The Impact of Export Price Volatility on Market Behaviour in the International Export Market: A Case Study of Canadian and German Pork Exports in China

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Abstract

This study delves into the intricate dynamics of export price volatility and its impact on the market behaviour of major pork exporters, Germany and Canada, in the world's largest pork market, China. Exporters' market behaviour often responds to the uncertainty arising from price fluctuations by curtailing their supply; a reduction in the supply by a major exporter can disrupt the overall market supply, potentially leading to an increase in prices. However, the extent to which an exporter can leverage this increase in price depends on the responsiveness of demand to such changes. To explore these relationships, a residual demand function elasticity model (RDE) is extended to incorporate price volatilities. Prices and their volatilities are modelled using Autoregressive and GARCH models, respectively. The results of the RDE analysis of pork exports reveals strong competition among pork exporters in the Chinese pork market and indicate that price volatility affects the market power of the exporting country. This research not only contributes to the understanding of the interplay between export price volatility and market power but also provides practical insights for major pork exporters. This study helps formulate informed strategies to navigate the challenges posed by price fluctuations in the international pork market.

Keywords: Imperfect competition; Market power; Price volatility; Residual demand elasticity; Pork exports; Canada; China; Germany

JEL code: L13, Q11, Q17, Q18

1 Introduction

In the realm of economics, the term ‘market power’ pertains to a firm’s capacity to wield influence over the prices at which it sells its goods (Landes & Posner in 1997). In its general definition, market power can be evaluated by modelling and measuring the differences between market price and marginal factor cost for inputs (mark-downs), or price and marginal cost for outputs (mark-ups) (Paul, 2001). On the one hand, the concentration in food supply chains and accretion of market power have been observed in both developed countries (Sexton & Xia, 2018) and low/middle income countries (Barrett et al., 2022). Furthermore, in the domain of international agricultural trade, market power can emerge when a country plays a significant role as exporter of a particular product, and importing countries depend on these products, such as wheat, fertilizer and others (Pall et al., 2014; Uhl et al., 2019; Gafarova et al., 2023). In such instances, alterations in the supply patterns of these pivotal exporters can exert a discernible impact on prevailing market prices. This, in turn, substantiates the assertion that major players engaged in international agricultural trade possess a degree of market power.

On the other hand, the phenomenon of price volatility represents a substantial source of risk for suppliers operating within agricultural markets (Boyd & Bellmare, 2020). In response to the unpredictable fluctuations in prices, these suppliers often opt to curtail their production output and an unsustainable pattern of consumption should be observed (Mustafa et al., 2023). Notably, major global exporters, holding a substantial share of the worldwide export market, may leverage this price volatility to their advantage, subsequently augmenting their market power. This supposition is corroborated by the observed positive correlation between the export activities of Russia, Kazakhstan, and Ukraine in the wheat market and the fluctuations in wheat prices during the period spanning from 1980 to 2010, especially at a juncture when the market share of these countries among Former Soviet Union (FSU) nations was on the ascent (Kemeny et al. in 2012).

However, the extent to which exporters are able to increase prices in response to price fluctuations depends on the demand elasticities. If the importer country switches to other alternative exporters, the exporter may be compelled to adjust its prices to remain competitive and attract the importer back. Thus, the impact of price volatility on market power of exporters remains ambiguous.

Price volatility can escalate either on the global stage or within the domestic market of an exporting country. When price volatility increases within a particular exporting nation, there is a potential scenario where a portion of the market share may be relinquished to competitors, leading to a reduction in the exporter's market power (Kumar & Dhawan, R, 1991).

This study is focused on the econometric analysis of the impact of price volatility on the market behaviour of two major pork exporters- Canada and Germany - in the world's largest pork market (China). The objectives of the study are threefold: (i) to measure the degree of competition in the Chinese pork market; (ii) to test how price fluctuations affect the market behaviour of pork exporters; and (iii) to examine how competitors restrict their market power in the Chinese pork market. This study is organized as follows: the next section provides a background of international pork market and trade focusing on Canadian and German export to China. This is followed by an overview of the relevant theoretical literature and empirical studies on imperfect competition with a main focus on empirical studies of the price volatility and the residual demand elasticity. The theoretical framework and empirical model specifications are outlined in Sections 4. Section 5 presents a description of the model variables with summary statistics and data sources. The results of model estimations are discussed in Section 6. The final section of the study summarizes the empirical findings and addresses competition policy implications.

2 International pork market and trade

Canada and Germany were respectively the fifth and third exporters of agricultural products in 2021(Agriculture Agri-food Canada, 2022; Simpson, 2022). In 2022, Canada exported nearly $CAN 92.8 billion in agriculture and food products (including raw agricultural materials, fish and seafood, and processed foods). Canada exported to over 200 countries in 2021 (Agriculture Agri-food Canada,2022). In 2021, Germany exported nearly $US 70.8 billion in agriculture and food products (Simpson, 2022).

Among all agricultural products both Canada and Germany and are top pork exporters in the world being the fourth and third and largest pork exporters respectively behind Spain and the United States (Workman, 2023). Consequently, policies that generate price volatility in the pork market may benefit Germany and Canada. Since China is a large market for both these countries (Canadian Pork Council, 2023; Reuters, 2023), it would be of interest to investigate if Canada and Germany could benefit from pork price volatility in the Chinese market. It is worth mentioning that China is one of the largest pork importers in the world (Workman, 2023). Thus, the research question is if with an increase in pork price volatility in the exporter's domestic market, the exporters' market power dominates China's market power as a major pork importer.

This study provides a significant empirical contribution, enhancing the current literature on the analysis of imperfect competition in the international markets. While existing literature on international pork market and trade has primarily focused on measuring market power, competition, or market behaviour the impact of market power on price volatility (Benabou & Gertner, 1993; Igami, 2015; Assefa et al, 2017) and the impact of market power on , price volatility transmission (Assefa et al., 2015), our study is a distinct perspective by investigating how market behaviour and competition among exporters are influenced by price fluctuations in the international market, contributing a unique angle to existing research.

3 Literature review

The studies on the relationship between price volatility and market power have mostly investigated how price volatility is affected by market power. The results of these studies are mixed. While several authors (Bergemann et al., 2021; Deltas, 2008; Borenstein & Shepard, 2002; Chirinko & Fazzari, 1994) concluded a negative impact of market power on price volatility, the study of Kremer& Nyborg (2004) and Mount (1999) reveals that market power exacerbates price volatility. However, our study aims to explore opposite perspective. We intend to discover how price volatility affects the market power in the pork market. While there is a study, which investigates the impact of price volatility on the market power in the electricity market, to the best of our knowledge, there is no study exploring this objective in the agricultural markets. The results of a study by Milstein & Tishler (2015) indicate that higher price volatility bestows market power on fossil using electricity producers

4 Theoretical and empirical framework

The theoretical and empirical foundation of this study combines both price volatility and residual demand approaches, specifically aiming to investigate the impact of price volatility on the market power of pork exporters. The descriptive analysis of the international pork market and trade discussed in Section 2 yields research questions and hypotheses for evaluating exporters' market power, with a particular focus on Canada and Germany as two major pork exporters to China. The impact of price volatility in each exporter's market on the other exporter's market power is modelled with a residual demand elasticity (RDE) model. In order to investigate the impact of price volatility in each exporter's market on its own market power, we develop the export function of Goldstein & Khan (1978) by including price volatilities in it.).

In the following section, we also analyse how price volatility affects market share of Canada and Germany in export to China.

4.1 Price modelling

We assume that prices follow an Autoregressive Integrated Moving Average (ARIMA) process.

(1) $$P_t = \beta(L)P_t + w_{it}$$

$$w_{it}|\Omega_{t-1} \sim N(0, h_t)$$

Where $\beta(L)$ is a polynomial lag operator, P_t is the current price, w_{it} is an error term, $\Omega_{t\text{-}1}$ is the information set of all past states available in period t-1 and h_t is the conditional variance of w_t.

4.2 Price volatility modelling

We have used the parametric approach to estimate the unexpected pork price changes or volatility of the pork price. Unlike the other time series models, generalized autoregressive conditional heteroskedasticity models (GARCH) allow the conditional variance to vary over time, which is very relevant given the dynamics of agricultural prices. This characteristic of these models led us to use GARCH models to model price volatilities. $w_t = h_t\epsilon_t$; ϵ_t $is\ iid(0,1)$

(2) $$h_t = \Theta_0 + \sum_{i=1}^{q} \Theta_{1i}.w_{t-i}^2 + \sum_{j=1}^{p} \Theta_{1j}\,.h_{t-i}$$

where Θ_{1i} is ARCH coefficient and Θ_{1j} is GARCH coefficient.

The following restrictions are imposed to ensure that the conditional variance is strictly positive:

$$\Theta_0 > 0,\ \ \Theta_{1i+}\Theta_{2i<1}$$

The order of the GARCH model is determined by visual examination of the correlogram of squared residuals of the price equation and the results of the Ljung-Box (1976) Q test (Bollerslev, 1988).

4.3 Model

Previous studies examined market power through the analysis of a residual demand elasticity function developed by Baker and Bresnahan (1988). In this study, we expand the residual demand approach by integrating the insights from literature that treats export quantities as a function of price volatilities.

For simplicity we consider two exporting countries, denoted as $k = 1$ for Germany and $k = 2$ for Canada. Let P^k and Q^k represent the export price and export quantity of competitor k, and Z be a vector of demand shifters. Each competitor faces the inverse residual demand function:

(3) $$P^1 = P^1(Q^1, Q^2, Z)$$

and

(4) $$P^2 = P^2(Q^2, Q^1, Z)$$

Let e^k represent the exchange rate between the importing country and exporter k. C^k is competitor k's cost function, W^k is a vector of k's cost shifters, and V is a vector of cost shifters relevant for all exporters, such as price volatilities.

The supply of both exporting countries is determined by the optimality condition for profit maximization, which states that marginal revenue (MR^k) equals marginal cost (MC^k):

(5) $$MR^1(Q^1, Q^2, Z) = e^1 \cdot MC^1(Q^1, W^1, V)$$

and

(6) $$MR^2(Q^2, Q^1, Z) = e^2 \cdot MC^2(Q^2, W^2, V)$$

The residual demand function for exporting country $k = 1$ is derived by simultaneously solving the demand function for exporting country $k = 2$ in equation (4), and the profit maximization in equation (6). Substituting the residual demand of for exporting country $k = 2$ into equation (3) yields the expression:

(7) $$P^1 = P^1(Q^1, Q^2(Q^1, Z, e^2, W^2, V), Z)$$

Equation (7) can be rewritten, with R representing the inverse residual demand, as follows:

(8) $$P^1 = R(Q^1, e^2, W^2, V, Z)$$

The inverse residual demand of both exporting countries in the export market is a function of the following arguments: export quantity, cost shifters of competitor, cost shifters relevant for all exporters and demand shifters in the destination country. The exported quantity on the right-hand side is endogenous and needs to be instrumented, resulting in the following inverse residual demand equation:

(9) $$P^1 = P^1(\widehat{Q^1}, e^2, W^2, V, Z)$$

According to Goldberg and Knetter (1999), equation (6) can be estimated in a reduced double logarithmic form:

(10) $$\ln P^k = \lambda + \eta \ln Q^k + \grave{\alpha} \ln Z + \grave{\beta} \ln e^n + \grave{\gamma} \ln W^n + \grave{\vartheta} \ln V + \varepsilon$$

where η, $\grave{\alpha}$, $\grave{\beta}$, $\grave{\gamma}$, $\grave{\vartheta}$ are coefficient to be estimated, and ε is error term ($\varepsilon \sim N(0, \delta)$) η is the inverse of residual demand elasticity, measuring the degree of competition or exporter's market behaviour in the destination market. In case where $\eta = 0$, a market is perfectly competitive, and the exporting country faces a perfectly elastic demand curve. In case, where $\eta < 0$ a market is imperfectly competitive, and the exporting country acts a price maker. $\grave{\alpha}$ represents coefficients of demand shifters, β' and $\grave{\gamma}$ represents coefficients of cost shifters, determining whether competing countries' products are a perfect or imperfect substitute for an exporting country's product. $\grave{\vartheta}$ represents coefficients of price volatilities of exporting countries, revealing the impact of price volatilities on exporter's market behaviour.

In this study, we consider the export price, exchange rate and price volatility of all competitors as cost shifters of all competitors. Consumer price index and GDP in China are considered as demand shifters.

4.4 Estimation approach

We use a Two-Stage Least Square (2SLS) approach to estimate our Residual Demand function. We have used the exchange rates and export price of all competitors, Canadian domestic pork prices, Chinese GDP and Chinese Consumer Price Index as instruments.

5 Data samples and sources

The timeframe being examined spans from 2010 to2023, with data collected on a monthly basis. Please refer to Tables A.1-A.3 in the Appendix for a detailed description of the data samples and model variables used in the analysis.

Canadian pork export value and quantity have been collected from the Canadian International Merchandise Trade Web Application (Statistic Canada, 2021). Specifically, data pertaining to category 203, which covers fresh, chilled, or frozen pork from swine, was extracted. Monthly averages for both the value ($) and volume (kg) of various pork products in this category were computed. Additionally, the monthly export price of pork ($/kg) was determined by dividing the export value by the export volume. For the purpose of consistency, all Canadian prices are converted to Chinese Yuan.

Export value (Thousands of Euros) and volume of pig meat export (Tonne) from Germany to China have been collected from the European Commission (European Commission, 2024). The export price (Thousands of Euros /Tonnes) has been calculated by dividing the export value by its quantity. For the purpose of consistency, the prices and quantities have been converted to Yuan per kilogram and Kilogram respectively.

We consider the United States, Spain and Brazil as prominent competitors for Canada and Germany.

The quantity and value of export for the United States and European countries have been collected from the United States Census (2023) and European Commission (2024) respectively. Prices have been calculated by deviding export values by export quantities.

Gross domestic product (GDP) for China is considered as a demand shifter. We collected the normalized GDP on a monthly basis from Federal Reserve Economic Data (2023) website. For the purpose of consistency, we manipulate this data to achieve non-normalized GDP. For this purpose, we gathered the annual GDP from The World Bank website (2023). We calculate non normalized GDP using the monthly GDP proportion in annual GDP of normalized data. The nominal GDP for China is available in US dollars. Thus, we converted it to Chinese Yuan using exchange rates.

Canadian, German and other competitors exchange rates relative to Chinese currency have been extracted from the OECD website (OECD, 2023). All exchange rates are available in USD dollars. Thus, we divided them by the Chinese one to get countries exchange rates relative to Chinese currency.

It is worth mentioning that Germany's prices and quantities are missing in three months during the period under study. These missing data were constructed using ipolate command.

The data clearly indicates a significant decrease in Canadian pork exports to China in 2019. Consequently, the relative proportion of German pork exports to China compared to Canadian exports to China increased by more than 150%. This shift can be attributed to China's decision to impose a ban on Canadian pork exports, which began in July 2019, as reported by the Globe and Mail (2019). However, it's worth noting that this ban was relatively short-lived and was lifted in November 2019. Subsequently, there was a notable increase in pork exports from Canada to China, as supported by the available data. We consider a dummy variable to account for the shock caused by China's ban on Canadian pork exports.

6 Results

6.1 Canadian export price volatility modelling

Table 1 (Panel A) demonstrates the estimation result of Canadian export prices.

The order of ARMA has been selected based on BIC criteria and the results of the GARCH model. According to the BIC criteria the optimum lag for Canadian pork export prices is determined to be an ARMA (1,1) model. Based on estimation results these lags are significant. A dummy variable is included in the model to capture the effect of the shocks discussed earlier.

The results of the Portmanteau (Q) test indicate that the residuals of the price equation exhibit characteristics of white noise, suggesting that they do not exhibit any significant patterns or autocorrelation.

Furthermore, an analysis of the correlation between the squared residuals of the equation reveals evidence of a GARCH (Generalized Autoregressive Conditional Heteroskedasticity) effect in the prices (Bollerslev 1987). This effect indicates that the volatility of the prices is not constant over time, and there are time-varying patterns in the variance of the price series. The application of an appropriate order of GARCH removes the correlation of squared residuals (Giannopoulos, (1995)). Engle's Lagrange multiplier (LM) test results provide further confirmation of the presence of an ARCH (Autoregressive Conditional Heteroskedasticity) effect in the price equations (see Figure A.1).

This effect signifies that the conditional variance of the prices is influenced by past values of the series, indicating that volatility clustering exists in the data.

Table 1 (Panel B) demonstrates the results of price equation and conditional variance estimation.

The results reveal that first lag of prices ($\beta_1 and\ \beta_2$) are significant. The coefficient of the conditional variance of pork prices expressed by θ_{i1} and θ_{j1} are significant and sum less than unity, which indicates time-varying and persistent volatility

. The Ljung-Box Q statistic test was applied to the residuals (wt) and the squared residuals (w^2t) of price equations to analyze the performance of the model. The results of this test on wt and w^2t support the non-rejection of the hypothesis that the residuals of the price equations are white noise and the correlation between square residuals has been removed.

Table 1: Results of Canadian pork export prices		
A: ARMA (1,1) estimation results		
Constant	β_0	0.004 (0.82)
First lag of prices	β_1	0.36 (0.001)
First lag of residue	β_2	0.85 (0.00)
Test of price equation's residual generated by the ARIMA model		
Q (6)		7.4884 (0.28)
Q (12)		13.3462 (0.34)
Q (18)		19.7504 (0.35)
Q (24)		25.4736 (0.38)
Q^2(6)		11.5560 (0.07)
Q^2(12)		18.7758 (0.09)
Q^2(18)		20.8779 (0.28)
Q^2(24)		26.4251 (0.33)
B: GARCH (1,1) estimation results		
ARMA (1,1)		
Constant	β_0	0.002 (0.51)
First lag of prices	β_1	0.34 (0.004)

Table 1-Continued		
First lag of residue	β_2	0.84 (0.00)
Residue		
Constant	θ_0	0.001 (0.12)
First lag	θ_{1i}	0.14 (0.004)
ARCH		
First lag	θ_{1j}	0.83 (0.000)
Test of price equation’s residual generated by the GARCH model		
Q (6)		6.1018 (0.4119)
Q (12)		10.5036 (0.57)
Q (18)		19.0616 (0.39)
Q (24)		22.3786 (0.56)
$Q^2(6)$		1.2441 (0.97)
$Q^2(12)$		4.9049 (0.96)
$Q^2(18)$		7.2002 (0.99)
$Q^2(24)$		12.3031 (0.98)

* Numbers in parenthesis are p-values

6.2 German export price volatility modelling

Table 2 demonstrates the estimation result of Canadian export prices. The order of ARMA has been selected based on LL criteria and the results of the GARCH model. According to the LL criteria the optimum lag for German pork export prices is determined to be an ARMA (5,0) model.

The results of the Portmanteau (Q) test indicate that the residuals of the price equation exhibit characteristics of white noise, suggesting that they do not exhibit any significant patterns or autocorrelation. Furthermore, an analysis of the correlation between the squared residuals of the equation reveals absence of a GARCH (Generalized Autoregressive Conditional Heteroskedasticity) effect in the prices (Bollerslev 1987). The correlogram of residuals confirms the absence of GARCH effect in German pork prices. As a result, we modeled the volatility of German pork export prices by square residuals of prices.

Table 2: Results of German pork export prices		
ARMA (5,0) estimation results		
Constant	β_0	0.04 (0.39)
First lag of prices	β_1	0.39 (0.00)
Second lag of prices	β_2	0.25 (0.00)
Third lag of prices	β_3	0.002 (0.97)
Fourth lag of prices	β_4	0.22 (0.00)
Fifth lag of prices	β_5	0.07 (0.24)
Test of price equation's residual generated by the ARIMA model		
Q (6)		0.0355 (1)
Q (12)		4.1353 (0.98)
Q (18)		20.7503 (0.29)
Q (24)		21.6789 (0.59)
Q^2(6)		6.8158 (0.34)
Q^2(12)		10.3279 (0.59)
Q^2(18)		14.7775 (0.68)
Q^2(24)		15.0143 (0.92)

* Numbers in parenthesis are p-values

6.3 Canadian export price volatility and market power

Table 3 demonstrates the results of the regression estimation of equation 10. The estimated results of RDE model for Canadian pork export indicate that Canadian export are price takers and Chinese pork market is competitive. The estimated parameter (-0.0175) is close to zero and statistically not significant. The estimated coefficient for cost shifters β' and $\grave{\gamma}$ reveals that Canadian exporters strongly compete with Spain exporters in Chinese pork market, but not with Brazilian, US, and German exporters. The estimated coefficient of price volatilities $\grave{\vartheta}$ demonstrate an increase in the market power of Canada following heightened volatility in the Canadian pork market.

Table 3: RDE results for Canadian pork export

Variable	Without monthly dummies		With monthly dummies	
	Coefficients	t statistics	Coefficients	t statistics
QX_CA_CN	-0.0756	[-0.55]	-0.0175	[-0.15]
ER_EUR_CNY	-0.7500*	[-1.86]	-0.7978**	[-2.35]
ER_USD_CNY	-1.3974	[-1.17]	-1.2129	[-1.12]
ER_BRL_CNY	-0.1404	[-0.78]	-0.099	[-0.56]
PX_ES_EUR	0.3228	[1.15]	0.4166*	[1.88]
PX_US_USD	-0.0736	[-1.06]	-0.0008	[-0.01]
PX_DE_EUR	-0.0751	[-0.65]	-0.0862	[-0.75]
GDP_CN_CNY	0.7149***	[2.65]	0.5036**	[2.26]
CPIF_CN	0.1949	[1.13]	0.13	[0.92]
pv_CA_gr	0.1236**	[2.36]	0.1308***	[2.68]
dm2			0.0438	[0.57]
dm3			0.146	[1.47]
dm4			0.1431	[1.56]
dm5			0.1257	[1.38]
dm6			0.1112	[1.39]
dm7			0.0895	[0.99]
dm8			-0.0701	[-0.81]
dm9			-0.0298	[-0.28]
dm10			0.0344	[0.37]
dm11			0.0306	[0.32]
dm12			0.0357	[0.38]
cons	-21.1223***	[-2.61]	-15.7234**	[-2.38]
N	161		161	
rank	11		22	
df_m	10		21	
r2	0.4832		0.5789	
r2_a	0.4488		0.5153	
r2u	0.9896		0.9915	
r2c	0.4832		0.5789	

Notes: t statistics in brackets, * p<0.10, ** p<0.05, *** p<0.01

6.4 Germany export price volatility and market power

Table 4 demonstrates the results of the regression estimation for Germany export to China. The results reveal a market power for pork exporters in Germany. Intriguingly, an increase in pork market volatility in Germany is associated with a decrease in export prices for the country. Further, the estimation of β' demonstrates that German exporters compete with Canadian, American and Brazilian pork exporters.

Table 4: RDE results for German pork export

Variable	Without monthly dummies		With monthly dummies	
	Coefficients	t statistics	Coefficients	t statistics
QX_DE_CN	-0.1240***	[-4.18]	-0.1224***	[-4.42]
ER_CAD_CNY	2.1370**	[2.33]	2.0950**	[2.32]
ER_USD_CNY	-2.6393***	[-3.37]	-2.7248***	[-3.54]
ER_BRL_CNY	-0.6578	[-1.61]	-0.6294	[-1.52]
PX_CA_CAD	-0.2193**	[-2.48]	-0.2375***	[-2.90]
PX_US_USD	0.0468	[0.54]	0.0762	[0.85]
PX_ES_EUR	-0.5163*	[-1.65]	-0.5554*	[-1.65]
PX_DK_DKK	1.5660***	[4.49]	1.5922***	[4.16]
GDP_CN_CNY	-0.4996**	[-2.08]	-0.5103**	[-1.96]
CPIF_CN	0.0533	[0.57]	0.0583	[0.65]
pv_DE_gr	-0.0362***	[-3.11]	-0.0369***	[-3.24]
dm2			-0.003	[-0.04]
dm3			0.0177	[0.23]
dm4			0.0753	[0.83]
dm5			0.0259	[0.30]
dm6			0.0153	[0.18]
dm7			0.0109	[0.12]
dm8			-0.06	[-0.69]
dm9			0.0031	[0.03]
dm10			0.0433	[0.42]
dm11			0.0545	[0.68]
dm12			-0.0451	[-0.46]
cons	15.5266**	[2.18]	15.5328**	[2.07]
N	161		161	
rank	12		23	
df_m	11		22	
r2	0.3339		0.3538	
r2_a	0.2847		0.2508	
r2u	0.9898		0.9901	
r2c	0.3339		0.3538	

Notes: t statistics in brackets, * p<0.10, ** p<0.05, *** p<0.01

7 Discussion

Our study investigates the impact of price volatility on the market power of two prominent pork exporters to China, namely Canada and Germany. The findings indicate that Canada operates within a framework of perfect competition in its pork market. Additionally, the study suggests that Canadian pork exporters view Spanish counterparts as competitors in the market. Furthermore, the data illustrates that heightened price volatility in the Canadian pork market amplifies their market influence. In perfect competition settings, suppliers lack control over prices and therefore adjust their product supply to mitigate risks associated with price fluctuations. Consequently, an upsurge in price volatility leads to an increase in Canadian pork prices. Conversely, our analysis of the German market indicates a presence of market power among pork exporters. According to our findings, Germany's competitors in the pork market include Canada, the US, and Brazil. Moreover, increased price volatility in the German pork market diminishes exporters' market dominance. In markets where suppliers wield influence over prices, they may opt to reduce prices to preserve their market share in response to heightened price uncertainty. Finally, our study indicates that the competitors price volatility in Canadian and German pork market does not affect the market power of the other exporter.

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Appendix

Table A.1 Description of notations and variables

Notation	Definition
η	Market power
Q^k	Export quantity
$\grave{\alpha}$	Sensitivity of export prices to demand shifters
Z	Demand shifters
$\grave{\beta}$	Sensitivity of export prices to exchange rates
e^n	Exchange rates
$\grave{\gamma}$	Sensitivity of export prices to cost shifters
W^n	Cost shifters
$\grave{\vartheta}$	Sensitivity of export prices to cost shifters relative to all competitors.
V	Cost shifters relative to all competitors
QX_CA_CN	Canadian export quantity to China
QX_DE_CN	Germany export quantity to China
ER_EUR_CNY	European-Chinese exchange rates
ER_USD_CNY	American - Chinese exchange rates
ER_BRL_CNY	Brazilian-Chinese exchange rates

PX_ES_EUR	Spanish export prices (Euro)
PX_US_USD	American export prices (USD)
PX_DE_EUR	Germany export prices (Euro)
GDP_CN_CNY	Gross domestic product for China (Yuan)
$CPIF\_CN$	Consumer price index for China
PV_CA_gr	Canadian price volatility
PV_DE_gr	German price volatility
dxs_CA_CN	Dummy variable capturing export shocks
Cons	Constant

Table A.2 Descriptive statistics of Canadian data sample

	Mean	SD	Min	Max
QX CA CN	14542036	11877909	149322	54341653
PX CA CNY	12.244	4.6724	4.8561	24.976
ER CAD CNY	.1832	.0184	.1467	.2161
ER EUR CNY	.1278	.01	.1026	.1509
ER USD CNY	.1528	.0069	.1393	.1638
ER DKK CNY	.9519	.0745	.7631	1.1307
ER BRL CNY	.5122	.1904	.242	.8875
PX DE EUR	1.5377	.5657	.6444	4
PX ES EUR	1.6401	.4886	.6053	2.9621
PX US USD	2.9175	.827	1.5994	7.259
PX DK DKK	1.5875	.4938	.7122	2.9511
PD DE EUR	1.5689	.2453	1.1187	2.4064
PD CA CAD	1.6659	.3301	1.0916	2.5468
GDP CN CNY	1.009e+12	3.028e+11	4.662e+11	1.508e+12
GDP CN CNY mln	1008553.9	302757.54	466203.47	1507832.4
POP CN	1.384e+09	25885380	1.334e+09	1.412e+09
POP CN thd	1383824.9	25885.381	1334482.4	1412359.9
CPIF CNc	362.0357	149.2618	100	789.3304
PPIP CN	27.8284	9.2252	16.41	57.97
pv CA gr	.0542	.0338	.0132	.1364
pv CA grh	.0374	.046	0	.1364
pv CA grl	.0165	.0169	0	.0557
dxs CA CN	.0248	.1561	0	1

Table A.3 Descriptive statistics of German data sample

	Mean	SD	Min	Max
QX DE CN	21629017	19665448	1000	79288000
PX DE CNY	12.0681	4.6944	4.7925	34.3332
ER CAD CNY	.1832	.0184	.1467	.2161
ER EUR CNY	.1278	.01	.1026	.1509
ER USD CNY	.1528	.0069	.1393	.1638
ER DKK CNY	.9519	.0745	.7631	1.1307
ER BRL CNY	.5122	.1904	.242	.8875
PX DE EUR	1.5377	.5657	.6444	4
PX ES EUR	1.6401	.4886	.6053	2.9621
PX US USD	2.9175	.827	1.5994	7.259
PX DK DKK	1.5875	.4938	.7122	2.9511
PD DE EUR	1.5689	.2453	1.1187	2.4064
PD DE EUR	1.5689	.2453	1.1187	2.4064
GDP CN CNY	1.009e+12	3.028e+11	4.662e+11	1.508e+12
GDP CN CNY mln	1008553.9	302757.54	466203.47	1507832.4
POP CN	1.384e+09	25885380	1.334e+09	1.412e+09
POP CN thd	1383824.9	25885.381	1334482.4	1412359.9
CPIF CNc	362.0357	149.2618	100	789.3304
PPIP CN	27.8284	9.2252	16.41	57.97
pv DE gr	.0388	.1441	0	1.577
pv DE grh	.0388	.1441	0	1.577
pv DE grl	0	0	0	0
dxs DE CN	.0311	.174	0	1

Figure A.1: ARCHLM test for Canadian pork export prices

LM test for autoregressive conditional heteroskedasticity (ARCH)

lags(*p*)	chi2	df	Prob > chi2
1	0.570	1	0.4503
2	4.562	2	0.1022
3	8.206	3	0.0419
4	9.545	4	0.0488
5	10.786	5	0.0558
6	13.231	6	0.0395
7	13.757	7	0.0557
8	14.257	8	0.0753
9	14.007	9	0.1221
10	16.546	10	0.0850
11	18.103	11	0.0792
12	19.237	12	0.0830
13	21.663	13	0.0608
14	24.420	14	0.0407
15	24.374	15	0.0590
16	24.577	16	0.0776
17	26.617	17	0.0639
18	27.469	18	0.0706
19	27.778	19	0.0878
20	27.853	20	0.1129
21	27.659	21	0.1501
22	34.477	22	0.0439
23	34.111	23	0.0636
24	26.086	24	0.3488
25	29.046	25	0.2620
26	31.253	26	0.2190
27	37.512	27	0.0859
28	38.789	28	0.0844
29	45.058	29	0.0290
30	45.508	30	0.0346
31	45.788	31	0.0423
32	46.883	32	0.0434
33	48.264	33	0.0420
34	46.826	34	0.0704
35	47.887	35	0.0720
36	47.889	36	0.0889
37	51.178	37	0.0605
38	50.944	38	0.0781
39	51.933	39	0.0805
40	53.938	40	0.0695