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The effects of international price volatility on farmer prices and marketing margins in cattle markets

RESEARCH ARTICLE

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Abstract

This study examines the effects of export price volatility in cattle markets using panel data from twelve countries between 1970 and 2013. Fixed-effects models with Driscoll and Kraay standard errors were estimated to control for cross-sectional dependence. Results indicate that price transmission depends on prices previously paid to farmers, variations in export prices and volatility of export prices, which reduces farmer prices in developed countries and it increases them in developing countries. In contrast, marketing margins are reduced by contemporaneous export price volatility and are increased by previous volatility. Exporters in developing countries take more time to transmit shocks in international prices, pay lower prices to farmers and absorb a bigger proportion of price fluctuations. These price transmission imperfections affect investments, technology adoption, production level and quality across the chain in developing countries, which negatively impact farmers, input and service providers, traders and other actors of the beef cattle chain.

Keywords: price volatility, vertical price transmission, marketing margins, cattle markets, panel cross-sectional dependence

JEL code: M21, Q13, Q18

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1. Introduction

Volatile prices in agricultural markets and their transmission through agro-food chains have been a focus of interest and public concern. Large unanticipated variations in prices create uncertainty, increase the price risk for producers, traders, consumers and governments, and lead to sub-optimal decision making (Minot, 2014). According to the Food and Agriculture Organization (FAO) (2011), food price volatility is likely to continue in the medium term and possibly increase, making farmers, input suppliers, processors and consumers more vulnerable to negative economic effects. Buguk *et al.* (2003) and Gilbert (2010) related volatility of food prices to increases in demand variability, especially in agricultural products used for food and bio-fuel purposes; increases in supply variability due to adverse weather resulting in poor production yields; low demand elasticity; low supply elasticity; and exchange rate variability. Other factors, including stockholding, speculation, and macroeconomic variables such as inflation and exchange rates, can also affect the volatility of food prices. The degree that each factor impacts on price volatility depends on supply and demand elasticities, which reflect the degree of response that producers and consumers have when prices vary (Gilbert, 2010; Nourou, 2015; Roache, 2010).

According to Shroeter and Azzam (1991), Tomek and Kaiser (2014) and Wohlgenant (2001), variability in the output price is positively related to marketing margins, and consequently, negatively affects vertical price transmission. In addition, market power, quality, risk, contracts, technical change, transport and transaction costs, public interventions, perishability of the product, and time lags in supply and demand have been indicated as factors that affect marketing margins and price transmission along agro-food chains (Brester and Marsh, 2001; Bunte, 2006; Conforti, 2004; Popovic *et al.*, 2016; Rapsomanikis and Mugeru, 2011; Wohlgenant, 2001). Even though vertical price transmission and marketing margins in agro-food chains have been studied by several researchers, including Ahn and Lee (2015), Facker and Goodwin (2001), Kaspersen and Foyn (2010), Newton (2016), Von Cramon-Taubadel (1998) and Wohlgenant (2001), there has been a lack of research to determine the effects of price volatility in international markets on farmer prices and marketing margins, which can help to highlight differences between groups of countries, providing valuable insights for policy interventions aiming to improve efficiency and competition in agro-food chains.

Prices signal consumer preferences back to producers, who can allocate more inputs to products preferred by consumers (Norwood and Lusk, 2008). Inefficiencies in price transmission compromise the performance of the whole chain; however, lags in price transmission could be positive for the performance of the value chain, as farmers experience reduced price risk and are able to make more efficient decisions in the short run (Swinnen and Vandeplass, 2013). Evidence of distortions in short-term price transmission, including price leveling¹ and price averaging², were found in the Australian beef market by Griffith *et al.*, (1991), and Griffith and Piggott (1994). These distortions smooth or reduce the price volatility in an effort to keep real prices relatively stable, but these studies also found evidence of asymmetric transmission in the short run, with wholesalers and retailers more prone to pass on price falls than price rises. These findings are consistent with those reported by other researchers, such as Xia and Li (2010).

Given the current relevance of volatility and transmission of food prices in global policy discussion, the study of the effects of price volatility can inform producers, input suppliers, processors, retailers and policy makers about the efficiency of agro-food chains and the level of risk protection for farmers. Thus, the contribution of this article to the literature lies in the way it formally tests the effects of export price volatility on vertical price transmission and marketing margins, being, at the best of our knowledge, the first research that directly estimates these effects on an agro-food chain in a group of developed and developing countries. Considering the differences in cattle production systems and characteristics of the chain between developed and developing countries, this research aims to identify main differences between these groups of countries that can contribute to policy recommendations.

¹ Wholesalers or retailers apply price levelling when they hold their selling prices relative stable when farm prices vary.

² Price averaging is a practice that sets a high spread on some meat types to compensate for other low price spreads set on other types.

The remainder of this article is organized as follow. The second section presents the theory of price volatility, vertical price transmission, and marketing margins, and the models used to test the impacts of export price volatility. The third section describes the data used in this study and presents some descriptive statistics, and the fourth section provides the results of the panel estimation modeling. Finally, the fifth section presents the main conclusions and discusses policy recommendations derived from the main results obtained in this research.

2. Methodological approach

According to Minot (2014), price instability is the variation over time in the prices of a product. This variation can be measured using the coefficient of variation (CV), with $CV=s/\mu$, where s is the standard deviation of a variable over time and μ is the mean value over the period under analysis. To avoid potential bias related to the length of time under analysis when price series are non-stationary, a popular alternative measure used is standard deviation of returns or unconditional volatility. Returns (r_t) are defined as the proportional change in price from one period to the following one.

$$stdev(r) = \sqrt{\left[\sum_{t=1}^n \frac{1}{n-1} (r_t - \bar{r})^2 \right]} \quad (1)$$

where $r_t = \ln(P_t) - \ln(P_{t-1})$ and $\bar{r} = \frac{1}{n} \sum_{t=1}^n r_t$. Based on this measure, this study uses a three-year standard deviation of proportional price changes as a measure of price volatility.

Tomek and Kaiser (2014) define price transmission as the process of price adjustments in the marketing system. Zorya *et al.* (2012) indicated that price transmission is essential to incentivize production and to respond to global food scarcity or surplus. Hence, this study focuses on vertical transmission of shocks from export to domestic prices, which is used as an indicator of market integration (Rapsomanikis and Mugera, 2011). In contrast, increasing marketing margins could inflate retail prices and deflate farmer prices, with subsequent negative implications for agribusinesses, including farmers, service providers and input suppliers (Wohlgenant, 2001; Norwood and Lusk, 2008). Therefore, the proportion of the variation in prices that are transmitted is a key indicator for assessing the degree of market integration, efficiency and competition in agro-food chains. Wohlgenant and Mullen (1987) modeled the vertical spread of prices from wholesale or export (downstream) to farm (upstream) based on the derived demand for farm output as presented in Equation 2:

$$P_{ft} = f(P_{et}, Q_{ft}, C_t) \quad (2)$$

where P_{ft} is the farmer price of a commodity at time t ; P_{et} is the export price of a commodity at time t ; Q_{ft} is the quantity of farm output at time t ; and C_t is a vector of marketing input prices in time t , including transport costs and wage rates. When price variations are perfectly transmitted throughout the chain, price fluctuations at different levels will be fully and instantaneously transmitted (Ahn and Lee, 2015, Kaspersen and Foyn, 2010; Rapsomanikis and Mugera, 2011). In addition, Meyer and von Cramon-Taubadel (2004), Frey and Manera (2007), and Ahn and Lee (2015) defined the relationship between wholesale and farmer prices, including current and previous prices in a vertical marketing chain, as shown below:

$$P_{ft} = \alpha_0 + \sum_{i=1}^n \alpha_i P_{ft-i} + \sum_{i=0}^n \beta_i P_{et-i} + \varepsilon_t \quad (3)$$

This specification is appropriate only when price series are stationary. In the case the series are non-stationary and integrated order one ($I(1)$), a model in first differences is more suitable for avoiding a potential spurious regression when there appears to be a significant relationship among variables trending over time (Granger and Newbold, 1974).

Moreover, in agricultural markets some periods may pass before prices adjust to shocks in other markets due to contracts and transport delays. Thus, dynamic models that include lagged endogenous and exogenous variables have been used to assess price transmission (Conforti, 2004; Fackler and Goodwin, 2001). The empirical model used in this study is based on the approach to test asymmetric price transmission introduced by Wolfram (1971) and Houck (1977), and further developed by Meyer and von Cramon-Taubadel (2004). Additionally, the model includes a term to measure the indirect effects on farmer price of volatility transmitted through export prices, based on the effects reported by Shroeter and Azzam (1991), Tomek and Kaiser (2014) and Wohlgenant (2001), and a dummy variable that can detect a structural break after the change in trend of commodity prices.

$$\begin{aligned} \ln P_{fit} = & \alpha + \sum_{s=1}^{S<T} \theta_s \ln P_{fit-s} + \sum_{s=0}^{S<T} \beta_s^- \ln P_{eit-s} D_{it-s}^- + \sum_{s=0}^{S<T} \beta_s^+ \ln P_{eit-s} D_{it-s}^+ \\ & + \delta \ln Q_{fit} + \sum_{h=1}^M \omega_h \ln C_{hit} + \sum_{s=0}^{S<T} \rho_s^- \sigma_{eit-s} \ln P_{eit-s} D_{it-s}^- \\ & + \sum_{s=0}^{S<T} \rho_s^+ \sigma_{eit-s} \ln P_{eit-s} D_{it-s}^+ + \varphi D_{2005-13} + u_{it} \end{aligned} \tag{4}$$

where P_{fit} is the farmer price in country i at time t ; P_{fit-s} is the farmer price in country i at time $t-s$; P_{eit-s} is the export price in country i at time $t-s$; D_{it-s}^- and D_{it-s}^+ are dummy variables with $D_{it-s}^- = 1$ if $P_{eit} < P_{eit-1}$ and $D_{it-s}^- = 0$ otherwise, and with $D_{it-s}^+ = 1$ if $P_{eit} \geq P_{eit-1}$ and $D_{it-s}^+ = 0$ otherwise; Q_{fit} is the quantity of farm output in country i at time t ; C_{hit} is the matrix of prices of marketing input h in country i at time t ; σ_{eit-s} is the export price volatility estimated as a three-year standard deviation in country i at time $t-s$; $D_{2005-13}$ is a dummy variable that covers the period since 2005 when commodity prices changed their declining trend; and u_{it} is a vector of stochastic errors.

According to Tomek and Kaiser (2014) and Wohlgenant (2001), marketing margins or price spreads are functions of the difference between downstream and upstream prices, which represents charges for processing, packaging, transporting, storing and any other activity that could add value to the raw farm product. In the study case of this research, marketing margins will be the difference between export and farmer prices. Thus, the derived wholesale demand, farm supply, and marketing inputs prices affect marketing margins, along with other factors such as market power, risk, quality, technical change, and time lags in supply and demand. Lyon and Thompson (1993) defined the following four marketing margin models:

$$MM_t = f(P_{er}, C_t) \tag{5} \quad \text{Mark-up model}$$

$$MM_t = f(P_{er}, P_{et}, Q_{fr}, C_t) \tag{6} \quad \text{Relative Price spread model}$$

$$MM_t = f(Q_{fr}, C_t) \tag{7} \quad \text{Marketing cost model}$$

$$MM_t = f(P_{fr}, E_t(P_{f,t+1}), C_t) \tag{8} \quad \text{Rational expectations model}$$

where MM_t is the marketing margin at time t and $E_t(P_{f,t+1})$ is expected value of farm price at time $t+1$. The marketing margin model used in the present study encompasses the four models previously presented, considering naïve farmer price expectations, with an expected farmer price at time $t+1$ equal to the one observed at time t . Additionally, in line with the price transmission model, the marketing margin model also includes dynamic lag components, the indirect effect of volatility transmitted through export prices, and a dummy variable that can detect a structural break after the change in trend of commodity prices.

$$\begin{aligned} \ln MM_{it} = & \alpha + \sum_{s=1}^{S<T} \theta_s \ln MM_{fit-s} + \sum_{s=0}^{S<T} \beta_s \ln P_{eit-s} + \delta \ln Q_{fit} + \sum_{h=1}^M \omega_h \ln C_{hit} \\ & + \sum_{s=0}^{S<T} \rho_s^- \sigma_{eit-s} \ln P_{eit-s} + \varphi D_{2005-13} + u_{it} \end{aligned} \tag{9}$$

where MM_{it} is the marketing margin between wholesale or export and farmer prices in country i at time t ; MM_{it-s} is the marketing margin in country i at time $t-s$; P_{eit-s} is the export price in country i at time $t-s$; Q_{fit} is the quantity of farm output in country i at time t ; C_{hit} is the matrix of prices of marketing input h in country i at time t ; σ_{eit-s} is the export price volatility estimated as a three-year standard deviation in country i at time $t-s$; $D_{2005-13}$ is a dummy variable for the period since 2005 when the declining trend in commodity prices changed; and u_{it} is a vector of stochastic errors.

Considering the relevance of production contracts agreed in advance to achieve vertical coordination and the cyclical behavior of beef cattle prices, it is expected a recursive process of price adjustments over time, where the quantity produced and farmer prices in year t depend on prices paid to farmers and other influential variables during the previous year $t-1$, following naïve expectations (Norwood and Lusk, 2008; Tomek and Kaiser, 2014). Hence, the price transmission and marketing margins empirical models estimated in this study include one lag of those variables that have expected lagged effects.

Empirical studies using panel data have become popular, as panels enable control for individual heterogeneity and they provide more data, more variability, less collinearity among the variables, more degrees of freedom, and more efficiency (Baltagi, 2013). However, when modeling cross-sections of countries, regions, states or counties, the aggregate units are likely to exhibit significant cross-sectional or spatial correlation among the groups included in the panel. This cross-sectional dependence can lead to biased statistical inference, which affects the validity of result estimation tests (Cameron and Trivedi, 2005; Pesaran, 2004). Therefore, panel estimation should properly test for cross-sectional dependence and, when necessary, overcome the negative effects of this issue by modifying the model to capture spatial correlation, or by adjusting the standard errors of the coefficient estimates as suggested by Driscoll and Kraay (1998).

3. Data

Beef cattle export and farmer prices, herd size and farmer maize prices panel data of twelve countries from 1970 to 2013 was obtained from FAOSTAT (2017). This research focuses on this case study in developed and developing countries, given their data availability and simplicity, as it requires the comparison of cattle prices at two different levels of the chain. The countries included in this study were the developed countries of The Netherlands, Germany, Switzerland, United States, Australia and New Zealand, and the developing countries of Panama, Colombia, Hungary, Kenya, South Africa and Thailand. These countries were selected according to their cattle exports relevance and data availability for this study. Oil prices were obtained from British Petroleum (BP) (2016), and gross domestic product (GDP) per capita was obtained from the Economic Research Services of the United States Department of Agriculture (2016). Increases in oil price are expected to affect vertical price transmission by raising marketing margins, as oil is a critical input in the value-added process, which includes transportation costs. However, oil is also a relevant input in the production process at farm level, similarly to maize used for feeding purposes. GDP per capita is related to income per capita, price of labor, and the level of development of the country, which should affect the degree of market efficiency. Finally, variations in cattle herd size represent fluctuations in the quantity of cattle supplied to the market.

All prices and GDP were transformed into United States dollars and then deflated using the annual consumer price index of the United States, which was obtained from the Bureau of Labor Statistics of the United States Department of Labor (2016). The data used in the models are in United States dollars in values for the year 2000. Table 1 presents descriptive statistics of average values for the variables used in the three groups of countries studied in this research, including a group of developed countries, a group of developing countries, and a group of all selected countries together.

The summary statistics demonstrate that farmer and export prices, on average, are higher in developed countries compared to developing countries. In contrast, marketing margins are bigger in developing countries than in developed countries, and export price volatility is bigger and more variable in developing countries than

Table 1. Panel data average statistics.¹

	All countries		Developed countries		Developing countries	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Farmer cattle prices (USD base 2,000/ton)	2,082	777	2,835	1,251	1,274	254
Export cattle prices (USD base 2,000/ton)	2,631	1,062	3,105	1,489	2,158	777
Marketing margins (USD base 2,000/ton)	578	501	425	622	875	700
Cattle herd size (thousands of heads)	18,485	944	27,270	2,381	9,700	800
Farmer maize prices (USD base 2,000/ton)	284	118	331	175	237	66
Oil price (USD base 2,000/barrel)	39	22	39	22	39	22
GDP per capita (USD base 2,000)	17,313	3,558	30,720	6,275	3,906	877
Export price volatility	0.28	0.06	0.23	0.08	0.34	0.12

¹ Marketing margin values included in this study are positive or equal to zero; GDP = gross domestic product.

in developed countries. To graphically confirm the relationships under analysis, Figure 1 plots the average farmer cattle prices, export cattle prices, and volatility of export prices for all countries, and for developed and developing countries.

Figure 1 shows that farmer and export prices tend to move together in both the all countries group and the developed countries group, while the relationship of both prices appears to be weaker in the case of developing countries. Consequently, exporters in developing countries appear to absorb most of the variations in export prices and offer more stable prices for farmers, which are substantially lower than those offered, on average, to farmers in developed countries. In addition, there is no clear evidence in the three cases presented in Figure 1 that export price volatility and farmer price are directly related, which supports the model of indirect effects transmitted through export prices to test whether exporters absorb most of the price fluctuations. Moreover, export price volatility in developing countries is greater than that exhibited in developed countries, which demonstrates the existence of more unstable prices for exporters in developing countries, and it could be considered as a reason for the lower prices offered to farmers in these less developed countries. Similarly, comparisons between average marketing margins and volatility of export prices for all countries included in this study, and for developed and developing countries, are presented in Figure 2.

In the graphs for all, developed and developing countries groups, there appears to be a relationship between marketing margins and export price volatility. However, marketing margins in developing countries are greater than those exhibited in developed countries, which supports the idea that exporters in developing countries absorb most of the variations in export prices and offer more stable but lower prices to farmers, as the lower prices appear not linked to the volatility faced when the cattle is exported. Further statistical analysis will be conducted in this study to formally test for potential relationships between export price volatility, vertical price transmission, and marketing margins in the three groups of countries.

4. Empirical results

Unit root tests were conducted on the series included in this study to test for non-stationarity. The series were initially tested using the test proposed by Im *et al.* (2003) with trend. Given the potential bias effects of cross-sectional dependence on this test, the series were also tested using the test proposed by Breitung (2000), and Breitung and Das (2005). The results of both tests are presented in Table 2.

The results of the unit root tests that considered the potential effects of cross-sectional dependence demonstrate that several series can be classified as stationary, with the exception of cattle herd size, farmer maize price, oil price and GDP per capita. These results corroborate the findings of previous studies, including those of Canova (2007) and Uhlig (2005), who demonstrated that several time series in economics are stationary

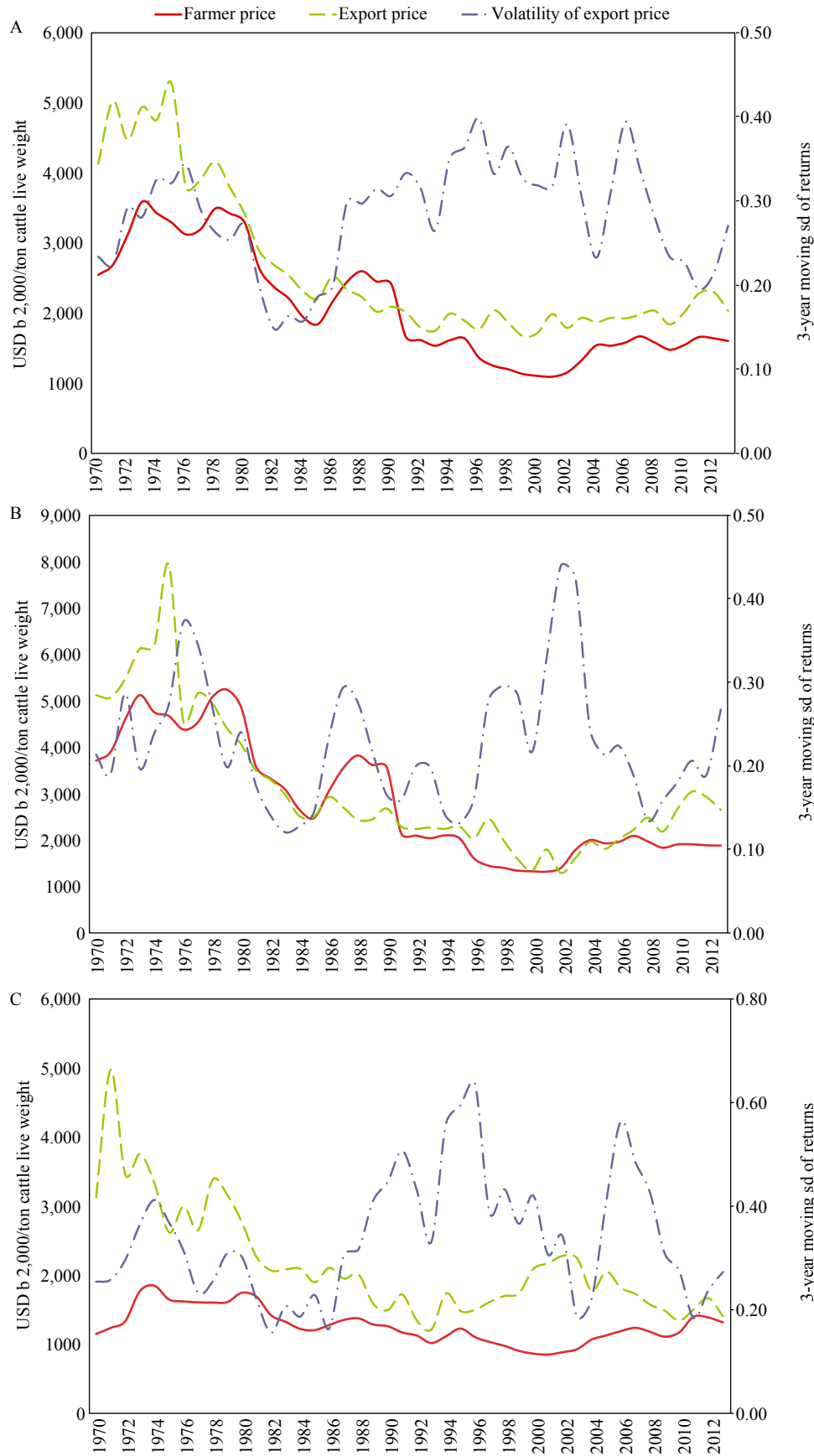


Figure 1. Average farmer and export cattle prices versus average volatility of export cattle prices. A = all countries; B = developed countries; C = developing countries.

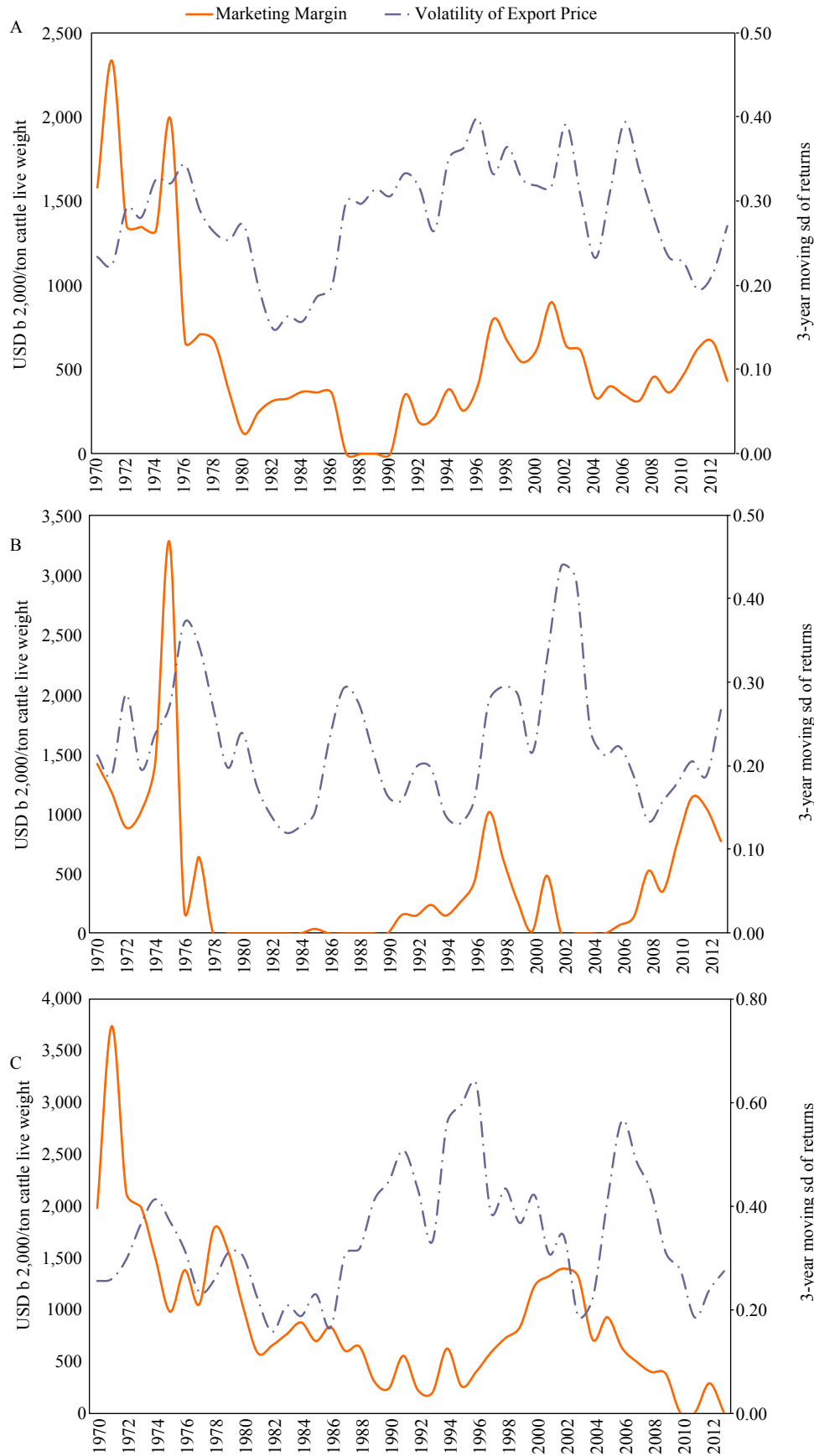


Figure 2. Average marketing margins versus average volatility of export cattle prices. A= all countries; B = developed countries; C = developing countries.

http://www.wageningenacademic.com/doi/pdf/10.22434/IFAMR2017.0020 - Tuesday, March 20, 2018 11:28:55 AM - University of Minnesota - Twin Cities IP Address:134.84.17.184

Table 2. Unit root tests results of series.¹

	$Z_{t\text{-bar}}$ test statistic (Im <i>et al.</i> , 2003)		Lambda test statistic (Breitung and Das, 2005)	
	Level	First difference	Level	First difference
Natural logarithm of farmer cattle prices (USD base 2,000/ton)	-3.1387***	-11.9577***	-2.1773**	-3.7385***
Natural logarithm of export cattle prices (USD base 2,000/ton)	-4.3843***	-14.6041***	-3.8548***	-8.5838***
Natural logarithm of marketing margins (USD base 2,000/ton)	-11.1528***	-16.4604***	-8.0453***	-7.0478***
Natural logarithm of cattle herd size	-2.0478**	-9.8657***	0.4942	-5.5399***
Natural logarithm of farmer maize prices (USD base 2,000/ton)	-1.8240**	-12.5354***	-0.7088	-5.8936***
Natural logarithm of oil price (USD base 2,000/barrel)	-2.5424***	-13.3666***	-0.6267	-5.9113***
Natural logarithm of GDP per capita (USD base 2,000)	0.1085	-10.8220***	2.4343	-4.6680***
Export price volatility	-6.2926***	-13.2735***	-4.5093***	-10.1597***

¹ The null hypotheses are series has unit root; *** and ** indicate that the parameter is significant at the 1 and 5% levels, respectively; the Breitung and Das tests for natural logarithm of farmer cattle and maize prices, and marketing margins, were conducted on data with imputed values given the unbalanced nature of the original panel data; GDP = gross domestic product.

and have been incorrectly classified as non-stationary. The test for pooled estimation versus fixed-effects demonstrated that it is not possible to reject that the constant coefficients are equal to zero, which supports the use of a single constant coefficient using fixed-effects estimation for the vertical price transmission and marketing margin models (Baltagi, 2013). In addition, a Hausman (1978) test supports the use of fixed-effects estimations instead of random-effects, while a Pesaran (2004) test found evidence of cross-sectional dependence in the vertical price transmission modeling³. An alternative estimation was run using a nonparametric covariance matrix estimator developed by Driscoll and Kraay (1998). This alternative method produces heteroskedasticity and autocorrelation consistent standard errors that are robust to spatial and temporal dependence. The estimated vertical price transmission models for the three groups of countries using Driscoll and Kraay standard errors are presented in Table 3.

The results for the all countries group indicate that lagged cattle farmer prices and first differences of herd size, farmer maize prices and GDP per capita are significant variables that explain variations in the cattle price paid to farmers. Farmer price lagged one period and first differences of farmer maize prices and GDP per capita have a positive influence on prices paid to farmers, while the first difference of herd size has a negative effect. This outcome suggests that farmer prices tend to follow the changes exhibited in the price paid during the previous year, following expectations according to the cattle price cycle. This result is consistent with the analysis for the U.S. market provided by Tomek and Kayser (2014). In addition, higher feeding and labor costs represented in first differences of farmer maize prices and GDP per capita have a positive influence on farmer cattle prices, while increases in herd size raise cattle supply, decreasing cattle prices paid to farmers. In contrast to other models, there is no evidence of asymmetry in price transmission. Finally, there is no evidence of a structural break in price transmission after 2005, and the volatility transmitted through export prices and the first difference of oil prices are non-significant.

³ In the case of marketing margin modelling, it was not possible to perform the Pesaran (2004) test due to the more restricted number of observations available in the panel, which contained a group of observations that reported values without a defined natural logarithm value.

Table 3. Price transmission estimation results using fixed-effects with Driscoll and Kraay (1998) standard errors.¹

	All countries		Developed countries		Developing countries	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Constant	0.5358**	0.2011	0.5751***	0.1824	0.7218**	0.3228
Log of farmer cattle prices lagged one period	0.8825***	0.0293	0.9093***	0.0372	0.8323***	0.0474
Decreases in log of export cattle prices	-0.0043	0.0269	0.1173	0.0733	-0.0322	0.0264
Increases in log of export cattle prices	0.0050	0.0265	0.1269*	0.0722	-0.0283	0.0255
Decreases in log of export cattle prices lagged one period	0.0385	0.0294	-0.1093	0.0683	0.0866**	0.0340
Increases in log of export cattle prices lagged one period	0.0395	0.0290	-0.1079	0.0689	0.0895**	0.0343
First difference of log of cattle herd size	-0.3152*	0.1744	-0.6388	0.4319	-0.1559	0.1651
First difference of log of farmer maize prices	0.2798***	0.0780	0.4167***	0.1037	0.1324	0.0843
First difference of log of oil price	0.0480	0.0306	0.0482	0.0430	0.0423	0.0327
First difference of log of GDP per capita	0.7367***	0.2557	0.3908	0.3533	0.7632**	0.2968
Export price volatility transmitted through decreases in log of export prices	0.0062	0.0056	-0.0016	0.0100	0.0093	0.0070
Export price volatility transmitted through increases in log of export prices	0.0017	0.0096	-0.0345***	0.0118	0.0224*	0.0119
Export price volatility transmitted through decreases in log of export prices lagged one period	0.0036	0.0058	0.0259***	0.0091	-0.0043	0.0088
Export price volatility transmitted through increases in log of export prices lagged one period	0.0028	0.0047	0.0139*	0.0077	-0.0068	0.0058
Dummy period 2005 to 2013	0.0041	0.0197	-0.0112	0.0286	0.0216	0.0211
Within R ²	0.8412		0.8924		0.7504	
Groups	12		6		6	
Observations	482		243		239	

¹ Dependent variable is log of farmer prices; ***, ** and * indicate that the parameter is significant at the 1, 5 and 10% levels, respectively; GDP = gross domestic product.

In the case of developed countries, lagged cattle farmer prices, raises in export prices, the first difference of farmer maize prices and volatility transmitted through increases and decreases in export prices lagged one period are significant and have a positive impact on cattle farmer prices. There is evidence of asymmetry in price transmission contemporaneously, where export price increases are transmitted, but not decreases, in contrast to the findings reported by Griffith and Piggott (1994), Griffith *et al.* (1991) and Xia and Li (2010). However, volatility transmitted through increases in export prices has a significant negative effect on cattle prices paid to farmers, which demonstrates a contemporaneous detrimental effect on price increases transmitted to farmer prices when export prices are more volatile. Similarly to the results obtained for the

all countries group, there is no evidence of a structural break in price transmission after 2005 or effects of oil prices on cattle prices paid to farmers in the developed countries group.

The model for the developing countries group indicates that lagged cattle farmer prices, increases and decreases in lagged export prices, the first difference of GDP per capita and volatility transmitted through increases in export prices are significant and increase the cattle prices paid to farmers. Moreover, there are no signs of asymmetry in price transmission, and transmission take longer in comparison to the results observed for the developed countries group. Nevertheless, there is asymmetry in the effect of export price volatility, with significant positive effects on farmer prices for volatility transmitted through contemporaneous increases in export prices, in contrast to the results obtained for developed countries. This outcome suggests that only large contemporaneous export price increases are transmitted to farmer prices, resulting in a smaller influence on farmer prices respect to the effect observed in developed countries, which supports the theory that exporters tend to absorb most of the price variations in less developed countries. In contrast to the results for the all countries and developed countries group, the first difference of maize prices are non-significant, which suggests a less intensive use of this type of feeding in developing countries, linked to lower cattle prices paid to farmers. Likewise to the results for the other groups, there is no evidence of a structural break in price transmission after 2005 and the first difference of oil prices are non-significant for the developing countries group.

To test for the indirect effects of volatility of export prices on marketing margins on the three groups studied, models were estimated using Driscoll and Kraay standard errors, and the results are presented in Table 4.

Table 4. Marketing margin estimation results using fixed-effects with Driscoll and Kraay (1998) standard errors.

	All countries		Developed countries		Developing countries	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Constant	-5.7130***	1.2867	-5.8760***	1.4974	-6.0047**	2.2122
Log of marketing margins lagged one period	0.3298***	0.0924	0.4040***	0.0937	0.2601**	0.1246
Log of export cattle prices	2.5656***	0.1647	2.4441***	0.3627	2.6584***	0.2426
Log of export cattle prices lagged one period	-1.2576***	0.2324	-1.1879***	0.4029	-1.2403***	0.2438
First difference of log of cattle herd size	-0.2320	0.6687	-0.8671	0.9585	0.2962	0.9348
First difference of log of farmer maize prices	-0.1620	0.1833	0.0586	0.2541	-0.2735	0.2393
First difference of log of oil price	-0.0593	0.0715	-0.1894	0.1721	0.0685	0.0758
First difference of log of GDP per capita	-1.2852*	0.7107	-2.4196	1.7666	-1.2982	1.3948
Export price volatility transmitted through log of export prices	-0.0001***	0.0000	-0.0002***	0.0001	-0.0001***	0.0000
Export price volatility transmitted through log of export prices lagged one period	0.0001***	0.0000	0.0001*	0.0001	0.0001***	0.0000
Dummy period 2005 to 2013	-0.0274	0.0535	0.0008	0.0623	-0.0541	0.0997
Within R ²	0.7062		0.7430		0.6848	
Groups	11		5		6	
Observations	301		141		160	

¹ Dependent variable is log of marketing margins; ***, ** and * indicate that the parameter is significant at the 1, 5 and 10% levels, respectively; Germany was excluded from these estimations due to a low number of positive marketing margins values; GDP = gross domestic product.

The estimation results for all, developed and developing countries groups indicate that marketing margins lagged one period, contemporaneous export cattle prices and volatility transmitted through export prices lagged one period are significant and have positive effects on marketing margins. Conversely, export cattle prices lagged one period and contemporaneous volatility transmitted through export prices have a significant negative effect on marketing margins. These outcomes confirm the expected positive effect on marketing margins of lagged marketing margins, contemporaneous export prices and the volatility transmitted through export prices lagged one period, which are consistent with the results of Shroeter and Azzam (1991), Tomek and Kaiser (2014) and Wohlgenant (2001). In addition, for the model of the all countries group the first difference of GDP per capita has a negative effect on marketing margins. This latest result indicates that in less developed countries, with lower GDP per capita, cattle exporters capture bigger marketing margins in comparison to those obtained in developed countries.

5. Conclusions

This article contributes to the literature by examining the relationships between volatility in international prices, farmer prices, and marketing margins in cattle markets using panel data from twelve countries, comprising both developed and developing countries. Consequently, this study addresses the question: does export price volatility affect prices paid to cattle farmers and marketing margins captured by exporters? The empirical results of the test on the complete group of all countries using fixed-effects estimation with Driscoll and Kraay (1998) standard errors to control for cross-sectional dependence indicate that indirect effects of volatility transmitted through export prices affect farmer prices and marketing margins. Relevant differences arise in the results for developed countries and for those countries categorized as developing countries. Previous cattle farmer prices increase prices paid to farmers for all groups and maize prices raise farmer prices for all countries and developed countries groups, where this feeding alternative is used more intensively, results consistent with those described by Tomek and Kaiser (2014). In addition, GDP per capita increases farmer prices for all countries and developing countries groups. Previous export prices are only significant for the group of developing countries, which demonstrates the longer period required for prices to be transmitted in those countries respect to developed countries. There are significant asymmetries in price transmission in developed countries with increases in contemporaneous export prices positively influencing cattle farmer prices, but not price decreases. This result differs from the findings reported by Ahn and Lee (2015), Facker and Goodwin (2001), Kaspersen and Foyen (2010), Von Cramon-Taubadel (1998) and Xia and Li (2010). However, in those countries there is a reduction on farmer prices that is adjusted by contemporaneous volatility transmitted through increases in export prices. Similarly, there is asymmetry in volatility for the developing countries group, with only contemporaneous volatility transmitted through increases in export prices raising cattle prices paid to farmers. This outcome and the non-significance of contemporaneous export prices suggests that solely large increases in current export prices are transmitted to farmer prices in developing countries.

In the case of cattle marketing margins, previous margins, contemporaneous export prices and volatility transmitted through the previous year export prices increase marketing margins, which corroborates the findings reported by Shroeter and Azzam (1991), Tomek and Kaiser (2014) and Wohlgenant (2001). Conversely, previous export cattle prices and contemporaneous volatility transmitted through export prices decrease marketing margins. Therefore, export price volatility decreases marketing margins contemporaneously, but increases marketing margins when lagged one period. This detrimental effect that contemporaneous volatility of export prices have on cattle marketing margins could be explained by production contracts with prices previously agreed. In contrast to the price transmission models, the GDP per capita reduces the marketing margins in the model for all countries group, which corroborates the findings that in more developed countries cattle prices paid to farmers are higher. These results demonstrate that even though the export price volatility is higher in developing countries, it is not the reason that prices paid to farmers are lower in comparison to those paid in developed countries. Cattle exporters in developing countries tend to pay more stable but lower prices to farmers, thus absorbing most of the fluctuation in export prices. These findings are different from the expected outcomes according to Shroeter and Azzam (1991), Tomek and

Kaiser (2014), and Wohlgenant (2001), who indicated that variability in international prices affect price transmission and marketing margins in agro-food chains.

The highly fluctuating behavior of marketing margins in developing countries, the longer period required for price shocks on export prices to be transmitted to farmers, the similarities of the effects of export price volatility on marketing margins across countries, the positive influence of GDP per capita on prices paid to farmers and the negative effect of this variable on marketing margins, suggest that exporters pay lower prices to farmers in developing countries to maximize profits rather than to minimize price risk for farmers and guarantee a firm production volume. These imperfections in the price transmission reduce the incentives for farmers to invest and adopt new technologies to increase the quality and quantity produced, which contributes to exacerbate price volatility in international markets, as highlighted by FAO (2011), and Zorya *et al.* (2010).

What are the policy implications of these findings? Instead of implementing price stabilizing programs that reduce price transmission from international to domestic prices, policy makers in developing countries are encouraged to take actions that promote more competition at wholesale level to improve the prices paid to farmers and allow a higher proportion of variations in international cattle prices to be transmitted to farmers. These actions could incentivize an increase in the level of farm investment and in the volume of cattle offered in each country, which would also benefit input and service providers, traders and other actors in the chain. Future research that aims to further test the theory of market integration and provide useful insights for policy recommendations should study the effects of market structure and spillover effects among related agro-food chains on price transmission and marketing margins.

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