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The Impact of Climate Change on Tourism Economies

Working Paper Series—12-01 | December 2011

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1. Introduction

"Recreation and tourism is one of the largest economic activities of the world, some even say it is the largest." (Bigano et al., 2007, p.147). For some economies such as Greece, Spain and Turkey, tourism is considered to be particularly important for promoting economic growth (e.g. Gunduz and Hatemi-J, 2005). Tourism is obviously highly sensitive to climate change since "climate defines the length and quality of tourism seasons, affects tourism operations, and influences environmental conditions that both attract and deter visitors" (UNWTO, 2009, p.2). Therefore, with mounting evidence in support of the notion of climate change,[1] an important question is: "What is the impact of climate change on tourism economies such as Greece, Spain and Turkey?"

One line of extant research focuses on the impact of climate change on the tourism industry. For instance, Ceron and Dubois (2000) show that mountainous parts of France, Italy and Spain could become more popular because of their relative coolness. Hamilton et al. (2005) show that global warming may have small impact on global tourism. Taylor (2009) finds that there is likely to be increased domestic tourism as a result of climate change.[2]

Another line of existing research concentrates on the relationship between the tourism industry and economic growth, testing the "tourism-led growth" hypotheses. Researchers have found evidence suggesting that tourism can lead to economic growth (e.g. Balaguer and Cantavella-Jorda, 2002; Dritsakis, 2004; Lanza et al., 2003; Eugenio-Martin and Morales, 2004; Gunduza and Hatemi-J, 2005; Proença and Soukiazis, 2008; and Brida et al., 2010 among others). However, to the best of our knowledge, there is no research that combines these two lines of research and studies the impact of climate change on economic growth of tourism economies. This paper intends to fill this gap.

In this paper, we focus on the relationship between temperature (a proxy for climate change) and GDP per capita (a proxy of economic growth) in a reduced-form framework. We could use a structural approach to model the impact of climate change on tourism economies. However, a major challenge of this approach is its complexity: UNWTO (2009) points out that the effects of climate change on tourism are complex including direct effects as well as indirect effects; furthermore, how the tourism industry affects growth is also unsettled in terms of theory.[3] In contrast, the cross-sectional relationship between temperature and GDP per capita motivates a simple reduced-form approach, and is gaining popularity in the area of climate-change research. Two prominent examples of using this approach to estimate the impact of climate change are Horowitz (2009) and Ng and Zhao (2010).

Empirically, we adopt the model in Ng and Zhao (2011) to estimate the relationship between temperature and GDP per capita for tourism economies as well as for all countries in our sample, the G-7 countries and a group of developing countries. Based on the parameter estimates, we then calculate the economic impacts of climate change on different types of economies. Our major finding is that climate change's negative impact on tourism economies is not smaller than its impact on other types of economies if temperature increases by more than 1 degree Celsius. Therefore, our findings suggest that tourism economies should also implement aggressive climate mitigation policy.

The remainder of the paper is organized as follows: Section 2 discusses our data and model, Section 3 reports our empirical results and Section 4 concludes the manuscript.

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[1] In its most comprehensive scientific assessment of climate change, Intergovernmental Panel on Climate Change (IPCC) concludes that "Warming of the climate system is unequivocal" (IPCC, 2007, Working Group I Report Summary for Policymakers, p. 5).

[2] See also Agnew and Viner (2001), Elsasser and Burki (2002), Becken (2005) and Ceron and Dubois (2005).

[3] Current research focuses on empirically testing the tourism-led-growth hypothesis.

2. Data and Methodology

Data

We use a geophysically-scaled economic data set (G-Econ) constructed by Nordhaus (2006). The G-Econ data compute variables at a 1-degree longitude by 1-degree latitude resolution at a global scale.[4] As a result, we are able to perform cell-level analysis of the relationship between temperature and GDP per capita in contrast to a majority of the other studies which use country-level data.

There are several advantages of using cell-level data as compared to country-level data. First of all, cell-level data makes temperature measurement more meaningful as Nordhaus (2006) argues that "for many countries, averages of most geographic variables (such as temperature or distance from seacoast) cover such a huge area that they are virtually meaningless, whereas for most grid cells the averages cover a reasonably small area." (Page 3511) Furthermore, using cell-level data increases the number of useful observations from around 100 countries to about 16,500 terrestrial cells and, hence, allows us to capitalize on the potentially higher accuracy of the estimations. Finally, having multiple observations per country enables us to control for factors that are unique to individual countries, which is important in our model specification.

The G-Econ data set contains measurement of GDP on "gridded output", gross cell product (GCP), which is similar to the gross domestic product (GDP) as developed in the national income accounts, except that the geographic entity of the latitude-longitude grid cell is used instead of political boundaries. The earth contains 64,800 such grid cells, of which 27,445 observations have reasonably complete data on climate, population, and output for 248 countries. After removing cells with zero GCP, area, population and data lower than the best quality, we are left with 174 countries and 16,511 observations. The 1990 output of all countries using national aggregates estimated by the World Bank is converted into a common metric using market exchange rates based on 1995 U.S. dollars. A full description of the data and methods can be found at the project web site (http://gecon.yale.edu). Table 1 contains summary statistics of the variables used in this paper.

Methodology

Ng and Zhao (2010) propose a theoretical model of temperature and GDP per capita, which takes into account the historical as well as contemporaneous effects of temperature on GDP per capita. For more details on the historical as well as contemporaneous effects of temperature on income, see Acemoglu et al. (2002), Easterly and Levine (2002), Rodrik et al. (2004), Gallup et al. (1998), Mellinger et al. (2000), Gallup and Sachs (2001), Sachs and Malaney (2002), and Sachs (2003). The model in Ng and Zhao (2011), which is based on a Cobb-Douglas type production function, specifies output per capita as:

$$\log(\frac{Y_i}{P_i}) = \varphi d_i + a_1 T_i + a_2 T_i^2 + a_3 T_i^3 + b\log(P_i) + \varepsilon_i \qquad (1)$$

where Y_i is the total income (output), P_i represents population, T_i is the temperature, φ is the row vector of country coefficients for the column vector of country dummy variables d_i, and ε_i captures the effects of all other variables. To model potential nonlinear effects of temperature on income empirically, their model includes a cubic polynomial in temperature. As explained by Ng and Zhao (2010), the historical effect of temperature on income is captured by the productivity of different countries approximated by the country dummy variables d_i, while the contemporaneous effect of temperature is modeled directly as a cubic polynomial in Equation (1). It is this contemporaneous effect that is of interest to us, because it is relevant for assessing the impact of climate change (see Horowitz, 2009, Ng and Zhao, 2011).

[4] The size of a cell depends on its latitude. In our sample, the average size of a cell is about 6,206 km^2.

Table 1 Summary statistics

Variable	Abbreviation in G-Econ	Mean	Median	Std. Dev.	Min	Max
Panel A: Tourism Economies n = 198						
Variable	Abbreviation in G-Econ	Mean	Median	Std. Dev.	Min	Max
1990 GCP (billions of 1995 US$)	MER1990_34	3.355	1.461	7.228101	0.0280	73.820
1990 Population (persons)	POPGPW_1990_34	488,096	365,532	602200.8	12,844	4,944,755
Temperature (C^0), average 1980-2008	TEMPAV_8008	12.885	12.955	3.554619	3.193	22.651
Panel B: World n=16,511						
Variable	Abbreviation in G-Econ	Mean	Median	Std. Dev.	Min	Max
1990 GCP (billions of 1995 US$)	MER1990_34	1.4862	0.0456	12.40147	0.0001	978.3143
1990 Population (persons)	POPGPW_1990_34	3.072e+05	2.432e+04	9.762751e +05	1.780	2.644e+07
Temperature (C^0), average 1980-2008	TEMPAV_8008	11.4732	13.0879	13.17878	-23.6881	30.9225
Panel C: G-7 Countries n = 2,382						
Variable	Abbreviation in G-Econ	Mean	Median	Std. Dev.	Min	Max
1990 GCP (billions of 1995 US$)	MER1990_34	6.9831	0.2611	31.05697	0.0001	978.3143
1990 Population (persons)	POPGPW_1990_34	2.643e+05	1.126e+04	9.378771e +05	1.780	2.644e+07
Temperature (C^0), average 1980-2008	TEMPAV_8008	4.523	4.684	8.249065	-18.189	24.576
Panel D: Emerging Countries n = 6,703						
Variable	Abbreviation in G-Econ	Mean	Median	Std. Dev.	Min	Max
1990 GCP (billions of 1995 US$)	MER1990_34	0.5230	0.0416	2.936020	0.0001	112.4327
1990 Population (persons)	POPGPW_1990_34	4.377e+05	1.872e+04	1.258054e +06	7.241	2.261e+07
Temperature (C^0), average 1980-2008	TEMPAV_8008	6.932	4.621	14.13317	-20.645	30.898

Table 1 contains summary statistics of the variables used in this paper.

To estimate the impact of climate change, we follow Horowitz (2009) and Ng and Zhao (2011) and compute the effect of a temperature increase on the combined GCP of the relevant economies (holding other relevant variables constant). More specifically, based on the parameter estimates from Eq. (1), the estimated change in output per capita of a single cell observation is computed using the formula: $\Delta\hat{y}_i = \hat{y}\left[{}_i e^{\hat{a}_1\Delta T+\hat{a}_2\left(T_{1i}{}^2-T_{0i}{}^2\right)+\hat{a}_3\left(T_{1i}{}^3-T_{0i}{}^3\right)}-1\right]$ where $\log_e\left(\hat{y}_i\right)$ is the fitted value of $\log_e\left(\frac{Y_i}{P_i}\right)$ at T_{0i} in Eq. 1 with T_{1i} being the new temperature, T_{0i} the current temperature and $\Delta T_i = T_{1i} - T_{0i}$ the change in temperature, and $\hat{a}_1$, $\hat{a}_2$ and $\hat{a}_3$ are the estimated coefficients of the polynomial in temperature. The total percentage change in output is then computed by $\Sigma_i \Delta\hat{y}_i P_i \,/\, \Sigma_i \hat{y}_i P_i$ where the summation is taken over all the cells of the relevant economies. We focus on three climate change scenarios: a one, two or three-degree increase in temperature, because IPCC's best estimate for global average surface warming at the end of the 21st century ranges from 1.8°C (with 66 percent confidence interval from 1.1°C to 2.9°C) to 4.0°C (with 66 percent confidence interval from 2.4°C to 6.4°C).

3. Empirical Results

Main results

Empirically, we focus on three major tourism economies: Greece, Spain and Turkey (see Gunduz and Hatemi-J, 2005). We estimate Eq. (1) using the ordinary least-squares regression for the three major tourism economies. For comparison, we also perform estimation for all countries in our sample, the developed G-7 countries and a group of developing countries[5]. The results are reported in panels A through D in Table 2.

Based on the parameter estimates in Table 2, we calculate the economic impacts of climate change on different types of economies. The estimated impacts are reported in Table 3 as well as in Panels A through D in Figure 1. In Figures 1, the three horizontal lines represent the impacts of the one-degree (solid red horizontal line), two-degree (dash red horizontal line) and three-degree (dotted red horizontal line) Celsius increase in temperature on combined GDP of different types of economies (i.e. tourism economies, all countries, the G7 countries and the emerging countries, respectively). As we can see, the average impact of a one degree Celsius increase in temperature on the three major tourism economies is slightly smaller than that on other types of economies. However, the lower estimate of global warming at the end of the 21st century of IPCC is 1.8°C. Therefore, it will be more informative to focus on the impacts when temperature increases by more than 1°C. As we can see from Table 3 as well as Figure 1, if temperature increases by more than 1°C, the estimated impacts of climate change on tourism economies are not smaller than its impacts on other types of economies. This is the central finding of the paper, which suggests that tourism economies should also implement aggressive climate mitigation policy.

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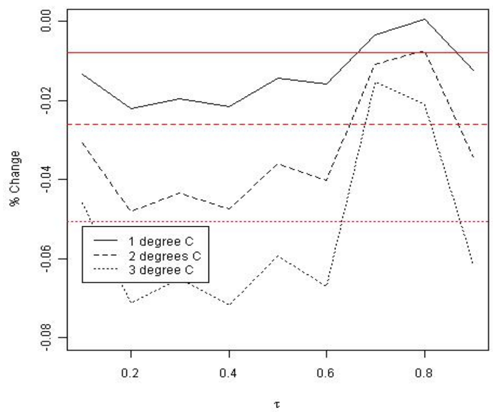
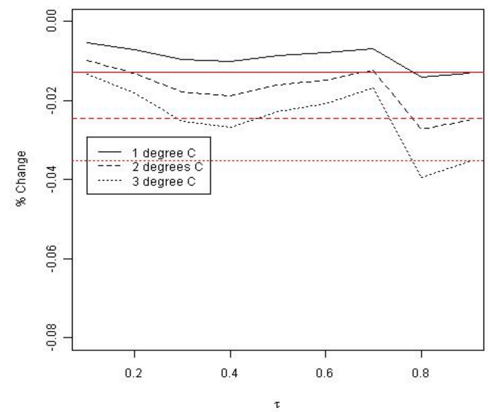
[5] Russia, Czech Republic, Poland, Chile, Hungary, South Korea, Turkey, China, Peru, Mexico, Morocco, South Africa, Brazil, Egypt, Colombia, Indonesia, India, Malaysia, Philippines and Thailand.

Figure 1 Estimates of The Global Warming Impact on Total Output for Greece, Spain and Turkey.

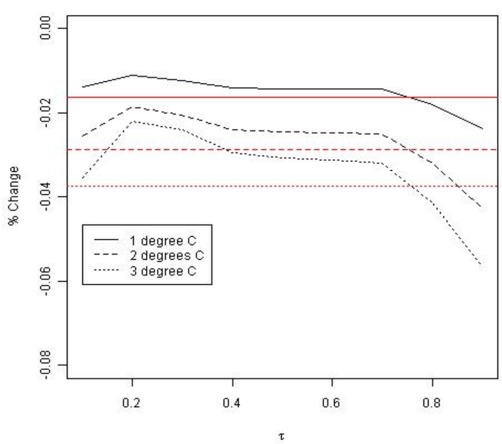
Panel A: Greece, Spain and Turkey



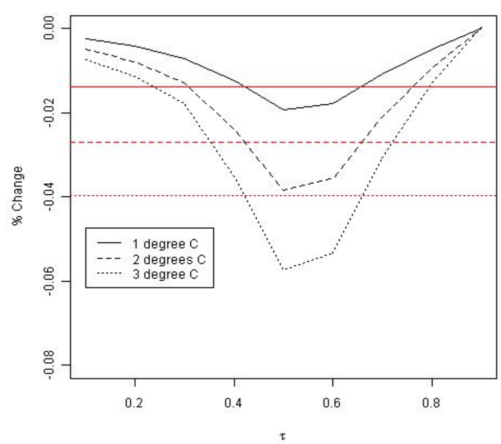
Panel B: All Countries



Panel C: G-7 Countries



Panel D: Developing Countries



Panel E: Top 19 Tourism Countries

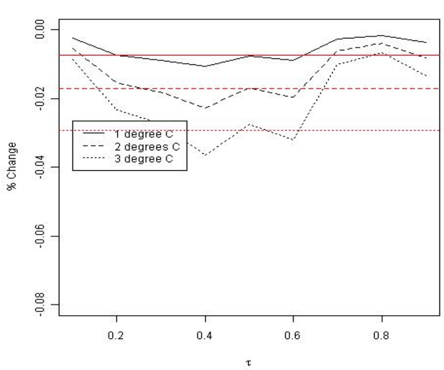


Figure 1 shows the estimated impacts of one-, two- and three-degree increases in temperature on the total GCP of relevant economies. The horizontal lines are the ordinary least-squares estimated impacts, while the curves are the quantile regression estimated impact on the τ -th quantile of the total GCP of relevant economies.

Table 2 Ordinary Least-squares Estimates of the Temperature-Income Relation

Panel A: Greece, Spain, Turkey (-0.89%)					
	T	T^2	T^3	*Log(P)*	R^2
Coefficient	0.6371	-0.0388	0.00077	0.05161	0.84
t-statistics	4.919	-3.629	2.619	2.13	
Panel B: World					
	T	T^2	T^3	*Log(P)*	R^2
Coefficient	-0.02750	0.00054	0.00000	-0.00899	0.95
t-statistics	-28.49	11.73	-0.45	-5.28	
Panel C: G-7 Countries					
	T	T^2	T^3	*Log(P)*	R^2
Coefficient	-0.03894	-0.00006	0.00005	0.01187	0.38
t-statistics	-19.71	-0.548	6.307	3.867	
Panel D: Emerging Countries					
	T	T^2	T^3	*Log(P)*	R^2
Coefficient	-0.02812	0.00074	-0.00001	-0.01484	0.87
t-statistics	-15.37	9.45	-2.43	-4.39	
Panel E: Top 19 Tourism Economies					
	T	T^2	T^3	*Log(P)*	R^2
Coefficient	0.01553	0.00009	-0.00003	0.00862	0.95
t-statistics	5.80	0.20	-2.19	1.41	

Table 3 Global warming impact estimates

	1 degree	2 degrees	3 degrees
Greece, Spain, Turkey	-0.89%	-2.82%	-5.37%
World	-1.29%	-2.46%	-3.51%
G-7 countries	-1.50%	-2.61%	-3.32%
Emerging countries	-1.40%	-2.72%	-3.95%
Top 19 tourism economies	-0.88%	-2.01%	-3.38%

Robustness check

If Eq. (1) has missing variables or our data have outliers or exhibit heteroskedasticity, the ordinary least-squares estimates in Table 2 would not be reliable. The *p*-value of the Breusch-Pagan test for heteroskedasticity for the three major tourism economies, all the countries, the G7 countries and the emerging countries are essentially zero. Hence, there is strong evidence of violation of the assumption of homoskedastic variance in the classical linear regression model. We, therefore, utilize the quantile regression invented by Koenker and Bassett (1978) to re-estimate Eq. (1). The quantile regression along with the ordinary least-squares regression estimates of the slope coefficients for $\log(P_i)$ and the three temperature polynomial coefficients are presented in Figures 2 through 5 for the three major tourism economies, all countries, the G7 countries and the emerging countries, respectively. As we can see, there is strong evidence of heteroskedasticity in the regression quantile coefficients.

Figure 2 Quantile Regression and Ordinary Least-squares Regression Estimates of the Slope Coefficients for $\log(P_i)$ and the Temperature Polynomial for Greece, Spain and Turkey.

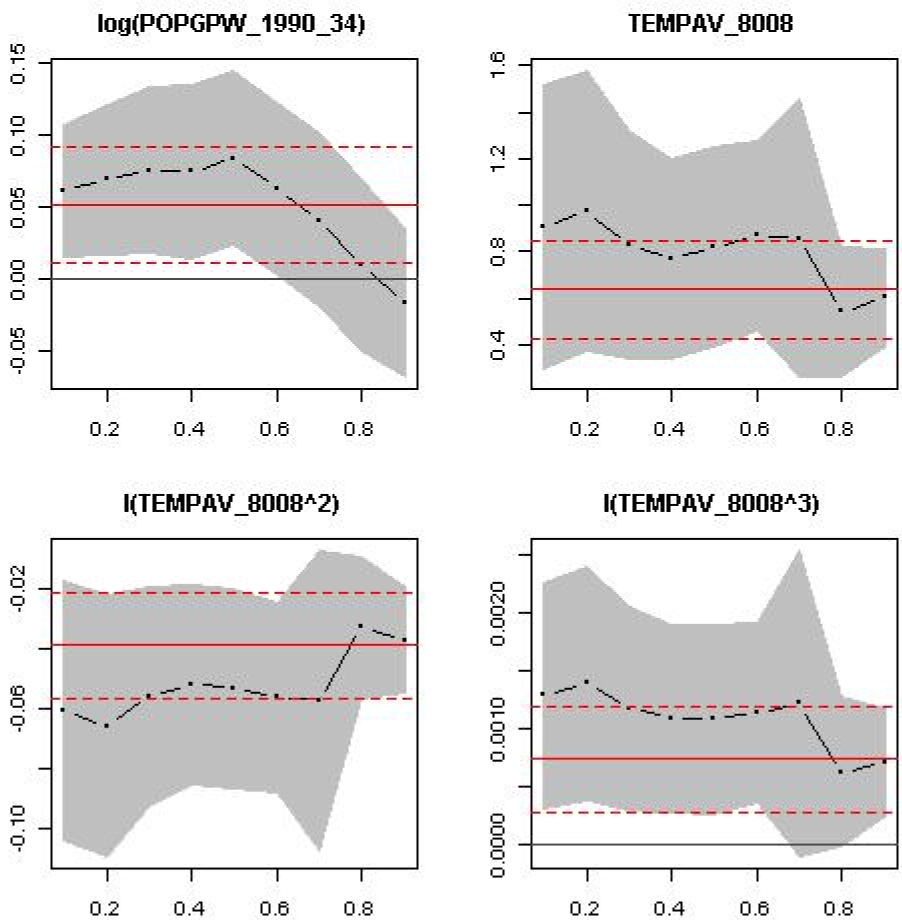


Figure 3 Quantile Regression and Ordinary Least-squares Regression Estimates of the Slope Coefficients for $\log(P_i)$ and the Temperature Polynomial for All Countries.

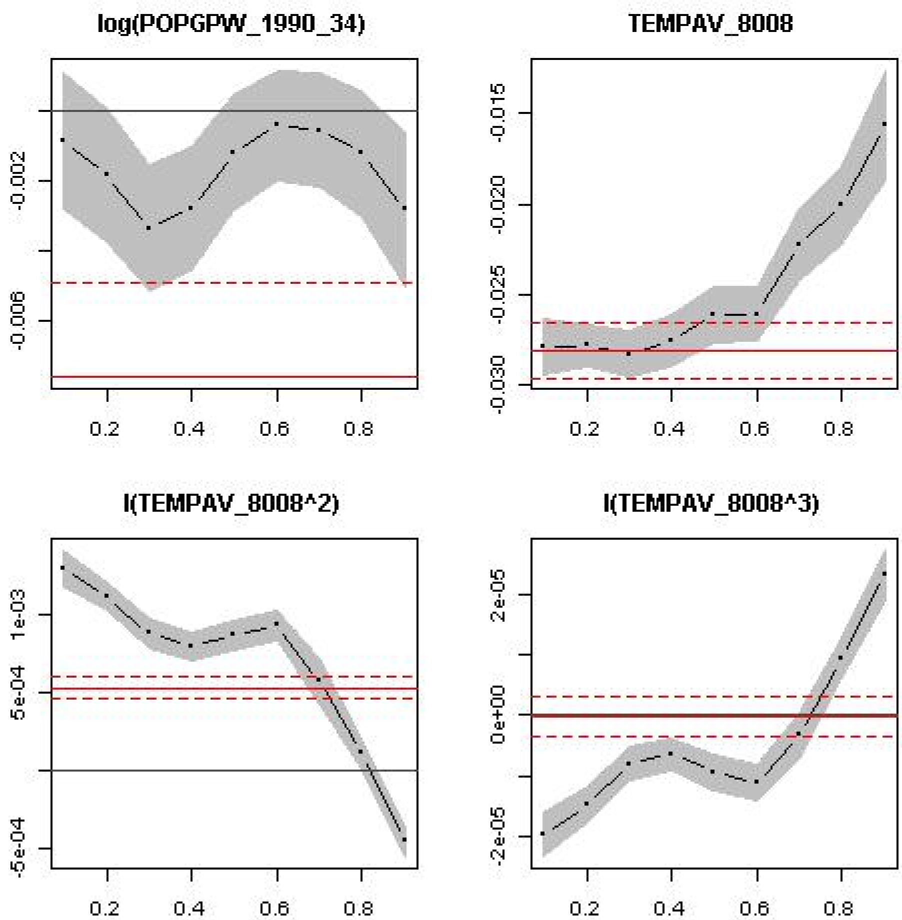


Figure 4 Quantile Regression and Ordinary Least-squares Regression Estimates of the Slope Coefficients for $\log(P_i)$ and the Temperature Polynomial for the G7 Countries.

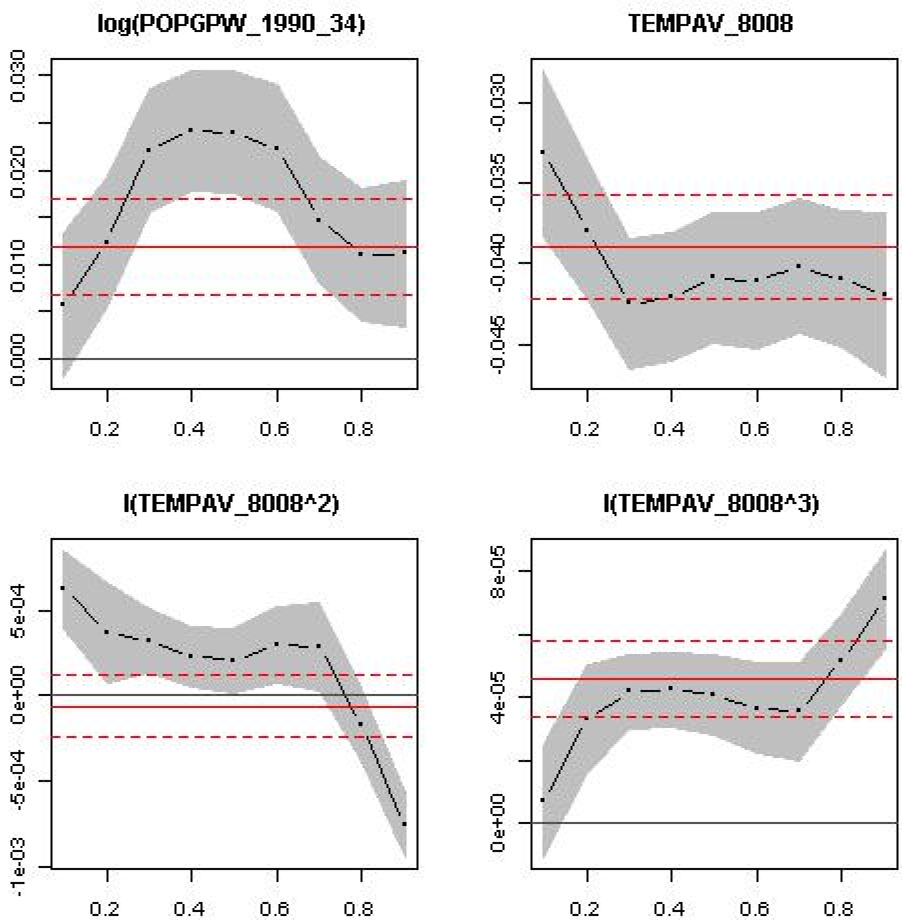
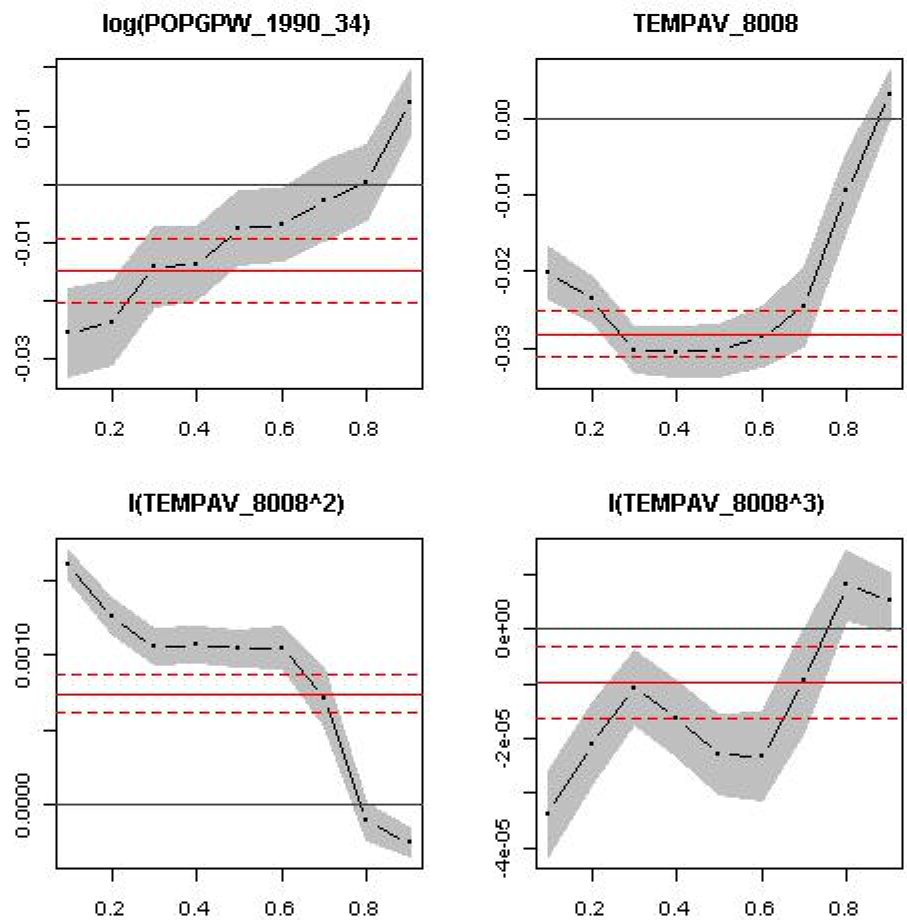


Figure 5 Quantile Regression and Ordinary Least-squares Regression Estimates of the Slope Coefficients for $\log(P_i)$ and the Temperature Polynomial for the Emerging Countries.



Based on our quantile regression estimated coefficients, we calculate and report the impacts of the one-degree (solid black curve), two-degree (dash black curve) and three-degree (dotted black curve) Celsius increase in temperature on the τ -th quantile of the GCP for $\tau \in [0.1, 0.9]$ in 0.1 increments in Figure 1. Although there is clear quantile effect on the estimated changes in GCP over the different quantiles, the general pattern is consistent with the OLS results. That is, in general, climate change's impact on tourism economies is not smaller than its impact on other types of economies if temperature increases by more than 1 degree Celsius. Therefore, our findings suggest that tourism economies should also implement aggressive climate mitigation policy.

Turkey, Greece and Spain may not be representative of tourism economies, since tourism as a percentage of GDP is still relatively small for these three economies. We, therefore, also look at a sample of the top 19 tourism economies[6] that have the highest international tourism receipt as a percentage of GDP as reported at NationMaster.com (2011). The regression result is reported in Panel E of Table 2, while the impact estimates are presented in Table 3 as well as in Panel E of Figure 1. We can see, in general, temperature increase also has significantly negative impacts on these economies. Therefore, our main findings in Tables 2 and 3 are robust.

Conclusion

Some economies such as Greece, Spain and Turkey depend particularly on tourism for promoting economic growth (e.g. Gunduz and Hatemi-J, 2005). Tourism is obviously highly sensitive to climate change. Therefore, with mounting evidence in support of the notion of climate change, an important question is:"What is the impact of climate change on tourism economies such as Greece, Spain and Turkey?" Previous studies focus on either the impact of climate change on the tourism industry or the impact of the tourism industry on economic growth. To the best of our knowledge, no research has combined these two lines of research and looks at the impact of climate change on economic growth of tourism economies. This paper intends to fill this gap. We use a model in Ng and Zhao (2011) to estimate the economic impacts of climate change on different types of economies. Our main finding is that climate change's impact on tourism economies is not smaller than its impact on other types of economies if temperature increases by more than 1 degree Celsius. Therefore, our findings suggest that tourism economies should also implement aggressive climate mitigation policy.

[6] Only 19 of the top 29 nations listed at NationMaster.com have quality GEcon data for the variables in Equation (1) and they are Albania, Bahamas, Belize, Bulgaria, Cambodia, Cape Verde, Croatia, Fiji, French Polynesia, Gambia, Jamaica, Jordan, Lebanon, Luxembourg, Mauritius, Mongolia, Morocco, Samoa, and Vanuatu.

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