That is the Story of a Hurricane: Within Country Impacts of Extreme Weather Events*

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December 2014

Abstract

In this paper, we consider the within-country, across-product impacts of hurricanes on export growth. While hurricanes are thought to exert large costs in terms of development on countries who bare the brunt of such events, there is little consensus on the literature to back up these claims. We argue that one reason for this is that the existing literature fails to take into account the potential for hurricanes to have differential impacts across products (or industries). We show that one important source of heterogeneity is a country's comparative advantage and demonstrate, using a triple-difference identification strategy, that product lines with lower comparative advantage suffer disproportionately more.

JEL classification: F14, O10, Q54.

Keywords: hurricanes, comparative advantage, trade.

*This paper was previously circulated with the title "The Cleansing Effect of Hurricanes". Without implicating them, we would like to thank Marius Brülhart, Olivier Cadot, Jean Imbs, Florian Pelgrin, Aude Pommeret, Katheline Schubert, Eric Strobl, Daniel Sturm, Mathias Thoenig and seminar participants at the University of Savoie, the EAERE Meeting 2012 (Prague) and the AERE Meeting 2013 (Banff). Jeanne Tschopp is grateful to the Swiss National Science Foundation for their financial support. We are grateful to Dean Yang for sharing his hurricane Index.

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1 Introduction

Costs related to extreme weather events keep growing and, according to the Stern Report (2007), will reach 0.5% to 1% of current world GDP by 2050. The bulk of the rise in damage is due to a surge in natural disasters, of which hurricanes are the most costly (Bevere et al., 2011) and broadly relevant form: 35% of the global population is affected by hurricanes (Hsiang and Narita, 2012) and worldwide, hurricanes caused approximately 280 billion dollars of damage over the period 1970-2002 (EM-DAT).[1]

Natural disasters, and more specifically hurricanes, have generated a significant amount of research. Despite this large body of literature, there is little consensus regarding their effects on economic outcomes (such as GDP growth). A hurricane may have a depressing effect on a country's economy. Yet, a period of de-growth may be followed by a period of expansion led, for instance, by a boost in consumption generated by the reconstruction or by the replacement of the damaged old capital with new and more efficient capital. This lack of consensus may depend on the fact that this literature has so far ignored the possibility for hurricanes to generate heterogeneous impacts within a country. This paper considers differences in comparative advantage as a potential source of heterogeneity. To test this hypothesis, we take advantage of highly disaggregated export data to examine whether the effect of hurricanes on the pattern of trade depends on product-country-specific comparative advantage.

The mechanisms underlying this hypothesis are consistent with theories of heterogeneous firms. In this class of model, firms may respond to hurricanes along at least three adjustment margins. First, firms may reduce exports by adjusting their mix of inputs (e.g. their capital-to-labor ratio), in which case, the adjustment occurs at the intensive margin. Alternatively, firms may adjust at the extensive margin: on one hand, since hurricanes reduce the oppor-

[1] EM-DAT: The OFDA/CRED International Database, Université Catholique de Louvain (www.emdat.net).

tunity cost of switching product lines (entrepreneurs do not have a choice and in order to continue to produce they have to sustain new sunk costs), some firms may find it profitable to reallocate resources and upgrade to a production which lines up more closely with the producing country's factor endowments; on the other hand, firms whose productivity level is below the export productivity cutoff (i.e. the productivity level required to realize profitable exports) may exit the export market and fall back into the domestic market. If the exit of firms is more pronounced for products with lower comparative advantage, this last margin of adjustment will also shift export patterns towards goods with higher comparative advantage.

This paper uses exports of 27 developing countries, disaggregated at the HS6 level over the period 1995-2005, to test whether product lines with lower comparative advantage suffer disproportionately more in the aftermath of a hurricane. While using product-country-specific disaggregated data allows us to gain insights on the heterogeneity of the impacts, it is important to note that these data do not provide information on firm dynamics and, therefore, on which of the above mechanisms dominates.

This paper focuses on developing countries, which are likely to suffer the largest damages, as adequate hurricane preparedness and complete insurance markets are often lacking. Notwithstanding their importance for developing countries, we leave out of our analysis agricultural products and focus only on manufacturing exports. Agricultural exports are often affected by tariffs and subsidies, making it more difficult to disentangle the effect in which we are interested.[2]

So far, the literature has failed to reach a general agreement about the effects of hurricanes on economic growth. In a recent paper, Hsiang and Jina (2014) review the hypotheses advanced by the literature and group them into four categories: (i) creative destruction (e.g.

[2]While manufacturing accounted on average for 19% of the GDP of the countries in our sample, manufacturing export accounted on average for 54% of total exports, making it a non-negligible share of exports.

Skidmore and Toya, 2002; Belasen and Polachek, 2008; Hsiang, 2010; Deryugina, 2011); (ii) build back better (e.g. Cuaresma et al., 2008; Hallegatte and Dumas, 2009; Field et al., 2012); (iii) recovery to trend (e.g. Miguel and Roland, 2011; Stromberg, 2007; Yang, 2008; Deryugina, 2011); and (iv) no recovery (e.g. Banerjee et al., 2010; Udry, 1994; Duflo, 2000; Maccini and Yang, 2009; Besley and Burgess, 2002; Hsiang et al., 2011; Hsiang and Jina, 2014). While earlier research used count or dummy variables as proxies for hurricanes, the studies reviewed by Hsiang and Jina (2014) treat hurricanes as phenomena with variable intensity. A distinguishing feature of our paper is that we focus not only on the heterogeneous aspect of hurricanes, but also on the heterogeneity of their effects. Our main contribution is to show that country-product specificities, such as comparative advantage, play an important role in the way a country adjusts to hurricanes, and that omitting these specificities can be misleading and lead to diverging conclusions regarding exports and, consequently, economic growth.

This paper also provides additional support to the literature highlighting the importance of comparative advantage as a determinant of the pattern of trade (e.g. Baldwin, 1971, 1979; Bowen et al. 1987; Davis et al. 1997; Davis and Weinstein 2001; Harrigan 1997; Harkness 1978; Leamer, 1980; Leontief, 1953; Romalis, 2004; Trefler, 1993, 1995; Wright, 1990). This literature establishes that countries tend to specialize in the export of good with high comparative advantage.

To quantify the comparative advantage of each good by country, we construct a variable that measures the distance between the vector of a product's revealed factor intensities and the vector of the producing country's factor endowments. Hurricanes are measured by an index reflecting their destructive potential at the country level. An appealing feature of this index is that it takes into account both the force of the hurricane and the population density along the hurricane's path.

A natural way of testing our hypothesis is to adopt a specification similar to that proposed by Rajan and Zingales (1998), Nunn (2007) or Levchenko (2007), who interact industry-specific with country-specific variables in various contexts to explain the pattern of trade.[3] In the particular case of this paper, such a specification consists in regressing a first difference of exports at the product-country level on the measures of comparative advantage, hurricanes and the interaction of the former variables. The coefficient on the interaction term is the estimate of interest and captures the differential impacts of a hurricane across products.

The drawback of such a specification is that it does not control for potential country-specific forces – such as country financial markets, institutions, contract enforcement or construction laws – that may affect the pattern of trade. To deal with this issue, we propose the introduction of an entire set of country-time dummies, which would imply comparing (periodical) changes in exports across products within a country.[4] Introducing country-time dummies boils down to comparing changes in exports for orange juice with those of textiles in China and estimating the role of comparative advantage in explaining the residual variation. The identifying variation results from the differential response of orange juice and textiles to the same hurricane. To ensure that this residual variation is not the result of unobserved product-specific components, such as global technological advances, we also add product-time dummies, which turns our specification into a triple-difference estimation. Therefore, an important contribution of our paper is to identify the coefficient of interest using "within-country across-product" as well as "within-product across-country" data variation.

Since the reorganization of production towards a better use of resources may take time, we also estimate long-term effects by adding dynamic components to the previous specification.

[3]Rajan and Zingales (1998) uses such a functional form to examine whether industries that rely more heavily on external financing grow faster in countries with better financial markets. Nunn (2007) tests whether countries with better contract enforcement specialize in contract-intensive industries. Levchenko (2007) asks if countries with better institutions specialize in goods which depend strongly on institutions.

[4]Introducing country-time dummies implies that the coefficient on the hurricane measure cannot be identified (but the coefficient of interest, on the interaction term, can be identified).

Most countries in our sample are constantly on their adjustment path as they face successive hurricanes over the period considered. Identifying an effect for these countries may be difficult as the reallocation potential induced by an additional shock is muted. In order to tackle this issue, we complement the dynamic specification with an event study approach.

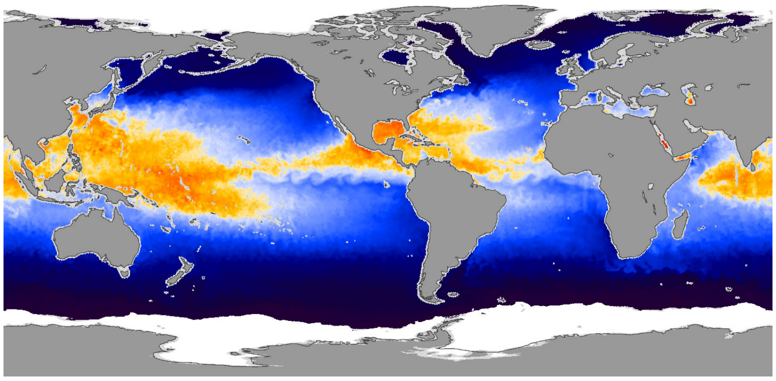
Our findings suggest that hurricanes generate heterogeneous impacts within countries, and that ignoring this heterogeneity would lead to the conclusion that hurricanes have no statistically significant impact on export values. Results indicate that product lines with lower comparative advantage suffer disproportionately more in the aftermath of a hurricane. Specifically, estimates indicate that in response to a hurricane of force one, exports decrease by an extra 6.4% for each additional unit increase in the distance between the vector of a product's revealed factor intensities and the vector of the producing country's factor endowments. In order to get a sense of what this result means, consider the most devastating hurricane in our sample and Belize. Results predict that in 2004, while this hurricane would have reduced exports of mens' overcoats (a good with a high comparative advantage) by 0.59%, exports of orange juice (a good with lower comparative advantage) would have decreased by 3%. The dynamic specification and the event study suggest that long-term effects are economically more important: at least six times bigger than the contemporaneous effects. Using the previous example, the estimated long-term effects suggest that exports of mens' overcoats and orange juice would have declined by 3.63% and 18.6% after three years, respectively. Overall, these findings suggest that hurricanes have negative impacts on export values in the short and in the long run, yet, due to differences in comparative advantage, these impacts exhibit substantial heterogeneity across products and countries.

2 Background on hurricanes

The term *hurricane* typically describes severe tropical storms over the Atlantic or the East Pacific Ocean (i.e. storms with a wind speed exceeding 74 miles/119 kilometers per hour). The same event in the Western Pacific is known as a *typhoon* – or *tropical cyclone* – over the Indian Ocean and in Oceania.

The formation of a hurricane requires a set of particular conditions. First, to a depth of 50 meters, the ocean needs to reach at least 79.7°F (26.5°C). Figure 1 depicts zones where these temperatures are usually achieved.

Figure 1: Hurricane-prone waters.



Source: NASA, Earth Observatory.

At this temperature, water creates instability in the overlying atmosphere. Second, the water vapor needs to cool rapidly while rising in the atmosphere. This condensation releases the heat which powers the hurricane. Third, high humidity is required: disturbances in the troposphere form more easily if it contains a lot of moisture. Fourth, the storm's circulation should not be disrupted by high amounts of wind shear.[5] Fifth, the Coriolis effect should be strong enough to deflect winds blowing toward the low-pressure center and to create a circulation, i.e. the distance from the equator needs to be greater than 555 km – or 5

[5]Wind shear refers to the variation of wind over either horizontal or vertical distances.

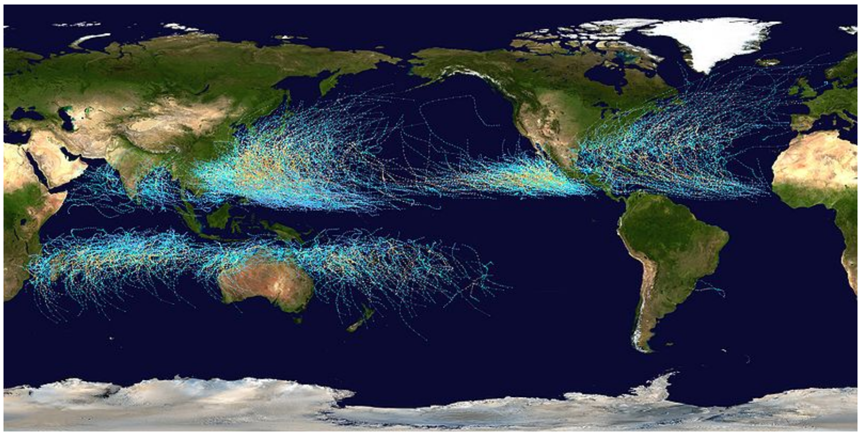
degrees of latitude.[6] While hurricanes always originate in tropical areas, they can end up in temperate areas, i.e. the US Atlantic coast or the temperate coast of East Asia and Japan.

3 Data

3.1 Hurricanes

We measure hurricanes using an index constructed in Yang (2008). The raw data used to build this index come from two US government agencies: the NOAA Tropical Prediction Center (for Atlantic and Eastern North Pacific hurricanes) and the Naval Pacific Meteorology and Oceanography Center/Joint Typhoon Warning Center (for hurricanes in the Indian Ocean, Western North Pacific, and Oceania). These centers provide *best tracks* for each hurricane. A *best track* reports the position and the wind-strength characterizing the eye of a hurricane at intervals of six hours. Figure 2 shows all best tracks over the period 1985-2005, while Figure 3 focuses on the best tracks for Oceania in 2010.

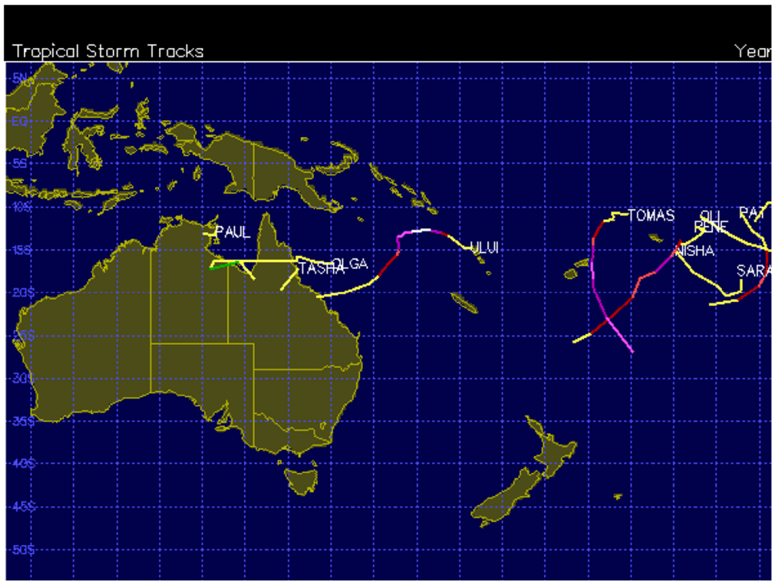
Figure 2: Best tracks, over the period 1985-2005.



Source: National Hurricane Center (NOAA).

[6]The Coriolis effect is caused by the rotation of the earth and the inertia of the mass experiencing the effect.

Figure 3: Best tracks, Oceania, 2010.



Source: Naval Pacific Meteorology and Oceanography Center.

The index reflects the destructive potential of hurricanes, taking into account both their force and the population density along their path. This measure is defined as,

$$S_{ct} = \frac{\sum_l \sum_s x_{lsct}}{L_{ct}}.$$

where L denotes population. x_{lsct} captures individual l's affectedness by hurricane s in country c at time t and is given by,

$$x_{lsct} = \frac{(w_{lsct} - 33)^2}{(w^{MAX} - 33)^2},$$

where w_{lsct} and w^{MAX} are hurricane-s wind speed and the maximum wind speed observed in the sample, respectively. The number 33 represents the hurricane wind speed threshold (in knots) and squares capture the force exerted by the wind on structures. Individuals within a 0.25-degree-square worldwide grid are treated homogeneously with respect to wind exposure.

Hurricanes inflict damage in three different ways: through the force exerted by wind, surges and precipitation. By focusing on wind speed, this index is well suited to studying the effect of hurricanes on economic activity. Wind speed, as opposed to surges, is not limited to coastal areas and can therefore account for damage inflicted to the country-wide economy. Moreover, focusing on wind speed renders the hurricane measure exogenous to economic activity. Indeed, whereas flooding may be caused by excessive deforestation, wind destruction does not depend on land usage.

The identification of the desired effect requires locating regions whose manufacturing activity is touched. Indeed, a storm with extremely high winds passing through a scarcely populated area is unlikely to affect the manufacturing industry. Using an index based on individual l's affectedness by hurricane s partially solves this issue, i.e. a hurricane crossing a densely populated area will be weighted more heavily in the index even if characterized by a low wind speed.

Expressing the index in per capita terms is convenient because it allows us to account for the size of the country. Consider a big country like China and a small one like Belize, and a strong hurricane crossing only one of the 0.25-degree-square grids. The hurricane will likely have a smaller impact on the Chinese economy. Normalizing the index by population size makes the impact of hurricanes on aggregate economic activity comparable across countries.

Table 1 shows summary statistics of the hurricane index, S, over the period 1995-2004.

Table 1: Summary statistics for hurricanes

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**Nb. of years with hurricanes**
Overall	0.010	0.031	0.000	0.243	
Bangladesh	0.006	0.010	0.000	0.024	5
Belize	0.069	0.089	0.007	0.132	2
Cambodia	0.000	0.000	0.000	0.001	4
China	0.002	0.001	0.000	0.004	9
Colombia	0.000	-	0.000	0.000	1
Cuba	0.013	0.011	0.000	0.031	6
El Salvador	0.000	-	0.000	0.000	1
Guatemala	0.011	-	0.011	0.011	1
Haiti	0.009	0.010	0.002	0.016	2
Honduras	0.005	0.007	0.000	0.013	3
India	0.001	0.001	0.000	0.004	7
Jamaica	0.002	0.002	0.000	0.003	2
Laos	0.001	0.001	0.000	0.002	6
Malaysia	0.001	0.001	0.000	0.001	2
Mauritius	0.038	0.060	0.001	0.127	4
Mexico	0.002	0.002	0.000	0.006	9
Mozambique	0.004	0.005	0.000	0.011	4
Nicaragua	0.005	0.007	0.000	0.010	2
Pakistan	0.002	0.003	0.000	0.004	2
Papua New Guinea	0.000	-	0.000	0.000	1
Philippines	0.042	0.078	0.000	0.243	9
Sri Lanka	0.003	-	0.003	0.003	1
Thailand	0.000	0.000	0.000	0.000	5
Tonga	0.037	0.044	0.006	0.069	2
Venezuela	0.000	-	0.000	0.000	1
Vietnam	0.007	0.009	0.000	0.025	8
Zimbabwe	0.001	-	0.001	0.001	1

Note: The column **Min.** represents the minimum value of a hurricane in a given country. Values of 0.000 denote values smaller than 0.001.

The table highlights the variation of the index both across years and across countries. The overall mean and the maximum values are 0.01 and 0.243, respectively. China, Mexico and the Philippines experienced hurricanes every year of the sample. Relative to China and Mexico, the index suggest that the hurricanes hitting the Philippines are on average 20 times stronger (with an average value of 0.042 for the Philippines against 0.002 for the two other countries). Countries like Thailand and Cambodia highlight the advantage of using this type of index over a dummy variable indicating the presence of hurricanes. For instance, Thailand experienced hurricanes in five out of the nine years included in the sample, yet the average hurricane intensity is below 0.001.[7] Since both countries were hit the same number of years, a dummy variable would treat the Thai and Bangladeshi cases identically, although the index indicates that hurricanes were on average 350 times larger in Bangladesh.

3.2 Economic data

Data on manufacturing exports are taken from the CEPII BACI database, which covers more than 200 countries over the period 1995-2005. Products are disaggregated at the 6-digit level according to the HS6 products classification. GDP per capita is from the World Bank Development Indicators. All values are expressed in constant 2000 USD. On average, manufacturing represents 18.3% of the GDP of the countries of our sample.[8] The interquartile range (7.4) indicates a low dispersion of the data, suggesting that the manufacturing sector is similarly important across countries. Manufacturing exports over total exports exhibits a larger variance: a standard deviation of 21.8 versus 7.1 for manufacturing over GDP. Nevertheless, the mean and median of the distribution (35.2% and 36.5%, respectively) show that manufacturing represents a significant part of exports.

Data on revealed factor intensities and national factor endowments are taken from Cadot et al. (2009). The authors construct these measures as follows. The physical stock of

[7]Values of 0.000 in the table denote values smaller than 0.001.

[8]The countries we consider are: Mauritius, Mozambique and Zimbabwe in Africa; Bangladesh, Cambodia, China, India, Laos, Malaysia, Pakistan, Philippines, Sri Lanka, Thailand and Viet Nam in Asia; Papua New Guinea and Tonga in Oceania; Belize, Cuba, El Salvador, Guatemala, Honduras, Haiti, Jamaica, Mexico and Nicaragua in Central America; and Colombia and Venezuela in Latin America.

capital is constructed using the perpetual inventory method (PIM). The PIM defines the stock of capital as the sum of yesterday's investment flow and depreciated capital stock. Importantly, since capital stock is an aggregate of past investment flows only, it is not contemporaneously affected by hurricanes. The stock of human capital is computed using average years of schooling. This measure is insensitive to hurricanes, given the low number of fatalities reported relative to a country's population (see e.g. EM-DAT). Revealed factor intensities are weighted averages of factor endowments across countries, where the weights are a variant of the Balassa index of comparative advantage.[9]

To construct a product-country-specific comparative advantage measure, we compute the distance between the vector of a product's revealed factor intensities and the vector of the factor endowments of the producing country. Let κ_{ct} be country c's stock of physical capital per capita and h_{ct} be country c's stock of human capital per capita. $\hat{\kappa}_{it}$ and $\hat{h}_{it}$ are the revealed physical and human capital intensity of product i, respectively. At a given date, the comparative advantage of product i in country c, denoted CA_{ict}, is

$$CA_{ict} = \sqrt{[std(\kappa_{ct} - \hat{\kappa}_{it})]^2 + [std(h_{ct} - \hat{h}_{it})]^2},$$

where std denotes standardized absolute differences with mean 0 and standard deviation 1. A high value of CA_{itct} denotes a product whose comparative advantage in country c is relatively low.

Table 2 shows summary statistics for comparative advantages. The mean and standard deviation are weighted by the share of every product in the country's total exports. Values of comparative advantage vary between a minimum of 0.001 and a maximum of 4.007. Ja-

[9]The weights are given by

$$\omega_{ict} = \frac{X_{ict}/X_{ct}}{\sum_c X_{ict}/X_{ct}},$$

where X denotes all exports (including manufacturing).

maica is the country whose export mix has the highest comparative advantage (1.009), while Mozambique is the country with the lowest (1.29).

Table 2: Summary statistics for comparative advantages

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Bangladesh	1.189	0.244	0.009	3.949
Belize	1.228	0.170	0.007	3.987
Cambodia	1.230	0.260	0.022	3.927
China	1.166	0.235	0.004	3.991
Colombia	1.198	0.178	0.004	4.004
Cuba	1.154	0.251	0.007	3.897
El Salvador	1.205	0.351	0.007	3.952
Guatemala	1.199	0.181	0.001	3.973
Haiti	1.182	0.213	0.034	3.943
Honduras	1.157	0.308	0.011	3.971
India	1.152	0.193	0.001	4.002
Jamaica	1.009	0.487	0.005	3.947
Laos	1.258	0.285	0.020	3.969
Malaysia	1.152	0.283	0.009	3.988
Mauritius	1.198	0.311	0.009	3.980
Mexico	1.164	0.215	0.002	3.979
Mozambique	1.290	0.256	0.016	3.956
Nicaragua	1.195	0.250	0.008	3.975
Pakistan	1.178	0.252	0.005	3.966
Papua New Guinea	1.129	0.247	0.002	3.968
Philippines	1.164	0.180	0.005	4.007
Sri Lanka	1.178	0.196	0.004	4.005
Thailand	1.164	0.173	0.008	4.004
Tonga	1.173	0.345	0.043	3.879
Venezuela	1.248	0.399	0.006	3.982
Vietnam	1.184	0.224	0.005	3.973
Zimbabwe	1.186	0.208	0.005	3.971

Note: The mean and standard deviation are weighted by the share of every product in the country's total exports.

4 Estimating Equation

We test our hypothesis by estimating the following specification:

$$\Delta \log X_{ict} = \Delta\delta_t + \beta_1 \Delta H_{ct} + \beta_2 \Delta CA_{ict} + \beta_3 \Delta(H_{ct} * CA_{ict}) + \Delta \mathbf{Z}_{ct} \boldsymbol{\gamma}_1 + \Delta \mathbf{Z}_{it} \boldsymbol{\gamma}_2 + \Delta\varepsilon_{ict}, \qquad (1)$$

where Δ indicates a yearly difference over time; X_{ict} denotes export values for product line i from country c to all other countries in the world at time t; H_{ct} is a measure reflecting the per capita affectedness in country c by hurricanes until time t. In order to account for persistence in the effect of hurricanes on export patterns, we use $H_{ct} = \sum_t S_{ct}$, a cumulated measure of the index over years, in our analysis. Finally, the term CA_{ict} is the comparative advantage of product i in country c at time t. Equation (1) controls for the determinants of comparative advantage and for other factors that may affect exports. Z_{ct} is a vector of country-specific variables including factor endowments and the GDP per capita of country c at time t, Z_{it} is a vector of product-specific variables including the revealed factor intensities of product i at time t, and ε_{ict} is the error term.[10]

β_1 measures the effect of hurricanes on the log export values of a country. If hurricanes decrease exports, one would expect this coefficient to be negative. β_2 captures the importance of country factor endowments as a source of comparative advantage. This coefficient will be negative if countries specialize in the good that uses one of their abundant factors intensively. Romalis (2004) uses a similar measure, interacting factor endowments with factor intensities of production. We are interested in β_3, the coefficient on the interaction term, which captures the effect of hurricanes on the pattern of trade. A negative coefficient indicates that goods with a lower comparative advantage suffer more from hurricanes. That is, hurricanes reduce

[10]We deal with zero trade flows by replacing zero export values with the first percentile of the distribution of strictly positive export flows. The same approach is used, for instance, in Van Bergeijk and Oldersma (1990) and McCallum (1995).

disproportionately more exports of goods with a weaker comparative advantage. Although hurricanes are exogenous phenomena, they may destroy capital and, therefore, modify the comparative advantage of a product. As a result, estimates of β_1 and β_3 may also capture the effect of hurricanes on capital. We deal with this issue using a measure of capital based on the *perpetual inventory method.* This method constructs capital stock by aggregating past investment flows. For this reason, CA_{ict} is not contemporaneously affected by a hurricane.

Previous studies have used a similar functional form, interacting industry- with country-specific variables, to explain the pattern of trade. For instance, Rajan and Zingales (1998) test whether industries that rely more heavily on external financing grow faster in countries with better financial markets. Nunn (2007) uses this functional form to test whether countries with better contract enforcement specialize in contract-intensive industries. Levchenko (2007) relies on a similar specification to examine if countries with better institutions specialize in goods which depend strongly on institutions. The drawback of equation (1) is that it does not control for these potential country-specific forces that may affect the pattern of trade. If a country's financial markets, institutions, contract enforcement or construction laws are correlated to the way exports react to hurricanes, then equation (1) may produce a biased estimate of β_3. To investigate whether such forces interfere with our coefficient of interest, we add an entire set of country-time dummies, denoted by $\Delta\delta_{ct}$, to equation (1), i.e.

$$\Delta \log X_{ict} = \Delta\delta_{ct} + \beta_2 \Delta CA_{ict} + \beta_3 \Delta(H_{ct} * CA_{ict}) + \Delta \mathbf{Z}_{it} \boldsymbol{\gamma}_2 + \Delta\varepsilon_{ict}, \tag{2}$$

where ΔH_{ct} and $\Delta \mathbf{Z}_{ct}$ have dropped from the equation because they are collinear to $\Delta\delta_{ct}$. The inclusion of country-time dummies implies that β_3 is identified by comparing periodical changes in exports across products within a country. For instance, in a framework with two products, equation (2) would compare changes in exports for product i with those of product j in country c and, after controlling for product-specific variables $\mathbf{Z}_{it}$, estimate the role of comparative advantages, as captured by CA_{ict} and $(H_{ct} * CA_{ict})$, in explaining the residual variation. Since the difference-in-difference is taken within a country, this residual variation cannot be the result of country-specific forces, which implies that the variation identifying β_3 most likely results from the differential response of products i and j to the same hurricane. However, this residual variation may still be explained by unobserved product-specific components, such as global technological advances. For this reason, we go a step further and implement a stricter specification adding product-time dummies, denoted by $\Delta\delta_{it}$, to equation (2), i.e.

$$\Delta \log X_{ict} = \Delta\delta_{ct} + \Delta\delta_{it} + \beta_2 \Delta CA_{ict} + \beta_3 \Delta(H_{ct} * CA_{ict}) + \Delta\varepsilon_{ict}. \tag{3}$$

Adding an entire set of product-time dummies turns specification (2) into a triple difference estimation, which, in addition to using 'within-country across-product' data variation, compares periodical differences in exports 'within product and across countries'.

5 Results and interpretation

Table 3 shows results for equation (1). Standard errors are clustered at the country level. In column (1) we examine whether our measure of comparative advantage aligns with earlier findings. The estimates on comparative advantage are negative and statistically significant at the 1% level, supporting the claim that factor proportions are determinants of the pattern of trade (see, for instance, Romalis (2004) and Nunn (2007)). We also control for country endowments and products' revealed factor intensities separately. The estimates on these controls are generally statistically insignificant, presumably because the effect of country endowments on exports is soaked up by the measure of comparative advantage. The coefficient

Table 3: Main results

	Dependent variable: Δ Log export value$_{ic}$					
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Comparative advantage$_{ic}$	-0.020^{***}	-0.020^{***}	-0.018^{***}	-0.019^{***}	-0.006	-0.007
	(0.004)	(0.004)	(0.004)	(0.004)	(0.010)	(0.007)
Δ Hurricane$_c$		-0.116	-0.052		-0.013	
		(0.676)	(0.667)		(0.691)	
Δ (Comparative advantage$_{ic}$ x Hurricane$_c$)			-0.064^{***}	-0.042^{***}	-0.058^{***}	-0.037^{**}
			(0.015)	(0.012)	(0.017)	(0.013)
Δ Physical capital$_c$	0.000	0.000	0.000		0.000	
	(0.000)	(0.000)	(0.000)		(0.000)	
Δ Human capital$_c$	0.124	0.120	0.119		0.125	
	(0.286)	(0.287)	(0.287)		(0.300)	
Δ Revealed capital intensity$_i$	-0.000^{***}	-0.000^{***}	-0.000^{***}	-0.000^{***}		
	(0.000)	(0.000)	(0.000)	(0.000)		
Δ Revealed human capital intensity$_i$	-0.005	-0.005	-0.005	-0.005		
	(0.013)	(0.013)	(0.013)	(0.012)		
Δ log of GDP per capita$_c$	0.400^{***}	0.399^{***}	0.400^{***}		0.406^{***}	
	(0.085)	(0.085)	(0.085)		(0.086)	
Time F.E.	yes	yes	yes	yes	yes	no
Country-time F.E.	no	no	no	yes	no	yes
Product-time F.E.	no	no	no	no	yes	yes
Observations	457,595	457,595	457,595	457,595	457,595	457,595

Notes: Standard errors, in parentheses, are clustered at the country level. *** p<0.01, ** p<0.05, * p<0.1.

on GDP per capita is statistically significant at the 1% level and of the expected positive sign.

Column (2) introduces hurricanes into the export equation. The estimate on hurricanes is negative, but not statistically significant. In order to capture the effect of hurricanes on the pattern of trade, column (3) adds the interaction between the measures of hurricanes and of comparative advantage. The estimate on the interaction term is negative and statistically significant at the 1% level, suggesting that the coefficient on hurricanes masks heterogeneity across products with different comparative advantages.

Columns (4), (5) and (6) report stricter specifications. Column (4) estimates equation (2), which adds country-time fixed effects to the former specification. These dummies control for country-time-specific forces such as a financial markets, institutions, regulations, insurances, contract enforcement or construction laws. In column (5), we replace country-time with product-time fixed effects. Finally, equation (3), presented in column (6), combines the two previous columns and estimates a triple difference that compares periodical changes in exports within and across countries. The coefficient of interest is robust across the different specifications. Its sign remains unchanged and it is statistically significant at the 1% level, except in the stricter specification, where the statistical significance drops to 5%.

In column (3), the coefficient on the interaction term indicates that in response to a hurricane of force one, exports decrease by an extra 6.4% for each additional unit increase in comparative advantage. In order to illustrate the heterogeneity of the effect within and across countries, consider the following example built upon the strongest hurricane in our sample (of force 0.243). Our database indicates that in 2004, *mens' or boys' overcoats, car-coats, knitted or crocheted* had a high comparative advantage (equal to 0.38) in Belize.[11]

[11] *Mens' or boys' overcoats, car-coats, knitted or crocheted* corresponds to product HS6 610110.

Therefore, the strike of the hurricane would have reduced its exports by 0.59%.[12] If, instead, we consider *orange juice*, a product with a lower comparative advantage (equal to 1.95), exports would have decreased by 3%.[13] In China, *orange juice* had a higher comparative advantage (equal to 0.32), which would have implied a 0.5% export reduction. This example clearly shows the importance of accounting for product heterogeneity when estimating the impact of a hurricane on exports.

Robustness Table 4 and Table 5 show two robustness tests for the main results. Table 4 presents a stricter specification in which the standard errors are two-way clustered at the country and the product level. The results are robust to this change in the specification: the level of statistical significance is not affected by this type of two-level clustering.

Table 5 shows that dropping geographically small countries (defined as countries whose surface is smaller than 200,000 square kilometers) from the sample does not alter the qualitative aspect of our estimate of interest β_3.[14] In small countries, the probability that the havoc from a hurricane affects the capital stock is higher, as hurricanes are likely to affect a large portion of a small country. Therefore, the aim of this robustness test is to ensure that our estimations do not suffer from a problem of bad controls in which hurricanes, in addition to export values, would also affect the measure of comparative advantage.[15] The coefficients of interest are also robust to this test, and do not change in terms of sign, magnitude or statistical significance.

[12] $\beta_3 * CA_{ict} * \Delta H_{ct} = -0.064 * 0.38 * 0.243$.

[13] *Orange juice* corresponds to product HS6 200911.

[14] These countries are: Bangladesh, Barbardos, Belize, Cambodia, Cuba, Fiji Islands, Guatemala, Haiti, Honduras, Jamaica, Mauritius, Nicaragua, San Salvador, Sri Lanka and Tonga.

[15] As mentioned above, in the case of this paper this problem should already be taken care of by the way in which the capital stock is measured. The perpetual inventory method constructs capital stock using past investment flows, and therefore ensures that it will not be affected by any contemporaneous event.

Table 4: Results, two-way clustering.

	Dependent variable: Δ Log export value$_{ic}$					
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Comparative advantage$_{ic}$	−0.020***	−0.020***	−0.018***	−0.019***	−0.006	−0.007
	(0.004)	(0.004)	(0.004)	(0.004)	(0.010)	(0.007)
Δ Hurricane$_c$		−0.116	−0.052		−0.013	
		(0.674)	(0.666)		(0.696)	
Δ (Comparative advantage$_{ic}$ x Hurricane$_c$)			−0.064***	−0.042***	−0.058***	−0.037**
			(0.016)	(0.013)	(0.021)	(0.019)
Δ Physical capital$_c$	0.000	0.000	0.000		0.000	
	(0.000)	(0.000)	(0.000)		(0.000)	
Δ Human capital$_c$	0.124	0.120	0.119		0.125	
	(0.286)	(0.287)	(0.287)		(0.301)	
Δ Revealed capital intensity$_i$	−0.000***	−0.000***	−0.000***	−0.000***		
	(0.000)	(0.000)	(0.000)	(0.000)		
Δ Revealed human capital intensity$_i$	−0.005	−0.005	−0.005	−0.005		
	(0.013)	(0.013)	(0.013)	(0.013)		
Δ log of GDP per capita$_c$	0.400***	0.399***	0.400***		0.406***	
	(0.085)	(0.085)	(0.085)		0.086	
Time F.E.	yes	yes	yes	yes	yes	no
Country-time F.E.	no	no	no	yes	no	yes
Product-time F.E.	no	no	no	no	yes	yes
Observations	457,595	457,595	457,595	457,595	457,595	457,595

Notes: Standard errors, in parentheses, are two-way clustered at the country and product level. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Results, excluding small countries.

	Dependent variable: Δ Log export value$_{ic}$					
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Comparative advantage$_{ic}$	-0.021^{***}	-0.021^{***}	-0.019^{***}	-0.021^{***}	0.007	-0.004
	(0.004)	(0.004)	(0.004)	(0.004)	(0.012)	(0.008)
Δ Hurricane$_c$		1.485	1.528		1.564	
		(1.082)	(1.079)		(1.159)	
Δ (Comparative advantage$_{ic}$ x Hurricane$_c$)			-0.047^{***}	-0.026^{***}	-0.047^{***}	-0.027^{**}
			(0.012)	(0.009)	(0.014)	(0.011)
Δ Physical capital$_c$	0.000	0.000	0.000		0.000	
	(0.000)	(0.000)	(0.000)		(0.000)	
Δ Human capital$_c$	0.144	0.156	0.155		0.180	
	(0.416)	(0.412)	(0.412)		(0.440)	
Δ Revealed capital intensity$_i$	-0.000^{**}	-0.000^{**}	-0.000^{**}	-0.000^{**}		
	(0.000)	(0.000)	(0.000)	(0.000)		
Δ Revealed human capital intensity$_i$	-0.013	-0.013	-0.013	-0.013		
	(0.013)	(0.013)	(0.013)	(0.013)		
Δ log of GDP per capita$_c$	0.429^{***}	0.434^{***}	0.434^{***}		0.444^{***}	
	(0.083)	(0.082)	(0.082)		(0.087)	
Time F.E.	yes	yes	yes	yes	yes	no
Country-time F.E.	no	no	no	yes	no	yes
Product-time F.E.	no	no	no	no	yes	yes
Observations	327,881	327,881	327,881	327,881	327,881	327,881

Notes: Standard errors, in parentheses, are clustered at the country level. *** p<0.01, ** p<0.05, * p<0.1. Excluded countries are: Bangladesh, Barbardos, Belize, Cambodia, Cuba, Fiji Islands, Guatemala, Haiti, Honduras, Jamaica, Mauritius, Nicaragua, San Salvador, Sri Lanka, Tonga.

Dynamic results The reorganization of production toward a better use of resources may take time. Yang (2008) shows that the bulk of the adjustment in the aftermath of a hurricane occurs within three years. Therefore, to evaluate long-term effects we also present, in Table 6, estimates of a dynamic specification, i.e. including three lags of the variables of interest.

Column (1) reports the baseline estimation, while lags are added one after the other in columns (2) through (4). The effect on the interaction term becomes stronger over time, and the long-term effect is six times greater than the contemporaneous effect, increasing from -0.064 to -0.393 when all lags are introduced. In columns (5), (6) and (7) we add country-time, product-time and country- and product-time fixed effects, respectively. Even when controlling for all these effects, the coefficients of interest are still statistically significant and of the expected sign, implying a long-term effect of -0.26, statistically significant at the 1% level.

Let us consider the above example and compute what happens in the long term. If a hurricane of force 0.243 hit Belize in 2004, in the long run exports of *mens' or boys' overcoats, car-coats, knitted or crocheted*, a product with a high comparative advantage, decrease by 3.63%, while exports of *orange juice*, a product with a lower comparative advantage, decrease by 18.6%. The same product hit by a hurricane of the same force but in China, where *orange juice* has a higher comparative advantage, would see its exports decrease by 3.05%.

Table 6: Results, lags.

	Dependent variable: Δ Log export value$_{ic}$						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Δ Comparative advantage$_{ic}$	−0.018***	−0.019***	−0.022***	−0.022***	−0.023***	−0.025*	−0.029**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.013)	(0.011)
Δ Hurricane$_c$	−0.052	−0.266	−0.193	−0.940		−0.866	
	(0.667)	(0.546)	(0.469)	(0.613)		(0.642)	
Δ (Comp. ad. $_{ic}$ x Hurricane$_c$)	−0.064***	−0.067***	−0.081***	−0.095***	−0.073***	−0.092***	−0.073***
	(0.015)	(0.022)	(0.023)	(0.021)	(0.013)	(0.023)	(0.015)
L.Δ Comparative advantage$_{ic}$		−0.000	−0.005	−0.005	−0.008***	0.013	−0.005
		(0.003)	(0.003)	(0.003)	(0.003)	(0.017)	(0.009)
L.Δ Hurricane$_c$		−0.332	−0.527	−1.009*		−1.137*	
		(0.497)	(0.508)	(0.579)		(0.603)	
L.Δ (Comp. ad.$_{ic}$ x Hurricane$_c$)		0.013	−0.035	−0.064**	−0.029	−0.061**	−0.029
		(0.019)	(0.028)	(0.030)	(0.021)	(0.026)	(0.019)
L2.Δ Comparative advantage$_{ic}$			−0.005	−0.002	−0.005	−0.003	−0.017
			(0.003)	(0.004)	(0.003)	(0.017)	(0.011)
L2.Δ Hurricane$_c$			0.245	0.599		0.415	
			(0.422)	(0.450)		(0.471)	
L2.Δ (Comp. ad.$_{ic}$ x Hurricane$_c$)			−0.012	−0.100***	−0.065***	−0.084***	−0.053*
			(0.015)	(0.025)	(0.022)	(0.028)	(0.026)
L3.Δ Comparative advantage$_{ic}$				0.002	−0.001	0.027***	0.013**
				(0.004)	(0.004)	(0.009)	(0.006)
L3.Δ Hurricane$_c$				1.954***		1.875***	
				(0.645)		(0.580)	
L3.Δ (Comp. ad. $_{ic}$ x Hurricane$_c$)				−0.134***	−0.108***	−0.128***	−0.106***
				(0.023)	(0.021)	(0.029)	(0.029)
Δ Physical capital$_c$	0.000	0.000	0.000	0.000		0.000	
	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	
Δ Human capital$_c$	0.119	0.086	0.127	0.187		0.192	
	(0.287)	(0.331)	(0.382)	(0.448)		(0.477)	
Δ Revealed capital intensity$_i$	−0.000***	−0.000***	−0.000***	−0.000***	−0.000***		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
Δ Revealed human capital intensity$_i$	−0.005	−0.004	−0.003	−0.003	−0.003		
	(0.013)	(0.010)	(0.009)	(0.010)	(0.010)		
Δ log of GDP per capita$_c$	0.400***	0.454***	0.464***	0.492***		0.503***	
	(0.085)	(0.093)	(0.096)	(0.083)		(0.089)	
Time F.E.	yes	yes	yes	yes	yes	yes	no
Country-time F.E.	no	no	no	no	yes	no	yes
Product-time F.E.	no	no	no	no	no	yes	yes
Observations	457,595	374,662	309,609	253,810	253,810	253,810	253,810
Δ Hurricane$_c$ (LT effect)		−0.597	−0.475	0.604		0.286	
Δ Hurricane$_c$ (p-value)		0.529	0.653	0.599		0.801	
Δ (Comp. ad.$_{ic}$ x Hurricane$_c$) (LT effect)		−0.054	−0.128	−0.393	−0.276	−0.366	−0.260
Δ (Comp. ad.$_{ic}$ x Hurricane$_c$) (p-value)		0.177	0.015	0.000	0.000	0.000	0.000

Notes: Standard errors, in parentheses, are robust for columns (1) to (4) and clustered at the country level for columns (5) and (6). *** p<0.01, ** p<0.05, * p<0.1.

5.1 Event Study

We now turn to the dynamics of the effect of comparative advantage in the response of exports to hurricanes. A difficulty in identifying long-term adjustments is that 80% of the countries in our sample faced multiple hurricanes over the period considered. Countries experiencing successive hurricanes are constantly on their adjustment path, which implies that the reallocation potential induced by an additional shock is muted and more difficult to detect.

We approach the question using an event study methodology similar to that of Trefler (2004) and Manova (2008). Trefler (2004) investigates the long-term effects of the Canada–U.S. Free Trade Agreement on various indicators of the Canadian economy. Manova (2008) applies the same methodology to study the impact of financial liberalization on trade flows. While trade or financial liberalizations are one-time occurrences, hurricanes are repeated phenomena, making the definition of an event more delicate. As mentioned above, Yang (2008) shows that the bulk of the adjustment in the aftermath of a hurricane occurs within three years. For this reason, we focus on events preceded and followed by three storm-free years and define an event as a cluster of hurricanes spreading over a maximum period of three years. Countries retained for the event study are Guatemala, Sri Lanka, Zimbabwe, Belize, Haiti and Pakistan. A brief description of these countries and of the events considered can be found in Table 7.

Table 7: Event study: hurricanes and countries used in the study (in bold).

Year	Date	Name	Max wind speed		Fatalities	Est. damages (2011 USD)	Affected countries
			mph	kmh			
1998	15 Sept.-01 Oct.	*Hurricane George*	155	250	604	8 billion	Dom. Republic, ***Haiti*** USA, Cuba, St. Kitts and Nevis, Antigua and Barbuda, Bahamas
1999	16 May-22 May	*ARB 01 / 02 A*	125	205	6400	7.9 milion	India, ***Pakistan***
2000	03 Feb.-23 Feb.	*Cyclone Leon-Eline*	130	215	1000	unknown	***Zimbabwe***, Madagascar
2000	19 Aug.-24 Aug.	*Hurricane Debby*	85	140	0	941'000	***Haiti***, Trinidad and Tobago, USA, Cuba, Jamaica
2000	28 Sep.-06 Oct.	*Hurricane Keith*	140	220	40	408 milion	***Belize***, Nicaragua, Honduras, El Salvador, Guatemala, Mexico
2000	23 Dec.-28 Dec.	*BOB 06 / 04 B*	105	165	9	unknown	***Sri Lanka***, India
2001	04 Oct.-09 Oct.	*Hurricane Iris*	145	250	49	186 milion	***Belize***, ***Guatemala***, Dom. Republic, Jamaica, Mexico

We estimate

$$\Delta \log \overline{X}_{ic\tau} = \eta_1 \Delta \overline{H}_{c\tau} + \eta_2 \Delta \overline{CA}_{ic\tau} + \eta_3 \Delta(\overline{H}_{c\tau} * \overline{CA}_{ic\tau}) + \Delta \overline{\mathbf{Z}}_{c\tau} \boldsymbol{\alpha}_1 + \Delta \overline{\mathbf{Z}}_{i\tau} \boldsymbol{\alpha}_2 + \Delta \upsilon_{ic\tau}, \quad (4)$$

where τ denotes the time window, bars denote an average over the time window τ and $\upsilon_{ic\tau}$ is the error term. η_1, η_2 and η_3 capture the long-term effects we seek to estimate.[16] Results are shown in columns (1) to (4) of Table 8. The structure is similar to the presentation of the main results.[17]

When introduced on its own, the hurricane measure appears to have a negative and statistically significant long-term effect on exports. The next column suggests that the estimate in column (2) masks an important source of heterogeneity across products. When adding the interaction term, the long-term effect of hurricanes on exports becomes statistically insignificant. As for the baseline results, the estimate on the interaction term is negative and statistically significant at the 10% level, supporting our hypothesis that hurricanes have a larger effect on products with weaker comparative advantage. The long-run effect is important. The relatively large magnitude is consistent with the characteristics of the sample used to perform the event study. By focusing on geographically small countries, subject to more severe but less frequent hurricanes, the destructive potential of hurricanes increases. Controlling for country-time fixed effects, the coefficient on the interaction term becomes statistically significant at the 5% level.

One concern with the event study is that hurricanes are likely to affect capital and com-

[16]In order to avoid overestimating the effect of hurricanes, we restrict this exercise to products that exhibit positive export values over the time period considered. For instance, let a product disappear after the first year of the time window preceding an event, and assume that the product stays out of the market thereafter. In this case, taking averages attributes the exit of the product to the hurricane, when in fact it had already disappeared by the time of the event.

[17]Note that we exclude the specifications with product-time and both country- and product-time dummies as the number of observations falls to 6,250 in the event study.

Table 8: Results, event study.

	Dependent variable: Δ Log export value$_{ic}$							
	OLS				IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Comp ad$_{ic}$	−0.147***	−0.146***	−0.137**	−0.130**	−0.151***	−0.153**	−0.152**	−0.147**
	(0.055)	(0.055)	(0.057)	(0.056)	(0.056)	(0.063)	(0.063)	(0.063)
Δ Hurricane$_c$		−2.812***	−0.371			0.430	4.116***	
		(0.893)	(1.964)			(1.503)	(1.581)	
Δ (Comp. ad.$_{ic}$ x Hurricane$_c$)			−1.986*	−2.316**			−3.579**	−1.996**
			(1.205)	(1.068)			(1.625)	(1.009)
Δ Physical capital$_c$	0.000***	0.000***	0.000***		0.000***	0.000***	0.000***	
	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	
Δ Human capital$_c$	−0.124	−0.218	−0.215		−0.215	−0.214	−0.217	
	(0.186)	(0.197)	(0.197)		(0.188)	(0.187)	(0.188)	
Δ Revealed capital intensity$_i$	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Δ Revealed human capital intensity$_i$	−0.159**	−0.155**	−0.155**	−0.146*	−0.153*	−0.153*	−0.155*	−0.146*
	(0.077)	(0.078)	(0.078)	(0.078)	(0.081)	(0.081)	(0.081)	(0.081)
Δ log of GDP per capita$_c$	−0.181*	−0.203**	−0.204**		−0.205**	−0.204**	−0.203**	
	(0.106)	(0.091)	(0.091)		(0.087)	(0.086)	(0.087)	
Country-time F.E.	no	no	no	yes	no	no	no	yes
Observations	6,250	6,250	6,250	6,250	6,250	6,250	6,250	6,250

Notes: Standard errors, in parentheses, are two-way clustered at the country and product level. *** p<0.01, ** p<0.05, * p<0.1.

parative advantages in the 3-year period that follows the event. Thus, the estimates in columns (1) through (4) may partially reflect the effect of capital rebuilding. We deal with this issue by instrumenting the change in comparative advantage with the average value of comparative advantage in the 3-year window preceding the event. In addition, we use this measure of past comparative advantage to build the interaction term. By construction, past comparative advantages are uncorrelated to hurricanes. Results are shown in columns (5) to (8) and suggest that OLS estimates are upward biased. The coefficient on the hurricane measure becomes positive and statistically significant at the 1% level. One of the likely reasons for this effect is that capital destruction and technology upgrading encourage exports in the longer run. This result is consistent with the finding of Skidmore and Hideki' (2002) that natural disasters promote long-run growth. Nevertheless, comparative advantage appears to play a statistically significant role in the adjustment of exports to hurricanes.

6 Conclusion

In this paper, we argue that the literature examining the effects of hurricanes may have failed to reach a consensus because it ignores the potential for hurricanes to generate heterogeneous impacts within countries. We have investigated the role of comparative advantage as a source of heterogeneity by examining whether the effect of hurricanes on the pattern of manufacturing trade depends on product-country-specific comparative advantage.

Our approach is similar to that used in Rajan and Zingales (1998), Nunn (2007) and Levchenko (2007). To control for all country-specific counfounding factors – such as country financial markets, institutions, contract enforcement or construction laws – that may affect the pattern of trade, we adopt a triple-difference identification strategy that compares periodical differences in export values within and across countries. Our findings suggest that hurricanes lead to a reorganization of exports towards goods with higher comparative advantage; product lines with lower comparative advantage suffer disproportionately more from a hurricane.

References

[1] R.E. Baldwin. Determinants of the Commodity Structure of U.S. Trade. *American Economic Review*, 61(1):126–46, March 1971.

[2] R.E. Baldwin. Determinants of Trade and Foreign Investment: Further Evidence. *The Review of Economics and Statistics*, 61(1):40–48, February 1979.

[3] A. Banerjee, E. Duflo, G. Postel-Vinay, and T. Watts. Long-Run Health Impacts of Income Shocks: Wine and Phylloxera in Nineteenth-Century France. *The Review of Economics and Statistics*, 92(4):714–728, November 2010.

[4] A.R. Belasen and S.W. Polachek. How Hurricanes Affect Wages and Employment in Local Labor Markets. *American Economic Review*, 98(2):49–53, May 2008.

[5] T. Besley and R. Burgess. The Political Economy Of Government Responsiveness: Theory And Evidence From India. *The Quarterly Journal of Economics*, 117(4):1415–1451, November 2002.

[6] L. Bevere, B. Rogers, and B. Grollimund. Sigma – Natural Catastrophes and Man-Made Disasters in 2010: a Year of Devastating and Costly Events. Technical report, Swiss Reinsurance Company Ltd., 2011.

[7] H.P. Bowen, E.E. Leamer, and L. Sveikauskas. Multicountry, Multifactor Tests of the Factor Abundance Theory. *American Economic Review*, 77(5):791–809, December 1987.

[8] O. Cadot, B. Tumurchudur, and M. Shirotori. Revealed Factor Intensity Indices at the Product Level. mimeo, UNCTAD, 2009.

[9] J.C. Cuaresma, J. Hlouskova, and M. Obersteiner. Natural Disasters As Creative De-

struction? Evidence From Developing Countries. *Economic Inquiry*, 46(2):214–226, 04 2008.

[10] D.R. Davis, S.C. Bradford, and K. Shimpo. Using International and Japanese Regional Data to Determine When the Factor Abundance Theory of Trade Works. *American Economic Review*, 87(3):421–446, June 1997.

[11] D.R. Davis and D.E. Weinstein. An Account of Global Factor Trade. *American Economic Review*, 91(5):1423–1453, December 2001.

[12] T. Deryugina. The Dynamic Effects of Hurricanes in the US: The Role of Non-Disaster Transfer Payments. Working papers, Massachusetts Institute of Technology, Center for Energy and Environmental Policy Research, 2011.

[13] E. Duflo. Child Health and Household Resources in South Africa: Evidence from the Old Age Pension Program. *American Economic Review*, 90(2):393–398, May 2000.

[14] C.B. Field, V. Barros, T.F. Stocker, Q. Dahe, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adap- tation. Technical report, IPCC, 2012.

[15] S. Hallegatte and P. Dumas. Can natural disasters have positive consequences? Investigating the role of embodied technical change. *Ecological Economics*, 68(3):777–786, January 2009.

[16] J. Harkness. Factor Abundance and Comparative Advantage. *American Economic Review*, 68(5):784–800, December 1978.

[17] J. Harrigan. Technology, Factor Supplies, and International Specialization: Estimating the Neoclassical Model. *American Economic Review*, 87(4):475–94, September 1997.

[18] S.M. Hsiang. Temperatures and cyclones strongly associated with economic production in the Caribbean and Central America. *Proceedings of the National Academy of Sciences*, 107(35):15367–15372, 2010.

[19] S.M. Hsiang and A.S. Jina. The Causal Effect of Environmental Catastrophe on Long-Run Economic Growth: Evidence From 6,700 Cyclones. NBER Working Papers 20352, National Bureau of Economic Research, Inc, July 2014.

[20] S.M. Hsiang, K.C. Meng, and M.A. Cane. Civil Conflicts are associated with the Global Climate. *Nature*, 476:438–441, August 2011.

[21] S.M. Hsiang and D. Narita. Adaptation To Cyclone Risk: Evidence From The Global Cross-Section. *Climate Change Economics (CCE)*, 3(02):1250011–1–1, 2012.

[22] E.E. Leamer. The Leontief Paradox, Reconsidered. *Journal of Political Economy*, 88(3):495–503, June 1980.

[23] W. Leontief. Domestic Production and Foreign Trade: The American Capital Position Re-examined. *Proceedings of the American Philosophical Society*, 97(4):332–349, September 1953.

[24] A.A. Levchenko. Institutional Quality and International Trade. *Review of Economic Studies*, 74(3):791–819, 2007.

[25] S. Maccini and D. Yang. Under the Weather: Health, Schooling, and Economic Consequences of Early-Life Rainfall. *American Economic Review*, 99(3):1006–26, June 2009.

[26] K. Manova. Credit Constraints, Equity Market Liberalizations and International Trade. *Journal of International Economics*, 76(1):33–47, September 2008.

[27] J. McCallum. National Borders Matter: Canada-U.S. Regional Trade Patterns. *American Economic Review*, 85(3):615–623, June 1995.

[28] E. Miguel and G. Roland. The long-run impact of bombing Vietnam. *Journal of Development Economics*, 96(1):1–15, September 2011.

[29] N. Nunn. Relationship-Specificity, Incomplete Contracts, and the Pattern of Trade. *The Quarterly Journal of Economics*, 122(2):569–600, 05 2007.

[30] R.G. Rajan and L. Zingales. Financial Dependence and Growth. *American Economic Review*, 88(3):559–86, June 1998.

[31] J. Romalis. Factor Proportions and the Structure of Commodity Trade. *American Economic Review*, 94(1):67–97, March 2004.

[32] M. Skidmore and T. Hideki. Do Natural Disasters Promote Long-Run Growth? *Economic Inquiry*, 40(4):664–687, 2002.

[33] M. Skidmore and H. Toya. Do Natural Disasters Promote Long-Run Growth? *Economic Inquiry*, 40(4):664–687, October 2002.

[34] N. Stern. *The Economics of Climate Change: The Stern Review.* Cambridge University Press, 2007.

[35] D. Strömberg. Natural Disasters, Economic Development, and Humanitarian Aid. *Journal of Economic Perspectives*, 21(3):199–222, 2007.

[36] D. Trefler. International Factor Price Differences: Leontief Was Right! *Journal of Political Economy*, 101(6):961–87, December 1993.

[37] D. Trefler. The Case of the Missing Trade and Other Mysteries. *American Economic Review*, 85(5):1029–46, December 1995.

[38] D. Trefler. The Long and Short of the Canada-U. S. Free Trade Agreement. *American Economic Review*, 94(4):870–895, September 2004.

[39] C. Udry. Risk and Insurance in a Rural Credit Market: An Empirical Investigation in Northern Nigeria. *Review of Economic Studies*, 61(3):495–526, July 1994.

[40] P.A.G. Van Bergeijk and H. Oldersma. Détente, Market-Oriented Reform and German Unification: Potential Consequences for the World Trade System. *Kyklos*, 43(4):599–609, 1990.

[41] G. Wright. The Origins of American Industrial Success, 1879-1940. *American Economic Review*, 80(4):651–68, September 1990.

[42] D. Yang. Coping with Disaster: The Impact of Hurricanes on International Financial Flows, 1970-2002. *The B.E. Journal of Economic Analysis and Policy*, 8(2), 2008.