International price volatility, exchange rate uncertainty and cereals exports: Empirical evidence from France

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Abstract

This paper investigates the impact of both exchange rate and futures price volatility on bilateral cereals exports from France. Using the Poisson pseudo-maximum likelihood (PPML) estimator developed by Santos Silva and Tenreyro (2006) to deal with the problem of zero trade flows when estimating a gravity equation, we show that the exchange rate uncertainty has a strong negative impact on french cereals trade. We find also that a higher futures price volatility is associated with an increase of french cereals exports. The PPML method also allows commodity specific estimation of the relationship. Results concerning price volatility support the idea that the positive effect is rather commodity-specific and not uniform across individual cereals commodities. We find that realized futures price volatility has a significant and positive impact on french exports of three commodities: barley, oats and maize.

Keywords: Exports, exchange rate, futures prices, volatility, Poisson pseudo-maximum likelihood (PPML)

JEL Classification: C23, F14

1. Introduction

The impact of exchange rate volatility on the export performance of a given economy has been widely studied in the literature. From a theoretical point of view, most papers show that the uncertainty resulting from this volatility has controversial effects on a country's level of exports. Indeed, while initial studies only consider the impact of the exchange rate instability on exports global volume and demonstrate a negative relationship (Hooper and Kohlhagen, 1978), more recent papers have attempted to consider the case of specific industries, including agriculture. However, despite the significant numbers of contributions in this area, the empirical results do not allow to conclude on the nature of relationship between these two variables (Ozturk, 2006).

These papers rely on hypothesis that producing countries can determine domestic prices of agricultural products, but have to face exchange rate volatility. However, these

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analyses underestimate the role of financial commodity markets in determining the physical (i.e commercial) prices of these products. In fact, we have to consider that, virtually all commercial agricultural prices, such as wheat, corn or soybeans can be divided into an international reference price and a price differential. This reference price comes from the listing of commodity futures on organized markets, such as the Chicago Mercantile Exchange (CME) or the Minneapolis Grain Exchange (MGE) whereas the price differential accounts for discrepancies between this future contract, standardized by nature, and the commercial contract. This con-substantial relationship between physical prices and commodity futures prices has been widely documented in the academic literature since Johnson (1960). It exists, because there are inventories on commodity markets, that should balance any disequilibrium between a seasonal supply and a continued demand, both inelastic in the short-run, and because those inventories consequently create a need for traders to find financial hedging solutions (Peck, 1985). In the absence of forward commercial deals, carrying stock is based on a fundamental uncertainty which imposes, all things being equal, an increase in profit margins in order to remunerate the risk. Conversely, the use of forward-type contracts or future contracts allows for more competitive prices since the risk premium partly disappears. Financial commodity markets are therefore essential, even on a commercial basis.

Offering hedging solutions is not the sole advantage of financial commodity markets. Thanks to clearing mechanisms, they also offer public reference prices for numerous maturities. Hence, those markets not only reveal the profit margins of the operators, but also provide information about futures prices and thus, tend to influence producers and end-users strategies. According to well-known theory of storage and the normal backwardation theory, the spread between futures prices and cash prices, i.e the basis, also reveals if the market is experiencing shortage or not. In that respect, we can assert that futures prices influence both production and export strategies. In other words, economic hazard that exporting country undergoes is not only dependent on exchange rate volatility , but also on the variability of international reference prices and on the basis level. This paper's contribution is therefore to take these variables into account in the analysis of the determinants of french bilateral export flows of five commodities: barley, maize, oats, rice and durum wheat.

The rest of the paper is organized as follows. Section 2 reviews the theoretical and empirical literature on the relationship between price and exchange rate uncertainty and trade. Section 3 presents the data and econometric specification of the estimated models. Section 4 summarizes the results of our gravity equation estimations. Section 5 provides some concluding remarks.

2. Literature review

Many articles have investigated the relationship between the uncertainty arising from exchange rate volatility and export flows. Since De Grauwe (1988), the ambivalent nature of this link has been highlighted: as an increase in export prices leads, *ceteris paribus*, to an increase in the rate of profit, risk aversion and the production adjustment cost due to exchange rate variability can, in turn, reduce the total volume of exports of a given country. While early studies highlight the existence of a negative relationship (Thursby and Thursby, 1987), more recent studies tend to temper this conclusion. A paper by Tenreyro (2007) develops a pseudo-maximum likelihood (PML) technique in order to take into account problems found in previous papers and generated by heteroskedsasticity and zero-trade observations and concludes, using a broad sample of countries from 1970 to 1997, that there is no statistical link between increased currency volatility and reduced international trade. One of the possible explanation brought to the fore by the author to explain this result is that derivatives contracts (swaps, options and futures) are now widely used to hedge foreign exchange risk arising from exchange rate volatility.

Can we generalize this statement? While early studies have attempted to describe the nature of this link for an economy as a whole, more recent analyses focus on particular industries and tend to demonstrate the specificity of the agricultural sector. For instance, May (2010) investigates the determinants of Thai exports for five agricultural products (corn, rice, rubber, sugar and tapioca), using various explaining variables, among which, the short-run real exchange rate volatility. This analysis reveals a direct link between increased volatility (whatever the measure of volatility that has been adopted: MA of the standard deviation , residual of an ARMA or ARIMA or GARCH process of the daily or monthly bath/US dollars real exchange rates) and the reduction in the volume of exports. The author also tests the hypothesis that this is rather production than the firm's export decision that is influenced by exchange rate volatility, but shows that there little evidence that producers choose to produce less in times of high exchange rate volatility.

A previous study from Cho *et al.* (2002) also confirms that the export volume of agricultural products, from the G10 countries, is much more sensitive to the uncertainty resulting erratic currency movements than other sectors. Kandilov (2008) extends the previous analysis by comparing the exchange rates sensitivity of agricultural trade in G10 countries to those of two groups of countries, emerging and developing countries. Using a gravity model to test the determinants of bilateral trade over the period 1975-1997, the author demonstrates that the link between export volume and variability of the real exchange rate is weak and not statistically significant when the economy as a whole is considered. However, this relationship turns out to be more pronounced in the case of agricultural products, although important differences remain between countries. Considering bilateral trade, it appears that the elasticity of the volume of agricultural exports to the variability of exchange is much higher for the G-10 countries than for emerging countries. Three explanations are suggested by Kandilov (2008) to explain this counter-intuitive result: the failure to take into account the non- linearity of exchange rates volatility, the choice of currency billing can significantly change the forex risk each partner country has to face (Goldberg and Tille, 2005), and finally, the existence of export subsidies within the G10 countries that appear to be statistically dependent on the variability of the exchange. However, when these factors are taken into account, the author shows that the sensitivity of agricultural exports from developing countries is much higher than for industrialized countries. Based on a similar econometric methodology, a more recent study by Karemera et al. (2011), based the on international trade of fruits and vegetables in the OECD countries, mitigate those results. The author indeed show that, over the period 1996-2002, the variability of currency, both on the short and long - term, can have a positive effect on the exports of specific commodities in the OECD countries. More specifically, this paper highlight the fact that if the link between exchange rate volatility and aggregate volume of agricultural exports is statistically proven, it is however not uniform and varies considerably from one commodity to another.

Zhang *et al.* (2002) assume however that exchange rate volatility is not the only uncertainty exporters have to face and that multiples volatilities (exchange rate, but also commodity prices and ocean freight costs volatilities) have to be taken into account in order to explain trade flows. They consider these variables to explain Brazilian and US soybeans exports from January 1996 to January 2006. They put forth the evidence that exchange rate volatility is a statistically significant variable to explain both Brazilian and US exports, on the contrary to soybean and heating oil price volatilities. The authors explain this result by asserting that the availability of commodity derivatives allows exporters to hedge their price risks and make export flows insensitive to volatility. This statement is hardly debatable, but ignores the fact that fix-price hedging strategies traditionally used by producers and users do not protect them against basis risk, that is the difference between export spot prices and futures prices. In other words, the protection offered by derivatives instruments, especially futures contracts is often imperfect. The variability of commodity prices can therefore have an impact on export flows even when hedging instruments are available.

3. Empirical model and data

3.1. The gravity model of trade

Since the pioneering work of Anderson (1979), the gravity equation of trade "has gone from an embarrassing poverty of its theoretical foundations to an embarrassment of riches" (Frankel, 1997, pp. 53). Nowadays, it is well recognized that the gravity equation can be derived from very different models of trade. For example, the model of Anderson (1979) assumes that goods are differentiated by country of origin as in Armington (1969) and that consumers have preferences defined over all the differentiated products. Bergrstrand (1985, 1989) derived directly the gravity equation from a model of trade with monopolistic competition and a demand for variety. Deardorff (2001) indicates that the gravity equation of trade could arise from a simple Hecksher-Ohlin model. Eaton and Kortum (2002) use a Ricardian type model to derive the gravity equation whereas Helpman *et al.* (2008) and Chaney (2008) refer to the Melitz (2003) model of firm heterogeneity to obtain the gravity equation.

In its general formulation, the model predicts that the volume of trade between two countries is proportional to their gross domestic products (GDPs) and inversely proportional to the transaction and transportation costs between them, as in:

$$T_{ij} = e^{\alpha_0} Y_i^{\alpha_1} Y_j^{\alpha_2} D_{ij}^{\alpha_3} \tag{1}$$

With Y_i and Y_j represent, respectively, country i and country j GDPs, D_{ij} represents the bilateral distance between country i and country j which is a proxy for transaction and transportation costs and α_0, α_1, α_2 and α_3 are the parameters to be estimated.

However, the contribution of the prominent research on the micro-foundations of the gravity equation developed by Anderson and van Wincoop (2003) has highlighted the importance of controlling for relative trade costs in the model. Adopting a constant elasticity of substitution demand function and assuming the Armington's (1969) hypothesis of product differentiation, they show that trade flows two countries are determined by trade barrier relative to the average barrier of the two countries with all their partners. This is what they called the "multilateral resistance". They also indicate that the empirical gravity literature fails to include any form of multilateral resistance in the gravity equation which entails bias estimates. This omission is called the "gold medal mistake" by Baldwin and Taglioni (2006). In a short sample period, Bladwin and Taglioni (2006) indicate that this mistake can be resolved by adding importer and exporter fixed effects to the gravity equation. However, in the case of a long sample period, we might expect that the multilateral resistance change over time. As a consequence, country fixed effects are not appropriate to evaluate multilateral resistance. In this case, the introduction of importer time-varying fixed effects allows to take into account the fact that multilateral resistance evolves through time.

The gravity equation of trade has been widely used to investigate the relationship between exchange rate volatility and agricultural trade (Cho *et al.*, 2002; Kandilov, 2008; Karemera *et al.*, 2011; Sheldon *et al.*, 2013). In these studies, the traditional gravity model of trade (equation (1)) is augmented with other factor that may create trade resistance, such as the exchange rate volatility and include trade costs. We assume that international futures price volatility of commodities can have an impact on bilateral trade and include it in our gravity model of trade. As a consequence, our model yield the following equation (Tenreyro, 2007):

$$X_{Fjkt} = e^{\alpha_0} Y_{Ft}^{\alpha_1} Y_{jt}^{\alpha_2} D_{Fj}^{\alpha_3} e^{(\alpha_4 cont_{Fj} + \alpha_5 lang_{Fj} + \alpha_6 col_{Fj} + \alpha_7 RTA_{Fjt} + \alpha_8 XV_{Fjt} + \alpha_9 PV_{kt})} \epsilon_{ijt} \tag{2}$$

Where X_{ijk} is the exports of product k from France to country j in t, Y_{it} is the GDP of France in t, Y_{jt} is the GDP of country j in t, XV_{Fjt} is the exchange rate volatility of the Euro against currency of country j in t, PV_{kt} is the futures price volatility of commodity k in tn D_{Fj} is the bilateral distance between France and country j, $cont_{Fj}$, $lang_{Fj}$, col_{Fj}, RTA_{Fjt} are dummy variables capturing respectively whether France and country j share a common border, a common language, whether France and country j

was ever in colonial relationship and whether France and country j are members of a regional trade agreement and ϵ_{ijt} is an error term assumed to be statistically independent of the regressors, and α's are parameters to be estimated.

The standard practice in the empirical literature studying exchange rate volatility and trade consists of log-linearizing equation (2) as follows:

$$Ln(X_{Fjkt}) = \alpha_0 + \alpha_1 ln(Y_{Ft}) + \alpha_2 ln(Y_{jt}) + \alpha_3 D_{Fj} + \alpha_4 contig_{Fj} + \alpha_5 lang_{Fj} + \alpha_6 col_{Fj} + \alpha_7 RTA_{Fjt} + \alpha_8 XV_{Fjt} + \alpha_9 PV_{kt} + ln(\epsilon_{ij}) \quad (3)$$

Note that if importer specific effects θ_j are added to the model to account for multilateral resistance, all time-invariant variables are perfectly collinear with these fixed effects and then removed from the estimated equation. Moreover, if time-varying country fixed effects are added to take into account the changing nature of the multilateral resistance term as suggested by Bladwin and Taglioni (2006), all importer time-varying characteristics such as GDP or exchange rate uncertainty are perfectly collinear with these effects and then removed from the model.

3.2. Estimation issues

As discussed in the previous section, the most frequent approach developed in the empirical literature studying exchange rate volatility and trade is to estimate the log-linearized model (equation (3)) using the Ordinary Least Squares (OLS) estimator (Rose, 2000; De Grauwe and Skudelny, 2000; Cho *et al.*, 2002; Kandilov, 2008; Chit *et al.*, 2010; Karemera *et al.*, 2011; Sheldon *et al.*, 2013). This estimation procedure entails two serious problems (Santos Silva and Tenreyro, 2006; Tenreyro, 2007). First, the error term of equations (2) and (3) is generally heteroskedastic. Thus, the OLS estimator of the log-linearized model can suffer from a serious bias due to the presence of heteroskedasticity (Santos Silva and Tenreyro, 2006). Second, all zero-value observations are simply dropped from the estimation creating a selection bias. This especially the case when working with disaggregated data such as agricultural products (Haq *et al.*, 2013).

In this paper we investigate the impact of futures price volatility on cereals exports using data at the *6-digit* level of disaggregation from the Standard International Trade Classification (SITC), where zero trade flows are frequent. Indeed, our dataset contains more than 60% of zero-value observations for french bilateral cereals exports. Thus, dropping zero trade flows would result in selection bias which could lead to wrong and biased interpretations of the impact of exchange rate and price volatility on french cereals exports. Indeed, Tenreyro (2007) points out that zero trade flows have to be included in the sample when investigating the relationship between exchange rate uncertainty and trade.

The most robust approach to estimate the model, in this case, is to implement the Poisson pseudo-maximum likelihood (PPML) proposed by Santos Silva and Teneyro

(2006). Indeed, Santos Silva and Teneryo (2006) and Westerlund and Wilhelmsson (2011) highlight that the PPML estimator is robust in presence of heteroskedasticity and that estimated parameters can be interpreted as elasticities. Moreover, according to Santos Silva and Tenreyro (2006) the data do not have to be Poisson at all. Furthermore, the PPML estimator still performs well when the dataset contains has a large proportion of zeros (Santos Silva and Tenreyro, 2011), which is the case in our study.

3.3. Measuring exchange rate and futures price volatility

There is no consensus in the empirical literature about the proper way to evaluate the exchange rate uncertainty (Clark *et al.*, 2004). As a consequence, a variety of methods have been implemented in the literature. However, the choice of the exchange rate volatility measure can affect the empirical results of the analysis. Therefore, we choose two different measures of exchange rate uncertainty in order to test the robustness of our results. In both measures, we use the real exchange rate rather than the nominal exchange rate. Indeed, Mc Kenzie (1999) show that both methods imply very similar results.

The first measure of exchange rate uncertainty that we compute evaluates the standard deviation of the first difference of the logarithm of the monthly exchange rate between France and its trading partner as in Dell' Ariccia (1999) and Tenreyro (2007):

$$XV^{S}_{Fjt} = Std.\ dev.[ln(e_{Fjt,m}) - ln(e_{Fjt,m-1})] \quad (4)$$

Where $e_{Fjt,m}$ is the real exchange rate between country j and France in month $m = 1, 2, ..., 12$, of year $t = t - 5, ..., t - 1$. This measure base on the standard deviation of the bilateral exchange rate captures the short-run volatility (Koray and Lastrapes, 1989; Chowdhury, 1993). We construct this measure for the period 2000 to 2011 using monthly average real exchange rates from the previous five years to year t.

We also implement a measure of long-run exchange rate volatility for robustness checks. Indeed, if firms can cover themselves against short-run uncertainty using an hedging strategy, it is more difficult to do so on the long-run. As suggested by Mc Kenzie (1999), firms may be exposed to higher and possible unhedgable exchange rate risk on the long-run. Thus, following the measure proposed by Peree and Steinherr (1989) and applied by Cho *et al.* (2002), Karemera *et al.* (2011) and Sheldon *et al.* (2013), we implement the long-run volatility of exchange rate between France and its trading partners as:

$$XV^{L}_{Fjt} = \frac{max\ e^{t}_{t-z} - min\ e^{t}_{t-z}}{min\ e^{t}_{t-z}} + \left[1 + \frac{|e_t - e^{p}_{t}|}{e^{p}_{t}}\right] \quad (5)$$

Where e_t is the real exchange rate on year t, $max\ e^{t}_{t-z}$ and $min\ e^{t}_{t-z}$ refer to maximum and minimum values of the real exchange rate over a time interval of size z up to time t, and e_t^p is the equilibrium exchange rate. The first term of equation (5) captures learned experience and the second term reflects a correction factor derived from current exchange rate misalignment from its equilibrium value. However, the evaluation of the equilibrium exchange rate remains an unsolved problem in forecasting models. As a consequence, in previous empirical studies, the equilibrium exchange rate is measured as the average of the real exchange rate over the previous years (Peree and Steinherr, 1989; Cho *et al.*, 2002; Karemera *et al.*, 2011; and Sheldon *et al.*, 2013). Following the analysis of Peree and Steinherr (1989), we set the value of z to 5[3].

Contrary to previous studies on agricultural products (Cho *et al.*, 2002; Kandilov, 2008; Zang *et al.*, 2010; Karemera *et al.*, 2011; Sheldon *et al.*, 2013), we also assume that commodity price volatility has a significant impact on bilateral cereals trade. Indeed, firms are exposed to both exchange rate and food price uncertainty on the cereals market. As for exchange rate volatility, the choice of the uncertainty measure can affect our results. Therefore, in order to test the robustness of our estimations, we implement two different measures of commodity price volatility.

The first measure refers to the standard deviation of the logarithm of the daily commodity futures price as in:

$$PV_{kt}^U = Std.\ dev.[ln(P_{kt,d}) - ln(P_{kt,d-1})] \quad (6)$$

Where $P_{kt,d}$ is the futures price of commodity k in day $d = 1, 2, ..., 360$ of year $t = t-1, t-2$. To compute this volatility measure we use the futures price volatility of 5 commodities: durum wheat, barley, oats, maize and rice. We use daily price data and refer to the previous two years to t to construct this measure of volatility for the period 2000 to 2011.

The previous measure reflects the unconditional, realized volatility. To capture price uncertainty *ex ante* and estimate the conditional futures price volatility, we implement a second measure base on a General Autoregressive Conditional Heteroscedasticity (GARCH) model. Moreover, it is well known that futures prices are characterized by heavy-tailed probability distributions which can be dealt using a GARCH model. This method has been widely used to model exchange rate uncertainty in the empirical literature (Baillie and Bollerslev, 1989; Clark *et al.*, 2004; Wang and Barrett, 2007; Kandilov, 2008; Chit *et al.*, 2010; May, 2010; Kandilov and Leblebicioğlu, 2011) or commodity price volatility such as crude oil prices (Sadorsky, 2006; Agnolucci, 2009). Such family of models allow to describe volatility clustering and model persistence and serial correlation in volatility dynamics. In our study, we estimate a GARCH (1,1) process using daily data for each of our 5 commodities. For a given year t, we estimate five versions

[3]Previous studies from Karemera *et al.* (2011) and Sheldon *et al.* (2013) put forth the evidence that results are robust to the choice of the parameter z.

of the following GARCH (1,1) model (one for each of the five commodities):

$$ln(P_{kb,d}) = \mu + \phi_1 ln(P_{kb,d-1}) + \epsilon_{kt,d} \tag{7}$$

Where $\epsilon_{kj,d} \sim N(0, h_{t,d})$ and the conditional variance is:

$$h_{t,d} = \omega + \beta\epsilon^2_{kbd} + \alpha h_{b,d-1} \tag{8}$$

Where P_{ktd} is the futures price of commodity k in da$d = 1, 2, ..., 360$, of year $b = t-1, t-2$. As far as we study 5 different commodities, we estimate 60 (12 years*5 commodities) different GARCH (1,1) models. Then, we use the last estimated conditional standard deviation as the approximation of conditional volatility, PV^C_{kt} at the beginning of the next period. For instance, the conditional volatility for 2000 is the estimated conditional standard deviation for the last day of 1999 in the GARCH (1,1) process using data from the 1^{st} January 1998 to the 31^{st} December 1999.

3.4. Data

The panel dataset used in this analysis covers the period 2000 to 2011 for a sample of 59 of France's trading partners[4]. The variable to be explained is the bilateral exports from France to these 59 countries in 5 commodities: durum wheat, barley, oats, maize and rice. Hence, our sample consists of 3540 observations of bilateral exports from France.

Information on bilateral exports at the *6 digit* level of the Harmonized System (HS) expressed in current dollar is from the UNcomtrade database.

GDP data expressed in constant US dollar are taken from the World Bank's *World Development Indicators* (WDI). Bilateral nominal exchange rates are taken from the International Monetary Fund *International Financial Statistics* (IFS). This variables is expressed in real terms using the Consumer Price Indexes (CPI) for France and its trading partners which come from the World Bank's WDI. Bilateral distance is computed using the distance in kilometres between France and its trading partners' capital city. This variable is taken from the CEPII's GeoDist database. Dummy variables capturing common border, common language, and whether France and its trading partners were ever in colonial relationship also come from the CEPII database. Information on regional trade agreements is from the World Trade Organization (WTO)[5].

Information on daily futures prices of durum wheat, barley, oats, maize and rice comes from the *Datastream* database,which offers continues series on these derivatives instrument listed on the Chicago board of trade (wheat, oats, maize and rice) and the International continental exchange Canada (Barley). These prices are defined, for each

[4] The complete list is contained in table A.1. in appendix

[5] The list of free trade agreements considered in the analysis is displayed in table A.1. in appendix

commodity, as the daily average of settlement prices of all futures contract traded at that time.

4. Empirical results

4.1. Baseline results

Table 1 presents the regression results and the test statistics for the OLS and PPML specifications. Columns 2 to 5 report the OLS estimates using the logarithm of trade as the dependent variable. Columns 6 to 9 show the results of the estimations of equation (2) using the PPML method proposed by Santos Silva and Tenreyro (2006), for the whole sample. In all estimations, we control for product heterogeneity using fixed effects.

At first glance, we can notice that OLS and PPML estimates give very similar results concerning GDPs. We find that french bilateral cereals exports strongly depends on french and trading partners GDPs. The elasticity of foreign income ranges from 0.43 to 0.56 according to the PPML estimator and is around 0.56 according to the OLS estimates. It confirms that higher foreign income stimulates export demand for french cereals. As expected, results also indicate that bilateral distance affects french cereals trade while sharing a common border (known as the border effect) strongly increase french exports. We can notice that the OLS estimator seems to overestimate all estimated coefficients especially the variable capturing the border effect.

However, several of the coefficients estimated using the PPML method differ significantly from those generated by OLS. Santos Silva and Tenreyro (2006) and Westerlund and Whilhelmsson (2011) attribute these differences to the problem of heteroskedasticity when using the OLS estimator which biases results. This is especially the case for the two measures of the exchange rate volatility. Indeed, results using the OLS estimator lead to assess that short-run exchange rate volatility has a significant positive impact on french cereals exports. The reverse is found when implementing the PPML estimator. In that case, we find that both short-run and long-run exchange rate volatility strongly affects french cereals exports which confirms previous studies on agricultural products (Cho *et al.*, 2002; Kandilov, 2008: Karemera *et al.*, 2011; Sheldon *et al.*, 2013). However, only the long-run measure is statistically significant at the 10 percent level. This effect can be detailed more precisely. At the mean value of XV^L_{Fjt} (1.196), the PPML estimator generates an elasticity of -4.19 (-3.5*1.196). It implies that if the long-run exchange rate volatility is reduced from its mean value, there will be about a 419 % increase in french cereals exports.

Turning to the main focus of the paper, we find, relying on the baseline equation including product fixed-effects, that futures price volatility tend to have a strong positive effect on french cereals exports. We find that the realized futures price volatility is significant at the 5 percent level and that the conditional futures price volatility is

Table 1: Baseline results with product fixed-effects

	OLS				PPML			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$ln(X_{Fjkt})$	$ln(X_{Fjkt})$	$ln(X_{Fjkt})$	$ln(X_{Fjkt})$	X_{Fjkt}	X_{Fjkt}	X_{Fjkt}	X_{Fjkt}
Y_{Ft}	3.861**	3.631*	4.528**	4.230*	6.318***	5.919***	6.612***	6.261***
	(2.08)	(1.75)	(2.35)	(1.92)	(6.00)	(6.76)	(5.26)	(6.31)
Y_{jt}	0.574***	0.563***	0.572***	0.563***	0.438***	0.554***	0.439***	0.556***
	(4.20)	(4.02)	(4.19)	(4.02)	(3.12)	(4.39)	(3.11)	(4.41)
RTA_{Fjt}	0.731	0.560	0.732	0.557	0.981	0.783	0.989	0.784
	(1.54)	(1.26)	(1.56)	(1.26)	(1.21)	(0.96)	(1.22)	(0.96)
XV^S_{Fjt}	2.631**		2.630**		-2.698		-2.595	
	(2.35)		(2.36)		(-0.33)		(-0.33)	
XV^L_{Fjt}		-0.488		-0.518		-3.488*		-3.534**
		(-0.43)		(-0.46)		(-1.94)		(-1.99)
PV^U_{kt}	21.82**	19.24*			23.08***	14.17**		
	(2.08)	(1.72)			(4.69)	(2.54)		
PV^C_{kt}			10.90	9.095			8.376*	3.470
			(1.18)	(0.97)			(1.85)	(0.88)
$contig_{Fj}$	2.082***	2.072***	2.086***	2.072***	1.185**	0.661	1.185**	0.652
	(3.65)	(3.28)	(3.66)	(3.29)	(2.34)	(1.56)	(2.35)	(1.55)
col_{Fj}	1.795*	1.800*	1.780*	1.781*	1.798	1.088	1.799	1.081
	(1.88)	(1.80)	(1.87)	(1.78)	(1.59)	(1.08)	(1.59)	(1.07)
$lang_{Fj}$	-1.016	-1.079	-1.009	-1.067	-0.267	0.398	-0.265	0.407
	(-1.27)	(-1.32)	(-1.26)	(-1.31)	(-0.33)	(0.72)	(-0.33)	(0.74)
D_{Fj}	-0.657*	-0.635*	-0.651*	-0.627*	-0.698*	-0.505	-0.697*	-0.502
	(-1.98)	(-1.91)	(-1.97)	(-1.90)	(-1.80)	(-1.59)	(-1.80)	(-1.58)
_cons	-111.2**	-103.8*	-129.9**	-120.5*	-175.7***	-164.5***	-183.7***	-174.0***
	(-2.12)	(-1.77)	(-2.41)	(-1.95)	(-6.15)	(-7.06)	(-5.25)	(-6.40)
N	1455	1455	1455	1455	3540	3540	3540	3540
R^2	0.436	0.434	0.436	0.434				
LL					-1.76e+10	-1.69e+10	-1.76e+10	-1.69e+10

Clustered t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$

significant at the 10 percent level. To get a better sense of the actual effect of the futures price volatility on french cereals exports, we can, as for the exchange rate volatility, implement the impact of increasing both realized and conditional volatility from zero up to its mean value. In this case when the realized price volatility is reduced from its mean value of 0.017, the increase of french cereals exports ranges from 24 % (14.17*0.017) to 39 % (23.08*0.017). If we consider the conditional volatility (PV^C_{kt}), the impact is smaller and about 14 %. Therefore, french cereals exporters care not only about exchange rate volatility but also about commodity futures price volatility, even if the impact remains lower in terms of intensity. However, the two types of volatility exhibit opposite signs. If, as previous studies, the exchange rate volatility has a strong negative impact on exports, we find, on the contrary, that the two measures of futures price volatility, that we have implemented, have a significant and positive impact on french exports. The explanation for this positive sign is the following one. In the short-run, price elasticities of supply and demand for agricultural products are low, which means that only storage capabilities can mitigate price volatility. It is indeed important to consider that inventories help producers to reduce costs of changing production in response to fluctuations in demand. As a consequence, producers determine their production along with their expected inventories holdings (Pindyck, 2001). Accordingly, when inventory levels are low, reflecting a shortage of supply and, therefore, high spot prices, price volatility will tend to be higher, since quantity adjustment is largely constrained on the market. This is confirmed by Symeonidis *et al.* who have empirically investigated the theory of storage using a dataset of physical inventory of 21 different commodities for the period 1993-2011, and pointed out that low inventory levels are not only associated with a backwardation market structure but also with high price volatility for the majority of commodities considered. In fact, the price the holder of inventories has to pay will be equal to the marginal convenience yield which has three components: the physical cost that holding a given commodity entails, the cost of capital (that is the forgone interest by paying a commodity at time t_0), and the expected decrease in the commodity price that can precisely be calculated using futures prices. Hence, any increase in futures prices volatility will bring uncertainty on the value of the convenience yield, that is the opportunity cost of holding inventories. As a consequence, producers or third parties (elevators) will sell their inventories when futures prices volatility are high, and increase their exports. The reverse is true.

In table 2, we estimate the baseline equation and include both product and country fixed-effects. It controls for unobserved heterogeneity and solves the "gold medal mistake" (Baldwin and Taglioni, 2006). In this case, all time invariant variables such as bilateral distance are removed from the equation.

This estimations confirm our previous results and show that french and foreign income strongly increase french cereals exports. This especially the case in all PPML specifications. We find also that, contrary to the OLS, the PPML generates a significant and positive coefficient for the variable capturing regional trade agreements. This support the idea that the development of free trade agreements and free trade areas strongly increase bilateral trade.

The impact of both realized and conditional futures price volatility on french cereals exports is also confirmed by the PPML estimation with country fixed effects. The estimated elasticities are very similar to those previously estimated using the PPML estimator. Indeed, results put forth the evidence that an increase in PV_{kt}^U from zero to its mean value entails an increase of french cereals exports which ranges from 37.4 % to 39 %. The exports should increase by around 14.4 % to 15.2 % as a result of an increase in PV_{kt}^C from zero to its mean value (0.018). However, conclusions for the exchange rate

Table 2: Baseline results with product and country fixed-effects

	OLS				PPML			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$ln(X_{Fjkt})$	$ln(X_{Fjkt})$	$ln(X_{Fjkt})$	$ln(X_{Fjkt})$	X_{Fjkt}	X_{Fjkt}	X_{Fjkt}	X_{Fjkt}
Y_{Ft}	5.639***	5.349***	6.464***	6.315***	5.860***	6.076***	6.077***	6.258***
	(3.04)	(3.16)	(3.65)	(3.91)	(11.58)	(11.64)	(10.53)	(10.02)
Y_{jt}	0.158	0.728	0.334	0.891	0.525**	0.636***	0.557**	0.675**
	(0.20)	(1.01)	(0.42)	(1.21)	(2.50)	(2.64)	(2.37)	(2.43)
RTA_{Fjt}	0.145	0.334	0.161	0.340	1.160***	1.278***	1.176***	1.284***
	(0.41)	(0.86)	(0.45)	(0.88)	(5.93)	(6.03)	(5.96)	(5.97)
XV^S_{Fjt}	1.403		1.384		0.0498		0.0528	
	(1.65)		(1.58)		(0.09)		(0.09)	
XV^L_{Fjt}		2.280***		2.143***		0.991**		0.916*
		(3.61)		(3.39)		(2.09)		(1.94)
PV^U_{kt}	29.45***	34.04***			22.05***	23.25***		
	(2.90)	(3.24)			(4.57)	(4.58)		
PV^C_{kt}			8.336	9.504			8.019*	8.466**
			(0.93)	(1.08)			(1.92)	(1.97)
_cons	-156.5***	-168.4***	-184.7***	-200.0***	-172.4***	-183.1***	-179.2***	-189.0***
	(-3.69)	(-4.43)	(-4.70)	(-5.68)	(-9.76)	(-11.43)	(-8.88)	(-9.56)
N	1455	1455	1455	1455	3540	3540	3540	3540
R^2	0.611	0.615	0.610	0.613				
LL					-8.96e+09	-8.93e+09	-9.00e+09	-8.98e+09

Clustered t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$

volatility are not supported by the country fixed-effects estimation.

If results from the whole sample clearly confirmed the positive relationship between futures price volatility and french cereals exports, conclusions could be different at a disaggregated level. To test the robustness of our results, we need to estimate commodity-specific gravity equations of trade (Karemera *et al.*, 2011; Sheldon *et al.*, 2013).

4.2. Commodity-specific results

Tables 3, 4 and 5 report the estimated parameters from the non-linear form of the model specification presented in equations (2) using the PPML estimator, for each of the five commodities of the sample.

First, results for all different specifications and all different commodities confirm the key role lead by foreign income in explaining french exports. The results indicate also that regional trade agreements enhance french exports of durum wheat, oats and rice.

Table 3: Commodity-specific results using the PPML estimator

	Durum Wheat				Barley			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	value	value	value	value	value	value	value	value
Y_{Ft}	10.00***	10.25***	9.602***	9.844***	4.630***	5.861***	3.553**	5.696***
	(2.95)	(2.78)	(2.83)	(2.66)	(4.02)	(4.77)	(2.32)	(3.25)
Y_{jt}	0.550**	0.458***	0.550**	0.459***	0.585***	0.658***	0.587***	0.658***
	(2.22)	(2.63)	(2.23)	(2.64)	(10.48)	(15.23)	(10.30)	(14.77)
RTA_{Fjt}	4.417**	3.991***	4.416**	3.986***	-0.653*	-0.602**	-0.657*	-0.599**
	(2.46)	(2.70)	(2.47)	(2.70)	(-1.88)	(-2.55)	(-1.90)	(-2.51)
XV^S_{Fjt}	2.978		2.975		-46.21**		-46.81**	
	(1.12)		(1.12)		(-2.40)		(-2.41)	
XV^L_{Fjt}		0.0664		0.0354		-4.736***		-4.723***
		(0.05)		(0.03)		(-2.87)		(-2.81)
PV^U_{kt}	12.75	13.77			38.68*	10.78		
	(0.50)	(0.52)			(1.94)	(0.52)		
PV^C_{kt}			20.77	21.63			15.83**	3.392
			(0.68)	(0.68)			(2.19)	(0.40)
$contig_{Fj}$	2.284***	2.414***	2.285***	2.409***	0.309	0.176	0.298	0.179
	(5.73)	(6.20)	(5.74)	(6.16)	(1.31)	(0.89)	(1.24)	(0.87)
col_{Fj}	5.540***	5.786***	5.543***	5.783***	-0.313	-0.757**	-0.321	-0.754**
	(8.70)	(7.29)	(8.68)	(7.31)	(-0.87)	(-2.32)	(-0.90)	(-2.29)
$lang_{Fj}$	-0.926	-1.265**	-0.928	-1.262**	0.645***	1.087***	0.654***	1.085***
	(-1.35)	(-2.22)	(-1.36)	(-2.21)	(3.42)	(4.75)	(3.37)	(4.63)
D_{Fj}	-0.782**	-0.911**	-0.784**	-0.912***	-0.645***	-0.561***	-0.642***	-0.561***
	(-2.15)	(-2.57)	(-2.16)	(-2.58)	(-17.35)	(-19.72)	(-17.11)	(-19.54)
_cons	-283.6***	-287.0***	-272.4***	-275.5**	-125.4***	-157.8***	-94.61**	-153.1***
	(-2.88)	(-2.68)	(-2.78)	(-2.57)	(-3.87)	(-4.52)	(-2.20)	(-3.08)
N	708	708	708	708	708	708	708	708
LL	-3.16e+09	-3.20e+09	-3.15e+09	-3.19e+09	-7.99e+09	-7.73e+09	-7.96e+09	-7.73e+09

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$

Our findings show that the long-run exchange rate volatility has a negative and significant effect on all studied commodities with the exception of durum wheat. Elasticities ranges from -4.30 for maize to -15.54 for rice. For this commodity the impact is strong and if the long-run exchange rate volatility is reduced from its mean value (1.196), there will be a 18585 % increase in french exports of rice. Results concerning short-run exchange rate volatility are significant and negative only for three commodities among the five studied here: barley, oats and rice. As a consequence, french exports of these commodities are affected by both long and short-run exchange rate volatility. For instance, we find that a decrease of the short-run exchange rate from its mean value (0.031) to zero should increase french cereals exports of about 532 %. This findings illustrate that both short and long-run exchange rate volatility affects agricultural trade, in line with

Table 4: Commodity-specific results using the PPML estimator

	Oats				Maize			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	value	value	value	value	value	value	value	value
Y_{Ft}	1.286	4.090***	2.061	4.179***	3.933***	4.255***	6.206***	5.750***
	(0.78)	(3.06)	(1.33)	(3.22)	(3.41)	(3.70)	(5.77)	(5.92)
Y_{jt}	0.745**	0.686**	0.741**	0.684**	0.365***	0.471***	0.365***	0.478***
	(2.40)	(2.38)	(2.40)	(2.37)	(3.00)	(4.15)	(2.98)	(4.20)
RTA_{Fjt}	4.178***	4.380***	4.187***	4.382***	0.0365	-0.384	0.0655	-0.401
	(2.79)	(3.05)	(2.79)	(3.07)	(0.07)	(-0.67)	(0.13)	(-0.70)
XV^S_{Fjt}	-100.7***		-99.91***		-6.304		-5.675	
	(-2.67)		(-2.59)		(-0.79)		(-0.78)	
XV^L_{Fjt}		-5.108**		-5.088**		-4.298***		-4.496***
		(-2.07)		(-2.07)		(-3.52)		(-3.68)
PV^U_{kt}	11.77*	5.280			29.48***	18.91***		
	(1.68)	(0.67)			(10.65)	(3.74)		
PV^C_{kt}			6.989	13.24*			8.503	4.710
			(1.16)	(1.79)			(1.40)	(0.68)
$contig_{Fj}$	0.698	1.130	0.710	1.136	1.600***	1.088***	1.605***	1.054***
	(0.74)	(1.27)	(0.76)	(1.27)	(3.88)	(3.58)	(3.87)	(3.53)
col_{Fj}	0.960	0.695	0.977	0.702	0.180	-0.585	0.195	-0.615
	(0.56)	(0.43)	(0.57)	(0.43)	(0.29)	(-0.92)	(0.31)	(-0.96)
$lang_{Fj}$	0.201	0.0498	0.184	0.0465	-2.126***	-1.515***	-2.126***	-1.485***
	(0.15)	(0.04)	(0.14)	(0.04)	(-4.11)	(-3.57)	(-4.12)	(-3.55)
D_{Fj}	-0.683	-0.795	-0.687	-0.794	-0.939***	-0.790***	-0.937***	-0.783***
	(-0.91)	(-1.17)	(-0.92)	(-1.17)	(-3.81)	(-3.79)	(-3.81)	(-3.83)
_cons	-43.23	-115.9***	-65.04*	-118.6***	-99.57***	-107.3***	-163.8***	-149.5***
	(-1.10)	(-3.35)	(-1.69)	(-3.37)	(-3.21)	(-3.47)	(-5.63)	(-5.76)
N	708	708	708	708	708	708	708	708
LL	-5.7e+07	-6.15e+07	-5.73e+07	-6.14e+07	-1.51e+09	-1.32e+09	-1.55e+09	-1.34e+09

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Commodity-specific results using the PPML estimator

	Rice			
	(1) value	(2) value	(3) value	(4) value
Y_{Ft}	-6.763	-3.555	-4.799	-2.395
	(-1.63)	(-0.91)	(-0.97)	(-0.53)
Y_{jt}	0.469***	0.393***	0.464***	0.397***
	(4.33)	(4.26)	(4.36)	(4.36)
RTA_{Fjt}	5.058***	4.795***	5.038***	4.836***
	(6.91)	(6.88)	(7.09)	(6.80)
XV^S_{Fjt}	-171.9***		-158.3***	
	(-4.38)		(-4.17)	
XV^L_{Fjt}		-15.54***		-15.20***
		(-5.53)		(-5.16)
PV^U_{kt}	-58.63	-37.12		
	(-1.10)	(-0.71)		
PV^C_{kt}			12.98	11.93
			(0.50)	(0.51)
$contig_{Fj}$	0.997**	1.263***	1.005**	1.268***
	(2.03)	(2.71)	(2.03)	(2.74)
col_{Fj}	-2.565***	-2.565***	-2.416**	-2.545***
	(-2.68)	(-2.93)	(-2.56)	(-2.90)
$lang_{Fj}$	0.486	0.277	0.367	0.274
	(0.85)	(0.57)	(0.65)	(0.57)
D_{Fj}	1.250***	0.970***	1.161***	0.962***
	(3.41)	(3.51)	(3.29)	(3.50)
_cons	180.5	108.5	123.9	74.04
	(1.54)	(0.98)	(0.88)	(0.58)
N	708	708	708	708
LL	-1.47e+08	-1.51e+08	-1.49e+08	-1.52e+08

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

previous studies (Cho *et al.*, 2002; Kandilov, 2008).

Results concerning price volatility support the idea that the positive effect is rather commodity-specific and not uniform across individual cereals commodities. Indeed, we find that realized futures price volatility has a significant and positive impact on french exports for only three commodities: barley, oats and maize. The impact is especially strong for french exports of maize. An increase from zero to its mean value (0.015) of unconditional futures price volatility should lead to an increase of 44 % of french maize exports. Results concerning conditional futures price volatility are also diversified and depend on the commodity under scrutiny. Indeed, the coefficient associated with this variable is only significant for french exports of barley and oats.

5. Conclusion

The main purpose of this paper is to investigate the relationship between exchange rate volatility, futures price volatility and french exports for five cereals: durum wheat, barley, oats, maize and rice. To address this problematic, we run a product-level analysis using data on french exports, in relation to 5 commodities and 59 trading partners during the 2000-2011 period. Like Santos Silva and Tenreyro (2006), we argue that the standard empirical procedures to estimate gravity equations are inappropriate. Indeed, estimation of gravity trade models using OLS leads to biased results on account of an heteroskedasticity problem and failure to take account of zero-value observations (Westerlund and Whilhelmsson, 2011). To address these issues, we choose to use the solution proposed by Santos Silva and Tenreyro (2006) and implement a PPML method to estimate our gravity equations.

Our main results confirm previous studies' conclusions and point out that the two measures of exchange rate uncertainty are significant and negative. As a consequence, the exchange rate volatility strongly affects french cereals exports. On the contrary, we find that the two measures of price volatility, that we have implemented, have a significant and positive impact on french exports. Indeed, since we use futures prices, these two measures reflect the price volatility anticipated by french producers, who try to manage to their stocks through time. Any increase in futures prices volatility will bring uncertainty on the opportunity cost of holding inventories and will lead producers, elevators or traders to sell their stocks. When investigating commodity-specific results, we find that this conclusion is especially true for french exports of barley, oats and maize, but not for wheat or rice. These differentiated results could be explained by the differences, in terms of liquidity that can be observed between the futures markets in this study, but also by the different pricing strategies used by exporters. This is, amongst others, a shortfall of our paper. The liquidity of a futures contract is an essential criterion for the latter to serve as a reference to commercial contracts and this should be taken account in further developments.

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Appendix

Table A.1. List of partners and countries and regional trade agreements (RTA)

Country	RTA	Country	RTA	Country	RTA
Albania	Yes (2006)	Greece	Yes	Poland	Yes (2004)
Algeria	Yes (2005)	Hong Kong	No	Portugal	Yes
Australia	No	Hungary	Yes (2004)	Romania	Yes (2007)
Austria	Yes	Ireland	Yes	Russia	No
Belgium	Yes	Israel	Yes	Saudi Arabia	No
Bulgaria	Yes (2007)	Italy	Yes	Senegal	No
Burkina Faso	No	Japan	No	Slovakia	Yes (2004)
Cameroon	Yes (2009)	Korea	Yes (2011)	Slovenia	Yes (2004)
China	No	Latvia	Yes (2004)	South Africa	Yes
Congo	No	Lithuania	Yes (2004)	Spain	Yes
Cte d'Ivoire	Yes (2009)	Luxembourg	Yes	Sweden	Yes
Cyprus	Yes (2004)	Mali	No	Switzerland	Yes
Czech Republic	Yes (2004)	Malta	Yes (2004)	Togo	No
Denmark	Yes	Mauritania	No	Tunisia	Yes
Egypt	Yes (2004)	Mauritius	No	Turkey	Yes
Estonia	Yes (2004)	Mexico	Yes	Ukraine	No
Finland	Yes	Morocco	Yes	United Kingdom	Yes
Gabon	No	Netherlands	Yes	United States	No
Germany	Yes	Nigeria	No	Yemen	No
Ghana	No	Norway	Yes		

Date of the RTA's implementation in brackets (only if after 2000)