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***Commodity price volatility:
the case of agricultural products***

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Abstract

The recent rise in commodity prices and the increase in price volatility have aroused certain concern and controversy among the leaders of the major world powers and international organisations over the possibility that a new food crisis could break out. This paper intends to delve into some aspects of the phenomenon known as commodity price volatility. First, we study the relationship between volatility and financial markets. We can infer from the literature that the empirical evidence as regards this relationship is not conclusive. Secondly, we present an econometric model to analyse the main factors that would determine the volatility of a group of agricultural commodities: corn, wheat, sorghum, rice, soybean, soybean oil and sunflower oil. Among the main factors that would determine volatility we found: US inflation volatility and US interest rate volatility; weather conditions related to Pacific Ocean currents, the growth of emerging countries and the level of inventories available. Lastly, we intend to determine whether the price volatility of the commodities under study affects Argentine exports of these products.

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1. Introduction

When the prices of some commodities rocketed in mid-2010, there were renewed fears that a new commodity crisis could break out, and therefore, the international community intensified the efforts to understand the real dimension of volatility.

Technically speaking, the volatility of the price of a certain asset can be associated with the standard deviation or error of price fluctuations of said asset with respect to the mean value or to the trend. It is also possible to see volatility as the rate at which asset prices change.

It is paramount to determine what factors cause volatility in order to consider economic policy measures or regulations to control excessive price fluctuations. Volatility is a highly complex issue, whose effects may have consequences in areas such as food security, financial markets, trade flows and may create distortions in the development of structurally net commodity-exporting or commodity-importing economies.

This paper intends to explore some aspects of this broad and complex topic, focusing on the case of agricultural products that are relevant to Argentina. Section 2 presents the link between commodity price volatility and financial speculation. In section 3 we carry out an econometric analysis which seeks to pinpoint what factors determine volatility, exploring, in particular, the relationship between volatility and Argentine exports. Lastly, section 4 summarises some final considerations.

2. Commodity price volatility and financial speculation

a) The theoretical debate

The aftermath of the last commodity crisis (2006–2008) has provoked a broad debate on what factors caused it. So far, the main idea arising from this debate is that commodity price volatility has been triggered by the combination of multiple variables, though it has been impossible to find a major cause or determinant.

At present the eventual effect that linking commodity price volatility to new available financial instruments may have is one of the most researched areas. The role commodities have played as alternative investments to traditional financial assets is widely known and cited in the literature. This is explained by several reasons: the lax monetary policy implemented by the United States, which kept interest rates at levels close to zero; the possibility commodities offer to diversify the risks of investment portfolios, as a result of the correlation of commodities with bonds and stocks; the depreciation of the US dollar against other currencies; and the large amount of capitals avid for greater returns, among others.

Although it is true that in the last few years there has been a growing interdependence between the evolution of commodity markets and the financial sector, the empirical

evidence is not enough to conclude that the increased speculative activity on commodities explains *per se* their price volatility. In this sense, while some authors seek to confirm—by means of different methods—the hypothesis that financial activity has not been a determining factor in commodity price volatility, others refute this hypothesis and conclude that volatility has worsened following the expansion of speculative activity. The main outcomes of the research conducted by the most important international organisations are briefly described below.

In this respect, a recent study from the OECD² carried out by Irwin and Sanders (2010) points out that there is no conclusive evidence that speculative mechanisms have triggered the price surge occurred during the period under analysis (June 2006 to December 2009). On the contrary, the participation of index funds³ in commodity markets provided liquidity which served to reduce volatility and overheating of the world's commodities and food products. Consequently, it is not possible to assert that positions held by index funds and swap dealers⁴ have an impact on market returns. Although it is worth mentioning that the increased participation of these new actors represents a structural change in commodity markets, the evidence available is not enough to infer that their participation has increased volatility. Thus, even when said structural change has undoubtedly coincided with the price surge recorded in the period under analysis, it would not have necessarily contributed to this phenomenon.

This paper makes reference to other studies which focus on the financial bubble argument, and claims that the link between index funds and commodity futures prices has not been well developed in most of those studies, since they have committed a frequent statistical error that consists in confusing correlation with causality. Thus, simultaneity between index funds' purchases of commodity futures and increased commodity prices does not imply causality between both variables.

Irwin and Sanders (2010) do not support the financial bubble hypothesis. In their view, it has been the factors linked to fundamentals⁵ that have pushed prices up; among these factors, it is worth mentioning the strong demand from China, India and other developing countries, a levelling out of crude oil production, US monetary policy, the increased biofuel production and the weather shocks that affected the production of certain commodities.

According to the authors, the bubble hypothesis can be rejected on the grounds of other facts which are structural in nature, since if such a phenomenon occurred, the inventories of the commodities involved would increase; and this was not the case, at least, not during the period under analysis. In this respect, the link between commodity prices and inventories is well-known—slight falls in inventories may lead to significant

² Organization for Economic Cooperation and Development.

³ Investment fund that enters into futures or commodity swap positions for the purpose of replicating the return of an index of commodity prices or commodity futures prices. Commodity swap: it implies a flow exchange between two parties; in this case, a swap in which the payout to at least one counterparty is based on the price of a commodity or the level of a commodity index.

⁴ An entity such as a bank or investment bank that markets swaps to end users.

⁵ They refer to supply and demand conditions for commodities and to factors that could have an impact on them, including, among others, weather-related aspects, stock levels, and sown and harvested areas.

price surges—and it could be observed that the inventories of the main commodities declined between 2006 and 2008.

Furthermore, the authors claim that the price of the commodities in markets without index fund participation (fluid milk and rice futures) and commodities without futures markets (apples and edible beans) have also increased. And they further add that index fund buying is transparent and predictable, since index funds widely publish portfolio reports, asset weights and roll-over periods⁶.

Since the outcomes of the report have implications for the economic policy of commodity producing and importing countries, the authors suggest that the different government authorities who deal with financial market regulations should be cautious about changing them. In particular, they point out that limiting the participation of index funds could deprive commodity markets of an important source of liquidity and risk-absorption capacity.

Though less bluntly, another important organisation, namely the FAO⁷ (2010) has contributed to this issue by describing the two prevailing standpoints on speculation, prices and volatility, and it has stressed the positive role played by the futures market in allowing farmers to shift price-risk⁸ to speculators. In this sense, the study mentioned highlights the importance of the increased participation of these agents—which has boosted liquidity of commodity markets—and states that only 2% of futures contracts are concluded by the delivery of commodities; and this is a negligible percentage that could be pointing at the minimum impact of futures market on commodity spot prices.

Lastly, as regards speculative processes, this paper claims that the empirical evidence is inconclusive, but it also suggests that there are a number of reasons to believe that speculation was not the main determinant of increasing commodity prices between 2006 and 2008.

In line with the OECD paper, the FAO states that the measures taken to reduce speculation might have unintended consequences, since they might lower liquidity in markets aimed at risk-shifting. Therefore, it suggests that regulatory measures should favour better market conditions through mechanisms which increase transparency and the amount of information available. In other words, it claims that in order to foster commodity market development, regulatory measures that hinder speculation should be avoided.

⁶ It refers to the period in which futures contracts become due, and it implies doing the reverse transaction in futures markets and re-establishing futures positions in a more deferred delivery month. For example, if traders have December futures positions already sold, near their maturity date they purchase other December futures positions, thus carrying out the reverse transaction in order to subsequently sell futures with delivery terms in May or June of the following year.

⁷ Food and Agriculture Organization.

⁸ It refers to the risk commodity producers run that the prices of their products be pushed down at the time of selling them.

In turn, the working group organized by the G-8⁹ finance ministers, “International Organization of Securities Commissions (IOSCO) Task Force on Commodity Futures Markets,” gathered and analysed the documents produced by international organisations, central banks and regulatory bodies in response to the concerns aroused by the excessive commodity price volatility during the period 2006–2008. The final report (OICV-IOSCO, 2009) submitted by this institution concludes that economic fundamentals, rather than speculative activity, explain commodity price changes. Nonetheless, it suggests that continued monitoring is appropriate to improve understanding of futures market price formation and the interaction between regulated futures markets and related commodity markets, thus calling for the improvement of the quality, availability and transparency of futures market information.

As the main international trade bloc, the European Union has also closely studied the issue of commodity price volatility. In this respect, a working group has elaborated a study that reviews the evidence for and against the existence of a speculative bubble in the commodity market (Commission of the European Communities, 2008 a and b). This study concludes that “the most likely explanation of price increases since the beginning of 2007 to mid-2008 seems to be a combination of economic fundamentals in particular and factors specific to the financial markets, which might have amplified price changes” (Commission of the European Communities, 2008 b: 17). It further states that volatility has increased, at least, in some commodities, and that higher prices seem to coincide with increased volatility. In turn, increased open interest¹⁰ also seems to coincide with increased volatility.

Despite these assertions, the fact that volatility increases in line with prices and with the amount of open interest does not necessarily establish a causal relationship between both variables. Therefore, in view of the impossibility of identifying what actual factors determine volatility, the Community report only expresses concern about the presence of volatility, and it analyses possible solutions that could be reached through a new regulatory framework.

The financial aspect is, without doubt, a factor that could explain volatility; however, it is worth mentioning that commodity markets have historically been volatile and very sensitive to fundamentals. In any case, the phenomenon known in the literature as “financialisation of commodities”¹¹ is a process that has developed over the last years. Unlike in the case of purely financial assets, in this case variables related to agricultural commodity supply and demand are intertwined, among which the weather, inventories and price elasticities play a highly important role.

⁹ Group of industrialised countries comprising Germany, Canada, the United States, France, Italy, Japan, the United Kingdom and Russia, whose main objective is to discuss world economic issues.

¹⁰ It refers to the number of contracts (futures and options) that have not been settled by a certain date in futures markets and gives an idea of market depth. Thus, the open interest rises if all traders open contracts or if they settle fewer contracts than those they open. In contrast, the open interest will remain unchanged if traders settle the same number of contracts they open, or if there is no transaction at all. In turn, it decreases if all traders settle their contracts or if they settle more contracts than they open.

¹¹ This refers to the growing link between the financial sector and commodity markets. Due to different reasons, these assets have been competing with traditional financial assets over the last years. In financial markets they are present through index funds, commodity swaps and ETFs (Exchange Traded Funds) which replicate index funds returns.

Strictly speaking, futures markets have a long-standing existence and have developed as a consequence of volatility. If volatility did not exist, farmers would not need to resort to markets to hedge the price-risk associated with their crops. Consequently, due to the possibility of realising higher profits, a volatility level exceeding the average would attract more speculators to markets. However, if greater speculative activity proves to be correlated with higher prices and higher volatility—and it is still impossible to establish a casual relationship between them—perhaps we could think of speculation more as a symptom of volatility rather than as a cause of it.

Furthermore, we should not forget that the presence of speculators is necessary for the development of futures markets, since farmers resort to the market to hedge their crop prices and thus get rid of the price-risk, which is taken on by speculators. That is, speculators bring liquidity to futures markets and play the role of price stabilisers. This hypothesis is supported by the following evidence (Costa Ran and Font Vilalta, 1992):

- Several studies have compared commodity prices from when there was futures trading with prices from when such instrument did not exist. The outcomes of these studies show that cash market volatility was generally lower in times when futures markets were already active. This enables us to conclude that the studies were establishing a statistical rather than a causal relationship between futures trading and volatility reduction.
- A study on the three most significant markets in the United States showed that hedging costs are lower in markets where there is greater speculative activity; that is, active speculation makes hedging easier for farmers.

b) New post-crisis regulatory measures

Within the process of financial reforms promoted by the G-20, the United States and the European Union are at present designing new regulatory frameworks that might have an impact on commodity price volatility. Specifically, the new regulations and regulation drafts are expected to have a direct impact on the financial sector and, in particular, on all commodities. Nevertheless, the impact of these measures on financial markets—for instance, on market volume and liquidity—cannot be perceived yet.

On the one hand, in July 2010 the United States enacted the Dodd-Frank Act¹² which contains specific provisions on commodity markets. It is worth noting that this new act represents the most significant financial reform in the last years, and is in fact a new regulatory framework for the financial sector of said country. Notwithstanding this, the enactment of said act fostered the need to develop further regulatory measures in order to implement such a reform, thus raising many questions on what its effects on markets and the economy will be. In particular, regarding commodities, the cited act requests the US Commodity Futures Trading Commission (CFTC) to limit the number of futures

¹² Dodd-Frank Wall Street Reform and Consumer Protection Act. Pub. L. 111-203; HR 4173. 21 July 2010. 111th United States Congress.

contracts or commodity futures positions that traders¹³ can acquire. Said act encourages transparency of futures markets, making the US Securities and Exchange Commission (SEC) and the CFTC jointly responsible for the design of regulations for the financial derivatives market¹⁴. It also requires that most derivatives transactions be standardised and negotiated in institutionalised markets, making it possible to channel them through clearing houses to avoid risks of default.

On the other hand, in the European Union, commodity derivatives are regulated by the MiFID¹⁵ (Markets in Financial Instruments Directive) and the UCITS¹⁶ (Undertakings for Collective Investment in Transferable Securities). During 2009 and 2010, the European Parliament and Commission have put forward tighter regulation proposals for these markets with the aim of restricting the excessive influence of one or some of the participants on the market, and of reducing the number of speculators. Other proposals aim at increasing transparency in over-the-counter¹⁷ (OTC) derivatives in order to avoid risks of fraud, default and manipulation, and to better supervise alternative investment funds, including hedge funds,¹⁸ which are very much involved in commodity trading.

It is worth highlighting that both regulatory frameworks intend to be consistent between them to prevent arbitration¹⁹ between European and US markets, for which international cooperation is crucial. However, since financial reforms in both markets constitute an ongoing process, the authorities of the European Commission have committed to keeping close communication with their US peers, with the aim of preventing possible and future divergences between their legislations.

In brief, what is known is that the measures to be shortly implemented will have a different impact on financial entities, futures markets and the different “users”—either producers or speculators—of said products. These measures are very much likely to have some impact on volatility; however, it is yet too early to foresee the magnitude of such change. In general, the reforms or proposals under analysis are aimed at amending very lax regulations that contributed to the outbreak of the financial crisis, and at enhancing the transparency and supervision of markets. In view of this, we can infer that there could be a reduction in price volatility. That is, although said reforms are expected to reduce volatility, that would not be their main objective. Consequently, it

¹³ Those buying or selling assets, such as commodity swaps, index funds, or commodity futures and options. Traders can be financial entities or stockbrokers.

¹⁴ Derivatives are financial instruments whose value depends on their underlying assets (stocks, currencies, commodities). Futures, options and swaps are the main derivatives. Derivatives constitute investment alternatives and they are traded in institutionalised markets, such as futures markets, and in over-the-counter (OTC) transactions.

¹⁵ Directive 2004/39/EC OJ L 145, 30/4/2004; Directive 2006/73/EC OJ L241, 2/9/2006 and Regulation N° 1287/2006 OJ L 241, 2/9/2006.

¹⁶ Directive 1985/611/EC OJ L 375/3, 31/12/1985; Directive 2001/107/EC OJ L041, 13/02/2002; Directive 2001/108/EC OJ L 041, 13/02/2002.

¹⁷ Financial transactions such as commodity swaps which do not enter institutionalised futures markets.

¹⁸ Private investment funds that trade and invest in different financial assets—such as stocks, commodities, foreign currencies and derivatives—on behalf of their clients, who are generally well-off people. They tend to be closed funds, and limited to a small number of investors.

¹⁹ In financial markets that have laxer regulations than (an)other market(s), traders might be able to earn profits through the purchase of financial assets in one market and their sale in another market, or through transactions with guaranteed returns.

will be necessary to closely monitor markets in order to perceive significant changes in the different commodities and their financial derivatives.

We can infer from the literature that the empirical evidence about the link between commodity price volatility and speculative activity is not conclusive. In fact, the research carried out by the most important international organisations—OECD, FAO, OICV-IOSCO and the European Commission, among others—has not been able to establish a causal relationship between increased speculative activity and commodity price volatility; a highly complex phenomenon that does not depend exclusively on a single variable. On the basis of said premise, in the next section we intend to approach the factors determining commodity price volatility, in particular, that of the main agricultural commodities.

3. *The econometric evaluation*

In this section we present an econometric model to analyse the link between commodity price volatility and the factors considered to be its main determinants. The main objective is to identify factors that can potentially trigger the increased volatility of a selected group of commodities—of which Argentina is a net producer and exporter. Secondly, we assess how volatility affects Argentine exports of said commodities.

a) *Definition of volatility*

Since volatility—the variable in question—cannot be directly observed, we need to determine a measure to construct it. In this paper, we adopt the historical definition of volatility used, among others, by the European Commission (European Commission, 2009) and the CME²⁰. CME's historical volatility calculation is equal to the annual standard deviation (STDEV) of the first differences in the logarithm (LN) of monthly prices (equation 1).

$$volatility = STDEV \left(LN \left(\frac{price_t}{price_{t-1}} \right) \right) \cdot \sqrt{12} \quad [1]$$

With the aim of giving greater weight to the estimates, we used a second measure of volatility, which is almost fully consistent with that expressed above. Specifically, we constructed a proxy²¹ for volatility based on monthly series. For this purpose, we used the absolute values of the residuals of an AR(1) model²² (equation 2), and then we calculated the annual averages (equation 3), in which the dependent variable ($\Delta \log Y_t$) is the return of a commodity or asset “*i*”.

$$\Delta \log Y_t = \mu + \varepsilon_t; \quad \varepsilon_t = \rho \cdot \varepsilon_{t-1} + e_t \quad [2]$$

where e_t is the error term.

²⁰ Chicago Mercantile Exchange (CME), afterwards renamed as CBOT (Chicago Board of Trade).

²¹ In this case, it constitutes an alternative method that approximates the method described.

²² Autoregressive model of order 1.

$$volatility = \frac{1}{12} \sum_{t=1}^{12} |e_t| \quad [3]$$

This procedure was applied to the commodity prices and macroeconomic variables used (exchange rate, interest rate, inflation), since there is some evidence that volatility in the fundamentals may have an impact on the volatility of agricultural commodities.

Table 1 below shows the statistics summarizing the series of returns of the selected commodities.

Table 1
Agricultural commodity returns*.
Statistical Summary. 1965–2009

	Mean	Deviation	Min.	Max.
Corn	-0.2	5.5	-25.5	28.2
Rice	-0.1	6.2	-28.5	40.6
Sorghum	-0.2	6	-26.8	33.8
Soybean	-0.1	6.4	-35.5	31.3
Soybean oil	-0.1	6.6	-24.3	34
Sunflower oil	-0.1	7.7	-42.4	65.2
Wheat	-0.2	5.6	-20.9	50.1

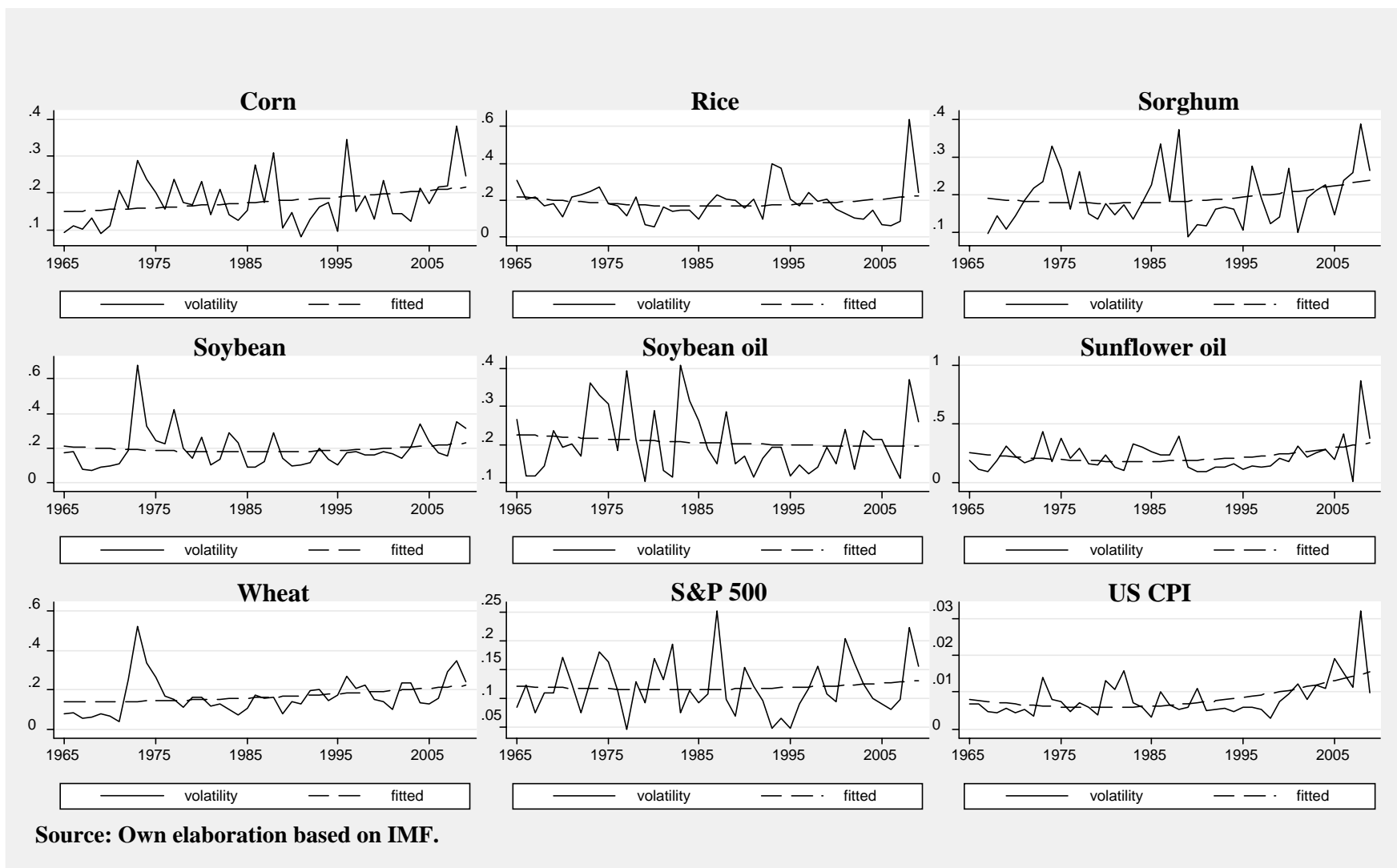
* Change in the logarithm of real prices multiplied by 100.

Source: Own elaboration.

Graph 1 shows the volatility series corresponding to the different commodities selected for the period 1965–2009 and their respective trends. We also present the S&P 500 volatility²³ and that of the US Consumer Price Index (CPI), because they are variables of the financial sector that can be linked to commodity price volatility. Except for rice and sunflower oil, the series seem to suggest that “high” volatility over the last years would not be an extraordinary event compared to the values recorded in the previous decades.

²³ The S&P 500 index is a stock market index that indicates the average profitability of the stocks that constitute it. It includes the 500 leading companies in the US industry, and it is considered as a simple thermometer of the US stock market.

Graph 1: Historical volatility 1965–2009



Source: Own elaboration based on IMF.

b) Variables used and sources of information

i) Commodity prices

Commodity spot prices were drawn from the International Financial Statistic (IFS) Database distributed monthly by the International Monetary Fund (IMF, 2011 a). Given the availability of series of data for a long period of time, the sample was restricted to the period 1965–2009. The analysis included seven commodities: corn/maize, wheat, soybean, soybean oil, rice, sorghum and sunflower oil. Each of the prices is denominated in current US dollars, so we had to deflate them first using the US Consumer Price Index (CPI) (Bureau of Labour Statistics, 2011). The information about the volume produced and exported by Argentina was drawn from the website PSD (*Production, Supply and Distribution online*) of the US Department of Agriculture (USDA, 2011).

ii) Potential determinants of volatility

One of the most original contributions of David Ricardo in the 19th century was his theory of rent, in which he states that the production of agricultural commodities is qualitatively different from industrial production, since the supply of the former is mostly limited by land area and the prevailing technological conditions. Consequently, commodity supply and demand are inelastic in the short run, because commodities are part of the household food basket, and therefore their consumption is almost constant over time in spite of sharp income changes. Although this might be true for the developed world, in emerging countries—where a large part of the population is slightly above the poverty line—income changes may affect the composition of the basic food basket and may have some impact on demand.

Thus, changes in volatility levels and in the volatility of the factors determining commodity supply and demand (its fundamentals) may increase or reduce uncertainty and commodity price volatility. Due to the historical role played by the United States as producer, exporter and price maker of agricultural products, most commodities are quoted in US dollars. Consequently, it would be reasonable to suppose that the price of said commodities will be influenced by the macroeconomic factors that affect the United States. In short, changes in the monetary policy carried out by the Federal Reserve System (the Fed)²⁴ may have a persistent impact on the rest of the markets and, especially, on commodity markets.

A number of exogenous factors that might somehow affect agricultural commodity prices are listed below.

²⁴ The Federal Reserve System (the Fed) serves as the US Central Bank.

▪ **Inflation**

As was explained in section 2, commodities currently represent financial assets in investors' portfolios, which implies that incentives to acquire them as stores of wealth grow with the level of prices, that is, with inflation (Roache, 2010). Nevertheless, the causal link may be established in both directions, since an increase in commodity prices exerts greater pressure on the price index. Yet, there are certain factors which tend to weaken this second possibility: on the one hand, the share of agricultural commodities in the price index composition is low and, on the other hand, these commodities have a marginal share with respect to the rest of commodities.

▪ **Inventories**

Several studies have shown that inventories have a direct impact on volatility (Williams and Wright, 1991), which tends to be greater in commodities whose production is restricted by their availability. This is the case of oil, coal and the rest of non-renewable resources (Geman, 2005). In this paper, inventories are calculated as the ratio between the inventory at the beginning of the year and the consumption of the previous year. Data for a relatively long period of time is available in the database of the USDA PSD (USDA, 2011).

▪ **Exchange Rate**

Like inflation, the exchange rate has an impact on asset prices. Thus, volatility in the value of the US dollar may entail short-run gains or losses in the profitability of assets denominated in US dollars, which may prompt investors to modify their positions in the short run, exacerbating overall market volatility. For this reason, we included the volatility of the US nominal exchange rate as one of the explanatory variables of the model.

▪ **Interest rate**

Another factor that has an impact on investors' portfolio decisions is the interest rate, which is expected to have direct and significant effects in the short run. When international interest rates are very low, investors look for more profitable alternatives in other financial assets, such as commodities. However, when interest rate volatility is used as an explanatory variable, the relationship is not altogether clear, and it can depend on the persistence or not of volatility in agents' expectations.

In this paper, we used the interest rate of one-month US treasury bonds (very short-run bonds), and then we deflated it using the CPI, in order to construct a consistent series of real interest and its volatility.

▪ **Income growth**

As was previously stated, accelerations and decelerations in world growth rates may cause variations in the demand for food, and therefore, give rise to higher or lower volatility levels. This paper included both emerging and developed countries' growth

rates as explanatory variables, since both groups of countries have grown at different paces over the last decades. Said series were taken from the IFS publication of the IMF (IMF, 2011 b).

▪ **The weather**

Although it is generally accepted that weather changes have an impact on agricultural output, this effect is very hard to measure. The global weather pattern used in this paper is based on the Southern Oscillation Index (SOI) estimated by the US National Oceanic and Atmospheric Administration (National Weather Service Climate Prediction Center, 2011). This index measures the global weather pattern caused by air pressure changes in the Pacific Ocean. Prolonged periods of negative SOI values coincide with abnormally warm ocean waters and constitute a typical episode of the cycle known as “El Niño”. In contrast, prolonged periods of positive SOI values coincide with cold ocean waters across the eastern Pacific and constitute a typical episode of the cycle known as “La Niña”.

“El Niño” tends to increase the probability of drought in tropical areas, whereas “La Niña” is related to increased probability of drought in mid-latitude regions, where most highly demanded crops (such as wheat, corn and soybean) are produced (Roache, 2010).

▪ **Speculation**

As was thoroughly described in section 2, the impact of speculators on price volatility is ambiguous and is currently under debate. As a proxy for speculation, this model includes a variable that captures the annual change in the weekly volume of speculative transactions in the CBOT futures market (US Commodity Futures Trading Commission, 2011). Since there is no data in this respect for periods prior to 1998, this variable was multiplied by a dummy²⁵ assuming values equal to one since 1998 and to zero before then.

▪ **Alternative financial assets**

An increase in stock price volatility can spread to the remaining financial markets, including those of bonds and commodities. In order to capture this potential relationship, we added the S&P 500 (Standard & Poors 500) volatility series (IMF, 2011 c).

c) The model

Agricultural commodity price volatility was modelled using the previously described variables as regressors²⁶. In order to capture the strong correlation existing between prices of different commodities, we decided not to resort to the standard methodology (i.e., Ordinary Least Squares) to carry out the estimation. Following Greene (2002), we

²⁵ That is, a dichotomous variable that takes discrete values on the interval [0,1].

²⁶ Explanatory or independent variables.

used Zellner's model (1962) instead, which allows a multi-equation estimation in which errors can be correlated across equations.²⁷

Table 2 below summarizes the results of the estimations carried out, whereas Annexe 1 shows the complete results of said regression.

As can be observed there is not a single factor homogeneously affecting all commodities. This reinforces the idea that each market has its own dynamics and can be affected by factors alien to other markets, which does not imply that markets are independent from one another but rather that they have a certain “idiosyncrasy” or distinctive features.

The results of the regression show that CPI volatility and interest rate volatility tend to significantly increase the price volatility of the commodities analysed. Likewise, the growth of emerging countries coincides with greater volatility, while the opposite effect is observed as regards the growth of developed economies. On the other hand, the inflation rate seems to have a negative impact, though the reasons for this are unclear and should be examined more thoroughly in further studies.

In line with the theory, larger inventories tend to reduce volatility, since agents' behaviour becomes less speculative as market uncertainty decreases. Although it was possible to assess the impact of speculation (as previously described) on a subset of the sample, the results show a negative correlation with the dependent variable. This outcome buttresses the argument of those who claim that futures markets tend to reduce agents' uncertainty, thus bringing about price stabilisation.

Lastly, there is positive correlation between SOI and price volatility. This effect coincides with the weather conditions observed over the last few years, which some analysts believe to be a period affected by “La Niña”, which is correlated with drought in areas where crops such as corn, wheat and soybean are grown.

²⁷ Annexe 2 includes the details of the model.

Table 2
Summary of regression results: determining factors in commodity price volatility

Volatility of the commodity <i>i</i>	Growth of developed economies	Growth of emerging economies	Speculative positions	US Inflation	Real interest rate	Southern Oscillation Index	US CPI volatility	US nominal exchange rate volatility	Interest rate volatility	S&P 500 volatility	Inventories
Corn	*	+	*	*	*	+	+	*	*	*	*
Wheat	-	+	-	-	*	*	+	*	-	+	-
Sorghum	-	+	NA	-	*	+	+	*	*	*	*
Rice	*	*	NA	*	-	*	+	*	+	*	-
Soybean	*	*	*	*	*	*	+	*	*	*	-
Soybean oil	*	*	*	*	*	+	*	*	*	*	*
Sunflower oil	*	*	NA	*	*	+	*	*	+	*	*
*	Non-significant at the 5% level										
+	Significant and positive										
-	Significant and negative										
NA	Not available										

Source: Own elaboration.

d) Does volatility affect Argentine exports?

The aim of this section is to determine whether there is enough evidence that commodity price volatility affects Argentine exports, assuming a sample of selected commodities.

In order to test this hypothesis, we used the following econometric procedure. Firstly, we tried to determine the degree of integration of the variables using the usual unit root tests. In order to avoid problems related to the incorrect specification of the deterministic component of each model, we used the procedure developed by Dolado, Jenkinson and Sosvilla-Rivero (1990).

Secondly, since in the case of exports the augmented Dickey-Fuller (ADF) tests indicated that the series are $I(1)$,²⁸ it was necessary to take the first differences in order to achieve stationarity²⁹. In the case of volatility, we concluded that the series are stationary and, therefore, they are $I(0)$. Due to the fact that the variables used must have the same order of integration³⁰ to perform the regression, it was possible to accurately develop an econometric model using the results obtained, with the aim of testing if volatility levels have had any impact on Argentine exports.

In order to test this hypothesis, we put forward the following model to be estimated:

$$\Delta \ln(y)_t = \alpha + \beta \cdot \Delta \ln(y)_{t-1} + \gamma_k \sum_{k=0}^1 \ln(x)_{t-k} + \varepsilon_t, \quad [4]$$

where ε_t is the error term.

In this case, exports (measured in tonnes) are the dependent variable (y), while the explanatory variables are price volatility (x) and the first lag of both variables. The purpose of this regression is to determine whether changes in the price volatility levels of a group of selected agricultural products have considerable effects on export growth. Due to the stationarity of the series employed, the model was estimated by Ordinary Least Squares (OLS).

Table 3 shows the results obtained in the model for the following commodities: corn, rice, soybean, soybean oil, wheat and sunflower oil. Taking into account these results, we can conclude that price volatility levels have no statistically significant impact on agricultural commodity exports.

²⁸ A variable is said to be integrated of order 1, i.e. $I(1)$, if it needs to be differentiated once so as to achieve stationarity. Therefore, a variable $I(0)$ is stationary and it is not necessary to apply the difference operator.

²⁹ If neither the mean nor the covariance of a random variable depend on the date t , then the process for the variable is said to be covariance-stationary or weakly stationary. In the case of a model including two or more variables, the stationarity condition avoids spurious relationships, that is, it prevents the model from estimating a non-genuine relationship between variables.

³⁰ For further details see Hamilton (1994), chapters 17 and 18.

Table 3
Regression results of the impact of volatility on Argentine exports
(in tonnes)

Variables	Corn	Rice	Soybeans	Soybean oil	Wheat	Sunflower oil
First lag (dependent)	-0,397*** (0,123)	-0.0184 (0,0542)	0,168** (0,0769)	-0,459* (0,233)	-0,334** (0,142)	-0.394 (0,323)
Volatility	0.0945 (0,19)	0.796 (0,937)	0.13 (0,578)	-0.107 (0,165)	0.292 (0,185)	0.00832 (0,615)
First lag (volatility)	-0.339 (0,224)	0.483 (0,515)	1.008 (0,775)	-0.111 (0,2)	-0.143 (0,16)	0.214 (0,534)
Constant	0.351 (0,225)	-1.568 (2,022)	-1.224 (1,231)	0.53 (0,339)	-0.176 (0,208)	-0.228 (1,019)
Observations	44	44	35	35	44	43
R-square	0.224	0.048	0.109	0.26	0.161	0.157

Standard errors between brackets.

*** p<0,01, ** p<0,05, * p<0,1

Source: Own elaboration.

4. Conclusions

- Commodity price volatility seems to be an extremely complex and multicausal phenomenon which does not depend on only one variable.
- An analysis of the literature on the relationship between volatility and speculation has yielded inconclusive results. While one of the approaches claims that financial activity was not a determining factor of volatility between 2006 and 2008, others have tried to prove that volatility has exacerbated as a result of speculative activity. Nevertheless, the research carried out by the main international organisations (OECD, FAO, OICV-IOSCO and European Commission, among others) has not been able to conclusively prove a causal relationship between increased commodity price volatility and speculative activity, which could be a symptom of volatility rather than its cause.
- As for the financial reforms that are currently under debate in the United States and the European Union, these are likely to have certain impact on commodity price volatility, although that is not their major goal. It is worth stressing that the new measures, which are in line with the rules put forward by the G-20, will be applied to financial derivatives, including all commodities. Consequently, since this process is currently underway both in the United States and the European

Union (where the main futures and commodity-based financial derivatives markets are located), its eventual effects cannot be quantified yet.

- There is empirical evidence that the price volatility of the agricultural commodities selected—which are of interest to Argentina—cannot be explained by the same factors. Each commodity is produced and traded under certain conditions, which might differ from market to market.
- According to the econometric study carried out, the main factors that tend to increase volatility include:
 - a) US inflation volatility;
 - b) US interest rate volatility;
 - c) Weather conditions related to currents in the Pacific Ocean;
 - d) Fast economic growth of emerging countries;
 - e) Smaller inventories.
- The main variables that cause volatility cannot be controlled *a priori* by a country like Argentina, which has little power to set world prices of its export commodities and is characterised by a poorly developed financial market.
- There is no evidence to affirm that commodity price volatility is somehow affecting Argentine commodity exports, since the econometric results have shown no significant causal relationship in any of the cases analysed.

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ANNEXE 1

Complete regression results: determining factors in commodity price volatility

Variables	Corn	Rice	Sorghum	Soybean	Soybean oil	Wheat	Sunflower oil
First lag (dependent)	0,0500 (0,0862)	-0,104 (0,105)	-0,00583 (0,0938)	-0,112 (0,0899)	-0,206* (0,107)	-0,253** (0,104)	-0,418*** (0,0840)
Growth of developed economies	-0,289* (0,166)	0,196 (0,262)	-0,643*** (0,209)	-0,184 (0,319)	-0,311 (0,273)	-0,606*** (0,216)	0,0214 (0,326)
Growth of emerging economies	0,271** (0,117)	-0,137 (0,181)	0,527*** (0,145)	0,287 (0,222)	0,153 (0,189)	0,449*** (0,153)	-0,0556 (0,226)
Speculative positions	-0,00354 (0,00304)	-	-	0,00150 (0,00570)	-0,00561* (0,00331)	-0,036*** (0,0130)	-
US inflation (CPI)	-0,260 (0,160)	0,0210 (0,258)	-0,537*** (0,204)	-0,318 (0,306)	-0,123 (0,267)	-0,439** (0,205)	-0,0232 (0,313)
Real interest rate	0,0927 (0,122)	-0,518*** (0,198)	0,144 (0,153)	-0,0175 (0,231)	-0,113 (0,199)	0,0812 (0,157)	-0,485** (0,235)
Southern Oscillation Index	0,00306** (0,00124)	0,00171 (0,00184)	0,00462*** (0,00158)	0,00332 (0,00240)	0,00417** (0,00206)	0,00236 (0,00161)	0,00656*** (0,00244)
US inflation volatility	7,243*** (2,282)	8,584** (3,449)	5,860** (2,888)	13,40*** (4,401)	3,379 (3,896)	8,737*** (2,909)	3,593 (4,587)
US nominal exchange rate volatility	-0,352 (0,593)	1,158 (0,896)	0,112 (0,763)	0,0430 (1,153)	0,406 (0,980)	0,437 (0,773)	0,520 (1,174)
Interest rate volatility	0,0115 (0,0423)	0,191*** (0,0638)	-0,0648 (0,0540)	-0,0254 (0,0855)	-0,0146 (0,0718)	-0,159*** (0,0553)	0,176** (0,0852)
S&P 500 volatility	0,0615 (0,171)	0,424 (0,266)	0,0693 (0,219)	0,0798 (0,331)	-0,0931 (0,280)	0,619*** (0,225)	0,299 (0,339)
Inventories	0,0156 (0,0180)	-0,0904** (0,0442)	0,0345 (0,0284)	-0,105*** (0,0399)	-0,0309 (0,0689)	-0,097*** (0,0318)	-0,0362 (0,0314)
Dummy 70s	0,0181** (0,00762)	-0,00819 (0,0113)	0,0202** (0,0101)	0,0236 (0,0160)	0,0115 (0,0126)	0,0186* (0,00993)	-0,00982 (0,0149)
Dummy 80s	0,0104 (0,0113)	0,0156 (0,0183)	0,00660 (0,0140)	0,00862 (0,0214)	-0,00227 (0,0192)	-0,00491 (0,0141)	-0,000804 (0,0219)
Dummy 90s	0,00544 (0,0116)	0,0255 (0,0198)	-0,00534 (0,0151)	-0,00322 (0,0222)	-0,0248 (0,0201)	0,00396 (0,0147)	-0,0369 (0,0230)
Dummy 2000s	0,000248 (0,0126)	-0,0318 (0,0200)	-0,0120 (0,0169)	-0,00364 (0,0246)	-0,0203 (0,0214)	-0,0110 (0,0164)	-0,0340 (0,0251)
Constant	0,0139 (0,0137)	0,0453** (0,0218)	0,0331* (0,0177)	0,0379 (0,0270)	0,0778*** (0,0224)	0,0567*** (0,0210)	0,0956*** (0,0274)
Observations	41	41	41	41	41	41	41
R-square	0.593	0.62	0.52	0.496	0.431	0.631	0.539

Standard errors between brackets.

*** p<0,01, ** p<0,05, * p<0,1

Source: Own elaboration.

ANNEXE 2

Estimation by SURE³¹ (Zellner, 1962):

We suppose there are “n” particular equations to be estimated:

$$y_{it} = \mu_i + \beta_i \cdot x_{it} + u_{it} \quad [5]$$

where $i=1,2,\dots,n$ represents the total of equations to be estimated, and $t=1,2,\dots,T$ is the number of observations.

Stacking the observations corresponding to each equation, we can rewrite [5] as:

$$y_i = \mu_i + \beta_i \cdot x_i + u_i \quad [6]$$

In turn, the previous model can be rewritten in a matrix form:

$$\begin{pmatrix} y_1 \\ \mathbf{M} \\ y_n \end{pmatrix} = \begin{pmatrix} x_1 & \Lambda & 0 \\ \mathbf{M} & \mathbf{O} & \mathbf{M} \\ 0 & \Lambda & x_n \end{pmatrix} \cdot \begin{pmatrix} \beta_1 \\ \mathbf{M} \\ \beta_n \end{pmatrix} + \begin{pmatrix} \varepsilon_1 \\ \mathbf{M} \\ \varepsilon_n \end{pmatrix} \quad [7]$$

One of the main assumptions of the model is that it does not permit serial autocorrelation, although it is possible that the idiosyncratic errors of each model are correlated with each other.

The estimation by SURE is performed in two stages. First, each “n” equation is estimated in an autonomous way and the resulting residual series are obtained. In the second stage the extended variance and covariance matrix is constructed, whose elements are given by:

$$\hat{\sigma}_{ij} = \frac{1}{T} \hat{\varepsilon}_i \hat{\varepsilon}_j \quad [8]$$

$$\Sigma = \begin{pmatrix} \hat{\sigma}_{ii} & \Lambda & \hat{\sigma}_{in} \\ \mathbf{M} & \mathbf{O} & \mathbf{M} \\ \hat{\sigma}_{ni} & \Lambda & \hat{\sigma}_{nn} \end{pmatrix} \quad [9]$$

Finally, the estimator of this second stage is given by:

$$\hat{\beta}_{FGLS} = \left[X'(\hat{\Sigma}^{-1} \otimes I_T)X \right]^{-1} X'(\hat{\Sigma}^{-1} \otimes I_T)y \quad [10]$$

³¹ Seemingly unrelated regressions.