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Abstract

As climate change is established to occur on scientific bases, it is imperative to identify the effect of climate shocks on economy. According to international organizations, agriculture, forestry and fisheries are the most vulnerable sectors to climate change predominantly for developing and tropical countries, and thus it is hypothesized to have significant impacts on world-wide international trade. Although Jones and Olken (2010) demonstrate the effect of climate shocks on exports with U.S. and world data, the evidence is still highly scarce for developing countries. Given these conditions, we examine how climate shocks affect international trade by focusing on the case of the Philippines as a representative of developing and tropical countries. To this end, we apply a fixed effects model with the data of Philippine international trade and world climate from 1991 to 2009. In particular, the novelty lies in examining both exports and imports within a single empirical framework and in clarifying climate shocks on both flows of international trade. The results show that both Philippine exports and imports are negatively affected by an increase in temperature of the trade partners. We have also identified some specific sectors are highly vulnerable such as agriculture and manufacturing. Overall, these results imply that Philippine international trade shrinks as the world temperature rises, and the same qualitative results may apply to other developing and tropical countries whose features are somewhat similar to those of the Philippines. The findings could be considered an important guidance on collective policy decisions on climate change in an international community especially as developing and tropical countries would have difficulties in mitigating the effect only by themselves.

Key Words: Climate change and shock; temperature; Philippine international trade

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1 Introduction

In its Fifth Assessment Report (AR5), the Intergovernmental Panel on Climate Change (2013) reports that there are apparent and undeniable changes in the climate system undertaking since the 1950s and are unprecedented over decades to millennia.[1] The global average temperature shows a warming of 0.85 °C, over the period of 1880 to 2012. In the Philippines, from the period 1951 to 2010, mean temperature anomalies, which indicate increase of 0.648 °C or an average of 0.0108 °C per year increase, were recorded (PAGASA, 2014). Although there are some major changes in rainfall in different parts of the Philippines, extreme changes in daily rainfall are not statistically significant.

Changes in the climate system are claimed to affect various economic activities (Stern, 2006, FitzRoy and Papyrakis, 2010) and there are many previous papers and reports to clarify the relationship. In particular, international organizations report that agriculture, forestry and fisheries are the most vulnerable to climate change, particularly for developing and tropical countries (see, e.g., Watson et al., 1998, United Nations General Assembly, 2008, Charnovitz, 2010). The evidence for the relationship between agriculture and climate change or between natural resource and climate change is well documented. Many papers present the evidence supporting the vulnerability of agricultural production to climate change, although there are variations in magnitudes and in directions of the effects depending on types of crops and the geographies of regions (Kaiser, 1991, Adams et al., 1995, Darwin et al., 1995, Kurukulasuriya and Rosenthal, 2003, Peng et al., 2004, Deschenes and Greenstone, 2007, Auffhammer et al., 2006, Sanghi and Mendelsohn, 2008, You et al., 2009, Knox et al., 2012, Poudel and Kotani, 2013, Barnwal and Kotani, 2013). Some literature also addresses negative impacts of climate change on fisheries (Grantz, 1992, Hannesson et al., 2006, Brander, 2007, 2010).

Compared to the research on the relationship between climate and economic activities of spe-

[1]The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts. In the same year, the UN General Assembly endorsed the action by WMO and UNEP in jointly establishing the IPCC.

cific sectors, there are only a few studies to address the issue in aggregate macroeconomic levels. Dell et al. (2012) examine the effect of climate shocks (i.e., temperature and precipitation) to economic growth. They find that year-to-year variations in temperature negatively affect economic growth especially for developing countries. Tamiotti et al. (2009) emphasize the importance of understanding the linkage between climate change and international trade in the current globalized world as many countries trade agricultural products among each other. Therefore, it is now hypothesized that climate change might have some significant effects on most sectors of the global economy and this might have some implications for trade. In addition, climate change might also affect the comparative advantage of sectors and their trade patterns.

Although climate change can potentially affect international trade, evidence supporting this is highly scarce. One exception is Jones and Olken (2010) who study the effect of climate shocks to exports to the United States and to the world. They employ a fixed effects model by controlling temperature and precipitation of the producer countries and clarify how climate shocks in producer countries affect their exports. They find substantially negative impacts of higher temperatures on poor countries' exports, with no effects on richer countries' exports. Specifically, an additional 1 $^{\circ}$C reduces the growth rate of a poor country's exports by between 2.0 and 5.6 percentage points.[2] The impacts are concentrated in exports of agricultural products and light manufactures.

Given the lack of evidence, this study investigates the impact of climate shocks to Philippine international trade. Jones and Olken (2010) study the effect of climate shocks to the exports to the United States and to the world by controlling temperature and precipitation of exporters, but it does not investigate the impacts on both flows of exports and imports with a central focus on the case of the developing and tropical country, such as the Philippines. The novelty of this paper lies in examining both exports and imports within a single empirical framework and in clarifying climate shocks on both flows of international trade by controlling temperature and precipitation of the trade partners. More specifically, when we examine Philippine exports, the climate variables of

[2]Jones and Olken (2010) argue that an increase in temperature adversely affect labor productivity, health and mortality, which may be the reasons for negative impacts of temperature on exports. There is evidence that empirically supports this argument (Grimm and Wagner, 1974, Niemela et al., 2002, Adams et al., 2003, Adda et al., 2003, Poterba, 2003, Patz et al., 2005, Kjellstrom et al., 2009, Vaneckova et al., 2010, Yu et al., 2010, Zivin and Neidell, 2014)

the importers from the Philippines are controlled. In investigating Philippine imports, the climate variables of the exporters to the Philippines are controlled. With this approach, we can answer the following important question:

How does Philippine international trade evolve as world temperature rises?

To this end, we apply a fixed effects model with the data of Philippine international trade and world climate from 1991 to 2009. The results show that both Philippine exports and imports are negatively affected by an increase in temperature of the trade partners. We have also identified some specific sectors are highly vulnerable such as agriculture and manufacturing. Overall, these results imply that Philippine international trade shrinks as the world temperature rises, and the same qualitative results may apply to other developing and tropical countries whose characteristics are somewhat similar to the Philippines. Recall what the Intergovernmental Panel on Climate Change (2013) stresses, that is, developing and tropical countries would have difficulties in mitigating the effect only by themselves and in achieving the Millennium Development Goals (MDG) by 2015 without any collective effort of countries. In this context, the findings could be considered an important guidance on collective policy decisions on climate change in an international community.

2 Data and descriptive statistics

2.1 Data

The historical climate data is taken from the Climate Data of the World Bank. These are climate data used on the World Bank's Climate Change Knowledge Portal (CCKP). The CCKP is a central hub of information, data and reports about climate change around the world. Here, we can query, map, compare, chart and summarize key climate and climate-related information. All the data are open for the public use certified by the World Bank. With the data source, annual average temperature (in $^{\circ}\mathrm{C}$ yearly average) and precipitation (in mm yearly average) in different time periods are collected for the countries in the world that have trade records with the Philippines

from 1991 to 2009.

The trade data is collected from the Philippine National Statistics Office (NSO).[3] These comprise both annual exports and imports of goods from 1991 to 2009 in terms of Free on Board (FOB) value, which includes inland freight, export duty and other expenses. The commodities are classified in accordance with the 2004 Philippine Standard Commodity Classification (PSCC) which is aligned with the United Nations Standard International Trade Classification (SITC), and the Harmonized Commodity Description and Coding System of the Philippines, otherwise known as Harmonized System of the Philippines (HSP) (table 1). Since the trade data is quite huge, the analysis is restricted to the one-digit SITC and two-digit PSCC category. The per capita GDP came from the World Development Indicators of the World Bank. The countries are classified into low income (LI), low middle income (LMI), high middle income (HMI), non-OECD and OECD countries. These are used to classify countries as poor and non-poor when we analyze the data.

[Table 1 about here.]

2.2 Temperature and precipitation in the world and Asia

We use the country-specific average of annual temperature and rainfall in the analysis, following Jones and Olken (2010). First, we present the average annual world temperature from 1991 to 2009 (figure 1). Figure 1 shows that the average annual temperature in the world is increasing in this period. Based on the data, the hottest temperature is recorded in Mali with $29.31\ ^{\circ}\mathrm{C}$ while the coldest is in Greenland with $-16.75\ ^{\circ}\mathrm{C}$. Taking all the countries in Asia, the same result is observed. Figure 2 illustrates that the temperature in Asia is increasing. In the same way, we present average annual precipitation in the world and Asian countries. First, it is increasing from 1991 to 2009 in the world as shown in figure 3. The maximum level of precipitation in a year is documented in Guam with 930.1 mm while the minimum level is in Bahrain with 2.44 mm. In

[3]The National Statistics Office (NSO), along with three other agencies namely, the National Statistical Coordination Board (NSCB), the Bureau of Labor and Employment Statistics (BLES), and the Bureau of Agricultural Statistics (BAS) shall be known as the PHILIPPINE STATISTICS AUTHORITY (PSA) starting December 29, 2013 as per Republic Act 10625 otherwise known as the Philippine Statistical Act of 2013.

Asia, the average precipitation level is also increasing (figure 4).

[Figure 1 about here.]

[Figure 2 about here.]

[Figure 3 about here.]

[Figure 4 about here.]

2.3 Philippine exports and imports

We use the product-country specific export and import data in the analysis. However, here, we present the aggregate Philippine export and import data to provide an overview of the time trend. Based on the data of the NSO, the growth rates of export and import of goods in the Philippines are seemingly decreasing. Figures 5 and 6 present the growth rates of Philippine export and import of goods from 1991 to 2012. There might be several reasons behind this decreasing trend, but it is worth noting that this decline might be due to climate shocks or to the variations in the world's annual average temperature and precipitation. In particular, we see some possibility that there is a negative relationship between world temperature and growth rates of Philippine international trade based on figures 1, 2, 5 and 6. In the next section, we will investigate this issue by controlling some other variables as regressors in addition to temperature and precipitation of the trade partners. Finally, we present the summary statistics of the main variables presented thus far in table 2.

[Figure 5 about here.]

[Figure 6 about here.]

[Table 2 about here.]

3 Empirical methodology

The basic empirical framework of this study follows Jones and Olken (2010) with a few minor changes:[4]

$$\ln(exp_{pct}) - \ln(exp_{pct-1}) = \alpha_{pc} + \beta_1 temp_{ct} + \beta_2 prec_{ct} + \beta_3 pgdp_{ct} + \beta_4 t + \epsilon_{pct}, \quad (1)$$

$$\ln(imp_{pct}) - \ln(imp_{pct-1}) = \alpha_{pc} + \beta_1 temp_{ct} + \beta_2 prec_{ct} + \beta_3 pgdp_{ct} + \beta_4 t + \epsilon_{pct}, \quad (2)$$

where exp_{pct} and imp_{pct} are the Philippine export and import of product category p with country c, $temp_{ct}$ and $prec_{ct}$ are the average annual temperature ($^\circ$C) and precipitation ($mm/year$) of country c in year t, t represents the time trending variable and $pgdp_{ct}$ is the per capita GDP of country c in year t. Equations (1) and (2) estimate the relationship between climate shocks on trade partners and the growth of Philippine exports and imports through the estimates of β_1 and β_2.

It is likely that different products have different growth patterns. Moreover, the same products may have different growth patterns depending on the country it produces. Even if such a pattern is unrelated to the temperature, given that some products are produced in a specific regions (e.g., pineapples are cultivated mainly in tropical regions), the product-country specific growth patterns may be correlated with temperature or precipitation in the cross-sectional data, making the estimated coefficients on temperature and precipitation being biased. To eliminate such biases, our model includes product-country fixed effects, α_{pc}.

The coefficient β_3 captures the effect of per capita GDP of the trader partners on Philippine exports and imports. This is included because the Philippines is not a big country and the economy scale of trade partners is expected to affect the growth of Philippine export and import. In addition, this variable can be correlated with temperature and precipitation, but be considered exogenous because the volume of Philippine international trade for the country of trade partners or its growth

[4]One reason for the minor changes is due to multicollinearity problems that arise when we use the exactly same specification with Jones and Olken (2010) in the regression. In fact, many independent variables are dropped in the estimation, although the final results are qualitatively similar to the ones presented as main results in this paper. The detailed results of the same specification used in Jones and Olken (2010) are presented in the appendix.

can be assumed not to affect the GDP per capita of the trade partner. Put differently, the Philippine international trade is not significant enough to affect the GDP per capita of the trade partners for most countries. Thus, including this variable does not suffer from the problem of endogeneity.

The coefficient β_4 is considered to capture the time trending effect in the regression so that the estimated coefficients on temperature and other independent variables do not suffer from spurious correlations. Remember from figures 1 to 6 that world temperature has been increasing over time, while the growth rate of Philippine exports and imports show secure declining trends. Even if the decline in the exports and imports are not the results of the change in temperature, simply regressing export and import growths on the temperature would cause spurious negative correlations between trade growth and temperature. To eliminate such spurious correlations, we include time trend variable t (Wooldridge, 2002, 2008).

Alternatively, we could include country-year fixed effects, α_{ct}, in the model to avoid such spurious correlation. This is the method employed by Jones and Olken (2010). However, in our data, some trade partners appear only a few times, and for such countries, many commodities do not appear in the data multiple times, forcing many country-time fixed effects to be dropped from the model. Moreover, the number of country-year fixed effects is large relative to our sample size, which slightly compromises the statistical significance of our results, although the results are qualitatively similar. Because of these reasons, we report the models that control for time trend variable as our preferred model. The model that includes country-year fixed effects are reported in the appendix.

Similar to Jones and Olken (2010), we have also tried to estimate the impact of climate variables on poor countries relative to non-poor countries in the context of Philippine international trade. For this, we have used the following specification:

$$\begin{aligned}\ln(y_{pct}) - \ln(y_{pct-1}) = \alpha_{pc} + \beta_1 \mathit{temp}_{ct} + \beta_1' \mathit{temp}_{ct} \cdot \mathit{poor} \\ + \beta_2 \mathit{prec}_{ct} + \beta_2' \mathit{prec} \cdot \mathit{poor} + \beta_3 \mathit{pgdp}_{ct} + \beta_4 t + \epsilon_{pct}\end{aligned} \tag{3}$$

where $y_{pct} = \mathit{exp}_{pct}$ or $y_{pct} = \mathit{imp}_{pct}$ and the *poor* is the dummy variable taking the value of 1 when

the country is poor. The judgment is made based on the World Bank data using the per capita PPP income of countries. The countries are classified as low income, low middle income, high middle income, non-OECD and OECD countries. The dummy variable of *poor* is 1 when the country is classified as low income.

Finally, note that a fixed effects model is applied for the estimation that follows. The panel data is unbalanced in the sense that for a given year, a set of partners (countries) and commodities for the trade with the Philippines varies little by little. We use the data of 2-digit category commodities for the main results where 97 product categories and 164 countries are considered in the sample. In our case, product-country specific effects, which are time-invariant, are expected to be significant due to geography and several other factors in international trade. While panel data allow us to control the variable that change over time, heterogeneity across product-country specific factors must be considered as well. Unfortunately, these product-country specific effects are likely to be correlated with other independent variables. In this case, a fixed effects model is more appropriate to generate the unbiased estimates (Wooldridge, 2002). In addition, we generate a cluster-robust estimate of standard errors to take care of heterogeneity, possible auto-correlation and outliers.

4 Results

Table 3 shows the results of the panel regression analysis using 2-digit PSCC data on Philippine exports to the world. Column (1) pertains to the results generated using equation (1). As temperature of importing countries increases by 1 degree Celsius, Philippine export growth reduces by 3.71 percentage points. Including the interaction variables of temperature and poor countries using equation (3), column (2) in table 3 show that 1 degree Celsius increase in temperature negatively affects Philippine export growth by 3.50 percentage points. The result is slightly lower than the result without interaction variables. These results are statistically significant at the 5 percent level. Precipitation using both equations is found not to be statistically significant.

[Table 3 about here.]

Table 4 presents the effect of climate shocks to Philippine import growth. Using 2-digit PSCC data on Philippine imports from the world, column (1) in table 4 shows that 1 degree Celsius increase of temperature of exporting countries decreases Philippine import growth by 10.53 percentage points. Including the interaction variables, the negative effect of temperature slightly decreases, but it still reduces Philippine import growth by 10.30 percentage points (column (2) in table 4). These results are statistically significant at the 1 percent level. Precipitation, however, shows slight effect on Philippine import growth using equation (3). The results are statistically significant at the 10 percent level.

[Table 4 about here.]

In summary, both Philippine exports and imports are negatively affected by a 1 degree Celsius increase in temperature. With respect to the magnitude, a 1 degree Celsius increase in temperature has greater effect on Philippine import growth than export growth while precipitation shows lesser effect on Philippine international trade. The interaction variables using both equations are not statistically significant on its effect on Philippine export and import growth. Hence, we can say that whether the country as a trade partner for the Philippines is poor or not, temperature of the countries negatively affects the growth of Philippine international trade thorough both channels of imports and exports.

4.1 Effect on commodities

We next study the effect of temperature on growth of commodities exported and imported by the Philippines. Commodities are classified as 1-digit SITC and 2-digit PSCC category using the export and import data of the Philippines to and from the rest of the world. The report presents those commodities with statistically significant effect. Table 5 summarizes the effect of temperature on commodities at 1-digit SITC major categories. It shows that two out of ten commodities exported by the Philippines are negatively affected by temperature (i.e., animal and vegetable oils, fats and waxes, manufactured goods classified chiefly by material).

[Table 5 about here.]

Table 6 exhibits the commodities imported by the Philippines from the rest of the world which are negatively affected by temperature increase. Four out of ten commodities at 1-digit SITC category (i.e., mineral fuels, lubricants and related materials, animal and vegetable oils, fats and waxes, miscellaneous manufactured articles, commodities and transactions not classified elsewhere) are negatively affected by temperature. Overall, we can say that several categories of products in both Philippine exports and imports are negatively affected by an increase in temperature, but no commodities show any positive sign with statistical significance.

[Table 6 about here.]

[Table 7 about here.]

On the other hand, commodities are also classified at 2-digit category using the broad structure of the 2004 PSCC which is aligned with the UN SITC and the HSP. Tables 7 and 8 present the results of the effect of temperature on commodities exported and imported by the Philippines, respectively. The results show large negative effects on some agricultural commodities (e.g., live animals, animal products and fruit and vegetable products) and manufacturing commodities (e.g., prepared foodstuffs, textiles, base metals, wood manufactures, footwear, raw hides and skins, plastics, products of chemical, optical equipment, photographic equipment, medical and surgical instruments, machinery and mechanical appliances, electrical equipment). These results are also evident in Jones and Olken (2010) wherein effects of temperature in agricultural and manufacturing products are negatively large.

[Table 8 about here.]

5 Discussion

This study shows that climate shocks, particularly, world temperature affects the growth of Philippine international trade. Based on the analyses and results obtained so far, we discuss some

implications and interpretation of the climate change to Philippine international trade focusing on each side of Philippine exports and imports. In particular, we provide some argument with the results.

5.1 Philippine exports: Agricultural sectors and international trade under climate change

Two commodities classified as 1-digit category and thirteen commodities classified as 2-digit category are negatively affected by the rise in temperature of trade partners, while no commodities at the 1-digit category and the five commodities at 2-digit category are positively affected (tables 5 and 7). This means that Philippine exports are more likely to suffer at the aggregate and commodity levels, although there are some mixed effects of positive and negative signs for 2-digit category products. We discuss that this result could be related with the fact that trade patterns could be distorted by climate change. Since climate change, in particular a rise in temperature, has a negative effect on agriculture, global food security can be in peril causing people at risk of hunger. In turn, international trade of agricultural products would be affected by these "food supply" changes in relation to climate system.

A key is that agricultural productions and yields are established to be negatively affected by a further increase in temperature based on the previous agricultural research. If it is the case for many countries in the world, such countries face domestic food supply shortage and seek to import more of the necessary food commodities (e.g., mainly staple food, such as rice, wheat and cereals) to satisfy domestic food demand and needs. Of course, food is the most necessary good among commodities internationally traded in the economy and must be prioritized for exchanges. When national income is assumed to be fixed in short run or medium run, it should come with a reduction of importing other commodities, say, more luxurious or less necessary goods. This story is consistent with our results that most of the commodities that are negatively affected by an increase in temperature are non-food and manufacturing commodities. There are some 2-digit agricultural commodities that are negatively affected. However, they are not staple food such as

fruits or vegetable. This would explain why they are negatively affected.

Recall that the Philippines does not export agricultural products much, although she exports some vegetable and fruits, such as mango, which are not staple foods for many countries. Thus, we think that Philippine exports are more likely to decline due to a reduction of import demands from the trade partners as a consequence of an increase in world temperature. On the basis of this story, we would like to pose a following conjecture or hypothesis to explain the result obtained from the regression of Philippine exports: A big player of staple-food exporting countries, such as Australia or the United States, can export and earn more due to world food shortage brought by the increase in temperature. However, less food exporting countries, such as the Philippines, tend to suffer and earn less due to a possible reduction in non-agricultural import demands of the world. This hypothesis is suggested to possibly explain the effect of climate change on international trade. We believe that it is a testable hypothesis by further studies.

5.2 Philippine imports: Labor productivity under climate change

The negative effect of temperature on manufacturing products might be explained due to the lower productivity of workers in hotter working environment as well as the fact that the Philippines imports many manufacturing products, such as semiconductors, transportation equipment and so on, from foreign countries. With respect to the loss of labor productivity, this argument is employed to support the negative association between exports and temperature in Jones and Olken (2010). An increase in temperature brought by climate change is reported to decrease labor productivity (Kjellstrom et al., 2009) wherein, workers are less productive when the condition in the working area becomes hotter. Several studies in the United States conclude that output in industries tend to decrease when daily temperature is too high or if under environmental heat stress (e.g., Dunne et al., 2013, Zivin and Neidell, 2014). These evidences suggest that domestic production, say, agricultural and manufacturing sectors with labor intensity, and the corresponding exports would decrease as labor productivity declines due to climate warms. If world temperature rises, this tendency is pervasive in many countries. Therefore, this would cause Philippine imports to decline,

because the Philippines imports many manufacturing products.

6 Conclusion

This study has examined the effect of climate shocks to the growth rates of Philippine international trade. An increase of temperature in the world has significant negative effects on the growth rates of both Philippine exports and imports. Growth rate of exports of goods decreases by 3.50 to 3.71 percentage points while growth rate of imports of goods reduces by 10.30 to 10.53 percentage points as temperature increase by 1 degree Celsius. It is observed that precipitation consistently shows insignificant effects on export growth rates, but records slight effect on import growth rates. Moreover, temperature has large negative effects on some agricultural products and light manufacturing products, irrespective of exports or imports.

This shows that variation in temperature has negative effect to trade of developing countries like the Philippines. Vulnerability of sectors to an increase in temperature, such as the agriculture sector, is also apparent. Since agriculture sector is linked with other economic sectors, this has some important implications in the socio-economic dynamics. To mitigate the effect of climate change, most particularly to the least developed and developing countries, collective efforts from the international community are urgent and imperative. At the same time, alternative ways on production procedures and patterns as well as adaptations to climate change should be explored.

In the near future, further investigation on the effect of climate change to the other least developed and developing countries should be examined. By doing so, we can establish the concrete effects of climate change on international trade. To our knowledge, Jones and Olken (2010) and this research are the only works focusing on climate change and international trade. Definitely, more evidence must be provided to clarify the relationship. Additionally, note that the Philippines is not a major food exporting country in the globalized world. Therefore, we argue that Philippine exports decline when temperature of trade partners rises. On the contrary, this argument also implies that a major player of staple food exporting countries such as USA or Australia may increase

their agricultural exports to the rest of the world when world temperature rises. Testing this hypothesis is another direction of future research. With these future research ideas, it is our belief that this paper becomes an important step toward understanding the relation between climate change and international trade. Our research shall be considered an important evidence that may apply to other tropical and developing nations.

7 Appendix

In this appendix, we show regression results of the same specification used in Jones and Olken (2010):

$$\ln(exp_{pct}) - \ln(exp_{pct-1}) = \alpha_{pc} + \gamma_{pt} + \beta_1 temp_{ct} + \beta_2 prec_{ct} + \beta_3 pgdp_{ct} + \epsilon_{pct}, \quad (4)$$

$$\ln(imp_{pct}) - \ln(imp_{pct-1}) = \alpha_{pc} + \gamma_{pt} + \beta_1 temp_{ct} + \beta_2 prec_{ct} + \beta_3 pgdp_{ct} + \epsilon_{pct}, \quad (5)$$

where γ_{pt} is a product-year specific dummy variable.

[Table 9 about here.]

[Table 10 about here.]

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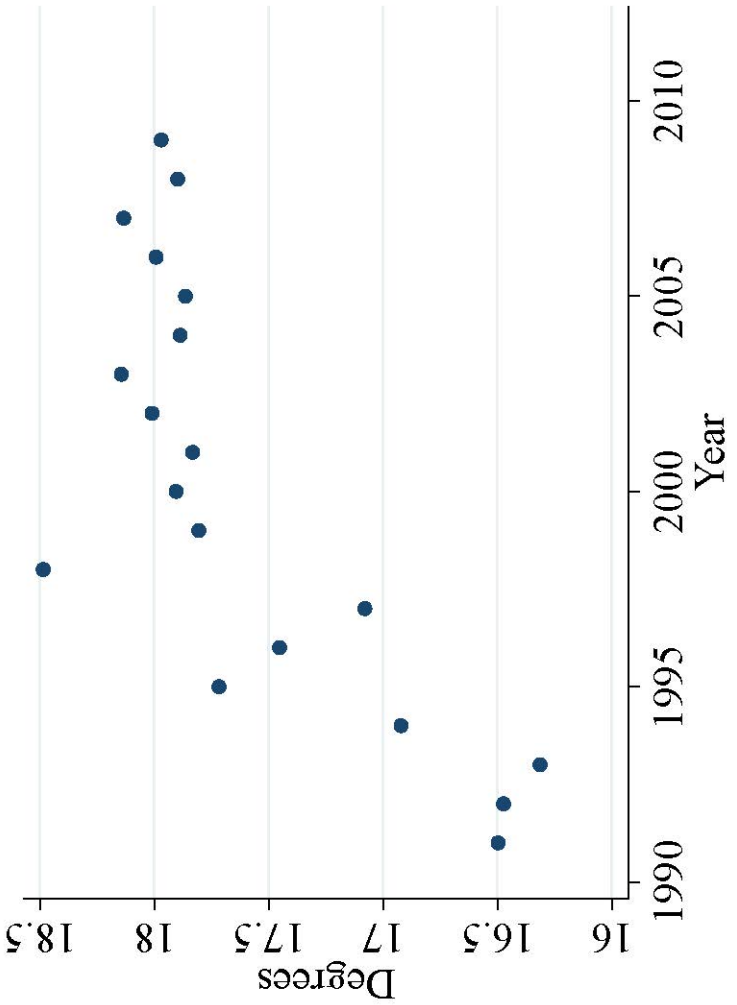
Figure 1: Annual average world temperature



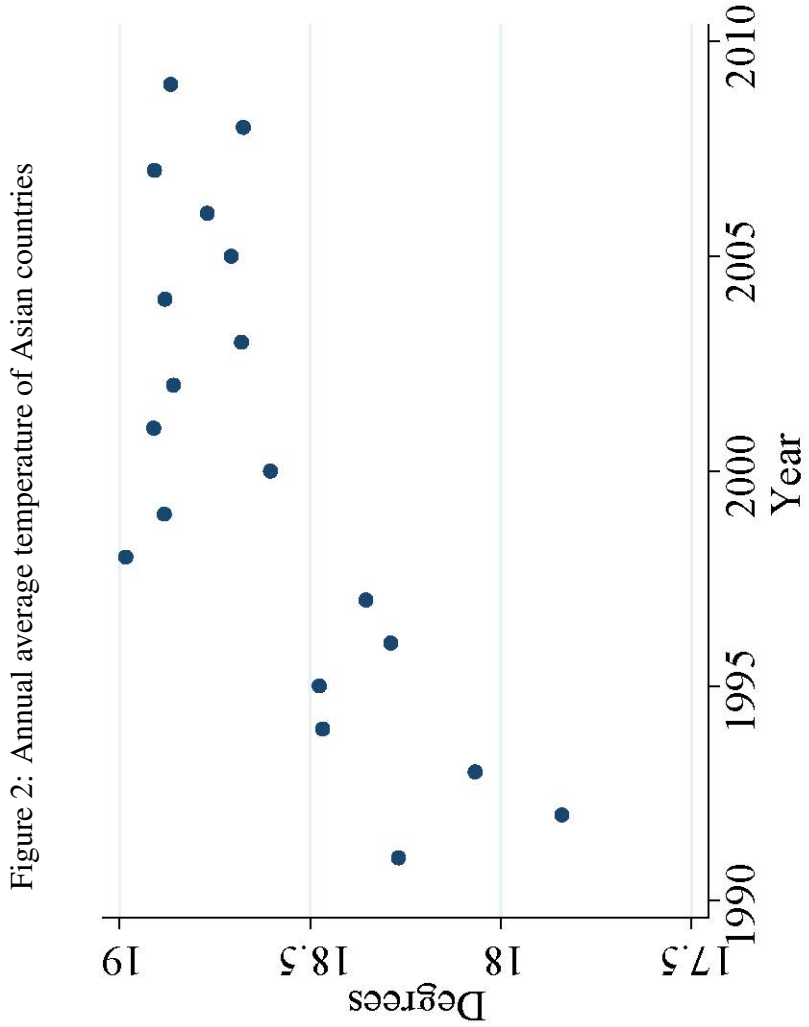


Figure 2: Annual average temperature of Asian countries

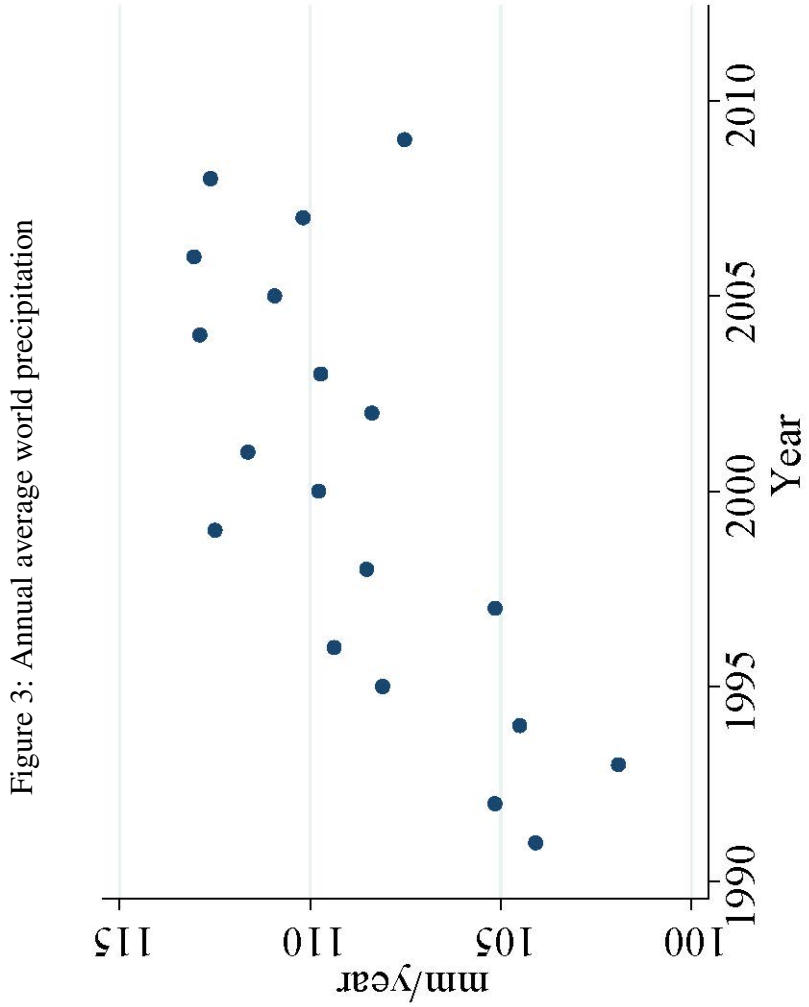


Figure 3: Annual average world precipitation

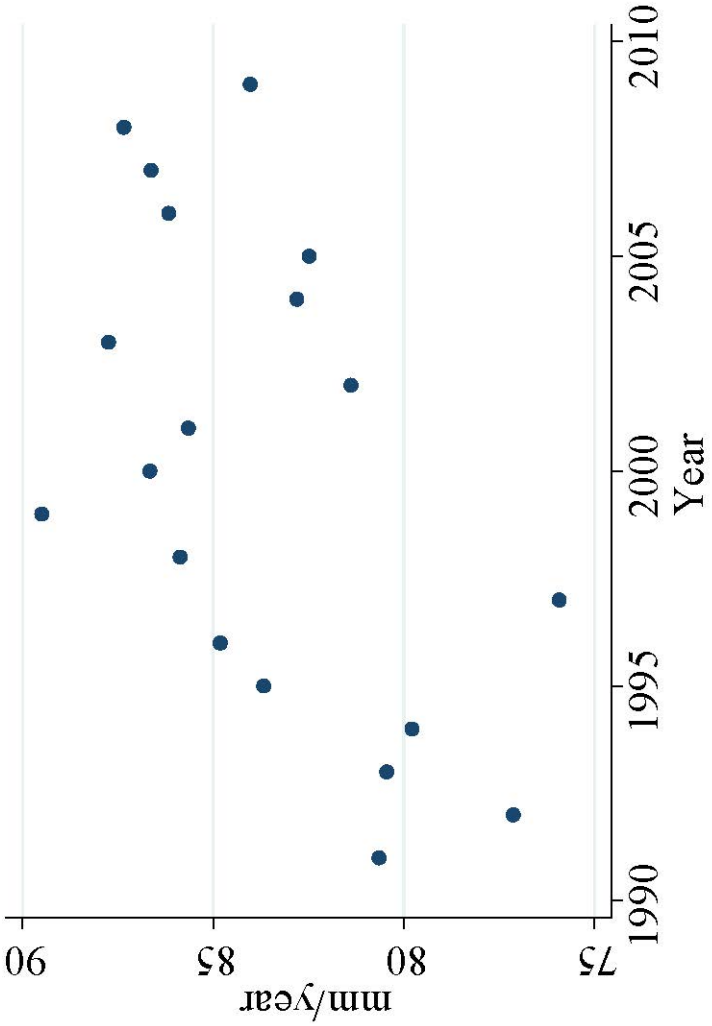
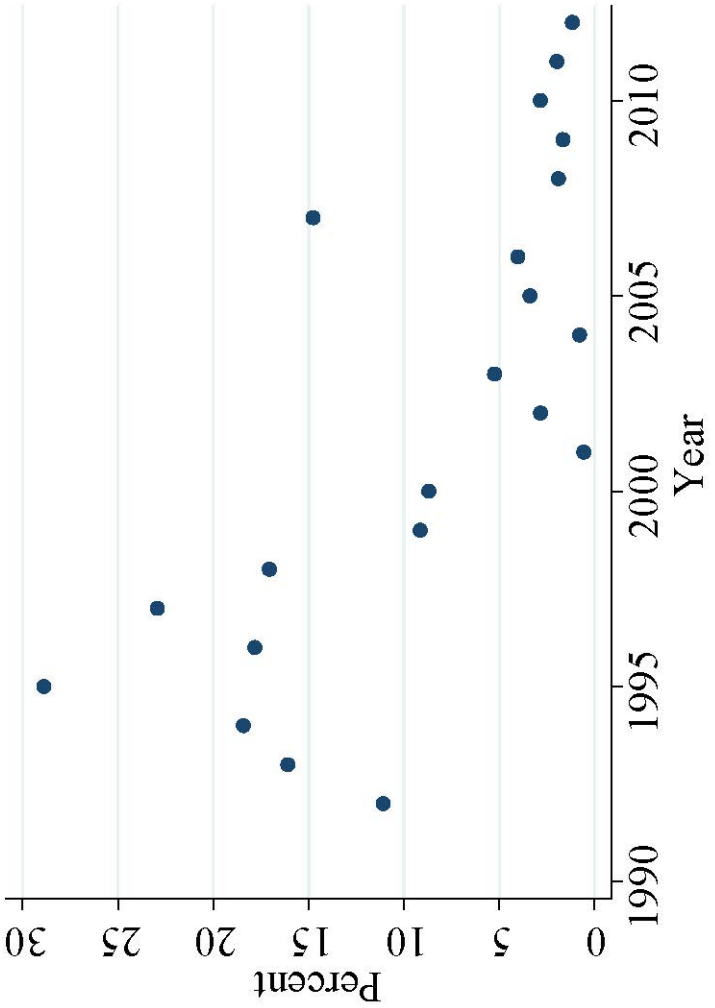


Figure 4: Annual average precipitation of Asian countries

Figure 5: Philippine export growth rate



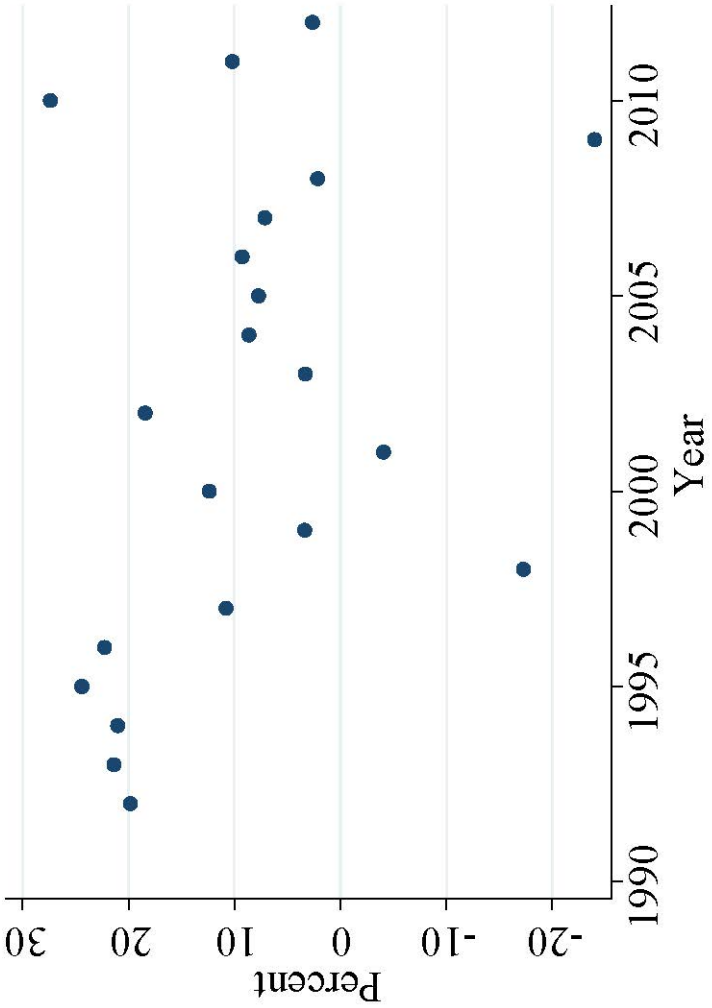


Figure 6: Philippine import growth rate

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Table 1: Broad structure of the 2004 Philippine standard commodity classification

Section	Chapter	Description
I	1-5	Live animals, animal products
II	6-14	Vegetable products
III	15	Animal or vegetable fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes
IV	16-24	Prepared foodstuffs; beverages, spirits and vinegar; tobacco and manufactured tobacco substitutes
V	25-27	Mineral products
VI	28-38	Products of the chemical or allied industries
VII	39-40	Plastics and articles thereof; rubber and articles thereof
VIII	41-43	Raw hides and skins, leather, furskins and articles thereof; saddlery and harness; travel goods, handbags and similar containers; articles of animal gut (other than silk-worm gut)
IX	44-46	Wood and articles of wood; wood charcoal; cork and articles of cork; manufactures of straw, of esparto or of other plaiting materials; basketware and wickerwork
X	47-49	Pulp of wood or of other fibrous cellulosic material; waste and scrap of paper or paperboard; paper and paperboard and articles thereof
XI	50-63	Textiles and textile articles
XII	64-67	Footwear, headgear, umbrellas, sun umbrellas, walking-sticks, seat-sticks, whips, riding-crops and parts thereof; prepared feathers and articles made therewith; artificial flowers; articles of human hair
XIII	68-70	Articles of stone, plaster, cement, asbestos, mica or similar materials; ceramic products; glass and glassware
XIV	71	Natural or cultured pearls, precious or semi-precious stones, precious metals, metals clad with precious metals and articles thereof; imitation jewellery; coin
XV	72-83	Base metals and articles of base metal
XVI	84-85	Machinery and mechanical appliances; electrical equipment; parts thereof; sound recorders and reproducers, and parts and accessories of such articles
XVII	86-89	Vehicles, aircraft, vessels and associated transport equipment
XVIII	90-92	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; clocks and watches; musical instruments; parts and accessories thereof
XIX	93	Arms and ammunition; parts and accessories thereof
XX	94-96	Miscellaneous manufactured articles
XXI	97-99	Works of art, collectors pieces and antiques

Table 2: Summary statistics of the main variables in the analysis from 1991 to 2009

Variables	Observations	Mean	Standard deviation	Minimum	Maximum
Temperature (in degree Celsius)	3420	17.67	8.74	-16.75	29.31
Precipitation (in mm/year)	3420	109.1	96.44	2.44	930.1
Export growth (in percent)	76531	0.0772	1.56	-11.42	12.29
Import growth (in percent)	53227	0.0814	1.64	-14.65	15.43

Table 3: Effects of climate shocks to Philippine exports to the world

Variables	Exports to the world, 2 digit (1)	(2)
Temperature	-0.037**	-0.035**
	(0.017)	(0.017)
Temperature $\times$ poor		-0.19
		(0.21)
Precipitation	-0.000247	-0.00023
	(0.00052)	(0.00052)
Precipitation $\times$ poor		-0.0018
		(0.0054)
per capita GDP	1.09×10^{-5}***	1.07×10^{-5}***
	(0.0000)	(0.0000)
Time trend	-0.019***	-0.019***
	(0.0015)	(0.0015)
F-statistic	65.11	43.43
$\mathrm{Prob}(F\text{-statistic})$	0.0000	0.0000
Observations	55133	55133
Years	1991-2009	1991-2009

***significant at the 1 percent level
**significant at the 5 percent level
*significant at the 10 percent level

Table 4: Effects of climate shocks to Philippine imports from the world

Variables	Philippine imports from the world, 2 digit Model 1	Model 2
Temperature	-0.105***	-0.103***
	(0.0251)	(0.0251)
Temperature $\times$ poor		-0.3157
		(0.361)
Precipitation	-0.00080	-0.00091
	(0.00051)	(0.00052)
Precipitation $\times$ poor		-0.0072
		(0.0072)
per capita GDP	6.26×10^{-5}**	6.17×10^{-5}**
	(0.0000)	(0.0000)
Time trend	-0.0178***	-0.0178***
	(0.0021)	(0.0021)
F-statistic	66.84	44.84
$\mathrm{Prob}(F\text{-statistic})$	0.0000	0.0000
Observations	40075	40075
Years	1991-2009	1991-2009

***significant at the 1 percent level
**significant at the 5 percent level
*significant at the 10 percent level

Table 5: Effect of temperature on Philippine exports to the world by 1-digit product category

SITC Code	Product description	Coefficient	Standard Error	t-stat	p-value	Obs
0	Food and live animals	0.0218	(0.0624)	0.35	0.727	4209
1	Beverages and tobacco	0.0433	(0.0625)	0.69	0.489	5110
2	Crude materials, inedible, except fuels	−0.0143	(0.0461)	−0.31	0.756	6017
3	Mineral fuels, lubricants and related materials	−0.0659	(0.0549)	−1.20	0.231	5741
4	**Animal and vegetable oils, fats and waxes**	**−0.1124**	**(0.0466)**	**−2.41**	**0.016**	**5947**
5	Chemicals and related products, n.e.s.	0.0135	(0.0618)	0.22	0.828	3852
6	**Manufactured goods classified chiefly by material**	**−0.1117**	**(0.0408)**	**−2.74**	**0.006**	**7169**
7	Machinery and transport equipment	0.0158	(0.0610)	0.23	0.821	3964
8	Miscellaneous manufactured articles	0.0128	(0.0612)	0.21	0.834	5676
9	Commodities and transactions not classified elsewhere in the SITC	−0.0592	(0.0427)	−1.38	0.167	7448

Rows with bold letters and numbers indicate that they exhibit statistical significance.
For each commodity, we have run a fixed effects model of equation (3). Here note that a country-specific fixed dummy is included instead of a country-product specific dummy. This is because a product is fixed in each regression.

Table 6: Effect of temperature on Philippine imports from the world by 1-digit product category

SITC Code	Product description	Coefficient	Standard error	t-stat	p-value	obs
0	Food and live animals	0.0180	(0.0809)	0.22	0.824	3030
1	Beverages and tobacco	−0.1170	(0.0808)	−1.45	0.148	3469
2	Crude materials, inedible, except fuels	−0.1083	(0.0692)	−1.56	0.118	4929
3	**Mineral fuels, lubricants and related materials**	**−0.1399**	**(0.0630)**	**−2.22**	**0.027**	**5091**
4	**Animal and vegetable oils, fats and waxes**	**−0.1308**	**(0.0747)**	**−1.75**	**0.081**	**3831**
5	Chemicals and related products, n.e.s.	0.0744	(0.0959)	0.78	0.438	3512
6	Manufactured goods classified chiefly by material	−0.060	(0.0896)	−0.67	0.503	3557
7	Machinery and transport equipment	−0.0716	(0.0861)	−0.83	0.406	3558
8	**Miscellaneous manufactured articles**	**−0.1805**	**(0.0783)**	**−2.30**	**0.022**	**4877**
9	**Commodities and transactions not classified elsewhere in the SITC**	**−0.2031**	**(0.0805)**	**−2.52**	**0.012**	**4221**

Rows with bold letters and numbers indicate the statistical significance.
For each commodity, we have run a fixed effects model of equation (3). Here note that a country-specific fixed dummy is included instead of a country-product specific dummy. This is because a product is fixed in each regression.

Table 7: Effect of temperature on Philippine exports to the world by 2-digit product category

Code	Description	Coefficient	Standard error	t-stat	p-value	Obs
	Negative effect					
22	Prepared foodstuffs; beverages, spirits and vinegar; tobacco and manufactured tobacco substitutes	-0.3730	(0.1261)	-2.96	0.004	810
08	Vegetable products	-0.2219	(0.0884)	-2.51	0.014	1029
90	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; clocks and watches; musical instruments; parts and accessories thereof	-0.3080	(0.1241)	-2.48	0.015	930
81	Base metals and articles of base metal	-0.6352	(0.2559)	-2.48	0.017	401
46	Wood and articles of wood; wood charcoal; cork and articles of cork; manufactures of straw, of esparto or of other plaiting materials; basketware and wickerwork	-0.1205	(0.0519)	-2.32	0.022	1139
67	Footwear, headgear, umbrellas, sun umbrellas, walking-sticks, seat-sticks, whips, riding-crops and parts thereof; prepared feathers and articles made therewith; artificial flowers; articles of human hair	-0.2282	(0.1102)	-2.07	0.042	644
70	Articles of stone, plaster, cement, asbestos, mica or similar materials; ceramic products; glass and glassware	-0.3499	(0.1753)	-2.00	0.049	824
05	Live animals, animal products	-0.1727	(0.0884)	-1.95	0.056	568
95	Miscellaneous manufactured articles	-0.1844	(0.0977)	-1.89	0.062	1215
61	Textiles and textile articles	-0.1961	(0.1074)	-1.83	0.071	1060
42	Raw hides and skins, leather, furskins and articles thereof; saddlery and harness; travel goods, handbags and similar containers; articles of animal gut (other than silk-worm gut)	-0.3194	(0.1844)	-1.73	0.087	852
91	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; clocks and watches; musical instruments; parts and accessories thereof	-0.7086	(0.4079)	-1.74	0.091	211
85	Machinery and mechanical appliances; electrical equipment; parts thereof; sound recorders and reproducers, and parts and accessories of such articles	0.1633	(0.0968)	1.69	0.094	1409
	Positive effect					
14	Vegetable products	0.7456	(0.2815)	2.65	0.012	251
92	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; clocks and watches; musical instruments; parts and accessories thereof	0.6906	(0.2726)	2.53	0.022	102
09	Vegetable products	0.6416	(0.2953)	2.17	0.036	331
26	Mineral products	0.5891	(0.2801)	2.10	0.046	259
98	Works of art, collectors pieces and antiques	0.1537	(0.0924)	1.66	0.098	2026

All of the commodities listed in this table exhibit statistical significance for the effect of temperature.
For each commodity, we have run a fixed effects model of equation (3). Here note that a country-specific fixed dummy is included instead of a country-product specific dummy. This is because a product is fixed in each regression.

Table 8: Effect of temperature on Philippine imports from the world by 2-digit product category

Code	Description	Coefficient	Standard error	t-stat	p-value	Obs
	Negative effect					
63	Textiles and textile articles	-0.6893	(0.2386)	-2.89	0.006	401
08	Vegetable products	-0.6448	(0.2303)	-2.8	0.008	377
34	Products of the chemical or allied industries	-0.4878	(0.1821)	-2.68	0.010	461
85	Machinery and mechanical appliances; electrical equipment; parts thereof; sound recorders and reproducers, and parts and accessories of such articles	-0.5938	(0.2357)	-2.52	0.013	935
40	Plastics and articles thereof; rubber and articles thereof	-0.2936	(0.1368)	-2.15	0.035	634
42	Raw hides and skins, leather, furskins and articles thereof; saddlery and harness; travel goods, handbags and similar containers; articles of animal gut (other than silk-worm gut)	-0.3983	(0.1859)	-2.14	0.037	395
35	Products of the chemical or allied industries	-0.3938	(0.1850)	-2.13	0.039	467
17	Prepared foodstuffs; beverages, spirits and vinegar; tobacco and manufactured tobacco substitutes	-0.4255	(0.2165)	-1.97	0.055	435
90	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; clocks and watches; musical instruments; parts and accessories thereof	-0.2647	(0.1402)	-1.89	0.062	667
72	Base metals and articles of base metal	-0.3774	(0.2132)	-1.77	0.081	536
92	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; clocks and watches; musical instruments; parts and accessories thereof	-0.4835	(0.2667)	-1.81	0.082	220
21	Prepared foodstuffs; beverages, spirits and vinegar; tobacco and manufactured tobacco substitutes	-0.4583	(0.2603)	-1.76	0.084	498
	Positive Effect					
61	Textiles and textile articles	0.5603	(0.2599)	2.16	0.035	414
14	Vegetable products	0.7968	(0.4228)	1.88	0.073	120

All of the commodities listed in this table exhibit statistical significance for the effect of temperature.
For each commodity, we have run a fixed effects model of equation (3). Here note that a country-specific fixed dummy is included instead of a country-product specific dummy. This is because a product is fixed in each regression.

Table 9: Philippine exports to the world using Jones and Olken (2010)

Variables	Philippine exports to the world, 2 digit Model 1
Temperature	-0.0314*
	(0.0189)
Temperature $\times$ poor	-0.0764
	(0.2016)
Precipitation	-0.0002
	(0.0005)
Precipitation $\times$ poor	-0.0020
	(0.0052)
per capita GDP	4.62×10^{-5}**
	(0.0000)
Observations	55133
Years	1991-2009

***significant at the 1 percent level
**significant at the 5 percent level
*significant at the 10 percent level

Table 10: Philippine imports from the world using Jones and Olken (2010)

	Philippine imports from the world, 2 digit
Variables	Model 1
Temperature	-0.0868***
	(0.0280)
Temperature $\times$ poor	-0.2109
	(0.3814)
Precipitation	-0.0010*
	(0.0006)
Precipitation $\times$ poor	-0.0106
	(0.0071)
per capita GDP	2.40×10^{-5}
	(0.0000)
Observations	40075
Years	1991-2009

***significant at the 1 percent level
**significant at the 5 percent level
*significant at the 10 percent level