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Price Dependence in the Supply Chain on the Mushroom Market in Canada

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ABSTRACT

The aim of this dissertation is to assess the dependence in the mushroom supply chain in Canada. Statistical research has proven that there exists vertical transmission of prices between those of the producers, wholesalers and retailers. According to the results, retail prices, which are definitely higher than prices at other distribution levels, did not exhibit a statistically significant relationship with other prices. At this stage of distribution, the level of prices depended mainly on values in previous periods at the same stage of sales. At the stage of wholesale trade and the producer's level, relations in price formation were demonstrated. The autoregressive distributed lag model (ARDL) therefore indicates the occurrence of asymmetry in the transmission of mushroom prices between trade levels. The results suggest that retail prices paid by the final consumers depend on retail prices from previous months. Wholesale prices seem to be significantly affected by both producer prices and retail prices. At the same time, it was pointed out that producer prices depend on prices from previous periods and as well as on those applied at the wholesale level.

Keywords: *price; mushroom; ARDL model; forecasting; price dependence.*

1 Introduction

A complex sales chain on the vegetable market, which includes the share of wholesalers, distributors, producers and traders, has an adverse effect on the flow of stimuli that shape the final price to be paid by the consumer (Vavra & Goodwin, 2005). In order to shed some light on the nature of price movements, economists have attempted to analyze the size, direction and speed at which price changes are transmitted at various stages of the agri-food chain (from farm to processing and to retail levels or vice versa) (Bakucs et al., 2014). Significant price differentials at various levels of the distribution of agricultural products may indicate a lack of integration of these markets (Serra et al., 2006). Consequently, prices do not serve their primary function of providing information on the supply and demand situation using a perfectly competitive market model. (Bakucs et al., 2012). The research on price transmission analyzes the nature of the relationship between price series at various levels of the supply chain (vertical price transmission/vertical integration) or on spatially separated markets (horizontal transmission/spatial integration) (Timer et al., 1983).

Vertical market integration refers to relationships between entities which carry out activities aimed at creating the final product (Goletti et al., 1995; Ghafoor et al., 2009). If the transfer of price signals through particular sales levels is disturbed, it leads to a frequently observed asymmetry in price transmission; as a result, entities at the beginning and at the end of the distribution chain are unable to acquire full information about the situation, which makes it difficult for them to adapt to the market situation (Bakucs et al., 2012). The manner in which price changes are transferred between individual distribution levels constitutes an important factor reflecting the actions of market participants within the market channel. The course of market adjustments to price shocks on the market may have a significant impact on shaping the level of margins and determining the pricing policy by entities involved in the distribution of products (Miller & Hayenga, 2001). The way the entities at particular stages of distribution shape the price level is a crucial issue that directly influences both the consumers and the producers. Understanding this mechanism facilitates taking proper action and choosing relevant strategies (including sales and purchasing) for all participants of a given distribution channel.

In the case of the vegetable market intended for direct consumption, it is important for the flow of price impulses to proceed smoothly, whereas price information reflects the decisions of entities participating in the marketing of these products. (Roche & McQuinn, 2003; Reziti & Panagopoulos, 2008). Vegetable prices are characterized by numerous fluctuations (McLaughlin, 2004) that significantly limit the possibilities of price forecasts in the future (Apergis & Rezitis, 2003) and identifying the mechanism which shape the prices at particular stages of distribution. Due to the importance of the price transmission phenomenon, on next level distribution, this topic has been attracting the attention of scientists on various commodity markets. Among the most recent, one can indicate research studies on the meat market, conducted by e.g. Gervais (2011), El Benni et al. (2014), Emmanouilides & Fousekis (2015), Fousekis et al. (2016), Panagiotou & Stavrakoudis (2017), milk market by e.g. Reziti (2011), Antonioli & Santeramo (2017), or the latest research from 2019 carried out by Rezitis & Tsionas (2019) with regard to the market of cereals and bread; meat; milk, cheese and eggs; oils and fats. In the case of the fruit and vegetable sector, research on price transmission has been carried out in the recent years, among others Assefa, et al. (2014), Pokrivcak & Rajcaniova (2014) or Jurkėnaitė & Paparas (2018) analyzing the potato market. In this area, the research was also carried out by, among others, Pérez-Mesa & Galdeano (2011) on the tomato market, Sexton & Zhang (1996) on the iceberg lettuce or Santeramo (2015) who analyzed tomatoes and cauliflowers sectors. However, it should be noted that there are no available studies on the mushroom market. It should be highlighted that this is a different market compared to other vegetables. It is characterized by much shorter distribution channels, which results, *inter alia*, from the low durability of the product. It should be emphasized that, unlike other vegetables, the specificity of mushroom production ensures a fairly stable output level, which largely eliminates the phenomenon of seasonality.

The developing food industry, along with growing health awareness among consumers around the world, is one of the key factors driving the progress of the mushroom market. Due to the shift in dietary preferences towards vegan foods, mushrooms are preferred as a protein, vitamin and mineral-rich meat substitute (Grimm, Kuenz, Rahmanna, 2020). Moreover, the widespread adoption of the products by the pharmaceutical industry also contributes to the momentum of development of this market. In addition, various advancements in mushroom packaging technology act as another important growth factor. Manufacturers develop moisture-regulating packaging materials that prevent water condensation on the mushrooms, thereby extending their shelf life. Other aspects, including increasing consumption of organic food products, rapid urbanization and increasing consumer spending opportunities, are projected to continue driving the market. Looking ahead, the publisher expects the global mushroom market to reach $ 80.86 billion by 2026 (IMARC Group, 2021). As it has already been mentioned, mushrooms are one of the most popular and most commonly consumed type of food all over the world for their edibility, taste and medical importance (Pallavi et al., 2020).

This topic seems interesting in relation to the Canadian mushroom market. Canada is the eighth largest mushroom producer in the international market, constituting about 1.2% of global production. It should be noted that about 72.5% of globally produced mushrooms originates from China. For comparison, mushroom production in the United States provides about 3.6% of global production. (FAOSTAT, 2016). Total mushroom production has not deviated significantly from the average of 108.4 tons over the last 20 years, while the average value in the said period was 344.96 thousand dollars. In 2019, Canadian businesses produced 145.63 tons of mushrooms with a total worth of 589.47 thousand dollars It should be mentioned that this value has been recently increasing on a year-by-year basis. This tendency continued in 2020 as well. As shown by preliminary estimates of Statistics Canada (the national statistical office), in 2020 the Canadians produced 146.15 tons of mushrooms with a total value of 619.69 thousand dollars (Figure 1).

It should also be noted that 2020 was an usual year due to the the COVID-19 pandemic. As Canada Statistic emphasizes, the impact of the pandemic was reflected in the shift in sales of fresh to processed mushrooms. The number of processed mushrooms increased by a record 52.3% in 2020 compared to the previous year, with most sales occurring at the start of the pandemic. At the same time, it should be noted that the opposite was true for fresh spines, sales of which decreased by almost 3%. This was due, among other reasons, to the fact that most restaurants were closed or offered limited meals for most of the year.

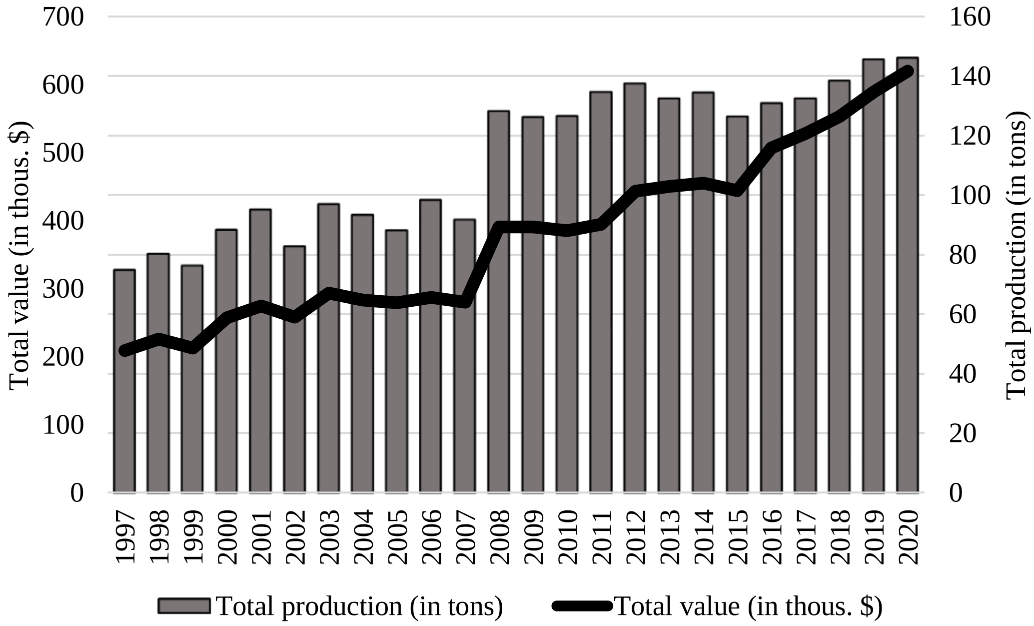

Figure 1. Change in total mushroom production and value in Canada in 1997-2020
Source: Own study based on the data of the Statistic Canada, Mushroom Growers Survey.

According to Statistics Canada, the shutdown of restaurants for personal meals in the early stages of the pandemic prompted some mushroom growers to destroy their crops, while others reduced productivity because they had accumulated a surplus of unsold mushrooms. Despite the initial shock of the pandemic, mushroom growers adapted to the new reality and production was in line with the demand.

There is a large regionalization in mushroom cultivation in Canada. Only two provinces stranded out in the 2020 Canadian mushrooms production, namely Ontario and British Columbia. These provinces alone accounted for 50% and 43% of total production, respectively, and 57% and 30% of the total value, respectively (Figure 2).

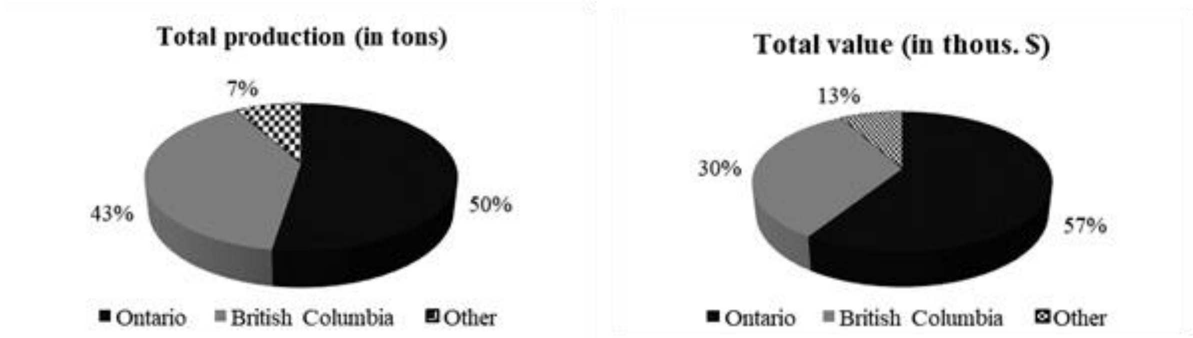

Figure 2. Mushroom growing regions in Canada (the data for 2020)
Source: Own study based on the data of the Statistic Canada, Mushroom Growers Survey.

Due to the aforementioned deficit of research on price relations between individual stages of the chain, the authors tackled the topic of analyzing the relationship between prices at subsequent levels of mushroom distribution in Canada.

In 2020, Canada exported 62,452 short tons of Agaricus mushrooms in 2020, 10.5% more than the year before, with the vast majority exported to the United States (99.2%)[1].

When mentioning the mushroom market in Canada, it should be mentioned that there is little data on the corporate sector. Official data on this issue available from Statistical Canada comes from the Census of Agriculture from 2016. New data in this regard will be available once the current Census of Agriculture is carried out this year. Nevertheless, according to data from 2016, there existed 305 mushroom producers with access to 6.1 million square feet of growing area. Ontario led with more than half (52.3%) of the national mushroom area, followed by British Columbia (37.6%). As one may notice, this is consistent with the production volume data shown in the figures above. It is essential that mushrooms are grown by large undertakings. The average size of a mushroom farm was 33,586 square feet in British Columbia and 23,918 square feet in Ontario. The result of the aforementioned Agricultural Census indicated that there were 194 undertakings specializing in growing mushrooms (the majority of their farm income was from sale of mushrooms).

2 Methodology

The time series used for the study were weekly mushroom prices in Canada in 2010-2020 (in order to present the price levels within the analyzed period, the prices were averaged to the level of the monthly price). Secondary data came from Statistics Canada - Canada's, Infohort - information collection and dissemination system in Government of Canada and National Statistical Agence. FAO. For the estimation, the authors used the EViews statistical package. In the case of modeling dependencies, dynamic econometric models were applied between time series. Popular methods for estimating the dependence between individual stages in distribution chains include, among others, the vector autoregression model (VAR) models or autoregressive model with the autoregressive distributed lag model (ARDL) delay distribution. In this study, to test how prices are determined at particular stages of distribution of mushrooms in Canada, the ARDL model developed by Pesaran & Shin (1998) was applied. This method reduces the problem of data endogenicity in comparison to the aforementioned VAR method. This method distinguishes between dependent variables and explanatory variables. In addition, this method is a better solution for relatively short time series.

In order to study the stationarity of the time series in this paper, the extended Dickey-Fuller test (ADF, Augmented Dickey-Fuller test) was used. These tests are characterized by oppositely formulated null hypotheses.

The ADF test is a regression equation of the form (Maddala, 1997):

$$\Delta y_t = \delta y_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta y_{t-1} + \varepsilon_t \ (1) \tag{1}$$

[1] Official data from Statistic Canada as of 23-06-2021

Where:

δ i γ – structural parameters - estimated using the least squares method,
k – number of delays,
t – time variable,
y_{t-1} – value in the first series of differences in the period t_i,
ε_t – random ingredient.

The null hypothesis for this test states that the series yt is non-stationary due to the occurrence of the unit element, while the alternative hypothesis indicates that the series is stationary.

This test should also be carried out to ensure whether none of the variables is integrated in the order I (2) or more, because in this case the ARDL procedure is not applied (Pesarana et al., 2001)As it has already been mentioned, in order to determine the relationship between the time series variable in the field of the mushroom prices at individual stages of the distribution chain, the model of the autoregressive distributed lag model (ARDL) was used, which gained popularity through the work of Pesaran & Shin (1998) Pesaran, Shin & Smith (2001). ARDL are standard least squares regressions, which include delays of both the dependent variable and explanatory variables, such as regressors (Greene, 2008). The model can be formulated in a general form as follows:

$$y_t = \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \cdots + \alpha_q y_{t-q} + \mu + \beta_0 x_{t-1} + \beta_1 x_{t-1} + \cdots + \beta_p x_{t-p} + \varepsilon \quad (2)$$

where:

y - dependent variable
x – regressor,
t – time,
ε – white noise,
This generally accepted model has been used by the authors in this study.

3 Results

Figure 3 depicts that wholesale and retail prices and producer prices fluctuated during the period 2010-2020. It should be noted here that the retail prices were the most volatile and were characterized by a large variation in individual months. However, when analyzing prices in the long term, the strong importance of seasonality was not clearly indicated.

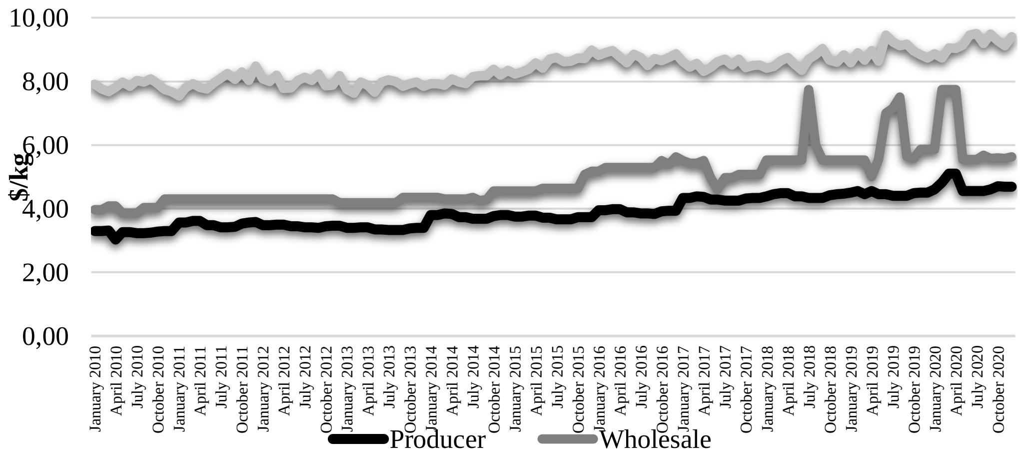

Figure 3. Price level of mushrooms in the analyzed period
Source: Own study based on the data of the Statistic Canada, FAO.

Despite these fluctuations, it should be highlighted that in the period under examination it exhibited a growing tendency. It should also be noted that there is a large discrepancy between retail prices and producer prices or even wholesale prices. It results from the level of margins and markups, which are the highest at this stage of distribution. At the same time, the level of margin at the wholesale stage fluctuated between 6.48% and 32.04%, while in the case of retail sales – 35.68% - 57.87%. Despite the fluctuation of prices at the level of retail sales, the level of margins was definitely more stable. Combining this with the results of the ARDL model parameters carried out at a later stage, this may be due to the way prices for mushrooms are determined at particular stages of distribution.

The Augmented Dickey-Fuller (ADF) test was used in this case. In the ADF stationarity test performed, the appropriate number of information was based on Schwarz's Information Criteria (Schwarz, 1978). The results indicate that initially the variables are non-stationary on the level, but their first differences are stationary. It should be pointed out that the results of cointegration at price levels did not show co-integration, but only the trend-directionality of variables. Therefore, the ARDL model with the deterministic trend will be used for further analysis.

Table 1.

Results of stationarity tests regarding time series of analyzed prices

Prices	ADF test statistics	The critical value for a *p-value* level of significance		
		p-value for 0,01	*p-value for 0,05*	*p-value for 0,1*
Retailer	-11,409	-3,501	-2,892	-2,583
Wholesale	-8,755	-3,501	-2,892	-2,583
Producer	-6,586	-3,501	-2,892	-2,583

Source: Calculations and authors elaboration using the EViews program.

Results of stationarity tests for the first differences of the examined prices

Prices	ADF test statistics	The critical value for a *p-value* level of significance		
		p-value for 0,01	*p-value for 0,05*	*p-value for 0,1*
Retailer	-1,441	-3,501	-2,892	-2,583
Wholesale	-1,312	-3,501	-2,892	-2,583
Producer	-0,735	-3,501	-2,892	-2,583

Source: Calculations and authors elaboration using the EViews program.

Moreover, one should keep in mind that the test of the number of Johansen cointegration vectors (Johansen cointegration test) using the trace test and the maximum value test showed that none of the variables was integrated in order I (2).

After determining that none of the variables is I (2), the ARDL model is executed to investigate the possible presence of cointegration between prices at different levels and to estimate long-term coefficients if such cointegration does exist.

The ARDL model was estimated on the basis of Akaike Information Criterion (AIC) (Akaike, 1973), using a delay of 4, selected on the basis of Schwarz's Information Criteria and amounted to 4. An attempt to estimate model parameters at a different delay size did not positively affect the obtained results, which confirms the correct selection of the delay.

The first model includes the method of price formation at the level of retail sales. This model took the form of ARDL (3,0,0) (Table 2). The results of the model indicate the rejection of the hypothesis regarding the long-term impact of wholesale prices and producer prices on retail prices.

The value of the F statistic for F-Bounds Test was lower than the value of the upper limit I (1) and I (0), indicating that there is no long-term relationship between the prices tested at different levels.

The above results suggest that prices at the last stage of mushroom distribution, i.e. retail prices, depend on prices from previous months, based on the following relationship:

$$\ln(retailer)= 0{,}442retailer\_price(-1) + 0{,}315retailer\_price(-3) +1{,}375 \quad (3)$$

Table 2.
Estimates of ARDL (3,0,0) to retailer prices

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Retailer(-1)	0,442	0,103	4,053	0,000
Retailer(-2)	0,175	0,125	1,258	0,203
Retailer(-3)	0,315	0,108	2,784	0,006
Wholesale	-0,036	0,101	-0,378	0,699
Producer	-0,058	0,115	-0,579	0,544
C	1,375	0,788	1,721	0,061
@Trend	0,002	0,001	1,509	0,135
R-squared	0,835	**Adjusted R-squared**		0,807

Source: Calculations and authors' elaboration using the EViews program.

The estimates of the second model regarding price formation at the wholesale level are presented in Table 3. Estimation of the model parameters suggests that the model assumed the form of ARDL (1,2,1) in ARDL (wholesale price, producer price, retailer price).

Table 3.
Estimates of ARDL (1,2,1) to wholesale prices

Variable	Coefficient	Std, Error	t-Statistic	Prob,*
Wholesale(-1)	0,815	0,058	14,334	0,000
Producer	-0,016	0,133	-0,120	0,904
Producer(-1)	0,195	0,171	1,152	0,248
Producer(-2)	-0,269	0,132	-1,928	0,055
Retailer	0,047	0,066	0,652	0,516
Retailer(-1)	0,159	0,059	2,236	0,027
C	-0,516	0,491	-1,062	0,290
@Trend	0,001	0,001	1,182	0,240
R-squared	0,938	**Adjusted R-squared**		0,945

Source: Calculations and authors' elaboration using the EViews program.

In the case of prices at the wholesale stage in the mushroom distribution chain, the value of the F statistics is higher than the value of the upper limit I (1) and the lower limit I (0), which indicates that there is a long-term relationship between other prices of the distribution chain and wholesale prices.

Summing up, the above results suggest that both producer prices and retail prices are important in shaping prices at the wholesale stage of distribution. This relationship can be described as follows:

ln(wholesale)= 0,815wholesale_price(-1) - 0,269producer_price(-1) + 0,159retailer_price(-1) -0,516 (4)

In the case of pricing at the first distribution level, i.e. at the stage of the producer, the model assumed the form of ARDL (1,1,0) where ARDL has a form (manufacturer_prices, wholesale_prices, retailer_prices) The result of the estimation of the model is included in table 4.

However, the value of the F-Bounds test statistic is higher than the value of the upper limit I (1), only at the level of 10% but at the same time it is lower than the bottom limit I (0). Therefore, the test is not conclusive. Nevertheless, one must bear in mind that in other cases the test statistic is less than I (0) and I (1). Therefore, the results suggest that there is no significant long-term relationship.

Table 4.
Estimates of ARDL (1,1,0) to producer prices

Variable	Coefficient	Std, Error	t-Statistic	Prob*
Producer(-1)	0,786	0,056	13,441	0,000
Wholesale	-0,022	0,077	-0,278	0,784
Wholesale(-1)	0,131	0,080	1,592	0,001
Retailer	-0,042	0,044	-0,967	0,336
C	0,563	0,346	1,658	0,102
@Trend	0,001	0,001	1,568	0,119
R-squared	0,941	**Adjusted R-squared**		0,937

Source: Calculations and authors elaboration using the EViews program.

Summary of the results obtained results suggest that producer prices are influenced by both prices from the same level from the previous month as well as wholesale prices. This dependence can be described as:

ln(wholesale)= 0,786producer_prices(-1) + 1,31wholeslae_prices(-1) + 0,563 (5)

The obtained results partly suggest that in the whole mushroom distribution chain, price impulses are not transferred completely, which may suggest an asymmetry in price transmission.

4 Conclusions

The main objective of the research was to assess the price relations between the various stages of the distribution chain aimed at illustrating how prices are determined on the Canadian mushroom market and whether individual markets have influence on each other through changes in prices. The results suggest that retail prices paid by final consumers depend on retail prices from previous months. In the case of wholesale prices, both producer prices and retail prices are important in shaping them. At the same time, it was pointed out that producer prices depend on prices from previous periods and on prices at the wholesale stage. It should be noted that the method of cessation of prices at individual stages of distribution may affect the rate of margins at this level, which would explain the much more stable level of retail trade margins than in wholesale trade. Due to the lack of data on the level of supply and demand on a monthly basis, those variables could not be included. However, this gives the area for further detailed analyzes in the future, for a detailed design of the model explaining the level of prices at particular stages of distribution.

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