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RUSSIA'S AGRICULTURAL IMPORT SUBSTITUTION POLICY: PRICE VOLATILITY EFFECTS ON THE PORK SUPPLY CHAIN

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Abstract

The pork sector has been at the centre of Russia's import substitution policy. It has shown a very dynamic development reaching the government's aim to increase self-sufficiency to 85% in 2015. However, this policy is facing several challenges. Results of a DCC-MGARCH model confirm our hypothesis that price volatility and thus risk have increased strongly in the pork supply chain in Russia. Concurrently, the volatility spill-overs between the price of slaughtered pork and the price of live swine have more than doubled, indicating increased price interdependence.

Keywords

Russia, import substitution policy, import ban, price volatility, pork supply chain, DCC-MGARCH

1 Introduction

Russia's agri-food sector is characterized by excellent natural conditions for agricultural production. In particular, it disposes over more than 200 million ha of agricultural land (FAO, 2016) which are covered by large areas of chernozem soil, accounting for over 40% of global chernozem soil resources¹. Russia also has good climatic conditions and benefits from sufficient water resources for rain-fed agriculture as a result of a relatively high level of rainfall. Moreover, Russia has a large domestic food demand by its population amounting to 146.5 million people in 2015 (ROSSTAT, 2016).

Therefore, it is surprising that until 2014, Russia was among the largest agricultural and food importers with dairy and dairy products, meat and meat products, fruits & vegetables and fish as the main imported food products accounting for over 40% of domestic food consumption (GLAUBEN, 2014, press release on 15.08.14).

The Russian government has become aware of this unutilized agricultural and food production potential. To further develop its food sector, the Russian government is following an agricultural import substitution policy, aiming to achieve self-sufficiency to a large extent in all agricultural and food products. Even more, the Russian government ultimately aims at Russia' agricultural sector heavily engaging in international agricultural trade as one of the largest agricultural exporters in the world (GÖTZ and DJURIC, 2016).

These two aims are mainly followed by two instruments: by imposing import taxes, non-tariff barriers and even import bans the import of agricultural and food products is reduced. Concurrently, additional incentives for investments in the domestic agricultural and food sector are created in order to substitute imports by domestically produced products. This is achieved by providing comprehensive financial support within several agricultural subsidization programs (PRIKHODKO and DAVLEYEV, 2014).

However, this policy is not without any challenges. Due to the import protection measures, an inefficient domestic agricultural sector, characterized by high production costs and/or low product quality relatively to competitors on the world market, might evolve. Thus, if the import

¹ Chernozems (Black earth) cover an estimated 230 million hectares world-wide (FAO, 2001) where 96 million hectares are located in Russia (FAO, 2006).

restrictions were removed, domestic inefficient suppliers could be driven out of the market by international competitors.

In this paper, we draw attention to a possible further challenge by investigating if the import substitution policy affects price volatility, defining price volatility as a measure of the unexpected price changes and thus risk. Focusing on Russia's pork supply chain, our research question is: does the import substitution policy affect price volatility and risk in Russia's pork supply chain? We hypothesize that due to the decrease in pork imports and its increased substitution by domestic supply, two different regimes can be observed in the Russian pork supply chain: In one regime the pork supply chain is dominated by pork imports mainly originating in Brazil which are supplied at a relatively low price level on the domestic market. In the second regime the pork supply chain is dominated by domestically produced pork which is supplied at relatively high prices. This implies large price fluctuations with high unexpected price changes and thus increased price volatility. Increased price volatility and thus risk decreases incentives for investments and counteracts the aim of the import substitution policy to increase investments in the Russian agricultural sector.

In this study we investigate price volatility and volatility transmission between two stages of the pork supply chain, the stages of swine production and the stage of slaughtering and meat processing. We explicitly take into account the influence of the Rouble-US\$ exchange rate within a DCC-MGARCH approach (ENGLE, 2002). This paper is structured as follows: Section 2 addresses Russia's import substitution policy regarding pork and section 3 provides an overview on the pork sector's characteristics. A literature review is given in section 4. Methods and data are explained in section 5 and empirical results are presented in section 6; section 7 draws conclusions.

2 Import substitution policy in the pork sector

The development of the Russian pork sector is central to Russia's agricultural import substitution policy. Figure 1 shows the composition of Russia's pork imports from the primary exporting countries. It becomes evident that the composition of the countries of origin of Russian pork imports has changed significantly with modifications of the Russia's pork import policy. The import substitution policy was started in the pork sector by implementing a tariff rate quota (450,000t) with an in-quota tariff of 40% and an out-of-quota tariff of 68% in 2004 (DJURIC, et al., 2015). This policy prevailed until August 2012 when the in-quota tariff was reduced to 5% and the out-of-quota tariff to 65% in the course of Russia's accession to the WTO. During this policy regime Russia's pork imports primarily originated from Germany, Denmark, Canada, the USA and Brazil.

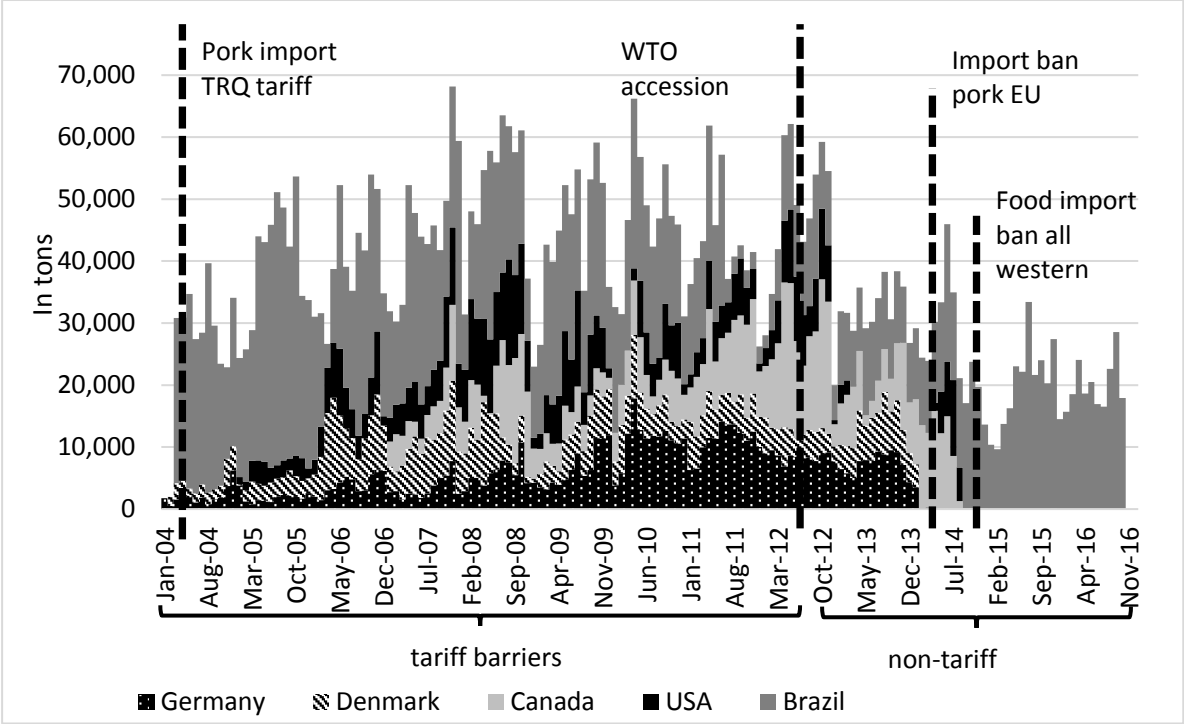
Despite the reduction of the pork import tax, pork imports started to decrease concurrently with the implementation of non-tariff barriers. As an example, since December 2012 selected pork exporting companies of Germany became banned by the Russian government and were no longer allowed to export pork to Russia. This ban was extended to all companies located in Bavaria, North Rhine-Westphalia and Lower-Saxony in February 2013. Rosselkhoznador, the Federal Service for Veterinary and Phytosanitary Surveillance of Russia, officially justified these interventions with non-compliance with Russia's phytosanitary and hygiene standards.

In January 2014 pork imports originating in the EU became completely banned due to the outbreak of the African swine fever in the Baltic countries². Therefore, pork imports from Germany and Denmark completely stopped. In August 2014, pork imports from all western

² In August 2016 the WTO has declared illegal the Russian import ban on pork from the EU since it violates the WTO Agreement on the Application of Sanitary and Phytosanitary Measures.

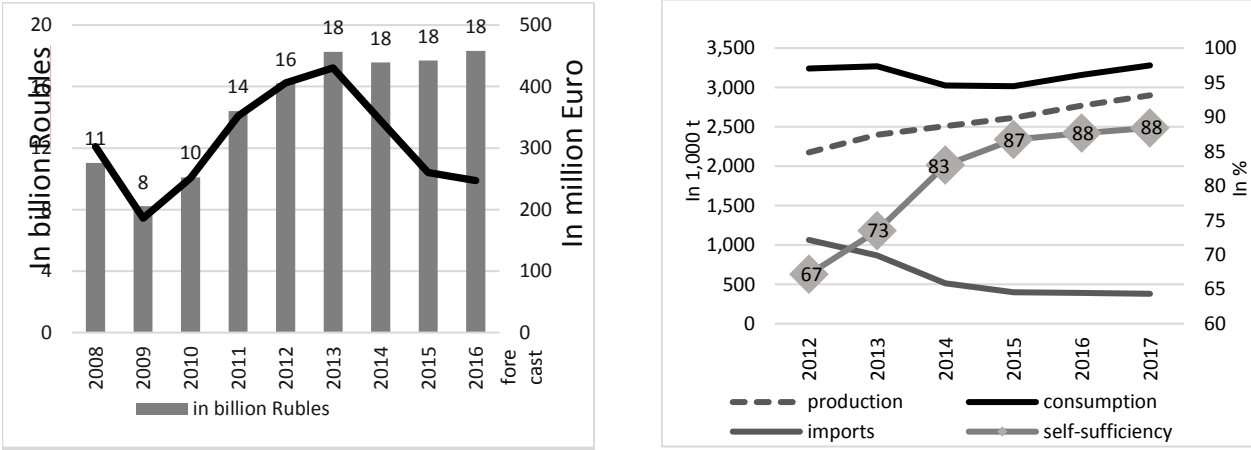
countries became banned by the Russian agricultural import ban imposed in the context of the Ukrainian crisis³. Consequently, pork imports from Canada and the USA were blocked as well. Since then, pork is almost exclusively imported from Brazil. The Russian agricultural import ban was twice prolonged and is currently valid until the end of 2017.

Figure 1: Russia's pork import and trade policies



Source: Own illustration, data: Rosstat (2016), ITC (2016)

Figure 2: Subsidization Russia’s pork industry (a); Self-sufficiency pork meat supply (b)



Source: Own illustrations, data: Union of Pork Production (2016), Rosstat (2016).

³ The Russian food import ban was implemented as a reaction to the financial sanctions imposed by western countries.

This trade policy was complemented by the comprehensive subsidization of investments in pork production within several agricultural programs: the National Priority Project initiated in 2006, the Agricultural Development Program lasting from 2008 to 2012, the Food Security Doctrine in 2010, the Agricultural Development Plan for the time period 2013 to 2020 and the Amendment to the Agricultural Development Plan in 2014. The major policy instrument was the subsidization of credits for financing agricultural investments for import substitution. Figure 2a presents the amount of subsidies attributed to the pork sector for the time period 2008 to 2016 in Roubles and Euro. The subsidies amounted to 18 billion Roubles from 2013 to 2016. However, when transformed to Euros, the subsidies were almost halved in the same period due to the strong devaluation of the Russian Rouble. This policy was successful regarding its politically fixed aim to increase self-sufficiency to at least 85%. As Figure 2b shows, self-sufficiency of pork increased from 67% in 2012 to 88% in 2016.

3 Characteristics of the pork supply chain

In Russia pork is primarily produced by large agricultural enterprises, the so-called agro-holdings, whereas the importance of household farms has decreased substantially in the last years. Many household farms were urged by the government to stop pork production due to the high risk of African swine fever outbreaks (USDA FAS, 2015, 2016). According to estimations, agro-holdings accounted for 87% and household farms for only 13% of pork production in 2016 (USDA FAS, 2015, 2016).

Agro-holdings are generally characterized by a high degree of vertical integration. An agro-holding might control the feed and swine production or even the full production cycle, which also includes slaughtering and meat processing. Some agro-holdings even own a retail chain to distribute meat and meat products to the end consumers (Figure 3).

Figure 3: Vertical integration of agricultural enterprises

- 1. Integration of feed & swine production



- 2. Full production cycle



- 3. Total integration



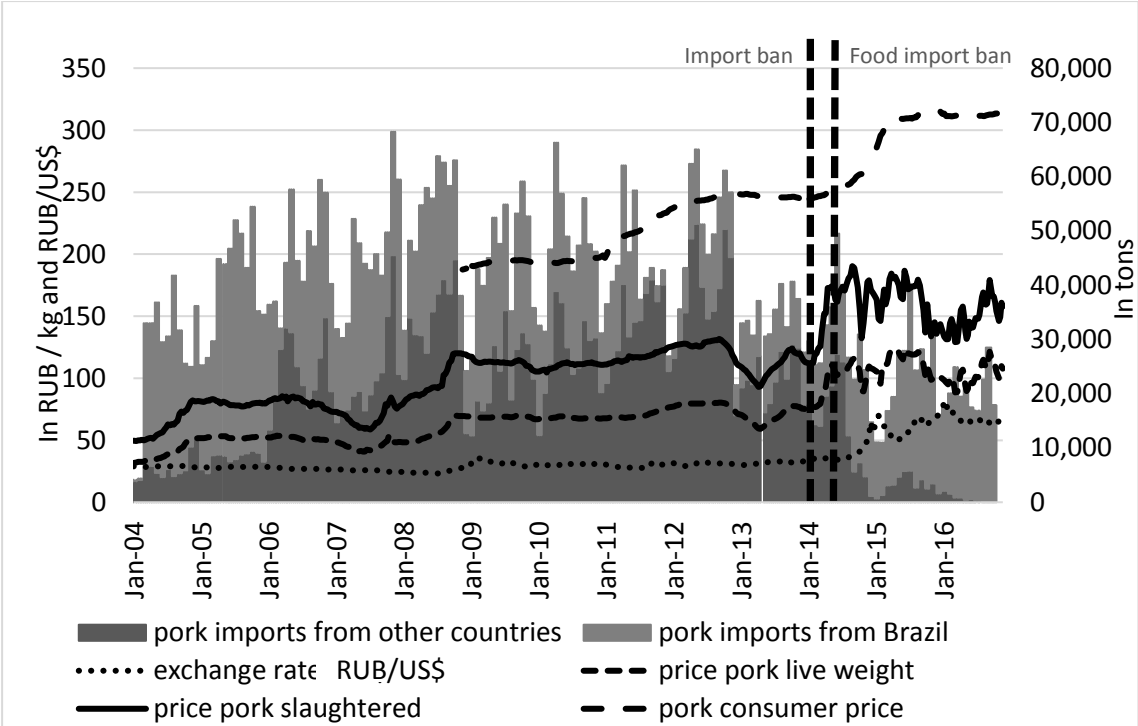
Source: Own illustration.

Figure 4 shows the price developments in the pork supply chain. It becomes evident that the prices of swine live weight and slaughtered pork have been very stable until the beginning of 2013. Afterwards, especially upon the implementation of the agricultural import ban in August 2014, changes of both prices have increased dramatically. Besides, the pork end consumer price

shows a strong increase in the price level in 2014/2015. We also find increased fluctuations of the US\$/Rouble exchange rate since the end of 2014.

Based on interviews with experts on the Russian pork sector, we hypothesize that due to the politically intended decrease in pork imports, and the simultaneous increase of domestic pork supply, two different regimes can be observed in the Russian pork supply chain: In one regime, the pork supply chain is dominated by pork imports from Brazil and a relatively low pork price level. In the second regime the domestic supply chain is dominated by domestically produced pork and a relatively high price level. The existence of these two regimes imply large price fluctuations with high unexpected price changes and thus high price volatility.

Figure 4: Price developments pork supply chain



Source: Own illustration, Data: Rosstat, ITC, Oanda

4 Literature review

Research in price volatility on agricultural markets and supply chains is gaining increasing interest in recent years. This paper is adding to the strand of literature focusing on the effects of governmental policy on price volatility (GÖTZ ET AL. 2013; BRÜMMER ET AL. 2013; RUDE and AN 2015; AN ET AL. 2016). In addition we contribute to the literature investigating the transmission of price volatility within agricultural and food supply chains (ASSEFA et al., 2013; REZITIS and STAVROPOULOS 2011; APERGIS and REZITIS 2003; SERRA 2011).

In their literature review, BRÜMMER ET AL. (2013) find that trade policies are often identified as the driver of food price volatility, however, the challenge lies in providing empirical evidence. The impact of wheat export restrictions implemented by the government in Ukraine on price volatility is addressed by GÖTZ ET AL. (2013) and AN ET AL: (2016). GÖTZ ET AL. (2013) apply a DCC-GARCH model to estimate volatility for the Ukrainian wheat market in comparison to the German and world wheat markets. Results show that during the export restrictions periods, the domestic price volatility did not decrease but rather increased compared

to periods without export restrictions. Moreover, AN ET AL. (2016) analyse the Ukrainian wheat market and investigate whether export policies succeeded in preventing transmission of prices and volatility during commodity price spikes. Using VEC-BEKK-GARCH model, they find that the transmission elasticity was reduced by 25% as the result of export restrictive measures. In line with GÖTZ ET AL. (2013), they find that volatility increased shortly before implementation and after withdrawal of export restrictions but not during the time of operation. RUDE AND AN (2015) analysed world wheat, maize, soybeans and rice price volatility and the effects of export restrictions. Using GMM approach, they find significant evidence that export restrictions have increased price volatility of wheat and rice, but not that of maize and soybeans.

A comprehensive review on studies addressing volatility and volatility spill-overs within food supply chains is provided by ASSEFA ET AL. (2013). Their literature review shows that the assertions made by a majority of the authors suggest that the degree of market power and the availability of contracts determine whether price volatility transmits along the chain. APERGIS and REZITIS (2003) use an ECVAR and MVGARCH in order to investigate volatility spill-over effects between agricultural input, output and retail food prices in Greece. They find that retail food price volatility had a larger impact compared to input price volatility on the volatility of output prices, indicating that demand-specific compared to cost factors have a stronger influence on the volatility of output prices. REZITIS and STAVROPOULOS (2011) examine the implications of the rational expectations in a primary commodity sector with the use of a structural econometric model with endogenous risk. They apply a MGARCH model for major meat markets in Greece (beef, lamb, pork, and broiler) from 1993-2006. They conclude that uncertainty caused by price volatility is a restrictive factor for the growth of the Greek meat industry. SERRA (2011) assesses the linkages between price volatility at different levels of the Spanish beef marketing chain resulting from the Spanish bovine spongiform encephalopathy (BSE) crisis for the period 1996-2005. Based on a smooth transition conditional correlation GARCH model framework, she finds that during turbulent times, price volatilities can be negatively correlated. Results further suggest that stabilizing prices in one market does not necessarily lead to stability in other related markets.

5 Methodology and data

To analyse the effects of the import substitution policy on price volatility in the pork sector, we investigate the price volatility development on two stages of the pork supply chain, swine production and slaughtering & meat processing, and also volatility transmission between these stages. In addition we account for the influence of the Rouble-US\$ exchange rate.

Our analysis is based on the volatility concept distinguishing between expected price changes and unexpected price changes (BRÜMMER ET AL., 2016). Price volatility refers to the unexpected price change and measures the magnitude of deviations from the expected price change, i.e. the standard deviation of the price change.

We choose a dynamic conditional correlation multivariate general autoregressive conditional heteroscedasticity model (DCC-MGARCH) tracing back to ENGLE (2002) as our framework to analyse the volatility dynamics and volatility correlations between the series. The advantage of the DCC-MGARCH model lies in its flexibility allowing not only the volatility but also the volatility correlation to be time-dependent.

We estimate a DCC-MGARCH according to the following strategy. The two price series and the exchange rate ($i = 1, 2$ and 3), are first transformed to returns according to

$$r_{it} = \ln\left(\frac{p_{it}}{p_{it-1}}\right)$$

with r_{it} corresponding to the actual relative price changes in percentage of the prices observed in the previous time period. The returns series r_{it} are each modelled as an ARMA (p,q) process with

$$r_{it} = \gamma_{0i} + \sum_{m=1}^p \gamma_{1im} * r_{it-m} + \sum_{n=1}^q \gamma_{2in} * z_{it-n} + \varepsilon_{it}$$

which allows distinguishing between the expected price change ($\gamma_{0i} + \sum_{m=1}^p \gamma_{1im} * r_{it-m} + \sum_{n=1}^q \gamma_{2in} * z_{it-n}$) and the unexpected price change (ε_{it}) and z_{it} the Gaussian white noise process with unit variance. Following BOLLERSLEV (1986) and POON and GRANGER (2005), the unexpected price change (ε_{it}) of each returns series, i.e. the price volatility, is measured as $\varepsilon_{it} = \sqrt{h_{it}} z_{it}$ with the conditional variance (h_{it}) modelled as a univariate GARCH(1,1) process with

$$h_{it} = \delta_i + \alpha_i * \varepsilon_{it-1}^2 + \beta_i * h_{it-1}$$

where z_{it} is -similarly to the ARMA model above- defined as a Gaussian white noise process with unit variance and δ_i a constant term. The volatility process is further characterized by the moving average parameter α_i , measuring the influence of the market shock in the previous period, and the autoregressive parameter β_i , reflecting the volatility persistence.

Dynamic conditional correlation multivariate GARCH (DCC-MGARCH) is a simple class of multivariate volatility estimation models which is selected for this study (ENGLE, 2002). By expanding the volatility estimation of univariate trend explained above to multivariate, we consider a multivariate residual return to be $\varepsilon_t = H_t^{1/2} z_t$ (similar as explained above). In this case $H_t^{1/2}$ is conditional variance-covariance matrix.

The conditional volatilities in the DCC-MGARCH are given by the conditional variance-covariance matrix $H_t^{1/2}$ defined as

$$H_t = D_t R_t D_t$$

with D_t the matrix of standardized conditional variances ($\text{diag}(\sqrt{h_{iit}})$) and R_t the correlation matrix containing the conditional volatility correlations, estimated as

$$\rho_{12t} = \frac{h_{12t}}{\sqrt{h_{11t}}\sqrt{h_{22t}}}$$

In the next step we use D_t and H_t to estimate the parameters of R_t by maximum likelihood method⁴.

Table 1: Data description

Series	Description	Source	Mean	SD	Max	Min
Swine live weight price (Rouble/kg)	39-98 kg (2nd category) live weight, Central Black-Earth Region	Rosstat	70.73	22.66	123.41	31.62
Slaughtered pork price (Rouble/kg)	39-98 kg (2nd category) slaughter weight, Central Black-Earth Region	Rosstat	110.94	33.37	190.36	49.37
Exchange rate	Rouble/USD	oanda.com	35.38	13.52	80.91	23.22

Source: Own estimations.

⁴ The maximum likelihood (ML) estimation is not presented due to space limitation. It can be review in detail in TSAY (2014) and LÜTKEPOL (2005).

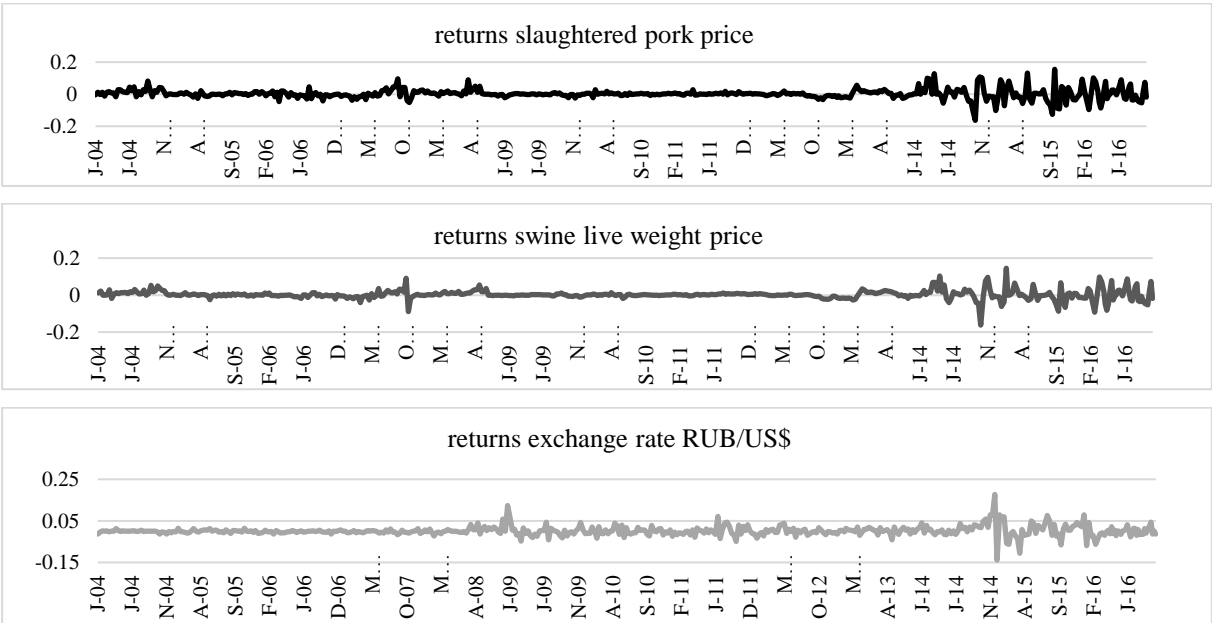
The analysis is based on 468 observations of the price of swine live weight (Rouble/kg; source: ROSSTAT), the price of slaughtered pork (Rouble/kg; source: ROSSTAT (2017)) and the Rouble/US\$ exchange rate (source: OANDA (2017)) in the time period January 2004 – December 2016 (Table 1 and Figure 4).

6 Empirical results

The returns price and exchange rate series are presented in Figure 6 and they are of a stationary nature. All the three returns series are best modelled as an ARMA(1,1)-process assuming a t-distribution. The Lagrange Multiplier (LM) test suggests significant ARCH-effects indicating that shocks play an important role in the volatility process. Univariate GARCH(1,1) models are specified according to the information criteria and maximum log-likelihood values. The ENGLE and SHEPPARD (2001) test rejects the null of constancy of correlation which motivates us to choose a DCC-MGARCH(1,1) for the analysis. Table 2 presents the parameters of the DCC-MGARCH(1,1) model and Table 3 presents characteristics of the estimated volatilities and conditional correlations.

The sum of GARCH model parameters ($\alpha+\beta$) is less than one for all three series indicating that the volatility process is mean-reverting and implying that it has a finite variance and is stationary. The estimated volatilities for the swine live weight price, the slaughtered pork price and the exchange rate are presented in Figure 7, indicating that price volatility increased dramatically especially since the beginning of 2014. Previously, the processes underlying the two pork prices have been relatively stable with the exception of the financial crisis in 2008. The exchange rate volatility also has increased strongly, however not until the end of 2014.

Figure 5: Returns series



Soure: Own illustration.

Table 2: Estimation results DCC-MGARCH(1,1)

	Swine live weight price	Slaughtered pork price	Exchange rate (RUB/\$)
γ_{0i} (drift)	0.001 (0.001)	0.001 (0.001)	-0.001(0.001)
γ_{1i} (autoregr. p.)	0.797 (0.070) ***	0.802 (0.065) ***	0.696 (0.091) ***
γ_{2i} (mov. avg. p.)	-0.566 (0.099) ***	-0.334 (0.109) **	-0.593 (0.095) ***
α_i (ARCH eff.)	0.301 (0.07) ***	0.343 (0.08) ***	0.199 (0.04) ***
β_i (GARCH eff.)	0.697 (0.13) ***	0.655 (0.12) ***	0.799 (0.05) ***
DCC_{α}	0.037 (0.01) ***		
DCC_{β}	0.962 (0.01) ***		
Log-Likelihood: 4096.753, Avg. Log-Likelihood: 8.75 Information Criteria: Akaike:-17.392, Bayes:-17.153, Hannan-Quinn:-17.298			

Notes: standard errors in parenthesis (), '***' statistical significant at 0.1%, '**' statistical significant at 1%, '*' statistical significant at 5%

Source: Own estimations.

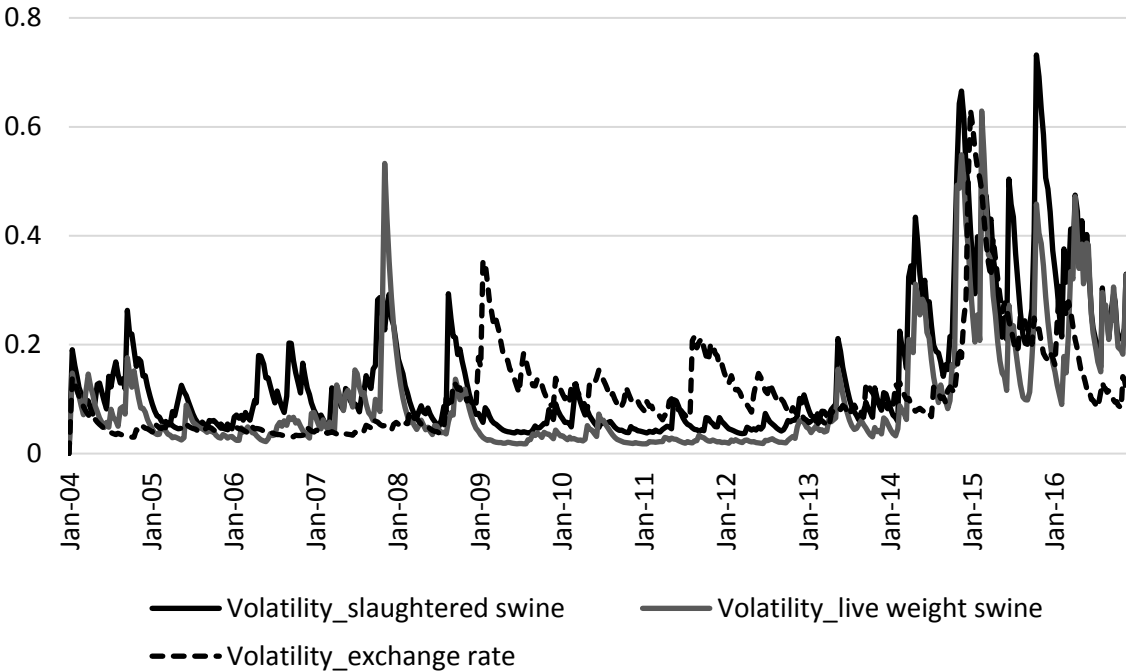
Table 3: Estimated volatilities and conditional correlation

	Series	Mean	SD	Min	Max
Estimated volatilities (%)	Slaughtered pork price	14.4	12.8	3.7	73.2
	Swine live weight price	9.9	10.9	1.8	62.9
	Exchange rate RUB/USD	11.1	8.8	3.0	63.1
Estimated conditional volatility correlation (%)	Swine live weight price – slaughtered pork price	51.6	22.8	19.5	94.5
	Swine live weight price - RUB/USD	-5.6	9.3	-33.4	14
	Slaughtered pork price - RUB/USD	-3.2	10.3	-25.1	30.2

Source: Own estimations.

Figure 8 shows the estimates for the conditional correlation between the volatility of the swine live weight price and the slaughtered pork price and the development of Russia’s pork imports. It becomes evident that the domestic volatility spill-over between the two pork prices, i.e. the linear dependence between the volatility of the two price series, has increased strongly with decreasing pork imports. As indicated above, the pork imports started to decrease already in 2013. Concurrently, the conditional correlation between the swine live weight price and the slaughtered pork price started to increase and more than doubled from about 0.4 to over 0.8. Figure 10 shows the estimated volatilities for the exchange rate and slaughtered pork price and their conditional correlations. Although the volatility of the pork prices and the exchange rate increased dramatically since 2014, their conditional correlation is nearly zero in this period (different to strong spill-over between the swine live weight and the slaughtered pork price volatilities). Therefore, our results do not suggest that the Rouble/US\$ exchange rate is a volatility driver of the slaughtered pork price.

Figure 7: Conditional standard deviation (annualised volatility) for exchange rate and slaughtered pork price and swine live weight price



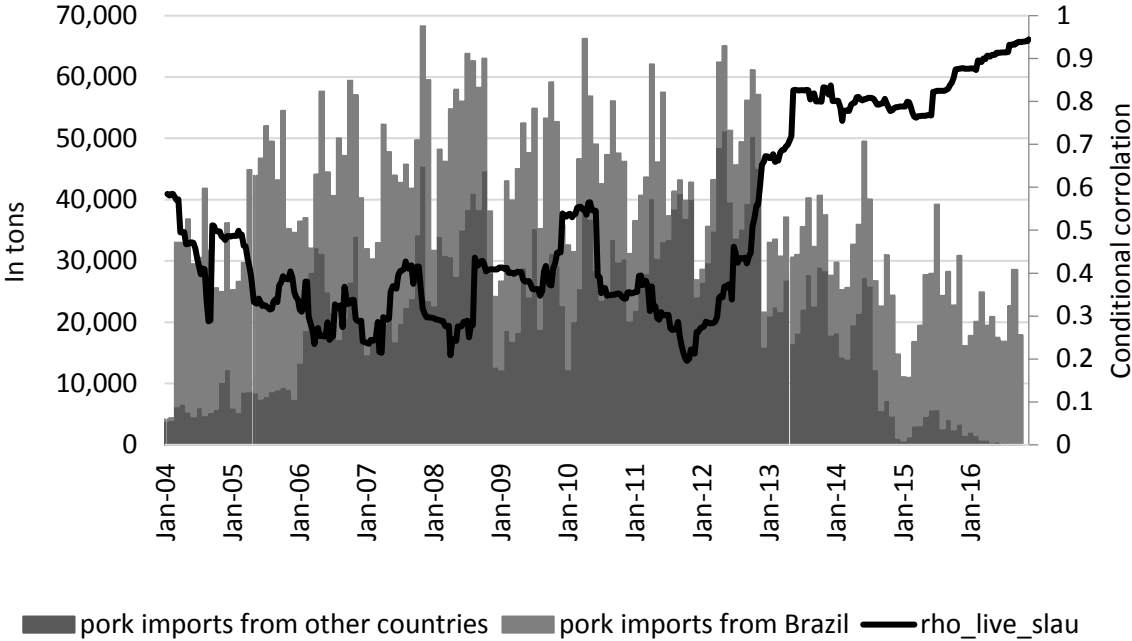
Source: Own estimations.

7 Conclusions

The Russian government is pursuing an agricultural import substitution policy in order to mobilize its unutilized potential for agricultural and food production. The pork sector has been at the centre of this policy. As a result, the politically fixed aim to increase self-sufficiency in pork to at least 85% has been met. However, this policy is facing several challenges. In this study we have investigated the import substitution policy’s effects on price volatility and thus risk in the pork sector.

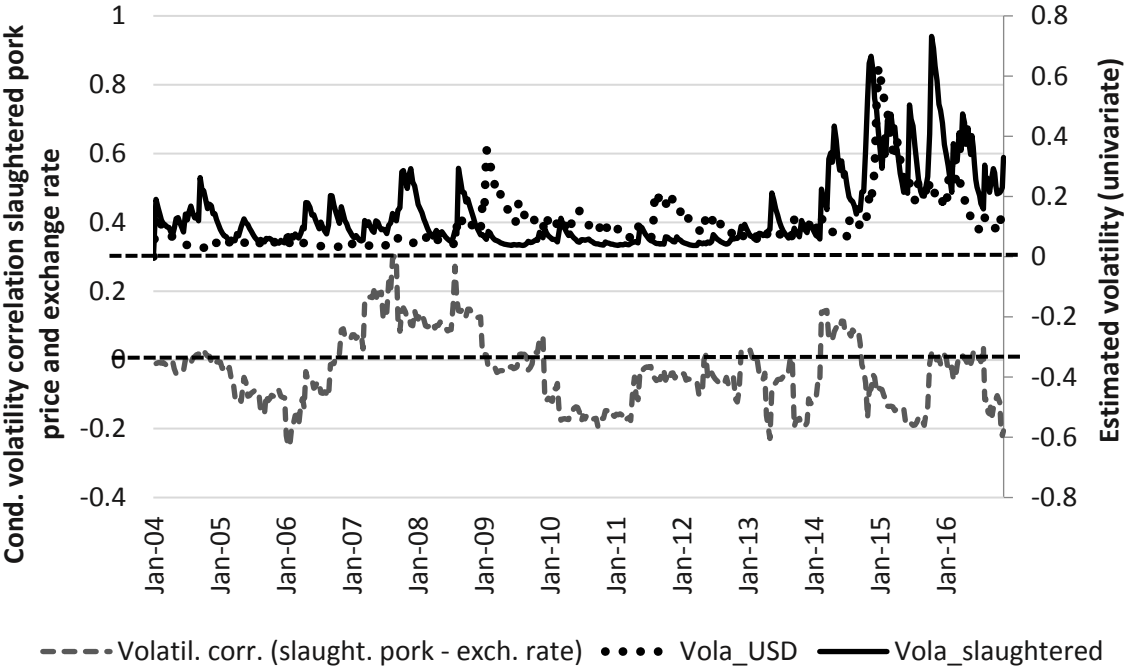
Our results confirm the hypothesis that price volatility and thus risk have increased strongly in the pork supply chain simultaneously with the decrease in pork imports and the increase in domestic pork supply. Concurrently, the volatility spill-overs and thus the interdependence

Figure 8: Conditional volatility correlation between the slaughtered pork price and swine live weight price (rho_live_slau) and the development of Russia's pork meat imports



Source: Own estimations.

Figure 9: Conditional correlation between the slaughtered pork price volatility (Vola_slaughtered) and the Rouble-USD exchange rate volatility (vola_USD)



Source: Own estimations.

between the price of slaughtered pork and the swine live weight price has risen strongly. Our results do not hint to the Rouble/US\$ exchange rate as a driver of those developments. Obviously, the Russian pork supply chain is governed by two regimes: one regime the pork supply chain is dominated by pork imports from Brazil and a relatively low pork price level. In the second regime the domestic supply chain is dominated by domestically produced pork and a relatively high price level. This implies large price fluctuations with high unexpected price changes and thus high risk.

The increased price volatility in the pork supply chain hampers optimal pork production and processing decisions. By increasing risk and thus decreasing incentives for investments, the import substitution policy counteracts its aim to increase pork production, decreasing policy efficiency and causing higher costs.

In future research we aim to further investigate the volatility and volatility correlation developments focusing on the potential role pork imports might play within a GARCHX model or by including pork imports as a further variable in the DCC-MGARCH model. A further open issue is to clarify the role of strengthened vertical integration between swine producers and the slaughterhouses for increased price interdependences in the pork supply chain.

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