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Climate Change and Internal Migration: A Case Study of Iran

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Abstract

Undeniably, climate change is one of the most disputed subjects of our era. Thus, it is crucial to learn more about this phenomenon as well as its possible impacts on our lives. This paper studies on the possible effects of climate change on internal migration in Iran using gravity-type models. We learn that climate factors do have a significant effect on migration specially the ones corresponding to the origin location. It is also suggested that destinations with more rainfall, or higher deviation in precipitation, are more desirable. Also, People tend to leave warm and dry regions. Although they do not necessarily go for the best climate, they tend to choose destinations with relatively better climatic conditions. Having in mind that climate factors do not differ much in small scales, choosing a relatively better climate rather than the perfect one, is coming from the fact that distance is a main obstacle in migration. This study also measures the effect of a change in temperature/precipitation on internal migration; $1^{o}C$ rise in temperature – in respect to climate and in average – increases emigration by 11.4%. Also, 100^{mm} fall in precipitation – in respect to climate and in average – would rise the number of emigrants by 12.6%. In addition, climate change could have different effect – in terms of sign and magnitude – in dissimilar locations even within a country; e.g. an increase in temperature has a 71.8% and 8.8% larger effect in Hot and Mild places compared to the Cold ones. In the end, evidently we should pay more attention to locations with unsuitable climatic conditions as the risk is higher there.

JEL Classification: Q5, O1, O5, R2, J6

Keywords: Climate Change; Migration; Development; MENA; Iran

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1. INTRODUCTION

One of the most disputed subjects of our era is the climate change and the negative consequences that might bring to us. There is solid evidence that our planet is getting warmer (Edenhofer et al, 2014; Pachuari et al. 2014), and this affects not only our surrounding environment, but also ourselves as human beings. World Economic Forum (2015) identifies 'Water crisis' as the first in terms of impact, and 'Extreme weather' events as the second most likely risk of 2015. Assuming business as usual, the challenge is to generate proper policies to control – and minimize – the damage caused by the change in climate. Similar to any other catastrophe, we should get to know the issue, as well as the triggers and the potential damage it might cause by collecting as much information as possible. Considering the multidisciplinary nature of this issue, we should use all the available knowledge from different disciplines to connect the dots in order to get the most precise picture. Numerous scientists, from various fields, showed interest in exploring the possible means this phenomenon could affect diverse aspects of our lives. It has been suggested that in average, a global temperature rise of 1.1^{o}C to 6.4^{o}C is predicted by the end of this century (Solomon, 2007). This would lead to change in precipitation patterns; i.e. wet gets wetter and dry gets drier (World Bank, 2014). For an example, World Resources Institute suggests that a 3°C increase in temperature would reduce Iran's crop yields by 30%. Decrease in crop yields reduces farmers' income, which may lead to rise in regional food insecurity and eventually more emigration. Also, keeping in mind that achieving many of the SDGs[1] will be much harder with 2°C warming, by a 4°C rise in temperature, there is serious doubt whether these goals can be achieved at all (World Bank, 2014)

One should note that the consequences of climate change is global and no country could get away with that in long-run; as it is true that initially it will hit some of the countries harder, like LDC`s[2] due to their poverty, weak infrastructure and instable governments, or countries with low altitude, these consequences will transfer to the unaffected or less-affected areas through different modern transformation mechanisms such as migration. Reuveny (2007) argues that people living in lesser developed countries may be more likely to leave affected areas – caused by climate change, which may cause conflict in receiving areas. Also, the U.S. Centre for Naval Analyses (2007, 2014) suggests climate change not only acts as a threat multiplier for instability in volatile regions but also, it would add tension to the stable regions of the world. These arguments have a similar point of view to Neo-Malthusians theory. Amongst different mechanism that climate and its change could influence migration, inducing armed conflicts are

[1] Sustainable Development Goals.
[2] Least Developed Countries.

amongst the important ones. There are a number of studies on this relationship such as Shiva and Kwiatkowski (2014) and Prediger et al. (2014) which suggest long-term weather – or simply climate – could shape the environment in a way to be more prone to violence. Also, Shiva (2015) suggests that there is in fact a causal effect from weather changes on the onset and incidence of armed conflicts which is a rise of 1.6% in the probability of conflict onset in case of a 1° F rise in temperature – in respect to climate. This rise is 6% and 2.5% percent more in hot and mild areas respectively – compared to the cold ones.

Iran, in particular, could be more disposed to the consequences of climate change as in terms of precipitation, more than 80% of the country is arid or semi-arid. Also around 20% of the country's land is covered with deserts, with roughly 9% forest area (SNC to UNFCCC, 2010). To compare Iran's climatic conditions with global averages, average annual precipitation and temperature in Iran is 326^{mm} and $17^{o}C$_respectively[3]; These values are 1121^{mm} and $19^{o}C$ globally[4] (calculated for 173 countries for 1997-2011, World Bank database). Clearly Iran's average precipitation is lower than the global average – in more details it is less than $^{1}/_{3}$ of the global average.

Studying on Romania, Bunea (2012) suggests migration is a key mechanism for adjustment to regional economic shocks, especially when other tools prove useless. One should keep in mind that migration by itself is not a threat, neither for people nor the country. However, excessive quantities of it – or uneven concentration – could bring many problems such as brain-drain, food scarcity, rise in crimes/conflicts, over urbanization, food insecurity, rise in the number of slums, pollution, human insecurity and etc. On the other hand, there are some positive effects from migration as well, such as improved individual's life quality, rise in household's welfare, stimulated development (not necessarily sustainable development), improved competitiveness in the labor market and etc.

To continue, there are a number of studies focusing on the similar issue for different countries. Namely, Verner (2010)[5] uses a two stage model, which studies on firstly, decision to leave and secondly, choice of the destination. In the chapter on migration and climate change, authors argue that about 2000 Bolivians annually leave their place of origin due to bad climate. Unfortunately, I could not use this methodology for this study due to the limited number of

[3] From my dataset, for the period 1997-2011.
[4] These values are 1138^{mm} and $19\,^{o}C$ for all countries averaged for 1980-2009 from the WorldBank.
[5] Chapter 7, Migration and climate change (Andersen, Lund and Verner, 2010).

provinces in Iran[6], as it may bring difficulties for the first part of the model. Using a similar methodology Joseph and Wodon (2013) suggest people – of Yemen – consider climate condition when deciding to emigrate (push factor), but not to select a destination (pull factors). In another work on Yemen, Joseph et al. (2011) argues that higher temperature and its variability has a significant, but small, effect on 'Net-Migration'. Moreover, Hassani-Mahmooei and Parris (2012) predicts that there will be around 3 to 10 million internal migrants over the next 40 years – in Bangladesh. In another study on international migrations developing to OECD countries, Beckaus et al. (2015) suggest a 1ºC increase in temperature is associated with a 1.9% increase in bilateral migration flows.

2. DATA

For the purpose of this study, 'Annual Number of Emigrants'[7] is getting used as the dependent variables. The set of controls are categorized in four main groups:

i) Gravity variables: Population[8] and Driving distance; ii) Labour variables: Share of educated people, Share of educated people living in rural areas, Share of people living in urban areas and Unemployment rate; iii) Economic variables: GDP growth (current prices) and GDP per capita (current prices); iv) Environment variables (focus variables): Average annual temperature/precipitation, Temperature/Precipitation's deviation from climate[9] (absolute and relative)[10].

The dependent variables are constructed by compiling the last two censuses prepared by SCI[11] covering 1997-2006 and 2007-2011. Most of my control variables are obtained from SCI while averaged for the census period. I have retrieved the driving distance data from the Google maps and it proxies for the travel cost. Climatic variables are constructed from the dataset retrieved from ICCO[12]. Variables - in this study - are created in a way to either correspond to the mid-

[6] There are only 30 provinces, which is not sufficient for a regression considering the number of controls in the model (10 control variables for each province, without fixed effects).
[7] I am also working on "Annual rate of emigration" using GLM and OLS estimations as well as "Net migration" and "Net migration rate" using OLS.
[8] Checked for population density as well. The results would be similar.
[9] IPCC defines climate as the '*average weather'*. World Meteorological Organization (WMO) suggest the average should be taken over 30 years.
[10] I have also tried weighting environment factors by population. Doing so does not affect the results substantially.
[11] Statistical Centre of Iran, http://www.amar.org.ir/
[12] Iran's Climate Change Office, http://climate-change.ir/

point or the average – of the census period. This dataset covers the migration matrix for 30 provinces, two censuses and 1740 (= 30×29×2) observations, with 870 different province-pairs.

Moreover, all factor variables correspond to provinces, except destination and the dependent variables that correspond to province-pairs. Therefore, average annual temperature stands for the

Table A: Data description

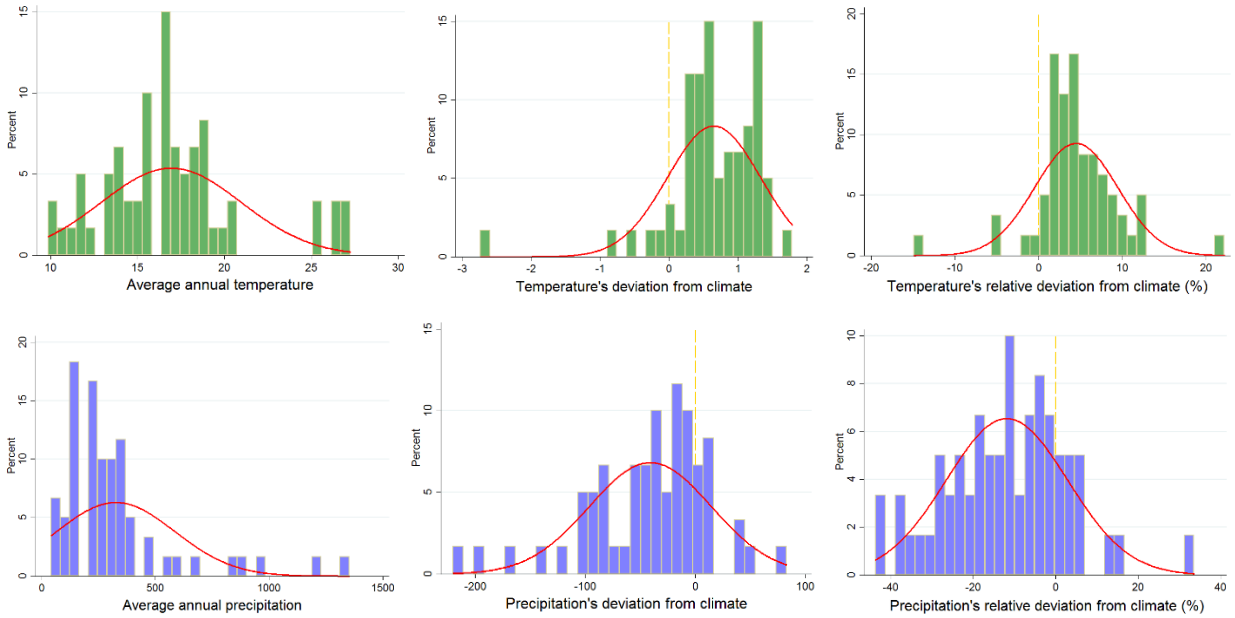
Variable	Obs	Mean	Std. Dev.	Min	Max
Emigration	1740	476.5457	1147.615	1	17263
Net migration	1740	-4.50747	797.657	-12573	12573
Emigration rate	1740	0.02373	0.05896	0.0005577	0. 72409
Educated	1740	81.97022	4.53725	63.66185	90.83269
Educated rural	1740	75.02954	4.20629	59.84174	82.41758
Urban share	1740	61.13685	12.84202	35.45595	94.56693
Unemployment	1740	13.47273	5.668302	6.782848	30.39204
GDP growth	1740	24.90142	6.774621	11.21329	53.45273
GDP per capita	1740	17.14601	0.7033027	15.79855	18.90401
Distance	1740	866.7861	431.3721	115.81	2171.33
Average T	1740	16.94816	4.033946	9.862378	27.25607
Average Pr	1740	326.3488	259.2501	42.724	1352.98
T deviation	1740	0.65454	0.67644	-2.73001	1.79134
Pr deviation	1740	-40.80884	55.50627	-220.4743	83.40334
T deviation rate	1740	4.497414	4.97414	-14.86927	22.19475
Pr deviation rate	1740	-11.82584	14.73599	-43.67249	33.64575

average of daily minimum and maximum temperatures throughout a year – for each province, then averaged again for the period that census covers. Average precipitation is the sum of precipitation throughout a year – for each province[13], then averaged for the period that census covers. Temperature's (precipitation's) deviation from climate indicates the difference between average temperature (precipitation) and the average climate. In this study I consider climate as a rolling average of the last 30 years. This somehow takes into account the resilience that habitants could build against harsh environmental conditions. Moreover, temperature's (precipitation's) relative deviation comes from dividing temperature's deviation by average climate, which is reported in percentage change instead of the value. Using relative change could be useful as a similar change in two provinces with different average annual temperature could have different influences; i.e. 50^{mm} change of rainfall in a province with average precipitation of 50^{mm} could

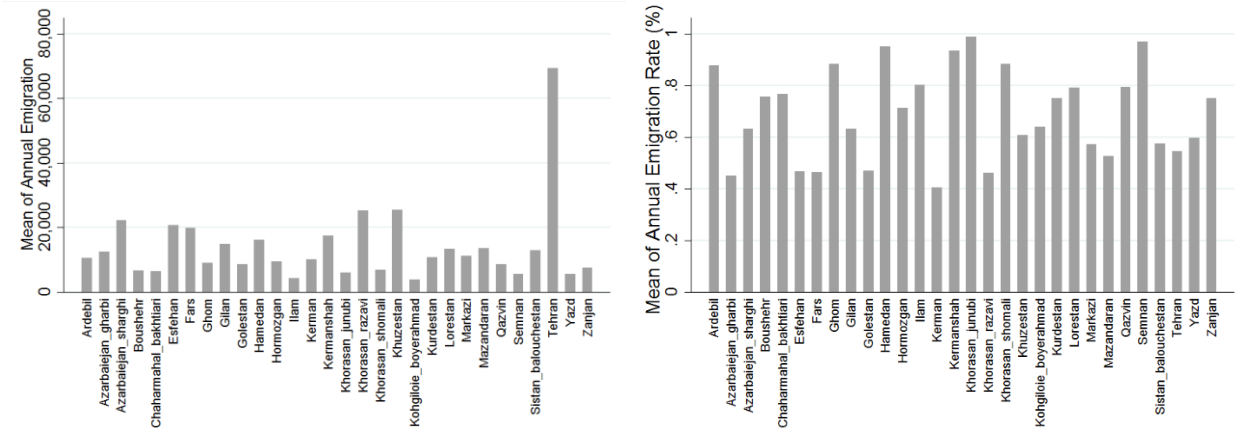
[13] Capital of the province in fact.

have a different (in magnitude and sign) effect compared to the one with average annual precipitation of 500^{mm}. There is a similar argument for temperature as well.

Having a quick look at the data, a positive (negative) deviation in temperature (precipitation) from climate is noticeable. Graph 1 suggests a +0.65^{o}C and -41^{mm} change in average temperature and precipitation, respectively. These value are +4.5% and -11.8% when considering the relative change.



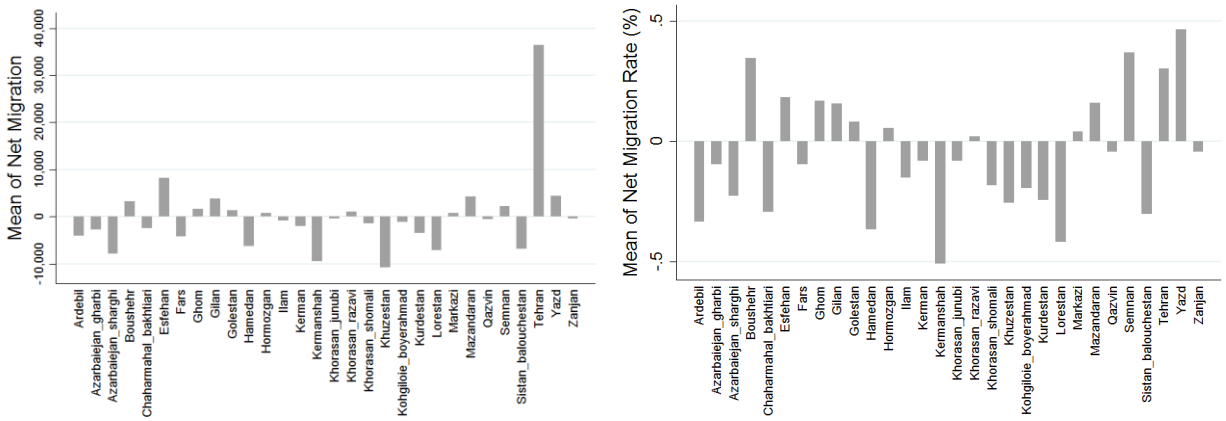
Graph 1: Histograms for climatic variables illustrating the distributions



Graph 2: Illustrating emigration by provinces in Iran[14]

Note: Migration data is corrected for Alborz and Tehran's bilateral migration for the latest census (2007-2011). Also, in the graph on the right, intra-state migrants are included in the population.

[14] Please find a map of most favorable migration destinations/origins in Iran in Appendix IV.



Graph 3: Illustrating net-migration[15] by provinces in Iran

3. METHODOLOGY

In this study, I am estimating a gravity-type model augmented with climate variables while controlling for the established socioeconomic factors**.** These types of models initially come from Newton's Universal Gravitation Law which suggests any two bodies attract one another with a force that is proportional to the product of their masses and inversely proportional to the square of the distance between them.

(1) $$F = G\frac{m_1 m_2}{r^2}$$

Where F stands for the force between the masses, G for the gravitational constant, m_1 and m_2 for masses and r for the distance between the masses. Applying this to migration, we get:

(2) $$M_{ij} = g\frac{P_i P_j}{D_{ij}^2}$$

Where M_{ij} is the migration from location i to j, g is a constant, P_i and P_j the origin and destination population, and D_{ij} the distance between i and j. This model has been extended by Lowry (1966) to the Econometrics form:

(3) $$M_{ij} = \beta_0 \times \log(g) + \beta_1 \times \log(P_i) + \beta_2 \times \log(P_j) + \beta_3 \times \log(X_i) + \beta_4 \times \log(X_j) + \beta_5 \times \log(D_{ij}) + \varepsilon_{ij}$$

[15] 'Net Migration$_{ij}$ = Annual Immigration$_i$ – Annual Emigration$_i$'. And 'Relative Net Migration$_{ij}$ = Net Migration$_{ij}$ ÷ Population$_i$'.

In this study, I use Ordinary Least Square regression for the main estimates, while allowing for clustered standard errors at province-pairs level to account for correlations in pairs[16]. To control for unobserved destination characteristics, destination district fixed effects are included as controls. A general overview of the main model used for this study is in the following:

$$(4)\quad \log(M_{ijt}) = \alpha_k \times \log(\text{population}) + \beta_l(\text{Labour variables}) + \gamma_m(\text{Economic variables}) + \delta_n(\text{Environment variables}) + \varphi \times \log(D_{ij}) + \omega_{jt} + \tau_t + \varepsilon_{ijt}$$

Where M_{ijt} denotes migration inflows from province i to province j in period t. Then, k, l, m, and $n \subset \mathbb{N}$ where, $k \in [1,2]$, $l \in [1,8]$, $m \in [1,4]$, $n \in [1,4]$. D_{ij} stands for driving distance between i and j, ω_{jt} indicates destination fixed effects, τ_t takes into account differences between two census periods and ε_{ijt} is the error term. The models including all the control variables for both the origin and destination provinces[17]. Similar to Backhaus et al. (2015), I am using bilateral emigration in its logarithmic form in the main analysis, as by using emigration rate, it is not identifiable whether changes in the emigration rate cross provinces – and over time – arise from changes in the migration flows, changes in the population size aside from emigration, or both. I have also checked the robustness of the results using 'Negative Binomial' regression without the destination fixed effects[18] and having total number of annual emigration as the dependent variable, while allowing for clustered standard errors at province-pairs level to account for correlations in pairs. This was done as the dependent variable has a Poisson distribution with over-dispersion[19]. However, the main results in this paper are coming from the OLS estimations.

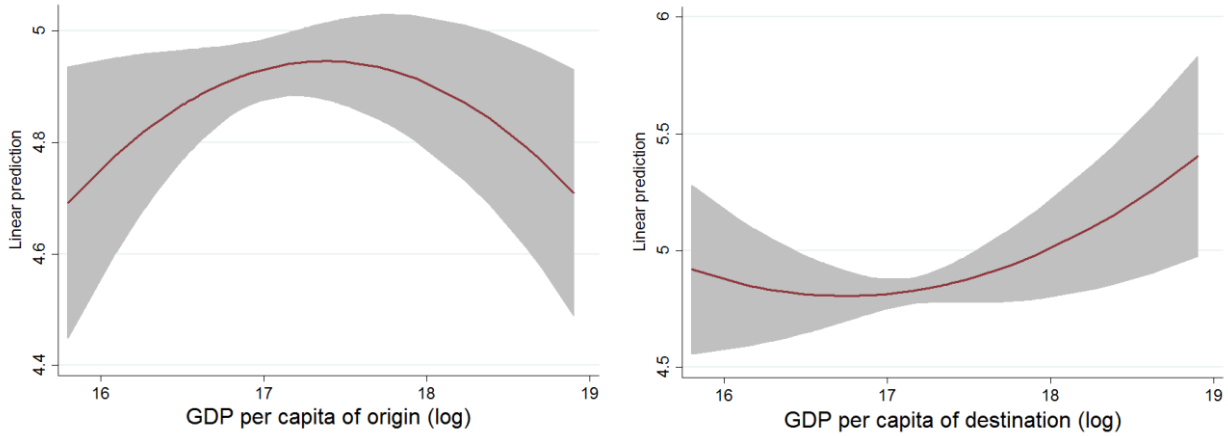
Lastly, here are some of the assumptions I made for the purpose of this study: i) people do not migrate only due to the direct effect of climate (disliking the weather); i.e. that climate affects other aspects of their lives, indirectly. ii) Assuming business as usual, this study tries to find solutions for minimizing the damage coming from the climate change, and not to prevent it from happening. iii) The focus is on migration in general and not just rural-to-urban migration.

[16] The reasons that a high number of people leave Province_i for Province_j could be correlated with the reasons that a low number of people enter Province_i from Province_j.
[17] Gravity, Labor, Economic and Environment variables.
[18] To avoid incidental parameter problem.
[19] The results stay consistent and they could be provided by request

4. MAIN ESTIMATIONS AND RESULTS

As expected, Distance and population of origin/destination are the most important factors in migration. Distance is a major obstacle for migration as it could proxy for the cost of migration i.e. closer places have a greater attraction for one another. It is interesting to know that 90% of internal emigrations in Iran occur in a radius of 625^{km} from origin (Appendix I). This is less than the average distance of provinces which is 867^{km}. This suggests the tendency to move to the closest neighboring province with suitable conditions. Also, as the importance of one or both of the locations increase, there will be a rise in movements between them; i.e. larger places attract more people, ideas, and commodities compared to the smaller ones.

Furthermore, people tend to leave less educated/urbanized places for more educated/urbanized ones. This suggests the tendency of rural population moving to industrialized area. Also, unemployment rate is one of the main reasons of migration. Interestingly, average income (GDP per capita) has a non-linear relationship with migration, where very rich and very poor areas possess relatively less emigrants (Graph 4). Therefore, middle-income people tend to move more often to places with higher prospective income. Although people in poorer area may like to move to better ones, they cannot afford the cost of relocating. Also, people with higher income tend to leave their place less often due to lack of motivation coming from satisfaction of their status quo.



Graph 4: GDP per capita and predicted number of emigrants (log)

Now on the results of the focus variables, people living in warm and dry provinces tend to emigrate more. Also, provinces which experienced a rise (fall) in temperature (precipitation) tend to send out more people. In more details, 1SD increase in the average annual temperature of the province, raise the number of emigrants by 25.6%. Also, 1SD decrease in the average annual

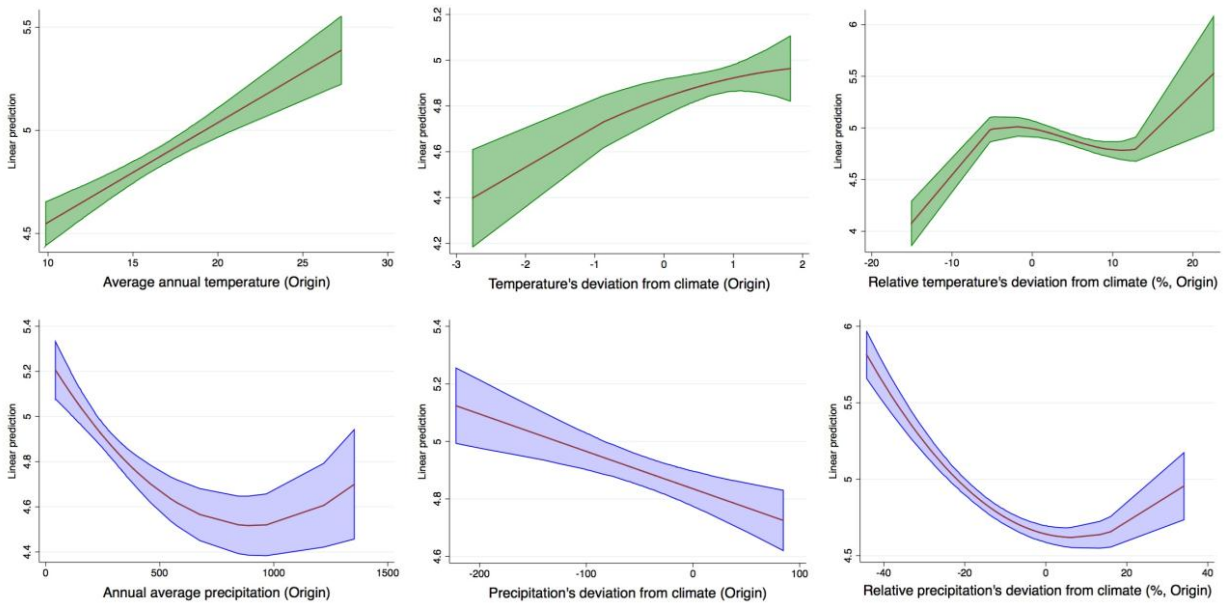
TABLE B: Average Marginal Effects for the standardized variables (OLS)

	ModelB1:Average Temperature/Precipitation	ModelB2: Temperature/Precipitation's deviation	ModelB3: Temperature/Precipitation's relative deviation
Dependent: Log (# of emigrations)			
Distance (log)	-0.930***	-0.877***	-0.896***
	(-29.63)	(-27.67)	(-29.19)
Population (log)	0.756***	0.766***	0.788***
	(35.79)	(35.48)	(37.48)
Educated rate	-0.174***	-0.281***	-0.176***
	(-3.45)	(-5.55)	(-3.44)
Rural educated rate	0.0430	0.102**	0.0444
	(1.06)	(2.51)	(1.09)
Urban share	0.0146	0.102***	0.0669**
	(0.45)	(3.51)	(2.25)
Unemployment rate	0.0522**	0.0170	0.0221
	(2.15)	(0.70)	(0.93)
GDP growth	0.0475**	0.170***	0.202***
	(2.45)	(7.56)	(9.22)
GDP per capita (log)	-0.0362	0.0703*	0.0387
	(-0.90)	(1.76)	(1.00)
Average annual temperature	0.256***		
	(9.06)		
Average annual precipitation	-0.118***		
	(-5.11)		
Temperature's deviation		0.0770***	
		(3.64)	
Precipitation's deviation		-0.0702***	
		(-3.54)	
Temperature's relative deviation			0.00640
			(0.25)
Precipitation's relative deviation			-0.181***
			(-7.78)
Population of D (log)	0.894***	0.751**	0.416
	(2.80)	(2.07)	(0.81)
Educated rate of D	0.0794	0.0807*	0.0823*
	(1.60)	(1.70)	(1.89)
Rural educated rate of D	0.160***	0.159***	0.151***
	(5.16)	(4.30)	(3.67)
Urban share of D	0.312***	0.275**	0.187
	(2.95)	(2.36)	(1.22)
Unemployment rate of D	-0.0220	-0.0291	-0.0192
	(-0.22)	(-0.28)	(-0.18)
GDP growth of D	-0.000501	0.00783	0.0227
	(-0.03)	(0.46)	(1.06)
GDP per capita of D (log)	0.111	0.123	0.0995
	(1.10)	(1.16)	(0.90)
Average annual temperature of D	0.107		
	(0.97)		
Average annual Precipitation of D	0.00574		
	(0.05)		
Temperature's deviation of D		0.0363*	
		(1.86)	
Precipitation's deviation of D		-0.00668	
		(-0.29)	
Temperature's relative deviation of D			0.0654**
			(2.10)
Precipitation's relative deviation of D			-0.0269
			(-1.03)
R2	0.8298	0.8088	0.8163
Log Likelihood	-1708.128	-1809.034	-1774.239
AIC	3516.257.	3718.069.	. 3648.479
BIC	3789.339.	. 3991.151	. 3921.561
Observations	1740	1740	1740

Controlled for census and province fixed effects. Only linear relationships measured. All variables are standardized. Temperature or Precipitation deviation is defined as temperature or precipitation - climate (the last 30 years' average). Temperature/Precipitation's relative deviation is defined as (Temperature or Precipitation deviation)/Climate). All standard errors are clustered at province-pair level. *** Significant at the 1 percent level ** Significant at the 5 percent level * Significant at the 10 percent level.

precipitation decreases the number of emigrants by 11.8% (Model B1). Similarly, 1SD increase in temperature's deviation from climate rises the number of emigrants by 7.7%. This value is 7% rise for 1SD decrease in precipitation's deviation from climate (Model B2). However, the effect of a change in either temperature or precipitation in hot areas is opposite to the cold ones (Graph7). This supports the idea that people tend to leave extreme climatic conditions.

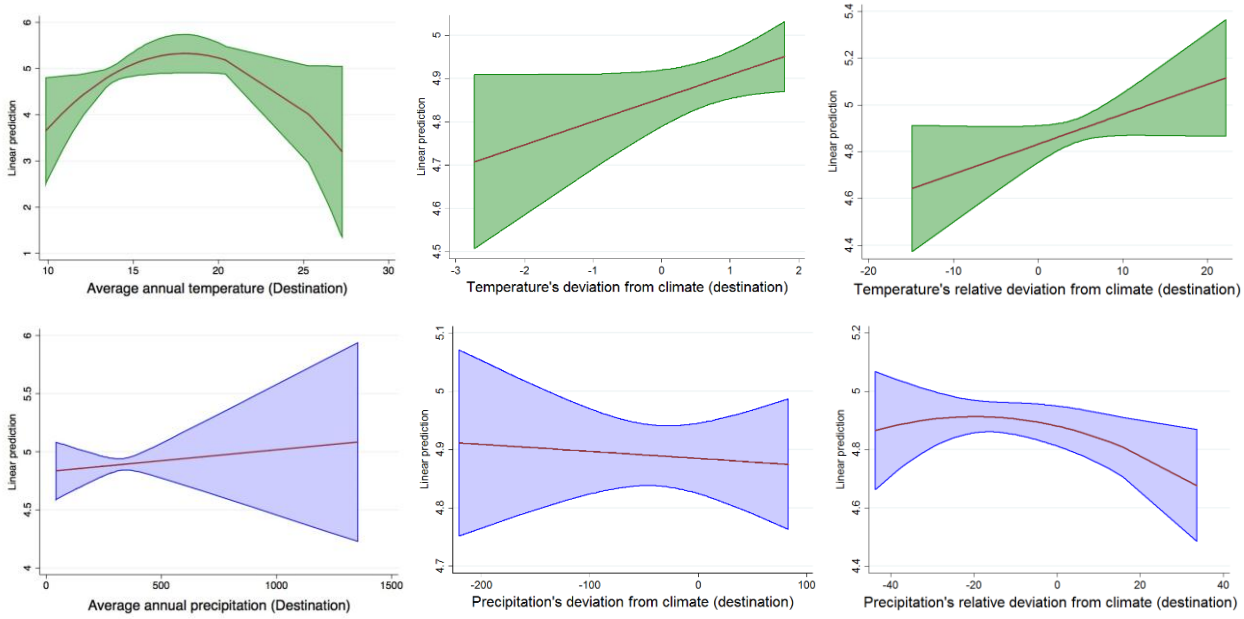
To continue, Graph 5 shows the shape of the relationship in between climatic factors of the origin province and emigration, with the predicted logarithm of number of emigrants on the vertical axis and climatic factors on the horizontal one. Looking at the graphs, we learn that hotter provinces and the ones experienced a bigger and positive deviation from their climate, tend to send more emigrants.



Graph 5: Margins for climatic variables of origin

There is a similar but opposite – in sign and direction – results for precipitation, however it is interesting to learn that areas with very high values of precipitation has a larger amount of emigrants compared to the ones behind them (convex shaped relationship). Moving on to the graphs on the right hand side, provinces with higher relative deviations in temperature seems to send out more people, where in precipitation's case, provinces with extreme relative changes (especially extreme decrease in rainfall) possess the highest number of emigrants. The results obtained when studying on the effects of climatic factors of destinations on emigration are neither robust nor strong – specially for precipitation. Consequently, we could argue that climate conditions of the provinces are more relevant in out-migration and not in-migration. Still, we could suggest that provinces with mild temperature receive most of the migrants (graph 6, top-

left). Oddly, we learn – from graph 6 on the top-right – that provinces that experienced a larger relative change in temperature receive more migrants. We could justify this by suggesting the following: More populated and more advanced provinces happened to be getting warmer as well. In other words, those areas got warmer because more people moved there! (more CO2 emissions from vehicles and industries).



Graph 6: Margins for climatic variables of destination

Moreover, segregating for the climatic conditon of the origin by their temperature and precipitation, we get some interesting results. Temperature conditions are divided by considering the mean-temperature to be mild, 1SD[20] less to be cold, and 1SD more to be hot[21]. Illustrating interaction of average annual temperature and precipitation with temperature conditions gives us graph 7. We learn that the effect of an increase/decrease in temperature/precipitation in different climatic conditions could have different – and even opposite – effects on emigration. For instance, increase in temperature's deviation in Hot regions has a large positive effect where it is not very considerable in Mild and Cold regions. This suggest suggest that vulnerable areas get more affected by a change in climate. Also, increase in precipitation's deviation has decreasing relationship with number of migrants in Hot regions where this relationship is increasing in Cold regions. We could argue that people in Hot regions – which are usually dry in Iran – loose some of their interest in leaving their origin when the rain situation get better.

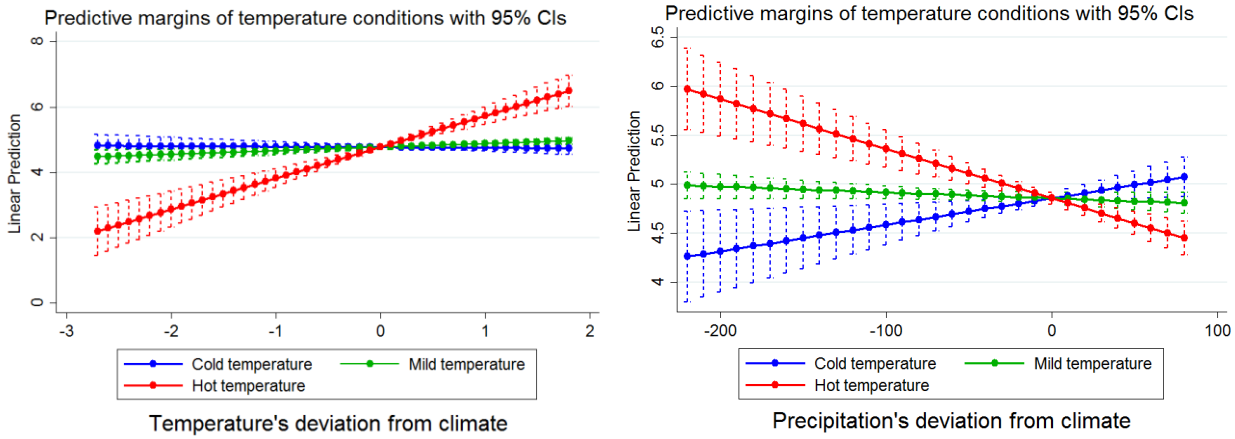
[20] One standard deviation
[21] Please find the histogram of climatic conditions in Appendix II.

TABLE C: Average Marginal Effects for the standardized variables

	ModelC1:Temperature deviation in different temperature conditions	ModelC2: Precipitation deviation in different temperature conditions	ModelC3: Temperature deviation in different precipitation conditions	ModelC4: Precipitation deviation in different precipitation conditions
Dependent: Log (# of emigrations)				
Distance (log)	-0.891***	-0.885***	-0.884***	-0.881***
	(-28.84)	(-28.61)	(-27.76)	(-27.67)
Population (log)	0.715***	0.772***	0.776***	0.798***
	(31.07)	(36.49)	(34.68)	(36.98)
Educated share	-0.231***	-0.234***	-0.287***	-0.150**
	(-4.63)	(-4.48)	(-5.57)	(-2.51)
Rural educated share	0.103**	0.0648	0.125***	0.0344
	(2.51)	(1.62)	(2.92)	(0.76)
Urban share	0.122***	0.103***	0.0748**	0.0377
	(4.21)	(3.57)	(2.34)	(1.07)
Unemployed share	0.0478*	0.0345	0.0478**	0.0251
	(1.87)	(1.36)	(2.04)	(1.01)
GDP growth	0.0588***	0.182***	0.136***	0.183***
	(2.74)	(8.49)	(6.41)	(8.03)
GDP pc (log)	-0.0785*	-0.00555	0.100**	0.0610
	(-1.73)	(-0.14)	(2.47)	(1.54)
Cold	0	0		
	(.)	(.)		
Mild	0.0882**	0.142***		
	(2.14)	(2.87)		
Hot	0.718***	0.348***		
	(7.11)	(5.51)		
Temperature's deviation	0.187***		0.0579*	
	(5.68)		(1.76)	
Precipitation's deviation		-0.000558		-0.00254***
		(-1.59)		(-5.76)
Dry			0	0
			(.)	(.)
Medium			-0.0807*	-0.589***
			(-1.74)	(-4.16)
Wet			-0.314***	-0.680***
			(-3.73)	(-4.61)
Population of D (log)	0.734**	0.810**	0.748**	0.772**
	(2.06)	(2.10)	(2.05)	(2.16)
Educated share of D	0.0807*	0.0838*	0.0805*	0.0822*
	(1.76)	(1.71)	(1.71)	(1.78)
Rural educated share of D	0.157***	0.159***	0.159***	0.161***
	(4.63)	(4.00)	(4.34)	(4.42)
Urban share of D	0.273**	0.293**	0.272**	0.280**
	(2.38)	(2.31)	(2.31)	(2.43)
Unemployed share of D	-0.0294	-0.0311	-0.0320	-0.0353
	(-0.28)	(-0.29)	(-0.30)	(-0.34)
GDP growth of D	0.00432	0.00582	0.00689	0.00673
	(0.27)	(0.32)	(0.41)	(0.41)
GDP pc of D	0.118	0.132	0.122	0.134
	(1.15)	(1.21)	(1.15)	(1.30)
Temperature's deviation of D	0.0361*	0.0349*	0.0357*	0.0329*
	(1.89)	(1.71)	(1.84)	(1.73)
Precipitation's deviation of D	-0.00418	-0.00592	-0.00496	-0.00610
	(-0.18)	(-0.25)	(-0.21)	(-0.26)
R2	0.8169	0.8138	0.8091	0.8102
Log Likelihood	-1771.507	-1786.248	-1807.913	-1802.849
AIC	3645.015	3674.495	3717.825	3707.698
BIC	3923.559	3953.039	3996.369	3986.242
Observations	1740	1740	1740	1740

Controlled for census and province fixed effects. Only linear relationships measured. All variables are standardized. Temperature or Precipitation deviation is defined as temperature or precipitation - climate (the last 30 years' average). Temperature/Precipitation's relative deviation is defined as (Temperature or Precipitation deviation)/Climate). All standard errors are clustered at province-pair level. Cold (Dry) is defined as the 'Mean annual temperature (precipitation)' – 1SD, Mild (Medium) temperatures stands in between 'Mean annual temperature (precipitation)' ± 1SD, Hot (Wet) regions have an annual temperature of more than 'Mean annual temperature (precipitation)' + 1SD.

*** Significant at the 1 percent level ** Significant at the 5 percent level * Significant at the 10 percent level.



Graph 7: Change in temperature and precipitation in different environments – in terms of temperature conditions

Moreover, interacting climate factors with climatic conditions in Table C suggests that: i) An increase in temperature has a 71.8% and 8.82% larger effect in Hot and Mild regions compared to the Cold ones. ii) An increase in Temperature has a 31.4% and 8% smaller effect in Wet and Mild regions compared to the Dry ones. iii) An increase in precipitation has a 34.8% and 14.2% larger effect in Hot and Mild regions compared to the Cold ones. iv) An increase in precipitation has a 68% and 58.9% smaller effect in Wet and Mild regions compared to the Dry ones.

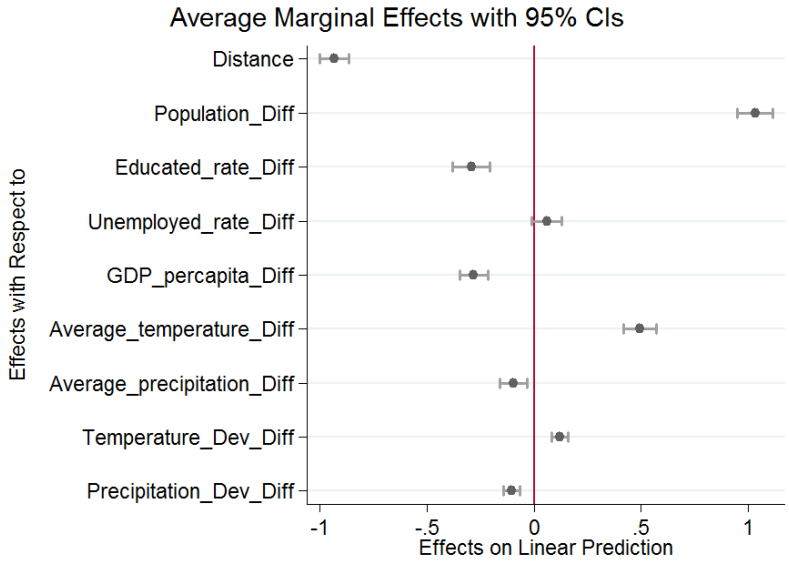
Studying on bilateral differences[22] – in Table D – instead of origin and destination characteristics, we get very similar and insightful results. For one, althought we did not find solid evidence whether climatic conditions are important in selecting a destination, but we could argue that people tend to move to cooler and wetter areas. Also, there is a trend in moving to areas which have experienced a decrease (increase) in deviation of temperature (precipitation). This could be interpreted as the tendancy to a relatively better climatic condition, but not the perfect one neccessarily. In other words, people tend to gradually move to better climates. We could also learn that people tend to move to more educated places with a lower unemployment rate and higher average income levels (Graph 8). The results for population did not fulfill the expectation, as it suggest the tendancy for movement to less population area. However, this could be due to the fact that in general places with higher population tend to send more migrants (in terms of volume) and the credibility of this should be tested by studying on the rate of migration. As I have mentioned earlier in this paper, migration is not necessarily bad for the country or people. But if everyone living is some area decide to move to a better one, we are going to be left out with some secluded cities with bad climate, low rate of education, high uneployment and low pay. Therefore it is essential to identify and support the most vulnerable places so we could avoid mass migration waves towards cities. There will be more on this in the end of this paper.

[22] As an example, GDP_percapita_diff = (GDP per capita of origin – GDP per capita of destination).

TABLE D: Average Marginal Effects for the standardized bilateral differences[23]

	ModelD1: Bilateral differences (OLS)	ModelD2: Bilateral differences (NB)
	Dependent: Log (# of emigrations)	**Dependent: # of emigrations**
Distance (km)	-0.897***	-548.7***
	(-20.86)	(-9.85)
Population differences (#)	1.064***	645.0***
	(25.99)	(8.14)
Educated rate differences (%)	-0.327***	-135.8***
	(-6.45)	(-3.87)
Rural educated rate differences (%)	0.00147	-41.88
	(0.03)	(-1.16)
Urban share differences (%)	-0.0483	-100.9***
	(-1.12)	(-3.03)
Unemployment rate differences (%)	0.0398	6.350
	(0.97)	(0.25)
GDP growth differences (%)	-0.00277	17.74
	(-0.12)	(1.00)
GDP per capita differences ($)	-0.298***	-182.2***
	(-7.85)	(-6.55)
Average annual temperature differences (ºC)	0.502***	291.2***
	(10.93)	(7.61)
Average annual precipitation differences (ºC)	-0.0922**	-70.82***
	(-2.39)	(-2.65)
Temperature's deviation differences (ºC)	0.123***	67.79***
	(5.43)	(4.11)
Precipitation's deviation differences (ºC)	-0.110***	-66.02***
	(-5.07)	(-4.17)
R2	0.7697	
Log Likelihood	-1971.054	-10627.42
AIC	4028.107	21342.84
BIC	4262.958	21583.16
Observations	1740	1740

Controlled for census and province fixed effects. Only linear relationships measured. All variables are standardized. Bilateral differences means: X_i-X_j, where "i" is the origin and "j" destination. Temperature or Precipitation deviation is defined as temperature or precipitation - climate (the last 30 years' average). Temperature/Precipitation's relative deviation is defined as (Temperature or Precipitation deviation)/Climate). All standard errors are clustered at province-pair level. *** Significant at the 1 percent level ** Significant at the 5 percent level * Significant at the 10 percent level.



Graph 8: Average marginal effects for standardized bilateral variable differences

[23] Please find more on these variables in Appendix III.

5. CONCLUSIONS

All in all, at this point we could suggest that climatic characteristics of the origin location are amongst the main factors of emigration. It is also suggested that destinations with more rainfall, or positive deviation in precipitation, are more desirable. Also, People tend to leave warm and dry regions. Although they do not necessarily go for the perfect climates, they tend to choose destinations with relatively better climatic conditions. Having in mind that climate factors do not differ much in small scales, choosing a relatively better climate rather than the perfect one, is coming from the fact that distance is a main obstacle in migration. Another point would be the fact that people tend to go to bigger cities; i.e. there is a tendency to emigrate to more populated urban areas with higher rate of educated people and payoff.

Quantifying the effects of climatic factors on internal migration in Iran, we learn that a 1°C rise in temperature – in respect to climate and in average – increases emigration by 11.4%[24]. This value for 100^{mm} fall in precipitation – in respect to climate and in average – would be around 12.6%[25] increase in emigration.

Having the average annual emigration for the country to be around 415 thousands persons[26], 12.9 million[27] movements will occur – or already happened – from 1990 to 2020 in total. Now, assuming the simulations by TNC (UNDP, 2015) to be accurate, Iran is going to experience a 1.4^{o}C deviation from the climate by 2020 (here, climate is the average temperature for 1961-1990). Out of this volume of people leaving their place of origin, 16.1%[28] of them – or 2.1 million[29] – are due to climate change. I suppose around 1.69[30] million people already moved from their place of origin due to change in climate from 1990-to-2014 and there are atleast another 410 thousands more people to emigrate in the time period of 2015-to-2020 – assuming stability of Iran's average socioeconomic status in respect to the observed period (1997-2011). We should also take this into account that these estimations are based on the fact that every other factor stays constant. Also, we are ignoring the effects that climatic variables could – indirectly – have on migration through other factors that we are already controlling in the model (e.g. GDP per capita).

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[24] This value could go up to 13.6% if we include non-linearities.
[25] This value could go up to 33% if we include non-linearities.
[26] Rough estimates, based on the observed period of 1997-2011.
[27] = 31×415,000
[28] Having an 11.4% rise in emigration for a 1 ^{o}C deviation in temperature.
[29] = %16.1×12,800,000
[30] = (25 ÷ 31)×2,100,000

In the end, one of the main obstacles in studying on developing countries is the lack of data or its accuracy. By overcoming such difficulties, we could improve the results as well as answering more complex research questions; e.g. having a trustable climate projection could help us predict the most vulnerable areas (provinces) in terms of in and out migration. Doing so could help the authorities with coming up with customized policies specifically designed for the needs of the region.

6. POLICY IMPLICATIONS

In the end, the results of this study could be used to come up with some propositions in order to help us minimize the effects of climate change especially on internal migration in Iran. First we should note that migration is not necessarily bad, as Bunea (2012) suggests migration is a key mechanism for adjustment to regional economic shocks, especially when other tools prove useless. But, excessive amount of it – or a considerable and unpredicted growth in it – could be harmful both in a regional and national level. In other words, if all people who could leave for a place with better opportunities will do, the result would be secluded cities without skilled workers, with weak infrastructure and bad climate.

One of the solutions for this could be i) tackling unemployment especially in small cities and villages, it could be done by strategic development of micro-climates, especially new forest cultivation (see more in Farzin, 2014). Moreover, we should ii) concentrate on vulnerable regions, for example in terms of climate, regions with hot and dry climate. As an increase in temperature has a 71.8% and 8.8% larger effect in Hot and Mild places compared to the Cold ones[31], respectively (Model C1). Also, increase in precipitation has 68% and 58.9% smaller effect in Wet and Mild regions, respectively, compared to the Dry ones (Model C4). As Lilleør and Van den Broeck (2011) argue that "Areas which are close to the upper threshold of, say, temperature for agricultural production are likely to suffer more than similar cooler areas. Likewise, already drought-prone areas will suffer more from further lack of rain than very wet areas, which may even benefit from such a change". Having in mind that migrants tend to move to the best closest place, we should equip the desirable neighboring areas of such vulnerable places as well.

[31] Cold is defined as the 'Mean annual temperature' – 1SD, Mild temperatures stands in between 'Mean annual temperature' ± 1SD, Hot regions have an annual temperature of more than 'Mean annual temperature' + 1SD.

Another way to fight with the consequences of climate change could be iii) preserving villages and preventing them from turning into cities (avoid granting city halls easily and only due to political reasons and lobbying). We should separate 'Modernization' from 'Urbanization'; i.e. having modern villages instead of urbanized/industrialized small cities. These villages would have high productivity in agricultural commodities and also, they would look interesting for the labor force to either stay or enter them because of the good pay. This comes from the fact that as the cost of production goes down, and productivity increases, there will be a rise in revenue and profit. This would attract more labor force and investors to get into the market. In this way, we could protect the nation's food security by supporting villagers with their agricultural productivity, and avoid turning them into cities.

Also, for some general policies, we could iv) implant development policies focusing on reducing fluctuations in agricultural production, e.g. new agricultural technologies, Introducing drought resistant crops, betterment of water access and irrigation. (Lilleør and Van den Broeck, 2011). Another solution would be v) introducing micro-insurance for weather-based anomalies, e.g. a rainfall insurance where pay-out is triggered when rainfall deviation reaches a certain size. (Gine et al., 2008; Hertel and Rosch, 2010). Lastly, considering that a vast share of Iran's water problems is due to weak management, implanting an vi) integrated water resource management could be helpful (Hosseini et al., 2009).

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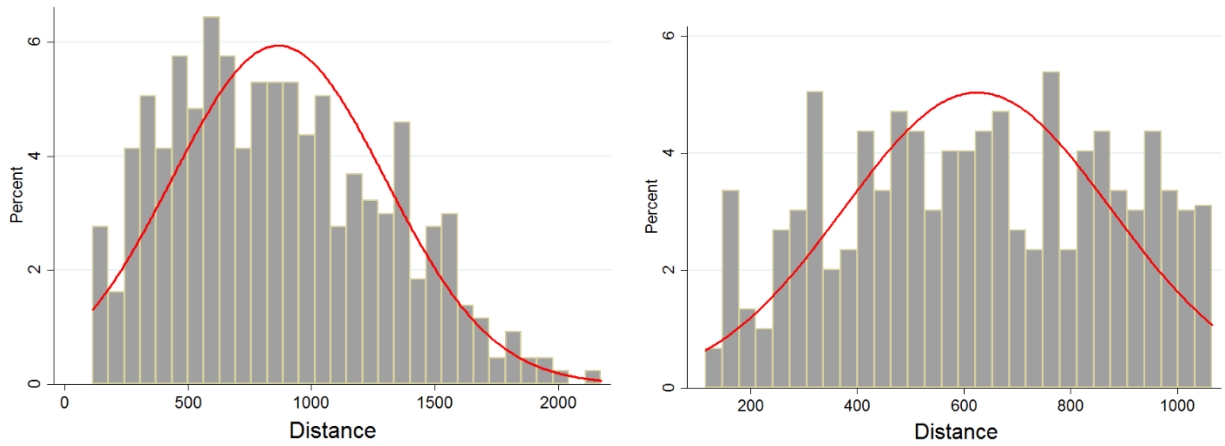
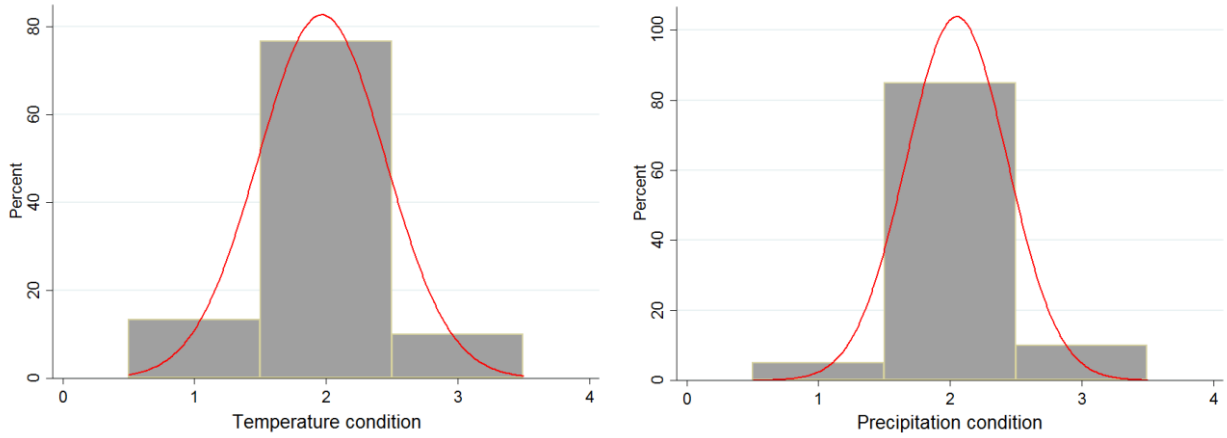
APPENDIX I



Graph 9: Distribution of distances migrated (left) and 90% of distances migrated (right)

APPENDIX II



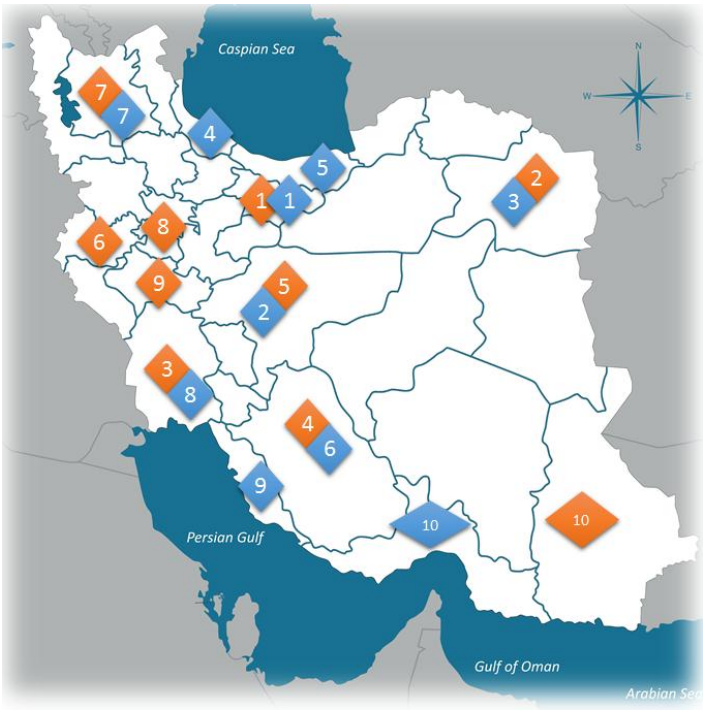
Graph 10: Distribution of climatic conditions

APPENDIX III

Table E: Data description (for differences)

Variable	Obs	Mean	Std. Dev.	Min	Max
Distance diff	1740	1.51E-10	1	-1.7409	3.024173
Population diff	1740	1.03E-09	1	-3.97687	3.974181
Educated rate diff	1740	1.32E-09	1	-4.21064	4.031204
Rural educated rate diff	1740	2.70E-10	1	-4.22429	3.653914
Urban share	1740	-6.59E-10	1	-3.25542	3.126334
Unemployment rate diff	1740	1.40E-10	1	-2.70373	2.699356
GDP growth diff	1740	-6.37E-10	1	-3.64269	3.642685
GDP per capita diff	1740	-8.83E-10	1	-3.82595	3.829081
Average annual temperature diff	1740	2.60E-10	1	-2.99972	2.999723
Average annual precipitation diff	1740	0	1	-3.50451	3.50451
Temperature's deviation diff	1740	3.48E-10	1	-4.77335	4.773359
Precipitation's deviation diff	1740	-1.38E-10	1	-3.11205	3.112044

APPENDIX IV



Graph 11: Iran provinces' ranking in terms of migrants received and sent away (1997-2011)

Note: Blue diamonds suggest most popular destinations, where the orange ones are the provinces sending away most of the migrants.