Can Global Climate Change affect Prices in the World Banana Market?

Daniella Blake[1] and Carolina Dawson[2]

Denis Loeillet[2]

Charles Staver[1]

[1]CGIAR, Montpellier, France and [2]CIRAD, Montpellier, France

Abstract

This paper explores the potential impacts of extreme weather events associated with climate change on prices in the international banana market. First, we made an inventory of the events reported to have affected banana export volumes for six exporter countries, as well as events reported to have affected banana import prices in the French market, between the years 2000 to 2015. We used weekly time-series to examine the impact of reported events on banana export volumes and on banana import prices. The first results indicate that weather events were the most frequently reported events to impact on export volumes and on consumer demand, thus confirming that they play a frequent role in determining prices. However, we also identified a wide range of other non-weather events which affect volumes, consumer demand and thus prices. We demonstrated that the extent to which extreme weather events affect prices is primarily determined by the coincidence of events and by the structural context of the exporting and importing countries. This study helps to put the potential impact of weather events related to climate change into perspective and highlights the ongoing role of market mechanisms, policy makers and stakeholders' strategies in price variations in international commodity markets.

Key Words

banana market; extreme weather events; global warming; commodity markets; food prices; international food trade

1 Introduction

Multiple stakeholders in the globalized food industry have expressed concern about the vulnerability of their supply chains to climate change (ANDREONI and MIOLA, 2014; PALOVIITA and JÄRVELÄ, 2015; SMITH et al., 2016). Studies have shown that the increasingly frequent and intense extreme weather events associated with climate change, have direct consequences on supply of food and agricultural products and have become a key factor leading to spikes and variability in agricultural commodity prices (ABBOT et al., 2008; TROSTLE, 2008; TADESSE et al., 2014).

Price variability is normal in most markets. However, excessive variability introduces uncertainty, vulnerability and has negative impacts on supply chain actors (STIGLER, 2011). In developing countries which depend on income from agricultural exports, it affects productive activities, undermines food security and economic growth (PRAKASH, 2011; SARRIS, 2013; RUDE and AN, 2015) by impacting on real output, government budgets and the conduct of macroeconomic policy (CASHIN and MCDERMOTT, 2001). Downward price fluctuations have negative consequences for producers, through their effects on farm revenue, by limiting capital investment spending (SUBERVIE, 2008; HUCHET-BOURDON, 2011) and by discouraging farmers from investing in better technologies which could improve yields (ELBEHRI et al., 2015). Price pressure also results in changes to employment conditions, where jobs are transformed into casual positions or outsourced and wages decrease (FAIRTRADE, 2014). Upward price fluctuations can negatively affect consumers due to their effect on food expenditures (HUCHET-BOURDON, 2011).

Price variations for agricultural commodities have received wide attention, particularly since the food price spikes after 2006 (ABBOT et al., 2008; MITCHELL, 2008; TROSTLE, 2008; CHRISTIAENSEN, 2009; COOKE and ROBLES, 2009; PIESSE and THIRTLE, 2009; GILBERT, 2010; GILBERT and MORGAN, 2010). Studies have focused on drivers of international prices of corn (BROWN, 2014), wheat, rice, soybeans and other oilseeds, although coffee and cocoa have also

received some attention (LEWIN et al., 2004; MEHTA and CHAVAS, 2008; MAURICE and DAVIS, 2011).

However, banana market dynamics are under-reported in the academic literature, despite its importance for both producing/exporter and consumer countries. Banana trade creates important revenue: the value of exports was over 10 billion dollars in 2016 (ITC, 2017). More than 35% of the agricultural GDP of Ecuador, the world's main banana exporter, is created by the export banana industry (BANCO CENTRAL DEL ECUADOR, 2015). Banana production provides a major source of rural employment: it creates around 10 000 direct and indirect jobs in the French West Indies (FWI) which makes it the largest private employer (AGRESTE, 2013) and in African countries, it is the main source of employment in some rural areas. In importing countries, bananas have become an essential item for consumers providing the best nutrition to cost ratio amongst the fruits (FRISON and SHARROCK, 1998). In Europe, bananas are present all year-round with a highly competitive price positioning and in the United States bananas are the most highly imported and consumed fresh fruit (HUANG and HUANG, 2007).

As with other agricultural commodities, climate change is predicted to affect banana production (ELBEHRI et al., 2015). An assessment of the potential impact of climate change on global banana production highlights current variability in weather and suggests that future variability will increase and be a more important factor for changes in banana supply than the projected increase in average temperatures (ELBEHRI et al., 2015).

The causes of price variations in the international banana market have received little attention. Most articles concerning banana markets have focused on the effects of the changes to the European Union import policy regime and on the so-called 'banana war' (CHACÓN-CASCANTE and CRESPI, 2006). Only a report by ARGUELLO (2014) provided initial answers about price variations in the banana market. This study concluded that rises in annual import prices in the USA and Europe were directly linked to a decrease in production in exporting countries due to climate events (ARGUELLO, 2014) and that, by order of importance, climate, trade, political, and productive events were the main factors that had led to a fall in banana exports. However, this study was based only on annual prices and export data thus erasing the intra-annual short-term effects that a climate event can induce. Also, the study did not consider other factors and complex market mechanisms that are involved in the determination of prices in a given market. Indeed, many studies have shown that other non-weather related factors can also drive food price variability, such as: increasing demand in consumer countries, oil and energy price rises, US exchange rate, exporter policies, prices of inputs, importer policies and aggressive purchases by importers, speculative activities in futures markets, expansion of biofuel production, slowing growth in agricultural yields, large foreign exchange reserves, etc. (ABBOT et al., 2008; MITCHELL, 2008; TROSTLE, 2008; COOKE and ROBLES, 2009; TADESSE et al., 2014).

Our objective was to explore the major aspects which contribute towards price fluctuations in the international banana market, focussing on both extreme weather events and on other non-climate related factors such as, market mechanisms, regulations, policy makers and stakeholder's strategies. To our knowledge, this is the first study that has deeply investigated and assessed these aspects. Therefore, our work provides valuable information for policy makers and industry stakeholders, on the potential of climate-change linked to international banana prices and contributes to the debate, which revolves around what might be the likely consequences of changes in the regulations of the banana market.

2 Methodology

2.1 Study Focus

Our study focused on the import price or "Green Price" in the French banana import market. The "Green Price" is the price at which importers sell their unripe bananas to ripeners or to other importers or intermediaries. A Green Price is the equivalent of a CIF (Cost, Insurance and Freight) or FOT (Free on Truck) in the traditional incoterms: the unripe bananas arriving at the port of destination and delivered to the first customer, transport included or not, depending on the case. It is the reference price for trade in international markets. We chose to study the import price in the French market because bananas are still mostly sold on a non-contractual, non-official weekly green price listing. Due to a lack of pre-set price structures, import prices for bananas are affected by global supply and demand balances (COLBERT, 2015). This market thus provides an opportunity to examine the main events that affect the supply and demand balance and whether this leads to price variations. Moreover, due

to its historic supply profile, the French market provides interesting ground to study the interaction between multiple suppliers. Indeed, this market is structured by a traditional supply from the French West Indies (FWI), Cameroon, Côte d'Ivoire and re-exports about 30% of its imports (LOEILLET, 2016). When there is a global lack in supply the French market continues to have a stable base and can complete its needs with supplies from Latin American sources or by decreasing its French West Indies (Guadeloupe and Martinique) or African exports to other EU countries. However, when there is a large global supply, the French market is fragile as it continues to receive supplies from its usual suppliers as well as those from the dollar zones (dollar banana is the name commonly given to the bananas produced in South and Central America and the Caribbean).

The relative impact of climate and other events on banana import prices was ascertained through qualitative correlation of reported events in producer and consumer countries with time-series graphs of export volumes from six exporting countries supplying the French market and time-series graph of import price in France.

2.2 Data for Analysis

Weekly exportation volumes of dessert bananas from Ecuador, Colombia, Costa Rica, Guadeloupe, Ivory Coast and Cameroon for the period 1999- September 2015 were taken from the dataset of the Market News Service (MNS) of the French Agricultural Research Centre for International Development (CIRAD). The MNS's data for Ecuador, Colombia, Costa Rica and Guadeloupe come from professional sources (national exporters associations) that declare on a weekly basis the quantities that are shipped from their countries to each destination market. For Ivory Coast and Cameroon, each week the MNS records the quantities that each importing company ship on a weekly basis. Data for weekly import prices for bananas in France (2000-2015) were also sourced from the dataset of the MNS of CIRAD (MARKET NEWS SERVICE, 2015a). For the past 20 years, the MNS of CIRAD publishes a Weekly Banana Market Report where the quotations of import prices and supply of bananas to the European market are registered, following interviews with an extensive panel of importers working in the banana sector across many European markets (MARKET NEWS SERVICE, 2015b).

The inventory of events affecting export prices was based on information sourced from trade publications concerning banana markets: FruiTrop, ReeferTrends, Sopisco News, Food and Agriculture Organisation (FAO) reports. Information about events was also gained through interviews with key actors in exporting countries (Ivory Coast, Costa Rica, Colombia, Guadeloupe). To explain how these events impact on export volumes and prices we use evidence from scientific work and insights from key actors in the banana trade as well as analysts.

2.3 Implementing Steps

1. We first identified the main events leading to variations in export volumes in the international banana market. We carried out an inventory of events that affected supply and demand of bananas between 2000 and September 2015 in seven exporting countries and in the French and European markets.
2. We qualitatively cross-correlated these inventoried events to historical weekly data of banana export volumes from Ecuador, Colombia, Costa Rica, Guadeloupe, Ivory Coast and Cameroon for the period 1999-September 2015. These countries were chosen for the following reasons: i) the availability of high resolution weekly data necessary to evaluate variability, ii) they represent different climatic regions; iii) they are the main suppliers of the French market (Ecuador, Colombia, Costa Rica, Guadeloupe, Martinique, Ivory Coast and Cameroon account for more than 90% of the French market's supply). Events were also correlated with import prices on the French market.
3. The weekly data for export volumes and price are time series, and like many time series consist of long-term directional trend, seasonal systematic movements and irregular, unsystematic short-term fluctuations (OECD, 2007). In order to assess long-term and short-term variations without the effect of seasonal fluctuations, it is necessary to decompose the time-series (XU YU et al., 2001). The time series for exportation and prices were decomposed using the stl function in R. The stl function in R decomposes a time-series into trend, seasonal and residual components using local regression (LOESS model) (EKSTROM, 2012). The 'trend' component of the time series represents variations of a low frequency in a time series, the high and

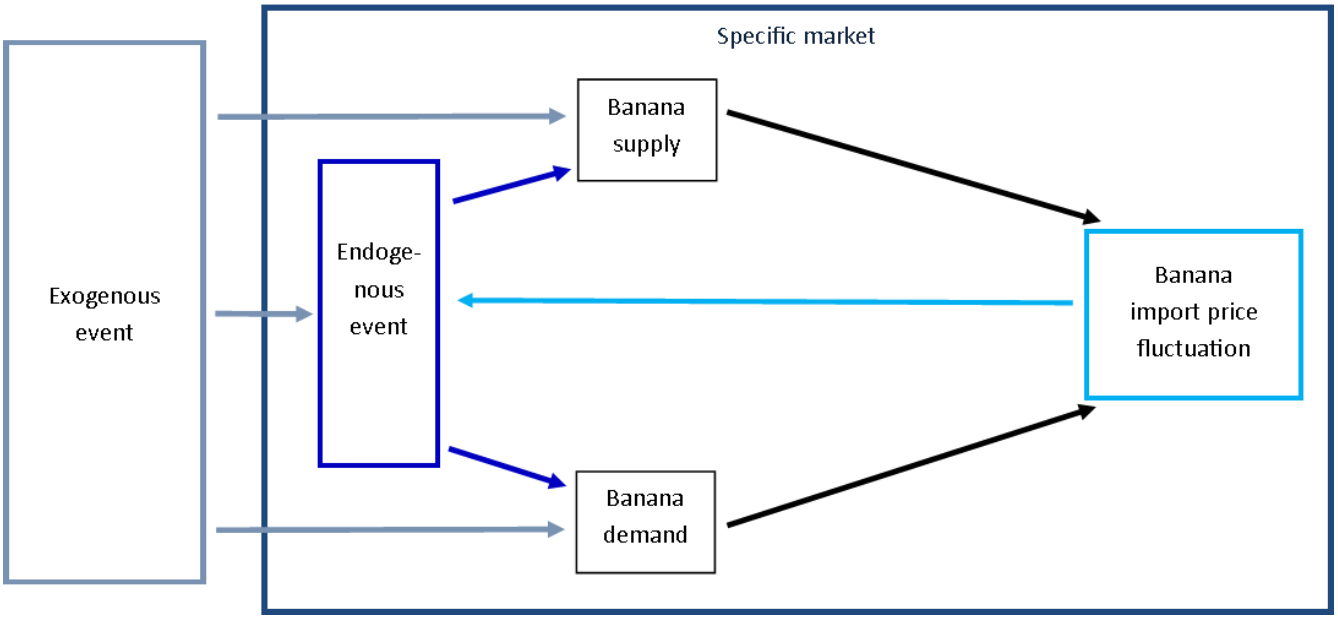
medium frequency fluctuations having been filtered out. This component can be viewed as those variations with a period longer than a chosen threshold. The 'seasonal' component comprises those variations in a time series representing intra-year fluctuations that are more or less stable year after year with respect to timing, direction and magnitude. The 'remainder' component comprises the deviations of the observed time series from the underlying pattern, once the trend and seasonal components have been removed. It corresponds to high frequency fluctuations of the series. It results from short-term fluctuations in a series which are not systematic and in some instances not predictable; eg uncharacteristic weather patterns. In a highly irregular series these fluctuations can mask trend and seasonality (OECD, 2007).

3 Results and Discussion

The results are presented in three parts. The first part presents a typology of events which affected supply and aligns these with major periods of decline in banana exports. The second part presents a typology of events which affected import prices and aligns these with major periods of price variations in the French import market. The third part discusses the role of structural factors and coincidence of events in price determination.

We have classified events as exogenous or endogenous as defined by (BOUSSARD, 2010; TADESSE et al., 2014). Exogenous events occur outside of the agricultural commodity market in question and are described as exogenous because there is no causal relationship going from the market to these causes. They are outside of the control of market actors along the chain. These events can be divided between those that affect the supply side (variations in export volumes), and those which affect the demand side (they stimulate or depress the market). Endogenous events are unexpected and irregular events that occur within the sphere of the agricultural commodity market in question, they are directly linked with the banana context. They can affect both supply and demand. Feedback effects occur. Price fluctuations can have a feedback effect and provoke or reinforce endogenous events. For example, a decrease in prices can heighten the risk of strikes among producers. Figure 1 shows a conceptual framework presenting how exogenous and endogenous events lead to import price variation in the international banana market.

Figure 1. Conceptual framework presenting how exogenous and endogenous events lead to import price variation in the international banana market



Source: the authors based on TADESSE et al.'s (2014) framework

3.1 Typology of Events affecting Banana Export Volumes between 2000 and 2015

Table 1 shows a timeline and typology of events which affected banana producer countries between 2000 and 2015. Climate events are not included in Table 1 but are shown with detail in Table 2. Several categories of exogenous events affected banana export volumes between 2000 and 2015: climatic, geopolitical, logistic, social. The endogenous events to have affected the banana market include disease outbreaks, producer company manoeuvres and changes to regulation (Table 1). Endogenous events can be positively or negatively influenced by exogenous events. For example an exogenous variation such as heavy rainfall can have a reinforcing effect on an endogenous event such as an outbreak of disease and result in a decrease in supply.

Table 1. Timeline and typology of exogenous and endogenous events, other than climate-related events, which affected banana producer countries between 2000 and 2015

Endogenous events		
Logistics	2006	Problems to access renewal material (Cameroon)
	2011	Inability to reinvest in inputs (Ecuador)
Social	2001	Strikes by producers/labourers (Ecuador)
	2002	Strikes by producers/labourers (Ecuador)
	2003	Strikes by producers/labourers (Ecuador, Guadeloupe)
	2004	Strikes by producers/labourers, truck drivers (Ecuador, Colombia, Guadeloupe)
	2005	Strikes by producers/labourers (Ecuador)
	2006	Strikes by producers/labourers (Ecuador)
	2009	Strikes by producers/labourers (Colombia, Guadeloupe)
	2011	Strikes by producers/labourers (Costa Rica, Guadeloupe)
	2014	Strikes by producers/labourers (Ecuador)
	2015	Strikes by producers/labourers (Costa Rica)
Diseases	2003	Black Sigatoka (Ecuador)
	2005	Black Sigatoka (Ecuador)
	2006	Black Sigatoka (Guadeloupe)
	2010	Black Sigatoka (Ecuador)
	2012	Black Sigatoka (Ecuador, Guadeloupe)
	2013	Scale insects (Costa Rica)
Actors strategy	2000	Conversion of 3,000 ha of land to other uses, because of poor financial conditions (Colombia)
	2001	Conversion of land to other uses (Guadeloupe)
	2002	Conversion of land to other uses (Guadeloupe)
	2003	Growers cut back on fertilizers due to being paid below-cost levels (Ecuador); conversion of land to other uses (Guadeloupe)
	2004	Conversion of land to other uses (Guadeloupe)
	2005	Renewal of contract between companies caused uncertainty, problems with renewal of planting material (Cameroon); blockades by banana producers around production conditions in May 2005 (Ecuador)
	2006	Conversion of land to other uses (Guadeloupe)
Regulations and policy	2001	Cost of licences under new African, Caribbean and Pacific Group of States (ACP) quota (Cameroon)
	2003	Licensing restrictions (Cameroon)
	2004	Licensing restrictions (Cameroon)
Exogenous events		
Environmental	2008	Volcanic eruptions (Ecuador)
	2010	Volcanic eruptions (Ecuador, Guadeloupe)
	2012	Fires (Ecuador)
Political and social	2002	Political instability (Ivory Coast)
	2004	Political crisis (Ecuador)
	2008	General strikes (Cameroon);
	2012	Political instability (Ivory Coast)
Logistics	2004	Bridge falls on key road, disrupts exports (Cameroon)

Source: the authors based on FruiTrop, ReeferTrends, Sopisco News, FAO reports

Table 2. Inventory of weather events, which affected banana production and supply in study countries, 2001-2015

South America	2002	**Heavy rains in** Costa Rica (May, 17,000 ha lost, 50% of crop)
	2003	**Cold in** Ecuador (July, -40% volume production, Sigatoka, fert). **Winds, drought, high temp in** Colombia (May, -40% exports, Uraba)
	2004	**Cold in** Ecuador (beginning of year). **Drought in** Colombia (March, -15% exports, Uraba). **Storms** in Colombia (June, 270ha). **Rains** in Costa Rica (beginning of year)
	2005	**Drought in** Ecuador (Feb). **Cold in** Ecuador (June, +Sigatoka). **Wind in** Colombia (June, 600ha). **Rain in** Costa Rica (Jan, -14% area). Ra**in and cold in** Costa Rica (Nov-Jan, exports down)
	2006	**Floods in** Ecuador (March). **Winds in** Colombia (July, 800ha)
	2007	**Floods in** Ecuador (June, delay). **Cold in** Ecuador (June, delay)
	2008	**Floods in** Ecuador (Feb, -25,000ha). **Cold and low sun in** Ecuador (Nov, volumes -30%). **Drought and cold in** Costa Rica (Jan-Apr; -12% exports). **Rains** in Costa Rica (Nov, 12,000ha, 25% of production, -100,000T)
	2009	**Floods in** Ecuador (Jan). **Droughts in** Ecuador (Nov). **Rains** in Costa Rica (Nov+Jan, 17,000ha,7M boxes)
	2010	**Floods in** Ecuador (Feb). **Rain in** Colombia (Dec, 9,000ha, 10% plantations) and Costa Rica (Dec). **Winds in** Ecuador (Sep). **Cold and low sun in** Ecuador (June, Nov). **Storm Mathew in** Costa Rica (Sep, 900,000 plants)
	2011	**Floods in** Colombia (ongoing effects from 2010, exports -16%)
	2012	**Floods in** Ecuador (Jan-March, 10,000ha). **Drought in** Colombia (Jan, -20% exports) and Costa Rica (Jan-Mar, -24% production)
	2013	**Cold and low sun in** Ecuador (Jan, July). **Floods in** Ecuador (March). **Drought in** Ecuador (June)
	2014	**Wind in** Colombia (July, 16,000ha, predict 10% decrease production). **Drought** in Costa Rica (May-ongoing)
	2015	**Floods in** Ecuador (Jan) and Costa Rica (June, July). **Drought in** Colombia (Jan-Mar). **Winds in** Colombia (June). **Cold and rain** in Costa Rica (March)
French West Indies (Martinique and Guadeloupe)	2001	**Drought in** Guadeloupe (first half of year, -50% rainfall)
	2004	**Hurricane Jean in** Guadeloupe (Sep)
	2007	**Hurricane Dean in** Guadeloupe (Aug, destroys 80% plantations)
	2010	**Storm Agatha in** Guadeloupe (June 18,000ha). **Hurricane Tomas in** Guadeloupe (Oct)
	2014	**Hurricane Gonzalo in** Guadeloupe (Oct, destroys 20% plantations)
	2015	**Storm Erika in** Guadeloupe (Aug)
Africa	2007	**Wind in** Cameroon (June, 700ha)
	2012	**Adverse climate in** Cameroon (year, exports down 10%)
	2014	**Floods in** Ivory Coast (July, 1,000ha, 25% crop destroyed)

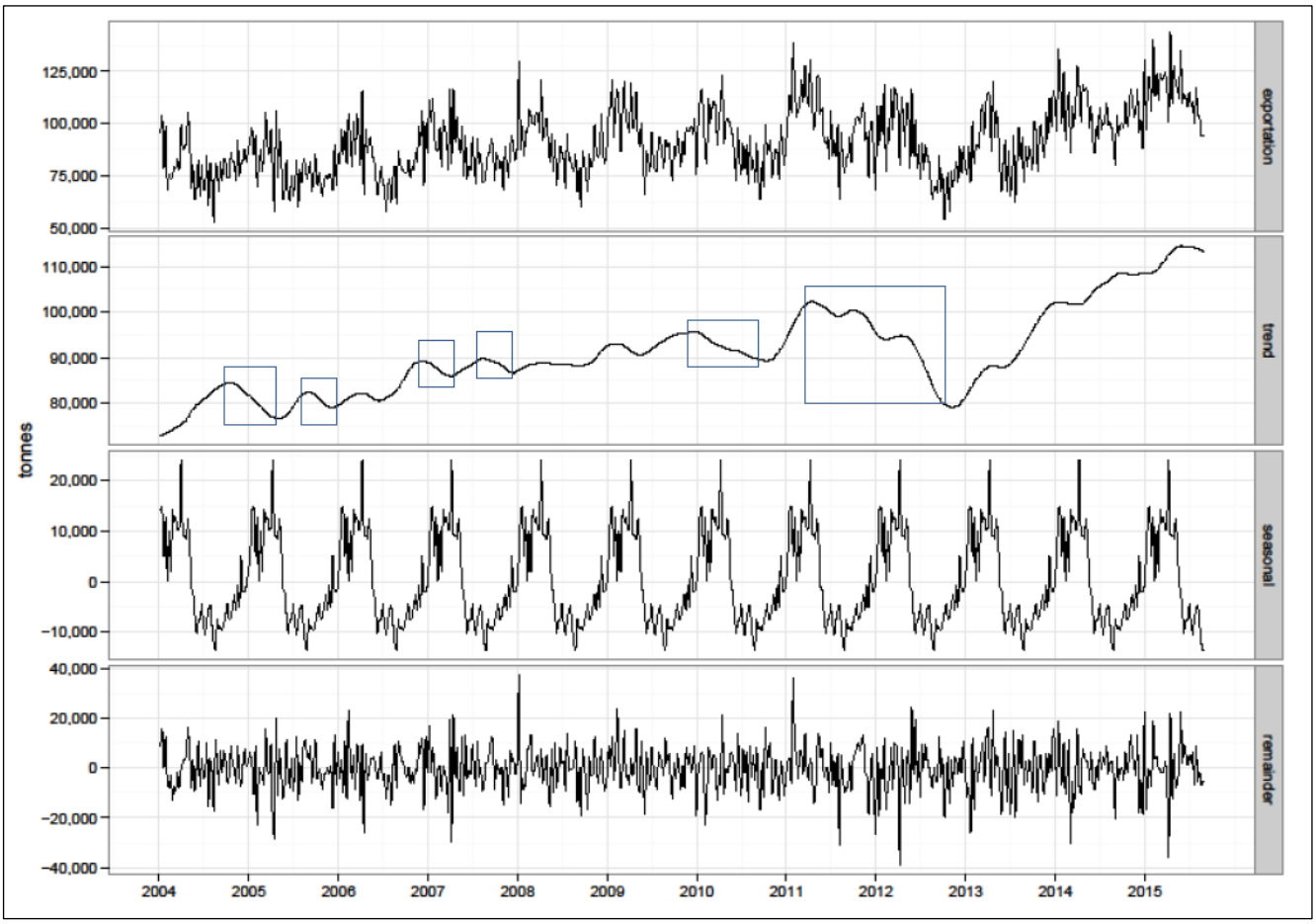
Source: the authors based on FruiTrop, ReeferTrends, Sopisco News, FAO reports

3.2 Frequency and Alignment of Endogenous and Exogenous Events with Major Periods of Decline in Export Volumes

Figure 2 identifies major periods of short and long-term decline in the time-series for export volumes from Ecuador. The same analysis was performed for the other five exporter countries of our study, Colombia, Costa Rica, Guadeloupe, Ivory Coast, Cameroon (see Appendix). Climate events were the most frequently occurring type of event associated with the identified declines in production and exportation volumes across the 6 study countries. While climate events play an important role, there are often other events which occur at the same time, making it difficult to quantify to what extent the climate event is responsible for the decline in exports.

In the case of Ecuador (Figure 2) all declines were associated with a climate event except for the medium-term decline between October 2004 and April 2005 which coincided with a time of political crisis in Ecuador (BBC, 2005) and blockades by banana producers around production conditions in May 2005 (REEFERTRENDS, 2005). The other identified declines were either uniquely due to a climate event or a coincidence of a climate event with another event such as lowered demand from Russia and the United States which affected exports between the beginning 2010 and October 2010 (MARCOTRADE NEWS, 2010; REEFERTRENDS, 2010b; REEFER TRENDS, 2010a) or weak international markets which contributed to the significant long-term decline starting in the first quarter of 2011 and lasting until the end of 2012 (REEFERTRENDS, 2011; USDA-FAS, 2012).

Figure 2. Decomposed time-series for export volumes (in tonnes) of bananas from Ecuador



Source: the authors based on weekly exportation data provided by the MNS of CIRAD. The decomposed time-series have the following components: a) 'exportation' represents the raw data before any decomposition; b) the 'trend' component of the time series represents variations of a low frequency in a time series, the high and medium frequency fluctuations having been filtered out. This component can be viewed as those variations with a period longer than a chosen threshold; c) The 'seasonal' component comprises those variations in a time series representing intra-year fluctuations that are more or less stable year after year with respect to timing, direction and magnitude. d) The 'remainder' component comprises the deviations of the observed time series from the underlying pattern, once the trend and seasonal components have been removed. It corresponds to high frequency fluctuations of the series. It results from short-term fluctuations in a series which are not systematic and in some instances not predictable; eg uncharacteristic weather patterns (OECD, 2007).

In the case of Colombia (see Appendix, Supplementary Figure 1) all declines were associated with climate events except for the very low value in the remainders in June 2009 was due to strikes; and in 2011 a combination of climate events with the 6.37% depreciation of the US dollar against the peso affected exports (REEFERTRENDS, 2011).

In Costa Rica (see Appendix, Supplementary Figure 2), all identified declines were associated with climate events except for the decline between mid-2012 to May 2013. This perceived drop is due to statistical error as during this period 5 million boxes from Chiquita were not included in the export volume counts.

Periods of decline in Guadeloupe's (see Appendix, Supplementary Figure 3) export volumes were due to both weather and other events. Weather events contributed to the declines in 2001, 2004, 2007 and 2010. However, the long-term decline between 2002 and 2006 was mainly due to a decrease in the number of banana plantations (AGRESTE, 2011); competition faced by French West Indies producers with the oversupply of the European market by dollar bananas (INSEE, 2002); strikes by producers, blockage of the port at the end of the year and floods in 2004 (REEFERTRENDS, 2004; INSEE, 2006). The short-term decline between November 2009 until mid-2010 was due to the complete block on exports between 8 March and 23 May 2010 due to volcano ash (INSEE, 2011). Exports fell between mid-2011 and beginning of 2012. Producers blamed this on the large volumes of dollar bananas weakening the market (REEFERTRENDS, 2011).

Ivory Coast's (see Appendix, Supplementary Figure 4) export volumes were less affected by cli-

mate events than by other exogenous events. The gradual decline between 2002 and 2009 in Ivory Coast's export volumes was not due to climate events but to political crises which installed a period of political and economic instability and insecurity which created problems with logistics, investors did not invest in the country and thus there was no progression in production as plantations were not renewed (personal communication, 10 November 2015). The sharp peak and drop in April 2011 was due to fighting in the country, which meant that access to the port was not possible and maritime countries did not venture there. Only the decline in 2014 was due to climate events.

Declines in Cameroon's export volumes (see Appendix, Supplementary Figure 5) were not aligned with climate events, apart from strong winds contributing to the decline in 2007. Instead the identified declines appear to be associated with the implementation of banana market policies. The short-term decline from the beginning of 2001 to mid-2001 may be linked to the establishment of an African, Caribbean and Pacific Group of States (ACP) quota, managed through licenses delivered to commercial operators. The cost of the licenses negatively affected the operations of companies and impacted on banana production. During the period 2003 to 2007, the production of the Cameroonian company, Société des Plantations de Mbanga (SPM), did not increase due to restrictions associated with the licenses and producers experience financial difficulties, as licenses were expensive. The drop in 2005 is likely due to the fall in production by the Cameroon Development Corporation (CDC) and Del Monte because of uncertainties around the renewal of the contract between CDC and Del Monte (FAO, 2011). The sharp drop from mid-2006 to the last part of 2007 was for two reasons. Cameroon's exports fell 14% in 2006, the first year of the Tariff Only system, and the drop was attributed to uncertainty over the new regime and difficulties with the renewal of planting material (REEFERTRENDS, 2007).

3.3 Typology of Events affecting Banana Import Prices between 2000 and 2015

Table 3 shows the main exogenous and endogenous events which were reported as affecting the European banana market between 2000 and 2015, which may have had some impact on French banana import prices. Exogenous events, which occurred outside the banana market sphere, can be categorized into climate, geopolitical, logistics, intermediary costs, currencies, competition and consumer preferences. There are two categories of endogenous events, which affected the banana market during this period: actors' strategy and regulations. Actors' strategies include the promotion of bananas in European supermarkets, as well as the decision by multinationals in 2010 to cut back on procurements, both of which have impacts on demand for bananas at different levels and can affect prices, although the real effect is not easy to measure.

3.4 Frequency and Alignment of Endogenous and Exogenous Events with Periods of Price Variation

Figure 3 identifies periods of short-term and long-term price variation in the French import market. As will be discussed in section 3.5, prices can vary rapidly within a year and many events can coincide within the same period, making it difficult to quantify the contribution of each event to an observed price variation. However, it is possible to gauge the frequency with which types of events are thought to have contributed to a price variation.

Climate events are the most frequently cited event associated with the identified price variations, through their effect on either supply or demand. Climate events in supplier countries can lead to an under-supply which in certain circumstances contributes to a price rise in the French import market. In some instances a series of climate events can create an illusion of an under-supply which can also lead to a rise in prices, although there is not an actual decrease in supply. Climate events in supplier countries led to an under-supply or an illusion of under-supply which caused price rises in 2003, 2004, 2005, 2007, 2010, 2012, 2014.

Climate events within the import markets can also contribute to price rises due to their impact on consumer demand. Consumer demand for bananas in Europe is affected by temperatures. Low temperatures encourage banana consumption, while hot temperatures cause a decline in banana consumption. Consumer demand for bananas is also dependent on competition with seasonal fruits such as local stone-fruits, apples and citrus, whose production is also impacted by climate events. Cool weather in Europe and less competition from seasonal fruits may have contributed to price rises in 2004, 2005, 2007, 2010, 2012, 2013. A clear example of this occurred in 2013 in France when prices of bananas remained high towards the end of the year, despite a stable supply. This was due to the lowest harvest of apples in 10 years in France in 2012 due to poor climatic conditions. There was also a poor

harvest of citrus. This increased the prices of these fruits and consumers turned towards bananas ensuring that prices for bananas remained high towards the end of the year, despite a stable global supply.

Climate events within European consumer countries were frequently cited as a factor which also contributed to price decreases. Heat waves in Europe in 2003, 2006, and a hot European spring in 2011 contributed to the identified price decreases as the climate decreased consumer demand for bananas due to less desire for bananas or because of better production of seasonal fruits.

Table 3: Inventory of exogenous and endogenous events, which affected the European banana market and international context between 2001-2015

Endogenous events		
Actors strategy	2008	Promotion of bananas in supermarket, France
	2009	Promotion of bananas in supermarket, France
	2010	Multinationals announce to cut back on procurement and work on margins
Regulations and policy	2001	Agreement at WTO between the EU, the United States and Ecuador in 2001 on the European Union Banana Import Regime
	2004	Application of tariff-quota system to new EU member states (10 new member states import under quota)
	2005	Shortage of import licences in EU
	2007	Application of changes in customs dues to bananas from dollar zones and over-quota ACP bananas
	2009	Geneva Agreement
Exogenous events		
Climate	2003	Hot spring/summer EU
	2004	Cool spring/summer EU
	2005	Cool spring/summer EU
	2006	Heatwave July (EU)
	2007	Cool spring/summer EU
	2011	Hot spring/summer EU
	2012	Cool spring/summer EU
	2013	Cool spring/summer EU
Geopolitical	2003	Iraq war
	2011	Arab Spring
	2014	Russian embargo leads to less demand
Competition	2001	Low competition from seasonal fruits in EU
	2003	Competition from seasonal fruits in EU
	2004	Low competition from seasonal fruits in EU
	2005	Low competition from seasonal fruits in EU
	2006	Competition from seasonal fruits EU
	2007	Low competition from seasonal fruits in EU
	2008	Low competition from seasonal fruits in EU
	2010	Low competition from seasonal fruits in EU
	2011	Low competition from seasonal fruits in EU. Competition from seasonal fruits EU
	2012	Low competition from seasonal fruits in EU
	2013	Low competition from seasonal fruits in EU. Competition from seasonal fruits EU
	2014	Competition from seasonal fruits EU
Intermediary costs	2004	Rise in sea transport costs
	2006	Rise in sea transport costs
	2010	Big increase in price of oil, cardboard
Currencies	2007	Impact of re-evaluation of peso against dollar (Colombia)
	2008	Weak dollar
	2011	Depreciation of US dollar against peso affected exports (Colombia)
	2012	Euro lost value against dollar
	2014	Crash of the rouble. Euro lost value against dollar
Consumer preferences	2011	Ecoli scare. Global consumption crisis for fruits and vegetables
Logistics	2007	Black Sea port closed

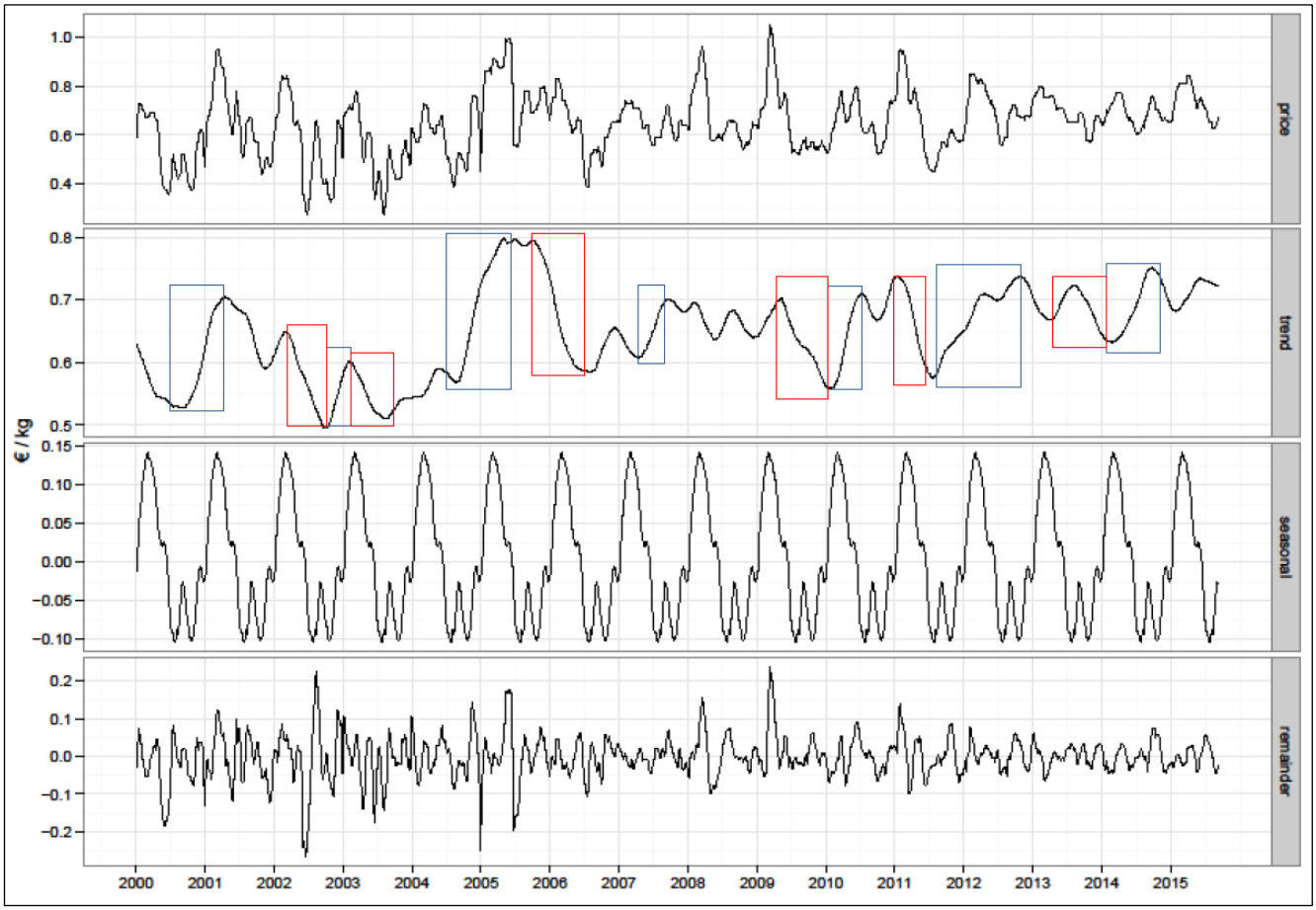
Source: the authors based on FruiTrop, ReeferTrends, Sopisco, FAO reports

The most frequently cited *exogenous* events which contributed to price increases apart from climate included the Arab Spring in 2011 which disrupted supply channels; increases in costs of oil and cardboard and sea transport in 2005, 2007, 2010. Prices in France and Europe may also have been pushed up by changes in currency values. The price rise visible at the end of 2011, beginning of 2012 (Figure 3) may have been partly due to the euro losing power against the dollar, making the EU market less attractive. Bananas were channelled towards the US market in a year when the supply was already constrained globally which may have pushed up the prices in Europe (LOEILLET, 2013).

Of the identified price variations there were two instances when these were partly attributed to *endogenous e*vents, notably changes to banana market regulations or market structure. The impact of changes in regulations on import prices is visible in Figure 3, between the end of 2004 and 2006. In 2004, 10 new European Union member states began to import under quota which pushed prices up (FAO, 2005a). European Union import prices remained high during the summer 2005 in the wake of a shortage of import licenses (FAO, 2005b). Altogether the effects of structuration of the market and role of quotas also meant that the market was not over-supplied (LOEILLET, 2006).

The historical drop in import prices, visible in 2006 (Figure 3), was due to a significant increase in the supply of bananas from dollar sources which took place in the first semester of the year as a result of importers' strategy trying to gain market shares thanks to the removal of quotas, thus causing an over saturation of the market (IMBERT, 2007). In order to protect European production and ensure a supply balance between the various sources, in 1993 the European Union set up a common management organisation COMB (Common Organisation of the Market in Bananas) founded on two principles: regulation of imports and revenue support for European producers. It limited dollar bananas and regulated ACP banana imports. Community bananas enjoyed free access to the European market, whereas dollar bananas were subjected to a tariff quota. Because of their historic relationships, ACP country bananas were entitled to a zero-duty quota. After numerous attempts to harmonise European regulations and the WTO rules, the interested parties in the case (Europeans, Americans, produc-

Figure 3. Banana import prices in France and main price variations 2000-2015



Source: the authors based on weekly data provided by the MNS of CIRAD

er countries) agreed to reform COMB. Since 2006, for dollar and 2007 for ACP countries, any concept of quotas for each source has been abandoned. The system adopted tariff-only management, without any quantitative restrictions for the dollar banana, and unlimited access without customs duty for ACP suppliers (DAWSON, 2016).

3.5 Result 3: Coincidence of Events and Market Structure determine the Impact of Weather Events and other Events on Prices

The analysis shows that in many instances it is the coincidence in time of different categories of exogenous and endogenous events which is important for whether a price variation occurs as well as the structural context of the market at supply and demand level.

3.5.1 Coincidence of Events

A period which demonstrates how the coincidence of several categories of events can affect prices occurred in the French market between the last quarter of 2004 and mid-2005 (Figure 3). This was the largest price rise and of the longest duration (of around 9 months) in the study period. A combination of factors caused prices to rise in 2004. There was less supply due to climate events and strikes in producer countries. Volumes were down from Colombia due to drought and storms; severe winds affected production in Cameroon and production in Guadeloupe fell 30% this year due to strikes and conversion of land (REEFERTRENDS, 2004). This decrease in supply coincided with steady demand from the EU due to cool weather and little competition from summer fruits. Intermediary costs rose this year (LOEILLET, 2005). 10 new member states began to import under quota which pushed prices up (FAO, 2005b). The continued rise into early 2005 was due to a continued reduction in supply from the Caribbean, Central and South America; continued firm demand (due to unseasonably low temperatures), lack of competition from citrus, red and stone fruits, continued rise in intermediary costs In the EU, import prices remained high during the summer 2005 due to the changes in the European Union regulatory structure, as described in the previous section.

Another period which demonstrates the importance of the coincidence of exogenous and endogenous events in determining price variations occurred in 2011. In this year there was under-supply of bananas due to climate events at the end of 2010, but due to other factors, such as the E.coli scare, the Arab revolutions, demand was low and resulted in low prices.

3.5.2 Structural Factors

Differences in the structural context of banana production and strategy of actors across supplier countries determines the impact that different exogenous and endogenous events will have on global supply, and subsequently on price variations.

Reported climate and other events do not impact on total exportation from a country in the same way across different countries, not only due to the nature of the event itself but also due to differences in the production system, the structural context of banana production and the exportation context. These structural factors can mask or mitigate the effect of events in the analysis. An example of differences in structural context can be seen in Ecuador which has a production margin and can mobilize large quantities from one week to another if necessary. Although the country may suffer a serious climate event the impact of this event will not necessarily be seen in the exports. For example in March and April 2008 it was announced that 28,000 ha of plantations were flooded in Ecuador but the weekly exports actually increased (LOEILLET, 2008). Ecuador is the only country which has this capacity.

Strikes are an example of a non-climate event whose impact differs according to the structural context. For example because the production in Ecuador is spread across different regions and workers and growers are not organized on a national basis, strikes will only have a localized short-term impact, whereas in Guadeloupe strikes are national and thus have more amplitude and more impact on exportations.

For a price variation to occur, it depends in which country the event occurs, as countries have different weights in global supply, and in different importing markets. For example events which impact on Ecuador, the largest producer, will impact on markets in the US and Europe. However, events which occur in the Ivory Coast and Guadeloupe will affect the French market but not the US.

4 Conclusions

In most of the recent literature on the causes of food commodity price fluctuations, little attention has been paid to other important food commodities apart from the main grains which are storable and traded on futures' markets. We broaden the analysis to another type of important food commodity which involves a global supply chain and international market. This is the first study to our knowledge that has investigated

the main factors which contribute towards price fluctuations in the international banana market, with a particular assessment as to the importance of extreme weather events. We used de-trended time-series for banana export volumes and banana import prices in France and used a qualitative approach to link variations observed in the time series with key events which occurred in producing countries or importing countries. We put special emphasis on the relative role of extreme weather events in observed price variations.

The analysis showed that there are a large number of exogenous and endogenous events in different categories which can cause price variations, under certain conditions. Intense weather events are the most frequently reported negative event, and have a direct effect on export volumes of bananas in producing countries as well as on demand in importing countries. Moreover, other exogenous events such as geopolitical issues in producing countries or importing regions can significantly reduce volumes or flows of bananas, volcanic eruptions which can drastically reduce exports over a period of time, changes in currency can all have an impact on banana trade. Events which are endogenous to the banana market such as the changes to regulation between 2006 and 2009 can have an important effect on prices.

However, the lesson from the banana market which applies to other fresh commodity markets, is that the occurrence of an event and its actual translation into fluctuations of import prices can be cushioned by or compensated by characteristics of the market itself as well as the structural context of producing countries. Our description of these characteristics of the banana market help to understand when and if price variations might occur, for a food commodity which does not share the same physical characteristics (storable) as the main commodities studied until now.

While climate events, both within exporting countries and within consuming countries, can cause price shifts through their impact on both supply and demand their impact is most seen when they cause a simultaneous under-supply from several of the largest exporting countries. However, it is rare that all countries are affected by weather events at the same moment, during the same year and period of the year. The impact of climate events in the global market can be shaded by a wide range of other events and structural factors, in particular if the climate event occurred in a small exporting country or when a lack of supply from one area is compensated for by another region or country. This study did not quantify the relative impact of events due to a lack of precise information concerning the localization, duration and specification of events such as their intensity, their delayed or lasting effects on production, the exact amount and level of damage in the affected production areas (total or partial damages) and the post shock management allowing a simultaneous or progressive return to production.

However, the findings of this study provide ground for enlightening the debate about the potential of climate-change related events to affect international banana prices, and also to further the debate which revolved around what might be the likely consequences of changes in the regulations of the banana market. While extreme weather events clearly play an important role in determining export volumes from particular countries, this does not necessarily translate into price variations due to the compensation effect explained by the presence of multiple actors and flexibility in sourcing and the other complex mechanisms involved in the price determination process.

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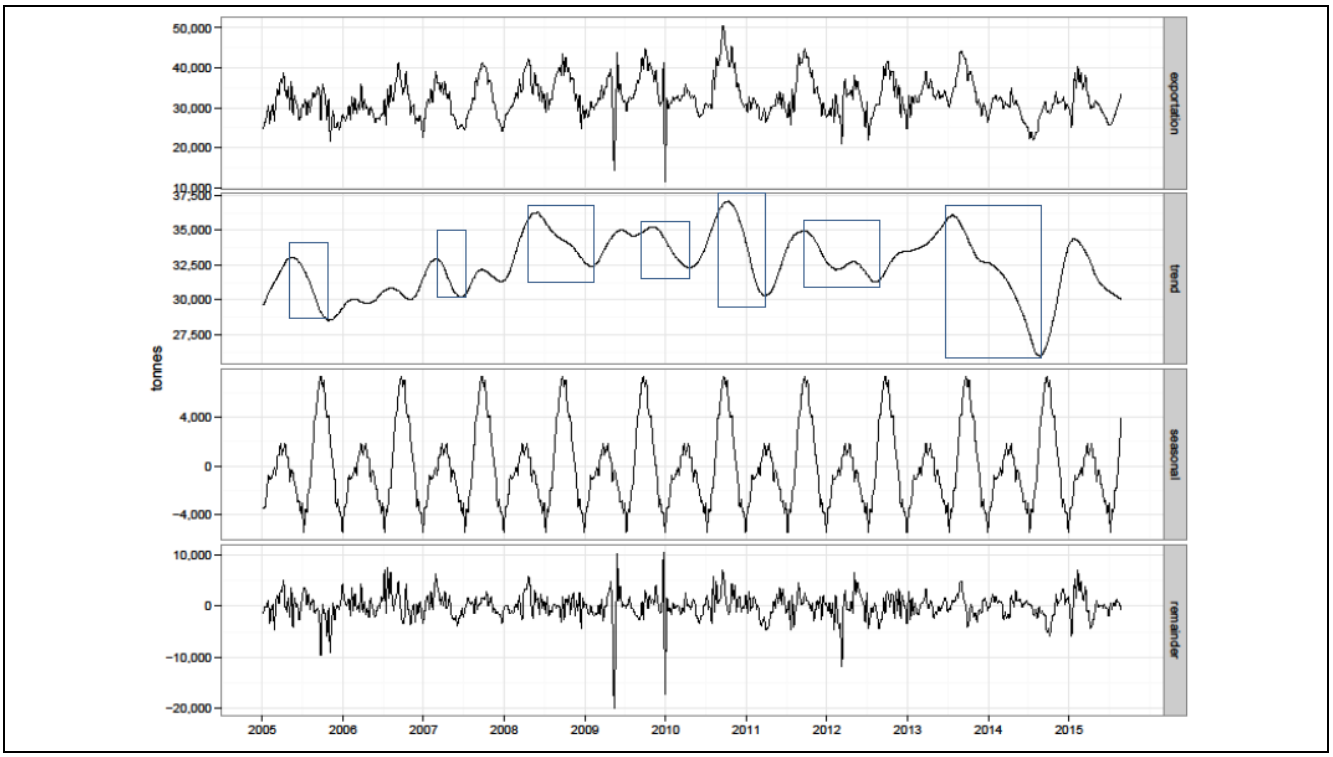
Contact author:
CAROLINA DAWSON
CIRAD, UR-GECO
Boulevard de la lironde, TA-B/PS4,
34398 Montpellier Cedex 5, France
e-mail: carolina.dawson@cirad.fr

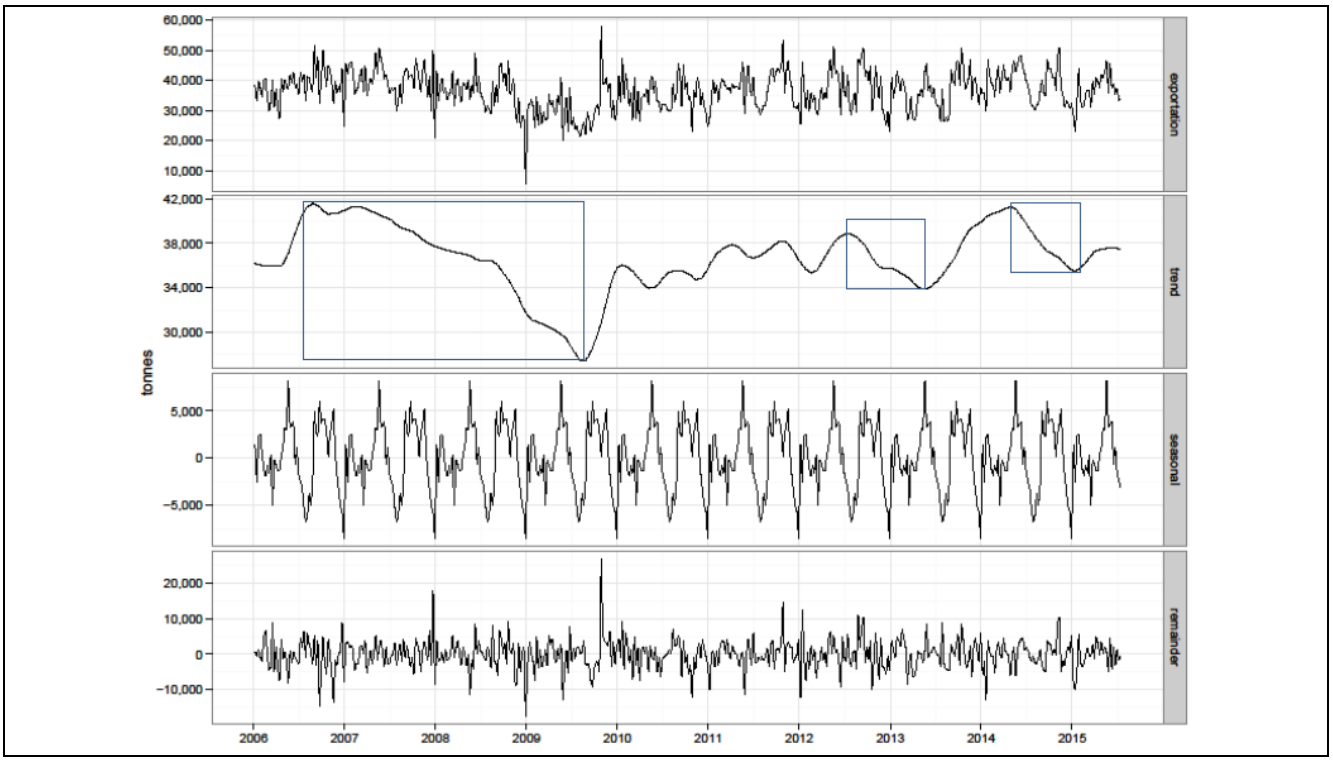
Appendix

Supplementary Figure 1. Decomposed time-series for export volumes (in tonnes) of bananas from Colombia



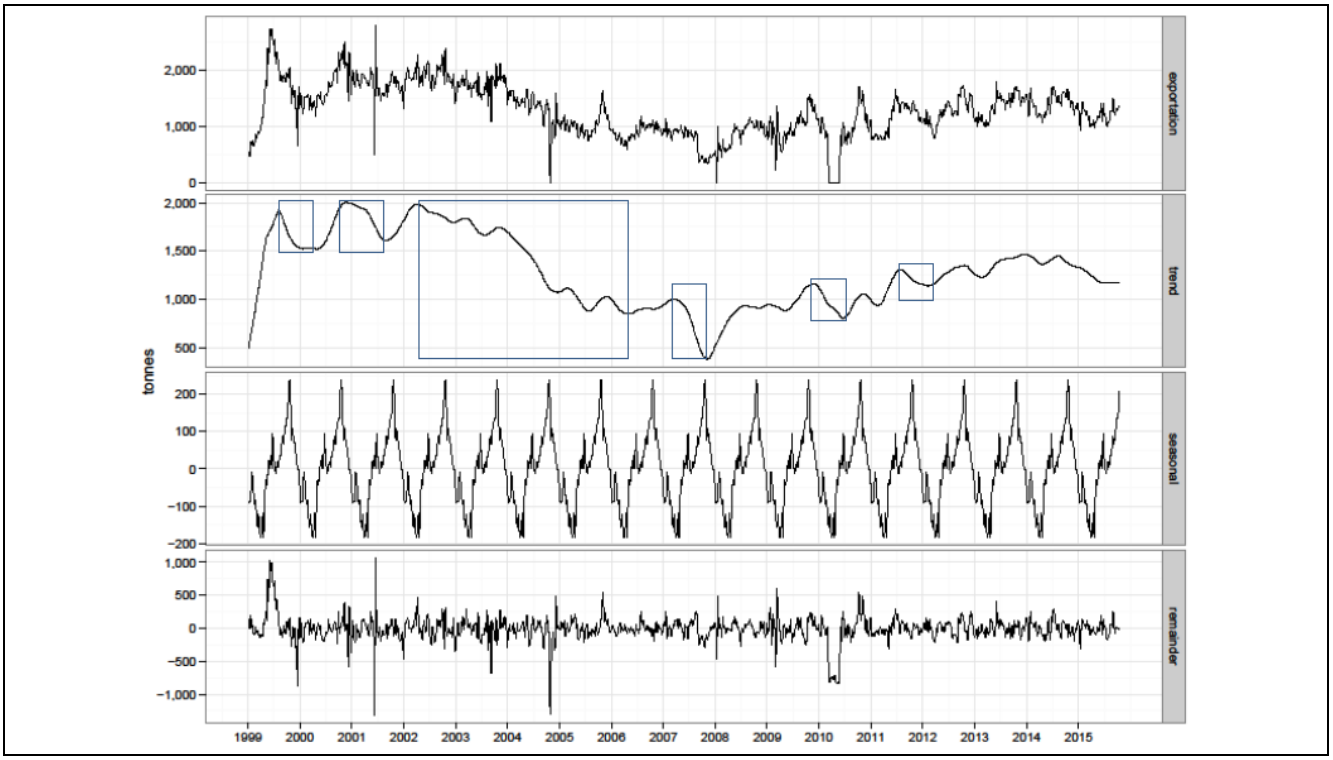
Source: the authors based on weekly exportation data provided by the MNS of CIRAD

Supplementary Figure 2. Decomposed time-series for export volumes (in tonnes) of bananas from Costa Rica



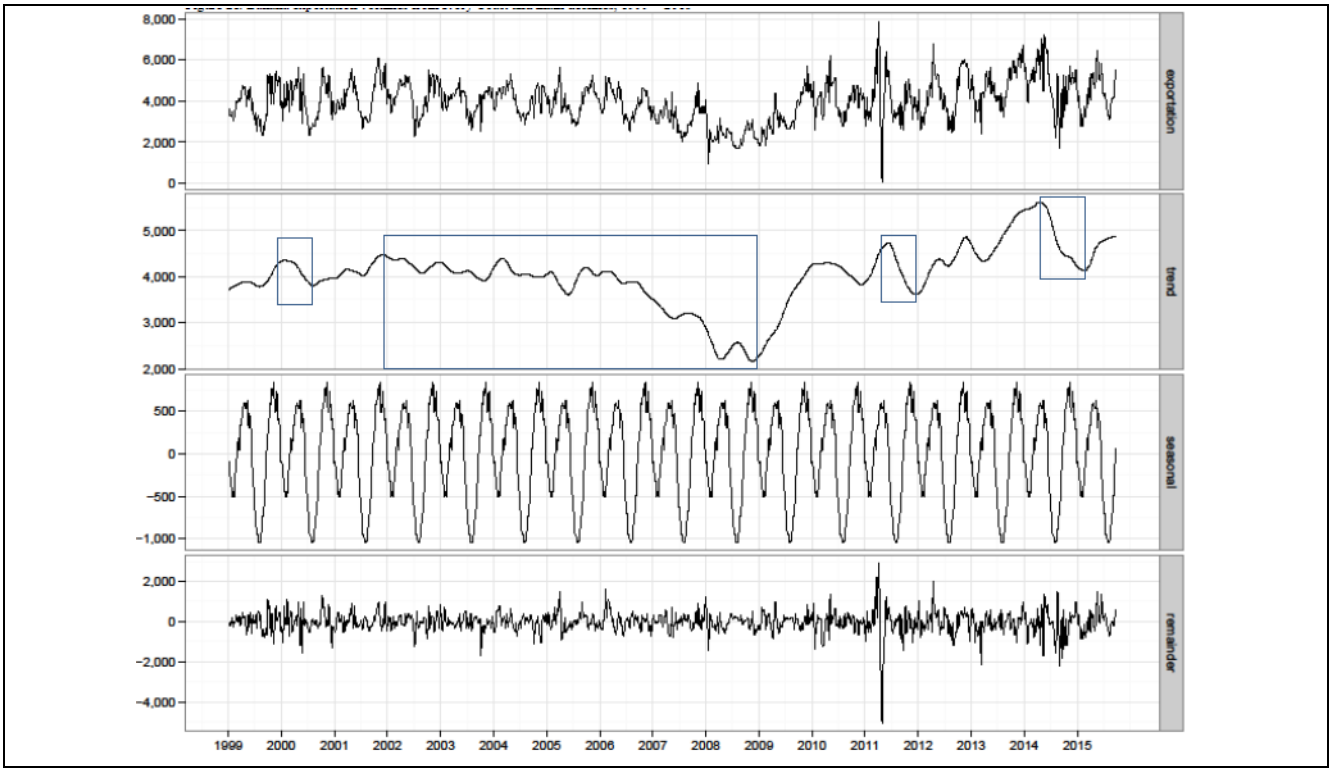
Source: the authors based on weekly exportation data provided by the MNS of CIRAD

Supplementary Figure 3. Decomposed time-series for export volumes (in tonnes) of bananas from Guadeloupe



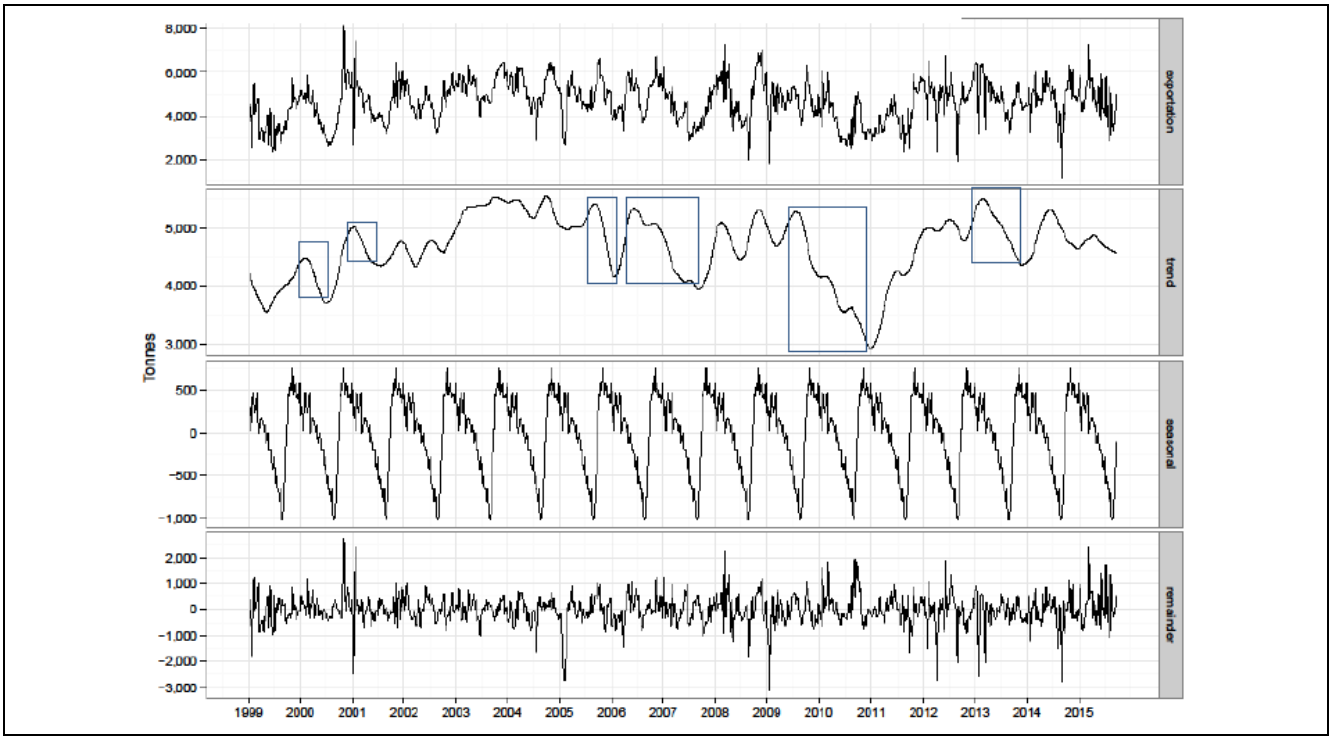
Source: the authors based on weekly exportation data provided by the MNS of CIRAD

Supplementary Figure 4. Decomposed time-series for export volumes (in tonnes) of bananas from Ivory Coast



Source: the authors based on weekly exportation data provided by the MNS of CIRAD

Supplementary Figure 5. Decomposed time-series for export volumes (in tonnes) of bananas from Cameroon



Source: the authors based on weekly exportation data provided by the MNS of CIRAD