Transmission of beef and veal prices in different marketing channels

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Abstract

This paper investigates price transmission in beef and veal markets in Switzerland. We extend earlier research by analyzing both prices in one system and considering two different marketing channels for meat. VAR and VEC models are estimated using monthly up- and downstream prices collected at the processors' level for 2004-2013. Tests on Granger causality for these markets suggest that a) multiple product investigation should be preferred over beef (or veal) only analysis and b) the results for the same product can differ across marketing channels. In both channels, veal (and not beef) prices adjust significantly if deviations from the long-run price equilibrium occur. Nonetheless, no empirical evidence can be found that downstream industries exercise market power over producers. In all marketing channels, no significant asymmetry in price transmission is found.

1. Introduction

As in other European countries, agricultural policy makers in Switzerland are concerned about the competitiveness of the domestic agricultural and food sector, including not only primary production but also the downstream industry such as processors and retailers. As the degree of market power influences the transmission of price changes along the marketing chain (McCorriston, 2002), the transfer of price signals through the food supply chain also provides information about competition in the food sector. In other words, the magnitude and speed with which prices are transferred between the different stages of the food supply chain reflect the structure and organization of the chain (Goodwin and Holt, 1999) and thus provide hints on the competition between different market actors.

In general, price changes at different points along the supply chain may have important consequences for producers' and consumers' welfare (Sexton, 2000, Sexton and Lavoie, 2001, Ben-Kaabia and Gil, 2007). Moreover, primary producers often claim that the downstream firms exercise market power over pricing (Ward and Stevens, 2000, Lloyd et al., 2006). This generally leads to lower price transmission between the different marketing channels (Holloway, 1991, McCorriston et al. 1998, 2001), with output prices responding faster to input price increases than to decreases (Peltzman, 2000), and thus induces asymmetrical price transmission (Abdulai, 2002, Bakucs et al., 2013). Empirical evidence suggests a high level of concentration in the European food chains, which facilitates the ability of retailers to exercise market power (Dobson et al., 2001, McCorriston, 2002, Frank and Lademann, 2014). This also holds for Switzerland where, for instance, the two major retailers held a market share of 66% on the total food and near-food sales (SMP, 2011)[1].

Our analysis focusses on the vertical price transmission between up- and downstream prices for beef and veal. This focus is motivated by the fact that milk and cattle are, due to the natural production conditions, the main production branches in Swiss agriculture (El Benni and Lehmann, 2010) contributing 33% to total agricultural gross revenues (FOAG, 2013)[2]. The analysis of vertical price transmission in beef agri-food chains has been the subject of several studies on European markets (Bakucs and Fertö, 2006, Bakucs et al., 2013, Bojnec and Günter, 2005, Guillen and Franquesa, 2010, London Economics, 2004, Palaskas, 1995) and non-European markets (e.g. Goodwin et al., 1999, Griffith and Piggott, 1994, Ward et al.,

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[1] While concentration is the Swiss retail market is remarkably high, research on vertical (a)symmetric price transmission is, to our knowledge, limited to one paper that analyzed vertical price transmission in the Swiss pork market using monthly farm-gate and retail prices between 1988 and 1997 (Abdulai, 2002).

[2] Total agricultural revenues were 9.98 billion Swiss Francs (CHF) in 2012. Animal production made up 47% and plant production 42% of total agriculture gross revenues with the remaining 11% resulting from agricultural services (e.g. agrotourism). Milk production contribute 21%, cattle production 12%, pork production 8%, and poultry, eggs and others 6% to total agricultural gross revenues (FOAG, 2013).

2000)[3]. These studies share the limitation that potential interactions (and differences) between beef and veal prices are not considered. In contrast, these studies focus mostly on beef or possibly combined beef and veal prices but veal prices are rarely considered in separated analyses[4]. These studies do not account for the interrelation between calf/heifer and bovine production respectively and the fact that, at the consumption level, veal and beef may be (at least partly) substitutes. But, veal and beef markets are naturally connected to each other because farmers can, e.g. dependent on actual market prices, decide on whether to slaughter the calves or to continue with fattening beef cattle. Furthermore, high cross-price elasticities at the consumers' level (e.g. Lambert et al., 2006) may affect vertical price transmission processes. Thus, not considering potential interactions between calves/heifers and bovine at the production level and beef and veal at the consumption level may cause spurious inference on price transmission in these agri-food chains. An additional limitation of the vertical price transmission literature at large is that it usually focusses on farm-gate and retail data[5], which does not allow a distinction between different possible downstream channels. However, beside the retail channel other channels can be equally important with respect to the quantity of meat distributed towards final consumers. For instance, 52% of total meat in Switzerland in 2011was distributed over retailers and 48% over the food service industry, i.e. restaurants, hotels or cafeterias (Proviande, 2011). This figure shows that different downstream channels can be of equal importance for agri-food chains and, if possible, should be analyzed separately. Differences between channels can be expected with respect to the quality and origin of meat; packaging sizes used as well as market concentration at the downstream level. Furthermore, consumption patterns are expected to be heterogeneous across these channels (Richards and Mancino, 2014). In this study, we aim to contribute to overcome the above described limitations in the price transmission literature by using upstream and downstream prices for the retail and the restaurant channel. In addition, we jointly consider beef and veal prices, which allow us to test for the relevance of interactions between both types of meat. Our analysis is based on monthly data of Swiss beef and veal prices for the period December 2004 to February 2013. Specifically, acquisition prices (i.e. producer prices including transportation costs) and net earnings of the processing and distribution sector for meat sold in the retail and restaurant channel (i.e. consumer prices excluding specific costs) is used. Thereby, the retail prices describe those prices paid by the final consumer and the restaurant prices those paid by the restaurants to the upstream industries. We estimate vector autoregressive (VAR) models and vector error correction (VEC) models and test for the causality of price relations in the above mentioned marketing channels. Furthermore, we test for asymmetries in price transmission processes to investigate whether the downstream sector exercises market power over producers.

2. Method

2.1 Integration and cointegration

In the first step of our price transmission analysis the order of integration of the time series is assessed using ADF tests (Dickey and Fuller, 1979). As the actual data generating process is not known in advance we follow the procedure recommended by Dolado et al.

[3] Overviews on the price transmission literature in other agribusiness sectors have been recently given, for instance, in Assefa et al. (In Press), Bolotova and Novakovic (2012), Capps et al. (2013) and Kaditi (2013).

[4] To our knowledge only one recent study analyzes the transmission of veal prices (Ihle et al., 2012), which focusses on horizontal price transmission across European markets, including policy impacts and effects of the blue tongue disease on transmission processes. It must furthermore be noted that a couple of studies concerned with beef markets have investigated the effect of the BSE (Bovine Spongiform Encephalopathy) crisis on the transmission of beef prices between the farm gate and retail level (e.g. Sanjuán and Dawson, 2003, Lloyd et al., 2006, Hassouneh et al., 2010). However, given the different focus of these papers and since asymmetry is not investigated in those studies the respective results are not discussed here. Furthermore, the BT (blue tongue) disease strongly affected many countries within the European Union but only a few dozen cases were recognized in Switzerland (FSO, 2009) and thus we do not expect any influences of the crisis on the results of this study.

[5] Only few studies analyze wholesale prices along with producer and retail prices (e.g. Lloyd et al. 2001, Lloyd et al., 2002).

(1990) and consider all possible trends and intercept specifications to identify whether a constant and/or trend should enter the equation. The AIC criterion is used to select the appropriate lag length[6].

In a second step the Johansen test (Johansen, 1991, 1995) is used to test whether the time series are cointegrated, i.e. whether stationary linear relations between non-stationary time series exist[7]. Cointegrated variables do not drift apart during time but move together and can thus be economically interpreted as long-run price equilibrium in the underlying study. Johansen (1991, 1995) proposes the trace and maximum eigenvalue test statistics to determine the number of cointegration vectors r in the system of prices[8] (see e.g. Paruolo, 2001 for a comparison between these tests). The Null hypothesis underlying the trace test is that there are at most r cointegration relations against the alternative of n cointegration relations. In contrast, the Null in the maximum eigenvalue test is that there are r cointegration relations against the Alternative of r+1 cointegration relations. We expect at least one cointegration relation, i.e. long run price equilibrium, in our analysis because beef and veal share (at least partly) the same production process and are, at least partially, substitutes from the consumers` perspective. Furthermore, we assume a non-zero intercept in the cointegration relation, reflecting (at least) processing costs. This choice is reasonable in the underlying study as the difference, i.e. the margin, between the up- and downstream prices is expected to be stationary around a non-zero mean because of fixed costs.

2.2 Granger causality and asymmetric price transmission

In a third step, vector-autoregressive models (VAR models) are estimated to test for Granger causality between the different prices. If the above described procedure reveals cointegrated, time series this would confirm the existence of a (one- or bi-directional) Granger causality between them. VAR models are used in our analysis (and Granger causality is investigated) as no priori causal relationship between up- and downstream prices as well as beef and veal prices can be made[9]. We use the procedure described by Toda and Yamamoto (1995) to reveal the direction of price flows across products, i.e. beef and veal, and between up- and downstream stages. We expect differences in the Granger causality patterns between the marketing channels due to differences in the share of labeled and imported meat as well as differences in the consumption patterns in the restaurant (out-of-home consumption) and retail channel (home consumption) respectively (Richards and Mancino, 2014)[10].

[6] To account for potential losses in power due to too small degrees of freedom, we follow Trapletti et al. (2013) and consider a maximal lag length of $(n(p)-1)^{1/3}$ with n being the number of observation of price series p.

[7] Optimal lag length selection is crucial for cointegration analysis using the Johansen test (Emerson, 2007). Lütkepohl (1993) showed that underfitting the lag length (selecting a lower order lag length than the true lag length) generates autocorrelated errors and that overfitting the lag length causes an increase in the mean-square forecast errors of the VAR. We have chosen to set the maximum lag length according to the formula of Trapletti et al. (2013).

[8] Most studies (including this one) first test the time series on their order of integration arguing that cointegration can only exist between variables of the same order of integration (most often I(1)). In contrast, Johansen (1995) states that variables must not necessarily be pre-tested, since the integration properties reveal themselves through the cointegration vector. For instance, if one variable is I(1) and the other I(0) the Johansen test will find one cointegration vector whose space is spanned by the only stationary variable in the model. In case of full rank, i.e. if there are as many ranks as variables, the time series are stationary (Hjalmarsson and Österholm, 2007).

[9] Granger causality tests are used to determine those price time series that can be used to predict other price time series without loss of information. More precisely, if e.g. "price series y_t contains information in past terms that helps in the prediction of x_t and if this information is contained in no other series used in the predictor, then y_t is said to (Granger)-cause x_t" (Granger, 1969: 430). In this sense, Granger causality does not measure real causality but investigate whether one time series follows another time series.

[10] In addition, knowledge on price relations enables researchers to correctly separate dependent and independent variables from each other.

In the VAR models, each of the two price series y_t and x_t is explained by its own lagged values and the lagged values of the other time series, i.e. y_{t-1} to y_{t-p} and x_{t-1} to x_{t-p} respectively, with v_t^y and v_t^x being the error terms[11]:

$$\begin{aligned} y_t &= \beta_{y0} + \beta_{yy1}y_{t-1} + \cdots + \beta_{yyp}y_{t-p} + \beta_{yx1}x_{t-1} + \cdots + \beta_{yxp}x_{t-p} + v_t^y \\ x_t &= \beta_{x0} + \beta_{xx1}x_{t-1} + \cdots + \beta_{xxp}x_{t-p} + \beta_{xy1}y_{t-1} + \cdots + \beta_{xyp}y_{t-p} + v_t^x \end{aligned} \qquad (1)$$

The choice of lag selection for the VAR model is based on different criteria (AIC, BIC and HQC[12]) and on residual tests for autocorrelation, heteroscedasticity and normality. The general approach is to fit VAR(p) models with different orders p and choose the value of p which minimizes the model selection criteria[13]. For each variable in the price system, we test the Null hypothesis that past realizations of a variable have no significant effect on the current realization of another price variable. In all models, heteroscedasticity and autocorrelation corrected standard errors are reported. If the price time series follow a I(1) process and if they are cointegrated, vector-error-correction (VEC) models reveal both the short- and long-run price relations. Furthermore, we use this framework to test for asymmetric price transmission:

$$\begin{aligned} \Delta y_t &= \beta_{y0} + \beta_{y1}\Delta y_{t-1} + \cdots + \beta_{yp}\Delta y_{t-p} + \gamma_{y1}\Delta x_{t-1} + \cdots + \gamma_{yp}\Delta x_{t-p} \\ &\qquad - \lambda_y^+(y_{t-1} - \alpha_0 - \alpha_1 x_{t-1})^+ - \lambda_y^-(y_{t-1} - \alpha_0 - \alpha_1 x_{t-1})^- + v_t^y \\ \Delta x_t &= \beta_{x0} + \beta_{x1}\Delta y_{t-1} + \cdots + \beta_{xp}\Delta y_{t-p} + \gamma_{x1}\Delta x_{t-1} + \cdots + \gamma_{xp}\Delta x_{t-p} \\ &\qquad - \lambda_x^+(x_{t-1} - \alpha_0 - \alpha_1 y_{t-1})^+ - \lambda_x^-(x_{t-1} - \alpha_0 - \alpha_1 y_{t-1})^- + v_t^x \end{aligned} \qquad (2)$$

The parameters of the lags of the differenced prices Δx and Δy respectively show the short term relationship between the prices. The short term adjustment parameters λ_y^+ and λ_y^- show how prices adapt to short run positive and negative deviations from the long run price equilibrium, which is captured by the error correction term $(y_{t-1} - \alpha_0 - \alpha_1 x_{t-1})$. More precisely, a positive (negative) value of the error correction term shows that the price is above (below) its equilibrium level. This suggests that prices have to move downwards and upwards respectively in order to adjust to the long run price equilibrium. Prices that significantly adjust to the long run price equilibrium are said to be endogenous. In contrast, prices that do not adjust are said to be weakly exogenous. This particularly implies that the price under consideration is the leading price within the system, since it is not influenced by any other price but determined outside the system. The Null of no exogeneity $H_0: \lambda = 0$ is tested by using F-tests[14], whereby $\lambda = \lambda_x^+ + \lambda_x^-$. This condition also allows for performing F-Tests on the Null of symmetry in the price transmission process $\lambda_x^+ = \lambda_x^-$ (von Cramon-Taubadel, 1998). Rejecting the Null implies that positive and negative deviations from the long run equilibrium are adjusted with different speed, meaning for instance, that retail prices respond differently to increases or decreases in farm prices which provides evidence of market failure or the abuse of market power (Meyer and von Cramon-Taubadel, 2004). All analyses are carried out separately for the retail and the restaurant channel. This is done because cross-price elasticities of demand are expected to be rather unelastic between these channels. For instance, Richards and Mancino (2014) found little willingness to substitute food-out-of-home

[11] In both equations, it is tested whether a trend or seasonal dummy variable has a significant effect on the price explained in the regression model . In case of significance the trend and/or seasonal dummy variables is included in the final model.

[12] AIC: Akaike information criterion, BIC: Bayesian information criterion, HQC: Hannan-Quinn information criterion.

[13] To overcome potential pretest biases with regard to integration and cointegration of the time series, we complement our analysis by following the procedure proposed by Toda and Yamamoto (1995). Therefore, the lag length is determined by $p=k+d_{max}$ with k being the lag lenth selected by the selection criteria and d_{max} being the maximal order of integration, which we expect to occur in the model. To infer on Granger causality between the different time series F-test are applied on the first k coefficients, while the d_{max} coefficients are ignored (since these are regarded as zeros).

[14] It must be noted, that Granger-causality is an implication for conditional (i.e. weak) exogeneity (White and Pettenuzzo, 2014) but Granger non-causality is neither necessary nor sufficient for weak exogeneity (Ericsson, 1994).

for food-at-home. In addition, the loss of degrees of freedom would be substantial if all price series would be analyzed within one system.

3. Data

This study is based on monthly upstream (producer) and downstream (sales) prices for beef and veal in Swiss Francs per kg dead weight (CHF/kg DW) without value added tax and some specific costs (i.e. excluding disposal fees, refining losses, basic marketing costs, heavy vehicle fee) over the time period December 2004 to February 2013. More precisely, the retail prices are those paid by the final consumers to the retailers. The prices of the restaurant channel are those paid by the restaurants to the upstream industry (i.e. to the processors). All prices used in this study are collected and edited by the Market Observation Group of the Swiss Federal Office for Agriculture and represent real prices (base January 1999). In total, eight price series are considered in our analysis, namely up- and downstream prices for beef and veal for both the retail and the restaurant channel. Upstream prices are acquisition prices, i.e. those paid on the processors stage to the producers including transportation costs[15]. Downstream prices are net earnings of the processing and distribution sector, i.e. prices paid by the final consumers for food bought at retailers and prices paid by restaurants to the processing industries, respectively. The downstream prices for the restaurant channel not only include prices paid for food sold at restaurants but also at kiosks and cafeterias and for convenience products that are bought out-of-home but are eaten at home. Differences between downstream prices in the retail and restaurant channel are due to i) differences in the share of labeled meat, which is lower in the restaurant than the retail channel, ii) bigger package sizes in the restaurant compared to the retail channel, and iii) a higher share of imports on the total of processed meat in the restaurants compared to the retail channel[16] (FOAG, personal communication). As shown in Figure 1, with 17.64 CH/kg DW for beef and 24.53 CHF/kg DW for veal, downstream prices for the retail channel are substantially higher than downstream prices for the restaurant channel, with 13.59 CHF/kg DW for beef and 19.55 CHF/kg DW for veal. This is mainly because prices for the restaurant channel are not collected at the level of the final consumer but at the previous stage in the value chain, i.e. downstream prices of the restaurant channel are those paid by restaurants to the processing industries. In contrast, no significant differences in upstream prices between the two channels are found. For the retail channel, the average upstream prices are 8.13 CHF/kg DW for beef and 12.68 CHF/kg DW for veal. For the restaurant channel, average upstream prices of 7.91 CHF/kg DW are observed for beef and 13.04 CHF/kg DW for veal. Thus, margins of the retail channel are slightly higher than margins of the restaurant channel.

We use ADF tests to examine the underlying data generating processes of the time series. To this end, the order of integration is estimated for three different models: Model 1 with neither constant nor trend, Model 2 with a constant only and Model 3 with both constant and trend. In all models seasonal dummy variables are considered. The test statistics in Table 1 show that all of the time series follow a stationary process of order one, i.e. an I(1) process.

[15] According to the Market Observation Group of the Swiss Federal Office for Agriculture, the upstream prices also exclude any advantages due to import tariffs.
[16] All prices analyzed in this study represent prices of domestically produced and processed meat. Nevertheless, as a result of competitive pressure, prices for domestic meat are lower the higher the share of imported meat is.

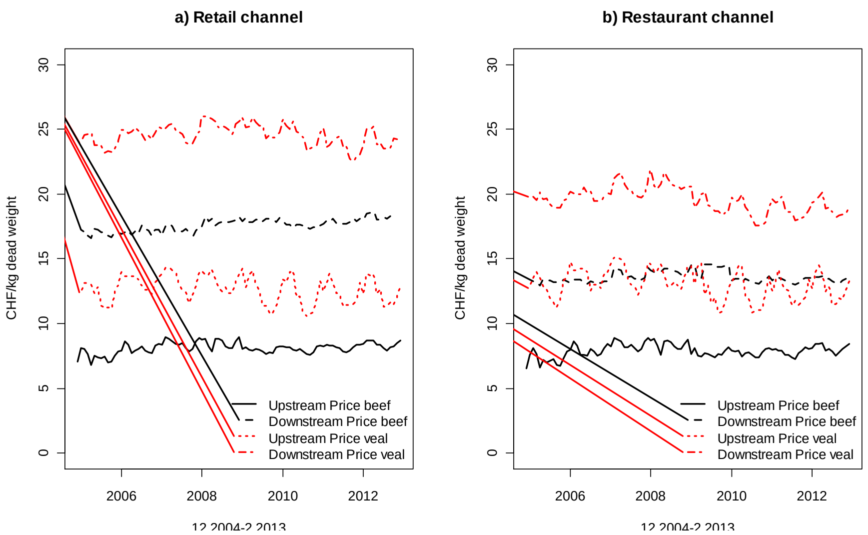

Figure 1. Up- and downstream prices for beef and veal distributed to the retail and restaurant channel

Table 1. Results of the ADF test statistics for beef and veal in the retail and restaurant channel

	Retail channel				**Restaurant channel**			
	beef		**veal**		**beef**		**Veal**	
	DP_{beef}	UP_{beef}	DP_{veal}	UP_{veal}	DP_{beef}	UP_{beef}	DP_{veal}	UP_{veal}
data in levels								
Model 1	0.912	0.508	0.214	-0.040	0.156	0.642	0.010	0.060
Model 2	0.049	-1.147	-1.902	-2.239	-1.722	-1.506	-1.131	-1.641
Model 3	-1.910	-1.330	-1.970	-2.515	-1.706	-1.452	-1.638	-2.521
data in first differences								
Model 1	-3.832***	-9.247***	-4.552***	-5.751***	-6.622***	-9.245***	-4.959***	-5.988***
Model 2	-3.425**	-9.999***	-5.344***	-8.672***	-5.462***	-10.523***	-6.180***	-8.992***
Model 3	-5.767***	-9.930***	-5.358***	-8.649***	-5.433***	-10.482***	-6.156***	-8.948***

Model 1: no constant, Model 2: constant, Model 3: constant and trend; DP: downstream price, UP: upstream price. ** and *** indicate that the hypothesis of stationarity is rejected at the 5% and 1% level of significance.

For the retail as well as the restaurant channel Johansen cointegration tests are applied to the four-price-system including up- and downstream prices for beef and veal. The optimal lag length for the Johansen cointegration tests is found to be 1 for the retail and the restaurant channel. In both models a constant restricted to the cointegration vector was assumed, representing a non-zero margin between the up- and downstream prices. The results of the Johansen cointegration tests are presented in Table 2 and show that for each of the system at least one cointegration relationship exists. Even if the hypothesis of having a maximum of two integration vectors could not be clearly rejected for the restaurant channel, we impose only one cointegration vector in the VEC model (following Esposti and Listorti, 2013) to enable a straight forward economic interpretation, i.e. the existence of one long run equilibrium between the price series.

Table 2. Johansen Cointegration Tests for beef and veal in the retail and restaurant channel (r:cointegration rank)

	Trace Test			**Maximum Eigenvalue Test**		
	$H_0: r = 0$ $H_A: r \geq 1$	$H_0: r \leq 1$ $H_A: r \geq 2$	$H_0: r \leq 2$ $H_A: r \geq 3$	$H_0: r = 0$ $H_A: r = 1$	$H_0: r = 1$ $H_A: r = 2$	$H_0: r = 2$ $H_A: r = 3$
Retail channel	61.851**	28.669	11.729	33.182***	33.182***	8.7412
Restaurant channel	112.53***	33.911*	11.289	78.615***	22.622**	7.037

*, **, and *** indicate that null hypothesis is rejected a t the 10%, 5% and 1% level of significance, respectively.

In addition, Johansen tests are applied to pair-wise price series to investigate whether the cointegration relations found for the four-price systems (see Table 2) are the result of interactions between the types of meat (beef and veal) and/or between up- and downstream prices (see Esposti and Listorti (2013) for a similar approach). For the retail channel it shows that one cointegration relation exists between the up- and downstream prices for beef and between downstream prices of beef and upstream prices of veal. For the restaurant channel it shows that one cointegration relation exists between the upstream and downstream prices for veal and between upstream prices for veal and beef. These results underline the importance of including both types of meat - veal and beef - in the price transmission analysis.

4. Results

4.1 Granger causality

In this section the results of the VAR-models (eq. 1) are presented. Based on selection criteria and the residual diagnostic results, two price lags for the retail and two price lags for the restaurant channel are included[17]. The standard errors of the parameters are robust against heteroscedasticity. For both, the retail and restaurant channel, residual diagnostics show no problems with autocorrelation for neither model. For both channels, the residual variance is homoscedastic for all models but for upstream prices of beef. The Doornik-Hansen test indicates no significant difference from normality of the multivariate price system for the retail channel but for the restaurant channel (not shown here). Furthermore, all unit roots lie inside the unit root circle implying stable systems for the retail as well as restaurant channel. Wald tests indicate significant effects of the seasonal dummies that are therefore included in all models (not shown here). As prices have been found to be cointegrated, showing that there must be some Granger causality, the VAR models are used to specify the direction of price flows across products and up- and downstream stages. More specifically, Granger causality between the up- and downstream prices of beef and veal along the retail and restaurant channel is tested using F-tests. For the retail channel the results in Table 3 show that downstream prices for beef DP_{beef} are Granger caused by previous up- and downstream prices of beef but not by the veal prices. The same is true for the downstream prices of veal DP_{veal} that are Granger caused not only by previous downstream prices but also by previous upstram prices of veal but not by beef prices. In contrast, upstream prices of beef UP_{beef} and veal UP_{veal} can be predicted mainly by upstream prices of previous months. Furthermore, upstream prices of veal are significantly affected by up- and downstream prices of beef (but only at a 10% level). This underlines again the necessity to investigate price transmission problems in beef and veal markets, simultaneously.

The VAR model results for the restaurant channel are presented in Table 4. It shows that downstream prices of beef are Granger caused by its own lagged prices. The same is true for the upstream prices of beef. Thus, no relation between up- and downstream prices for beef can be observed in the here considered time series. In contrast, a bi-directional relation between up- and downstream prices of veal can be observed. And the first lag of the veal upstream price significantly affects upstream prices of beef (even if only at the 10% significance level).

[17] Furthermore, following the procedure proposed by Toda and Yamamoto (1995) additional models including one additional lag in each of the models (as we assume one cointegration relation between the price series) are estimated and F-tests are carried out on the first two and first three coefficients, respectively. However, as this does not change the qualitative interpretation of the results, the respective models are not shown here, but can be provided by the authors upon request.

Table 3. Retail channel: VAR model results and Granger Causality tests

	DP_{beef}	UP_{beef}	DP_{veal}	UP_{veal}
Constant	-0.613 (0.958)	0.133 (1.456)	1.956 (1.358)	6.523*** (2.256)
$DP_{beef\ t-1}$	0.538*** (0.107)	-0.053 (0.117)	-0.032 (0.161)	-0.282 (0.252)
$DP_{beef\ t-2}$	0.440*** (0.109)	0.084 (0.128)	0.028 (0.147)	-0.005 (0.255)
$DP_{veal\ t-1}$	-0.008 (0.075)	-0.037 (0.074)	0.528*** (0.155)	-0.101 (0.127)
$DP_{veal\ t-2}$	0.012 (0.067)	0.007 (0.070)	0.358** (0.139)	0.143 (0.131)
$UP_{beef\ t-1}$	0.298** (0.119)	0.701*** (0.171)	-0.044 (0.151)	-0.132 (0.294)
$UP_{beef\ t-2}$	-0.207* (0.108)	0.090 (0.159)	0.067 (0.129)	0.418 (0.258)
$UP_{veal\ t-1}$	0.040 (0.048)	0.074 (0.060)	0.334*** (0.083)	0.753*** (0.115)
$UP_{veal\ t-2}$	-0.033 (0.048)	0.030 (0.055)	-0.268*** (0.077)	-0.117 (0.115)
adjusted R^2	0.88	0.76	0.86	0.83
F-Tests of all lags (Test on Granger causality)				
DP_{beef}	206.03***	0.236	0.020	3.076*
DP_{veal}	0.025	0.329	141.03***	0.597
UP_{beef}	3.177**	54.209***	0.140	2.425*
UP_{veal}	0.426	2.223	9.034***	27.023***

DP: downstream price, UP: upstream price. *,**, and *** indicate significant differences from zero at the 10%, 5%, and 1% respectively once for the single lags (upper panel) and once over all lags (lower panel).

Table 4. Restaurant channel: VAR model results and Granger Causality tests

	DP_{beef}	UP_{beef}	DP_{veal}	UP_{veal}
Constant	0.453 (0.552)	-0.147 (1.114)	0.800 (0.811)	5.352*** (1.975)
$DP_{beef\ t-1}$	0.961*** (0.114)	-0.166 (0.124)	-0.202 (0.149)	-0.478 (0.504)
$DP_{beef\ t-2}$	-0.060 (0.100)	0.177 (0.134)	0.163 (0.141)	0.114 (0.435)
$DP_{veal\ t-1}$	0.004 (0.055)	-0.012 (0.132)	0830*** (0.106)	0.608** (0.272)
$DP_{veal\ t-2}$	0.020 (0.050)	-0.036 (0.103)	0.056 (0.076)	-0.129 (0.182)
$UP_{beef\ t-1}$	0.017 (0.075)	0.690*** (0.163)	-0.043 (0.116)	-0.225 (0.309)
$UP_{beef\ t-2}$	0.029 (0.059)	0.084 (0.115)	0.129 (0.085)	0.343 (0.238)
$UP_{veal\ t-1}$	0.010 (0.031)	0.103* (0.060)	0.374*** (0.069)	0.394** (0.165)
$UP_{veal\ t-2}$	-0.007 (0.031)	0.063 (0.051)	-0.238*** (0.060)	-0.180 (0.148)
adjusted R^2	0.87	0.76	0.94	0.81
F-Tests of all lags (Test on Granger causality)				
DP_{beef}	92.755***	0.959	0.941	1.762
DP_{veal}	0.191	0.251	67.281***	3.805**
UP_{beef}	0.643	52.608***	1.818	1.290
UP_{veal}	0.058	1.857	23.697***	3.645**

DP: downstream price, UP: upstream price. *,**, and *** indicate significant differences from zero at the 10%, 5%, and 1% respectively once for the single lags (upper panel) and once over all lags (lower panel).

The comparison of Granger causality results in the retail and restaurant channel shows differences in the price relationships. For instance, in the retail channel up- and downstream prices of beef affect upstream prices of veal. In contrast, only weak interaction effects between beef and veal prices can be observed in the restaurant channel. Furthermore, in the retail channel, upstream prices of beef and veal, respectively, can be used to predict downstream prices for both types of meat. This is not true for the restaurant channel, where up- and downstream prices of beef do not significantly affect each other.

4.2 VEC models and tests for asymmetric price transmission

VEC models are estimated since each of the price series is I(1) and cointegration between the beef and veal prices was found for both the retail and the restaurant channel. In a first step, the long-run price equilibrium is estimated. Deviations from this long-run equilibrium (i.e. the error terms) are then divided into positive and negative deviations to model potential asymmetry in price adjustments dependent on whether the margins are squeezed or stretched.

In the case of positive asymmetric price transmission, price reactions that squeeze the margins (i.e. an increase in inputs prices or a fall in output prices) are transmitted more rapid than equivalent price movements that stretch the margin. Subsequently, negative asymmetric price transmission refers to price reactions that stretch the margin (i.e. that result in a decrease in input prices or an increase in output prices), and which are transmitted more rapidly than equivalent price movements that squeeze the margin (Meyer and von Cramon-Taubadel, 2004). For the retail and restaurant channel the long-run price equilibrium between the downstream prices DP and upstream prices UP of beef and veal is given by the following equations (with standard errors in parentheses and ***, **, * denoting significance at the 1, 5, and 10% level, respectively):

Retail channel:

$$1 \times DP_{beef} - \underset{(0.39)}{1.64^{**}} \times UP_{beef} - \underset{(0.23)}{0.43^{*}} \times DP_{veal} + \underset{(0.28)}{1.62^{***}} \times UP_{veal} - \underset{(4.69)}{14.18^{*}} \text{ CHF/kg DW} = 0$$

Restaurant channel:

$$1 \times DP_{beef} - \underset{(0.30)}{0.53} \times UP_{beef} - \underset{(0.38)}{1.84^{***}} \times DP_{veal} + \underset{(0.37)}{2.81^{***}} \times UP_{veal} - \underset{(3.03)}{10.04^{**}} \text{ CHF/kg DW} = 0$$

For both models, the constant term is found to be significantly different from zero, showing an average margin of about 14 CHF/kg DW for the retail and a 10 CHF/kg DW for the restaurant channel. As described above, margin differences between the channels are due to differences in the share of labeled meat, differences in the share of imported meat and packaging size. However, no significant difference between the constant terms (i.e. the average margins) in the long-run equilibrium equation is found. Furthermore, the estimates show that up- and downstream prices of veal are more important in determining the equilibrium in the restaurant than in the retail channel (i.e. the magnitude of the coefficients is higher for the restaurant compared to the retail channel). In contrast, upstream prices of beef do not have a significant effect on the long-run equilibrium in the restaurant channel, but in the retail channel. All differences between the estimates of the price parameters of the retail and restaurant channel are significant. The results of the asymmetric VEC-models (eq. 2) for the retail and restaurant channel, respectively, are presented in Table 5 and Table 6. For both channels, it shows that upstream prices for veal are adjusted significantly if prices deviate from the long-run price equilibrium. For all other prices, no significant adjustment is observed in case of a short-run deviation from the price equilibrium, which suggests that these prices are weakly exogenous[18].

Table 5. Results of the asymmetric VEC-models for the retail channel

row		**Beef**		**Veal**	
		ΔDP_{beef}	ΔUP_{beef}	ΔDP_{veal}	ΔUP_{veal}
1	$\Delta DP_{beef\ t-1}$	-0.403*** (0.114)	-0.095 (0.150)	-0.069 (0.151)	-0.130 (0.245)
2	$\Delta UP_{beef\ t-1}$	0.259** (0.109)	-0.006 (0.193)	-0.061 (0.124)	-0.476* (0.267)
3	$\Delta DP_{veal\ t-1}$	0.003 (0.066)	0.023 (0.070)	-0.414*** (0.132)	-0.192 (0.117)
4	$\Delta UP_{veal\ t-1}$	0.024 (0.047)	0.008 (0.057)	0.297*** (0.077)	0.149 (0.117)
5	EC+	-0.008 (0.033)	-0.070 (0.044)	0.042 (0.047)	-0.187** (0.087)
6	EC-	0.001 (0.047)	0.029 (0.035)	0.045 (0.069)	-0.225*** (0.073)
	adjusted R^2	0.17	0.38	0.47	0.58

DP: downstream price, UP: upstream price. *, ** and *** indicate that the null hypothesis of the coefficient being equal to zero is rejected at the 10%, 5% and 1% level of significance, respectively.

[18]In a first step, VEC-models with an error correction term showing the adjustment to the deviations from the long-run price equilibrium independently on whether the deviations are positive or negative were estimated. The estimates from this combined effect were used to test for weak exogeneity of prices within the system (not shown here). In a second step the error correction term was divided into positive and negative deviations from the long-run price equilibrium. These results are shown in Table 5 and 6 respectively.

Table 6. Results of the asymmetric VEC-models for the restaurant channel

row		Beef		Veal	
		Δ DP_{beef}	Δ UP_{beef}	Δ DP_{veal}	Δ UP_{veal}
1	Δ $DP_{beef\ t-1}$	0.041 (0.083)	-0.111 (0.149)	-0.199 (0.156)	-0.304 (0.450)
2	Δ $UP_{beef\ t-1}$	0.007 (0.062)	-0.059 (0.155)	-0.085 (0.096)	0.385 (0.261)
3	Δ $DP_{veal\ t-1}$	0.012 (0.040)	0.136 (0.062)	-0.079 (0.079)	0.102 (0.190)
4	Δ $UP_{veal\ t-1}$	-0.004 (0.031)	0.014 (0.062)	0.233*** (0.058)	0.160 (0.130)
5	EC+	-0.009 (0.015)	-0.065 (0.044)	0.054* (0.028)	-0.190** (0.075)
6	EC-	0.022 (0.019)	0.060 (0.037)	0.028 (0.036)	-0.312*** (0.076)
	adjsuted R^2	0.16	0.32	0.64	0.58

DP: downstream price, UP: upstream price. *, ** and *** indicate that the null hypothesis of the coefficient being equal to zero is rejected at the 10%, 5% and 1% level of significance, respectively.

The results furthermore show that upstream prices for veal adjust more rapidly when margins are too low (i.e. a negative deviation from the long run equilibrium is observed), compared to situations where they are too high. This leads to the conclusion that producer prices for veal are adjusted downward in order to allow the whole system to be shifted back to the long-run price equilibrium. No evidence is found in either model that positive and negative deviations from the long-run equilibrium are adjusted with different speed. Thus, no asymmetric price transmission can be observed, neither in the retail nor the restaurant channel.

5. Discussion and conclusion

In this paper monthly up- and downstream prices for beef and veal between December 2004 and February 2013 are analyzed in one system. We test for Granger causality and asymmetric price transmission in the Swiss retail and restaurant channel. The results of the Granger causality analysis show significant relations between beef and veal prices for the retail as well as the restaurant channel. Moreover, differences in Granger causality are found across both channels.

In the retail channel, upstream prices of beef and veal Granger cause downstream prices of beef and veal, respectively, but not the other way around. These results are in line with other studies[19] and suggest that beef and veal prices are set at the farm-gate and transmitted to the upstream industry. However, the empirical results of this study also suggest that the upstream prices of veal are Granger caused by up- and downstream prices of beef. This result is supported by results of the pairwise Johansen cointegration tests that suggest a cointegration relation between downstream prices of beef and upstream prices of veal. Thus, while a product-by-product comparison would have suggested uni-directional relations from up- to downstream prices the across-product analysis reveals that price relations between both types of meat are significant and that beef or veal only considerations would be misleading.

In contrast to the results for the retail channel, no Granger causality between up- and downstream prices of beef and a bi-directional relation between the veal prices are found for the restaurant channel. Thus, compared to the retail channel, less price relations can be observed for the restaurant channel. This lower interaction between up- and downstream prices of meat in the restaurant channel might be particularly caused by a higher and more flexible share of imported as well as unlabeled meat compared to the retail channel.

The results of the error correction models show that, if the price system deviates (due to external shocks) from the long-run equilibrium, upstream veal prices are adjusted while all other prices do not change significantly, i.e. all other prices are weakly exogenous. This

[19] For instance, using monthly farm-gate and retail prices for 1992-2000 and 1990-2000, respectively, Bakucs and Fertö (2006) and Bojnec and Günter (2005) found retail prices following producer prices in the Hungarian and Slovenian beef markets.

observation is true for the retail as well as the restaurant channel. While the adjustment of upstream veal prices is not surprising, given that slaughtering calves can be postponed in case of unfavorable market conditions. The result nevertheless shows that prices in downstream sectors do hardly depend on producer prices. For neither the retail nor the restaurant channel the Null hypothesis of symmetric price transmission could be rejected. Thus, there is no empirical evidence that the downstream industry exercises market power over producers, which is in line with other studies conducted for the beef market in European countries (Bakucs and Fertö, 2006, Lloyd et al., 2002, London Economics, 2004).

In conclusion, our analysis shows that considering cross-product relations can alter the conclusions drawn from price transmission models. Especially for interrelated products such as beef and veal, which share (at least partly) the same production process and which may be substitutes from the consumers' perspective, the estimation of price transmission across multiple products allows us to gain more detailed insights into the functioning of markets than single product analyses. Furthermore, this study shows that the results for the same products can differ between marketing channels, a topic that has, to our knowledge, not been investigated so far and that needs attention in future research.

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