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The Impact of Climate Change on International Trade: A gravity model estimation.

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Abstract

The aim of this paper is to analyse the impact of climate change on bilateral trade flows. To this end, we estimate a theory-grounded gravity model using bilateral trade flows on a sample of 65 countries during the period 1986-2016. We use temperatures and extreme weather events (and its consequences) as proxies for climate change. Overall, we find that international flows are less affected by the evolution of temperatures and events than domestic ones. However, there is an interesting heterogeneity across countries and across types of events. In particular, the results suggest that biological events (epidemics and insect infestation) have a negative differential impact on international flows relative to internal ones. Additionally, the differential average behaviour observed for China (the biggest exporter) is associated with the occurrence of storms (cyclones, tornados, convective hails, etc). Finally, our General Equilibrium estimations show that the aforementioned biological events have a remarkable negative impact on welfare.

Key words: Climate change, Domestic flows, International flows, Temperatures, Weather events.

JEL classification: C1, F14, F15.

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1.- Introduction

Nowadays, climate change is the World's biggest concern and it will continue to be so in the future. The socio-economic consequences of this phenomenon are certainly very broad and diverse and, will, undoubtedly, substantially affect the citizens´ welfare. In this research, we focus on the impact of climate change on international trade, an area of great institutional interest but lacking rigorous studies in the academic circle; on the contrary, many studies have made research on the effect of international trade on climate change.

In fact, the World Bank (World Bank, 2010; Onder, 2012; or Brenton and Chemutai, 2021), the World Trade Organization and United Nations Environmental Program (WTO and UNEP report, 2009) or the OECD (for instance, Dellink et al., 2017; van Hassel, 2017; or Yamaguchi, 2021) raise concerns about the relationship between trade and climate change in various reports and working papers. Yet their analysis is merely either descriptive, qualitative or rest on projections based on simulations. International trade can influence climate change through three main channels (Grossman and Krueger, 1992; Copeland and Taylor, 2003). On the one hand, the increase in countries´ GDP derived from trade expansion induces more polluting emissions and the intensification of the exploitation of natural resources (e.g. the affectation to forest areas). This is the "scale effect". On the other hand, in those countries with lower environmental standards, trade liberalization can lead to an over-specialization in pollution-intensive activities. This is the so-called "composition effect". Finally, there is a countervailing force as trade allows less developed countries to gain access to cleaner technologies that will prompt less pollution as well as a more efficient use of resources. Likewise, those firms aiming to access rich countries markets will have to comply with more demanding environmental requirements, which will encourage cleaner production processes. This is the so-called "technique effect". Antweiler et al. (2001) find that the first and third channels are relevant but not the second one which mostly depends on the specific characteristics of countries such as their abundance of capital or environmental standards.

Additionally, the international conscience about global warming has driven countries to increasingly consider the environmental consequences of their actions. This is the reason for including environmental provisions in the negotiations of preferential trade agreements (deep agreements), especially if development countries are part of these negotiations. The argument is that trade partners can carry out actions to attenuate the harmful impact of international trade flows on environment. The literature on this ambit is scarce. For instance, Baghdad et al. (2013) asses the effectiveness of these provisions on reducing emissions and conclude that do only those regional trade agreements (RTAs) with environmental harmonization policies successfully reduce pollution in absolute and relative levels. Monteiro (2016) establishes a typology of this kind of provisions whereas Clive and Shunta (2018) analyse the extent of their implementation in RTAs. Very recently, Abman et al. (2021) obtain that environmental provisions are able to limit deforestation in tropical developing countries.

However, climate change could also affect trade through three main channels: infrastructure damages and lower productivity growth of factors of production on the negative side and the possibility of openness of new trade routes on the positive one. The first of these channels arises as a result of extreme weather events (such as tornados, tropical cyclones, convective storms, floods, forest fire, etc.) as well as the rise of sea levels. The second channel, in the short or medium term, derives from the first one: effects on labour productivity and other biological effects as insect infestation, or the expansion of viruses (e.g., COVID-19). Finally, the thaw can facilitate the opening of new routes for maritime transport.

The aim of this paper is to analyse the impact of climate change on international trade flows. To this end, we estimate a theory-grounded gravity equation using data on a sample that covers 65 countries over the period 1986-2016. Our estimation strategy takes into account all the best practices in the estimation of gravity equations including the use of panel data techniques (to account for unobserved bilateral heterogeneity and endogeneity), the inclusion of controls for multilateral resistance terms, the use of the PPML estimator (to deal with econometric problems resulting from heteroscedastic residuals and the prevalence of zeros in bilateral trade flows), and the use of intra-national (in addition to international) trade flows.

We make two contributions to the literature on trade and climate change. We examine for the first time (to the best of our knowledge) the effect of climate change on trade using the gravity equation. Second, we directly focus on an output measure of climate change rather than on an input-based measure. With the exception of the paper by Abman et al. (2021) which directly focus on deforestation, the rest of the papers in this context use emissions as the variable of interest. Specifically, the United Nations define "Climate change" as "long-term shifts in temperatures and weather patterns". Additionally, it states that the main responsible of that are "human activities" …. "primarily due to burning fossil fuels like coal, oil and gas" which "…. generates greenhouse gas emissions that act like a blanket wrapped around the Earth, trapping the sun's heat and raising temperatures". Relying on these definitions, we can conclude that greenhouse gas emissions, the variable commonly used, is the input in the production of harmful environment whereas the increase in temperatures and other meteorological events is the output. This is our second main contribution: our output measure of climate change consists on temperature raise and extreme weather events using data from the Climate change knowledge Portal (World Bank) for temperatures and the “International Disasters Database” (EM-DAT) for extreme natural events, respectively.

To preview our results, we find no general evidence that the increase in temperatures or adverse meteorological events negatively affect international trade (relative to internal one), but quite the opposite. However, we find non-trivial differences on this relationship across events and countries. In particular, biological events are negatively linked to international trade with respect to domestic one. Interestingly, the analysis by countries reveals that for China (the biggest exporter) *storms* negatively affect international trade relative to intra-national one, this result is at odds with the positive effect (on average) found for the other countries. We argue that this result could be harmful for World’ wellbeing.

The next section explains the channels through which climate change may affect international trade. Section 3 outlines the methodology and describes the data. Section 4 presents the results. Finally, section 5 concludes.

2.- How climate change may affect international trade?

Climate change is a fact. Figure 1 shows the evolution of average temperatures for our dataset over the period 1986-2016. At first glance, there is a clear upward trend in average yearly temperatures which is accentuated in last years. We have plotted the same information for each individual country and we have obtained a similar picture (in a higher or lower extent) with very few exceptions (see Appendix).

As it is well known, the rise in temperatures are consider as a major driver of a higher prevalence of extreme weather events like tornadoes, storms, floods, and other adverse consequences which are directly related to, forest fires, the rise of sea levels, insects' infestation, or epidemics. Figure 2 shows clear evidence of the connection between these two types of events. As it is showed, there exists a remarkable positive connection between these events and temperatures. These phenomena may affect international trade through three different channels: damages on infrastructures, reduction in labour productivity and opening of new routes.

First, the aforementioned meteorological events could damage infrastructures directly related to international trade such us ports, airports, routes, etc. Additionally, indirect effects could also appear because of these events may either urge to carry out maintenance of these infrastructures more frequently or have a negative impact on the functioning of electronic devices related to international trade. An in-depth analysis about the material consequences of climate change is provided by Dellink et al. (2017).

Second, climate change may reduce productivity growth of factors of production and, particularly, the productivity of the labour input. International trade, as economic activity, could also be affected due to this. The connection between high temperatures and productivity of labour has been previously analysed in the literature. Heat stress affects human performance (Hancock et al., 2007) with, among other things, has a harmful impact on labour productivity "involving office, factory, or outdoor workers" (Federspiel et al., 2002). In this respect, Gosling et al. (2018) estimate up to a 10-15% loss in productivity for Southern European countries and between 2-4% for Northern ones in the more adverse scenario of no mitigation and adaptation, being the impact greater for outdoor activities. Deryugina and Hsiang (2014), for the USA, estimate a loss in labor productivity around a 1.7% for each degree Celsius of increase in daily average temperature above 15 degrees Celsius and a cost of around $20 per person if temperature is above 30 degrees Celsius. An additional negative consequence of climate change on labor productivity stems from unnormal high temperatures arises from diverse biological effects as insect infestation or the expansion of viruses.

Third, generalised higher temperatures accelerate melting in the arctic zone facilitating the opening of new routes as could be the Arctic seaways: northeast passage north of Russia, northwest passage north of Canada and the polar Route. These new routes could reduce shipping distances by 20 to 40% compared with the routes through the Panama and Suez Canal. However, transport cost reduction is not necessarily of a similar magnitude because difficulties of transportation differ across these routes. Anyway, it seems that Artic routes are still very limited (Babin et al., 2020).

Determining which of the aforementioned factors dominate is an empirical matter. In this paper, we focus to examine this issue. To this end, we estimate structural gravity equations of trade accounting for all the known biases in the literature up till now.

3.- Methodology and data

The gravity equation methodology is one of the most successful econometric tools in economics and is particularly adequate to the study of international trade flows since the well-known pioneering article by Timbergen (1962). In its simplest version, the gravity model relates bilateral trade flows to economic size, GDP of origin and destination countries, and geographical distance between the partners. Subsequent developments introduce other variables affecting barriers to trade such as whether countries share a common border, a common language, are islands, etc. This is the so-called “augmented” gravity model. This econometric tool allows us to carefully examine the determinants of bilateral trade flows.

Over time, the gravity equation has become more sophisticated with the theoretical contributions of diverse authors. In a very famous article, Anderson and van Wincoop (2003) state that gravity estimations must take into consideration not only bilateral trade barriers but also those barriers that the exporter and the importer face with respect to third partners. These are the multilateral resistance terms, in the Anderson and van Wincoop (2003)'s terminology. In practice, the introduction in the gravity equation of dummies for countries when acting as exporters and importers control for these multilateral resistance terms. However, the multilateral resistance may change over time. Therefore, we have to introduce exporter-time and importer-time dummies into the gravity equation. This is known in the literature as country-year fixed effects (CYFE). Additionally, unobservable constant bilateral heterogeneity and endogeneity is controlled for with county-pair-fixed effects -CPFE- (Baier and Bergstrand, 2007; Baldwin and Taglioni, 2007; Gil-Pareja et al., 2008). In another influential article, Santos Silva and Tenreyro (2006) note that residuals in the gravity equation are usually heteroskedastic. This latter together with the existence of zeros in bilateral trade flows, make traditional estimates be biased. Therefore, these authors propose a Poisson Pseudo Maximun Likelihood (PPML) estimator in order to solve both problems. Finally, some authors (Yotov, 2012; Bergstrand et al., 2015; Baier et al., 2019) have recently outlined the necessity to include both international and intra-national trade flows both to avoid biased estimations and to properly measure trade creation and trade diversion effects of trade policy. In fact, in our context, the inclusion of intra-national trade flows is very important since it enables us to identify country specific climate change effects on trade.

Therefore, we will estimate a PPML gravity equation with CYFE and CPFE using a database incorporating domestic in addition to international flows. It is important to note that, relying exclusively on international trade flows, the inclusion of CYFE and

CPFE only enables us to identify those variables that are pair-specific and vary over time. However, as pointed out by Beverelli et al. (2018) the introduction of domestic flows in gravity equations allows for the identification of the impact of country-specific variables (as are our interest variables) on international trade, but only *relative* to international trade. Additionally, introducing intra-national flows is also an alternative to deal with endogeneity issues.[1]

We estimate the following gravity equations:

$$X_{ijt} = \exp^{(\beta_1 PTA_{ijt} + \beta_2 (GATT-WTO)_{ijt} + \beta_3 temp_{i(j)t} + \mu_{ij} + \delta_{it} + \gamma_{jt})} u_{ijt}$$

and

$$X_{ijt} = \exp^{(\beta_1 PTA_{ijt} + \beta_2 (GATT-WTO)_{ijt} + \beta_3 event_{i(j)t} + \mu_{ij} + \delta_{it} + \gamma_{jt})} u_{ijt}$$

(1)

where X_{ijt} are exports from country "i" to country "j" in time "t", *PTA* is a dummy for Preferential Trade Agreements, *GATT-WTO* is a dummy for the GATT/WTO system, *temp* are countries' yearly temperatures and *event* are the number of *extreme weather* events (and their consequences), μ_{ij} are CPFE and δ_{it} and γ_{jt} are CYFE, for the exporter and the importer, respectively.

[1] These authors provide a battery of reasons giving support for controlling by endogeneity through the methodology used. On the one hand, the inclusion of exporter and importer fixed effects control for country-specific behaviour between trade and climate change. On the other hand, the variable of interest is the result of interacting a dummy for 'international trade' (that takes the value zero for domestic flows) and climate change. As these authors state, according to Nizalova and Murtazashvili (2016), consistent estimates are obtained because the intrinsic exogeneity of the international trade dummy implies the no-correlation with our measures of climate change. Finally, pair-fixed effects greatly control for omitting variables. Thus, following these authors, our methodology allows to obviate the use of an instrumental variables (IV) estimation

The data for PTAs and the GATT/WTO system have been taken from the Dynamic Gravity Dataset (DGD) developed by the United States International Trade Commission – USITC - (see Gurevich and Herman, 2018). This database was designed to easily combine with usual sources of bilateral trade data. In our case, we use a balanced panel dataset constructed by Thomas Zylkin. The advantage of these data is that they incorporate both domestic (intra-national) trade flows and international trade flows for manufacturing trade over the period 1986–2006 for 69 countries that has been extended to 2016. We have selected 65 countries for our analysis because of the lack of enough data for some of the countries included in the aforementioned sample.

As before stated, we have chosen two measures reflecting climate change: *temperatures* and *extreme weather events* (or their consequences). On the one hand, average yearly temperatures have been taken from the Climate change knowledge Portal (World Bank). On the other hand, extreme weather events (or their consequences) are taken from International Disasters Database (EM-DAT), Center for Research on the Epidemiology of Disasters. In particular, we have considered the following events: Storms, Wildfires, Floods, Epidemics, Extreme Temperatures, Landslides, Droughts and Insect Infestation.

4.- Results

4.1 "Partial" equilibrium.

We estimate equation (1) by PPML with CPFE and CYFE. Table 1 presents the results. In addition to PTAs and the GATT/WTO system, in column (1) we introduce countries' temperatures, in column (2) extreme weather events and in column (3) both variables at once. As showed, belonging to both PTAs and the GATT/WTO system have a positive and significant impact on bilateral trade flows (relative to domestic ones), as expected, with an especially strong effect in the case of the GATT/WTO system. Note that due to the inclusion of country-pair fixed effects in the regressions we only identify the impact of those countries that joined the agreements over the sample period. Regarding our variables of interest, we obtain a positive and significant coefficient in both cases (columns 1 and 2). With respect to temperatures (column 1), the estimated parameter implies that an increase in a degree Celsius leads to a 20% increase in international flows relative to domestic ones. In the case of events, an additional event will imply that international flows increase relative to intra-national ones in just 0.5%. If we include both variables in the regression, we observe that the coefficient on events loses its statistical significance. Although both variables have a very small correlation in the sample (0.028), as we have showed the tendency is similar, therefore it is advisable to make the estimations separately.

We must be cautious with the interpretation of these results. The estimations suggest us that climate change and its consequences enhance international flows (relative to intra-national ones). This is probably because infrastructures related to internal trade are relatively more affected, or because the evolution of labour productivity related to exports of goods is less affected than that involved in domestic production. In order to dig deeper into these results we have carried out some additional estimations. Firstly, we have analysed countries' specific impacts. In Table 2, we present these estimations for temperatures and events separately. We have made a regression for each country splitting the corresponding variable of interest between the average effect excluding the corresponding country plus the own effect of the country. Table 2 reports country-specific estimates.[2] As it is observed, the positive average coefficient for temperatures

[2] To save space, we do not report fixed effects and other estimates but are available upon request.

showed in Table 1 is widely generalised, although there are some countries with very high impacts (Malawi, Qatar or Mexico, among others) for which domestic flows are specially affected in relation to international ones. In any case, the positive and significant coefficient is found in 56 out of 65 cases. When focussing on events, the average positive and significant coefficient is not so homogeneous: there are 27 individual positive and significant coefficients, 37 non-significant (for which international and intra-national flows do not behave differently when facing an *event*) and one negative and significant coefficient. In this last case, the estimated coefficient suggests that international flows are specially impacted by weather events in relation to domestic ones. Additionally, in this particular case, the average coefficient for the rest of countries in the sample doubles its value to 0.01. Although there is just one case, it is a very relevant one, China, since it is the first world exporter and the second world importer.

With respect to events we can go one step further that might shed some light for the China case. In our database, we have information about the "type of event". Therefore, we have split our variable "event" into the following eight categories depending on the kind of event: wildfire, flood, extreme temperature, epidemic, insect infestation, storm, drought, and landslide. The results are presented in column 1 of Table 3. Additionally, we have split each of these variables into the effect on China and the rest of the sample (column 2). As shown, only storms do not seem to have a differential impact on international trade flows relative to domestic ones. Additionally, there is a clear heterogeneity across types of events in this respect hidden in the general positive effect. As it is observed, epidemics, insect infestation and landslides affect negatively international flows with respect intra-national ones whereas the contrary occurs with respect to the rest of events, except "storms" as previously discussed. Focussing on the particular case of China (column 2), there are some cases of a different behaviour. For instance, in general, extreme temperatures affect positively international flows in relation to domestic ones, except for China. Similar results are obtained for landslides, yet in the opposite direction. However, the real difference of the average negative impact of "events" observed for China in Table 2 seems to be on the variable *storms*. As observed, this type of events (mainly, cyclones, tornados and convective hails) impact negatively on China's trade but a non-significant average coefficient is observed for the rest of the sample. It seems that these events probably affect critical infrastructures related to international trade in the Asiatic giant.

4.2. General Equilibrium

Following our last estimations (Table 3, column 1), we run a General Equilibrium analysis with the methodology used in Baier et al. (2019),[3] which, basing on a one sector Armingon-CES model and with labour as a unique factor of production, solves for general equilibrium effects of changes in trade policies. In our case, this methodology allows us to estimate the change in welfare as a consequence of the occurrence of a specific event. We consider the trade balance of the first year in the sample (1986). With unbalanced trade (which is the norm), the balance is treated as an additive component of national expenditure. Additionally, we also assign a value of four to trade elasticity[4] as Baier et al. (2019) done.

In Table 4, we present the change in welfare in percentage terms[5] for each of the considered events. We show the average and extreme values. As showed, and in

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[3] In http://www.tomzylkin.com/uploads/4/1/0/4/41048809/help_file.pdf, the Stata command and the methodology are described by Thomas Zylkin.
[4] In the model trade elasticity coincides with the degree of substitutability across goods from different origins.
[5] The ouput in Stata is the new level of welfare divided by the old level of welfare.

consonance with previous estimations, the events with relative negative impacts on trade also show negative welfare effects. These are particularly high for "insect infestation"[6], with and average value of -2.41%. To be aware of the magnitude of these results note that Baier et al. (2019) obtain for trade agreements maximum values of welfare of around 1.35% (particularly, for Ireland. A high negative (average) value is also found for "epidemic" events with a -0.9% loss in welfare.

It is hard to speak about increase in welfare when referring to extreme weather events or its harmful consequences. Note that the methodology used implies that variation in welfare is the result of the evolution of wages in relation to prices as a consequence of the occurrence of the respective event. If we make the parallelism with Baier et al. (2019) in which it is analysed the impact of trade agreements on international trade we found negative welfare effects, when positive ones were usually expected.

6.- Conclusions

In this paper we have estimated the impact of climate change on international flows through a sound econometric methodology. We have estimated a theory-consistent gravity equation using data on a sample of 65 countries over the period 1986-2016. Our main variables of interest are *temperatures* and *extreme weather events and its consequences: wildfire, floods, extreme temperatures, epidemics, insect infestation, storms, droughts and landslides*.

Our results suggest that the increase on temperatures mainly affect domestic flows in relation to international ones and this conclusion is fairly generalised across countries.

[6] For comparison reasons, you can see the values obtained by Baier et al. (2019).

However, we observe a clear heterogeneity with respect to type of "events". In particular, biological events (epidemic and insect infestation) negative affect international flows in relation to domestic ones whereas the contrary occurs, in general, with the rest of events (except landslide). Additionally, China seems also to be an outlier in this case. For China, storms (cyclones, tornados, etc.) negatively impact international trade. Additionally, the General Equilibrium analysis shows a particular negative effect on welfare for biological events.

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TABLES AND FIGURES

Table 1. Trade and Climate change. Period 1986-2016.

	(1)	(2)	(3)
Dependent variable	**Nominal trade flows in current US dollars**	**Nominal trade flows in current US dollars**	**Nominal trade flows in current US dollars**
PTA_{ijt}	0.295***	0.331***	0.296***
	(0.067)	(0.069)	(0.067)
$GATT/WTO_{ijt}$	1.466***	1.505***	1.476***
	(0.101)	(0.108)	(0.098)
$temp_{i(j)t}$	0.205***		0.206***
	(0.013)		(0.013)
$event_{i(j)t}$		0.005***	-0.001
		(0.002)	(0.002)
Constant	10.974***	11.494***	10.963***
	(0.099)	(0.107)	(0.097)
Observations	137,475	137,475	137,475
Country pair FE	Yes	Yes	Yes
Importer-year and Exporter year FE	Yes	Yes	Yes
Intra-national trade	Yes	Yes	Yes
Pseudo R2	.99	.99	.99

Note: *significant at 10% level, ** significant at 5% level, ***significant at 1% level.

Table 2. Trade and Climate change. Period 1986-2016.

	(1)	(2)
Country	**Coefficient of temperatures (temp)**	**Coefficient of events (event)**
Australia	0.088*** (0.024)	0.001 (0.005)
Austria	0.282*** (0.018)	0.013*** (0.003)
Belgium	0.069*** (0.018)	0.016* (0.008)
Bolivia	0.296*** (0.079)	0.030*** (0.010)
Brazil	0.360*** (0.035)	0.017*** (0.003)
Bulgaria	0.494*** (0.053)	0.036*** (0.006)
Cameroon	0.240 (0.188)	0.031** (0.014)
Canada	0.190*** (0.013)	0.010** (0.003)
Chile	0.239*** (0.042)	0.012*** (0.003)
China	0.079*** (0.023)	-0.005* (0.003)
Colombia	0.233*** (0.070)	0.011* (0.007)
Costa Rica	0.310*** (0.129)	0.003 (0.006)
Denmark	0.131*** (0.011)	-0.002 (0.003)
Ecuador	0.093*** (0.047)	0.005 (0.006)
Egypt	0.476*** (0.076)	0.015*** (0.006)
Finland	0.102*** (0.017)	-0.002 (0.007)
France	0.195*** (0.016)	0.003 (0.003)
Germany	0.220*** (0.002)	0.009 (0.003)
Greece	0.159*** (0.037)	0.002 (0.003)
Iceland	0.291*** (0.008)	0.008 (0.005)
India	0.506*** (0.086)	0.007 (0.005)
Indonesia	-0.010 (0.060)	0.007 (0.005)
Iran	-0.138 (0.095)	0.026* (0.014)
Ireland	0.176*** (0.041)	0.003 (0.005)
Israel	0.465*** (0.066)	0.014* (0.007)
Italy	0.177*** (0.018)	0.006* (0.003)
Japan	0.086*** (0.025)	-0.004 (0.005)
Jordan	0.093* (0.054)	0.013 (0.010)
Kenya	0.183*** (0.063)	0.023** (0.010)
Korea	0.084*** (0.033)	-0.000 (0.004)
Kuwait	-0.003 (0.061)	0.005 (0.007)
Macao	0.434** (0.207)	-0.027 (0.020)
Malawi	1.024*** (0.338)	0.058 (0.036)
Malaysia	-0.017 (0.075)	0.002 (0.006)
Malta	0.225** (0.104)	0.010 (0.008)
Mauritius	0.084 (0.067)	0.014*** (0.005)
Mexico	0.543** (0.117)	0.019*** (0.003)
Morocco	0.723** (0.208)	-0.007 (0.010)
Myanmar	0.532* (0.300)	0.031 (0.029)
Nepal	-0.365*** (0.129)	0.004 (0.013)
Netherlands	0.228** (0.031)	0.007 (0.004)
Niger	0.168 (0.131)	-0.013 (0.011)
Nigeria	0.201*** (0.061)	-0.001 (0.011)
Norway	0.166** (0.034)	-0.002 (0.006)
Panama	0.299*** (0.087)	-0.000 (0.008)
Philippines	0.317*** (0.071)	0.017*** (0.004)
Poland	0.437*** (0.028)	0.040*** (0.012)
Portugal	0.247*** (0.035)	0.013** (0.005)

Qatar	0.549*** (0.173)	0.009** (0.008)
Romania	0.415*** (0.052)	0.107** (0.043)
Senegal	0.303*** (0.108)	0.039** (0.015)
Singapore	-0.162 (0.103)	-0.013 (0.009)
South Africa	0.251*** (0.043)	0.008 (0.005)
Spain	0.345*** (0.025)	0.008** (0.004)
Sri Lanka	0.127** (0.061)	-0.001 (0.004)
Sweden	0.114** (0.009)	0.001 (0.003)
Switzerland	0.374*** (0.046)	-0.000 (0.007)
Tanzania	0.212** (0.084)	0.022 (0.014)
Thailand	0.192*** (0.045)	0.011*** (0.004)
Trinidad and Tobago	0.283 (0.175)	0.013*** (0.006)
Tunisia	0.411*** (0.067)	0.004 (0.010)
Turkey	0.412*** (0.036)	0.005 (0.004)
United Kingdom	0.236*** (0.015)	0.015*** (0.003)
United States	0.213*** (0.026)	0.007*** (0.002)
Uruguay	0.238*** (0.058)	-0.001 (0.005)

Note: *significant at 10% level, ** significant at 5% level, ***significant at 1% level. Full estimates are available from the authors upon request.

Table 3. Trade and Climate change. Period 1986-2016.

Dependent variable	(1) Nominal trade flows in current US dollars	(2) Nominal trade flows in current US dollars
$Wildfire_{ijt}$	0.072***	
	(0.007)	
$Wildfire\text{-}no\text{-}China_{ijt}$		0.066***
		(0.008)
$Wildfire\text{-}China_{ijt}$		0.069***
		(0.088)
$Flood_{ijt}$	0.013***	
	(0.002)	
$Flood\text{-}no\text{-}China_{ijt}$		0.019***
		(0.003)
$Flood\text{-}China_{ijt}$		0.015***
		(0.003)
$Ext\_Temp._{ijt}$	0.045***	
	(0.016)	
$Ext\_Temp\text{-}no\text{-}China_{ijt}$		0.051***
		(0.017)
$Ext\_Temp\ \text{-}China_{ijt}$		0.019
		(0.016)
$Epidemic_{ijt}$	-0.142***	
	(0.013)	
$Epidemic\text{-}no\text{-}China_{ijt}$		-0.148***
		(0.015)
$Epidemic\text{-}China_{ijt}$		-0.119***
		(0.019)
$Insect_{ijt}$	-0.418***	
	(0.072)	
$Insect\text{-}no\text{-}China_{ijt}$		-0.514***
		(0.092)
$Insect\text{-}China_{ijt}$		-0.413***
		(0.116)

$Storm_{ijt}$	-0.005 (0.003)	
$Storm\text{-}no\text{-}China_{ijt}$		0.005^{**} (0.002)
$Storm\text{-}China_{ijt}$		-0.025^{***} (0.006)
$Drought_{ijt}$	0.023^{**} (0.011)	
$Drought\text{-}no\text{-}China_{ijt}$		0.012 (0.010)
$Drought\text{-}China_{ijt}$		0.066^{***} (0.021)
$Landslide_{ijt}$	-0.009^{*} (0.005)	
$Landslide\text{-}no\text{-}China_{ijt}$		-0.065^{***} (0.011)
$Landslide\text{-}China_{ijt}$		-0.007 (0.007)
Observations	137,475	137,475
Country-pair FE	Yes	Yes
Importer-year and Exporter-year FE	Yes	Yes
Intra-national trade	Yes	Yes
Pseudo R2	.99	.99

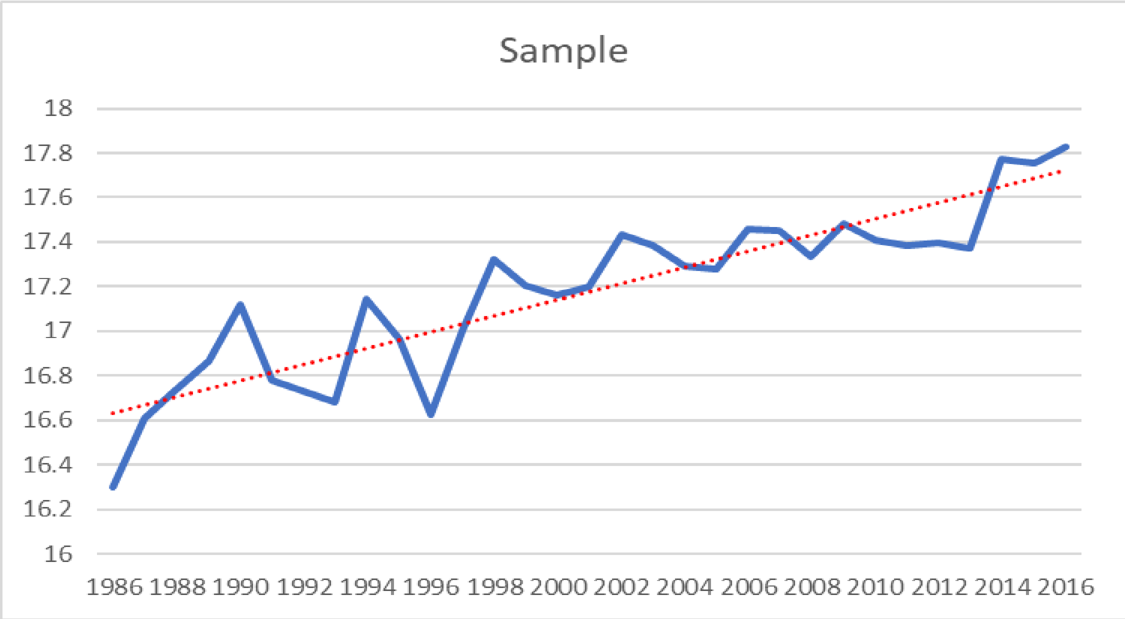
Note: *significant at 10% level, ** significant at 5% level, ***significant at 1% level. The coefficients for PTAs, GATT-OMC and the constant have been omitted for brevity. Full estimates are available from the authors upon request.

Table 4. General Equilibrium. Welfare effect (% change) of events.

Period 1986-2016.

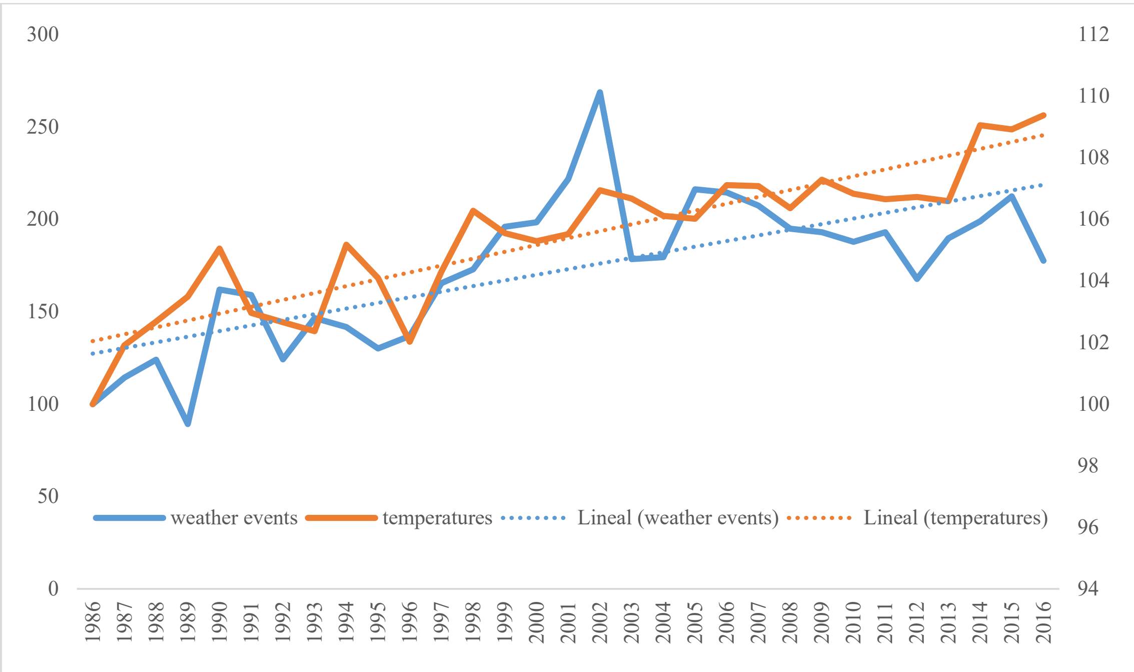
Event	Average Impact	Highest Impact	Lowest Impact
Wildfire	0.49%	1.41%	0.02%
Flood	0.09%	0.24%	0.01%
Ext_Temp	0.30%	0.86%	0.03%
Epidemic	-0.9%	-2,54%	-0.095
Insect Infestation	-2.41%	-6,66%	-0.26%
Storm	-0.03%	-0.09%	-0.003%
Drought	0.15%	0.43%	0.02%
Landslide	-0.06%	-0.1709	-0.0063

Figure 1. Evolution of average yearly temperature in our sample (65 countries)



Note: Own elaboration based on data from Climate change knowledge Portal (World Bank).

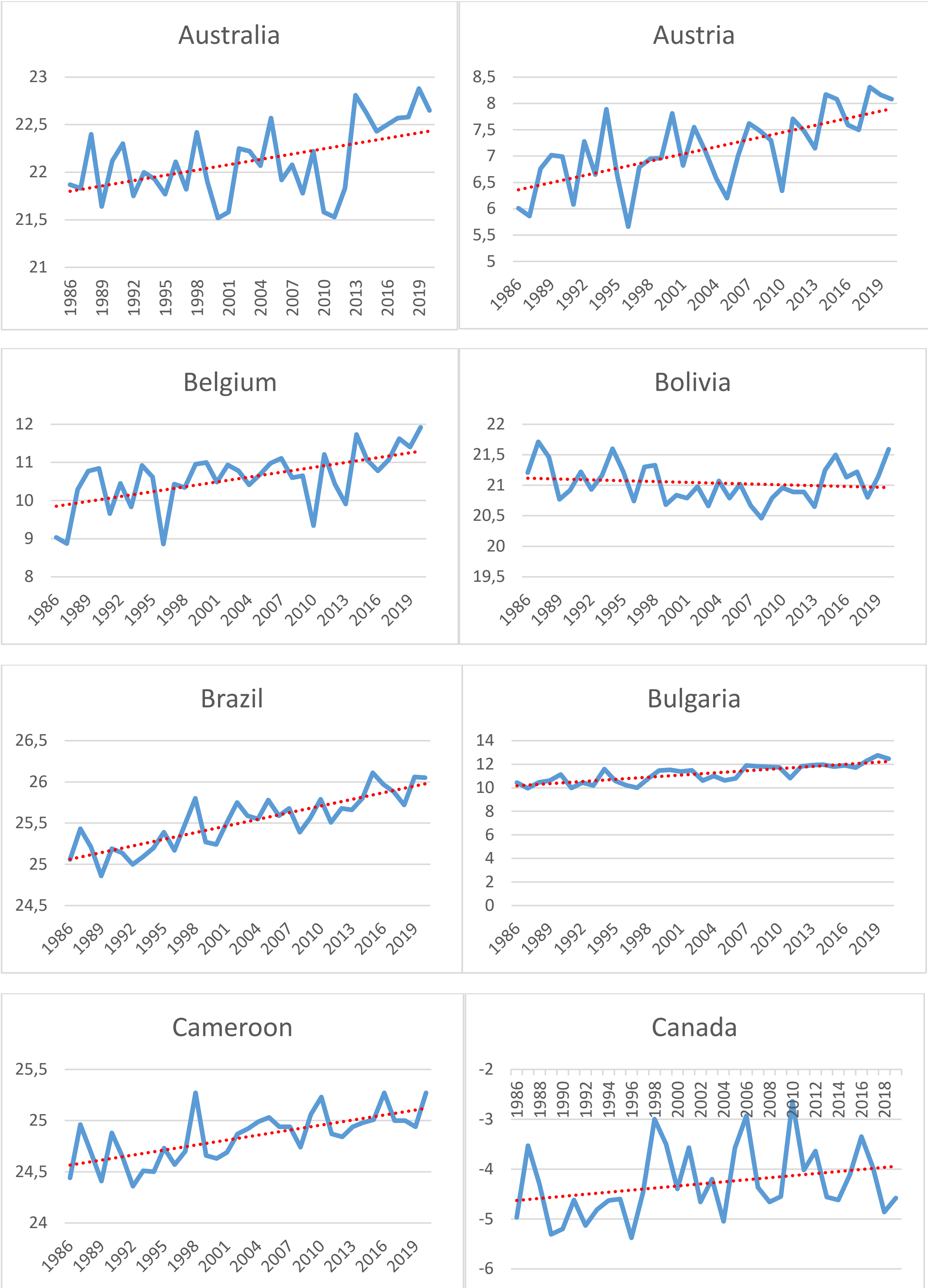
Figure 2. Evolution of average yearly temperature and weather events

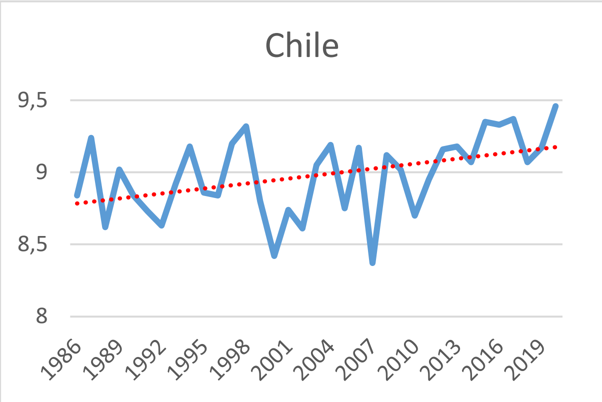


Note: Own elaboration based on data from Climate change knowledge Portal (World Bank) and "International Disasters Database" (EM-DAT).

APPENDIX

Figure 1A. Evolution of average yearly temperature by countries.

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9,5
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8,5
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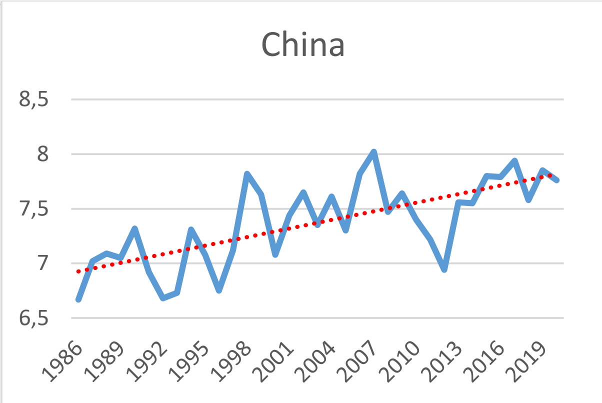
1986 1989 1992 1995 1998 2001 2004 2007 2010 2013 2016 2019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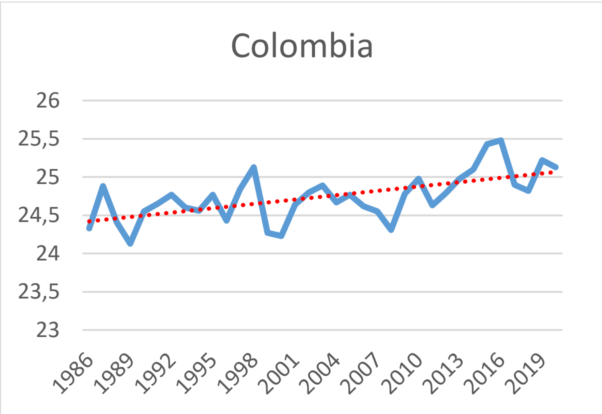
8
7,5
7
6,5
1986 1989 1992 1995 1998 2001 2004 2007 2010 2013 2016 2019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24,5
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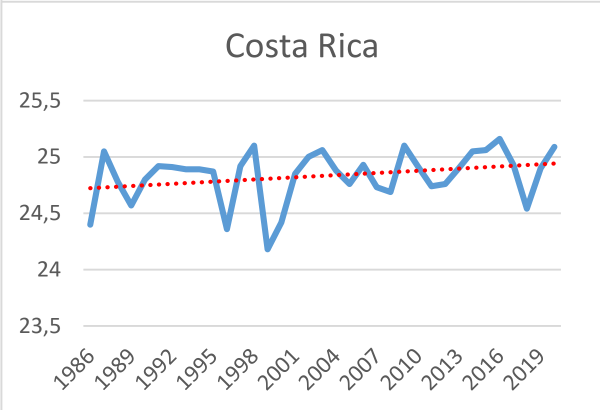
23,5
23
1986 1989 1992 1995 1998 2001 2004 2007 2010 2013 2016 2019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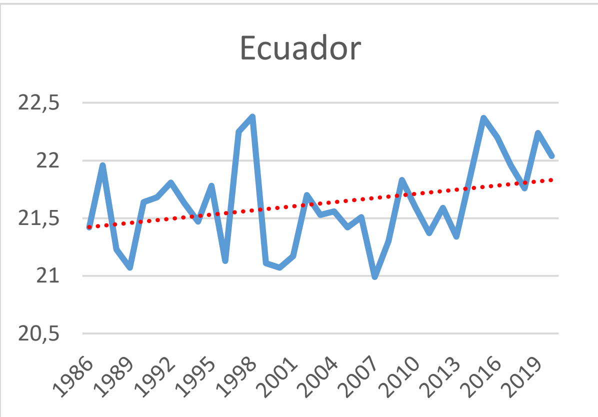
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20,5
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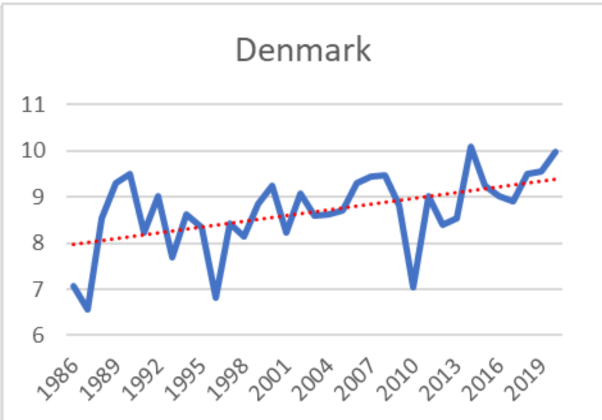
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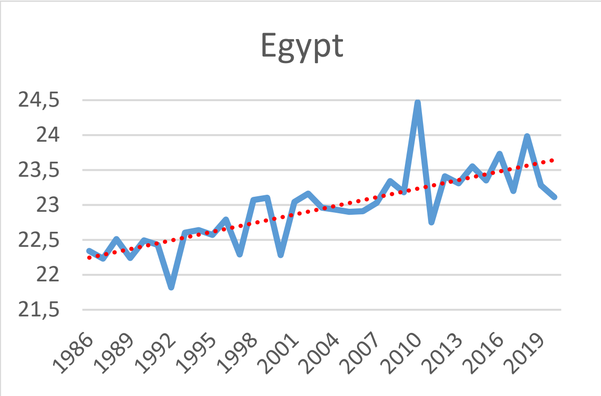
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21,5
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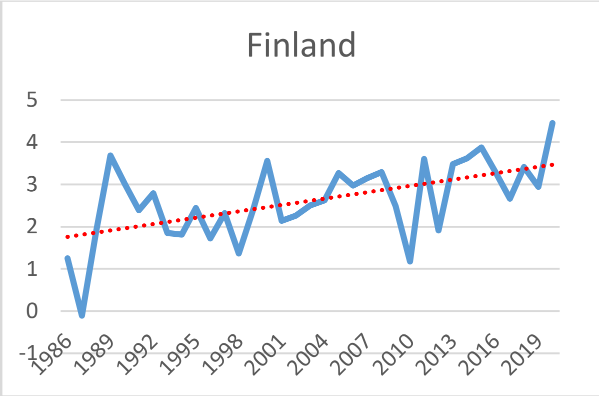
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3
2
1
0
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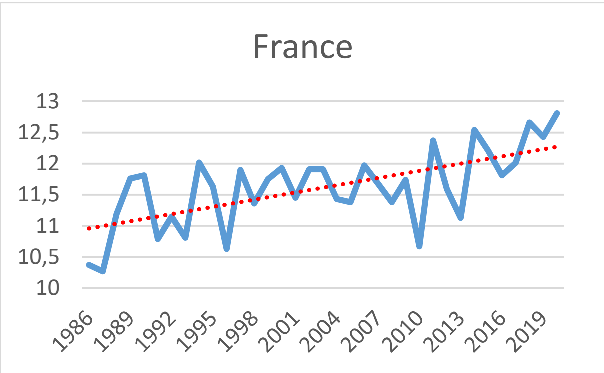
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10,5
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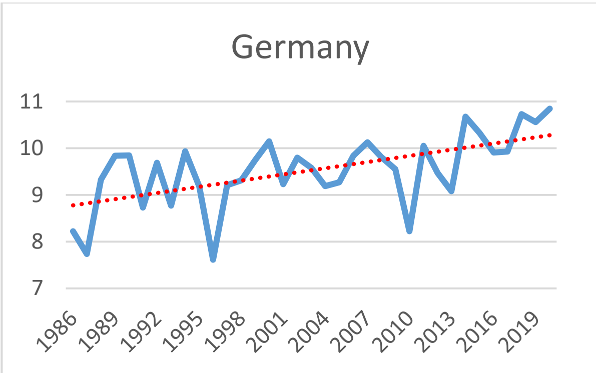
1986 1989 1992 1995 1998 2001 2004 2007 2010 2013 2016 2019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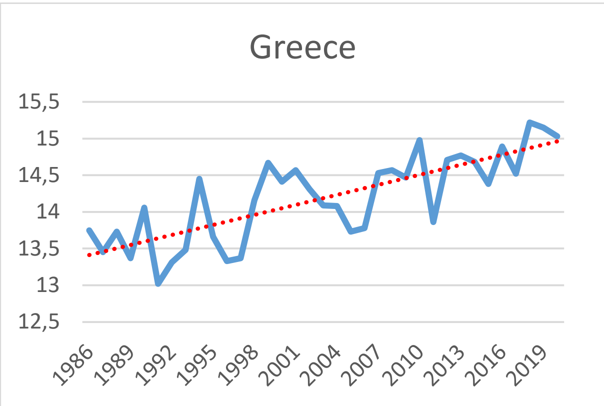
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13,5
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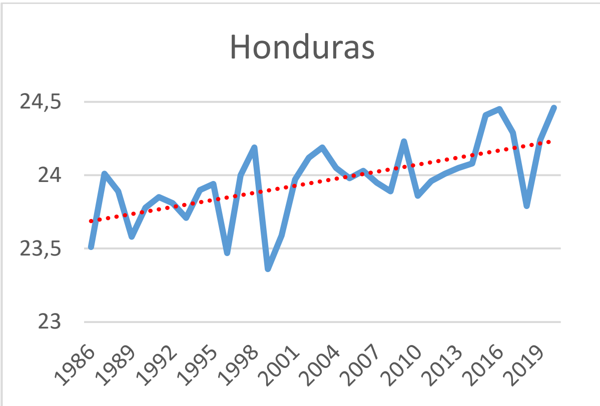
12,5
1986 1989 1992 1995 1998 2001 2004 2007 2010 2013 2016 2019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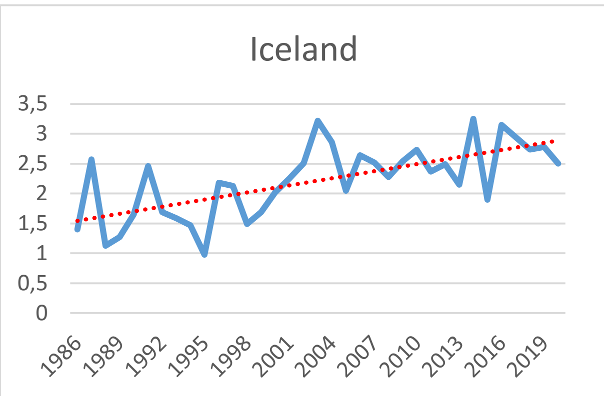
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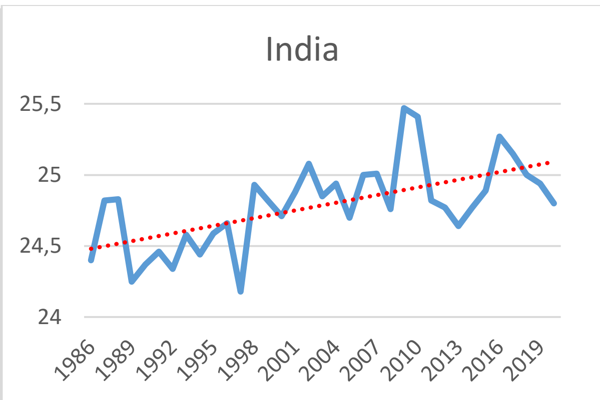
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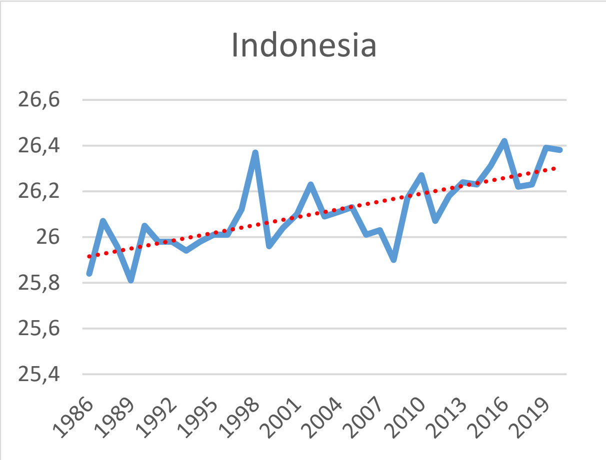
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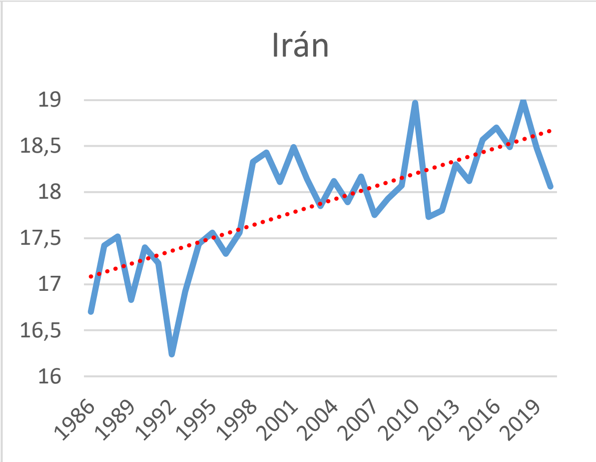
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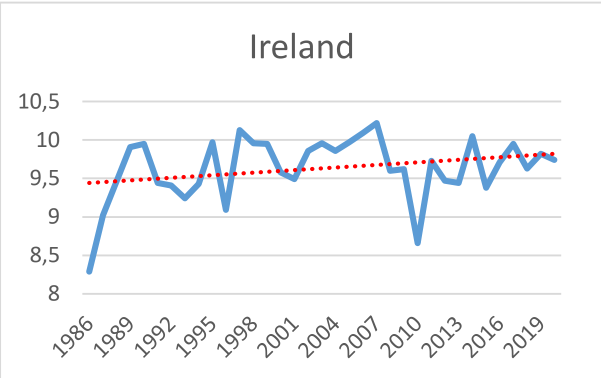
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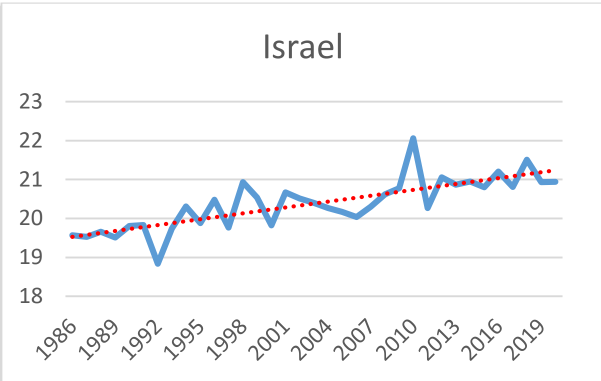
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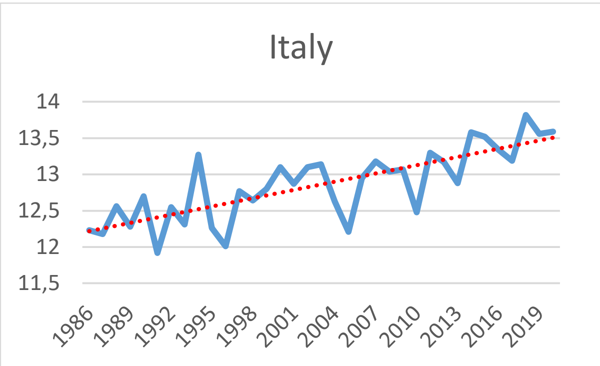
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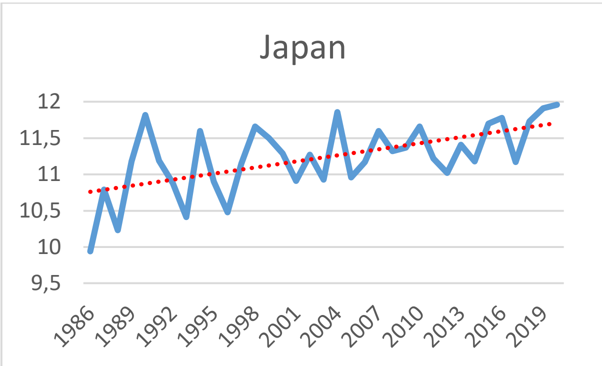
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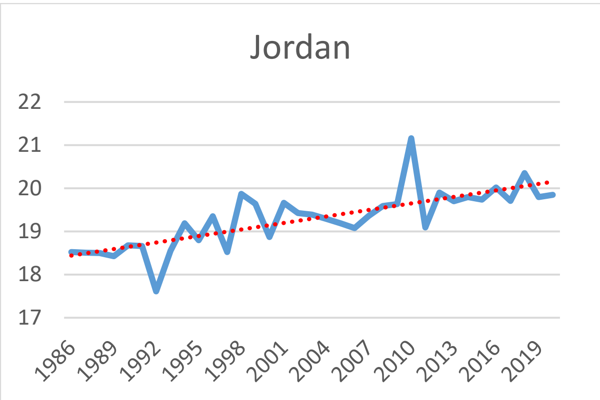
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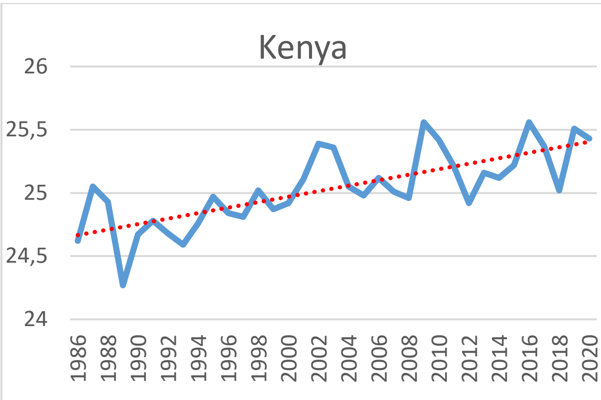
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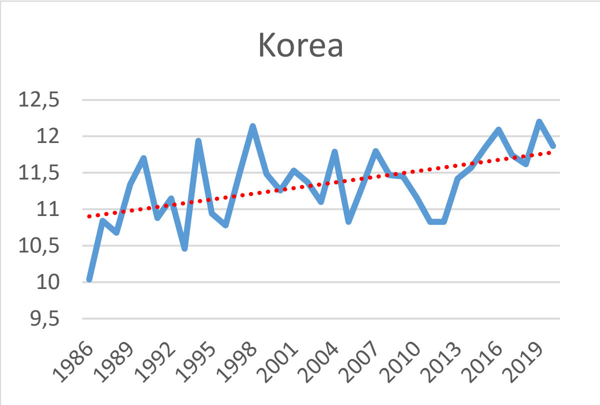
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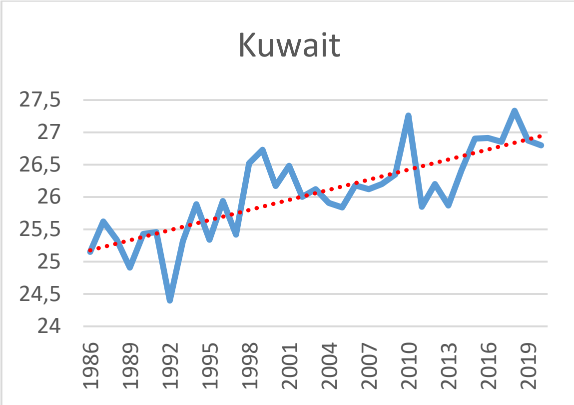
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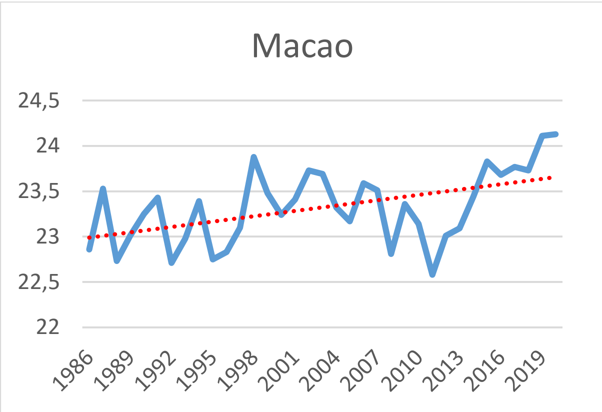
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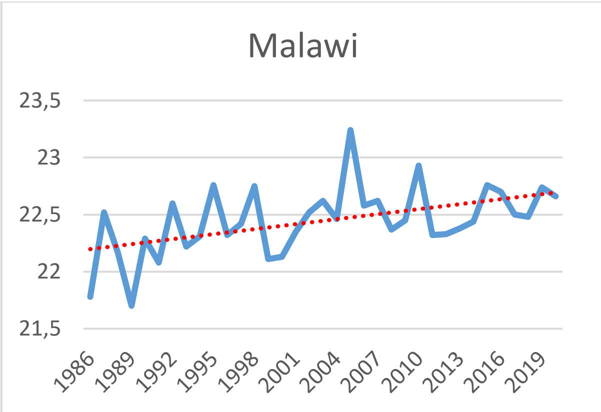
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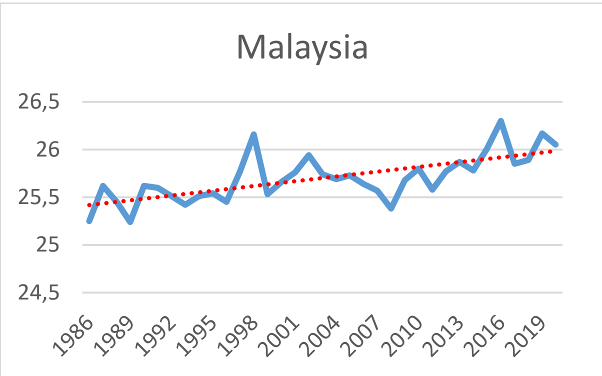
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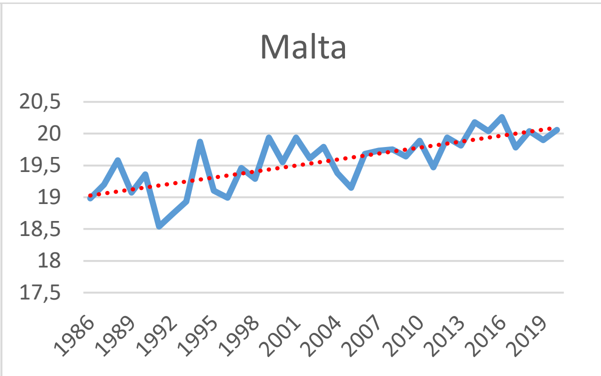
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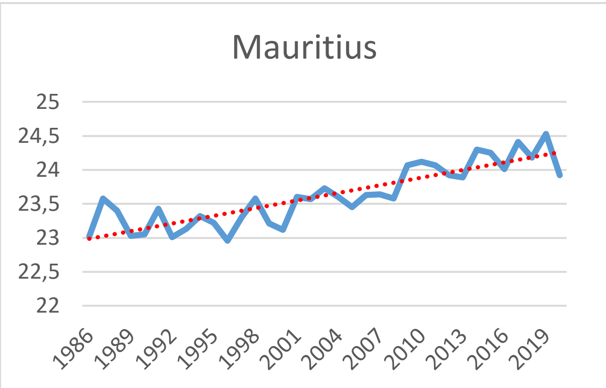
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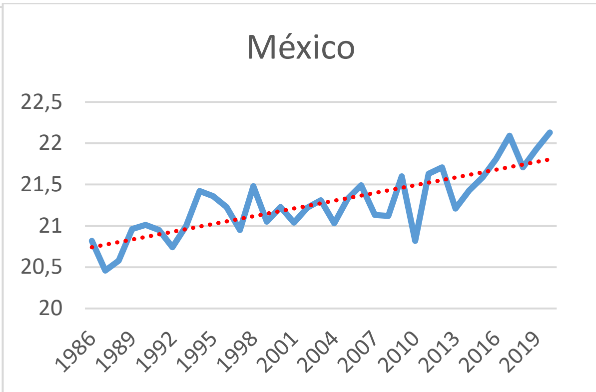
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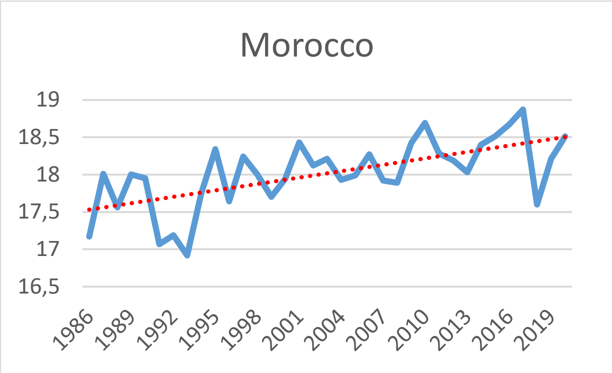
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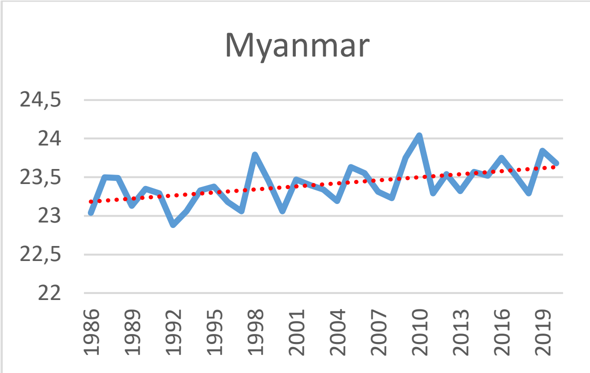
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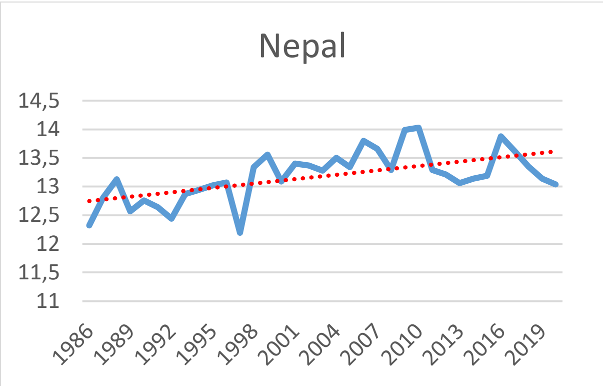
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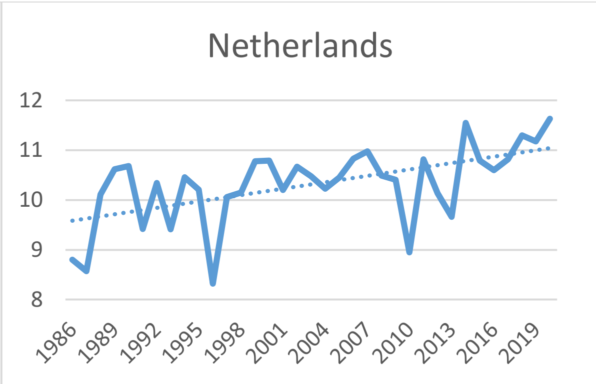
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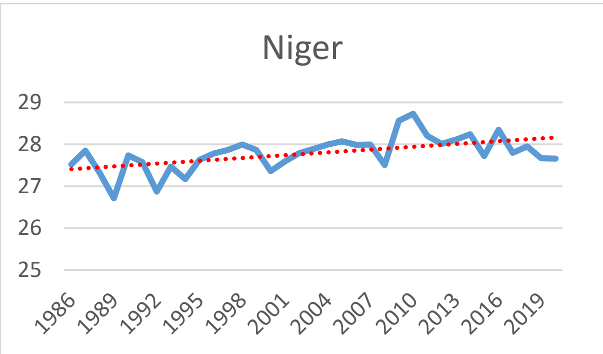
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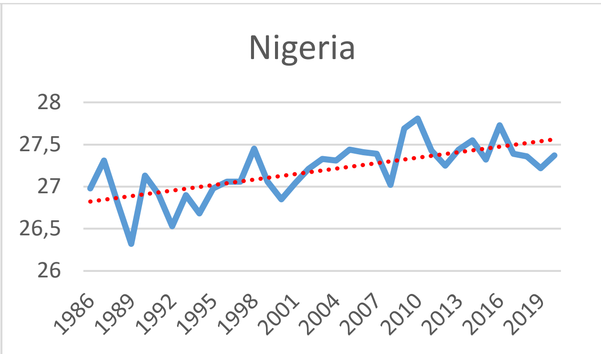
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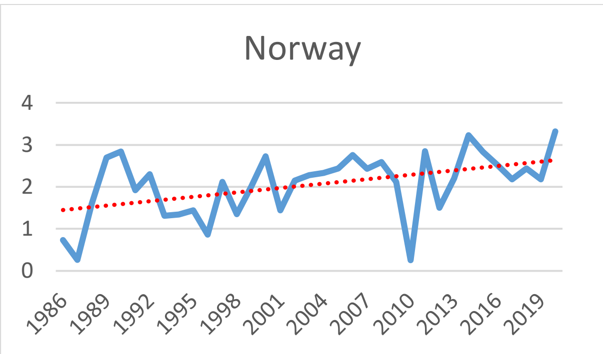
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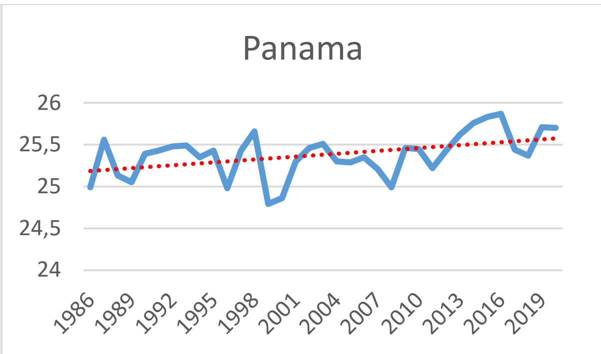
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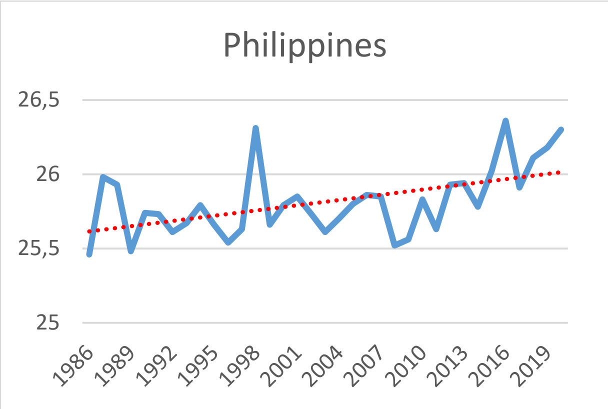

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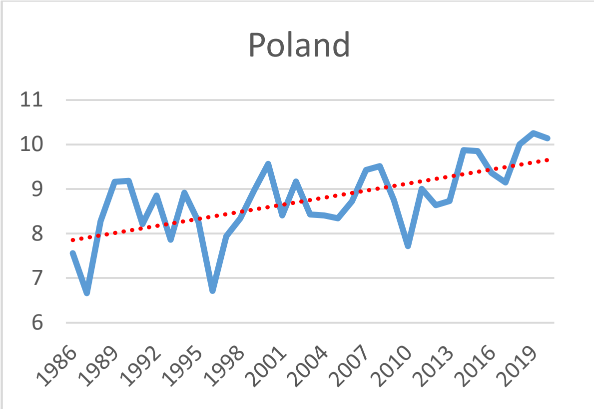

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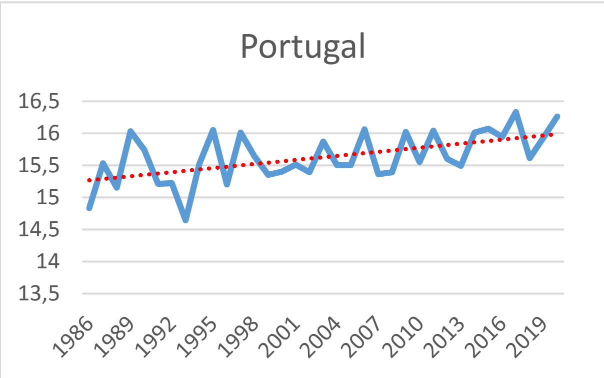

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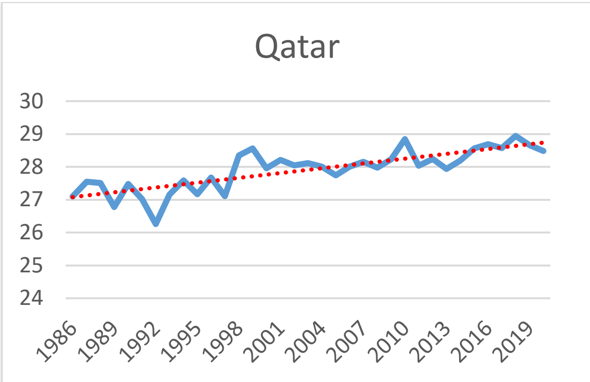

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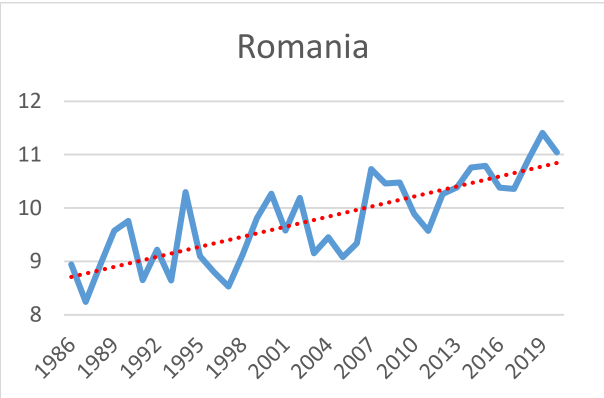

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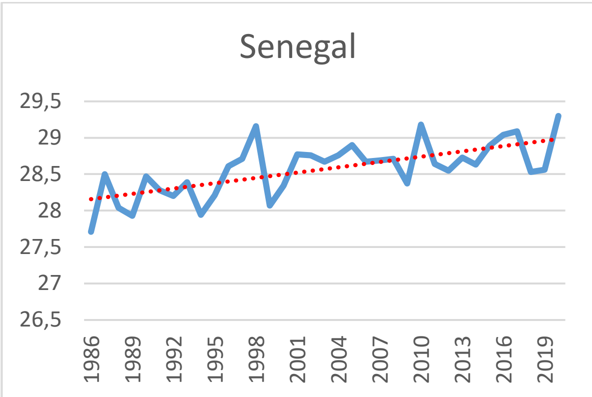

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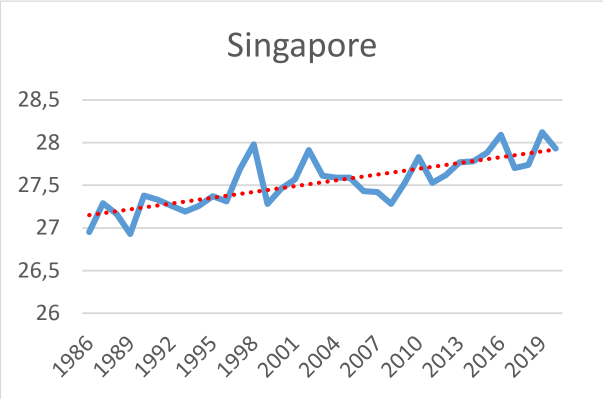
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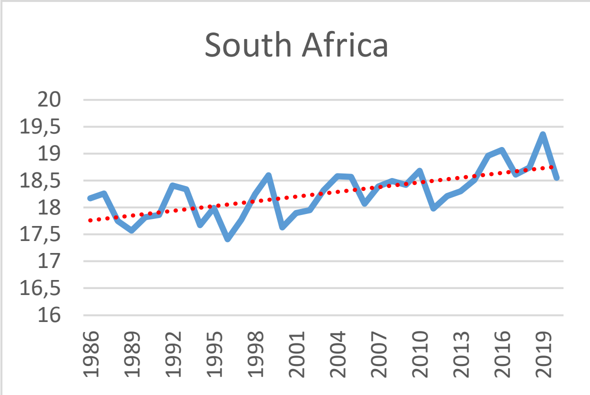
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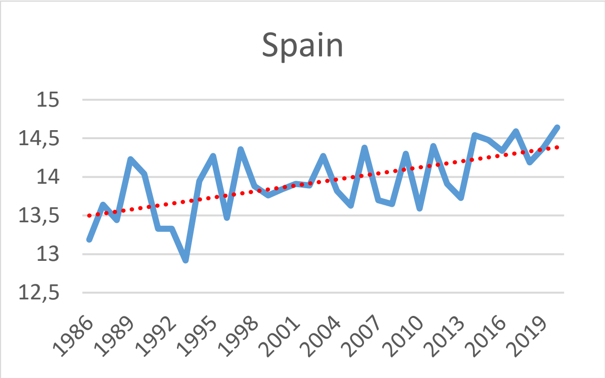
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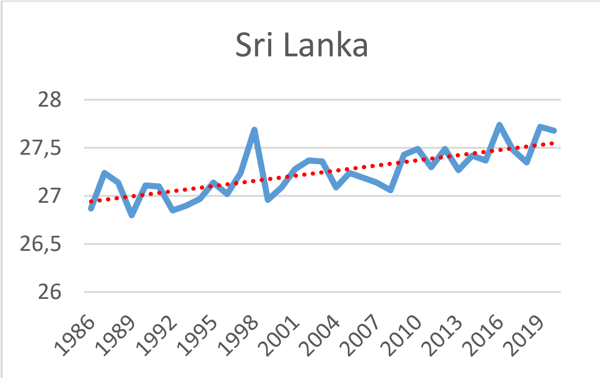
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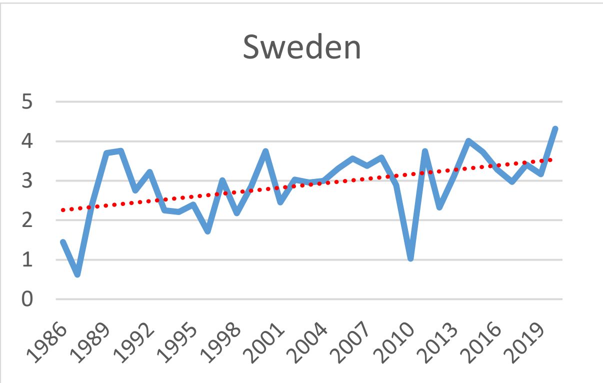
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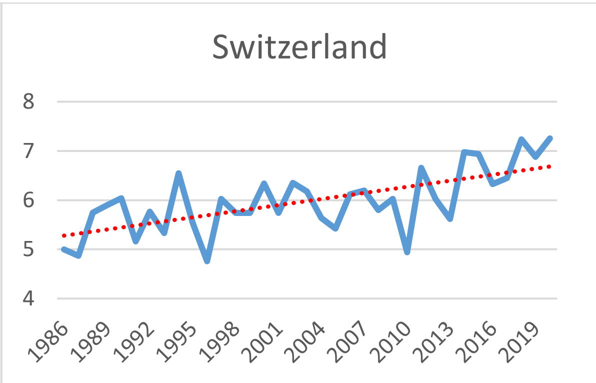
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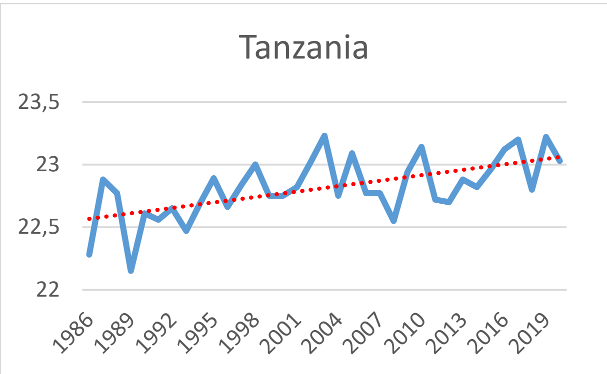
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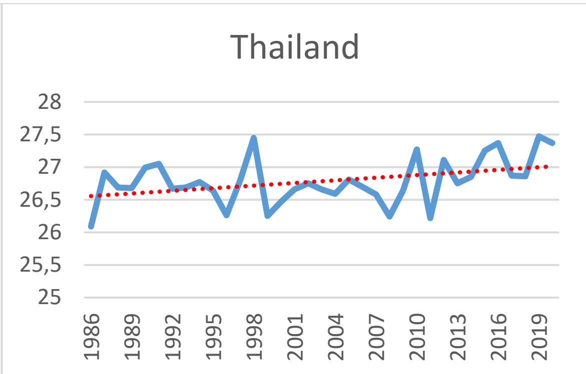
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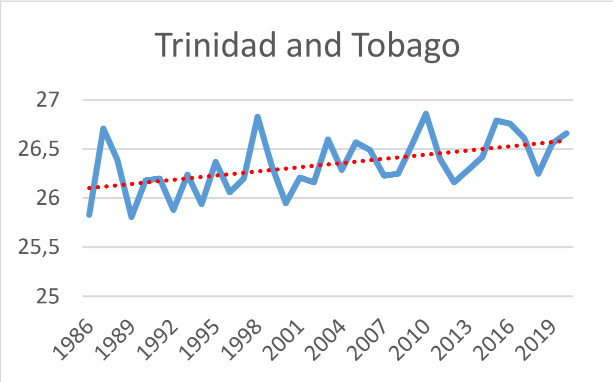
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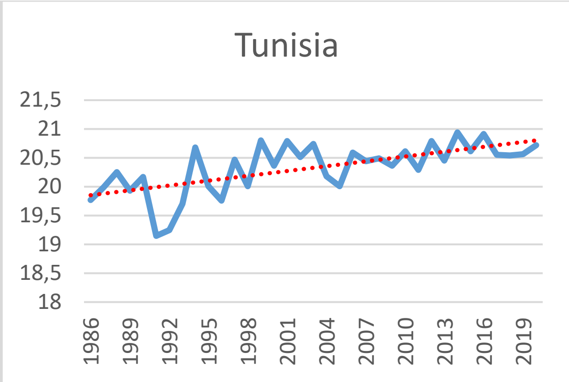
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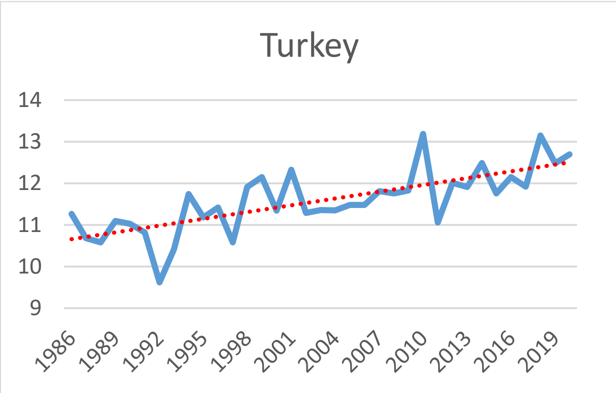
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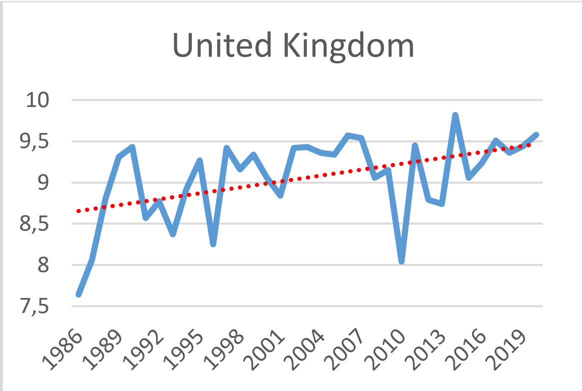
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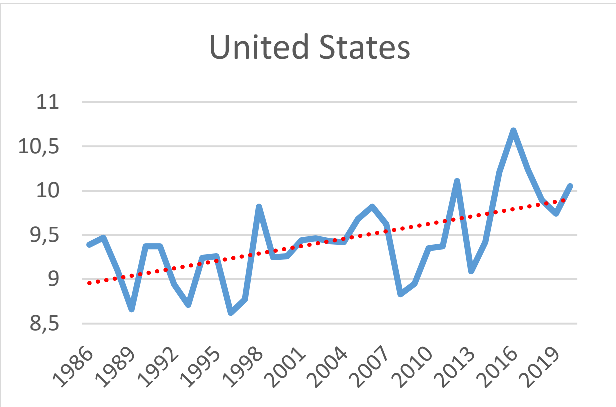
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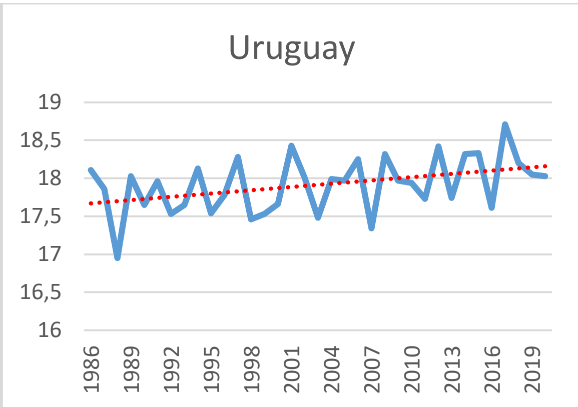
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