.124)	(0.125)	(0.124)
lnSchooling	–0.571***	–0.585***	–0.619***	–0.528***	–0.535***	–0.620***	–0.663***
	(0.180)	(0.181)	(0.182)	(0.179)	(0.179)	(0.184)	(0.185)
lnGov	–0.0317	0.00337	–0.0363	–0.0718	–0.0774	–0.0260	–0.0947
	(0.324)	(0.326)	(0.333)	(0.320)	(0.322)	(0.320)	(0.325)
lnTrade	0.992***	0.975***	0.953***	0.947***	0.894***	0.982***	0.934***
	(0.248)	(0.249)	(0.251)	(0.249)	(0.252)	(0.247)	(0.248)
Corrupt							
ECI_Corrupt							
Gov_Effect							
ECI_Gov_Effect							
Accountability							
ECI_Accountability							
Polit_Stability	0.164						
	(0.125)						
ECI_Polit_Stability	–0.318**						
	(0.124)						
Rule_of_Law		–0.248	–0.0438				
		(0.231)	(0.246)				
ECI_Rule_of_Law			–0.506***				
			(0.176)				
Reg_Quality				0.115	0,181		
				(0.190)	(0.195)		
ECI_Reg_Quality					–0.273*		
					(0.149)		
Institut						–0.540*	–0.326
						(0.282)	(0.294)

Continuation

	(8)	(9)	(10)	(11)	(12)	(13)	(14)
ECI_Institut							–0.519*** (0.181)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	No	No	No	No	No	No	No
Observations	1040	1040	1040	1040	1040	1040	1040
S-H test (p)	0.7461	0.8629	0.8095	0.8292	0.8162	0.9041	0.8542
Countries	52	52	52	52	52	52	52

Notes: *, ** and *** denote a significance level at 10%, 5%, and 1%, respectively; heteroskedasticity-robust standard errors are in parentheses; IVs: lagged ECI; dependent variable: Gini coefficient.

Table 6.

Estimation results with interaction terms: time fixed effects are added

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ECI	1.266*** (0.370)	1.369*** (0.368)	1.255*** (0.366)	1.738*** (0.400)	1.422*** (0.372)	1.481*** (0.396)	1.366*** (0.367)
lnGDP	3.905* (2.112)	4.446** (2.104)	4.043* (2.148)	4.604** (2.134)	4.630** (2.018)	4.445** (2.004)	3.334 (2.150)
lnGDP2	–0.256** (0.126)	–0.272** (0.125)	–0.268** (0.127)	–0.294** (0.126)	–0.313*** (0.120)	–0.311*** (0.120)	–0.248* (0.127)
lnSchooling	–0.817*** (0.204)	–0.746*** (0.205)	–0.755*** (0.202)	–0.760*** (0.205)	–0.888*** (0.205)	–0.877*** (0.204)	–0.788*** (0.203)
lnGov	–0.0808 (0.324)	–0.0973 (0.329)	–0.194 (0.316)	–0.353 (0.327)	–0.0580 (0.316)	–0.0161 (0.316)	–0.139 (0.318)
lnTrade	0.807*** (0.258)	0.739*** (0.258)	0.743*** (0.255)	0.806*** (0.261)	0.877*** (0.256)	0.915*** (0.254)	0.749*** (0.261)
Corrupt	–0.430** (0.191)	–0.204 (0.199)					
ECI_Corrupt		–0.576*** (0.157)					
Gov_Effect			–0.320* (0.193)	0.0771 (0.209)			

Continuation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ECI_Gov_Effect				−0.768*** (0.167)			
Accountability					−0.701*** (0.182)	−0.742*** (0.187)	
ECI_Accountability						0.234 (0.169)	
Polit_Stability							0.204* (0.120)
ECI_Polit_Stability							
Rule_of_Law							
ECI_Rule_of_Law							
Reg_Quality							
ECI_Reg_Quality							
Institut							
ECI_Institut							
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1040	1040	1040	1040	1040	1040	1040
S-H test (p)	0.8905	0.8697	0.8864	0.6259	0.8949	0.9032	0.7962
Countries	52	52	52	52	52	52	52

Continuation

	(8)	(9)	(10)	(11)	(12)	(13)	(14)
ECI	1.391***	1.302***	1.446***	1.329***	1.389***	1.270***	1.370***
	(0.366)	(0.369)	(0.378)	(0.368)	(0.373)	(0.369)	(0.368)
lnGDP	3.341	3.858*	4.223**	3.783*	3.455	4.197*	4.346**
	(2.129)	(2.122)	(2.139)	(2.115)	(2.128)	(2.151)	(2.148)
lnGDP2	−0.243*	−0.262**	−0.273**	−0.273**	−0.249**	−0.278**	−0.275**
	(0.126)	(0.126)	(0.127)	(0.126)	(0.126)	(0.127)	(0.127)
lnSchooling	−0.771***	−0.803***	−0.790***	−0.762***	−0.743***	−0.794***	−0.772***
	(0.204)	(0.207)	(0.208)	(0.204)	(0.206)	(0.206)	(0.208)
lnGov	−0.115	−0.148	−0.154	−0.229	−0.212	−0.168	−0.192
	(0.325)	(0.320)	(0.329)	(0.317)	(0.322)	(0.318)	(0.325)
lnTrade	0.785***	0.786***	0.776***	0.735***	0.689***	0.799***	0.773***
	(0.261)	(0.260)	(0.263)	(0.262)	(0.266)	(0.259)	(0.260)
Corrupt							
ECI_Corrupt							
Gov_Effect							
ECI_Gov_Effect							
Accountability							
ECI_Accountability							
Polit_Stability	0.282**						
	(0.126)						
ECI_Polit_Stability	−0.264**						
	(0.126)						
Rule_of_Law		−0.226	−0.0333				
		(0.227)	(0.240)				
ECI_Rule_of_Law			−0.515***				
			(0.179)				
Reg_Quality				0.173	0.227		
				(0.186)	(0.191)		
ECI_Reg_Quality					−0.263*		
					(0.153)		
Institut						−0.358	−0.192
						(0.275)	(0.286)
ECI_Institut							−0.512***
							(0.190)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Continuation

	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1040	1040	1040	1040	1040	1040	1040
S–H test (p)	0.7242	0.8768	0.8332	0.8291	0.8203	0.9008	0.8535
Countries	52	52	52	52	52	52	52

Notes: *, ** and *** denote a significance level at 10%, 5%, and 1%, respectively; heteroskedasticity-robust standard errors are in parentheses; IVs: lagged ECI; dependent variable: Gini coefficient

Tables 5 and 6 present results with interaction terms. Table 5 contains results with country fixed effects and Table 6 – with country and time fixed effects. The results, especially concerning interaction terms of ECI and institutional variables remain consistent confirming robustness of the model.

The control of corruption in a country demonstrates a significantly negative effect on inequality (i.e., the higher the control of corruption, the less income inequality there is). As for its mediating effect, we observe that the sign of its interaction term with ECI is significantly negative; in other words, the impact of economic complexity on income inequality is conditional on the control of corruption in a country, with lower corruption and higher economic complexity leading to lower inequality.

Overall, the moderating variables «control of corruption» (*Corrupt)*, «government effectiveness» (*Gov_effect*), «political stability» (*Polit_Stability*), «rule of law» (*Rule_of_Law*) and «regulatory quality» (*Reg_quality*) demonstrate negative and statistically significant coefficients of the interaction terms with the *ECI*. In other words, these factors contribute to the reduction of income inequality in a country by mitigating the adverse effect of economic complexity. Meanwhile, higher values of the indicator «Voice and Accountability» (*Accountability*) reduce income inequality, though interaction term turned out to be insignificant.

Finally, the interaction term between aggregate measures of institutions and economic complexity displays a similar effect, suggesting that the high quality of institutions and governance in a country can reverse the pattern of economic complexity increasing inequality. According to this observation, a country with effective governance and redistribution systems, low levels of corruption, and political stability may experience a reduction in income inequality when its level of complexity increases; conversely, low-quality national institutions can inhibit the otherwise positive effects of increasing economic complexity and exacerbate inequality.

Thus, we can conclude that well-functioning institutions can play a crucial role in shaping the impact of growing sophistication in the economy, and economic complexity can reduce income inequality if institutions are well-functioning. Institutional factors such as political stability; effective governance, high quality of public and civil service, sound policy formulation and implementation, private sector regulation and development; rule of law (e.g., expressed by the quality of contract enforcement and property rights, effective policing, and independent and competent courts); and control of corruption create favourable conditions for more equal benefits from growing economic complexity. The improvement of institutional conditions through any of these channels can facilitate a decrease in income disparities.

5. Conclusion

This paper provides new insights into understanding the essence of the relationship between economic complexity and income inequality. To address heterogeneity across groups of countries, and identify possible non-linear patterns in this relationship, we analysed the impact of economic complexity on income inequality in two regions: ECA, and MENA. There is a significant gap in levels of inequality and economic complexity between these two regions, and our analysis accounts for these diverse economic conditions. Our results underscore that the effect of increasing economic complexity may vary depending on countries' individual characteristics, such as the level of economic development, regional affiliation, human capital, and quality of institutions.

Supporting previous findings, we argue that the overall relationship between economic complexity and income inequality is positive. In other words, generally increasing economic complexity leads to higher inequality. As for a non-linear relationship, there is a lack of reliable evidence to confirm it for a sample of all countries. However, the regional sub-groups analysis indicates a U-inverted relationship between economic complexity and inequality in ECA countries, while in MENA countries there are no significant results, partially confirming ***H1*** on the non-linear relationship between economic complexity and income inequality.

This result implies that economic sophistication and diversification of production initially increase income disparities in ECA economies, but after reaching a certain level of economic complexity, these countries start to experience a decrease in income inequality alongside further increases in economic complexity. Meanwhile, we highlight the importance of considering the institutional and socio-economic environment in a particular region or country, since the beneficial effects of increasing economic complexity are associated with a more conducive environment (as explained previously), in line with previous studies.

Our finding that education, as a proxy for human capital, reduces income inequality, reflects that an increase in economic complexity is closely related to technological progress and development of productive knowledge. Therefore, sustainable economic development requires education and training of personnel that would enable employees to adapt to new knowledge and technologies and interact in the complex economic system. Thus, government should both provide equal opportunities for education, and ensure the quality and relevance of education and training to address the real challenges in the economy. In addition, it is necessary to develop and support institutions that help enhance the quality of education and its compliance with the standards as well as challenges of the modern world.

Estimation results also indicate an adverse effect of international trade on income disparities. On one hand, the economic openness and integration into international trade can contribute to the formation of competitive markets and attract capital and human resources to industries, providing jobs for employees with various skill levels, and thus decreasing income inequality. On the other hand, the gains from international trade can be distributed disproportionately, thus increasing wage differentiation between groups of workers, as well as enlarging a gap between employees and individuals in charge of business or involved in policy making. When top management, business owners, government officials, or workers from specific industries benefit from openness relatively more than the other population groups, this can deepen income inequality.

The finding that higher institutional quality decreases income inequality implies that institutional reforms are needed to create effective checks and balances and thus reduce inequality

and prevent further distortions in income distribution. However, while carrying out these reforms, it is essential to avoid restricting economic freedom and hindering innovations and entrepreneurial activity. An increase in economic complexity along with the transformation and strengthening of a country's institutions will facilitate a sustainable economic growth beneficial for all social strata, and imply a fairer distribution of income in society. This type of economic development will help reduce inequality or at least will not lead to its egregious exacerbation with increasing economic complexity.

Besides, in line with previous research, our results suggest that the quality of institutions has a significant mediating role in the relationship between economic complexity and income inequality, thus confirming ***H2***. Indeed, well-functioning inclusive institutions can strengthen the positive effects of economic complexity and level-out its negative consequences. Accordingly, we claim that the relationship between economic complexity and income inequality can be influenced through policy measures aimed at promoting sound and effective regulations, providing people with high quality public services, lowering corruption, preventing disproportionately high gains for some income groups, ensuring law enforcement, maintaining the independence of the judiciary branch of power, and preserving political stability.

We believe that to maximize benefits from the increasing economic complexity accompanied by technological progress and the transition to the knowledge economy, it is vital to prioritize the development of institutions as well as implement national systems and programs for monitoring their quality and improving the most vulnerable areas.

Overall, determining policy implications should concern not only increasing economic complexity, as if it were a single causal factor for inequality, since the economic complexity indicator is determined by a combination of unknown causes and factors [Hidalgo, 2022]. Instead, policies should focus on considering the underlying factors and mechanisms that allow society to benefit from economic complexity. Consequently, further research is required to explore the relationship between economic complexity and factors that can play a mediating role between it and inequality, and also to develop rational policies addressing these factors. Besides, differences across countries and patterns of their development deserve further research to shed new light on the nexus between economic complexity and inequality for various groups of countries, and to provide new insights into the impact of economic complexity on income inequality.

Appendix A

Sampled countries

High income	GINI 2020	ECI rank 2020	Upper middle income	GINI 2020	ECI rank 2020	Lower middle income	GINI 2020	ECI rank 2020
Slovakia	22.3	13	Belarus	24.6	31	Ukraine	27.0	49
Slovenia	24.3	11	Kazakhstan	27.7	81	Kyrgyzstan	32.0	54
Czech Republic	24.4	6	Azerbaijan	30.6	121	Algeria	32.4	108
Finland	26.0	14	North Macedonia	32.0	58	Uzbekistan	35.9	78
Belgium	26.1	22	Russia	32.8	51	Tunisia	37.9	44
Norway	26.2	37	Serbia	33.4	38	Iran	38.4	85
Sweden	26.7	8	Armenia	36.3	77	Egypt	40.0	69
Denmark	26.9	23	Jordan	37.2	59	Morocco	40.6	80
Netherlands	27.4	28	Albania	37.3	74	Tajikistan	45.3	94
Austria	27.5	7	Georgia	37.5	68			
Hungary	28.3	9	Bosnia and Herzegovina	38.6	36			
Ireland	28.6	15	Bulgaria	38.9	39			
Croatia	29.5	32	Turkey	39.9	41			
Poland	29.7	26						
Germany	29.8	3						
France	30.0	18						
Cyprus	30.1	45						
Switzerland	30.9	2						
Estonia	30.9	27						
Greece	30.9	50						
United Kingdom	31.4	10						
Spain	32.0	33						
Portugal	32.1	34						
Italy	33.7	16						
Romania	34.1	19						
Israel	34.4	21						
Latvia	35.0	35						
Lithuania	35.4	29						
Qatar	40.2	71						
Saudi Arabia	46.7	42						

Appendix B

Robustness check

Table 7.

Estimation results for all countries in the sample: with lagged ECI and lagged GDP p.c. as IVs

Dependent variable: Gini coefficient

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ECI	1.196***	1.294***	1.449***	1.498***	1.386***	1.464***	1.632***	1.680***
	(0.352)	(0.368)	(0.361)	(0.374)	(0.369)	(0.386)	(0.379)	(0.392)
lnGDP	5.051**	5.420**	4.046*	4.286*	4.628**	4.866**	3.258	3.420
	(2.187)	(2.225)	(2.255)	(2.301)	(2.204)	(2.240)	(2.295)	(2.338)
lnGDP2	−0.295**	−0.313**	−0.240*	−0.252*	−0.302**	−0.311**	−0.217	−0.224
	(0.128)	(0.129)	(0.132)	(0.134)	(0.130)	(0.131)	(0.136)	(0.137)
lnSchooling	−0.601***	−0.627***	−0.644***	−0.658***	−0.787***	−0.790***	−0.765***	−0.768***
	(0.186)	(0.188)	(0.186)	(0.187)	(0.211)	(0.212)	(0.208)	(0.209)
Institut	−0.569**	−0.574**	−0.511*	−0.516*	−0.393	−0.413	−0.375	−0.387
	(0.284)	(0.286)	(0.280)	(0.281)	(0.279)	(0.283)	(0.277)	(0.280)
lnGov	−0.0470	−0.0852	−0.0168	−0.0394	−0.187	−0.206	−0.100	−0.112
	(0.322)	(0.326)	(0.322)	(0.324)	(0.321)	(0.326)	(0.325)	(0.329)
lnTrade	0.999***	0.997***	0.910***	0.911***	0.815***	0.821***	0.723***	0.728***
	(0.248)	(0.249)	(0.252)	(0.253)	(0.261)	(0.262)	(0.266)	(0.268)
ECI2		−0.123		−0.0699		−0.0926		−0.0542
		(0.113)		(0.118)		(0.120)		(0.125)
Institut2			−0.642***	−0.623***			−0.685***	−0.677***
			(0.200)	(0.204)			(0.207)	(0.211)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	No	No	No	No	Yes	Yes	Yes	Yes
N	1035	1035	1035	1035	1035	1035	1035	1035
S-H test (p–value)	0.8586	0.8992	0.7939	0.8185	0.3024	0.3446	0.3034	0.3180
Countries	52	52	52	52	52	52	52	52

Notes: *, ** and *** denote a significance level at 10%, 5%, and 1%, respectively; heteroskedasticity-robust standard errors are in parentheses; IVs: lagged ECI and lagged GDP p.c.

Table 8.

Estimation results for all countries in the sample:
GDP per capita and GDP per capita squared are excluded

Dependent variable: Gini coefficient

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ECI	1.012***	1.045***	1.314***	1.319***	1.173***	1.221***	1.483***	1.503***
	(0.343)	(0.351)	(0.351)	(0.357)	(0.367)	(0.376)	(0.376)	(0.383)
lnSchooling	−0.569***	−0.568***	−0.656***	−0.655***	−0.740***	−0.736***	−0.759***	−0.756***
	(0.165)	(0.166)	(0.166)	(0.166)	(0.204)	(0.204)	(0.202)	(0.202)
Institut	−0.434*	−0.418*	−0.424*	−0.419*	−0.493**	−0.469*	−0.463**	−0.451*
	(0.249)	(0.247)	(0.241)	(0.240)	(0.243)	(0.240)	(0.235)	(0.233)
lnGov	0.0455	0.0230	0.0830	0.0769	0.0601	0.0265	0.105	0.0863
	(0.305)	(0.309)	(0.308)	(0.309)	(0.314)	(0.318)	(0.316)	(0.319)
lnTrade	0.774***	0.768***	0.726***	0.725***	0.657***	0.648**	0.613**	0.609**
	(0.245)	(0.245)	(0.246)	(0.245)	(0.252)	(0.252)	(0.255)	(0.255)
ECI2		−0.0561		−0.0148		−0.0814		−0.0430
		(0.107)		(0.110)		(0.112)		(0.116)
Institut2			−0.677***	−0.674***			−0.739***	−0.730***
			(0.191)	(0.192)			(0.196)	(0.197)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	No	No	No	No	Yes	Yes	Yes	Yes
Observations	1040	1040	1040	1040	1040	1040	1040	1040
S-H test (p)	0.9379	0.9369	0.7686	0.7676	0.9070	0.9061	0.7118	0.7093
Countries	52	52	52	52	52	52	52	52

Notes: *, ** and *** denote a significance level at 10%, 5%, and 1%, respectively; heteroskedasticity-robust standard errors are in parentheses; IVs: lagged ECI.

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Макроэкономический анализ влияния экономической сложности на неравенство доходов: Какова роль качества институтов?

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В статье рассматривается взаимосвязь между экономической сложностью и неравенством доходов с учетом роли институтов на основе данных за 1996–2020 гг. по 52 развитым и развивающимся странам Европы и Центральной Азии, а также Ближнего Востока и Северной Африки. Вклад исследования состоит, во-первых, в том, что проанализировано влияние экономической сложности на неравенство доходов с учетом качества институтов в целом и отдельных аспектов институционального развития. Во-вторых, учтена нелинейная форма зависимости между экономической сложностью и неравенством доходов, а также разнородность данной взаимосвязи для разных групп стран. Проблема эндогенности решена при помощи двухшагового метода наименьших квадратов с фиксированными эффектами и инструментальными переменными. Полученные результаты свидетельствуют о том, что для общей выборки стран рост экономической сложности в стране приводит к росту неравенства доходов. Вместе с тем влияние экономической сложности на неравенство варьируется по группам стран, а для стран Европы и Центральной Азии эта зависимость имеет форму перевернутой U. При этом в условиях развитости институтов экономическая сложность способствует снижению неравенства. Можно сделать вывод о том, что развитие всех аспектов институтов приводит к снижению неравенства доходов. Также результаты исследования свидетельствуют о том, что снижению уровня неравенства способствует развитие сферы образования. Кроме того, полученные результаты позволяют сделать вывод о необходимости экономической политики, способствующей более равномерному распределению выгод от экономического развития и международной торговли.

Ключевые слова: экономическая сложность; неравенство доходов; качество институтов; экономическое развитие; инструментальные переменные; экономическая политика.