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Institutions to the rescue? Examining their moderating role in climate- induced migration

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Abstract

Climate change, particularly global warming, poses serious challenges for policymakers, especially through its influence on migration, which exacerbates humanitarian crises and regional instability. The migration response to climate change is shaped by contextual factors that influence a nation's adaptive capacity. One such factor is institutional quality, which may enhance resilience by improving the implementation and effectiveness of adaptation policies. Using data from 86 middle-income countries between 2002 and 2019, I examine whether a country's institutional quality moderates the relationship between rising temperatures and emigration. Fixed effects and long-difference regressions provide limited evidence that stronger institutions, in particular *Government Effectiveness* and *Rule of Law*, may mitigate emigration responses to rising temperatures in lower-middle-income countries. However, this moderating role appears non-linear: it weakens under extreme temperatures. The climate-migration nexus appears highly context-dependent. Unlike lower-middle-income countries, upper-middle-income countries show no significant migration response to climate or institutional factors, possibly due to stronger existing institutions and reduced dependence on climate-sensitive livelihoods. Despite insufficient consistent statistical significance and robustness across model specifications, the findings tentatively suggest that institutional quality may enhance climate resilience. These insights underscore the need for more targeted, context-specific studies on climate-induced migration to help shape more effective and tailored policy actions.

1 Introduction

Climate-induced migration is one of the most pressing challenges in today's society. Estimates suggest that climate change, especially global warming, may lead to the migration of 50 to 700 million people by 2050 (Ionesco et al., 2017; Warner, 2010). Such large-scale migration likely triggers regional conflicts, humanitarian crises and increased refugee flows (Liang et al., 2023). Recognizing the urgency of this issue, the World Meteorological Organization (2024) recently issued a red alert. While climate-induced migration has been extensively studied, findings vary significantly across contexts in both magnitude and direction. Accordingly, recent research suggests that a nation's adaptive capacity, shaped by the interaction between global warming and social, economic and political factors, plays a key role in determining migration outcomes (Black et al., 2011; Hoffmann et al., 2023; Warner, 2010). Yet, the role of institutions in the climate-migration relationship remains largely unaddressed.

In this paper, I examine the interplay between institutional quality, climate change and emigration. A country's institutional system, a measure of governance quality, is shown to significantly shape its adaptive capacity. This suggests a crucial role for a country's governance system to moderate climate-induced migration (Adger et al., 2005; Dell et al., 2014). Weak institutions may exacerbate migration pressures by undermining adaptation policies, whereas strong institutions may enhance both their effectiveness and implementation (Hsiang et al., 2013; Liang et al., 2023; Schwan & Yu, 2017). Nevertheless, despite growing recognition of the importance of a country's adaptive capacity, the role of a country's institutional quality remains largely unexplored in the climate-migration relationship. This study expands the broader research perspective on the moderating role of contextual factors by focusing on the interplay between global warming and governance. Accordingly, this study seeks to answer the following research question: To what extent does a country's institutional quality moderate the relationship between temperature changes and emigration?

This issue is also highly relevant from a practical perspective. Numerous studies have illustrated that climate-induced migration results in significant challenges, including refugee flows, humanitarian crises and regional conflicts (Burrows & Kinney, 2016; Heltberg et al., 2009; Liang et al., 2023). By analysing the moderating role of institutional quality, this study aims to

explore whether high-quality institutions can enhance countries' adaptive capacity to climate change. Greater resilience may reduce migration tendencies, thereby mitigating refugee streams, civil unrest and humanitarian emergencies. Therefore, this study may signal the relevance of targeted interventions in a country's institutional system to strengthen climate change adaptation (Cai et al., 2016; Carleton & Hsiang, 2016).

To test this empirically, this research employs panel data for 86 middle-income countries from 2002 to 2019. To ensure greater data accuracy, annual net migration rather than emigration is used as the dependent variable. To at least partially address endogeneity concerns, a fixed effects OLS regression is run. Institutional quality, measured through a composite index, is interacted with temperature to examine the moderating effect. I follow the literature by only controlling for annual precipitation to avoid the 'bad control'¹ problem (Burke et al., 2015; Dell et al., 2014; Hoffmann et al., 2021). Additionally, I estimate a long-difference regression to explore adaptation effects (Burke & Emerick, 2016).

I estimate multiple robustness tests. First, governance indicators enter separately in regressions to explore potential mechanisms through which institutions shape migration. On top of that, I include country-specific quadratic time trends to examine the context-specific nature of this relationship (Cattaneo & Peri, 2015). Besides this, I conduct a heterogeneity analysis by dividing the sample into lower- and upper-middle-income countries to further explore this potential context-specificity.

My main findings show that better institutions, especially *Government Effectiveness* and *Rule of Law*, can reduce emigration in response to temperature increases in lower-middle-income countries. This is most effective at moderate temperatures, as I find evidence of non-linearity across temperature levels. Even though the magnitude is reduced at more extreme temperatures, institutions continue to mitigate climate-induced migration. The long-difference regressions suggest a stronger moderating role in the mid/long-run due to adaptational effects.

The heterogeneity analysis reveals that the climate-migration nexus is highly context-specific. Upper-middle-income countries exhibit no significant migration response to climate or

¹ A 'bad control' problem involves the inclusion of a potentially mediating variable as control, that itself is affected by climate change and at the same time has a causal effect on migration. When including this variable as a control, the model no longer estimates the total effect of climate change on migration, hence the term 'bad control'.

institutional factors. A possible explanation may be stronger baseline institutions and less reliance on climate-sensitive livelihoods, like agriculture. Overall, my findings lack consistent statistical significance and robustness. Nonetheless, they offer preliminary evidence that institutional quality may enhance climate resilience in specific contexts. More targeted, context-specific studies on climate-induced migration are essential for more effective and concrete policy advice.

The remainder of this paper is organized as follows. Chapter 2 discusses the relevant literature and formulates the hypothesis. Chapter 3 presents this study's dataset, followed by a discussion of the methodological approach. Chapter 4 covers the results, before concluding and discussing in chapter 5.

2 Literature review

Despite extensive research on the relationship between climate change and migration, little attention has been devoted to the role of governance quality. Climate change has been shown to drive migration, but the institutional mechanisms that moderate this relationship remain largely unexplored (Black et al., 2011; Dell et al., 2014). The literature reveals that temperature change affects migration more than any other environmental factor. This effect may run through multiple mechanisms (Bohra-Mishra et al., 2014; Carleton & Hsiang, 2016). Many studies have identified an exacerbation of migration pressures through reduced agricultural productivity, as rising temperatures significantly alter drought and flood occurrences (Cai et al., 2016; Liang et al., 2023). Research also highlights the adverse effects of temperature changes in the non-agricultural sector. In both cases, declining incomes will hamper economic growth, thereby directly reducing economic opportunities (Dell et al., 2008). This may trigger emigration in pursuit of greater financial prosperity. However, emigration may be constrained by resulting liquidity problems, primarily in low-income countries (Cattaneo & Peri, 2015). Moreover, temperature changes may trigger violent conflicts, thereby undermining social stability. This may be another reason for emigration (Hsiang et al., 2013).

Given the substantial variability in the climate-migration relationship across contexts, both in terms of magnitude and direction, several leading papers suggest that socioeconomic and political conditions may function as moderators (Black et al., 2011; Hoffmann et al., 2023). Dell et al. (2014) identify adaptive capacity as a key factor influencing migration decisions. This is directly linked to institutional quality, which assesses governance quality through factors such as Government Effectiveness, Rule of Law and Political Transparency. A seminal study in this area is Adger et al.'s (2005) work on successful climate change adaptation. They reveal that adaptational actions are not autonomous but instead affected by institutions. Similarly, Acemoglu (2025) argues that institutional constraints can limit the adoption and adaptation of new and existing technologies, thereby weakening a nation's adaptive capacity. Climate change is a collective action problem with distributional and context-specific impacts. Given this problem's nature, a country's adaptive capacity, and thus most critically its institutions, play a crucial role in mitigating climate-induced migration (Dell et al., 2014; Ghorbani et al., 2023).

Despite the growing understanding of the factors driving climate-induced migration, this moderating role of institutional quality remains largely unexplored.

Building on this knowledge gap, this study directly examines the moderating effect of institutional quality on climate-induced migration, particularly in how it enhances the efficacy of adaptation strategies and facilitates their emergence. Specifically, I draw on two key studies to illustrate the mechanisms through which governance shapes climate change management, thereby influencing migration decisions. Broadly speaking, better institutions may positively affect the uptake and effective implementation of adaptation policies, thereby reducing the need for emigration.

Firstly, Alam et al. (2024) study the moderating role of a country's commitment to environmental, social and governance standards (ESG) on the relationship between climate change and geopolitical conflicts. Their analysis reveals that climate change is associated with less geopolitical conflicts in nations with higher environment, social and governance standards. This stronger moderating effect is likely explained by higher-quality institutions enhancing the effectiveness and implementation of adaptation policies, thereby limiting climate-induced conflicts (Acemoglu, 2025; Alam et al., 2024). Given the negative impact of conflicts on migration, migration may be mitigated in contexts where high-quality institutions help to limit climate-induced conflicts. Similarly, a second study by Kahn (2005) finds that institutions may enhance climate change adaptation. His work examines to what extent institutions protect populations from deaths due to natural disasters. He finds fewer deaths from natural disasters in countries with strong institutions. This likely reflects better adaptation to climate change, which in turn mitigates migration tendencies.

Zooming in on the mechanisms, strong institutions may first of all enhance the quality of adaptation strategies, thereby reducing the need for migration. Kahn (2005) shows that political accountability, fostered by good institutions, incentivizes the government to install better adaptation strategies, thereby improving climate change management. This is because political transparency will expose corruption faster, thereby jeopardizing re-election. So, this danger incentivizes the government to protect its population through launching improved adaptation

strategies, that likely enhance adaptation to climate change. This in turn reduces the incentives for climate-induced migration.

On top of that, accountability, another proxy of strong institutions, is essential for the government's ability to implement effective adaptation policies. Climate change may be a slow-onset process, but fast, adequate adaptation is required. The United Nations Adaptation Committee claims that accountability clarifies responsibilities across stakeholders, thereby preventing inaction and freeriding. Accordingly, stakeholders, fully aware of their responsibilities, can react appropriately. This is essential for policy quality, especially because climate change is a multi-stakeholder problem (Ghorbani et al., 2023; United Nations Framework Convention on Climate Change (UNFCCC), 2014).

Clearly identifying stakeholder responsibilities directly relates to government effectiveness, a potential third mechanism. As a key indicator of institutional strength, government effectiveness may also improve the quality of adaptation policies by bringing an effective coordination mechanism. An effective coordination mechanism is essential for the success of policies aimed at mitigating climate-driven migration (Huynh & Hoang, 2024). As higher government effectiveness enhances allocative efficiency, it facilitates adaptation to the distributional impacts of global warming. Accordingly, high-quality institutions are essential for adaptation policies to effectively control climate-induced migration. As an example, Schwan and Yu (2017) demonstrate the importance of institutional quality for social protection programs. Their study on India's NREGA program illustrates that social protection is only effective in mitigating climate-induced migration when strong institutions are in place. For the timing and targeting of transfers, government effectiveness was a must. Weak administration and a lack of flexibility hindered the allocation of government aid, particularly when this aid addressed the specific household-level needs arising from the distributional impacts of climate change (Schwan & Yu, 2017; United Nations Framework Convention on Climate Change (UNFCCC), 2014). Therefore, poor institutional quality, reflected in allocative inefficiencies, limits effective adaptation to climate change, thereby plausibly incentivizing inhabitants to emigrate.

Another channel through which good governance may support adaptation policies is public trust. Good institutions, characterized by low corruption and high regulatory quality,

signal the government's ability to adapt to climate change. This significantly influences migration decisions by maintaining economic and political stability. Hsiang et al. (2013) show that individuals may attempt to redistribute resources themselves when the government fails to do this. Also, they show that a perceived inability of the government to control food prices triggers food riots. In both cases, conflicts emerge and the economic and political stability rapidly disappears due to the absence of robust institutions. This escalation may trigger emigration (Hsiang et al., 2013). Therefore, a strong rule of law, a key indicator of institutions, is crucial for public trust in the effectiveness of government programs, thereby maintaining economic and political stability (Acemoglu, 2025). In this way, robust institutions facilitate better adaptation during climate change problems, thus reducing the need for migration (Liang et al., 2023; Subbarao et al., 2013; Zhong et al., 2024).

However, strong institutional frameworks do not only support adaptation strategies. They also function as starting points for their emergence. The above-mentioned stability, underpinned by trust in the government, also fosters a favourable environment for information sharing (Diem Le et al., 2021). This mechanism is particularly important, because empirical studies in Africa reveal that limited knowledge is a significant constraint to climate change adaptation (Nyiwul, 2021; Oluwatayo & Ojo, 2016). Oluwatayo and Ojo (2016) report that not only the attitude of citizens to migration will change with more information, but so do their skills and adaptive capacities, thereby altering their aspirations. Therefore, high-quality institutions also function as the foundation of the development of adaptation strategies. In this manner, climate-induced emigration may also be moderated.

Overall, this study examines the role of a country's institutional framework in climate-induced migration, a topic that has received little attention in the literature. Concerning the key mechanisms, a country's institutions play a critical role in shaping both the quality and perceived credibility of adaptation strategies to climate change, thereby influencing migration patterns. Based on the discussed theoretical and empirical insights, the following hypothesis follows logically:

H₁: A country's institutional quality weakens the positive relationship between temperature changes and emigration.

3 Data and Methods

3.1 Data

3.1.1 *Sample*

To examine the moderating role of institutions in climate-induced emigration, this study focuses on middle-income countries for two reasons. Firstly, the effect of rising temperatures on emigration is predominantly found in agriculturally-centred economies, also known as low- and middle-income countries (Cai et al., 2016). As the latter group shares more variation in institutional quality amongst them, the sample is further restricted to middle-income countries (Cattaneo & Peri, 2015). This study follows the World Bank's classification of middle-income countries, that is listed in appendix 6.1.1.

Methodologically, this study aims to approximate mid-term trends in international migration. Accordingly, I will examine panel data on annual migration for 86 middle-income countries from 2002 to 2019. Concerning the data structure, I have a balanced panel.

3.1.2 *Variables*

For migration data, I turn to the extensive gridded dataset on net migration for 216 countries over the past two decades that Niva et al. (2023) compiled. As they have converted this into a country-level dataset, I will specifically use this data. By comparing national and subnational birth and death data, they successfully performed a partial validation of their data. This enhances confidence in their data's accuracy, which is especially relevant concerning middle-income countries that often deliver data of lower quality. Accordingly, their global data on migration seems to have significant validity. This has guided my choice to measure the dependent variable as the net migration rate rather than the emigration rate. Regarding the net migration rate, a negative number implies that a country has experienced more out-migration than in-migration, also known as emigration. It is measured in persons per 1000 people per year.

Table 1: Variable description

Variable	Code	Definition and calculation	Type of variable
Net migration	netMgr	Net migration measured in persons per 1000 people per year. A negative number indicates that a country has experienced more out-migration than in-migration in that year.	Dependent Variable
Temperature	temp	The yearly average surface temperature in degrees Celsius	
Institutional Quality	IQ	A composite index measuring a country's institutional quality on a percentile rank from 0 to 100, with higher scores reflecting higher-quality governance. The index is composed by taking the geometric mean of the following six institutional quality indicators: Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Control of Corruption, Regulatory Quality, Rule of Law, Voice and Accountability.	Independent Variable
Political Stability and Absence of Violence/Terrorism	PLST	Percentile rank (0 to 100) measuring political stability, with higher scores indicating greater stability and less politically-motivated violence.	
Government Effectiveness	GE	Percentile rank (0 to 100) measuring perceptions of the quality and independence of public services, and the credibility of the government's commitment to these policies. Higher score indicates higher government effectiveness.	
Control of Corruption	CC	Percentile rank (0 to 100) measuring perceptions of the misuse of public power for private benefit, with 0 representing high corruption and 100 low corruption/strong governance	indicators IQ, going into the index
Regulatory Quality	RQ	Percentile rank (0 to 100) measuring the government's ability to implement effective policies and regulations, where a higher score indicates a higher ability.	
Rule of Law	Rol	Percentile rank (0 to 100) capturing the degree of public confidence in legal institutions, such as property rights, the police and courts. A higher score indicates higher confidence.	
Voice and Accountability	VaA	Percentile rank (0 to 100) measuring citizens' ability to select their government and enjoy freedom of expression and association. A higher score reflects greater freedom.	
Precipitation	prcp	Total yearly precipitation in millimetres.	Control variable

To measure the temperature change, this study uses the yearly average surface temperature (°C), obtained from the Global Data Lab (Global Data Lab, 2025).

The data for institutional quality, the other main variable of interest, is collected from the Worldwide Governance Indicators (WGI) database of the World Bank. More specifically, I obtained data on six institutional quality indicators for each country: Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Control of Corruption, Regulatory Quality and Rule of Law (World Bank, 2024). Each of these indicators captures a distinct but interrelated dimension of institutional quality. As I demonstrated in chapter 2, each of these indicators may shape the climate-migration relationship. Therefore, I follow previous studies by considering these indicators equally important (Buchanan et al., 2012; Daude & Stein, 2007; Globerman & Shapiro, 2002). Table 3 in appendix 6.3 reports the correlations on the six governance indicators, which reveal, as expected, significant correlation. Therefore, multicollinearity issues would arise if I include all indicators into one regression (Daude & Stein, 2007; Globerman & Shapiro, 2002). Thus, this paper measures institutional quality by including an institutional index, that summarizes a country's governance quality. This method is more suitable than techniques focused on additional clustering, like principal

component analysis and factor analysis (Abu-Ismail & Ishak, 2021; Nardo et al., 2008). This is because the high correlations among all these indicators imply that further grouping of the indicators into smaller sub-categories does not improve the measurement of institutional quality.

As the World Bank does not provide a composite index, this paper constructs a composite institutional quality index by taking the geometric mean² of the six World Bank governance quality indicators to measure institutional quality. My choice for the geometric mean follows the approach of Abu-Ismail and Ishak (2021), who apply this in their study on institutional quality for the United Nations in Western Asia. This methodology is also consistent with the construction of the Human Development Index, thereby enhancing its credibility. The geometric mean is an appropriate aggregation method, because it preserves all relationships among the indicators. On top of that, unlike the arithmetic mean, the geometric mean only permits partial substitutability. This means that countries must perform well on all dimensions to obtain a high overall score on the index. So, the index is less sensitive to extreme values, making it a robust measure of institutional quality. Therefore, the geometric mean is a powerful tool to represent the underlying concepts adequately, without having to conduct complex analyses (Abu-Ismail & Ishak, 2021; Gerstein et al., 2021; Nardo et al., 2008).

Since the World Bank standardizes the indicators on percentile ranks between 0 and 100, I can directly compute their geometric mean. Accordingly, the index is also a percentile rank between 0 and 100, with a higher score reflecting higher-quality institutions. For further details, please refer to the variable description in table 1.

On top of that, the annual average precipitation in millimetres is included as a control variable to rule out alternative explanations for the relationship between temperature changes and emigration (Cattaneo & Peri, 2015; Dell et al., 2014). I obtained this data from the Global Data Lab as well (Global Data Lab, 2025).

² To calculate the geometric mean, I take the n^{th} root of the product of all numbers, where 'n' is the amount of numbers in my data.

3.2 Methods

This study runs a two-way fixed effects estimation to estimate the moderating effect, thereby accounting for potential unobserved heterogeneity in panel data. The Hausman test reveals that a random effects estimation is inconsistent, as the independent variables are correlated with the error term. Therefore, I use the following fixed effects estimation³:

$$(1) \quad netMgr_{i,t} = \beta_1 temp_{i,t} + \beta_2 temp_{i,t}^2 + \beta_3 IQ_{i,t} + \beta_4 temp_{i,t} * IQ_{i,t} + \beta_5 temp_{i,t}^2 * IQ_{i,t} + \beta_6 prcp_{i,t} + a_i + \rho_{r,t} + \mu_{i,t}$$

Every regression consists of 2 models to distinguish between the baseline and the effect of adding institutional quality, that is the moderator variable, and the interaction terms. I include an interaction term between temperature and institutional quality, as well as temperature squared and institutional quality, to empirically test the moderating effect. In the first model, I regress net migration on temperature, both linear and squared, precipitation, year-by-region fixed effects and country-fixed effects. Subsequently, the institutional quality index and the interaction terms are added to this model.

Cattaneo et al. (2024) recently only found a linear effect of temperature on agriculture, the main driver of the climate-migration relationship. However, earlier studies did identify non-linear relationships, primarily in agriculture-dependent countries (Bohra-Mishra et al., 2014; Cai et al., 2016; Carleton & Hsiang, 2016). To account for this discrepancy, I include a squared term for temperature in the regression models, both for the main effect and within the interaction term. This allows me to explore if the moderating effect of institutions differs at moderate and extreme temperatures. The model adheres to the literature by not including additional control variables besides precipitation, as this would introduce the ‘bad control’ problem. Temperature is a powerful predictor that explains variation in many variables. Therefore, including control variables that are partially explained by temperature could lead to biased estimates (Burke et al., 2015; Dell et al., 2014; Hsiang et al., 2013).

By including country-specific fixed effects, the model captures variation over time within a country, whilst controlling for permanent heterogeneity across countries (Cai et al., 2016). On

³ To see the what the abbreviations stand for, I direct you to table 1 on page 13 that includes the variable descriptions.

top of that, $\rho_{r,t}$ is a year-by-region fixed effect. Regions refer to continents specifically. This term is included to account for more transnational time trends, like localised economic shocks and political patterns. Clustered standard errors are used to account for heteroskedasticity, that has been found by the Breusch-Pagan test. This is relevant, as heteroskedasticity biases the variance of the coefficients, thereby affecting the regression results (Gujarati, 2011).

Turning to the interpretation of the results, it is necessary to look at the marginal effect of temperature and institutional quality on migration. For temperature, the marginal effect is :

$$\frac{\partial Mgr}{\partial temp} = \beta_1 + 2\beta_2 temp_{i,t} + \beta_4 IQ_{i,t} + 2\beta_5 temp_{i,t} * IQ_{i,t}$$

This shows that the effect of temperature on migration is not a stand-alone effect. Instead, the level of institutional quality affects this relationship. Specifically, β_4 and β_5 capture this moderating effect. As these coefficients reveal the interaction effect, I am primarily interested in the signs for those two coefficients.⁴ A positive coefficient for β_4 means that stronger institutions increase net migration, so they dampen the emigration response to temperature. Conversely, a negative coefficient for β_4 implies that better institutions amplify the emigration response to temperature, as net migration would fall. Similarly, a negative coefficient for β_5 means that at more extreme temperatures, the moderating role of institutions weakens, so institutions mitigate migration responses to temperature increases less effectively at higher temperatures. Therefore, I investigate whether the relationship between temperature and migration is shaped by the governance quality.

In line with Burke and Emerick (2012, 2016), I complement the panel estimates by applying a long-difference approach. Longer-term responses to climate change may differ fundamentally from shorter-term reactions, because they account for potential adaptation that is driven by permanent changes in weather over time (Liu et al., 2023). This approach averages the variables for the first and latter five years (2002-2006 and 2015-2019) of the sampling

⁴ As I interact two continuous variables, temperature and institutional quality, a straightforward interpretation of the coefficients $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ requires recentering of both variables. However, this study's primary objective is to examine whether institutional quality moderates the temperature-migration relationship. To avoid unnecessary complexity and potential confusion, I do not attempt to interpret every coefficients in detail. Therefore, I have not recentred those two variables.

period. By exploiting this longer-term climate variation, I may better approximate medium-run impacts, including adaptation effects, by comparing coefficient sizes in the base and long-difference regression (Burke & Emerick, 2012, 2016; Dell et al., 2014; Liu et al., 2023). Given the study's focus on the moderating effect, I will look at the coefficient β_4 for adaptation. When β_4 rises in the long-difference specification relative to the base regression, it means that, given a temperature rise, a higher institutional quality dampens the emigration response more in the medium/long-run. Therefore, an increased effect size of the moderating effect, captured by β_4 , implies stronger adaptation to climate change in the medium/long-run, as less people emigrate to temperature rises with higher governance quality.⁵

Besides this, I will conduct some robustness checks. Firstly, I will run separate regressions for each indicator of institutional quality as an alternative to using the composite institutional quality index. Besides testing for robustness, this disaggregation allows me to explore whether the indicators differ in significance regarding climate-induced migration. Accordingly, I may touch upon the mechanisms through which a country's institutions affect migration. Secondly, I will re-run the regression after including country-specific quadratic time trends. This allows me to capture country-specific variation over time that may drive the results. When the sign of the interaction term does not change, I can interpret the results as robust.

On top of that, I subdivide the sample of middle-income countries into lower-middle-income and upper-middle-income countries according to the World Bank's classification to conduct a heterogeneity analysis. Please refer to appendix 6.1.2 and 6.1.3 for the complete country list. By comparing the regression results for these subsamples, this micro-level distinction also allows me to explore the context-specific nature of this relationship (Cattaneo & Peri, 2015).

⁵ As mentioned, this study focuses on the moderating effect. To establish the net effect of temperature on migration, you should interpret all coefficients from β_1 through β_5 after recentering institutional quality and temperature. To avoid confusion, this study restricts itself to the moderating term (β_4).

4 Results

4.1 Summary Statistics

This section presents descriptive statistics for the key variables in the analysis. The summary statistics reveal that the mean net migration for middle-income countries was -1.2 per 1000 people annually. This implies that, on average, 1.2 individuals emigrate per 1,000 inhabitants each year in these countries. The variable exhibits a relatively wide range at both tails, indicating substantial dispersion across countries. This pattern corresponds to the literature, which finds emigration to be common among middle-income countries, with the mean being lower due to the inclusion of relatively poorer countries in the sample (Cai et al., 2016; Cattaneo et al., 2024; Cattaneo & Peri, 2015). The high dispersion in net migration rates across middle-income countries underscores the importance of examining country-specific determinants in the empirical analysis.

The yearly average temperature ranges from -0.6 °C to 30 °C, with Mongolia and Kyrgyzstan primarily accounting for the variability at the lower tail, whereas African countries, like Mauritania and Djibouti, are responsible for the higher tail. The mean annual temperature is 20 °C. Overall, these temperatures are consistent with middle-income countries (Cattaneo & Peri, 2015; Dell et al., 2008; Huynh & Hoang, 2024).

TABLE 4: SUMMARY STATISTICS

Variable	N	Mean	Std. Dev.	Min	Pctl. 25	Pctl. 50	Pctl. 75	Max
Net Migration	1548	-1.2	5.8	-29	-3.1	-0.94	0.15	55
Temperature	1548	20	6.7	-0.6	16	23	25	30
Institutional Quality	1548	34	16	2	21	34	45	77
Precipitation	1548	43	29	0.51	21	38	58	165
Political Stability	1548	34	20	0	18	32	48	95
Government Effectiveness	1548	36	19	0	20	35	51	85
Control of Corruption	1548	33	20	0	16	32	48	91
Regulatory Quality	1548	36	20	0	19	36	51	86
Rule of Law	1548	32	18	0.47	17	30	46	83
Voice & Accountability	1548	35	20	0	18	36	51	86

Dell et al. (2008) affirm that precipitation has not only declined enormously over time but also tends to exhibit greater variation compared to temperature. This pattern is also evident in this study, as precipitation has a wide range from 0.51 to 165 millimeters a year with significant variation. On top of that, Dell et al. (2008) emphasize that precipitation effects are highly sensitive to their operationalization, thereby requiring caution in interpretation. Due to data constraints, this study uses precipitation data aggregated at the annual level. Consequently, the above-reported precipitation levels are considerably lower than those found in studies employing monthly aggregation instead (Cattaneo & Peri, 2015; Huynh & Hoang, 2024). This methodological difference should be taken into account when interpreting the results.

Regarding institutional quality, the percentile rank varies between 2 and 77, with a mean score of 34. This average lies significantly below the mid-point of the scale, and the 75th percentile lies at a score of 45. So, most countries seem to score in the lower half of the index, indicating room for improvement concerning the institutional system. Huynh and Hoang (2024) similarly report a mean below the midpoint for 35 Asian countries between 1990 and 2021, whereas Buchanan et al. (2012) find a mean exactly halfway the scale for 165 countries between 1996 and 2006. As my sample contains middle-income countries, the results align with the literature.

A closer examination of the six indicators for institutional quality reveals that the mean scores for Government Effectiveness, Regulatory Quality and Voice and Accountability slightly exceed those for Political Stability, Control of Corruption and Rule of Law. However, each indicator has a mean score of approximately 34. This suggests that countries' institutional weaknesses are not confined to a single domain, but are distributed across the entire system. Nevertheless, all indicators have a broad range from 0 to between 85 and 95 due to some outliers at the upper end of the distribution (Buchanan et al., 2012; Huynh & Hoang, 2024).

4.2 Correlation

I run a Pearson correlation between all variables to explore potential multicollinearity (see table 2 in appendix 6.2). As previously noted in relation to the institutional quality indicators, high correlation among explanatory variables may inflate standard errors, thereby biasing regression estimates. Net migration is weakly positively correlated with temperature,

suggesting that higher temperatures are associated with higher in-migration. The mean temperature is 22 °C. So, an increase in temperature likely does not mean we move towards extremely high temperatures, that typically are associated with emigration. This may explain the reported positive correlation between temperature and in-migration. Precipitation, on the other hand, shares zero correlation with net migration but is moderately correlated with temperature (0.29). This finding suggests that higher temperatures do not trigger extreme droughts, as rainfall seems to increase alongside temperature. Given this moderate correlation, it is essential to include precipitation and temperature in the regression to obtain unbiased coefficients.

As expected, the institutional quality index shares a strong positive correlation with the separate indicators, ranging from 0.62 to 0.93. For further discussion on the correlation among the individual indicators, see section 3.1.2. The institutional quality index shows a marginally negative correlation with temperature (-0.04) and a small positive correlation with precipitation (0.07). Therefore, aside from the high correlations among institutional indicators, I do not identify any multicollinearity issues that may bias the results.

4.3 Regression results

This section analyzes the results of several estimated regression models. The primary coefficients of interest (β_4), which captures the moderating effect of institutional quality on the relationship between temperature changes and net migration, is presented in table 5. Columns (1) and (2) display the baseline regression results, while columns (3) and (4) report the estimates from the long-difference specification. Both models include country and year-by-region fixed effects, as well as a squared form of temperature to account for potential non-linear effects. I selected this final specification based on theoretical relevance, the statistical significance of key interaction terms, particularly the interaction terms, and robustness across alternative model specifications, such as different institutional quality indicators and the long-difference approach. This specification consistently captures some key relationships and demonstrates the highest stability across tests.⁶

⁶ For completeness, I include a regression without temperature squared in table 10 in the appendix. This shows that the results do not change much.

4.3.1 Main regression specification

TABLE 5: MAIN REGRESSION SPECIFICATION

	Dependent variable:				
	Base regression		Net Migration		Robustness Check
	(1)	(2)	(3)	(4)	
Temperature	1.133*	-0.437	4.515	3.183	-0.416
	(0.670)	(0.800)	(4.279)	(4.418)	(0.821)
Temperature ²	-0.023	0.021	-0.197*	-0.143	0.020
	(0.017)	(0.030)	(0.107)	(0.115)	(0.031)
Precipitation	0.021	0.019	0.220*	0.180	0.018
	(0.024)	(0.023)	(0.128)	(0.122)	(0.022)
Institutional Quality		-0.286		-0.731	-0.303
		(0.188)		(0.490)	(0.192)
Temperature * Institutional Quality		0.053*		0.106*	0.054*
		(0.032)		(0.060)	(0.032)
Temperature ² * Institutional Quality		-0.001		-0.003	-0.001
		(0.001)		(0.002)	(0.001)
Country FE	Yes	Yes	Yes	Yes	Yes
Year-by-Region FE	Yes	Yes	Yes	Yes	Yes
Country-specific quadratic time trends	No	No	No	No	Yes
Observations	1,548	1,548	172	172	1,548
R ²	0.059	0.082	0.121	0.232	0.083
Adjusted R ²	-0.047	-0.023	-0.902	-0.729	-0.023

This table reports regressions of net migration (netMgr) on change in temperature (temp / temp sq2) and multiple country characteristics. Variables are defined in accordance with table 1. For each variable, the coefficient is provided with the clustered standard error in parentheses. The asterisks **, *** and **** denote significance at the 10, 5 and 1 % level respectively.

The baseline regression model, reported in columns (1) and (2) of table 5, has 1548 observations. Net migration is regressed on temperature, both linear and squared, precipitation, institutional quality and the interaction terms between institutional quality and temperature, both linear and squared. When I add the institutional quality variable and the corresponding interaction terms, the direct effect of temperature on migration loses statistical significance at the 90% confidence level. In column 2, temperature has a negative, statistically insignificant coefficient of -0.437. The squared term is positive, but also statistically insignificant (0.021). These results suggest that temperature does not affect net migration directly when controlling for precipitation and institutional quality.⁷ While several studies in the literature report a direct link between temperature and migration, others which focus more on broader cross-country samples, such as Dell et al. (2008), also find no significant direct effect. This discrepancy may stem from factors like the absence of a sufficient agricultural linkage, differences in the operationalization of temperature (e.g. monthly versus annual aggregation), or a country's capacity to cope with temperature fluctuations. Later in this chapter, I will further explore the role of context-specificity in explaining this finding.

Similarly, institutional quality itself, with a coefficient of -0.731, is not statistically significant. However, this study focuses on the moderating role of institutions on climate-based migration. So, I am primarily interested in the interaction terms. The linear interaction term that combines institutional quality and temperature is statistically significant at the 10% level. The positive coefficient of 0.053 implies that an increase in the institutional quality index reduces emigration, when holding the temperature constant. This means that institutions seem to moderate the migration response to increasing temperatures. To interpret this effect in real-world terms, I look at this effect in isolation.⁸ A 10-unit increase in the institutional quality index, given a mean of 34, reduces emigration annually by 0.53 emigrants per 1000 people to a given temperature increase. For a population of 10 million inhabitants, this means that a 10-unit increase in the institutional quality index reduces emigration annually by 5300 emigrants to a

⁷ To determine the overall effect of temperature on migration, one must look at the marginal effect. Here, I just describe the direct effect of temperature on migration, captured by β_1 and β_2 . This is only identical to the marginal effect when institutional quality is zero, which is unrealistic. Therefore, it is essential to keep in mind that those coefficients are not directly interpretable.

⁸ For a correct real-world interpretation, I should evaluate the marginal effect of temperature on migration. This introduces additional complexity, that I want to avoid given my focus on the moderating effect.

temperature increase. This effect is quite significant in real-world terms, although a 10-point increase in the institutional quality score requires strong improvements. Given the range of institutional quality from 2 to 77, I do not say this is unfeasible, yet it requires significant effort. As the interaction between institutional quality and temperature squared is not statistically significant, the moderating role of institutions seems to be equally effective at all temperatures. Finally, precipitation has a small, statistically insignificant coefficient. This compares well to the literature, as precipitation effects are usually very small. As mentioned above, caution in interpretation is required due to the sensitivity of precipitation to the manner of aggregation.

Columns (3) and (4) present the results from the long-difference specification, which includes 172 observations. The direction and statistical significance of the key coefficients remain consistent. As expected, the coefficients generally increase in size, indicating long-term effects may vary in magnitude. The coefficient of interest, that of the linear interaction term, remains statistically significant at the 10% level, but the coefficient doubles to 0.106. To say something about adaptation, I isolate this moderating effect. It means that, given a temperature increase, the same 10-unit increase in institutional quality now reduces emigration by 1060 emigrants annually for a country with 10 million inhabitants. This stronger reduction in emigration implies successful adaptational effects in the mid/long-run.

Direct effects of temperature and institutional quality remain statistically insignificant in the long-difference model. This reinforces the role of institutions as moderators rather than primary drivers of migration.

In an attempt to account for unobserved, time-varying country-specific effects, I control for country-specific quadratic time trends in column (5) of the main specification. As the significance and direction of the coefficients do not change relative to the base specification in column (2), my results are robust. This means that country-specific factors that change over time do not drive the results. This enhances their validity.

4.3.2 *Heterogeneity analysis (1) : Measuring IQ as a composite index*

The literature documents a wide range of findings on the relationship between temperature and migration across different contexts. To explore this context-specific nature of the relationship, this section turns to the heterogeneity analysis. Table 6 presents the base and long-difference

regression models for two sub-samples: lower-middle-income countries (LMICs) and upper-middle-income countries (UMICs). Column (1) displays the results for LMICs of the base regression, based on 738 observations, while column (2) shows this estimation for UMICs with 810 observations.

As in the full sample, the direct effects of temperature, precipitation and institutional quality on net migration are not statistically significant in either sub-sample. So, based on my results, it seems that temperature does not have significant effect on migration on its own. However, notable differences arise in the interaction terms. For LMICs, the interaction terms of temperature with institutional quality, both linear and squared, are statistically significant at the 90% confidence level. So in LMICs, the effect of temperature on migration seems to depend on the level of institutional quality. In contrast, neither interaction term is statistically significant in the UMIC sample, and the direction of the coefficients is inversed. Therefore, temperature seems to have no effect on migration at all in UMICs, independent of the level of institutional quality. This suggests variation in the moderating role of institutional quality across countries, thereby referring to the context-specific nature of the relationship.

Focusing on LMICs, the linear interaction term has a positive coefficient of 0.095, while the squared interaction term is -0.003. This implies that institutions mitigate emigration responses to temperature changes at moderate temperature levels, though this mitigating effect slightly weakens at more extreme temperatures.⁹

Similarly to the original sample, the results remain consistent in the long-difference specification, based on 82 and 90 observations for LMICs and UMICs respectively. As in the baseline model, the linear and squared interaction terms in the LMIC sample are statistically significant and their effect sizes increase. Specifically, the linear interaction term for LMICs almost doubles to 0.184. As mentioned before, this indicates a stronger reduction in emigration to the same temperature increase in the longer-run. Accordingly, this suggests successful adaptation in the mid/long-run (Liu et al., 2023). On top of that, the interaction coefficient (0.184) exceeds that of the complete sample (0.106).

⁹For a concrete real-world interpretation, I should evaluate the marginal effect of temperature on migration or use recentering. This introduces additional complexity, that I want to avoid given my focus on exploring the moderating effect.

TABLE 6: HETEROGENEITY ANALYSIS: MAIN SPECIFICATION FOR LOWER- AND UPPER-MIDDLE-INCOME COUNTRIES

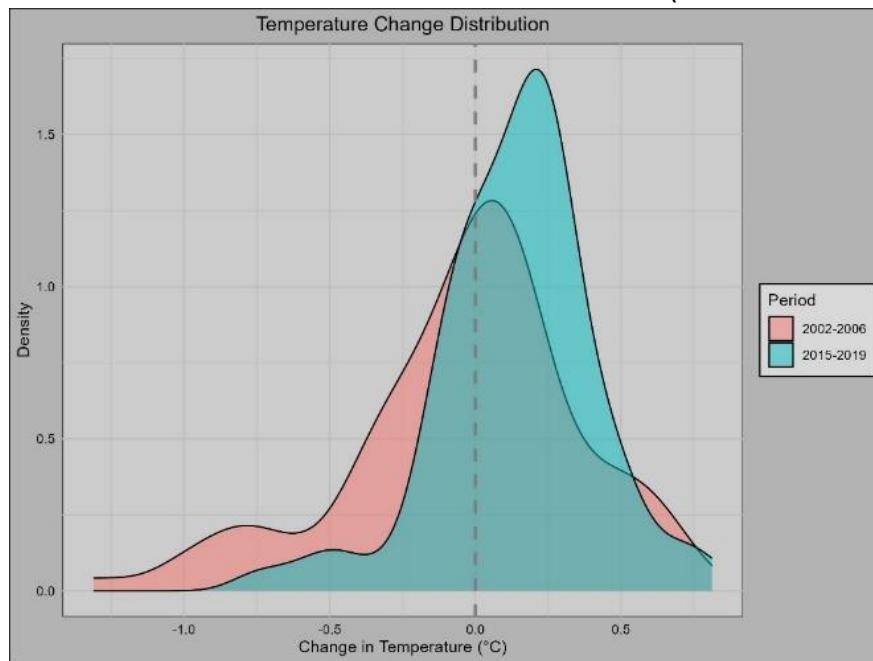
	Dependent variable:				
	Net Migration				
	Base regression		Long Difference regression (LD)		
	LMIC	UMIC	LMIC	UMIC	
	(1)	(2)	(3)	(4)	
Temperature	1.100	0.831	0.499	6.766	
	(1.538)	(1.070)	(6.260)	(6.902)	
Temperature ²	0.010	-0.030	-0.219	-0.096	
	(0.033)	(0.036)	(0.147)	(0.181)	
Precipitation	0.011	0.033	0.138	0.195	
	(0.031)	(0.033)	(0.167)	(0.181)	
Institutional Quality	-0.293	-0.013	-1.319	-0.195	
	(0.314)	(0.160)	(1.080)	(0.663)	
Temperature * Institutional Quality	0.095*	-0.006	0.184*	0.024	
	(0.057)	(0.025)	(0.111)	(0.089)	
Temperature ² * Institutional Quality	-0.003*	0.001	-0.005*	-0.0003	
	(0.002)	(0.001)	(0.003)	(0.003)	
Country FE	Yes	Yes	Yes	Yes	
Year-by-Region FE	Yes	Yes	Yes	Yes	
Observations	738	810	82	90	
R ²	0.115	0.107	0.437	0.223	
Adjusted R ²	-0.019	-0.046	-0.425	-0.976	

This table reports regressions of net migration (netMgr) on change in temperature (temp / temp sq2) and multiple country characteristics for lower and upper middle-income-countries. Variables are defined in accordance with table 1. For each variable, the coefficient is provided with the clustered standard error in parentheses. The asterisks **, *** and **** denote significance at the 10, 5 and 1 % level respectively.

This suggests a stronger moderating effect of institutional quality in LMICs. Therefore, table 6 highlights that the moderating effect of institutions in climate-induced migration is moderately present in LMICs, but absent in UMICs.

For a possible explanation, I look into differences in climate trends across the two income groups. Figure 1 presents a density plot of long-term temperature changes, comparing the first (2002-2006) and final (2015-2019) five years of the sample. These plots focus on longer-run shifts in the average temperature. As shown in the general distribution, the mean change in temperature in the early period is statistically indistinguishable from zero, as indicated by the vertical dotted line. In contrast, between 2015 and 2019, the mean change in temperature is positive, approximately 0.25 °C.

FIGURE 1: DENSITY PLOT FOR 5-YEAR TEMPERATURE CHANGES (COMPLETE SAMPLE)

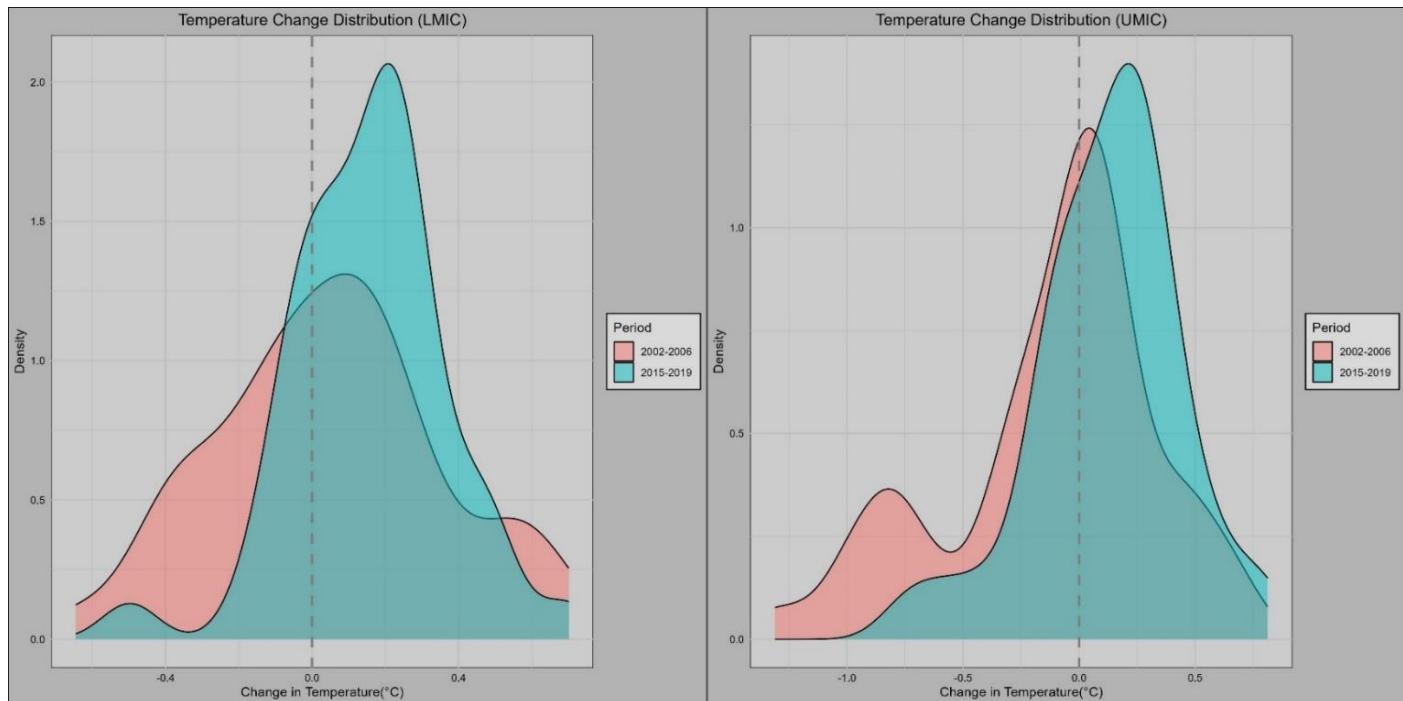


This aligns with expectations of global warming becoming more severe over time (Liang et al., 2023; Pörtner et al., 2022; WMO, 2024). However, the relatively limited variation in temperature change across countries and over time may constrain the ability to identify the effect of temperature on migration in the full sample. This may potentially explain the statistical insignificance of temperature observed in table 5. The distribution also becomes more clustered over time, thereby suggesting that we do not experience climate change as both lower and higher temperatures.

When disaggregating the plot by income level, two distinct density plots emerge in figure 2. For UMICs, the distributions for the two time periods largely overlap. The mean change in temperature is approximately 0 °C initially and just below 0.25 °C in the later period. Combined with the relatively limited variation in institutional quality among UMICs, these findings may explain the difficulty in identifying a moderating effect in that subsample. For LMICs however, the distribution shifts more noticeably, suggesting more severe global warming over time. Although the change in means may not be highly statistically significant, it signals greater climatic stress in LMICs.

In summary, the divergence in distributions across the two groups of countries underscores the context-specific nature of the relationship between temperature and migration. This reinforces the need for further heterogeneity analyses in climate-migration research. These findings may help guide policymakers in anticipating and managing climate-induced migration by focusing particular attention on lower-middle-income countries. Given the varying effects across income groups, targeted—rather than one-size-fits-all—policies are likely more effective in building climate resilience. This approach will be crucial to prevent a widening of the inequality gap between lower and upper-middle-income countries (Cai et al., 2016; Cattaneo & Peri, 2015).

FIGURE 2: DENSITY PLOT FOR 5-YEAR TEMPERATURE CHANGES PER INCOME GROUP



4.3.3 Indicators of Institutional Quality

In addition to using the composite index for institutional quality, I estimate separate regressions for each of its six indicators. This approach tests the robustness of the main findings but also allows to explore potential mechanisms through which institutions may moderate climate-induced migration. Table 7 displays 12 regressions, 2 for each indicator: a base (columns 1-6) and a long-difference regression (columns 7-12). In the base regressions with 1548 observations, the results are strongly consistent across the different proxies, with only minor differences in magnitude. Three institutional indicators—*Rule of Law*, *Regulatory Quality*, and *Government Effectiveness*—statistically significant at the 10% level, negatively affect net migration on its own.

I am interested however in the moderating role of institutions, so I focus on the interaction terms specifically. None of the proxies shows statistically significant interaction effects in the base regression. However, the previously observed moderating role of institutional quality re-emerges when the sample is restricted to lower-middle-income countries (see Table 8 in Appendix 6.4). This likely reflects two factors. First, heterogeneity between LMICs and UMICs within the full sample may dilute the overall effect. Second, the composite governance index likely captures synergistic effects that individual indicators fail to detect. By focusing solely on LMICs, the more uniform context allows clearer identification of mechanism-specific effects. This may help explain the absence of such effects in the broader, more heterogeneous sample, shown in table 7. As before, precipitation, temperature squared and the squared interaction term remain statistically insignificant.

When extending the analysis to the long-difference regression, based on 172 observations, the results correspond to the main specification. Specifically, a direct, negative effect of temperature squared on migration is found for *Regulatory Quality*, *Political Stability*, and *Government Effectiveness*, statistically significant at the 5% level for the first and 10% level for the latter two. This suggests that only at more extreme temperatures, temperature increases seem to trigger emigration on its own.¹⁰ I will further elaborate on this in the discussion of the marginal effect in figure 3 on page 31.

¹⁰ It is important to highlight that this relates to the effect of temperature on migration on its own, so independent of the institutional quality. This is not fully realistic, but helps to interpret the data in a comprehensible manner. The literature reports similar findings, so this enhances trust in the validity of my results.

TABLE 7: SIX ALTERNATIVE SPECIFICATIONS OF INSTITUTIONAL QUALITY FOR THE COMPLETE SAMPLE

<i>Dependent variable:</i>													
	Net migration						Long Difference regression (LD)						
	Base regression												
	RoL	VaA	RQ	CC	PLST	GE	RoL	VaA	RQ	CC	PLST		
	(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)
Temperature	0.189	1.335*	0.066	0.857	0.845	-0.065	3.586	4.091	5.416	4.145	4.676	3.320	
	(0.628)	(0.790)	(0.547)	(0.570)	(0.734)	(0.671)	(4.721)	(4.475)	(4.148)	(4.541)	(4.359)	(4.195)	
Temperature ²	0.001	-0.027	0.004	-0.014	-0.013	0.003	-0.149	-0.179	-0.226**	-0.173	-0.200*	-0.181*	
	(0.021)	(0.021)	(0.022)	(0.018)	(0.019)	(0.024)	(0.118)	(0.115)	(0.106)	(0.119)	(0.111)	(0.106)	
Precipitation	0.021	0.024	0.018	0.020	0.017	0.021	0.230*	0.202	0.175	0.208	0.184	0.204*	
	(0.023)	(0.025)	(0.023)	(0.023)	(0.022)	(0.023)	(0.128)	(0.127)	(0.124)	(0.129)	(0.127)	(0.120)	
Institutional Quality	-0.214*	0.141	-0.200*	-0.043	0.006	-0.306**	-0.376	0.014	-0.423	-0.193	-0.004	-0.719**	
	(0.123)	(0.120)	(0.105)	(0.077)	(0.066)	(0.144)	(0.346)	(0.380)	(0.304)	(0.364)	(0.275)	(0.299)	
Temperature *	0.030	-0.008	0.034	0.011	0.008	0.038	0.057	0.009	0.054	0.033	0.012	0.086**	
Institutional Quality	(0.019)	(0.015)	(0.022)	(0.014)	(0.009)	(0.025)	(0.044)	(0.046)	(0.037)	(0.046)	(0.033)	(0.039)	
Temperature ² *	-0.001	0.0002	-0.001	-0.0003	-0.0003	-0.001	-0.002	-0.0002	-0.001	-0.001	-0.0003	-0.002*	
Institutional Quality	(0.001)	(0.0005)	(0.001)	(0.0005)	(0.0003)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Year-by-Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Observations	1,548	1,548	1,548	1,548	1,548	1,548	172	172	172	172	172	172	
R ²	0.070	0.067	0.078	0.062	0.071	0.079	0.166	0.172	0.213	0.145	0.177	0.254	
Adjusted R ²	-0.037	-0.040	-0.028	-0.046	-0.035	-0.027	-0.877	-0.864	-0.770	-0.924	-0.851	-0.679	

This table reports regressions of net migration (netMgr) on change in temperature (temp / temp sq2) and multiple country characteristics by using six different operationalizations of Institutional Quality. Variables are defined in accordance with table 1. For each variable, the coefficient is provided with the clustered standard error in parentheses. The asterisks '*', '**' and '***' denote significance at the 10, 5 and 1 % level respectively.

Concerning precipitation, a statistically significant, positive effect is found when using *Rule of Law* and *Government Effectiveness* as proxies. Under the proxy *Rule of Law*, the coefficient of 0.23 for precipitation suggests that a 100-millimeter increase in precipitation increases migration by 23 immigrants per 1000 people annually. While this effect has a moderate economic magnitude, it should be interpreted carefully due to measurement sensitivity to the aggregation method.

In contrast to the base regression (columns 1-6), the direct effect of *Regulatory Quality* and *Rule of Law* on net migration are no longer statistically significant. *Government Effectiveness* retains its statistical significance at the 10% level, with the coefficient rising from -0.306 to -0.719 in the long-difference model. To examine the size and direction of this effect, one should focus on the marginal effect of institutions, thereby including the direct effect as well as interaction effects. This study focuses on the moderating effect instead.

Turning to the interaction effects, among the six institutional proxies, only *Government Effectiveness* exhibits a statistically significant moderating effect. This finding supports the argument made in chapter 2 that *Government Effectiveness* is a key mechanism in moderating climate-induced migration by managing the allocative efficiency and adaptive response to the distributional consequences of climate change. The positive linear interaction term (0.086), statistically significant at the 5% level, suggests that an increase in government effectiveness reduces emigration in response to a change in temperature. Meanwhile, the squared interaction term (-0.002), statistically significant at the 10% level, implies that institutions mitigate migration at moderate temperatures but become less effective in doing so at more extreme temperatures.

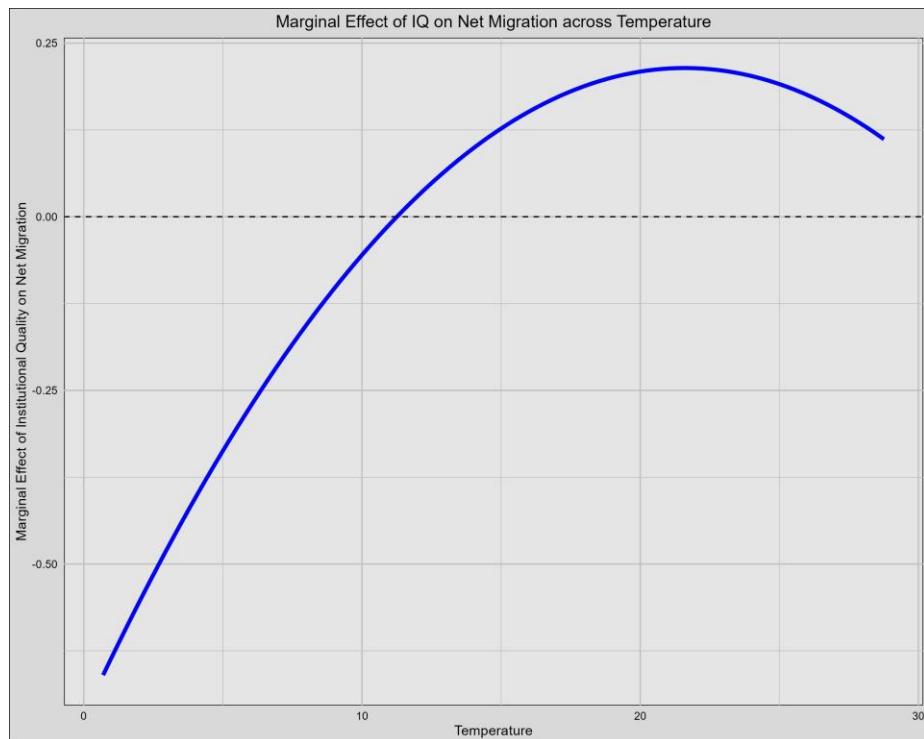
For a correct interpretation of the effect of institutional quality, I graphically show the marginal effect of institutional quality—measured using the *Government Effectiveness* indicator—on net migration, across varying temperature levels in figure 3. The figure suggests that at lower temperatures, improvements in institutional quality are associated with a slight, diminishing increase in emigration. As temperature rises above approximately 11°C, the estimated relationship shifts, and higher institutional quality is associated with reduced emigration. This corresponds to the moderating effect that I identified. This effect appears strongest around 22°C, after which the reduction in emigration weakens but remains present.

Overall, the pattern suggests that institutional quality may have the greatest potential to mitigate emigration at moderate temperatures. When temperatures become more extreme, specifically above 22°C, the marginal benefit of institutional improvements appears to decline. Yet, institutional improvements continue to moderate climate-induced migration. This seems to indicate that the effect of institutional quality on migration is non-linear across temperature levels. Given that the mean temperature in this sample is 20°C, institutional improvements could be particularly relevant for the examined middle-income countries. However, these interpretations should be treated with caution, as the underlying estimates are not consistently statistically significant. As such, the observed patterns in Figure 3 should be regarded as indicative rather than conclusive.

Hsiang (2010) similarly identifies, as part of the bigger ergonomic literature, 25°C as an inflection point for non-linear effects across temperature levels. Beyond this temperature, performance losses are identified due to effects on human productivity and economic growth.

Thus, the non-linear moderating effect of institutions across temperature levels that I observed in this study corresponds to the ergonomic literature.

FIGURE 3: THE MARGINAL EFFECT OF INSTITUTIONAL QUALITY ON NET MIGRATION ACROSS TEMPERATURE LEVELS



4.3.4 Heterogeneity analysis (2) : Measuring IQ as six separate indicators

To further investigate the context-specific nature of the climate-migration relationship, I also run the heterogeneity analysis when I measure institutional quality using the six individual proxies. Table 8 (see appendix 6.4) reports both a base and long-difference regression for each indicator in the sample of LMICs, with 738 and 82 observations respectively. Notably, the coefficients remain largely consistent in magnitude with those reported in table 7, although some variation in statistical significance arises in the long-difference regression in the sample of LMICs.

Consistent with the main specification in table 5, there is no direct effect of linear temperature or precipitation on net migration. However, for *Regulatory Quality* and *Political Stability*, I can again identify a negative coefficient for the squared temperature term in the long-difference regression, that is significant at the 10% level. This suggests that temperature changes on its own are only associated with emigration from LMICs at more extreme temperatures.¹¹ The effect of temperature squared under *Government Effectiveness* is no longer statistically significant but maintains its negative coefficient as in table 7. This may indicate that the same pattern is present but is less robust in this sub-sample of lower-middle-income countries.

Regarding the institutional variables themselves, the direct, negative effects of *Rule of Law* and *Government Effectiveness* on migration observed in table 7 are preserved—and even increase in magnitude—in the LMIC sample. For example, a one-point increase in *Rule of Law* is associated with a direct increase in annual emigration of 2.3 persons per 1000 people. For the marginal effect of an increase in *Rule of Law* however, the interaction terms should also be evaluated.

Previously, *Government Effectiveness* emerged as a key moderating mechanism. The LMIC results in table 8 reinforce this and expand the picture: *Rule of Law* also reports statistically significant interaction terms. Specifically, both the linear (0.067) and squared (-0.002) interaction term are statistically significant at the 5% level in the baseline regression. In the long-difference regression, these effects maintain their statistical significance and more than double in magnitude to 0.264 and -0.007 respectively. Under *Government Effectiveness*, the linear

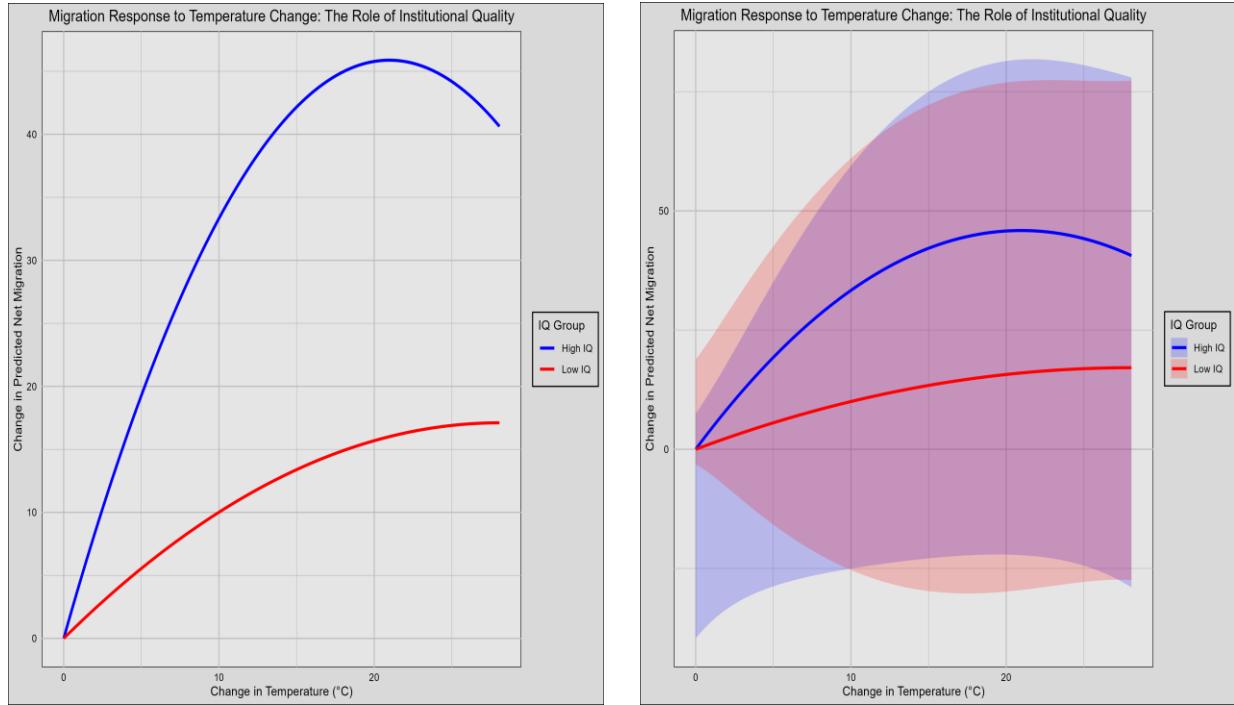
¹¹ It is important to highlight that this just relates to the effect of temperature on migration on its own, so independent of the institutional quality. As I mention consistently, the effect of temperature on migration depends on the level of institutional quality. This moderating role is examined without focussing significantly on the interpretation of individual coefficients to prevent confusion.

interaction term, with a coefficient of 0.139, remains statistically significant at the 10% level, whilst the squared interaction term loses significance in the long-difference regression.

These results suggest that both *Government Effectiveness* and *Rule of Law* moderate the migration response to rising temperatures. Both proxies report a positive coefficient for the linear interaction term and a negative coefficient for the squared interaction term. This indicates that institutional quality helps to reduce emigration to temperature rises at moderate temperatures, but becomes slightly less effective as temperatures become more extreme. This supports the theoretical claim that institutions, most notably *Government Effectiveness* and *Rule of Law*, enhance the adaptive capacity to climate change by sustaining allocative efficiency as well as economic and political stability, brought by public trust. While theory also highlights accountability, regulatory quality and corruption as plausible mechanisms, I do not find sufficient evidence for those mechanisms.

Figure 4 illustrates the non-linear moderating role of institutions by using the predicted migration response to a temperature change, disaggregated by institutional quality. The left-hand panel shows that countries with higher institutional quality, specifically institutional quality above the median, experience a greater reduction in emigration (i.e. an increase in predicted net migration) in response to the same temperature increase. The relationship takes the shape of a downward parabola, indicating that the moderating effect of institutional quality diminishes at more extreme temperatures. This is visible at the inflection point where the blue curve begins to flatten. As mentioned before, this non-linear relationship across temperature levels is grounded in theory (Hsiang, 2010). However, as the right-hand panel demonstrates, the confidence intervals of the two curves substantially overlap. Statistically, this suggests that the migration response to temperature changes does not differ significantly between low and high institutional quality systems.

FIGURE 4: THE MIGRATION RESPONSE TO TEMPERATURE CHANGE FOR COUNTRIES WITH LOW VERSUS HIGH INSTITUTIONAL QUALITY



Returning to the heterogeneity analysis, displayed in table 8 and 9, I observe substantial increases in the economic magnitude of the estimated effects, despite some differences in statistical significance, when shifting from the full sample to the LMIC sub-sample. These changes may, in part, be attributed to the absence of any statistically significant effect in the UMIC sub-sample. As shown previously in table 6 and reaffirmed in table 9 (see appendix 6.4), none of the estimated coefficients—whether for temperature, precipitation or institutions—are statistically significant across all six proxies for UMICs.

The absence of any effect in UMICs may be interpreted as the highly context-dependent nature of the relationship between climate change, institutional quality and migration. Another possible interpretation is that in UMICs, higher baseline levels of institutional quality, climate resilience and socio-economic development may mitigate the perceived urgency to migrate in response to climate changes. Inhabitants may feel more confident towards institutions managing climate change or are less exposed to climate-sensitive livelihoods, that generally drive migration to climate change. As a result, minor changes in temperature or precipitation may not result in significant migration patterns. This explanation finds some support in the

existing literature, that reaffirms both the heterogeneity of climate impacts and the stabilizing role of strong institutional and economic systems (Cai et al., 2016; Dell et al., 2008).

All in all, I find limited evidence that, particularly in the longer run and at extreme temperatures, temperature increases may trigger emigration from lower-middle-income countries, and that institutions may moderate this response—albeit less effective at higher relative to moderate temperatures. This moderating role appears to run primarily through *Rule of Law* and *Government Effectiveness*. However, due to a lack of robustness and consistent statistical significance across models, this study ultimately fails to reject the null hypothesis that a country's institutional quality strengthens/does not affect the positive relationship between temperature changes and emigration.

5 Conclusion and discussion

5.1 Conclusion

Addressing climate-induced migration is becoming increasingly urgent in the face of global environmental change. While its consequences—ranging from humanitarian crises to regional conflicts—are widely known, considerable uncertainty remains regarding the moderating role of contextual factors in shaping migration responses to climate stressors. This paper contributes to the climate migration puzzle by investigating the role of a country's institutional quality on the relationship between temperature changes and emigration.

Strong institutions and high adaptive capacity are closely interconnected. A robust institutional framework is considered essential for resilience against climate-change, as it ensures the necessary levels of allocative efficiency, fosters public trust, and provides an effective coordination mechanism to enhance the implementation and effectiveness of adaptation policies. In this manner, strong institutions are hypothesized to mitigate migration responses to temperature changes.

To examine this empirically, I use panel data from 2002 to 2019 for 86 middle-income countries, a sample that exhibits notable agricultural dependence and variation in institutional quality. Due to data constraints, I operationalize the dependent variable as net migration and take the geometric mean of the six World Bank indicators of Institutional Quality to generate an index-based score. In a fixed effects model, net migration is regressed on temperature, including a squared term to account for non-linearity, precipitation, institutional quality and interaction terms, along with country and year-by-region fixed effects. Additionally, I supplement these panel estimates with a long-difference regression to approximate medium-run impacts and adaptation.

The findings provide limited evidence that rising extreme temperatures on its own contribute to emigration from lower-middle-income countries over the longer term. The overall effect of temperature on migration depends on the level of institutional quality. The institutional framework may moderate this relationship by reducing emigration responses to temperature increases. This effect, primarily found to be running through the mechanisms of

Government Effectiveness and *Rule of Law*, seems to become slightly weaker at more extreme temperatures. The inflection point of 22 °C for this non-linear moderating relationship across temperature levels closely matches the ergonomic literature. The long-difference regressions reveal that adaptational responses may strengthen the moderating role of institutions in the medium/long run. The heterogeneity analysis reinforces the context-specific nature of the climate-migration relationship: while lower-middle-income countries exhibit sensitivity to both climate and institutional factors, no statistically significant effects are identified in the sample of upper-middle-income countries. This may reflect their higher baseline levels of institutions and reduced exposure to climate-sensitive livelihoods, such as agriculture.

Nonetheless, the overall lack of consistent statistical significance and robustness across the various model specifications suggests caution in drawing definitive conclusions. As such, this study does not provide sufficient evidence to reject the null hypothesis that institutional quality has an amplifying/no moderating effect on the relationship between temperature changes and migration. While the current findings do not support clear-cut policy recommendations, the suggestive patterns identified may still encourage policymakers to consider the potential role of institutional quality in enhancing climate resilience.

5.2 Discussion

These preliminary insights, however, must be interpreted within the context of several limitations, which are addressed in the following paragraphs.

Firstly, a key methodological limitation lies in the aggregation of the geospatial data. Due to data availability, this study relies on annual averages for temperature and precipitation. Prior research has highlighted the sensitivity of climate variables, particularly precipitation, to their operationalization (Dell et al., 2008). The summary statistics also revealed a slightly different pattern for precipitation in this study. Therefore, future studies should use temperature and precipitation data that is based on monthly aggregation (Cattaneo & Peri, 2015; Huynh & Hoang, 2024). This would enable better capture of seasonal climate patterns, which significantly alter migration dynamics (Maurer & Hidalgo, 2007; Waidelich et al., 2024). Annual data often

overlooks those trends. This limitation requires caution when interpreting the estimated effects, especially concerning the statistical significance of the climate stressors.

In addition to this, I suggest that future research extends the time span of the dataset. Due to limited data availability on institutional quality, this study's sampling period is restricted to the period between 2002 and 2019. As demonstrated in figure 1 (section 4.3.2) changes in temperature over five-year periods remain relatively small. Given that climate change is a gradual, long-term process, an extension of the sampling period would better align with the study's objective and enhance the validity of the long-difference regression results.

Unfortunately, this study did not manage to find reliable cross-national emigration data. Therefore, the dependent variable is operationalized as net migration. Whilst this is a common proxy, it fails to capture the full dynamics of emigration, especially in low and middle-income countries where data quality is often limited. Future studies should aim to compile more robust emigration-specific datasets, particularly for countries where data validity remains a challenge. This increase in the validity of the data on the dependent variable may result in more accurate estimates.

Moreover, the operationalization of a country's institutional framework poses some limitations. Given the absence of a validated index, this study constructs an unweighted composite score by taking the geometric mean of the six World Bank governance indicators. While this decision is supported by the literature, robustness checks suggest that *Government Effectiveness* and *Rule of Law* may be the primary mechanisms through which institutions moderate climate-induced migration. It is unclear whether alternative operationalizations of institutional quality, such as weighted indices or dimension reduction techniques like principal component analysis and factor analysis, would give different results. Future research should explore such alternatives.

Nonetheless, it should continue to include individual governance indicators to be able to uncover potential mechanisms. This is because the observed context-specific patterns — especially in LMICs — suggest possible mechanisms worth exploring further, despite the lack of robustness. Future research should try to refine these findings and examine whether institutional capacity influences climate-related migration in more targeted settings. In this

manner, studies can also offer more tangible advice to policymakers concerning the benefit of targeted interventions in the institutional system to enhance climate change adaptation.

Despite these limitations, this study certainly adds to the literature by investigating the moderating impact of a country's institutional system on the climate-migration nexus. The context-specific effects observed in lower-middle-income countries suggest that institutions may mitigate migration responses to temperature changes, though further evidence is needed. Additional research into this area, that addresses this study's limitations, will be essential to develop more robust estimates and guide effective policy interventions. The impacts of climate change intensify. So, understanding the role of contextual factors—among which institutional quality—in shaping climate-induced migration becomes increasingly urgent for both researchers and policymakers.

6 Appendix

6.1 Data: List of Countries

I adhere to the country classification of the World Bank (World Bank, 2024).

6.1.1 *List of Middle-Income Countries*

The following 86 countries:

Albania, Algeria, Angola, Argentina, Armenia, Azerbaijan, Bangladesh, Belarus, Belize, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Cambodia, Cameroon, China, Colombia, Comoros, Congo Brazzaville, Costa Rica, Cote d'Ivoire, Cuba, Djibouti, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Fiji, Gabon, Georgia, Ghana, Guatemala, Guinea, Haiti, Honduras, India, Indonesia, Iran, Iraq, Jamaica, Jordan, Kazakhstan, Kenya, Kyrgyzstan, Lao PDR, Lebanon, Lesotho, Libya, Malaysia, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Myanmar, Namibia, Nepal, Nicaragua, Nigeria, North Macedonia, Pakistan, Papua New Guinea, Paraguay, Peru, Philippines, Sao Tome and Principe, Senegal, Serbia, South Africa, Suriname, Tajikistan, Tanzania, Thailand, Tunisia, Turkey, Turkmenistan, Ukraine, Uzbekistan, Venezuela, Vietnam, Zambia, Zimbabwe

6.1.2 *List of Lower-Middle-Income Countries*

The following 41 countries:

Angola, Bangladesh, Benin, Bhutan, Bolivia, Cambodia, Cameroon, Comoros, Congo Brazzaville, Cote d'Ivoire, Djibouti, Egypt, Ghana, Guinea, Haiti, Honduras, India, Jordan, Kenya, Kyrgyzstan, Lao PDR, Lebanon, Lesotho, Mauritania, Morocco, Myanmar, Nepal, Nicaragua, Nigeria, Pakistan, Papua New Guinea, Philippines, Sao Tome and Principe, Senegal, Tajikistan, Tanzania, Tunisia, Uzbekistan, Vietnam, Zambia, Zimbabwe

6.1.3 List of Upper-Middle-Income Countries

The following 45 countries:

Albania, Algeria, Argentina, Armenia, Azerbaijan, Belarus, Belize, Bosnia and Herzegovina, Botswana, Brazil, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Equatorial Guinea, Fiji, Gabon, Georgia, Guatemala, Indonesia, Iran, Iraq, Jamaica, Kazakhstan, Libya, Malaysia, Mauritius, Mexico, Moldova, Mongolia, Namibia, North Macedonia, Paraguay, Peru, Serbia, South Africa, Suriname, Thailand, Turkey, Turkmenistan, Ukraine, Venezuela

6.2 Correlation table

TABLE 2: CORRELATION TABLE

	Net Migration	Temperature	Institutional Quality	Precipitation	Political Stability	Government Effectiveness	Control of Corruption	Regulatory Quality	Rule of Law	Voice & Accountability
Net Migration	1									
Temperature	0.040	1								
Institutional Quality	0.070	-0.040	1							
Precipitation	0	0.290	0.070	1						
Political Stability	0.040	-0.020	0.620	0.020	1					
Government Effectiveness	0.120	-0.100	0.880	0.060	0.400	1				
Control of Corruption	0.020	-0.020	0.890	0.050	0.550	0.780	1			
Regulatory Quality	0.080	-0.100	0.830	0.030	0.290	0.780	0.610	1		
Rule of Law	0.110	-0.050	0.930	0.030	0.510	0.850	0.840	0.770	1	
Voice & Accountability	-0.040	0.080	0.760	0.170	0.320	0.550	0.580	0.660	0.640	1

6.3 Correlation table on institutional quality indicators for complete sample

TABLE 3: CORRELATION TABLE FOR INSTITUTIONAL QUALITY INDICATORS

	Political Stability	Government Effectiveness	Control of Corruption	Regulatory Quality	Rule of Law	Voice & Accountability
Political Stability	1					
Government Effectiveness	0.400	1				
Control of Corruption	0.550	0.780	1			
Regulatory Quality	0.290	0.780	0.610	1		
Rule of Law	0.510	0.850	0.840	0.770	1	
Voice & Accountability	0.320	0.550	0.580	0.660	0.640	1

6.4 Regression models

See table 8, 9 and 10 below.

TABLE 8: SIX ALTERNATIVE SPECIFICATIONS OF INSTITUTIONAL QUALITY FOR THE SAMPLE OF LOWER-MIDDLE-INCOME COUNTRIES

<i>Dependent variable:</i>												
	Net Migration						Long Difference regression (LD)					
	Base regression						Long Difference regression (LD)					
	RoL (1)	VaA (2)	RQ (3)	CC (4)	PLST (5)	GE (6)	RoL (7)	VaA (8)	RQ (9)	CC (10)	PLST (11)	GE (12)
Temperature	1.406 (1.631)	2.252 (1.515)	1.153 (0.947)	2.138 (1.632)	2.512 (1.652)	0.544 (1.027)	-5.778 (7.678)	0.263 (6.208)	4.388 (6.438)	1.696 (5.893)	1.693 (5.586)	-0.085 (5.804)
Temperature ²	-0.009 (0.027)	-0.038 (0.029)	-0.006 (0.029)	-0.024 (0.025)	-0.040 (0.029)	0.0004 (0.022)	-0.050 (0.189)	-0.234 (0.156)	-0.334 ^{**} (0.149)	-0.185 (0.141)	-0.289 ^{**} (0.143)	-0.238 (0.147)
Precipitation	0.015 (0.031)	0.014 (0.034)	0.017 (0.036)	0.009 (0.030)	0.013 (0.032)	0.016 (0.035)	0.207 (0.175)	0.126 (0.186)	0.138 (0.180)	0.139 (0.166)	0.113 (0.175)	0.208 (0.170)
Institutional Quality	-0.334 [*] (0.196)	0.090 (0.121)	-0.262 (0.235)	0.176 (0.279)	0.191 (0.176)	-0.614 [*] (0.326)	-2.311 [*] (1.271)	-0.112 (0.447)	0.410 (1.333)	-0.457 (0.998)	-0.170 (0.429)	-1.300 ^{**} (0.637)
Temperature *	0.067 ^{**} (0.027)	-0.0001 (0.015)	0.065 (0.050)	0.022 (0.024)	-0.006 (0.016)	0.081 (0.052)	0.264 ^{**} (0.130)	0.026 (0.053)	-0.008 (0.124)	0.119 (0.097)	0.031 (0.045)	0.139 [*] (0.072)
Temperature ² *	-0.002 ^{**} (0.001)	-0.0002 (0.0005)	-0.002 (0.002)	-0.001 (0.001)	0.00001 (0.0004)	-0.002 (0.002)	-0.007 ^{**} (0.003)	-0.001 (0.001)	-0.0001 (0.003)	-0.004 (0.002)	-0.001 (0.001)	-0.003 (0.002)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-by-Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	738	738	738	738	738	738	82	82	82	82	82	82
R ²	0.097	0.079	0.115	0.101	0.089	0.101	0.415	0.311	0.382	0.444	0.386	0.450
Adjusted R ²	-0.039	-0.060	-0.019	-0.036	-0.049	-0.035	-0.480	-0.743	-0.564	-0.408	-0.553	-0.391

This table reports regressions of net migration (netMgr) on change in temperature (temp / temp sq2) and multiple country characteristics by using six different operationalizations of Institutional Quality for lower-middle-income countries. Variables are defined in accordance with table 1. For each variable, the coefficient is provided with the clustered standard error in parentheses. The asterisks ^{*}, ^{**} and ^{***} denote significance at the 10, 5 and 1 % level respectively.

TABLE 9: SIX ALTERNATIVE SPECIFICATIONS OF INSTITUTIONAL QUALITY FOR THE SAMPLE OF UPPER-MIDDLE-INCOME COUNTRIES

<i>Dependent variable:</i>												
	Base regression						Net Migration					
	RoL	VaA	RQ	CC	PLST	GE	RoL	VaA	RQ	CC	PLST	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	
Temperature	0.917 (0.871)	1.556 (1.405)	0.842 (0.716)	1.030 (0.836)	0.043 (0.822)	0.404 (0.719)	7.878 (7.267)	6.413 (6.288)	8.941 (6.219)	9.904 (6.929)	6.458 (7.296)	5.895 (6.540)
Temperature ²	-0.028 (0.032)	-0.043 (0.047)	-0.029 (0.024)	-0.029 (0.029)	0.005 (0.030)	-0.017 (0.026)	-0.107 (0.182)	-0.112 (0.167)	-0.148 (0.161)	-0.183 (0.183)	-0.055 (0.203)	-0.083 (0.168)
Precipitation	0.031 (0.033)	0.039 (0.037)	0.028 (0.032)	0.027 (0.031)	0.023 (0.031)	0.032 (0.034)	0.229 (0.188)	0.229 (0.167)	0.173 (0.177)	0.256 (0.184)	0.207 (0.188)	0.209 (0.178)
Institutional Quality	0.008 (0.093)	0.353 (0.271)	-0.049 (0.106)	0.077 (0.102)	-0.026 (0.086)	-0.102 (0.090)	0.073 (0.428)	0.096 (0.765)	-0.196 (0.388)	0.372 (0.456)	-0.162 (0.510)	-0.401 (0.409)
Temperature *	-0.012	-0.036	-0.007	-0.018	0.010	0.003	-0.012	-0.002	0.015	-0.056	0.030	0.050
Institutional Quality	(0.015)	(0.035)	(0.017)	(0.017)	(0.014)	(0.014)	(0.060)	(0.095)	(0.052)	(0.062)	(0.064)	(0.059)
Temperature ² *	0.001	0.001	0.0005	0.001	-0.0003	0.0002	0.0005	0.0004	0.00000	0.002	-0.001	-0.001
Institutional Quality	(0.0005)	(0.001)	(0.001)	(0.001)	(0.0004)	(0.0004)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Country FE	Yes											
Year-by-Region FE	Yes											
Observations	810	810	810	810	810	810	90	90	90	90	90	90
R ²	0.094	0.126	0.102	0.084	0.091	0.109	0.165	0.315	0.261	0.177	0.174	0.242
Adjusted R ²	-0.060	-0.024	-0.051	-0.073	-0.064	-0.043	-1.122	-0.742	-0.880	-1.092	-1.101	-0.926

This table reports regressions of net migration (netMgr) on change in temperature (temp / temp sq2) and multiple country characteristics by using six different operationalizations of Institutional Quality for upper-middle-income countries. Variables are defined in accordance with table 1. For each variable, the coefficient is provided with the clustered standard error in parentheses. The asterisks '*', '**' and '***' denote significance at the 10, 5 and 1 % level respectively.

TABLE 10: REGRESSION MODELS WITH AND WITHOUT TEMPERATURE SQUARED

	<i>Dependent variable:</i>			
	Net Migration			
	(1)	(2)	(3)	(4)
Temperature	0.502*	0.661	0.376	-0.437
	(0.258)	(0.605)	(0.499)	(0.800)
Temperature ²		-0.005		0.021
		(0.016)		(0.030)
Precipitation	0.032*	0.031*	0.023	0.019
	(0.019)	(0.018)	(0.023)	(0.023)
Institutional Quality			0.067	-0.286
			(0.142)	(0.188)
Temperature *				
Institutional Quality			0.003	0.053*
			(0.005)	(0.032)
Temperature ² *				-0.001
Institutional Quality				(0.001)
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Year-by-Region FE	No	No	Yes	Yes
Observations	1,548	1,548	1,548	1,548
R ²	0.004	0.005	0.075	0.082
Adjusted R ²	-0.055	-0.056	-0.029	-0.023

This table reports regressions of net migration (netMgr) on change in temperature (temp / temp sq2) and multiple country characteristics. Variables are defined in accordance with table 1. For each variable, the coefficient is provided with the clustered standard error in parentheses. The asterisks ‘*’, ‘**’ and ‘***’ denote significance at the 10, 5 and 1 % level respectively.

7 GenAI use

7.1 Statement of purpose

This appendix contains a detailed description of the use of Generative AI tools during the development and writing of this thesis. Generative AI tools (e.g., ChatGPT, Copilot) were used to assist in refining the language of this thesis and the R-code. By submitting this thesis I declare that I am fully responsible for the accuracy and completeness of its content.

7.2 Tools Used

ChatGPT

7.3 Scope of Use

7.3.1 Writing and Grammar Refinement

- Tool: ChatGPT
- Purpose: Improved readability in writing, as well as provision of synonyms.
- My role: I critically reviewed the suggestions provided by AI, before including them in my thesis.
- My reflection: By using AI, I have been able to improve the readability of the text whilst maintaining the meaning of my story.
- Applied in sections 1 and 2.

7.3.2 Coding assistance in data visualization

- Tool: ChatGPT
- Purpose: Improved data visualizations through customizations
- My role: I critically reviewed the suggestions provided by AI on my initial snippets of code, before refining my code.
- My reflection: By using AI, I have been able to improve the visualization of my data.
- Applied in section 4 for figures 1,2,3 and 4.

7.4 Complete log of AI interaction

Example 1: Writing assistance

- **Query to ChatGPT:** What do you think of this conclusion of a literature review in an academic paper? Please consider readability and clarity. All in all, this study examines the role of a country's institutional framework on climate-induced migration, something that has long been understudied. Concerning the main mechanisms, a country's institutions play a critical role in shaping both the quality and perceived credibility of adaptation strategies to climate change, thereby influencing migration patterns. Based on the discussed theoretical and empirical insights, the following hypothesis follows logically:
- **Output:** Your conclusion is generally well-structured and clear, but it could be slightly refined for better readability and flow. Here are a few suggestions:
 1. **"All in all"** – This phrase is somewhat informal for an academic paper. A more formal alternative could be **"In summary"** or **"Overall"**.
 2. **"Something that has long been understudied"** – This phrasing is a bit conversational. You could make it more formal by saying **"a topic that has received limited attention in the literature."**
 3. **"Concerning the main mechanisms"** – This phrase is slightly awkward. You could clarify by saying **"Regarding the key mechanisms at play"** or **"With respect to the main mechanisms influencing this process."**
 4. **"The following hypothesis follows logically"** – The word "follows" is somewhat redundant here. You could simplify it to **"The following hypothesis logically emerges from these insights."**

Example 2: Writing assistance

- **Query to ChatGPT:** synonym for **to mitigate** migration
- **Output:** A synonym for *to mitigate migration* could be:

- To reduce migration
- To curb migration
- To alleviate migration
- To ease migration
- To control migration
- To temper migration
- To moderate migration

The best choice depends on the context. Are you referring to reducing the causes of migration, slowing the rate, or making the process smoother?

Example 3: Writing assistance

- **Query to ChatGPT:** Greater resilience could reduce migration pressures, thereby mitigating refugee flows, regional conflicts, and humanitarian crises. i want synonyms for refugee flows, regional conflicts and humanitaeian crises

- **Output:** Here are some synonyms for "refugee flows, regional conflicts, and humanitarian crises":

Refugee flows → Displacement patterns, Migration waves, Forced migration, Population movements

Regional conflicts → Localized wars, Geopolitical tensions, Civil unrest, Interstate disputes

Humanitarian crises → Humanitarian emergencies, Social crises, Humanitarian disasters, Relief crises

A refined version of your sentence could be:

"Greater resilience could reduce migration pressures, thereby mitigating forced migration, civil unrest, and humanitarian emergencies."

Let me know if you need further adjustments!

Example 4: Data visualization

- **Query to ChatGPT:** I have this command to output regression to a table. however, in m3 i also used year-by-region fixed effects. Can i include a row in the table, where it says Year-by-Region FE, and then there is a 'Yes' or 'No' for every model?

```
stargazer(m1,m2,m3,m1_tsq,m2_tsq,m3_tsq,type = "html",
se=list(HC_SE_m1,HC_SE_m2, HC_SE_m3,
HC_SE_m1_tsq,HC_SE_m2_tsq,HC_SE_m3_tsq), keep.stat = c("n",
"rsq","adj.rsq"),star.cutoffs = c(0.1, 0.05,0.01),out = "Results/regressions_basic.doc")
```

- **Output:** Yes, you can definitely include a custom row in your regression table indicating whether Year-by-Region Fixed Effects (or any other fixed effects) are included in each model.

To add such a row in `stargazer()`, you can use the `add.lines` argument. The `add.lines` argument allows you to add custom rows to your regression table, which is perfect for your use case.

Here's how you can modify your code to add a row for Year-by-Region Fixed Effects:

Updated Command:

R

```
stargazer(m1, m2, m3, m1_tsq, m2_tsq, m3_tsq,
type = "html",
se = list(HC_SE_m1, HC_SE_m2, HC_SE_m3, HC_SE_m1_tsq, HC_SE_m2_tsq,
HC_SE_m3_tsq),
keep.stat = c("n", "rsq", "adj.rsq"),
star.cutoffs = c(0.1, 0.05, 0.01),
out = "Results/regressions_basic.doc",
add.lines = list(
  c("Year-by-Region FE", "No", "No", "Yes", "No", "No", "Yes") # Add custom row here
)
)
```

Explanation:

- `add.lines = list(...)`: This allows you to add custom rows to your output table. Each vector inside `add.lines` corresponds to a new row in the table.

- `c("Year-by-Region FE", "No", "No", "Yes", "No", "No", "Yes")`: This row corresponds to a new line in the table. The first element "Year-by-Region FE" is the label for this row, and the following elements correspond to the models (m1, m2, m3, etc.), where you specify "Yes" or "No" based on whether Year-by-Region fixed effects are included.

Adjustments:

- The elements "No" and "Yes" should match the models you are working with. For instance, if m3 includes Year-by-Region fixed effects and m1, m2, m1_tsq, m2_tsq do not, the row for "Year-by-Region FE" would have "Yes" for m3, and "No" for the others.

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