How droughts change specialization of countries?

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Abstract

This paper focuses on the adaptation capacity of the farmers and evaluates the extent to which droughts push them to adopt more resistant crop or incite them to abandon agriculture for manufactured activities. To assess the change in specialization, it uses exporting data. A comparison between developed and developing nations are realized. A sample of 151 countries over the period 2000 to 2015 is mobilized. Relying on drought indicators based on the standardized precipitation index and trade data at six-digit level, we find that a lack of precipitation leads countries to a substitution towards crops which are tolerant to drought, and away from crops that are drought sensitive. Moreover, our results also indicate a reorganization of exports in favour of manufacture in the aftermath of drought. And, more precisely, countries are moving towards the production of goods for which they have a comparative advantage.

Keywords: Natural Disasters, Trade and Environment, Agriculture in International Trade, Empirical Studies of Trade

JEL codes: Q54, F18, Q17, F14

1 Introduction

While much natural disasters we face are sudden and brief, droughts are different. They are usually characterized by an extended duration and a larger spatial coverage. In the upcoming years, droughts are expected to be more frequent, severe and longer as a result of global warming. And the main victims are the farmers. Water scarcity is indeed expected to impact negatively crops and livestock production.

Because of drought, agricultural sector in developing countries has experienced a loss of 29 billion dollars between 2005 and 2015.[1] Yet agriculture is one of the main activities in developing nations and may contribute up to 30% to the national GDP in the lowest income nations.[2]

Would this sector resist to higher frequencies of droughts? Would those droughts push farmers to adopt more resistant crop? Or would they just convince them to abandon agriculture for manufacture activity? In consequence, what is the impact of drought on the specialization of countries?

An extensive literature has highlighted the impact of drought on agricultural production. Some authors study specific disasters. For instance, Howitt et al. (2015) look at the impact of the 2015 California drought. They show that drought affects negatively farming revenues. And by a spillover effect, other sectors are impacted. As farmers have less resources, they reduce their input requirements. Other authors have preferred to focus on a specific crop. Lesk et al. (2016) find that, globally, droughts have reduced cereal production by 10%. Their study covers the period 1964 to 2007, and also shows that the negative impact has become stronger for the more recent catastrophes. More generally, this literature has developed in two directions. To investigate agricultural losses from droughts some authors have used simulation models (Muchow et al., 1996; Jongdee et al., 1997; Heinemann et al., 2007) whereas others have preferred regression models (Lesk et al., 2016; Hernandez-Barrera et al., 2016). Nevertheless, both models have highlighted the detrimental effect of drought on agriculture.

In this context, a literature has emerged to identify adaptation strategies to cope with drought and more globally with climate change. Surveyed farmers in Kenya reveal to purchase new crops with climate change (Bryan et al., 2013). Similarly, a survey conducted on 223 farming households in India indicates that some farmers adopt less water intensive crops, to mitigate drought (Udmale et al, 2014). They also change their planting date and increase soil and water conservation practice to overcome climate change.

Technological developments are also recognized as an adaptive strategy. Smithers and Blay Palmer (2001) identify the biological and mechanical innovation. The first refers to the development of

[1] FAO (2017) "2017 The impact of disasters and crises on agriculture food security".

[2] World Bank Development Indicators.

drought resistant crop whereas the latest designates the development of irrigation systems. In Zimbabwe, for example, farmers consider these strategies to reduce their vulnerability to climate change (Mano and Nhemachena, 2007). However, Rosegrant et al. (2002) indicates that irrigation efficiency is relatively low in developing nations. The lack of resources may impede the maintenance and the modernization of existing systems.

Finally, income diversification constitutes a response to drought. Farm household can allocate part of their labour to non-agricultural activities. Participating in non-farm activities allow them to lessen the fluctuation of farm income, inherent to drought (Reardon et al., 1998). In consequence, drought can push some members of the households to migrate to urban centre, in search of a non-farm work. And this strategy is not limited to the poorest states. Skinner et al. (2001) show that agricultural households also diversify the source of their income in Canada.

This paper contributes to this strand of literature. First, it offers a more complete picture of how drought affects the agricultural sector, by considering the impact of catastrophe across the globe. And, to the best of our knowledge it is the first to analyse how drought impacts country's specialization. As drought may push farmers to adopt strategies to overcome drought shocks, we evaluate if this disaster finally leads to a reorganization of the production among the country. In particular, we investigate if the agricultural sector evolves towards the production of drought tolerant crops or if it share is reduced in favour of manufacturing production. Although this paper does not investigate more the implication of such change in specialization for the overall performance of a country, one could think that it might be beneficial for the country and may stimulate its growth if it operates towards industrialized item. A country which specializes in high technology products is expected to grow faster, compared to other nations (Grossman and Helpman, 1991). And so, we extend our analysis by considering the different manufacturing sectors.

And to assess the specialization, among the less water intensive goods, we use different datasets. Ideally, disaggregated production data are required. However, production data are lacking for the industrial sector of a wide range of developing countries. To overcome this issue, we attempt to explain the change in specialization by using export data. The reasoning is simple, as exports may follow the same pattern as production. In consequence, we mobilize the BACI database of the CEPII. It provides us detailed exports data at 6 digit level of the harmonized system nomenclature.

In order to evaluate the change in specialization among agricultural sector, we need to identify the drought tolerant crops. In consequence, we construct an original dataset: we collect for the plant, for which we observe some matching with the trade data at the product level, the water required for its growth. Data are coming from different websites.

And finally, to measure drought, we use the Standardized Precipitation Index. It quantifies the rainfall deficit, and can be computed for different time scales. Here, we employ in a systematic way 1 month SPI and 12 month SPI, to identify respectively meteorological and hydrological drought. Unlike the literature which usually treats the short term, we propose a more global picture as a lack of rainfall from one month may disturb the growth of crop whereas a diminution of precipitation over a larger period may affect in addition water resources.

We run a series of regressions and find three noticeable results.

First meteorological droughts conduct both high income economies and developing nations to substitute exports of drought tolerant plants for more water dependant crops. Nevertheless, when it comes to hydrological droughts, no country changes its agricultural specialization.

Second, meteorological and hydrological droughts lead countries to reduce export of water intensive crop in favor of manufacturing goods, whatever the level of development.

Finally, countries are moving toward the production of goods for which they have a comparative advantage. In consequence, less developed countries specialize in low technologies and resource based products, whereas high income countries prefer to reorganize their exports towards middle and high technology items.

This paper is structured as follows: section 2 presents the data. Section 3 discusses the empirical strategy, whereas section 4 shows the empirical results. Section 5 provides some robustness checks, and section 6 concludes.

2 Data

To study the impact of drought on trade specialisation, we consider the BACI database, at the six level digit of disaggregation. And we focus our attention on agricultural commodities. Drought is a major factor in agricultural productivity, as water scarcity affects negatively farming. And because some crops require more water to grow one would expect a more severe effect on exports. In consequence, one need to associate each crop with water requirement. And as no database provides this information, different sources are mobilized like Food and Agriculture Organization (FAO), specific crop websites...[3] We consider the crop as water dependant if the amount of water needed for the product is above the median of the distribution across all agricultural commodities. If not, the good is classified into the group "drought tolerant" crop. To illustrate our database, consider the example of cereals. Their consumption for developing countries contribute to provide more than 50% of caloric intake.[4] If millet is a drought tolerant crop as the water requirement is relatively low; it takes three

[3]see Appendix A

[4]FAO (2003) Agriculture Food and Water. A contribution to the World Water Development Report

times more water to grow rice. Then rice appears to be more vulnerable to dry condition and belongs to the water dependant group.

Then, to create a drought's variable, monthly rainfall data are used. They come from the Climatic Research Unit of the University of East Anglia, and were aggregated on a state level by Feindouno et al. (2015). For our measure of drought, we use the approach of the Standardized Precipitation Index (SPI) developed by McKee et al. (1993) [5]. Conceptually, it is equivalent to a z-score, which we define as the difference of total monthly precipitation from the average monthly precipitation of the entire period (1901-2015) divided by the standard deviation. So it can be interpreted as the number of the standard deviation by which the observed precipitation deviates from the long term mean.
Different time scales may be used to compute SPI. In literature, cumulative precipitation for 1, 3, 6, 9, 12 or 24 months are generally employed to construct this index.
If 1 month-SPI identifies meteorological drought, a situation of rainfall deficit, a larger period as 12 months allows us to detect hydrological drought. The deficit of precipitation over this long time scale, reflects a shortage of water resources; groundwater, reservoir or stream levels are consequently, reduced. Intermediates time scales (3, 6 or 9 months) are finally more useful to detect soil moisture drought. Precipitation deficiencies lead to a diminution of water available on the surface of soil.
For this study, two time scales are mobilized. As some developing countries relies on rainfed agriculture, one can easily understand that 1 month-SPI might be more appropriate to characterize drought. A diminution of precipitation may affect negatively agricultural production, as water constitutes a major factor in the growth of crops. It is particularly true for Sub Saharan Africa where more than 95% of farmer's lands are rainfed. But for other countries, a 12 month SPI might be more suitable, as agriculture heavily depends on irrigation. The water required for the expansion of production comes now from reservoir, as groundwater. But also, as developed countries have more resource to mitigate the negative impact of drought, one can easily understand that they are more sensitive to longer periods of droughts.
Drought occurs when negative values are recorded, whereas a SPI above 1 mean wet conditions. Moreover, McKee et al. (1993) create a classification system to categorize droughts.

Because of the normal distribution, about 95% of the SPI will fall within two standard of deviation, in the interval [-2;2]. In consequence the probability of observing extreme drought is very small. The main advantage of the SPI, is that it can be used to compare different locations at different

[5] To construct this index, we need to fit a statistical probability distribution to the rainfall series. As McKee et al. (1993), we use the gamma distribution which provides one of the best model for describing monthly precipitation. Then, we transform those rainfall records to a normal distribution.

Table 1: Classification of the SPI and drought category

SPI values	Drought Categories
0 to -0.99	Mild Drought
-1 to -1.49	Moderate Drought
-1.50 to -1.99	Severe Drought
≤ -2	Extreme Drought

Source: McKee et al.(1993)

periods. Moreover, it allows us to quantify the severity and to deduce the frequency and the duration of the drought. One can imagine that violent, recurrent or long duration drought has negative impact on agriculture production and forces farmers to adopt more resistant crop, or to leave agriculture for industry.

Furthermore, one can easily understand that the effect of drought on agricultural production and thus trade, if any, is expected to appear in the medium or long run. In fact, because a substitution of a culture into another is costly in value and time, one would not expect farmers to substitute a production to another in case of random drought shocks that affects their production plans. It is only when droughts period become persistent over a certain time that one expects agricultural firms to end up changing their behaviour. This is why, to construct our indicators of drought, we measure the extent of drought during the 5 years preceding the time of export of agricultural commodities or manufacture goods that is observed. But we also test shorter periods of respectively 3 and 1 year. In a first step we create a dummy drought, which takes the value of one if a moderate, a severe or an extreme drought occurred (i.e. SPI$<$-1). Then we construct our two variables:

- Frequency: It refers to the number of months with a drought. We count the number of months where a country experienced a drought, during our period of 5 and respectively 3 or 1 years. More frequent drought might encourage farmers to produce resistant crop or to leave agriculture for less vulnerable activities.

- Severity: It corresponds to the accumulated deficit of precipitation. We sum the absolute value of the SPI, when a drought was reported during the 5, and respectively 3 or 1 year preceding exports. Severe drought might affect negatively exports of highly water dependant crops by destroying them.

According to Zargar et al. (2011) those variables constitute two main dimensions to characterize drought. These measures are widely mobilized (Edossa et al., 2010; Li et al., 2015; Dallmann et al., 2017...).

3 Empirical Model

Our empirical analysis assesses the impact of drought on agriculture. The model is estimated based on 151 countries over the period 2000 to 2015. Following the literature as one expects poorer countries to be more vulnerable to natural disasters, we also divided our model into two sub-samples: developed versus developing countries. And as the source of water required for agriculture production differs for farmers, we use respectively 1 and 12 month-SPI to construct our drought indicators.

We first study if a country hit by severe or frequent drought reduce the exports of agricultural commodities. As we are interested in the change in agricultural exports, the specification is computed in log difference, and is represented by what follows:

$$ln(Agr_{it}^k) - ln(Agr_{it-5}^k) = \beta_1 \ln(drought_{i\bar{t};t\bar{-}5} + 1) + \lambda_i^k + \lambda_t^k + \epsilon_{it}^k \quad (1)$$

with, $ln(Agr_{it}^k)$, the logarithm of export of agricultural commodities k, of the country i, at a given year t.

Let the variable $\ln(drought_{i\bar{t};t\bar{-}5} + 1)$ denotes the following expressions:

- $\ln(frequency_{i\bar{t};t\bar{-}5} + 1)$, the logarithm of one plus the number of months with drought during the 5 years preceding exports of country i;
- $\ln(severity_{i\bar{t};t\bar{-}5} + 1)$, the logarithm of one plus the magnitude of the precipitation deficit, during a period of 5 years before exports of country i.

And, we add the exporter $\times$ product fixed effects λ_i^k to capture cross-country differences in growth of export for each product and the product time fixed effects λ_t^k to control for any characteristics that are specific to the product in the world market. We also add the ϵ_{it}^k term which represents the residual. Standard errors are clustered at the country i-year level to address the potential problem of heteroscedasticity and autocorrelation in the error terms.

As water requirements differ between crops, we replicate the same model by considering respectively the impact of drought on exports of highly water dependant commodities and on drought "tolerant" crops.

Furthermore, we propose to augment the model to investigate if those countries adopt new strategies to cope with drought. Recurrent and a priori more violent droughts might lead farmer to export more drought tolerant crops comparatively to "vulnerable" products.

Let $\frac{Vul_{it}^k}{Tol_{it}}$ denotes the relative exports of highly water dependant crop in term of total agricultural tolerant crop's export. Our model becomes now:

$$ln(\frac{Vul_{it}^k}{Tol_{it}}) - ln(\frac{Vul_{it-5}^k}{Tol_{it-5}}) = \beta_1 \ln(drought_{i\bar{t};\bar{t-5}} + 1) + \lambda_i^k + \lambda_t^k + \epsilon_{it}^k \tag{2}$$

And as production data[6] are available for agricultural products, we explore if all farmers adopt this strategy and not just those who are involved in exporting activities. The specification becomes:

$$ln(\frac{YVul_{it}^k}{YTol_{it}}) - ln(\frac{YVul_{it-5}^k}{YTol_{it-5}}) = \beta_1 \ln(drought_{i\bar{t};\bar{t-5}} + 1) + \lambda_i^k + \lambda_t^k + \epsilon_{it}^k \tag{3}$$

with, $\frac{YVul_{it}^k}{YTol_{it}}$, the ratio of production of country i of highly water dependant commodities k at a given year t to the total agricultural tolerant crop's production.

Finally, countries could take profit of drought to neglect agriculture exports and to opt for manufacturing specialization. To identify this phenomenon we have rewritten equation 2 as follows:

$$ln(\frac{Vul_{it}^k}{Manuf_{it}}) - ln(\frac{Vul_{it-5}^k}{Manuf_{it-5}}) = \beta_1 \ln(drought_{i\bar{t};\bar{t-5}} + 1) + \lambda_i^k + \lambda_t^k + \epsilon_{it}^k \tag{4}$$

where $\frac{Vul_{it}^k}{Manuf_{it}}$ is the export's share of vulnerable agriculture product k in total manufactured goods of the country i at a given year t.

And, as manufactured sector is very heterogeneous, we propose to replicate this model by considering the exports share of water dependant commodities respectively in terms of:

- Manufactured resource based items $ManufRes_{it}$;
- Low technology products $ManufLow_{it}$;
- Middle technology goods $ManufMid_{it}$;
- High technology items $ManufHigh_{it}$;

To disaggregate manufacturing sector into those 5 branches, we consider Lall's classification (2000), used by the United Nations Conference on Trade and Development (UNCTAD) (2002) and the United

[6]We use the FAO database.

Nations Industrial Development Organization (UNIDO) (2004).

Here, we investigate if developing countries highly endowed with low skilled workers move towards the exports of mineral or low technology products; whereas developed nations do not change their trade pattern, due to their numerous financial resources, or move their resources into mid or high technology products in the aftermath of severe or frequent droughts.

Finally, if one may expect to observe a change in trade specialization for this interval of 5 years, the results may differ for a shorter period. One can easily understand, that one year after a drought, it would be premeditated for a farmer to opt for a new product as change in trade pattern may induce numerous fixed costs. Before engaging in change of crop or activity, farmers must be convinced of the negative and permanent impact of drought on their outcomes.[7]

4 Empirical Results

4.1 Meteorological Droughts

We first report results corresponding to meteorological droughts. Before analyzing in details the results regarding the change in specialization, we begin by presenting the result of the export equation.

The table 2 shows that one year after, drought deters exports of all agricultural items. Both the intensity and the frequency of this disaster, reduce the trade of agricultural products (columns 1 and 2) in all countries.

Table 2: Meteorological droughts and exports of agricultural products

Country's sample	All		Developed		Developing		All		Developed		Developing	
Drought's period	1 year						5 year					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Severity	-0.018*		-0.022		-0.012		-0.071**		-0.028		-0.10**	
	(0.010)		(0.014)		(0.015)		(0.030)		(0.043)		(0.040)	
Frequency		-0.024*		-0.038**		-0.011		-0.079**		-0.014		-0.12**
		(0.013)		(0.017)		(0.020)		(0.034)		(0.049)		(0.046)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.084	0.084	0.117	0.118	0.097	0.097	0.208	0.208	0.245	0.245	0.218	0.218
Observations	115,513	115,513	52,674	52,674	62,817	62,817	115,513	115,513	52,674	52,674	62,817	62,817

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Nevertheless, when we reproduce the model by considering the level of development, the results appear to be either non robust (in case of developed countries) or statistically unsignificant (developing countries).

[7] An intermediate period of three years must be more suitable to observe the beginning of change in exports. Results upon request.

Let us, turn now to the impact of drought over a period of 5 years. As previously, severe or recurrent droughts have a negative, but a higher impact on agricultural exports (columns 7 and 8). This result suggests a cumulative impact of drought on agricultural trade. Moreover, analysis by level of development shows that only developing countries observe a drop in agricultural trade. The lack of education, financial and technological resources may explain their difficulty to cope effectively with drought.

We then breakdown agricultural product by water requirement, in order to test for a higher sensitiveness to drought for products that usually require high quantities of water input. Table 3 presents results for drought tolerant crop whereas table 4 focuses on most water dependant products.

Table 3: Meteorological droughts and exports of tolerant drought crops.

Country's sample	All		Developed		Developing		All		Developed		Developing	
Drought's period	1 year						5 year					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Severity	-0.039***		-0.034*		-0.040*		-0.334		0.014		-0.041	
	(0.014)		(0.018)		(0.021)		(0.037)		(0.053)		(0.054)	
Frequency		-0.047***		-0.054**		-0.039		-0.024		0.014		-0.033
		(0.018)		(0.022)		(0.026)		(0.042)		(0.060)		(0.062)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.090	0.090	0.130	0.130	0.102	0.102	0.220	0.220	0.268	0.268	0.224	0.224
Observations	51,266	51,266	24,528	24,528	26,725	26,725	51,266	51,266	24,528	24,528	26,725	26,725

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3 shows that export of tolerant crop decreases after one year of drought and it doesn't matter how developed the nation is (columns 1 to 6). However, columns 7 to 12 tend to show that a severe or frequent drought has no effect on trade when a period of 5 years is considered. After a prolonged period of drought, exports of a priori drought-tolerant crops do not appear to be affected.

Table 4 presents the results for water dependant crops.

Table 4: Meteorological droughts and exports of water intensive crops

Country's sample	All		Developed		Developing		All		Developed		Developing	
Drought's period	1 year						5 year					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Severity	-0.002		-0.012		0.0100		-0.101***		-0.040		-0.144***	
	(0.012)		(0.016)		(0.016)		(0.032)		(0.046)		(0.042)	
Frequency		-0.006		-0.025		0.010		-0.123***		-0.038		-0.180***
		(0.015)		(0.020)		(0.021)		(0.037)		(0.054)		(0.050)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.079	0.079	0.104	0.104	0.093	0.093	0.198	0.198	0.221	0.221	0.212	0.212
Observations	64,247	64,247	28,146	28,146	36,092	36,092	64,247	64,247	28,146	28,146	36,092	36,092

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

At first sight, frequent or severe droughts are not associated with a negative and statistically significant estimator, when an interval of one year is considered (columns 1 to 6). But it is a different story for a long interval of 5 years. When all countries are considered, recurrent and severe droughts come to affect negatively exports of water dependant products (columns 7 and 8). But columns 9 to 12 tend to show that the negative effect is only observed when the drought hit developing countries. An additional month of drought is associated with a reduction of 0.124% of exports of water intensive crops.[8] Farmers in the wealthiest nations appears to be more resilient to meteorological droughts. To overcome the reduction of surface water, those farmers may rely on groundwater reservoir. And as they have more resources, they may adopt more efficient technologies to lessen the impact of drought.

In order to limit the impact of drought; farmers may also decide to produce more tolerant crop relatively to water dependant plants. As mentioned earlier, this suggests then that a part of the resources has to be reallocated from cultivating water-dependant to more drought-tolerant ones which implies a change in the specialization of countries. In table 5 we begin by using export data to test the specialization equation 2.

Table 5: Meteorological droughts and agricultural specialization: exports data

Country's sample	All		Developed		Developing		All		Developed		Developing	
Drought's period	1 year						5 year					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Severity	0.037* (0.021)		0.039 (0.032)		0.028 (0.029)		-0.114** (0.056)		-0.144 (0.089)		-0.095 (0.071)	
Frequency		0.043 (0.027)		0.048 (0.039)		0.028 (0.037)		-0.166*** (0.062)		-0.174* (0.101)		-0.158* (0.081)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.076	0.076	0.105	0.105	0.086	0.086	0.181	0.182	0.206	0.206	0.192	0.192
Observations	64,247	64,247	28,146	28,146	36,092	36,092	64,247	64,247	28,146	28,146	36,092	36,092

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

When a period of one year is considered redundant or violent droughts do not lead to a change of specialization in both developed and high income economies (columns 3 to 6).

Nevertheless, when extending the period of drought to period to five years, frequent catastrophes conduct rich and poor nations to substitute exports of drought tolerant plants for water dependant crops (columns 10 and 12). An additional month of drought leads high income economies to reduce by 0.120% their exports of water intensive products comparatively to drought resilient plant and by 0.109% for less developed economies. But the severity of the catastrophe has no incidence on the change of trade pattern (columns 9 and 11). Those results suggest that a change of trade specialization takes time. One can easily understand that farmers who go to export are more efficient producers; and consequently their productions are more resilient to the catastrophe, one year

[8] When a drought is recorded the switch from 0 to 1 of the frequency variable affects ln(1+frequency) by ln(1+1)-ln(0) = ln(2) = 0.69.In consequence, we multiplied by 0.69 our parameters to estimate the impact on exports growth: 0.69*(-0.180) = -0.124

after. Nevertheless, a larger period of drought should affect negatively their production and frequent droughts may convince them to engage cost in order to adopt more tolerant crops.
Table 6 uses production data to observe if all farmers move towards the production of the more resilient crops after droughts.

Table 6: Meteorological droughts and agricultural specialization: production data

Country's sample	All		Developed		Developing		All		Developed		Developing	
Drought's period	1 year						5 year					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Severity	-0.021***		0.0002		-0.025***		-0.035**		-0.072*		-0.028*	
	(0.006)		(0.016)		(0.006)		(0.014)		(0.041)		(0.015)	
Frequency		-0.022***		0.004		-0.029***		-0.034**		-0.061		-0.031*
		(0.008)		(0.021)		(0.008)		(0.017)		(0.045)		(0.018)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.080	0.079	0.157	0.157	0.087	0.087	0.307	0.307	0.372	0.372	0.304	0.304
Observations	33,795	33,795	7,425	7,425	26,322	26,322	33,795	33,795	7,425	7,425	26,322	26,322

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In the short term, the results obtained are consistent with the idea that farmers in general produce more tolerant crop comparatively to water intensive plants (columns 1 and 2). However, the developing countries sample appears to be driving this negative impact (see columns 5 and 6 and columns 3 and 4). Then, in the poorest countries, adding one month of droughts deteriorates the production of water intensive products by 0.021% comparatively to the cultivation of drought tolerant plants. Those results are consistent with the idea that in less developed countries, farmers have to mitigate the negative impact of drought and to adapt, relatively early, less water intensive crops. Only farmers who are involved in exporting activities, have sufficient resources to cope with drought, and do not opt for this strategy.
However, when observing a longer period of drought (5 years) severe droughts appear to play some role even in the case of developed countries. And in poor countries, the change of specialization continues: severe or abundant droughts induce more change towards drought tolerant crops (columns 11 and 12).

As drought deteriorates agricultural production and exports, countries could diversify and develop the manufacturing sector. In table 7, we now evaluate if countries reduce exports of water intensive crop at the expense of industrial goods.

Table 7: Meteorological droughts and manufacture: change of specialization

Country's sample	All		Developed		Developing		All		Developed		Developing	
Drought's period	1 year						5 year					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Severity	-0.001		-0.004		0.005		-0.060*		-0.045		-0.076	
	(0.013)		(0.017)		(0.019)		(0.036)		(0.051)		(0.050)	
Frequency		-0.001		-0.013		0.009		-0.072*		-0.049		-0.093
		(0.017)		(0.021)		(0.024)		(0.042)		(0.058)		(0.060)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.078	0.078	0.105	0.105	0.091	0.091	0.193	0.193	0.216	0.216	0.207	0.207
Observations	64,247	64,247	28,146	28,146	36,092	36,092	64,247	64,247	28,146	28,146	36,092	36,092

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

We observe no change in specialization after one year of drought for all countries (columns 1 to 6). And the result remains unchanged for both developed and developing nations, when a larger interval of 5 years is introduced. However, we may assume that the absence of significant results is due to the heterogeneity of industrial products. This is why we breakdown the manufacturing sector by technological intensity.

Tables 8 and 9 report our results for respectively developed and developing nations, by using an interval of one year for drought.

Table 8: Meteorological droughts and change in specialization in the short term- Manufacturing sector- Developed countries

Manufacturing sector	Resource Based		Low Tech.		Middle Tech.		High Tech.	
Drought's period	1 year							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Severity	-0.020		-0.018		-0.008		0.016	
	(0.019)		(0.018)		(0.018)		(0.025)	
Frequency		-0.033		-0.032		-0.019		-0.001
		(0.024)		(0.023)		(0.023)		(0.031)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.106	0.106	0.105	0.105	0.102	0.102	0.187	0.187
Observations	28,146	28,146	28,146	28,146	28,146	28,146	28,146	28,146

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Here again, one year after, droughts do not lead to change in specialization. As exports of more water intensive crops are not impacted by droughts, farm households do not need to diversify their activities.

Table 9: Meteorological droughts and change in specialization in the short term- Manufacturing sector- Developing countries

Manufacturing sector	Resource Based		Low Tech.		Middle Tech.		High Tech.	
Drought's period	1 year							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Severity	0.015		-0.003		0.008		-0.023	
	(0.026)		(0.021)		(0.024)		(0.031)	
Frequency		0.023		-0.009		0.009		-0.013
		(0.033)		(0.026)		(0.030)		(0.040)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.092	0.092	0.090	0.090	0.092	0.092	0.158	0.158
Observations	36,092	36,092	36,092	36,092	36,092	36,092	36,092	36,092

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

However a prolonged period of drought conducts high income economies to substitute exports of water dependant crops with high technology items (table 10, column 8).

Table 10: Meteorological droughts and change in specialization in the medium term- Manufacturing sector- Developed countries

Manufacturing sector	Resource Based		Low Tech.		Middle Tech.		High Tech.	
Drought's period	5 years							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Severity	-0.021		-0.076		-0.075		-0.089	
	(0.060)		(0.050)		(0.055)		(0.072)	
Frequencye		-0.047		-0.087		-0.064		-0.205**
		(0.070)		(0.058)		(0.064)		(0.082)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.221	0.221	0.217	0.217	0.221	0.221	0.345	0.345
Observations	28,146	28,146	28,146	28,146	28,146	28,146	28,146	28,146

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Poorest countries also decrease their exports of water intensive crops in favour of resource based goods (table 11, column 1) and in a greater extent of low technology items (table 11, columns 3 and 4). One can easily understand that water scarcity reduces the income of rural households and pushes them to seek additional employment in the non-farm sector.

Table 11: Meteorological droughts and change in specialization in the medium term- Manufacturing sector -Developing countries

Manufacturing sector	Resource Based		Low Tech.		Middle Tech.		High Tech.	
Drought's period	5 years							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Severity	-0.138**		-0.131**		0.019		-0.116	
	(0.070)		(0.059)		(0.058)		(0.073)	
Frequency		-0.128		-0.161**		0.037		-0.122
		(0.077)		(0.068)		(0.068)		(0.084)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.217	0.217	0.209	0.209	0.215	0.215	0.319	0.319
Observations	36,092	36,092	36,092	36,092	36,092	36,092	36,092	36,092

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

And it comes as no surprise that countries are moving towards the production of goods for which they are expected to have a comparative advantage a priori. Less developed countries which are abundant in unskilled labor and natural resources, should be then incited to specialize in low technology and resource based industries, whereas wealthiest nation which have more well-educated workers and technologically advanced equipment reorganize their exports towards high technology products.

4.2 Hydrological Droughts

In what follows, we present a series of results based on alternative indicators. As already mentioned, these indicators are computed in such a way so as to reveal a priori hydrological droughts. Again hydrological droughts might not be affecting agriculture in the same manner as meteorological droughts. Now the level of groundwater reservoir is reduced, making irrigation more difficult.

Tables 12 to 14 depict the results of the impact of drought on agricultural exports. Several results can be highlighted.

Table 12: Hydrological Droughts and exports of agricultural products

Country's sample	All		Developed		Developing		All		Developed		Developing	
Drought's period	1 year						5 year					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Severity	-0.034 (0.025)		0.001 (0.032)		-0.061 (0.037)		-0.040* (0.022)		-0.047 (0.031)		-0.051 (0.031)	
Frequency		-0.050 (0.033)		-0.010 (0.045)		-0.084* (0.050)		-0.063** (0.029)		-0.071* (0.042)		-0.09** (0.041)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.084	0.084	0.117	0.117	0.097	0.097	0.208	0.208	0.245	0.245	0.218	0.218
Observations	115,513	115,513	52,674	52,674	62,817	62,817	115,513	115,513	52,674	52,674	62,817	62,817

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 13: Hydrological Droughts and exports of tolerant drought crops

Country's sample	All		Developed		Developing		All		Developed		Developing	
Drought's period	1 year						5 year					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Severity	-0.053 (0.034)		-0.010 (0.041)		-0.080 (0.052)		-0.008 (0.029)		-0.002 (0.039)		-0.014 (0.042)	
Frequency		-0.081* (0.046)		-0.028 (0.057)		-0.116 (0.071)		-0.018 (0.038)		-0.005 (0.050)		-0.039 (0.056)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.090	0.090	0.130	0.130	0.102	0.102	0.220	0.220	0.268	0.268	0.224	0.224
Observations	51,266	51,266	24,528	24,528	26,725	26,725	51,266	51,266	24,528	24,528	26,725	26,725

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 14: Hydrological Droughts and exports of water intensive crops

Country's sample	All		Developed		Developing		All		Developed		Developing	
Drought's period	1 year						5 year					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Severity	-0.019		0.010		-0.045		-0.066***		-0.088**		-0.077**	
	(0.026)		(0.037)		(0.037)		(0.024)		(0.035)		(0.033)	
Frequency		-0.026		0.004		-0.059		-0.099***		-0.130***		-0.120***
		(0.035)		(0.052)		(0.050)		(0.033)		(0.049)		(0.044)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.079	0.079	0.104	0.104	0.093	0.093	0.198	0.198	0.222	0.222	0.212	0.212
Observations	64,247	64,247	28,146	28,146	36,092	36,092	64,247	64,247	28,146	28,146	36,092	36,092

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

At short term (1 year) drought does not affect agricultural exports in both developing and developed nations (table 12). And the results remain unchanged when we respectively focus on drought tolerant and water intensive crops (tables 13 and 14). They are resilient to hydrological droughts. At short term, countries have the resources to face water scarcity.

However, at medium term (5 years) frequent droughts have a statistically significant and negative impact on agricultural exports for both high income economies and less developed countries (table 12, columns 7 to 9). As a reminder, meteorological droughts do not disturb agricultural exports for rich nations. But now, as the reserves of groundwater are at lower levels, wealthiest countries have less strategies to cope with droughts and become now new victims of this scourge. Nevertheless, only water intensive crops decrease in the aftermath of violent or recurrent catastrophes. Droughts do not deter exports of drought tolerant crops.

It is why in table 15, we assess if exporters move towards the trade of less vulnerable crops.

Table 15: Hydrological Droughts and agricultural specialization: exports data

Country's sample	All		Developed		Developing		All		Developed		Developing	
Drought's period	1 year						5 year					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Severity	0.004		0.004		-0.022		-0.053		-0.071		-0.047	
	(0.042)		(0.062)		(0.058)		(0.039)		(0.054)		(0.056)	
Frequency		0.012		-0.007		-0.019		-0.071		-0.090		-0.071
		(0.057)		(0.087)		(0.077)		(0.054)		(0.074)		(0.075)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.076	0.076	0.104	0.104	0.086	0.086	0.181	0.181	0.206	0.206	0.192	0.192
Observations	64,247	64,247	28,146	28,146	36,092	36,092	64,247	64,247	28,146	28,146	36,092	36,092

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The main difference with meteorological drought is that now countries do not change their agricultural exports, at medium term. The results are unequivocal, they never pick the less intensive crop in the aftermath of hydrological droughts; whatever the level of development and the period of drought. The decline of groundwater may push them to reconsider this option. Those results suggest that exporters are privileging other strategies to cope with water scarcity. For example, they may change planting date, use resistant varieties of crops. But all farmers do not follow this option.

Table 16: Hydrological Droughts and agricultural specialization: production data

Country's sample	All		Developed		Developing		All		Developed		Developing	
Drought's period	1 year						5 year					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Severity	-0.039***		-0.016		-0.045***		-0.015		-0.087***		0.002	
	(0.012)		(0.032)		(0.013)		(0.011)		(0.025)		(0.011)	
Frequency		-0.054***		-0.024		-0.062***		-0.025**		-0.114***		-0.002
		(0.008)		(0.021)		(0.008)		(0.017)		(0.045)		(0.018)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.079	0.079	0.378	0.378	0.087	0.086	0.307	0.307	0.375	0.375	0.303	0.303
Observations	33,795	33,795	7,425	7,425	26,322	26,322	33,795	33,795	7,425	7,425	26,322	26,322

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Data in production in table 16, shows us that farmers in developing countries shift towards the production of drought tolerant crops at short term, after severe or recurrent droughts. But at middle term , they abandon this strategy. On the contrary wealthiest nations change their specialization only at middle term. The results differ from meteorological drought. As the reserve of water declines, farmers can no longer count on them and become now vulnerable to drought.

Water scarcity may also lead a country to favour manufactured sectors. Those results are presented in table 17. In the short term we do not assist to a reorganization of exports towards industrial goods. But 5 years latter, all countries seem to trade less water intensive products comparatively to manufactured items.

Table 17: Hydrological Droughts and manufacture: Change of specialization

Country's sample	All		Developed		Developing		All		Developed		Developing	
Drought's period	1 year						5 year					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Severity	-0.018		0.024		-0.054		-0.056**		-0.103***		-0.063*	
	(0.030)		(0.043)		(0.042)		(0.026)		(0.038)		(0.036)	
Frequency		-0.026		0.014		-0.068		-0.089**		-0.145***		-0.107**
		(0.039)		(0.059)		(0.055)		(0.035)		(0.052)		(0.049)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.078	0.078	0.105	0.105	0.091	0.091	0.193	0.193	0.217	0.217	0.207	0.207
Observations	64,247	64,247	28,146	28,146	36,092	36,092	64,247	64,247	28,146	28,146	36,092	36,092

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

And when we breakdown manufacturing sector by their level of technologies, we still no find an impact at short term for both developed and wealthiest nations (table 18 and table 19). These results confirm the resilience at short term.

Table 18: Hydrological Droughts and change in specialization in the short term- Manufacturing sector- Developed countries

Manufacturing sector	Resource Based		Low Tech.		Middle Tech.		High Tech.	
Drought's period	1 year							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Severity	0.012		-0.019		0.002		-0.046	
	(0.043)		(0.048)		(0.043)		(0.060)	
Frequency		0.008		-0.042		-0.018		-0.046
		(0.060)		(0.066)		(0.061)		(0.077)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.106	0.106	0.105	0.105	0.102	0.102	0.187	0.187
Observations	28,146	28,146	28,146	28,146	28,146	28,146	28,146	28,146

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 19: Hydrological Droughts and change in specialization in the short term- Manufacturing sector-Developing countries

Manufacturing sector	Resource Based		Low Tech.		Middle Tech.		High Tech.	
Drought's period	1 year							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Severity	-0.011		-0.049		0.017		-0.076	
	(0.052)		(0.042)		(0.057)		(0.057)	
Frequency		-0.012		-0.056		0.051		-0.118
		(0.072)		(0.057)		(0.077)		(0.084)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.092	0.092	0.090	0.090	0.092	0.092	0.158	0.158
Observations	36,092	36,092	36,092	36,092	36,092	36,092	36,089	36,089

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

However, a change of specialization occurs at middle term. Table 20 shows that high income economies after recurrent or violent droughts decide to reduce exports of water intensive crops and favour middle technology products. And to a lesser extent, they also move toward low technologies and resource based products. On the contrary, developing countries abandon agricultural exports for resource based sector and low technology products, when a frequent or a severe drought happens (table 21). And in a lower degree, they move toward middle technology products, but only when persistent disasters took place.
Here again, countries reorganize their exports toward the production of goods for which they have a comparative advantage.

Table 20: Hydrological Droughts and change in specialization in the medium term- Manufacturing sector- Developed countries (Hydrological Droughts)

Manufacturing sector	Resource Based		Low Tech.		Middle Tech.		High Tech.	
Drought's period	5 years							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Severity	-0.104**		-0.090**		-0.155***		-0.086	
	(0.042)		(0.039)		(0.045)		(0.060)	
Frequency		-0.161***		-0.143***		-0.207***		-0.054
		(0.056)		(0.053)		(0.062)		(0.080)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.222	0.222	0.218	0.218	0.222	0.222	0.345	0.345
Observations	28,146	28,146	28,146	28,146	28,146	28,146	28,146	28,146

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 21: Change in specialization in the medium term- Manufacturing sector- Developing countries (Hydrological Droughts)

Manufacturing sector	Resource Based		Low Tech.		Middle Tech.		High Tech.	
Drought's period	5 years							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Severity	-0.111**		-0.109***		0.065		0.056	
	(0.047)		(0.042)		(0.045)		(0.060)	
Frequency		-0.146**		-0.151***		-0.102*		0.0256
		(0.062)		(0.056)		(0.060)		(0.083)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.218	0.217	0.209	0.209	0.215	0.215	0.319	0.319
Observations	36,092	36,092	36,092	36,092	36,092	36,092	36,092	36,092

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5 Robustness Tests

To investigate the robustness of our results, we have run additional estimations. As developing countries rely heavily on rainfed agriculture, we have decided to report in this part, only results with meteorological droughts. And as wealthiest economies show some resilience to those droughts, we have focused for those nations, on the impact of hydrological droughts. The results are reported in Appendix C.

5.1 Additional Variables

Auffhamer et al. (2013) underline the correlation of weather variables. To avoid biased estimates, they recommend to include both temperature and precipitation in the regression equations. In consequence, we redo the estimation by controlling with temperature's variable. Moreover, higher temperature also plays a role in drought, by increasing water loss by evapotranspiration. As Machiori et al. (2012), we first compute an indicator of anomalies in temperature. It corresponds to the deviation of temperature in one month, from the average monthly temperature of the long run period (1901-2015), divided by the long run standard deviation. Then, as drought and high temperatures often happen simultaneously, we focus our attention on positive deviation. And we create two variables derived from these indicators.

- $Frequency_Temp$: The number of observation, during a period of 5 years, where a positive deviation is recorded.
- $Severity_Temp$: The sum of the index, during a period of 5 years, where a positive deviation is recorded.

The results are reported in tables 23 and 24. First, one can observe that temperature variables are not statistically significant. They do not deter agricultural exports. Nevertheless, developing countries still adopt more resistant crops in the aftermath of meteorological droughts and move toward resource based and low technological items (table 23), whereas high wage states favour more advanced technology goods (table 24).

5.2 Alternative Drought Measure

An alternative index of drought is now used to compute our frequency variable. As the SPI, the percent of normal precipitation relies on monthly rainfall data, and can be computed for different time scale. To construct this simple indicator, we divide the monthly precipitation by the normal rainfall; typically the long run mean (1901-2015), and then we multiply by 100. According to Barua et al. (2011) a drought is recorded when the precipitation is below 80%. And as previously, the total number of droughts over a period of 5 years constitutes our new variable of frequency. Once again our results appeared to be similar (table 25). A prolonged period of drought leads economies to substitute less vulnerable products for water intensive crops. Countries continue to reallocate their exports toward the production for which they have a comparative advantage.

5.3 Alternative Sample

If the exports of water intensive crop are decreasing in the aftermath of prolonged periods of droughts, one can easily understand that trade of animal and animal products may decline. As their feed and their water are under pressure, livestock are vulnerable to drought. Moreover, higher temperature threats their life too by increasing the prevalence of diseases. In the same way, drought is detrimental to fish, as higher temperature and a lower level of water drop the amount of oxygen. Here again, by reducing their income, drought may discourage farmers to pursue those activities and may push them to opt for manufacturing activity. We replicate our model, to test whether the change of specialization holds for this agricultural sector. Agriculture is now covering live animals and animal products. It corresponds to the section 1 of BACI database. The results are reported in tables 26 and 27.
First, in table 26 we observe that at medium term, developing countries abandon animal exports for low technology products, when frequent or severe meteorological droughts are recorded. This, confirms the finding that the poorest nations are moving toward labour intensive products. Our findings are also robust for wealthiest states. In table 27, we note that hydrological droughts lead them to opt for medium technology items when a severe or a recurrent disaster happens. And in a lesser extent, frequent droughts decrease animal exports in favour of resource based and low

technology products. Once again, the change in specialization follows their comparative advantage.

6 Conclusion

This paper has focused on change in specialization consecutive to drought. We have asked if a nation could take profit of drought to specialize in less vulnerable crops or to opt for industrial goods. And to test this hypothesis, we have employed exports data.

We have found that at medium term, only meteorological droughts push countries to move toward the trade of drought tolerant crops. The decline of groundwater level may discourage farmers to adopt new varieties of crops, even if they require less water.

We have also found that meteorological and hydrological droughts conduct economies to substitute exports of water intensive crop with industrial items. More precisely, we observe a reallocation of resources towards comparative advantage industries. Then, developing countries shift towards low technology and resource based industries whereas high wage states with well educated workforce move towards middle and high technology products. Several robustness checks are provided and confirm our results.

While this paper has attempted to identify empirically the change in specialization in the aftermath of drought, we do not investigate the mechanisms through which the change of trade pattern becomes possible. A better access to credit,or low levels of corruption may play a role in the change of trade pattern. Further researches are needed.

7 Appendices

7.1 Appendix A: Agricultural Products And Water Requirements: Data Sources

Table 22: Agricultural product and water requirements: data sources

HS6 Codes	Products	Sources
70190	Potatoes	http://www.fao.org/land-water/databases-and-software/crop-information/potato/fr/
70200	Tomatoes	http://www.fao.org/land-water/databases-and-software/crop-information/tomato/fr/
70310	Onions and shallots	http://www.fao.org/land-water/databases-and-software/crop-information/onion/fr/c236423
70320	Garlic	http://eujournal.org/index.php/esj/article/viewFile/4346/4166 https://cgspace.cgiar.org/bitstream/handle/10568/77373/thesis$_{t}adesse_{2}015.pdf?sequence = 1$
70390	Leeks other alliaceous vegetables	http://rhone-alpes.synagri.com/synagri/pj.nsf/TECHPJPARCLEF/13687/$File/poireau2013-170114-WEB.pdf?OpenElement
70410	Cauliflowers and headed broccoli	http://www.fao.org/land-water/databases-and-software/crop-information/cabbage/en/
70420	Brussels sprouts	https://www.fellah-trade.com/fr/filiere-vegetale/fiches-techniques/choux
70490	Edible brassicas nes	http://www.fao.org/land-water/databases-and-software/crop-information/cabbage/en/
70511	Cabbage lettuce	http://www.fao.org/land-water/databases-and-software/crop-information/cabbage/fr/
70519	Lettuce	http://www.sunshineseedlings.co.za/guidelines-tips/vegetable-guidelines/lettuce-production-guidelines/
70521	Witloof chicory	http://www.daff.gov.za/Daffweb3/Portals/0/Brochures%20and%20Production%20guidelines/Production%20guideline%20chicory.pdf
70529	Chicory	http://www.evergraze.com.au/wp-content/uploads/2013/06/Evergraze-Action-Chicory-WA-A4.pdf
70610	Carrots and turnips	http://www.daff.gov.za/Daffweb3/Portals/0/Brochures%20and%20Production%20guidelines/Production%20Guidelines%20%20Carrot.pdf
70690	Beetroot,salsify,celeriac, radishes	http://www.daff.gov.za/Daffweb3/Portals/0/Brochures%20and%20Production%20guidelines/Production%20Guidelines%20%20Beetroot.pdf
70700	Cucumbers and gherkins	http://www.irrigation.org/IA/FileUploads/IA/Resources/TechnicalPapers/2006/CropWaterAndIrrigationWaterRequirementsOfCucumberInTheLoamySandsOfKuwait.pdf Gopalkrishnan,T.R. 2007. Vegetable Crops.New Dehli : New India Publishing Agency.
70810	Peas shelled or unshelled	http://www.fao.org/land-water/databases-and-software/crop-information/pea/fr/
70820	Beans	http://www.fao.org/land-water/databases-and-software/crop-information/bean/fr/
70890	Legumes except peas beans	http://teca.fao.org/sites/default/files/technology$_{f}iles/Soya\%20and\%20other\%20leguminous\%20.pdf$
70910	Globe artichokes	http://www.gard.chambagri.fr/fileadmin/Pub/CA30/Internet$_{C}A30/Documents_{I}nternet_{C}A30/Diversification_{F}iches/Fiche_{A}rtichaut.pdf$ http://www.agrimaroc.net/bul102.htm
70920	Asparagus	http://www.aprel.fr/pdfClasse/0Fiche$_{c}ulturale_{A}sperge_{C}A13_{a}vril_{2}015.pdf$
70930	Aubergines(egg-plants)	http://www.elbroteurbano.com/como-cultivar-berenjena/
70940	Celery	http://www.biblioteca.org.ar/libros/210764.pdf
70952	Truffles	http://arborinnov.com/en/truffle-cultivation/the-art-of-truffle-cultivation/
70960	Peppers (Capsicum)	http://www.fao.org/land-water/databases-and-software/crop-information/pepper/fr/
70970	Spinach	Krishna, KR. 2014. Agroecosystems: Soils, Climate, Crops, Nutrient Dynamics and Productivity. Oakville, Ontario: Apple Academic Press.
71410	Manioc (cassava)	Yamaguchi, M., 1983. World Vegetables: Principles, Production and Nutritive Values. Westport, Connecticut: AVI
71420	Sweet potatoes	http://www2.hawaii.edu/ hector/prod%20guides%20fold/swpotato.html
71490	Arrowroot	Peter, K.V 2007. Underutilized and Underexploited Horticultural Crops.Volume 1 Delhi : New India Publishing
80110	Coconuts	http://agritech.tnau.ac.in/expert$_{s}ystem/coconut/coconut/coconut_{p}lanting_{s}easons.html$
80120	Brazil nuts	http://www.fao.org/docrep/v0784e/v0784e0k.htm
80130	Cashew nuts	http://www.nda.agric.za/docs/Infopaks/cashew.htm
80211-80212	Almonds	http://agriculture.vic.gov.au/agriculture/horticulture/fruit-and-nuts/nuts/almonds
80221-80222	Hazelnuts and filberts	Janick, J.; Paull, R.E. 2008. The Encyclopedia of Fruit& Nuts. Wallingford, UK: CAB International.
80231-80232	Walnuts	http://www.pirinoble.eu/docs/Fiche$_{L}e\%20noyer\%20hybride.pdf$
80240	Chestnuts	https://www.emme-forstbaumschulen.ch/index.php?option=com$_{c}ontent\&view = article\&id = 208\&Itemid = 983\&lang = fr$
80250	Pistachios	http://www.agrimaroc.net/01-45.htm
80300	Bananas	http://www.fao.org/land-water/databases-and-software/crop-information/banana/fr/
80410	Dates	http://www.fao.org/docrep/006/Y4360E/y4360e08.htm
80420	Figs	http://p487.phpnet.org/Web-SFR/Figuierculture.htmlmozTocId221698
80430	Pineapples	http://www.itfnet.org/gfruit/Templates%20English/pineapple.biology.htm
80440	Avocados	http://www.daff.gov.za/docs/Infopaks/avocado.htm
80450	Guavas	https://www.hort.purdue.edu/newcrop/morton/guava.html
80450	Mangoes	http://nhb.gov.in/pdf/fruits/mango/man012.pdf
80510	Oranges	http://www.fao.org/land-water/databases-and-software/crop-information/citrus/fr/
80520	Mandarin	http://www.fao.org/land-water/databases-and-software/crop-information/citrus/fr/
80530	Lemons and limes	http://www.fao.org/land-water/databases-and-software/crop-information/citrus/fr/
80540	Grapefruit	http://www.fao.org/land-water/databases-and-software/crop-information/citrus/fr/
80590	Citrus fruits	http://www.fao.org/land-water/databases-and-software/crop-information/citrus/fr/
80610	Grapes	http://www.fao.org/land-water/databases-and-software/crop-information/grape/fr/
80710	Melons (including watermelons)	http://www.fao.org/land-water/databases-and-software/crop-information/watermelon/fr/
80720	Papaws (papayas)	http://www.aguayriego.com/en/2015/08/riego-del-cultivo-de-la-papaya/
80810	Apples	http://www.agrimaroc.net/bul115.htm
80820	Pears and quinces	https://agrolib.rs/en/quince-production/
80910	Apricots	http://www.gard.chambagri.fr/fileadmin/Pub/CA30/Internet$_{C}A30/Documents_{I}nternet_{C}A30/Diversification_{F}iches/Fiche_{A}bricot.pdf$
80920	Cherries	http://www.pirinoble.eu/docs/Ficha%20Cerezo.pdf

Table 22: Agricultural product and water requirements : data sources

HS6 Codes	Products	Sources
80930	Peaches	https://www.netafim.com.au/crop/peaches-and-nectarines/best-practice
80940	Plums	http://ciruelospuc.blogspot.fr/
81010	Strawberries	https://www.growcom.com.au/$_{u}ploads/LWR/CB1_{S}trawberries\%20TP.pdf$
81020	Raspberry	http://www.guichetdusavoir.org/viewtopic.php?t=33578
81030	Black, white or red currants and groseberries	http://www.omafra.gov.on.ca/french/crops/facts/98-096.htm
81040	Cranberries	http://www.nrcresearchpress.com/doi/abs/10.1139/cjss-2015-0095?journalCode=cjss.Wh0623mDPIU
90111-90112-90122-90130	Coffee	http://www.scielo.br/scielo.php?script=sci$_{a}rttext\&pid = S1677 - 04202007000400014$
90210-90220-90230-90240	Tea	http://www.omafra.gov.on.ca/french/crops/facts/98-096.htm
90300	Mate	https://www.ushuaia.pl/yerba/where
90411-90412	Pepper of the genus Piper	http://www.arccjournals.com/uploads/articles/ar292002.pdf
90420	Capsicum or Pimenta	http://www.agrimaroc.net/198.pdf
90500	Vanilla beans	http://www.fao.org/fileadmin/user$_{u}pload/inpho/docs/Post_{H}arvest_{C}ompendium_{-V}anilla.pdf$
90610-90620	Cinnamon and cinnamon-tree flowers whole	https://www.cabi.org/isc/datasheet/13573
90700	Cloves	http://ultranl.com/global-cove-markets-2017/
90810	Nutmeg	Weiss EA 2002. Spice crops. Wallingford : CABI Publishing
90820	Mace	http://factsanddetails.com/world/cat54/sub345/item1610.html
90920	Coriander seeds	Weiss EA 2002. Spice crops. Wallingford : CABI Publishing
90930	Cumin seeds	Lim, T. K. 2013. Edible Medicinal And Non-Medicinal Plants. Vol. 5 Netherlands :Springer
90940	Caraway seeds	Bajaj, Y.P.S. 1995 . Medicinal and Aromatic Plants VIII. Springer Science & Business Media: Berlin/Heidelberg, Germany
90950	Fennel seeds	https://www.cabi.org/isc/datasheet/24271
91010	Ginger	http://www.iccoa.org/download/ginger.pdf
91020	Saffron	http://www.boobookhill.com/Kiwi%20Saffron.pdf
91030	Turmeric (curcuma)	http://agritech.tnau.ac.in/banking/PDF/Tumeric.pdf
91040	Thyme and bay leaves	http://www.daff.gov.za/Daffweb3/Portals/0/Brochures%20and%20Production%20guidelines/Production%20Guidelines%20Thyme.pdf
100110	Durum wheat	http://www.fao.org/land-water/databases-and-software/crop-information/wheat/fr/
100190	Wheat except durum wheat	http://www.fao.org/land-water/databases-and-software/crop-information/wheat/fr/
100200	Rye	https://www.feedipedia.org/node/385
100300	Barley	http://www.daff.gov.za/Daffweb3/Portals/0/Brochures%20and%20Production%20guidelines/Brochure%20Barley.pdf
100400	Oats	Behnassi , M., Muteng'e,M.S. , Ramachandran, G. , Shelat,K.N. 2014 Vulnerability of agriculture, water and fisheries to climate change: toward sustainable adaptation strategies
100510	Maize	http://www.fao.org/land-water/databases-and-software/crop-information/maize/fr/
100610-100620-100630-100640	Rice	http://www.knowledgebank.irri.org/step-by-step-production/growth/water-management
100700	Grain sorghum	http://www.fao.org/land-water/databases-and-software/crop-information/sorghum/fr/
100810	Buckwheat	http://www.poitou-charentes.chambagri.fr/fileadmin/publication/CRA/15$_{I}nnovation/Agronomie_{f}t/Fiche_{S}arrasin.pdf$
100820	Millet	http://www.fao.org/docrep/u3160e/u3160e04.htm
100830	Canary seed	https://rirdc.infoservices.com.au/downloads/01-178
120100	Soya beans	http://www.fao.org/land-water/databases-and-software/crop-information/soybean/fr/
120210-120220	Ground-nuts	http://www.fao.org/land-water/databases-and-software/crop-information/groundnut/fr/
120400	Linseed	http://dpipwe.tas.gov.au/Documents/WfW-Linseed$_{f}actsheet.pdf$
120500	Rape or colza seeds	http://www.daff.gov.za/Daffweb3/Portals/0/Brochures%20and%20Production%20guidelines/Canola%20-%20Production%20Guideline.pdf
120600	Sunflower seeds	http://www.fao.org/land-water/databases-and-software/crop-information/sunflower/fr/
120710	Palm nuts and kernels	https://www.netafim.com/crop/oil-palm/best-practice
120720	Cotton seeds	http://www.fao.org/land-water/databases-and-software/crop-information/cotton/fr/
120730	Castor oil seeds	http://www.parc.gov.pk/index.php/en/csi/137-narc/crop-sciences-institue/732-castor
120740	Sesamum seeds	http://cdn.intechopen.com/pdfs/37648/InTech-Sesame$_{s}eed.pdf$
120750	Mustard seeds	Lim, T. K. 2013. Edible Medicinal And Non-Medicinal Plants. Vol. 5 Netherlands :Springer
120760	Safflower seeds	http://www.fao.org/land-water/databases-and-software/crop-information/safflower/fr/
120791	Poppy seeds	Lim, T. K. 2013. Edible Medicinal And Non-Medicinal Plants. Vol. 5 Netherlands :Springer
120792	Shea nuts (karite nuts)	http://wwwsp.inia.es/Investigacion/centros/CIFOR/redes/Genfored/Documents/Karite$_{S}hea - Trees.pdf$
121010	Hop cones	https://onspecialtycrops.wordpress.com/2011/07/21/irrigation-requirements-for-your-hop-yard/
121110	Liquorice roots	http://bioweb.uwlax.edu/bio203/s2012/olsen$_{b}ran/habitat.htm$
121120	Ginseng roots	https://hort.purdue.edu/newcrop/afcm/ginseng.html
121291	Sugar beet	http://www.fao.org/land-water/databases-and-software/crop-information/sugarbeet/fr/
121292	Sugar cane	http://www.fao.org/land-water/databases-and-software/crop-information/sugarcane/fr/
130211	Opium sap	Lim, T. K. 2013. Edible Medicinal And Non-Medicinal Plants. Vol. 5 Netherlands :Springer
140110	Bamboos	https://www.guaduabamboo.com/forum/how-much-water-is-needed-to-grow-bamboo
140120	Rattan	http://www.fao.org/docrep/003/Y2783E/y2783e11.htm
180100-180200	Cocoa beans	https://www.icco.org/about-cocoa/growing-cocoa.html
240110-240120	Tobacco	http://www.fao.org/land-water/databases-and-software/crop-information/tobacco/fr/

7.2 Appendix B: List of Countries

Afghanistan
Albania
Algeria
Angola
Antigua and Barbuda
Argentina
Armenia
Australia
Austria
Azerbaijan
Bahamas
Bangladesh
Barbados
Belarus
Belgium
Belize
Benin
Bhutan
Bolivia
Bosnia and Herzegovina
Brazil
Bulgaria
Burkina Faso
Burundi
Cambodia
Cameroon
Canada
Central African Republic
Chile
China
Colombia
Congo
Costa Rica
Côte d'Ivoire
Croatia
Cyprus
Czech Republic
Democratic Republic of the Congo
Denmark
Djibouti
Dominica
Dominican Republic
Ecuador
Egypt
El Salvador
Eritrea
Estonia
Ethiopia
Fiji
Finland
France
Gabon
Gambia
Georgia
Germany
Ghana
Greece
Grenada
Guatemala
Guinea
Guyana
Haiti
Honduras
Hong Kong
Hungary
Iceland
India
Indonesia
Iran
Iraq
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kazakstan
Kenya
Korea, Rep. of
Kyrgyzstan
Laos
Latvia
Liberia
Libya
Lithuania
Macau
Madagascar
Malawi
Mali
Mauritius
Mexico
Moldova, Rep.of
Morocco

Mozambique
Myanmar
Nepal
Nherlands
New Zealand
Nicaragua
Nigeria
Norway
Pakistan
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Poland
Portugal
Roumania
Russian Federation
Rwanda
Saint Kitts and Nevis
Saint Lucia
Saint Vincent and the Grenadines
Samoa
Senegal
Seychelles
Sierra Leone
Singapore
Slovakia
Slovenia
South Africa
Spain
Sri Lanka
Sudan
Suriname
Sweden
Switzerland
Syrian Arab Republic
Tajikistan
Tanzania, United Rep. of
Thailand
The former Yugoslav Rep. of Macedonia
Togo
Tonga
Trinidad and Tobago
Tunisia
Turkey
Uganda
Ukraine
United Kingdom
United States of America
Uruguay
Vanuatu
Venezuela
Viet Nam
Yemen
Zambia
Zimbabwe

7.3 Appendix C: Additional Tables

Table 23: Temperature and change in specialization at medium term- Developing countries

Sector	Drought tolerant crop		Resource Based		Low Tech.		Middle Tech.		High Tech.	
Drought's type	Meteorological									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Severity	-0.094 (0.071)		-0.147** (0.070)		-0.128** (0.059)		0.031 (0.058)		-0.112 (0.074)	
$Severity_Temp$	-0.026 (0.125)		0.018 (0.120)		-0.074 (0.098)		-0.251** (0.115)		-0.085 (0.0137)	
Frequency		-0.159** (0.081)		-0.130* (0.078)		-0.163** (0.068)		-0.038 (0.068)		-0.125 (0.083)
$Frequency_Temp$		0.176 (0.241)		0.283 (0.196)		0.356** (0.179)		-0.283 (0.213)		0.403 (0.0262)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.192	0.192	0.217	0.218	0.209	0.209	0.215	0.216	0.319	0.319
Observations	36,092	36,092	36,092	36,092	36,092	36,092	36,092	36,092	36,092	36,092

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 24: Temperature and Change in specialization at medium term- Developed countries

Sector	Drought tolerant crop		Resource Based		Low Tech.		Middle Tech.		High Tech.	
Drought's type	Hydrological									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Severity	-0.079 (0.055)		-0.108** (0.042)		-0.093** (0.039)		-0.147*** (0.045)		-0.086 (0.059)	
$Severity_Temp$	0.442** (0.224)		0.210 (0.166)		0.120 (0.175)		-0.379* (0.199)		-0.021 (0.241)	
Frequency		-0.0849 (0.075)		-0.159*** (0.055)		-0.143** (0.053)		-0.210*** (0.061)		-0.055 (0.080)
$Frequency_Temp$		0.755** (0.298)		0.287 (0.218)		-0.025 (0.226)		-0.485* (0.268)		-0.173 (0.331)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.207	0.207	0.222	0.222	0.218	0.218	0.223	0.223	0.345	0.345
Observations	28,146	28,146	28,146	28,146	28,146	28,146	28,146	28,146	28,146	28,146

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 25: Percent of Normal Precipitation and Change in specialization at medium term.

Manufacturing sector	Drought tolerant crop	Resource Based	Low . Tech.	Middle Tech.	High Tech.	Drought tolerant crop	Resource Based	Low Tech.	Middle Tech.	High Tech.
Country's sample	Developing					Developed				
Drought's type	Meteorological					Hydrological				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Frequency	-0.184*** (0.077)	-0.0341 (0.088)	-0.161** (0.071)	0.001 (0.078)	-0.038 (0.097)	-0.316** (0.128)	-0.236* (0.139)	-0.280** (0.124)	-0.525*** (0.160)	-0.605*** (0.212)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.192	0.217	0.209	0.215	0.319	0.206	0.222	0.218	0.223	0.346
Observations	28,146	28,146	28,146	28,146	28,146	28,146	28,146	28,146	28,146	28,146

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 26: Animal trade and change in specialization at medium term-Developing countries

Manufacturing sector	Resource Based		Low Tech.		Middle Tech.		High Tech.	
Drought's type	Meteorological							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Severity	-0.116		-0.196***		0.025		-0.123	
	(0.072)		(0.069)		(0.061)		(0.082)	
Frequency		-0.085		-0.203**		0.013		-0.106
		(0.079)		(0.079)		(0.072)		(0.095)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.243	0.243	0.239	0.239	0.248	0.248	0.337	0.337
Observations	63,879	63,879	63,879	63,879	63,879	63,879	63,879	63,879

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 27: Animal trade and change in specialization at medium term-Developed countries

Manufacturing sector	Resource Based		Low Tech.		Middle Tech.		High Tech.	
Drought's type	Hydrological							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Severity	-0.055*		-0.039		-0.099***		-0.033	
	(0.033)		(0.029)		(0.034)		(0.046)	
Frequency		-0.084*		-0.066*		-0.119***		-0.009
		(0.043)		(0.039)		(0.045)		(0.060)
Export x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
Time x Product FE	YES	YES	YES	YES	YES	YES	YES	YES
R-squared	0.209	0.209	0.210	0.210	0.208	0.208	0.342	0.342
Observations	81,517	81,517	81,517	81,517	81,517	81,517	81,517	81,517

Notes: Standard errors are clustered by exporting year level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.