How do environmental shocks affect competitors in a supply chain? Evidence from a competitors' weighting matrix

Jhorland Ayala – García[1]; Federico Ceballos – Sierra[2]
[1]Central Bank of Colombia, [2]Aliance of Bioversity International and CIAT

Abstract

Quantifying the impact of supply shocks on global commodity trade networks is an increasing concern for researchers under the current threats of climate change and the COVID-19 pandemic. This paper proposes a novel methodology to estimate these effects across the entire trade network: we create a weight matrix based on an index that captures the extent to which two coffee-producing countries compete within consumer markets. Using this matrix, we estimate the degree to which an adverse weather shock in a coffee-producing country influences the coffee production of its competitors. Our results show that this adverse shock has a negative direct effect on the country's coffee exports and, importantly, a positive effect on the quantities produced by competitors.

Introduction

The negative direct effect of adverse weather conditions has already been shown by several empirical studies. However, the indirect effect on competitor countries has largely been ignored by these studies, which fail to recognize the interdependence between seemingly unrelated countries as they belong to interconnected supply chains (Fold, 2014). This could lead to biased estimates of the impact of climate change on global trade, as negative direct impacts of adverse weather conditions on the dyadic relationship between exporter and importer might be offset by increased production coming from competitor countries as information is transmitted via prices (Lybbert et al., 2014).

Methods and Materials

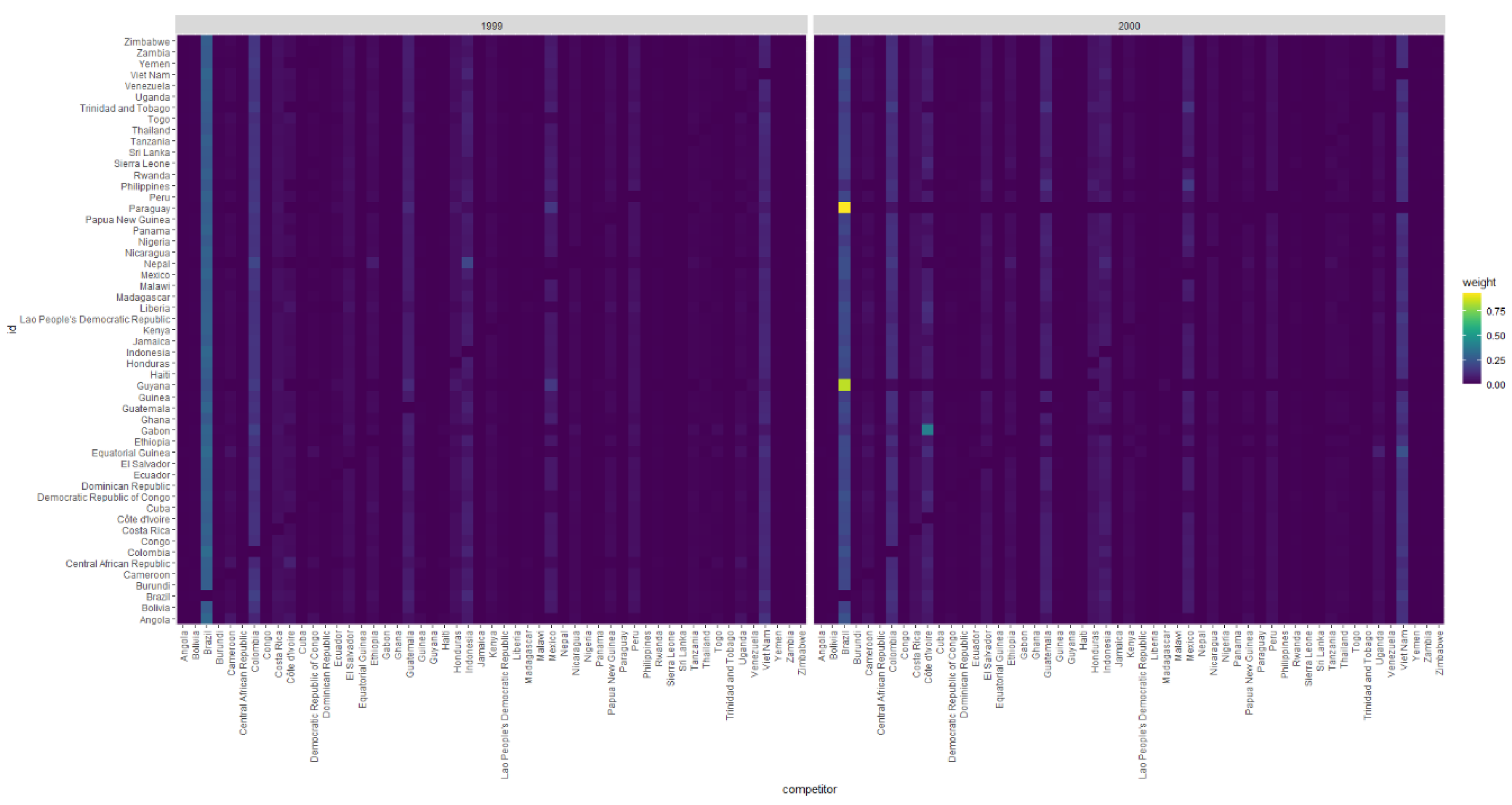
The degree of competition between any pair of countries i and j is measured based on the predicted potential coffee demand from country i, $\widehat{PD}_{it}$. We define $\widehat{PD}_{it}$ as the difference between the total predicted coffee demand of the buyers of country i, $\widehat{D}_t$, and the total predicted coffee sales of country i at year t, that is, $\widehat{PD}_{it} = \widehat{D}_t - \widehat{D}_{it}$.

We obtain the predicted trade between countries j and i, $\widehat{T}_{jit}$ which equals $\widehat{D}_{ijt}$. Next, for every country i and year t, we sum up the predicted coffee demand of all buyers for which $\widehat{D}_{ijt} > 0$. As a result, we have the predicted demand of all countries that sell coffee to the same set of buyers, $\widehat{D}_t = \sum_j \widehat{D}_{ijt}, \forall\, \widehat{D}_{ijt} > 0$. Then, the degree of competition between countries i and j at time t, w_{ijt} can be defined as follows:

$$w_{ijt} = \frac{\widehat{D}_{jt}}{\widehat{PD}_{it}},$$

Where $\widehat{D}_{jt}$ is the total predicted coffee sales by country j to all the buyers of country i at time t. The larger $\widehat{D}_{jt}$, the stronger the degree of competition between countries i and j. By construction, $\boldsymbol{W_t}$ is a row standardized weighting matrix. That is, $\sum_j w_{ijt} = 1$.

Figure 1. Comparison of the *W1999* and *W2000* matrices.



Results

The results indicate that extreme weather events happening in competitor countries significantly affect local coffee markets. Frosts happening locally do not affect total production, exports, consumption, nor stocks, whereas frosts happening in competitor countries have a positive effect on production and exports, and a negative impact on local consumption and stocks. In addition, frosts happening in neighboring countries one year before increase local production, exports, and stocks, but reduce local consumption.

The increase in local production after a contemporary frost may explain why the stock is larger in the next year. Specifically, a contemporary frost in all competitor countries can increase local coffee production by 2,632 tons, exports by 729 tons, while reducing local consumption by 79 tons and stocks by 855 tons. One possible explanation can be that countries decrease their stock after a negative production shock in competitors to capture the potential demand

Table 1. Gravity estimation of coffee exports: PPML results.

Dependent variable	Exports
Population of origin	-2.458***
	(0.527)
Population of destination	0.673
	(0.522)
Ln(GDP per capita) origin	0.968***
	(0.172)
Ln(GDP per capita) destination	0.812***
	(0.222)
Frost at origin	-0.071***
	(0.024)
	-5.970
Constant	(14.118)
Observations	109,707
Pseudo R-squared	0.951

Table 2. Frosts and coffee production, consumption, exports, and stocks.

	Production	Exports	Consumption	Stocks
ln(production) (t-1)	0.66***			
	(0.09)			
ln(exports) (t-1)		0.85***		
		(0.03)		
ln(consumption) (t-1)			0.98***	
			(0.00)	
W*Frost	2,631.93***	729.27***	-78.63***	-855.04***
	(497.75)	(217.09)	(17.58)	(169.83)
W*Frost (t-1)	611.66***	309.07***	-62.48***	389.08***
	(190.62)	(107.50)	(13.56)	(74.89)
Constant	-1,839.04***	-360.16	33.82	42.90
	(655.56)	(347.84)	(44.13)	(199.32)
Observations	1,171	1,171	1,171	1,171
Adjusted R-squared	0.61	0.79	0.99	0.78

Discussion

Ignoring this indirect effect would lead us to incorrect conclusions about the effect of natural disasters on coffee production and exports. The fact that frosts in competitor countries affect local production and exports is another example of the potential compensating effect of trade after negative weather shocks (Ayala et al., 2022). Not surprisingly, the dependent variables show a very strong dependance on its lagged values, which is consistent with having a sample of coffee producing countries. In addition, there is no elasticity of coffee production, exports, consumption, nor stocks to per capita GDP, as well as no significant relationship with other weather control variables such as temperature and precipitation, possibly because we consider countries fixed effects in our regressions.

Conclusions

Our approach consists of creating a row standardized weighting matrix of competitor countries, where the weights represent the market share of producer countries among all the producers facing the same international demand for the product each year. It is expected that a negative weather shock in a producer country that reduces local coffee production will also reduce the market segment of the same country in the international market. That segment will be captured by the closest competitors. As a result, this paper contributes to the literature by proposing a method for estimating this indirect effect of weather shocks applied to the coffee trade network.

Contact

Federico Ceballos-Sierra
Alliance of Bioversity International and CIAT
Federico.Ceballos@cgiar.org

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