Economic impacts of El Niño: the case of the the Colombian coffee market

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November 19, 2015 - FEEM-IEFE Joint Seminar

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Research questions & Results

What is ENSO and why do economists care?

ENSO and the Colombian coffee industry

A Structural VAR model for the coffee market

Results

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Introduction

ENSO: Current Status & Predictions

THE WALL STREET JOURNAL.

Get Ready to Weather the Price of El Niño

Forecasters in the U.S., Australia and Japan have confirmed El Niño is back

Le Monde.fr

El Niño de retour après cinq ans d'absence

The New York Times

Fed Upgrade El Nino to Strong, but Not as Big as 1997-98

REUTERS

Almost 20 pct of Colombia coffee crop affected by El Nino-federation

SPIEGEL ONLINE

Meteorologen warnen vor Super-El-Niño

CORRIERE DELLA SERA

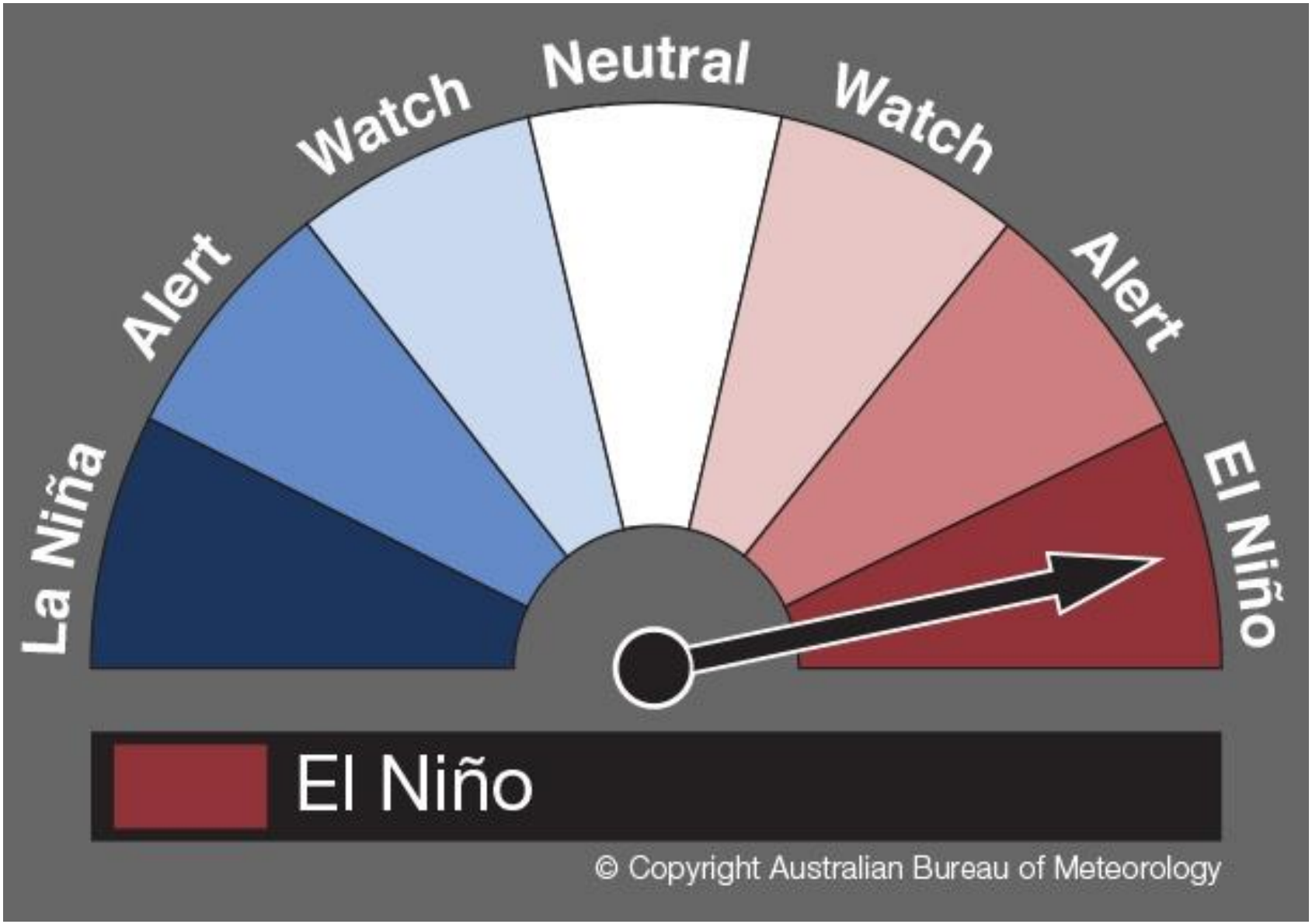
Clima, il ritorno del Niño: «Anno record, come il 1997»

EL PAÍS

'El Niño' será uno de los peores desde 1950 por el cambio climático

Introduction

ENSO: Current Status & Predictions



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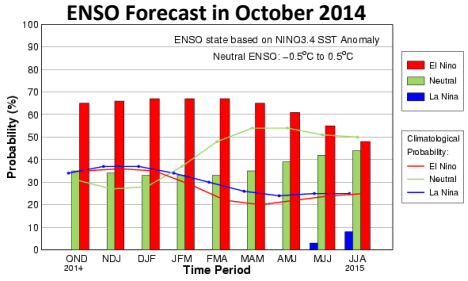
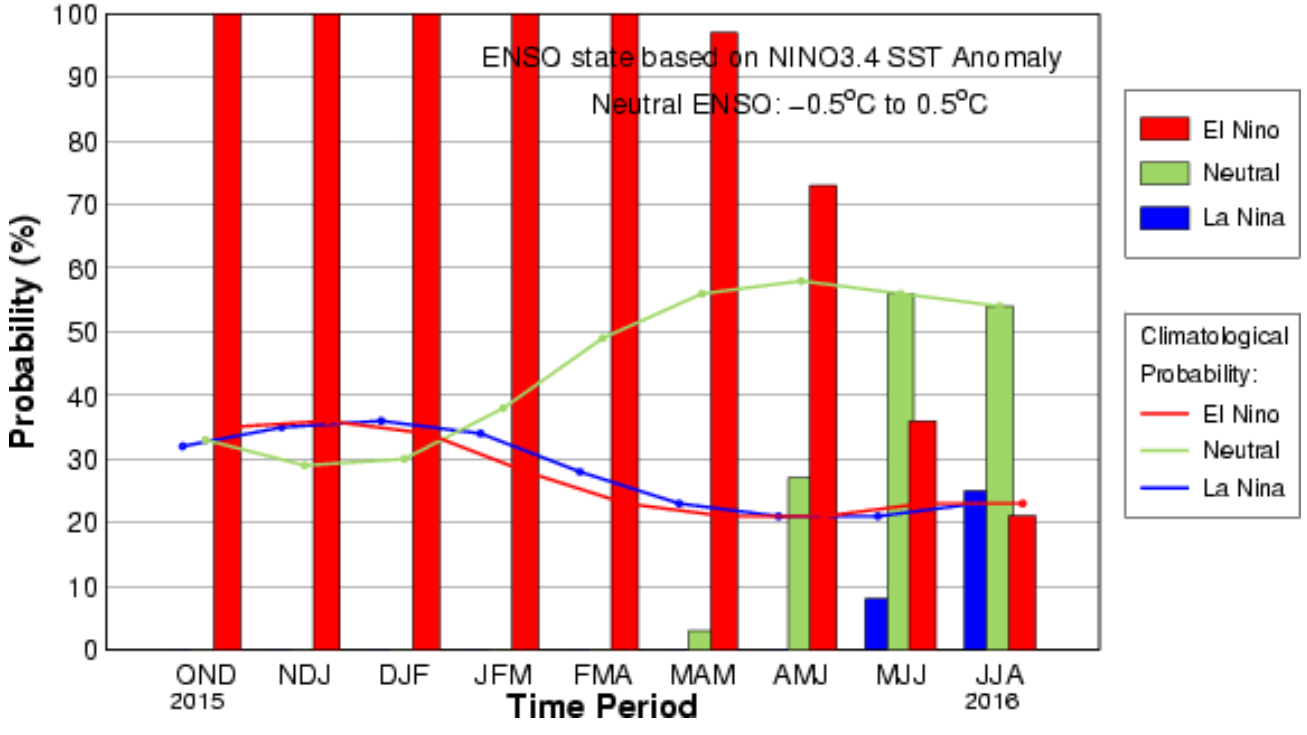
ENSO: Current Status & Predictions



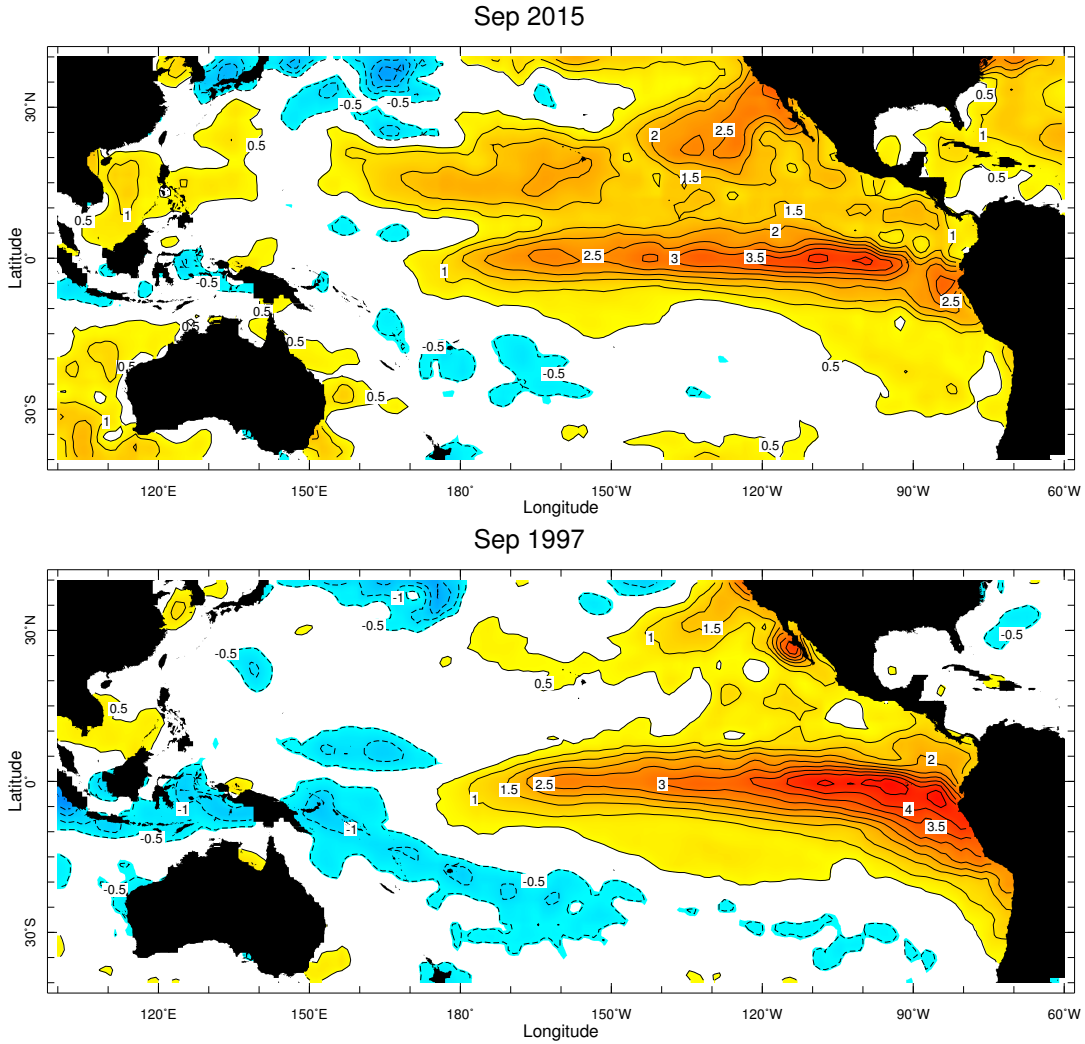
ENSO Forecast in October 2015



Source: The International Research Institute for Climate and Society (IRI) - The Earth Institute, Columbia University.

Introduction

Sea Surface Temperature Anomalies in 2015 & 1997 (Strong El Niño)



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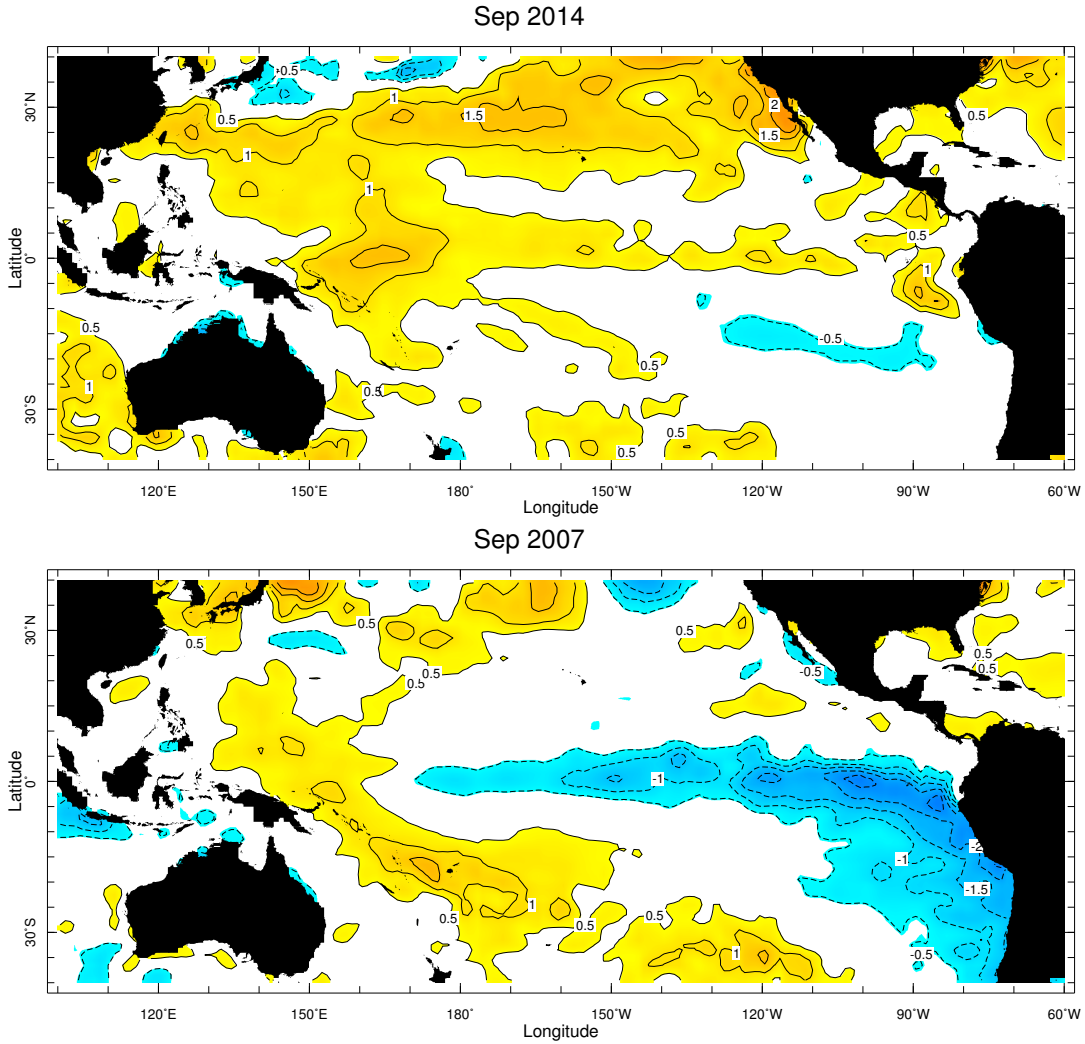
Sea Surface Temperature Anomalies in 2014 (neutral) & 2007 (La Niña)



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Research questions

1. Economic impacts of El Niño Southern Oscillation (ENSO) on the Colombian coffee market

2. Develop an econometric model of the coffee market
   - Structural Vector Autoregressive (VAR) model to describe how coffee export, production and price react to ENSO, demand and supply shocks

Main Results

- The impact of ENSO shocks is small compared with other supply and demand-side innovations

  - El Niño shocks increase production and reduce price;
  - La Niña shocks reduce production and increase price.

Introduction

Research questions & Results

What is ENSO and why do economists care?
- What is ENSO?
- How do we measure ENSO?
- How does ENSO affect world economies?
- Why do economists care about ENSO?
- Literature

ENSO and the Colombian coffee industry

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What is ENSO?

- El Niño Southern Oscillation (ENSO) refers to the interaction between the atmosphere and ocean in the tropical Pacific.
  - El Niño refers to the ocean component of ENSO.
  - The Southern Oscillation component identifies swings in atmospheric pressure between the eastern and western tropical Pacific.

- Peruvian fishermen observed the warmer water during the Christmas season: El Niño means the Little Boy, or Christ Child in Spanish.

What is ENSO?

- El Niño and La Niña are opposite phases of the ENSO cycle.

	El Niño	**La Niña**
	ENSO Warm Phase	ENSO Cold Phase
Temperature	Warmer than usual	Cooler than usual
SST[1] anomalies	Positive	Negative
Air pressure	below-normal at Tahiti above-normal at Darwin	above-normal at Tahiti below-normal at Darwin
Rainfall anomalies	droughts more likely throughout the tropics	droughts more likely throughout much of the mid-latitudes

- Effects: periodic changes in sea-level pressure, sea-surface temperature, precipitation and winds all around the world.

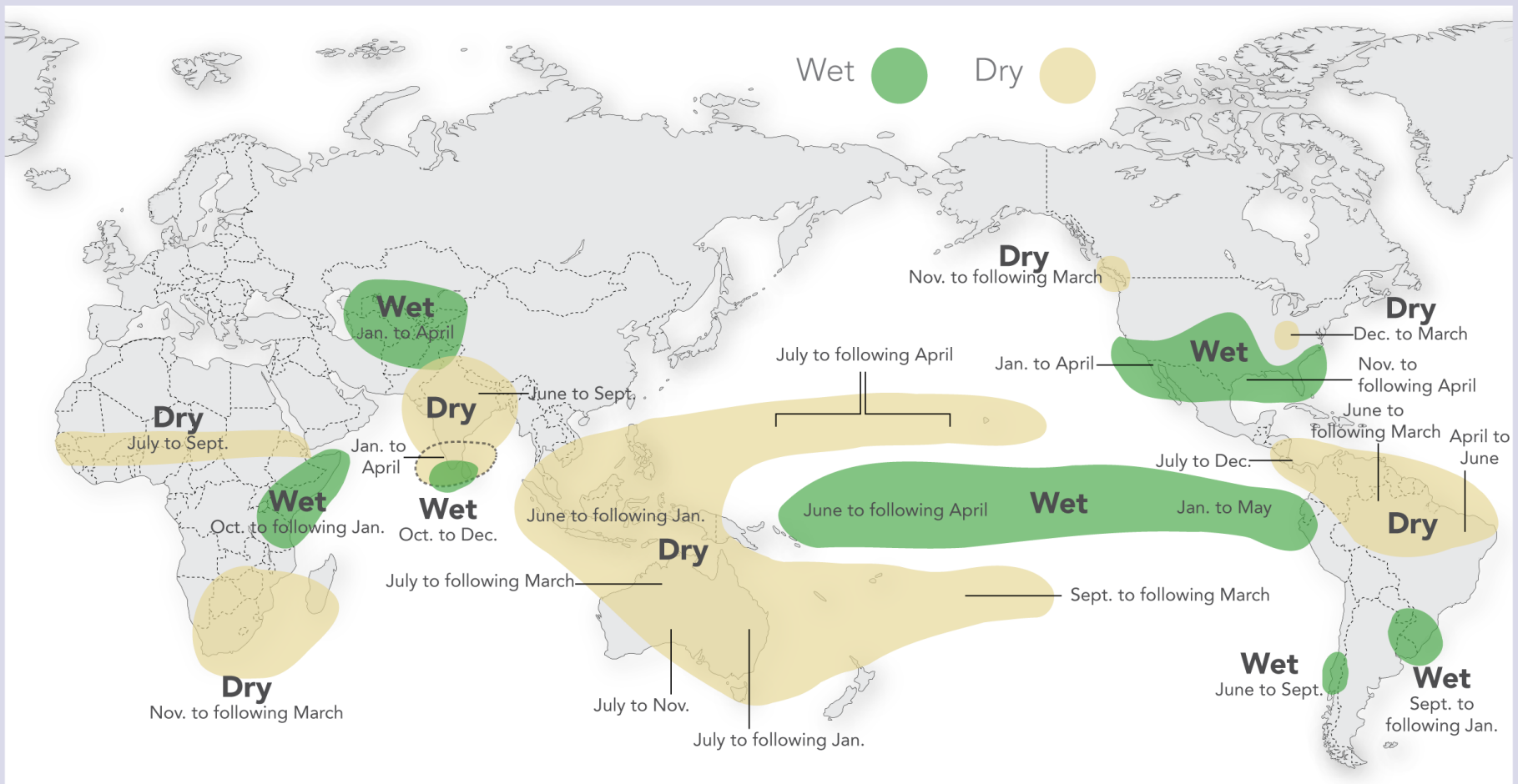
- Effects of El Niño and La Niña on weather and hence on economies vary through time and space.

[1] SST = Sea Surface Temperature

El Niño and Rainfall

El Niño and Rainfall

El Niño conditions in the tropical Pacific are known to shift rainfall patterns in many different parts of the world. Although they vary somewhat from one El Niño to the next, the strongest shifts remain fairly consistent in the regions and seasons shown on the map below.



For more information on El Niño and La Niña, go to: http://iri.columbia.edu/enso/

Sources:
1. Ropelewski, C. F., and M. S. Halpert, 1987: Global and regional scale precipitation patterns associated with the El Nino Southern Oscillation. Mon. Wea. Rev., 115, 1606-1626;
2. Mason and Goddard, 2001. Probabilistic precipitation anomalies associated with ENSO. Bull. Am. Meteorol. Soc. 82, 619-638

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La Niña and Rainfall

La Niña and Rainfall

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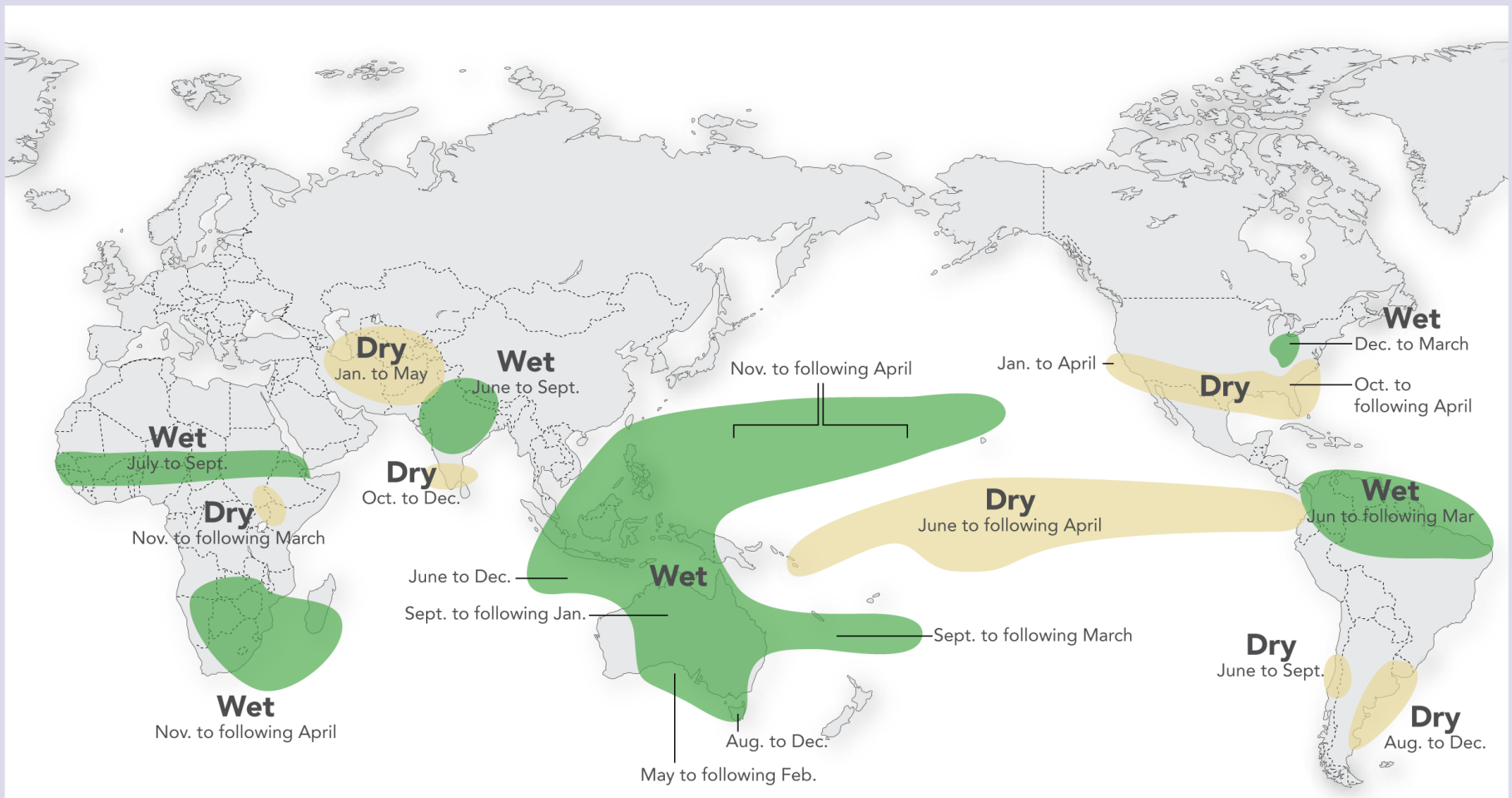

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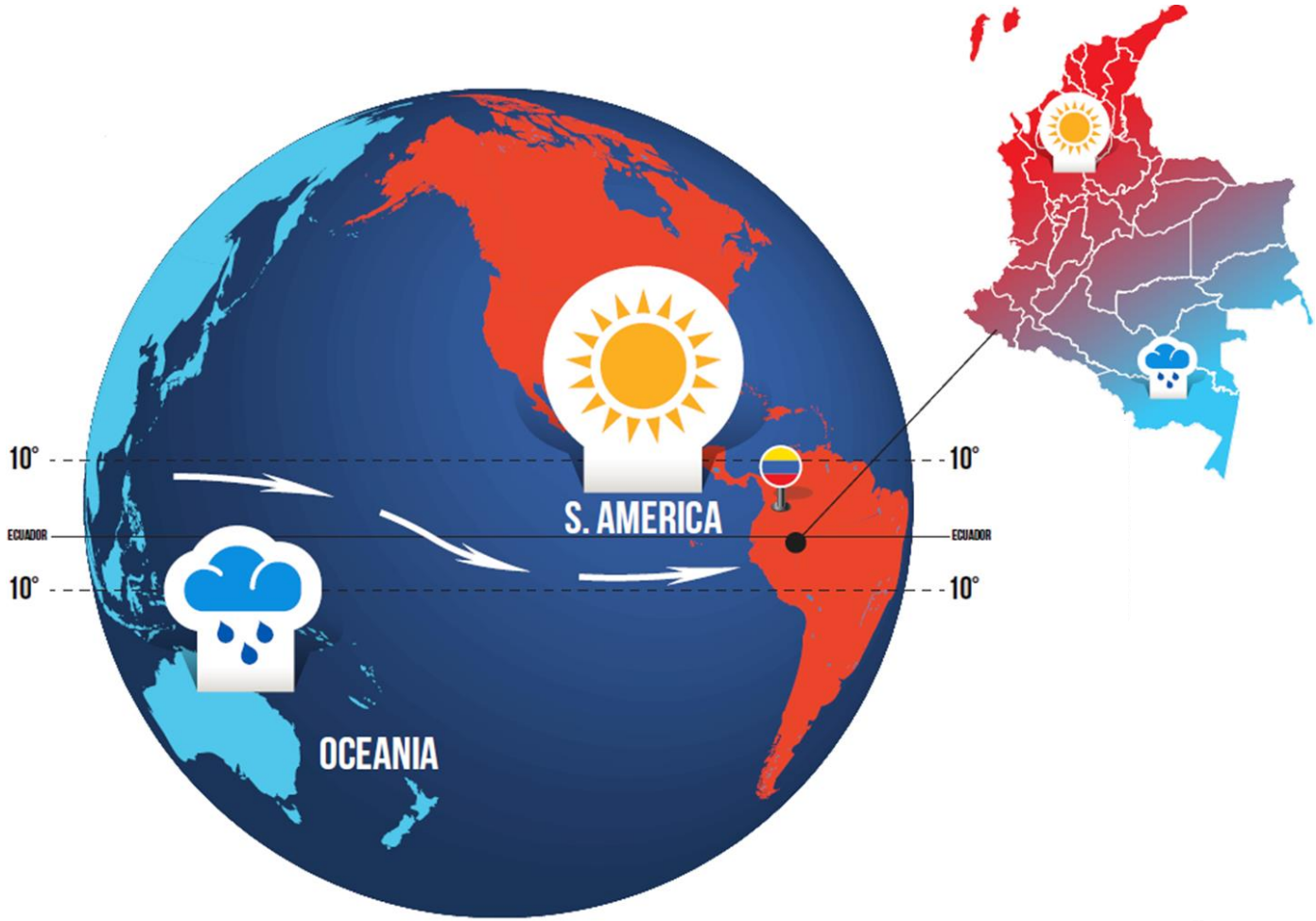
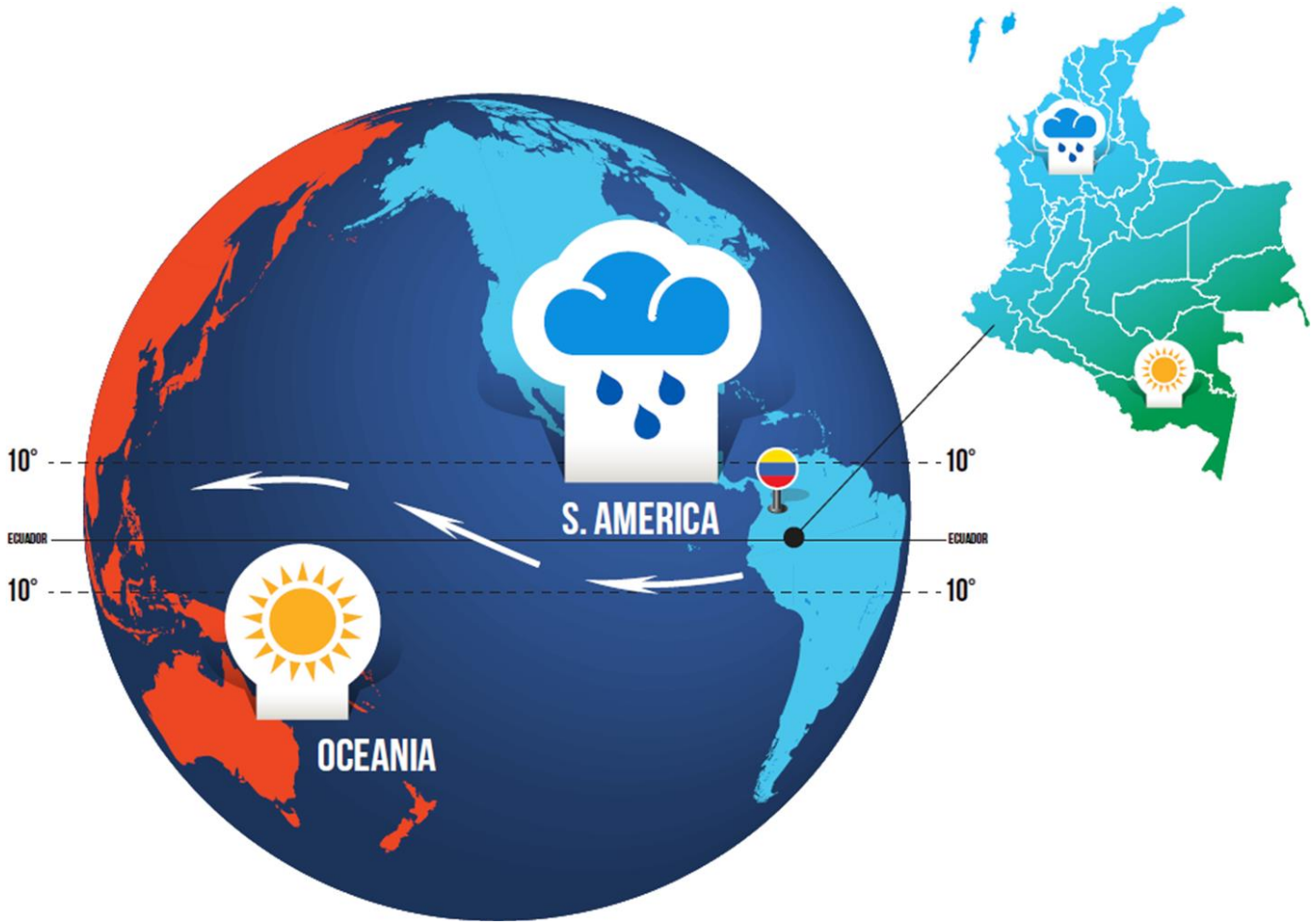
El Niño in Colombia

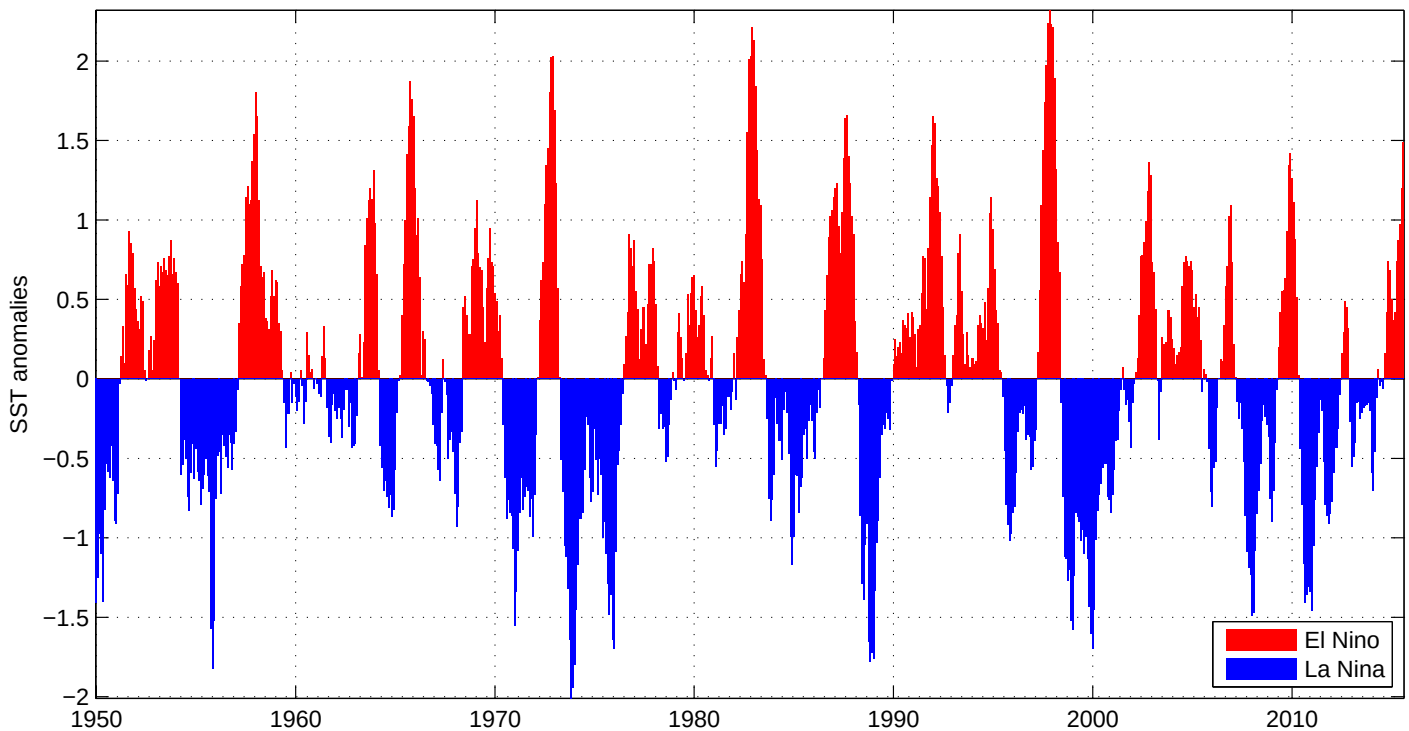


La Niña in Colombia



How do we measure ENSO?

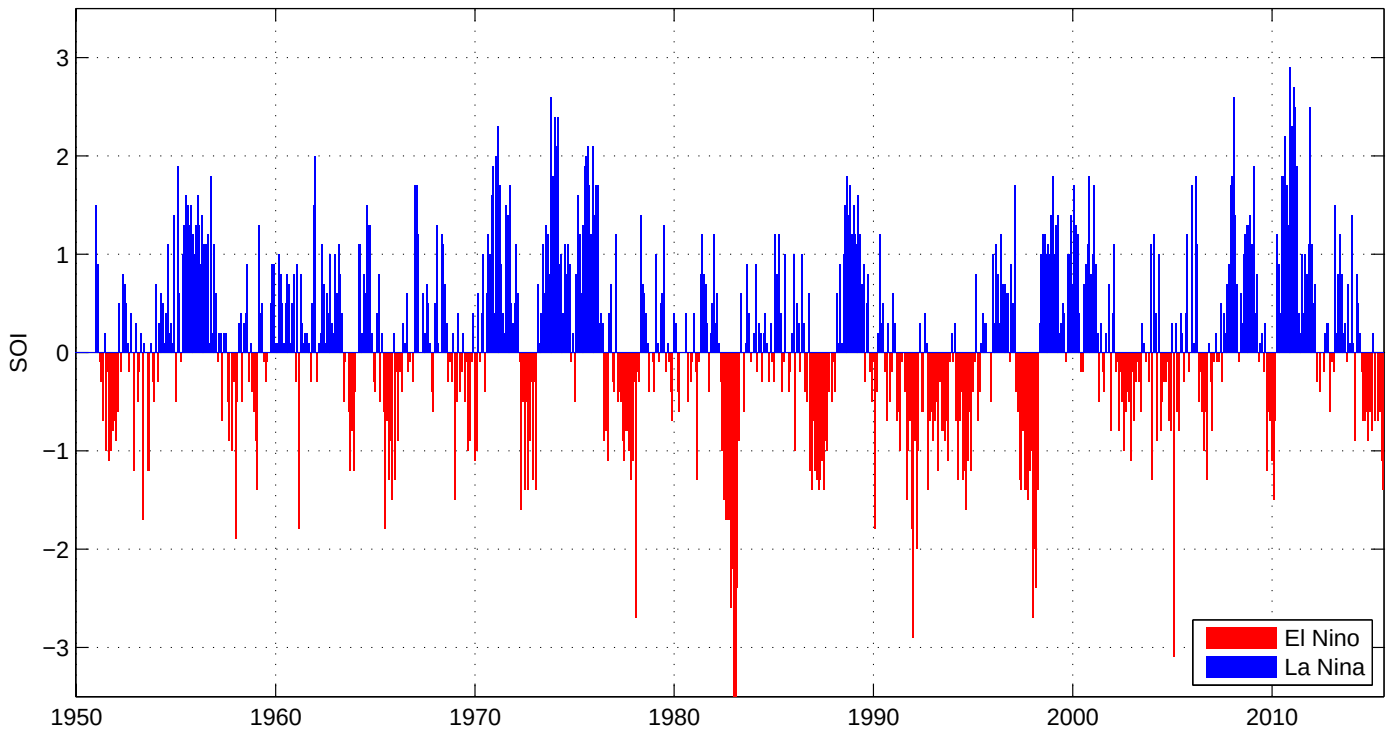
1. Sea Surface Temperature anomalies (SST): El Niño (La Niña) corresponds to five consecutive 3-month running mean of SST anomalies in the Niño 3.4 region that is above (below) the threshold of +0.5° C (-0.5° C).[2]



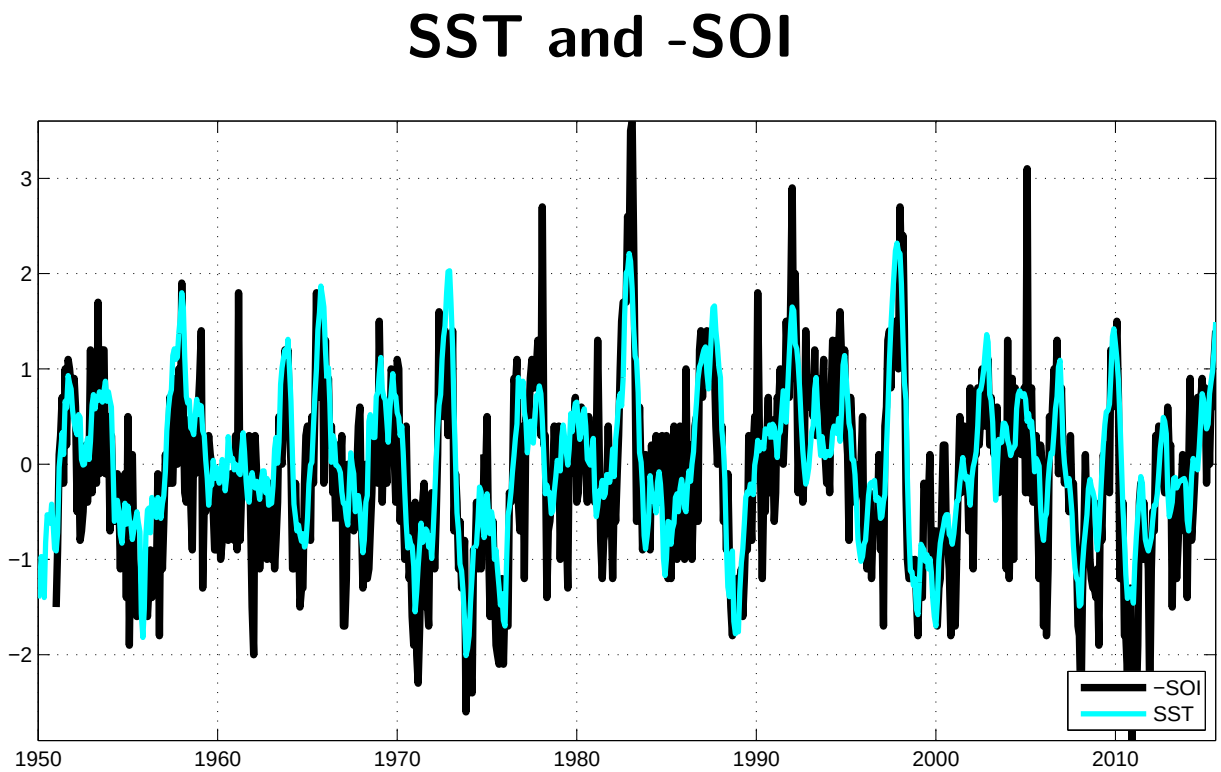
[2]SST is also known as the Oceanic Niño Index (ONI).

How do we measure ENSO?

2. Southern Oscillation Index (SOI): a standardized index based on the observed sea level pressure differences between Tahiti and Darwin (AUS).



How do we measure ENSO?



- corr(SST,-SOI) = 0.7
- Results based on SST;
- Results based on -SOI are qualitatively identical.

How does ENSO affect world economies?

Nasdaq

Will El Nino Give a Boost to Commodities?

TIME

Why El Niño Might Make Your Latte Cost More

THOMSON REUTERS

Miners on weather watch through to year-end as "super" El Niño yet to peak

Posted in: Charts, News & Data, Agriculture, Commodities · 20 Aug 2015

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El Niño Drought Forces Panama Canal to Restrict Ship Size

Falling water levels, a byproduct of an El Niño-triggered drought, is forcing the Panama Canal to limit container ships to 39 feet of draft, a small reduction that will affect nearly 20% of vessels passing through the waterway.

BloombergBusiness

Citigroup: Here's How El Niño Could Derail Monetary Policy

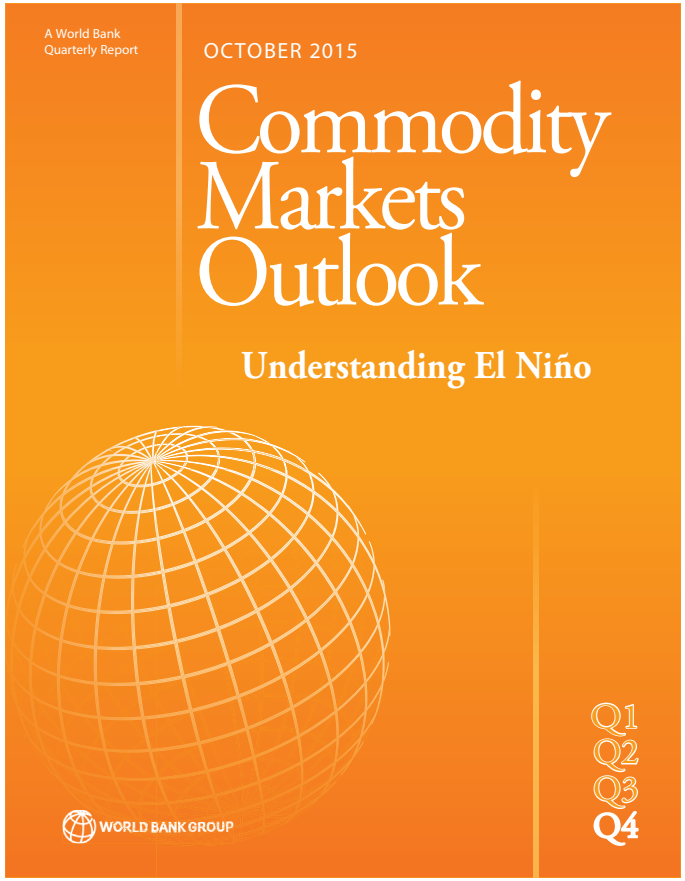
Indonesia, India, and the Philippines are three countries the bank says are particularly vulnerable to inflation, given the weight of food in

How does ENSO affect world economies?

- Direct and indirect effects on growth and inflation:
  - Commodity price inflation due to production shortfalls;
  - Warmer water damages fishing industries;
  - More rain is detrimental for coffee production (e.g. plant diseases);
  - Flooded mines;
  - Droughts affecting hydroelectric power generation and waterway transportation;
  - Health effects;
  - State budget used to recovery from weather disasters.

Why do economists care about ENSO?

- Hot topic for policy makers
- Sizable economic consequences
- Weather risk management



Why do economists care about ENSO?

Sizable economic consequences

TABLE 1. National tally of impacts from weather conditions attributed to El Niño, 1997–98.

LOSSES	
Human lives lost	189
Economic losses and costs	$4.2–$4.5 billion

Source: Changhon S.A. (1999) "Impacts of 1997–98 El Niño– Generated Weather in the United States" Bulletin of the American Meteorological Society , 1819-27.

It means: **$6.2 - $6.4 billion (in 2015 dollars)**

Why do economists care about ENSO?

Sizable economic consequences

How much is 6 billion dollars?

- The cost of CERN's particle accelerator (Large Hadron Collider) is 6.1 billion dollars.[3]

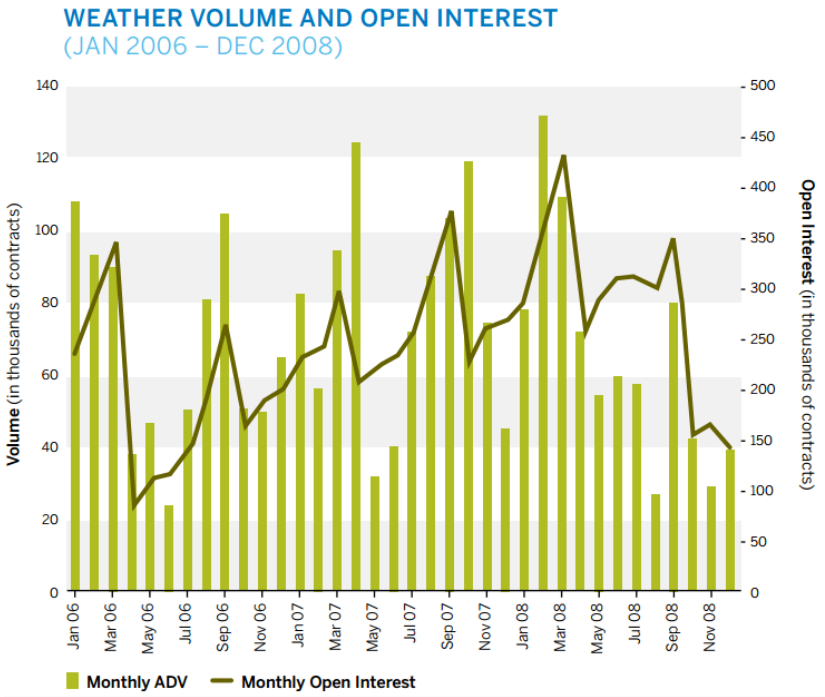
- Berlusconi's estimated net-worth is $7.4 billion[4]

[3] Source: CERN Ask an Expert service

[4] Source: Forbes World's Billionaires list, 2015

Why do economists care about ENSO?

Weather risk management



Source: CME group

Weather derivatives at the Chicago Mercantile Exchange:

- Temperature-based (HDD, CDD, Avg. Temp.)
- Hurricane Index based derivatives
- Frost and snowfall-based options and futures

What do economists say about ENSO?

• ENSO - via its effects on cereal production, yield and agriculture value added - explainins the fact that wealth and growth are systematically lower in the tropics (Hsiang and Meng, 2015, panel of 78 countries);

• Non-oil commodity price inflation increases by 3.5% following ENSO shocks (Brunner, 2002, quarterly structural VAR, 1968-1998);

• Berry and Okulicz-Kozaryn (2008), with annual data (1894-1999), fail to discover any long-run or short-run co-movements of ENSO and U.S. growth and inflation.

• Ubilava (2012), relying on regime switching models, shows that the impact of ENSO shocks on the price of coffee depends on the variety of coffee, as well as on the sign of the shock to ENSO. He uses monthly data for the 1989-2010 period.

- A positive shock to ENSO (El Niño) reduces the price of Arabica coffee, while increases the price of Robusta coffee;
- A negative shock to ENSO (La Niña) rises the price of Arabica coffee, while depresses the price of Robusta coffee;
- The magnitude of the effects of positive and negative shocks is similar;
- Impact of ENSO depends on geography: Arabica is mainly produced in South America, Robusta in Southeast Asia.

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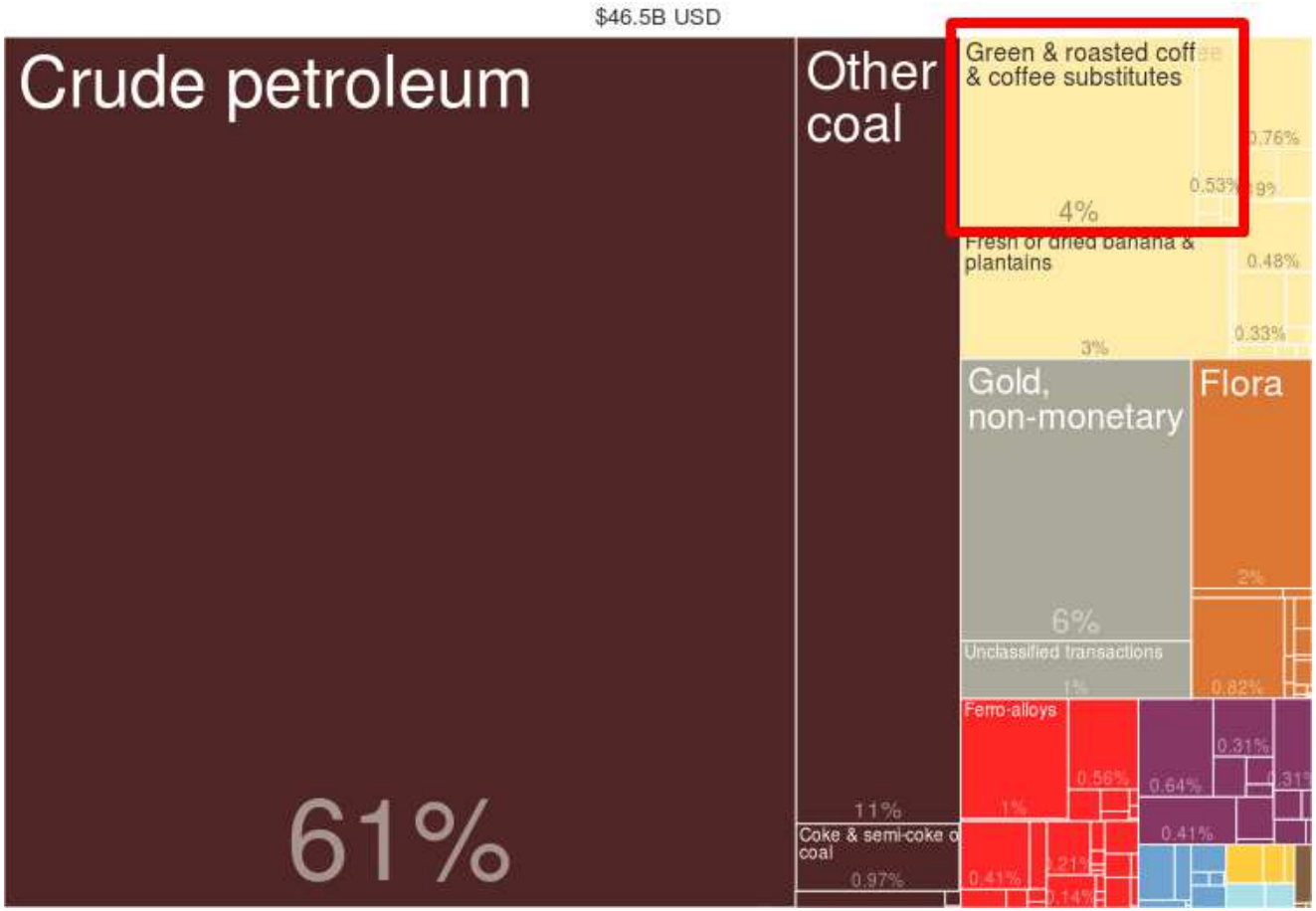
The impact of ENSO in Colombia

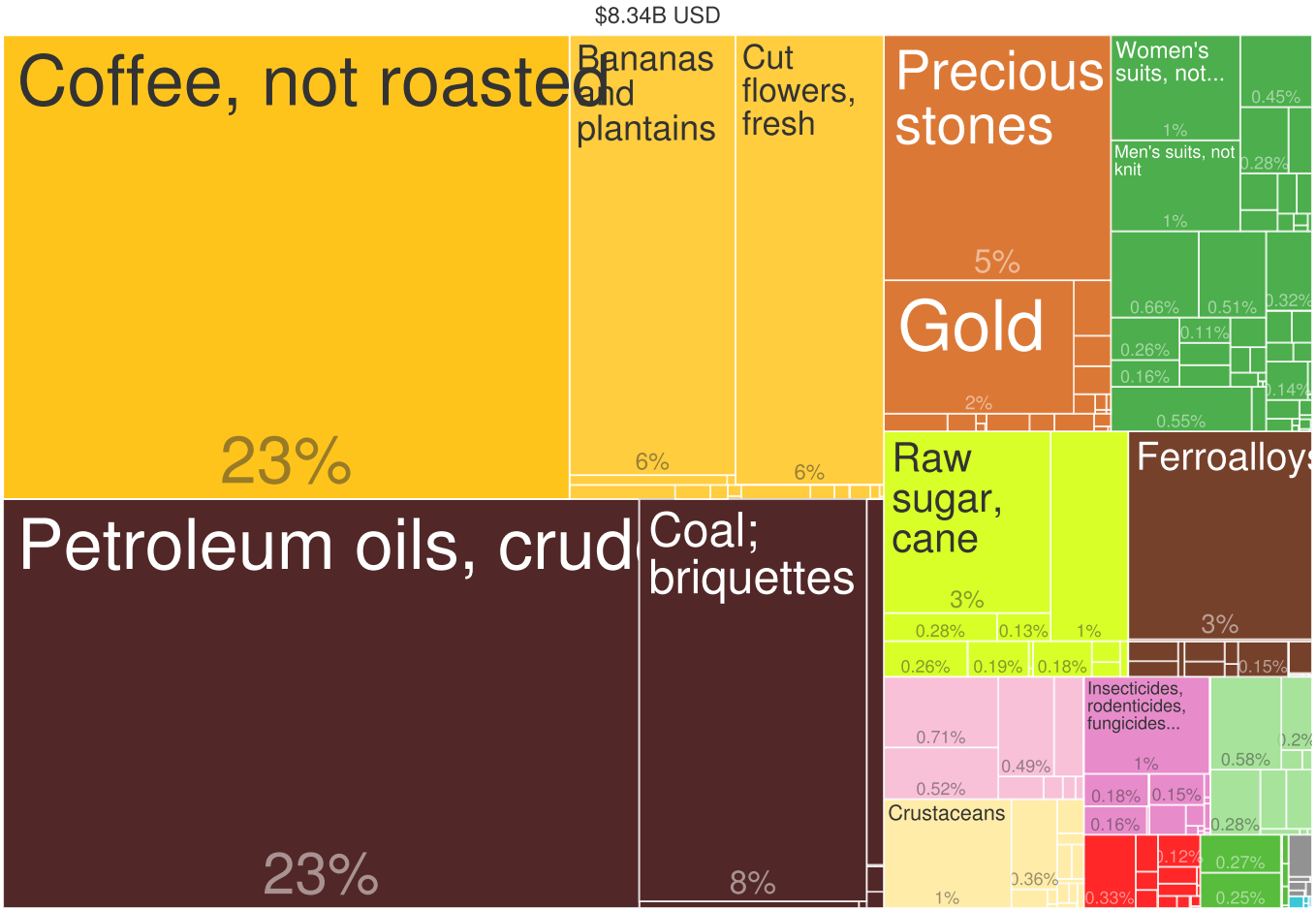
What did Colombia export in 2013?



Source: Center for International Development at Harvard University, "The Atlas of Economic Complexity"

The impact of ENSO in Colombia

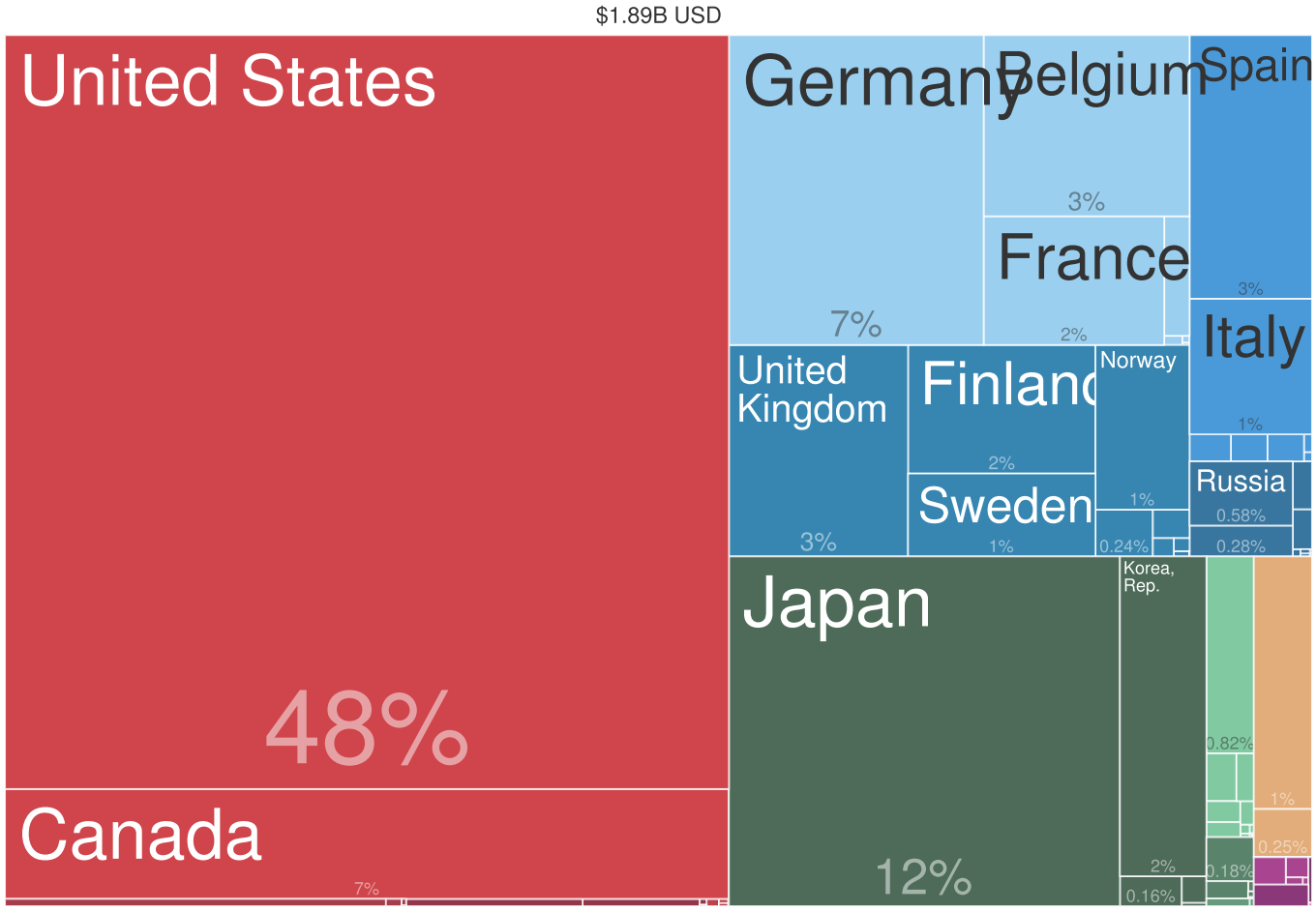
What did Colombia export in 1995?



Source: Center for International Development at Harvard University, "The Atlas of Economic Complexity"

The impact of ENSO in Colombia

Where did Colombia export green and roasted coffee in 2013?



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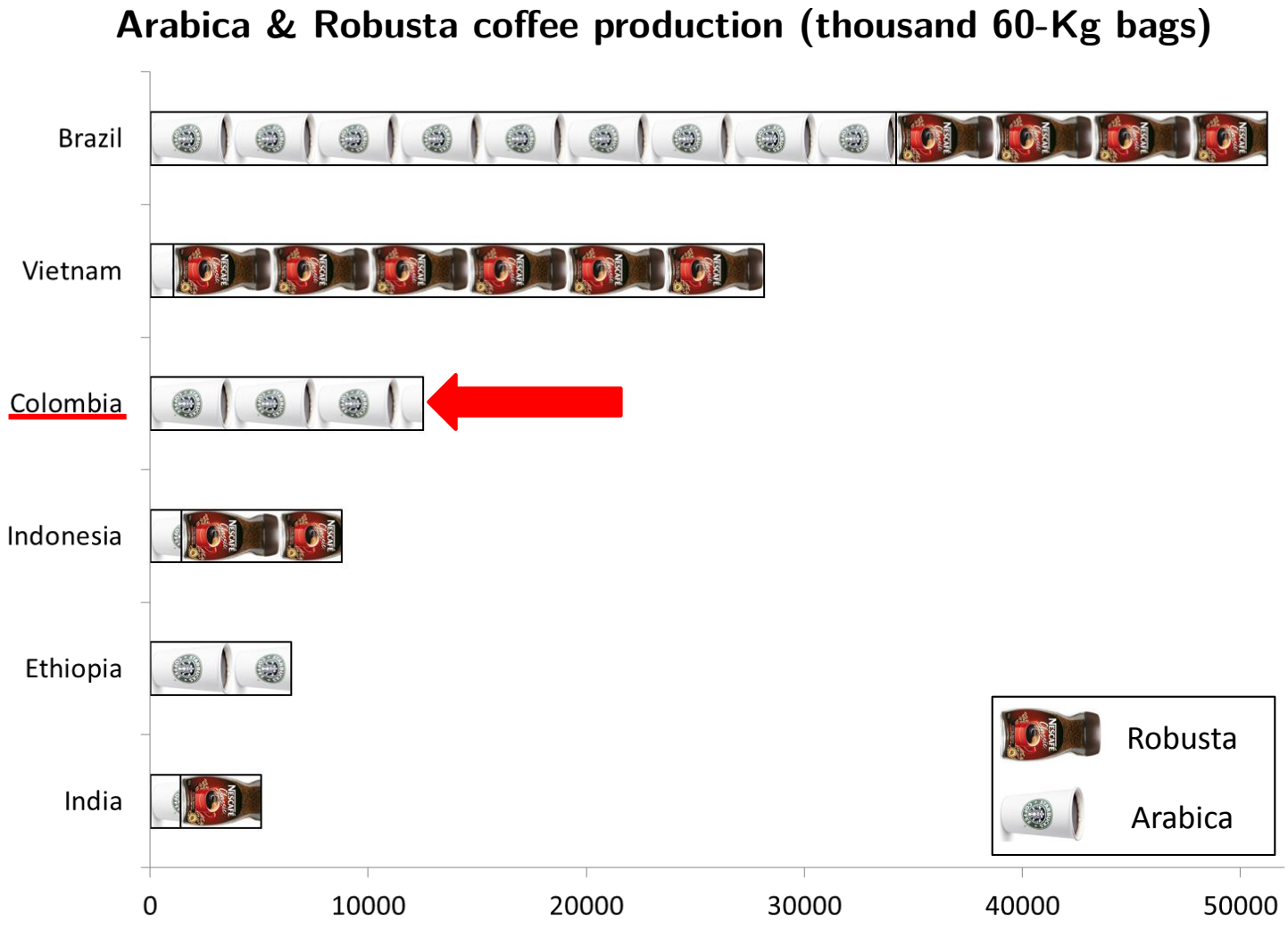
The impact of ENSO in Colombia

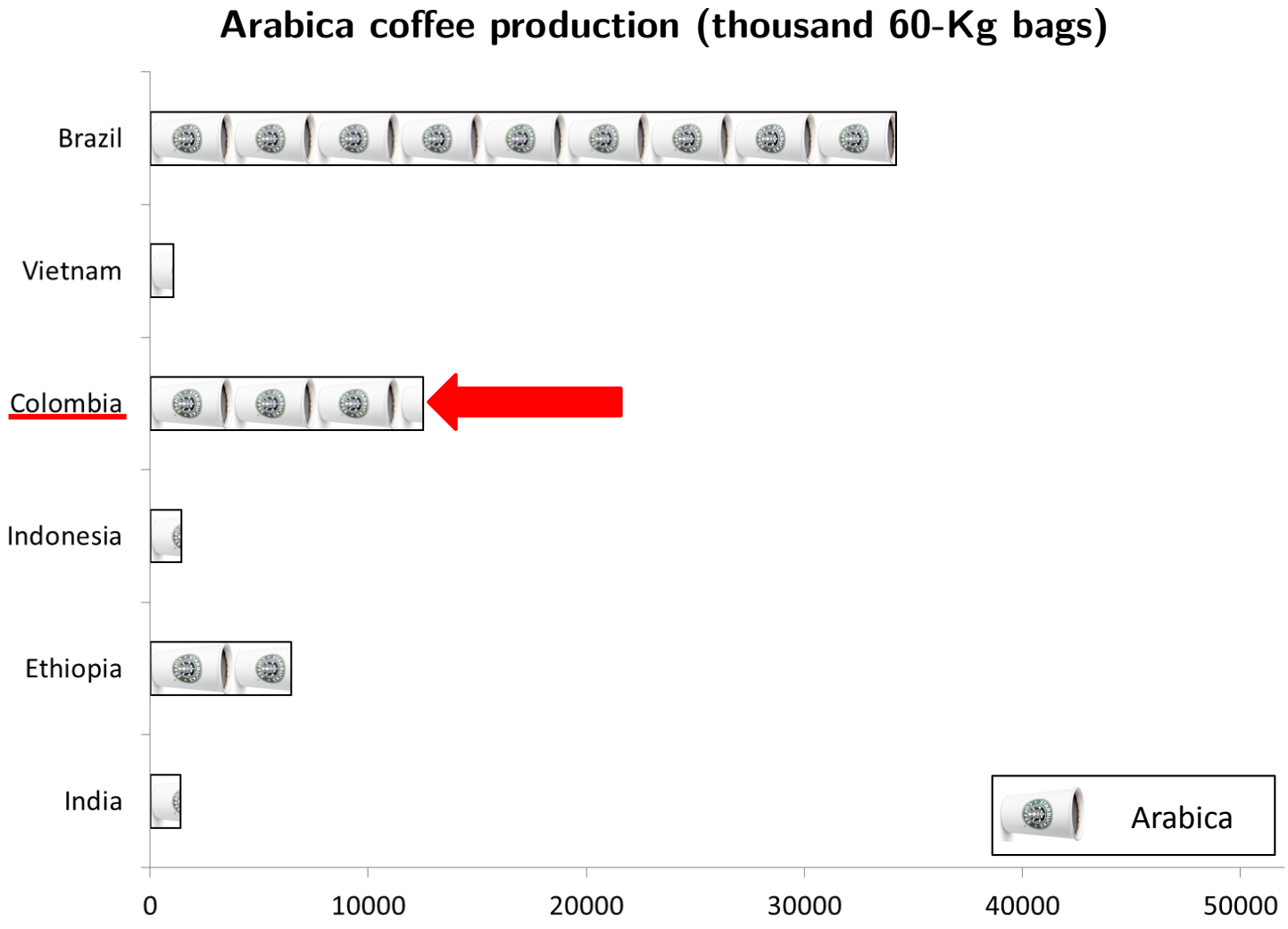
Arabica & Robusta coffee production 2014-15



Source: USDA-FAS, Production, Supply and Distribution Online.

The impact of ENSO in Colombia

Arabica coffee production 2014-15



Source: USDA-FAS, Production, Supply and Distribution Online.

The impact of ENSO in Colombia

The geography of El Niño impacts in Colombia

El Niño	La Niña
Drier weather	Higher rainfall
Higher temperatures	Cooler weather
Higher productivity	Lower productivity
Periods of drought and erosion	Rain and floods
Broca bug	La Roya fungus

Source: National Federation of Coffee Growers of Colombia

"In principle La Niña is more harmful to Colombian coffee growing than El Niño."

Source: Carlos Armando Uribe, Technical Manager of the Colombian Coffee Growers Federation (FNC).

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A Structural VAR model for the coffee market

A theoretical model for the coffee market

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A structural VAR model for the coffee market

Data and model

We consider a VAR (i.e. multivariate) model for:

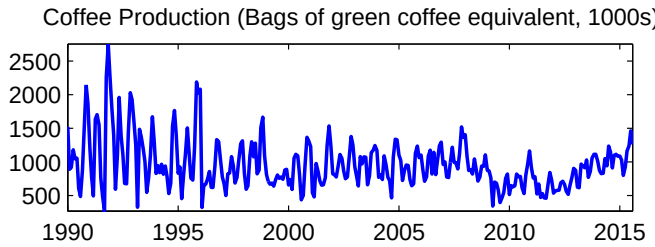
1. sst_t (or -soi_t);
2. $\Delta prod_t$: (first difference of log) Colombian production of coffee (bags);
3. $cexp_t$: (log) Volume of export of Colombian coffee (bags);
4. rpc_t: (log) External price of Colombian coffee (US $ cents per pound) - adjusted for inflation using US CPI.

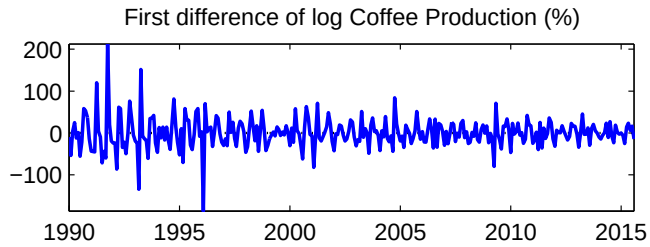
- Monthly data: 1990:1 - 2015:8.

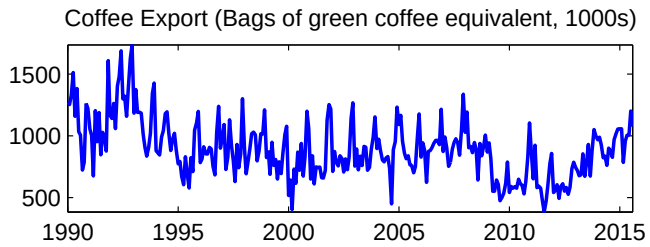
- Coffee price was regulated by international agreements in the 1962-1989 period: target price and export quotas for producing countries.

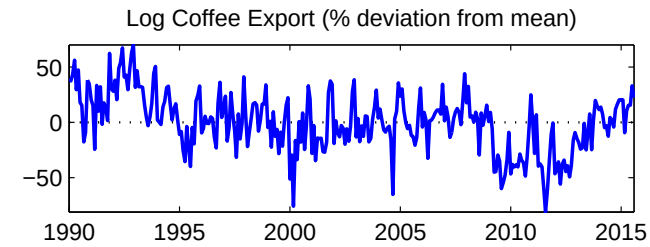
A structural VAR model for the coffee market

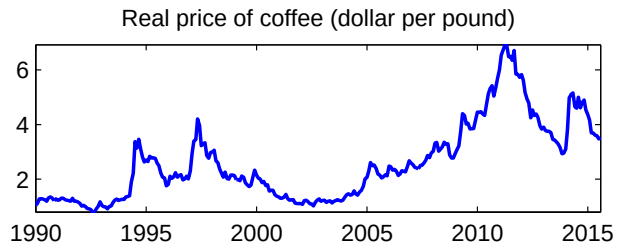
Data and model

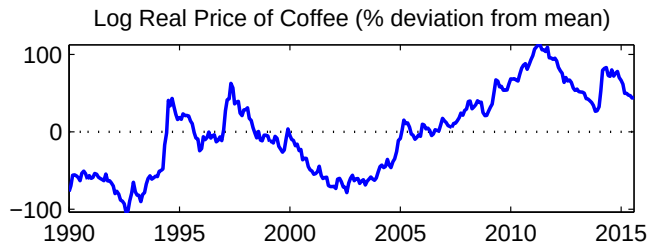












A structural VAR model for the coffee market

Data and model

Let $\mathbf{y}_t \equiv [sst_t, \Delta prod_t, cexp_t, rpc_t]'$, then a Structural VAR model can be written as:

$$\mathbf{A}_0 \mathbf{y}_t = \boldsymbol{\mu}_t + \sum_{j=1}^{24} \mathbf{A}_j \mathbf{y}_{t-j} + \boldsymbol{\varepsilon}_t$$

$\boldsymbol{\mu}_t$ includes a constant and seasonal dummy variables;

$\boldsymbol{\varepsilon}_t$ are structural shocks;

reduced form errors $\mathbf{e}_t$ are obtained as follows:

$$\mathbf{e}_t = \mathbf{A}_0^{-1} \boldsymbol{\varepsilon}_t$$

A structural VAR model for the coffee market

Identification

$$\begin{pmatrix} e_t^{sst} \\ e_t^{\Delta prod} \\ e_t^{cexp} \\ e_t^{rpc} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \begin{pmatrix} \varepsilon_t^{\text{El Niño shock}} \\ \varepsilon_t^{\text{coffee supply shock}} \\ \varepsilon_t^{\text{coffee demand shock}} \\ \varepsilon_t^{\text{residual shock}} \end{pmatrix}$$

Structural VAR models in a nutshell: use (economic) theory to impose restrictions - zero restrictions, in this case - that help providing an economic interpretation of shocks hitting the variables in the system.

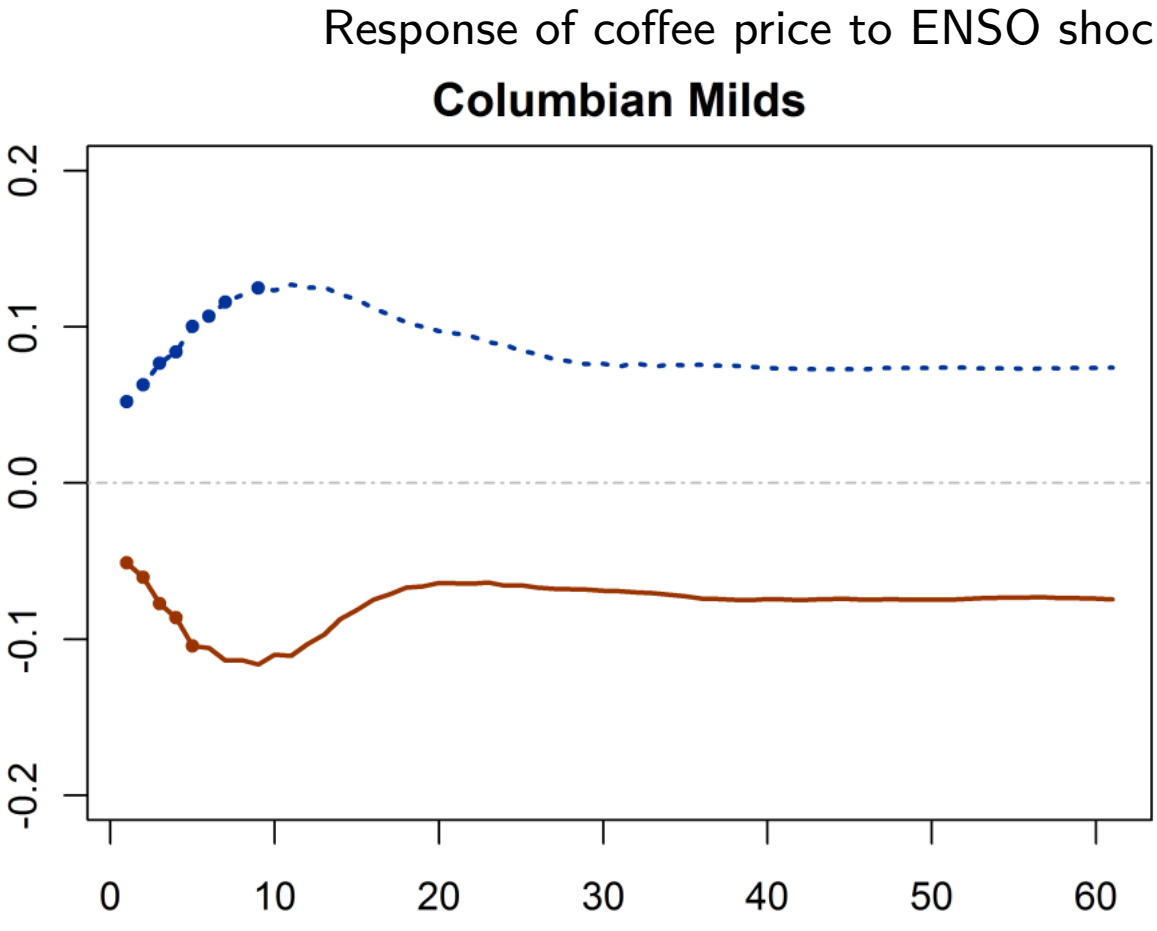
A structural VAR model for the coffee market

Identification

- An ENSO shock is an unpredictable change in the SST index.
- Positive (Negative) ENSO shocks identify El Niño (La Niña) events
- Exclusion restrictions imply ENSO shocks affect Colombian coffee production, export and price within the same month, but not vice-versa.
- Without further restrictions, ENSO shocks can move the supply as well as the demand for coffee

A structural VAR model for the coffee market

Identification

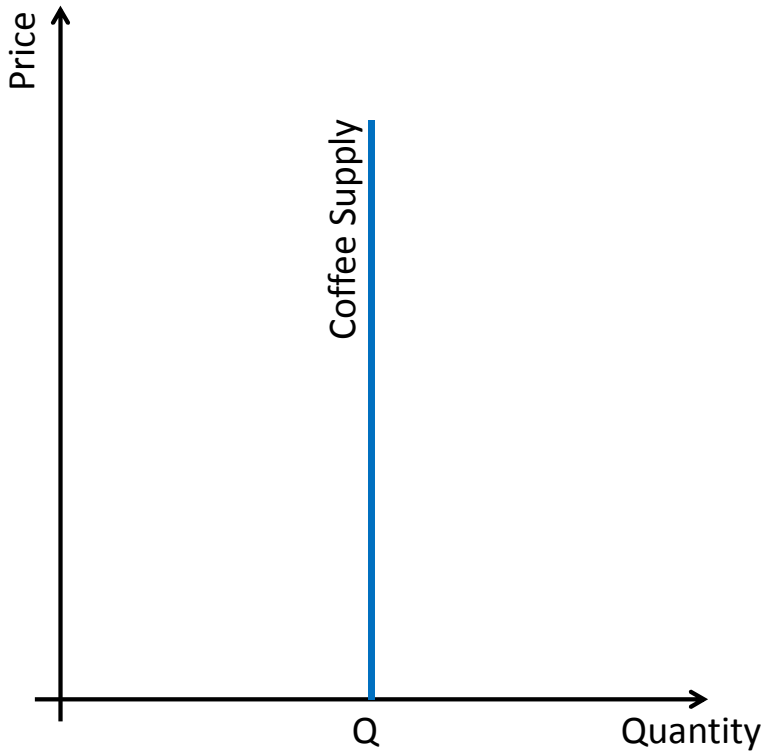


Source: Ubilava (2012)

• The model implicitly assumes that responses of coffee price, production and export to positive and negative ENSO shocks are symmetric (i.e. responses are of opposite sign but of the same magnitude).

A theoretical model for the coffee market

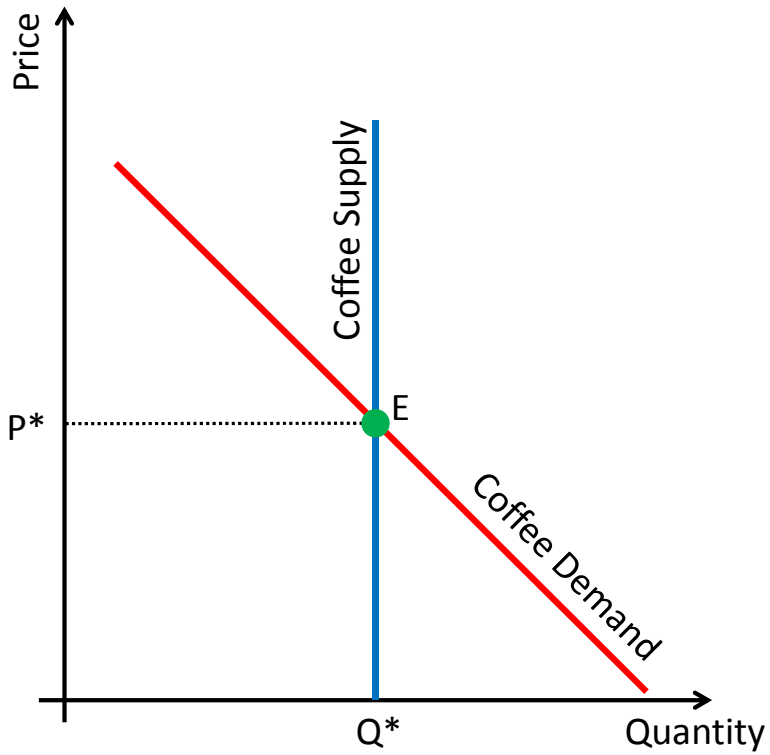
Vertical short-run supply



1. Coffee production involves long lags between planting, cropping, harvesting, and marketing
   - At least 2 years before a coffee tree begins to bear fruits
   - Several other years to reach full productivity
2. Consistent with the literature
   - Price elasticity of supply is very low (Ponte, 2002);
   - Theoretical models of coffee production use vertical supply functions (Wickens and Greenfield, 1973).

A theoretical model for the coffee market

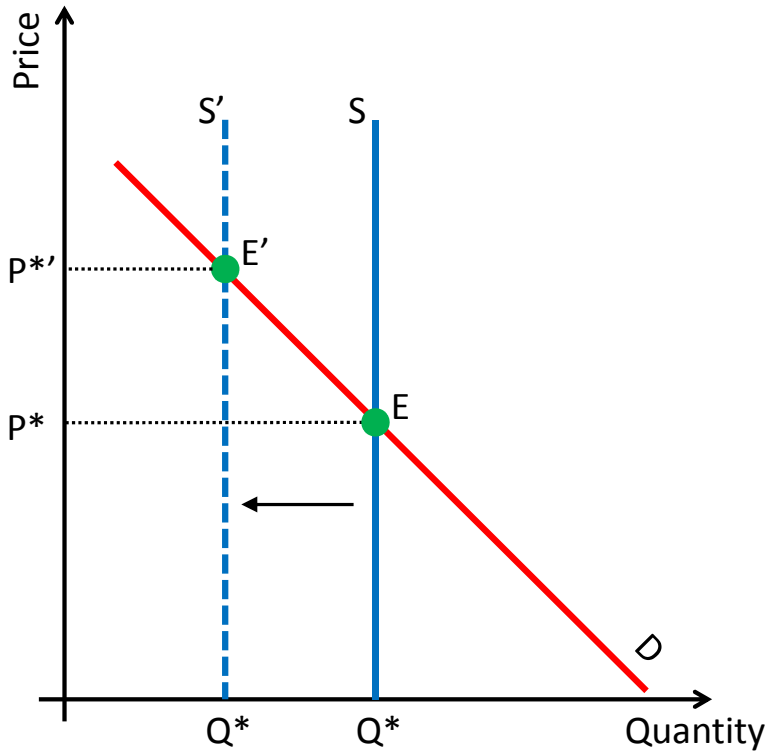
Short-run demand



- Standard downward sloping demand

A theoretical model for the coffee market

Supply shocks



- *Coffee supply shocks* are innovations to Colombian coffee production that cannot be explained based on El Niño shocks;
- Coffee supply is assumed not to respond to shocks to the demand for coffee or to residual shocks on impact (i.e. within the same month);
- This is plausible since adjusting coffee production takes time and is costly;
- Coffee production adjusts only in the medium/long-run to expected trend growth in demand.

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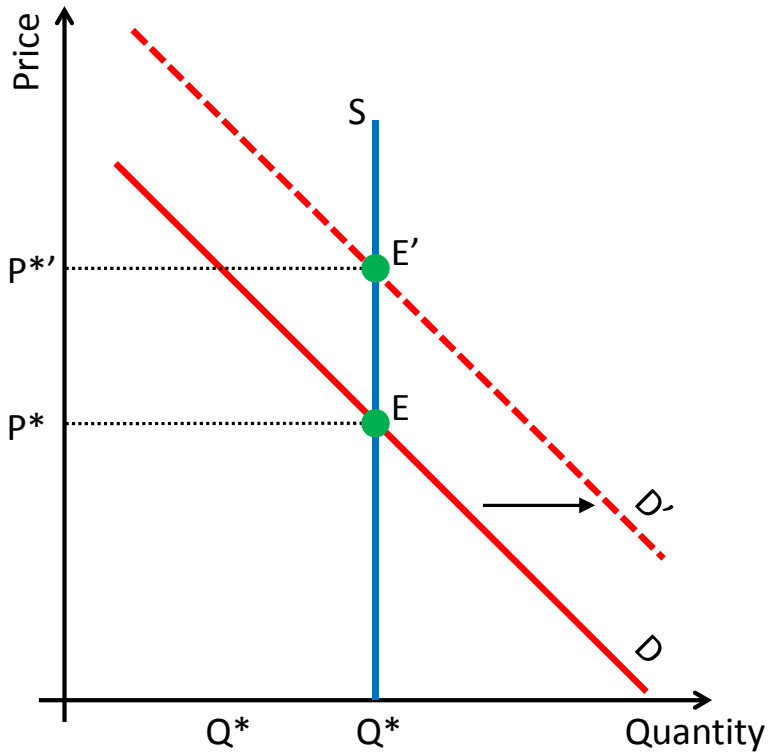
Demand shocks



- Innovations to Colombian coffee exports that cannot be explained based on El Niño or supply shocks are called *coffee demand shocks*.
- These shocks are specific to the external demand for Colombian coffee.
- Increases in the real price of coffee due to the fourth shock affect coffee exports with a delay of at least one month.

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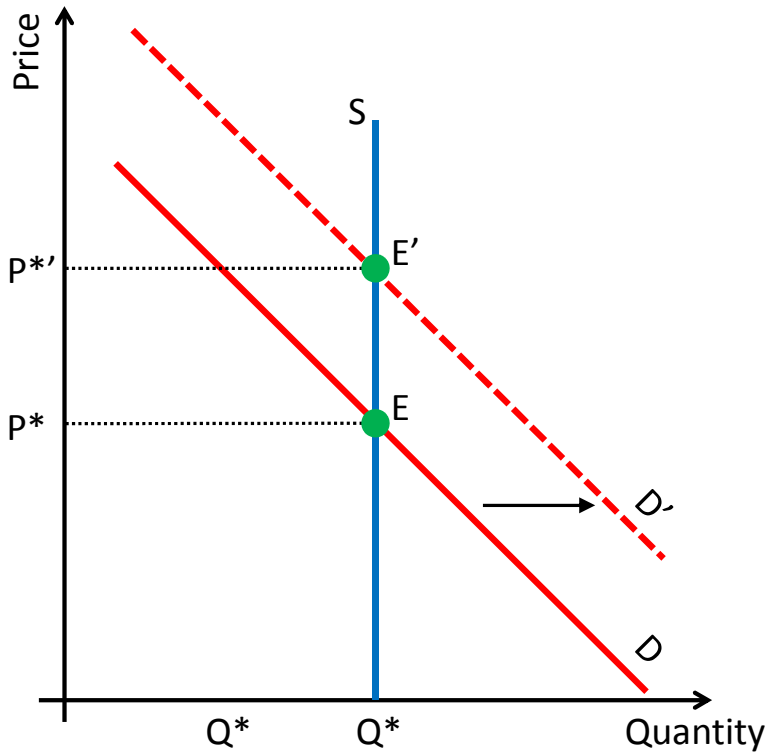
Demand shocks



- Innovations to the real price of coffee that cannot be explained based on El Niño, supply, or external demand shocks are called *residual shocks*.
- Without further information it is not possible to exactly define the nature of the fourth shock.
- It captures a variety of coffee demand-side shocks such as changes in preferences, shocks to internal coffee demand and fluctuations in precautionary demand for coffee driven by uncertainty about future coffee supply shortfalls.

Introduction

Research questions & Results

What is ENSO and why do economists care?

ENSO and the Colombian coffee industry

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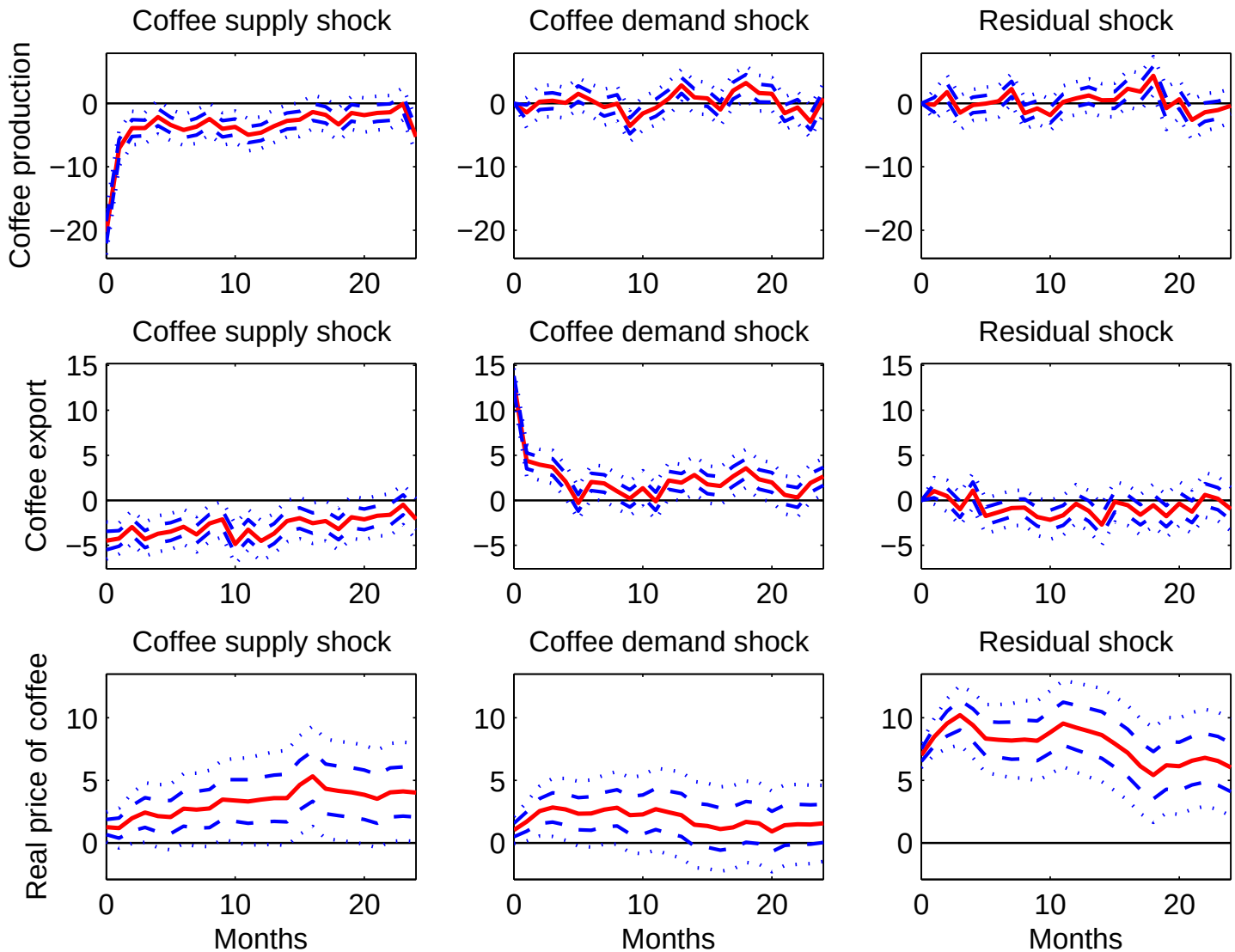
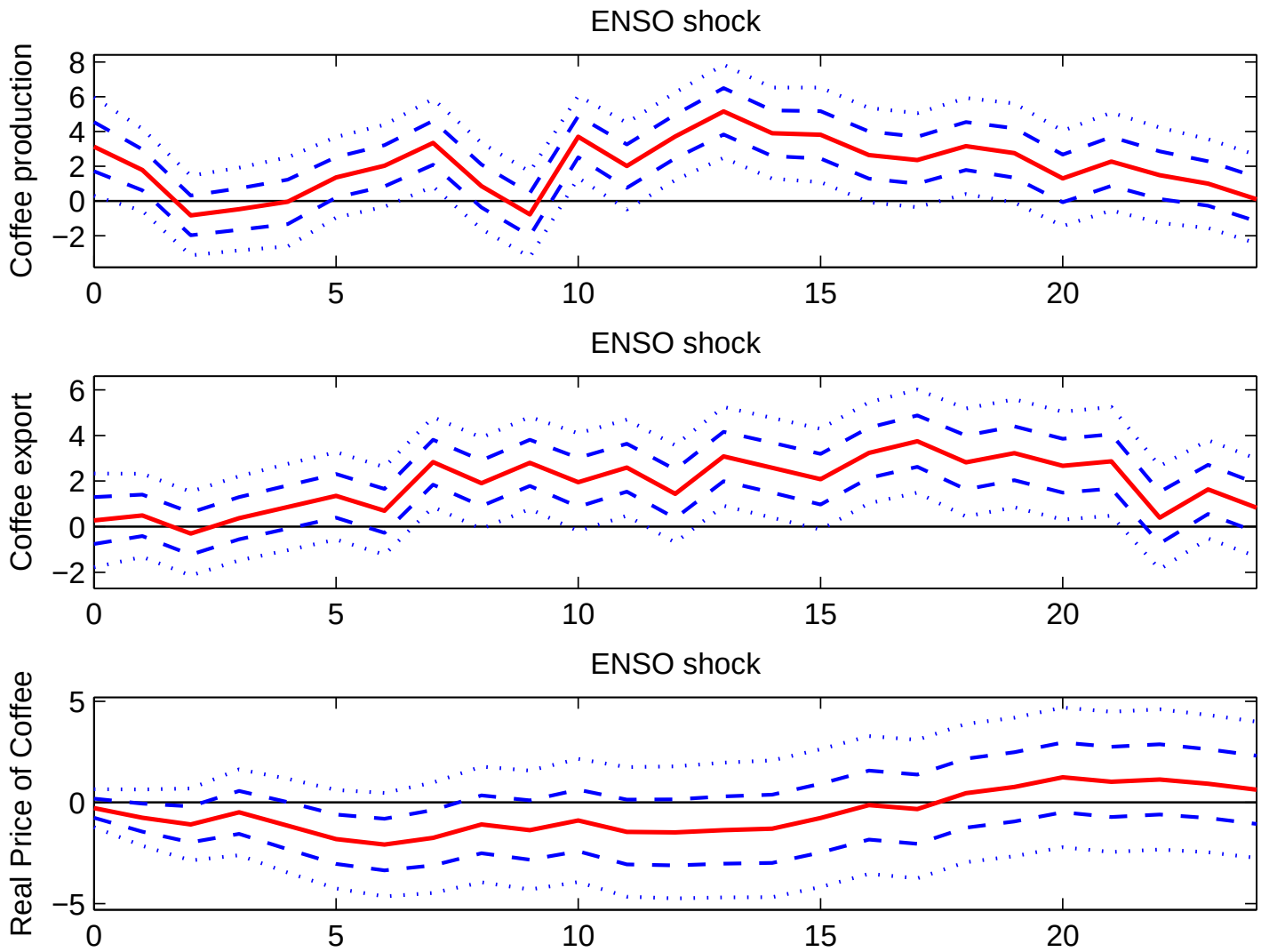
Results

Conclusions

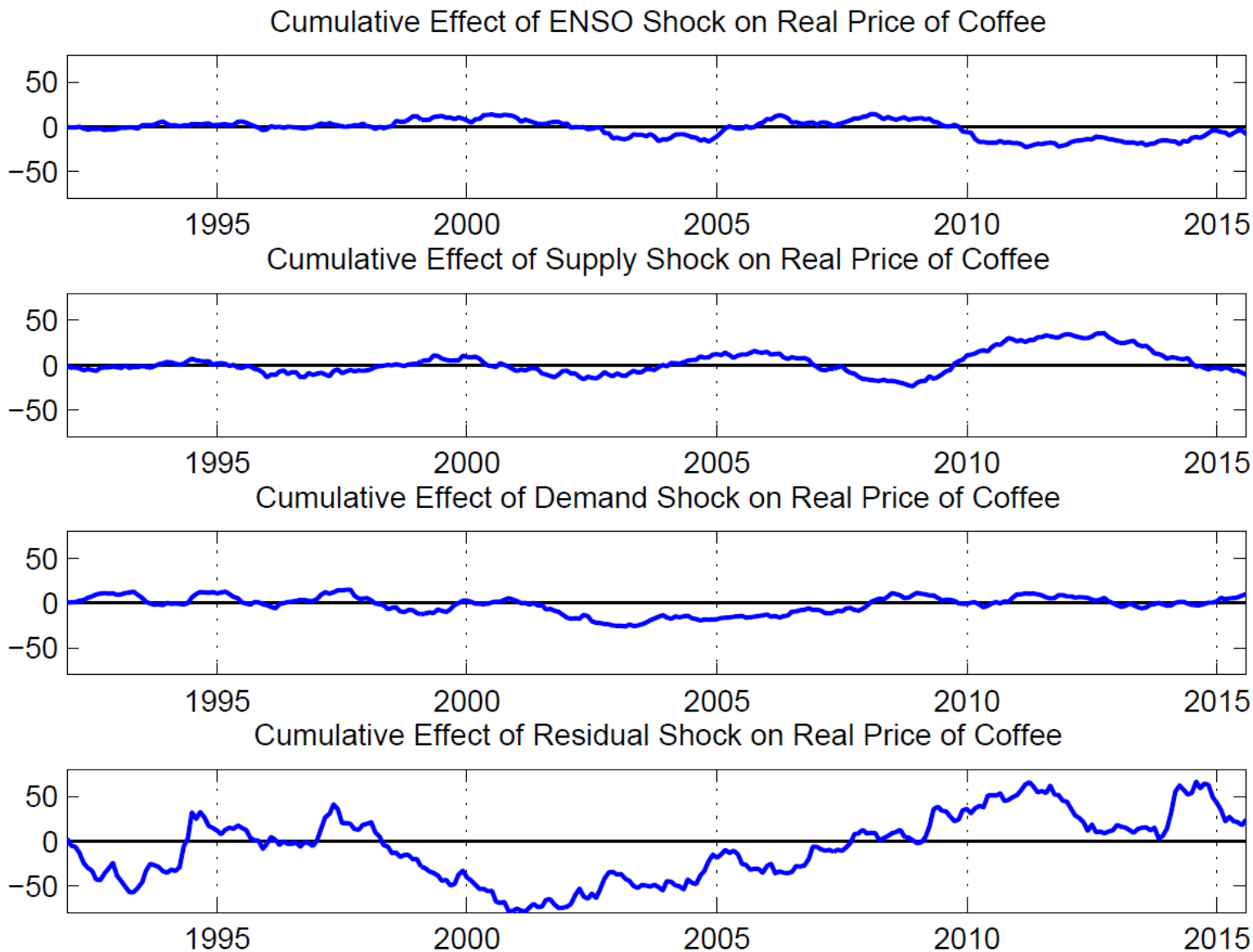
Impulse response functions for the coffee market block



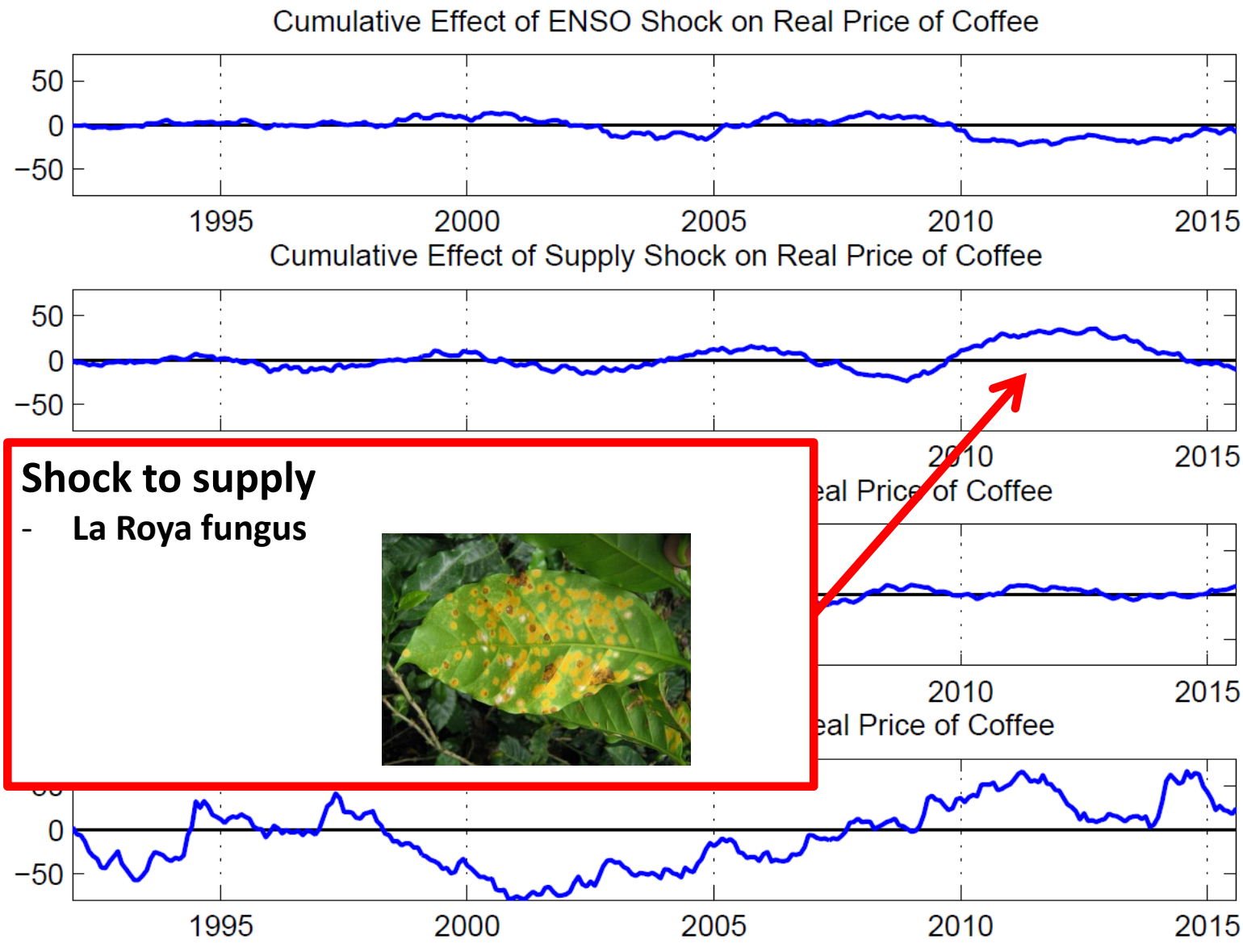
Impulse response functions: (positive) ENSO shock



Historical Decomposition of the real price coffee



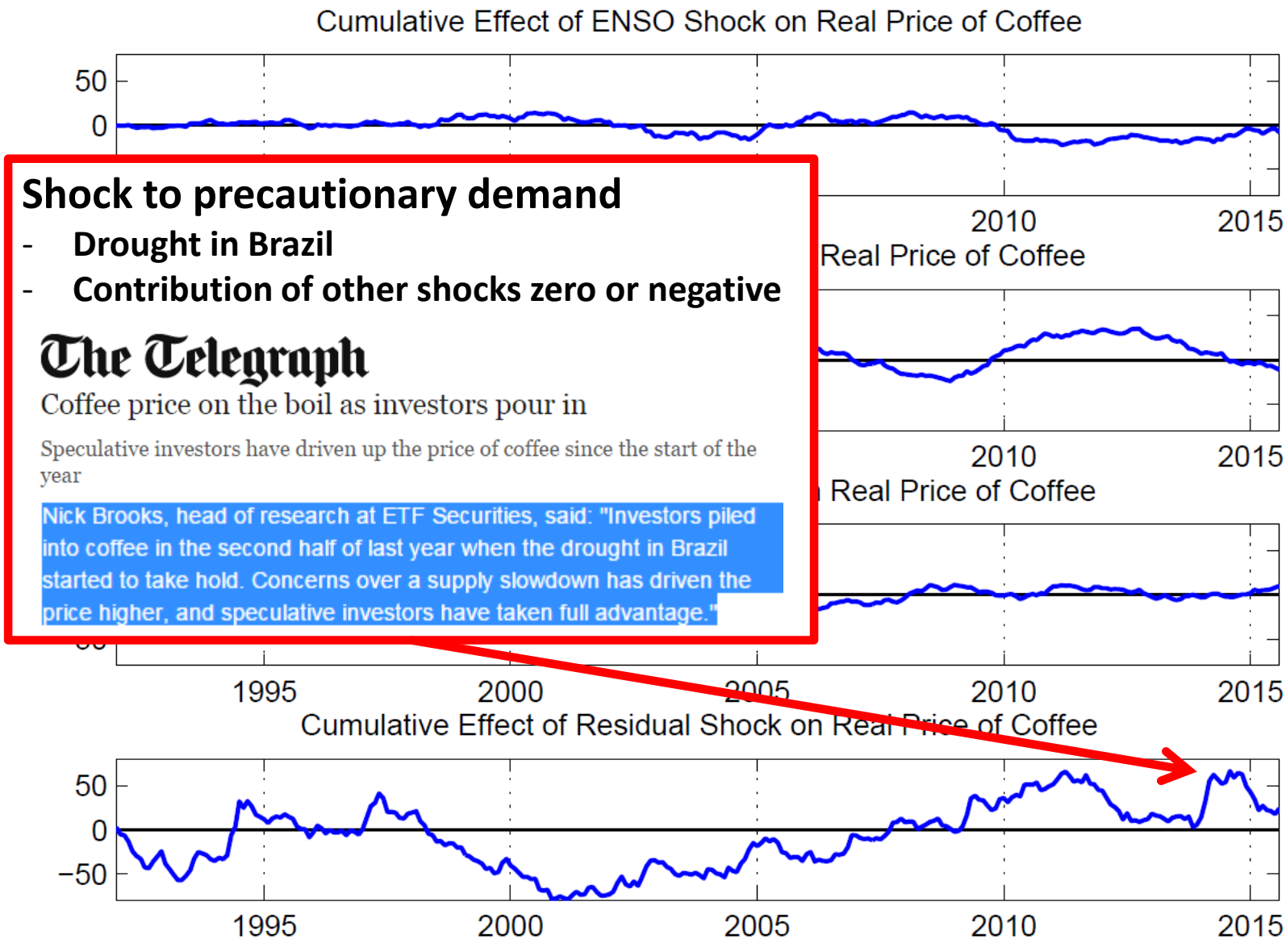
Historical Decomposition of the real price coffee



Shock to supply

- **La Roya fungus**

Historical Decomposition of the real price coffee



Shock to precautionary demand

- **Drought in Brazil**
- **Contribution of other shocks zero or negative**

The Telegraph

Coffee price on the boil as investors pour in

Speculative investors have driven up the price of coffee since the start of the year

Nick Brooks, head of research at ETF Securities, said: "Investors piled into coffee in the second half of last year when the drought in Brazil started to take hold. Concerns over a supply slowdown has driven the price higher, and speculative investors have taken full advantage."

Variance Decomposition

Variance Decomposition of Coffee Production				
t	**ENSO**	**Supply**	**Demand**	**Residual**
1	0.75	99.25	0.00	0.00
12	7.73	84.30	3.58	4.39
∞	11.58	69.76	8.71	9.95

Variance Decomposition of Coffee Export				
t	**ENSO**	**Supply**	**Demand**	**Residual**
1	0.44	7.46	92.10	0.00
12	10.33	24.68	59.82	5.17
∞	23.26	25.83	41.53	9.38

Variance Decomposition of Real Price of Coffee				
t	**ENSO**	**Supply**	**Demand**	**Residual**
1	1.24	0.98	0.60	97.18
12	2.09	4.95	6.80	86.17
∞	4.43	6.96	16.35	72.26

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1. The impact of ENSO shocks is small compared with other supply and demand-side innovations
   - El Niño shocks increase production and reduce price;
   - La Niña shocks reduce production and increase price;
2. In the short-run, ENSO shocks explain 0.7% of the fluctuations of coffee production and 1% of the variability of the real price of coffee.
3. In the long-run these percentages rise to 12% and 4%, respectively.
4. Determinants of the price: demand-side shocks more important than suply-side shocks.

Conclusions

- When studying the impact of ENSO on commodities it is important to control for other fundamentals.

- The impact of a coffee price shocks on the economy of Colombia depends on the source of the price shock
e.g. demand-side price shocks more important than supply-side price shock?

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