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Vertical price transmission along the apple supply chain in Slovak Republic

Vertikálny prenos cien v rámci dodávateľského reťazca jabĺk v Slovenskej republike

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ABSTRACT

Currently, most of the Slovak apple production is situated in the southern region of Slovakia and it consists of small-scale producers (mostly family farms) which raises challenges in production, finances, quality, and coordination within the supply chain. This study aims to investigate vertical price transmission (VPT) in this sector. Understanding VPT can help identify inefficiencies in apple's supply chain. A poor price response or a conflict in the transmission process can lead to unnecessary costs and lower profits for those involved in product production and consumption. The VPT has significant policy implications, particularly in relation to cost control and response. By monitoring the VPT, policymakers can identify areas that require intervention to promote fairness, efficiency, and market transparency. The study focuses on consumer and producer prices of apples to monitor price transmission as well as long-term relationships for the period from January 2006 to December 2021. Johansen's cointegration test confirms a long-term relationship between producer and consumer prices, the same as the Granger causality test which shows that prices share a common long-run trend and there is a cause-and-effect relationship between them. However, threshold autoregression results suggest that there is cointegration, but the symmetry hypothesis is rejected, so positive and negative consumer price shocks do not affect producer prices to the same extent.

Keywords: agriculture, supply chain, cointegration, apple, price transmission

ABSTRAKT

V súčasnosti sa väčšina slovenskej produkcie jabĺk nachádza v južnom regióne Slovenska a tvoria ju malovýrobcovia (väčšinou rodinné farmy), čo prináša výzvy v oblasti výroby, financií, kvality a koordinácie v rámci dodávateľského reťazca. Cieľom tejto štúdie je preskúmať vertikálny prenos cien (VPC) v tomto sektore. Pochopenie VPC môže pomôcť identifikovať neefektívnosť v dodávateľskom reťazci jabĺk. Zlá cenová odozva alebo konflikt v procese prenosu môžu viesť k zbytočným nákladom a nižším ziskom pre tých, ktorí sa podieľajú na výrobe a spotrebe produktu. VPC má významné politické dôsledky, najmä v súvislosti s kontrolou nákladov. Monitorovaním VPC môžu tvorcovia politiky identifikovať oblasti, ktoré si vyžadujú zásah na podporu spravodlivosti, efektívnosti a transparentnosti trhu. Štúdia sa zameriava na spotrebiteľské a výrobné ceny jabĺk s cieľom sledovať prenos cien, ako aj dlhodobý vzťah v období od januára 2006 do decembra 2021. Johansenov kointegračný test potvrdzuje dlhodobý vzťah medzi výrobnými a spotrebiteľskými cenami, rovnako ako test Grangerovej kauzality, ktorý ukazuje, že ceny zdieľajú spoločný dlhodobý trend a existuje medzi nimi vzťah príčiny a následku. Výsledky prahovej autoregresie však naznačujú, že existuje kointegrácia, ale hypotéza symetrie je zamietnutá, takže pozitívne a negatívne šoky spotrebiteľských cien neovplyvňujú ceny výrobcov v rovnakej miere.

Kľúčové slová: poľnohospodárstvo, dodávateľský reťazec, kointegrácia, jablko, prenos cien

INTRODUCTION

Because of the short-term flexibility of production and consumption, prices of agricultural commodities fluctuate widely. Annual crop yields are less sensitive because planting decisions are made before prices for the new crop are known. FAO (2017) stated that the future trajectory of food prices hinges on several factors, notably how agricultural production can adapt to increasingly constrained resources how well the supply chain operates and the impact of climate change. Apples, the subject of this study, play an important role in the fruit industry worldwide. The popularity of apples for consumption and price changes directly affect people's daily lives and are related to income from the fruit (Gan, 2021). Understanding vertical price transmission (VPT) in the apple market in the Slovak Republic can help identify inefficiencies in the supply chain that can negatively impact producers and consumers. Researchers have focused on vertical price transmission in the food industry in recent decades because it is an important issue for promoting fairness, efficiency, and economic outcomes. The literature on vertical price transmission in agricultural products has examined various aspects of price linkages and patterns of transmission in different markets. A study by Hassouneh et al. (2015) focused on evaluating price linkages and pass-through patterns in the apple sector in Slovenia using nonlinear error correction models. The results indicated nonlinearities in price adjustments, with producer and consumer prices tending to increase rather than decrease. Moreover, the study highlighted the limitations of parametric threshold approaches in capturing the dynamic behaviour of prices in this context. Similarly, Pokrivcak and Rajcaniova (2014) studied the price relationship along the food supply chain in Slovakia, analysing in particular the long-term relationship between producer and retail prices for various agricultural products, including apples. Their research used cointegration analysis and autoregressive threshold models, which revealed evidence of asymmetry in price transmission along the food supply chain. Richter and Richterova (2019) focused on the dairy vertical supply chain in Slovakia and examined the relationship between prices at different levels and the distribution of value added within the sector. The study used descriptive analyses, unit root tests, cointegration analyses, and vector error correction models. The results indicated changes in the distribution of value-added and the existence of long-term relationships between the different levels of the dairy food vertical supply chain, revealing an asymmetry in the distribution of prices. Their analysis using an error correction model suggests that the asymmetries tend to disappear for perishable products. Wu et al. (2019) examined the asymmetry of vertical price transmission in the Nigerian cowpea market and compared two cities, Kano and Ibadan. The study used autoregressive distributed lag and asymmetric error correction models and found that price transmission was symmetric in Kano but asymmetric in Ibadan. Differences in market structure, such as the level of competition, inventory duration, and transaction costs, were identified as factors contributing to the observed asymmetry. Jaramillo-Villanueva and Palacios-Orozco (2019) analysed the potato sector in Lithuania and examined changes in key indicators and vertical price transmission within the potato chain. Their study involved econometric techniques, including Johansen cointegration and Granger causality tests. The results indicated a long-run relationship between producer and retail prices, as well as bidirectional causality between the series studied, suggesting efficient price transmission despite shrinking production and domestic consumption of potatoes. Onegina et al. (2022) focused on the Mexican dairy market and examined spatial and vertical price transmission between farm milk prices, international milk prices, and retail prices. The study found unidirectional transmission from international milk prices to domestic milk prices and from producer prices to retail prices. In addition, asymmetric price transmission was found depending on whether milk prices were increasing or decreasing. Hillen (2021) focused on milk and cheese value chains in Switzerland, which operate separately and differ in terms of industry concentration, value chain governance, and product characteristics. In their study, asymmetric vector autoregressive and vector error correction models were used to analyse vertical

price transmission. In contrast to most of the existing literature, the results showed minimal long-run price relationships and insignificant asymmetries between different stages and products in the value chains, highlighting the unique characteristics of Swiss dairy and cheese markets. Jurkenaite and Paparas (2018) studied the potato sector in Lithuania and analysed changes in key indicators and vertical price transmission within the potato chain. The study included econometric techniques and examined the long-term relationship between producer and retail potato prices. Despite statistics indicating shrinking potato production and declining domestic consumption, the analysis provided no evidence of market inefficiencies. The Johansen cointegration test confirmed the existence of a long-run relationship between producer and retail prices, while the Granger causality test indicated bidirectional causality between the series studied. In addition, the momentum threshold autoregression (M-TAR) model revealed no long-run asymmetry between agricultural and retail prices. The study by Byeong-il and Hyunok (2015) examined price transmission in fresh fruit in the western U.S. and found that adjustment rates and demonstrated structural asymmetry were related to product characteristics, particularly perishability. Another study by Santeramo and von Cramon-Taubadel (2016) examined vertical price transmission for a heterogeneous group of fruits and vegetables, considering their perishability as a potential factor influencing asymmetries in price transmission. Inefficiencies in the apple´s vertical supply chain could cause the Slovak industry to shrink. This article examines the relationship between production and consumer prices to identify different supply chain vulnerabilities. A comprehensive analysis of VPT is crucial as it can reveal whether there are any conflicts or inadequacies in the price response, which may result in unnecessary costs and reduced profits for stakeholders involved in apple production and consumption. By closely monitoring the VPT, policymakers can gain valuable insights into areas that may require intervention to promote fairness, efficiency, and market transparency within the apple sector.

Apple sector in the Slovak Republic

Self-sufficiency in fruit growing in Slovakia is low and imports of these products greatly exceed exports. The average Slovak consumes 60-70 kg of fruit and berry products per year (TASR, 2018). The reason for this is that although Slovakia's climate is suitable for apple production, it also imports apples (Hilbertová, 2021). Slovakia is a small country in Central Europe with a long tradition of apple production (The Slovak Spectator, 2018). The most popular fruit of Slovak growers is apples. Apple trees make up almost half of the acreage of all fruit species registered in the Register of Orchards, which includes 150 varieties (SITA, 2017). As further informed by the Ministry of Agriculture and Rural Development of the Slovak Republic (MPRV), among them the most produced varieties are Gala (29% of production area), Pinova (7%), Idared (7%), Stark and Golden Delicious (6%), Evelina and Topaz, (both 5% of the production area) (PRAVDA, 2017). According to the Food and Agriculture Organization of the United Nations (FAO), the country produced around 29 thousand tons of apples in 2021, which was a decrease of around 41% compared to 20 years ago (Figure 1).

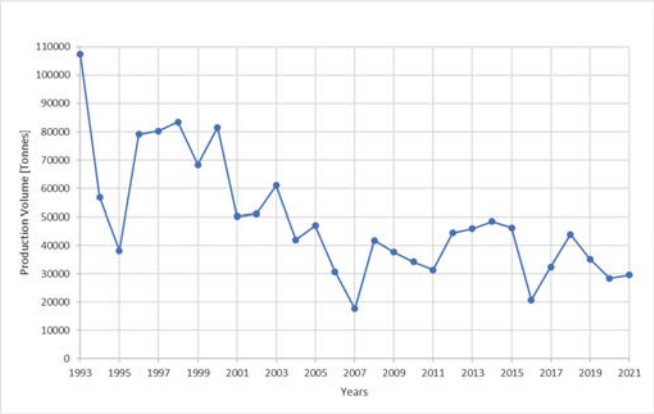

Figure 1. Yearly apple production volume in Slovakia (Source: Food and Agriculture Organization of the United Nations)

The majority of apple production in Slovakia is concentrated in the southern regions, especially in Štúrovo, Nové Zámky, and Galanta districts (Gaillard, 2018). The apple supply chain in Slovakia is characterized by the presence of small producers and a fragmented market.

Many apple producers in Slovakia are family farms that often face challenges related to low productivity, limited access to finance, and difficulties in accessing modern technologies (Koreň, 2022). As a result, the apple supply chain in Slovakia is often characterized by inefficiencies such as high postharvest losses, lack of quality standards, and limited coordination among stakeholders. The Slovak fruit industry needs to join forces so that the fruit it produces can enter large trade networks. Plantex or Danubius Fruct or some fruit cooperatives deviate from this line with the size of their orchards (Sedlák, 2017). To survive, small family farms have to join distribution organizations - cooperatives that can become partners of large business networks.

Figure 2 shows producer and consumer prices of apples from 2006 to 2022. Based on them, we can observe that the consumer price is much more volatile than the producer price which may be caused by the seasonality of the given food. Consumer prices have generally shown a gradual increase from around 0.98 € in 2006 to 1.34 € in 2021, with some fluctuations along the way. This indicates a long-term upward trend in the average prices paid by consumers for apples in Slovakia. Producer prices, on the other hand, have remained relatively stable during the earlier years, ranging from 0.35 € to 0.37 €. However, from 2016 onwards, there has been a noticeable increase in average producer prices, reaching 0.51 € in 2021.

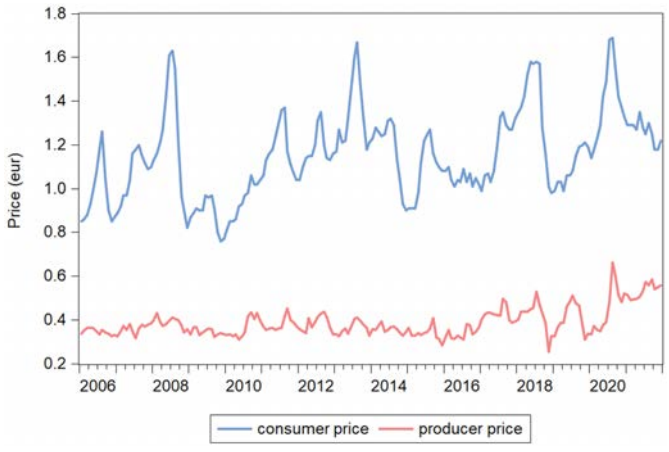

Figure 2. Yearly apple production volume in Slovakia (Source: Own elaboration based on data from the Agricultural Market Information of Slovakia (ATIS) and the Slovak Statistical Office)

MATERIAL AND METHODS

To monitor VPT, this study uses an asymmetric error correction model for quantity, velocity, and price volatility. As a first step, it is important to test the stationarity of the time series. To capture the asymmetric response of the series, Enders and Granger (1998) recommend using the unit root tests to ensure that the data are stationary over time, specifically the Augmented Dickey-Fuller (ADF) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. Stationarity in prices is tested firstly by the ADF test. If the null hypothesis is not rejected, the series has a unit root. In the case of KPSS testing, if the null hypothesis is not rejected, the observed time series is stationary around a deterministic model. Non-stationarity of the data set allows to conduct Johansen cointegration test. It is a method used to test the existence of cointegration between a set of time variables. It refers to the relationship between two or more non-stationary variables, i.e., they move together over time despite short-term changes. This involves running a Vector Error Correction Model (VECM) that predicts short- and long-term relationships between variables. The VECM is estimated using the maximum likelihood estimation and the number of covariance vectors is selected based on statistical methods such as Akaike's Information Criteria (AIC) or Schwarz's Information Criteria (SIC). After the coordinates have been estimated, the final step is to evaluate the values of the coordinate vectors. The Johansen test evaluates statistical significance and significance to determine whether the null hypothesis of cointegration can be rejected. If the null hypothesis is rejected, it means that the variables are mutually exclusive and there is a long-run relationship between them. To capture the asymmetric response of data series Enders and Granger (1998) and Enders and Siklos (2001) propose using the momentum threshold autoregressive model (M-TAR). The word "momentum" describes the rate of price acceleration. This is especially important when it is determined that the change shows more force in one direction than the other. Assuming a long-run relationship between two non-stationary variables X and Y:

$$Y_t = \lambda_0 + \lambda_1 X_t + \mu_t \quad (1)$$

where μ is the correction term. Engle and Granger (1987) emphasize that cointegration exists if the null hypothesis $\rho = 0$ is rejected in:

$$\Delta\mu_t = \rho\ \mu_{t-1} + \xi_t \quad (2)$$

where ξ is the correction term for residuals. The modification of the series of residues expressed in $\rho\mu_{t-1}$ would be symmetric. To capture the asymmetry in the adaptation process, a two-mode threshold cointegration approach is used:

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1-I_t)\rho_2\mu_{t-1} + \xi_t \quad (3)$$

where I_t is the Heaviside indicator $I_{t=1}$ if $\mu_{t-1} \geq \tau \geq \tau$ or $I_{t=0}$ if ak $\mu_{t-1} < \tau$. If μ_{t-1} is greater than the threshold value τ, then the change is at the level of ρ_1. If μ_{t-1} is less than the threshold value τ, the change is represented by ρ_2. When $\rho_1 = \rho_2$, then the process is symmetric. If the null hypothesis $\rho_1 = \rho_2 = 0$ is rejected, then X and Y are cointegrated and we estimate the following TAR model:

$$\Delta Y_t = \theta_Y + \delta_Y^+ E_{t-1}^+ + \delta_Y^- E_{t-1}^- + \sum_{j=1}^{J} \alpha_{Yj}^+ \Delta Y_{t-j}^+ + \sum_{j=1}^{J} \alpha_{Yj}^- \Delta Y_{t-j}^- + \sum_{j=1}^{J} \beta_{Yj}^+ \Delta X_{t-j}^+ + \sum_{j=1}^{J} \beta_{Yj}^- \Delta X_{t-j}^- + \upsilon_{Yt} \quad (4)$$

where ΔY_t and ΔX_t are dependent and independent variables in their first differences, E is the expression of error correction, δ represents the rate of correction coefficients ΔY_t if Y_{t-1} is above and below its long-term equilibrium, θ, δ, α and β, are coefficients and υ is an error term, t is the period and j is the number of lags. Another test that helps to display whether there is a relationship between two variables is the Engle-Granger causality test, which shows if variables are linked in the long run. The null hypothesis of the Engle-Granger causality test is that there is no relationship between the two variables. Another hypothesis is that there is a relationship between the two variables. The time series of the apple prices are obtained from the databases of Agricultural Market Information of Slovakia (ATIS) and the Slovak Statistical Office. The proposed methodology is original and based on the most modern econometric models. Although some of these methods have been utilized in previous studies, their integration within this research contributes to an original application in the context of our investigation. The effectiveness of the methods has been demonstrated in various case studies for other countries. We expect that the achievement of scientific goals will have a long-term benefit in the field of scientific research and will create a basis for further studies in Slovakia. Prices were collected monthly from January 2006 to December 2021. In our research, we utilized EViews 10 software and its additions for data analysis and econometric modelling.

RESULTS AND DISCUSSION

For price transmission, the stationarity of the time series data needs to be evaluated. Table 1 shows the Augment Dickey-Fuller test results for the production and consumer prices of apples. The table includes tests with a constant ($Test_c$) and tests with a constant and a trend ($Test_{ct}$). According to this test, prices were non-stationary.

Table 1. Augment Dickey-Fullerov test

Apple Variable	$Test_c$	$Test_{ct}$
Producer price	-0,596	-1,558
Consumer price	-2,416	-2,669

Note: $Test_c$ stands for stationarity test with a constant and $Test_{ct}$ stands for stationarity test with a constant and trend
Source: Estimated by author

The results of Kwiatkowski–Phillips–Schmidt–Shin test of stationarity of data are shown in Table 2 and it can be concluded that all variables are non-stationary at the level.

Table 2. Kwiatkowski–Phillips–Schmidt–Shin test

Apple variable	Level
Producer price	0.782
Consumer price	0.822

Source: Estimated by author

The Johansen cointegration test was performed to test for the existence of a long-run relationship between different price series. The approach used maximum likelihood estimation in a VAR model, and two levels of tracking statistics were used to present the test results.

The Johansen cointegration test results presented in Table 3 indicate that there is a significant long-run relationship between producer and consumer prices for apples in Slovakia. The *P*-value for these variables was below the significance level of 0.5, which means that the alternative hypothesis of a long-term relationship between prices could be accepted. This suggests that changes in one series would affect the other series in the long run, indicating the potential for price transmission along the supply chain. A study from Jurkenaite and Paparas (2018) also confirms the existence of a long-run relationship between farm and retail prices of potatoes in Lithuania.

Table 3. Johansen cointegration test

Variables	Level	Johansen tracking statistics
Apples	0	20,987***
	1	5,531

Note: *** indicate 1% significance level
Source: Estimated by author

The results of the momentum threshold autoregression model for Slovak producer and consumer prices of apples from Table 4, suggest that there is cointegration between the two series. However, the symmetry hypothesis is rejected, suggesting that positive and negative consumer price shocks do not have the same impact on producer prices. This suggests the presence of an asymmetric price transmission mechanism. To test for this asymmetry, the residuals from the long-run equation were split into positive and negative residuals with a zero threshold. The positive residuals (above the threshold) are denoted ρ_1, while the negative residuals (below the threshold) are denoted ρ_2. The values obtained for these residuals are -0.151 and -0.262, respectively. The F-joint test (Phi) was used to test the hypothesis that there is no cointegration, and the results indicate that the alternative hypothesis suggesting the presence of cointegration is valid. The F-equal test was used to test the symmetry hypothesis, and the results indicate that the alternative hypothesis suggesting the presence of asymmetry is valid. Overall, the results suggest that there is an asymmetric price transmission mechanism between Slovak producers and consumer prices for apples. The negative residuals below the threshold indicate that consumer prices tend to fall more when producer prices are below a certain threshold. Similarly, the positive residuals above the threshold indicate that consumer prices tend to increase more when producer prices are above a certain threshold. Similarly, a study by Richter and Richterova (2019) also finds evidence of non-linearities in price adjustments, with producer and consumer prices tending to increase rather than decrease. However, a study by Gan (2021) suggests that the main factors affecting the price of apples in China are varieties, logistics level, and production area. On the other hand, a study from Wu et al. (2019) indicates that price transmission is symmetric in Kano but asymmetric in Ibadan in the Nigerian cowpea market. The differences in market structure, such as the level of competition, inventory duration, and transaction costs, contribute to the observed asymmetry. These results provide important insights for policymakers and market participants interested in understanding the price transmission dynamics in the Slovak apple market.

The unit root test encouraged the use of the data in their first differences and a VAR model with four lags. The Engle-Granger causality test for producer and consumer prices is presented in Table 5, which shows that the P-values are less than 0.05. Further analysis of the F-statistic with critical values shows that there is bidirectional causality between producer and consumer prices, suggesting that both variables interact simultaneously for apples. This means that changes in producer prices can cause changes in consumer prices and vice versa. In other words, apple prices are not independent of each other but influence each other in a Granger sense. The fact that both variables interact simultaneously indicates that the supply chain for apples in Slovakia is well integrated and changes in one stage of the supply chain affect the other stages as well. A study by Richter et al. (2018) also finds inelasticity in the elasticity of price transmission between individual milk food vertical prices, indicating that price changes at different levels of the milk food vertical were not fully distributed proportionally.

Table 4. Momentum threshold autoregression model

Variable	MODEL	Threshold	Above threshold (ρ_1)	Below threshold (ρ_2)	F-joint (Phi): ($\rho_1 = \rho_2 = 0$)	F-equal: ($\rho_1 = \rho_2$)
Apple	MTAR	0.011	-0.151	-0.262	12.449**	1.927**

Note: ** indicate 5% significance level; MTAR stands for the momentum threshold autoregressive test method.
Source: Estimated by author

Table 5. Granger causality results

Variables	*F*-statistics	*P*-value
The consumer price of apples does not affect the producer price of apples in terms of Granger causality	13.4829	<0.000***
The producer price of apples does not affect the consumer price of apples in terms of Granger causality	2.74434	0.0669*

Note: *, *** indicate 10%, and 1% significance levels, respectively
Source: Estimated by author

CONCLUSIONS

The analysis of the apple sector in the Slovak Republic revealed important insights into VPT and supply chain dynamics. The study used various econometric techniques to examine the relationship between producer and consumer prices to identify inefficiencies and potential vulnerabilities in the apple supply chain. The results of the Augmented Dickey-Fuller (ADF) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test indicate that the price series for apples in Slovakia are not stationary. The Johansen cointegration test provided evidence of a significant long-term relationship between producer and consumer prices for apples in Slovakia. This indicates that changes in one price series affect the other series in the long run, suggesting price transmission along the supply chain. These results suggest that consumer price behaviour can be affected by changes in producer prices and vice versa, indicating interdependence among the different stages of the apple supply chain. The results of the momentum autoregressive threshold model (M-TAR) show that there is cointegration between producer and consumer prices. However, the rejection of the symmetry hypothesis suggests that positive and negative consumer price shocks do not affect producer prices to the same extent. This asymmetry in price transmission suggests that market dynamics and factors affecting consumer behaviour play a role in price adjustments along the supply chain. Overall, the analysis shows that the apple supply chain in Slovakia is subject to both long-term relationships and asymmetries in price transmission. These findings have implications for actors in the apple industry, including producers, consumers, and policymakers. Understanding the dynamics of price transmission and identifying potential inefficiencies in the supply chain can help improve market outcomes, increase fairness, and support the sustainable development of the apple sector. Similarly, a study conducted by Hillen (2021) investigated vertical price transmission in Swiss dairy and cheese chains and discussed potential reasons for minimal long-run price relationships and insignificant asymmetries between different stages and products in the value chains. The study highlights the need for improved coordination, quality standards, and reduced postharvest losses. Because many apple growers are small businesses, they must work with distribution organizations or cooperatives to access larger trade networks. By addressing these inefficiencies and promoting better integration within the supply chain, the Slovak apple industry can improve its competitiveness and sustainability. The results of this study contribute to the existing literature on vertical price transmission

in the agricultural sector, particularly in the context of apple markets. However, it is important to note that the results are specific to the Slovak Republic and may not be directly transferable to other countries or regions. Further research is needed to investigate the factors driving price dynamics, the impact of supply chain inefficiencies, and potential strategies to improve market performance in the Slovak apple sector. One of the limitations of our study is the availability and quality of the data. Research relies on historical price data obtained from databases of Agricultural Market Information of Slovakia (ATIS) and the Slovak Statistical Office, but these datasets may have limitations, such as missing or inconsistent data, which may affect the accuracy and reliability of the findings. Other than that, this study uses various econometric methods to analyse price transmission. However, this method is based on some assumptions such as stationarity and linearity of time series data. This study focuses only on apples in the Slovak Republic, and this may limit the generalization of the findings to other agricultural products or regions. Different crops and business models may exhibit different rates of price transfer, and more research is needed to expand the analysis. To address this limitation, future research of other agricultural products and examination of their price transmission in different countries can provide a better understanding of the supply chain dynamics and price linkages of different agricultural products. As an alternative to time analysis, researchers may consider using panel data analysis to investigate price transmission across multiple regions/countries simultaneously. The panel data analysis has the advantage of controlling unobservable heterogeneity, resulting in greater security and generality of the results. This research is based on quantitative analyses, so qualitative research methods, such as interviews with stakeholders in the supply chain, can provide different insights into the underlying drivers of price transmission and supply chain inefficiencies. Qualitative research models can help uncover characteristics that quantitative analysis cannot. Lastly, further research can explore the impact of policy interventions on price transmission and supply chain utilization. Analysing the impact of government policies, trade agreements or subsidies can provide policymakers with valuable information for developing proper business strategies.

In summary, the analysis of the apple sector in the Slovak Republic shows the importance of studying vertical price transmission and understanding supply chain dynamics. The results shed light on the relationship between producer and consumer prices and show the interdependence of the different stages of the apple supply chain. The results can help policymakers and industry stakeholders in their efforts to increase market efficiency, improve coordination, and support the sustainable development of the apple industry in Slovakia. While the research contributes to the existing literature on price transmission, it is important to acknowledge the limitations, such as data quality and scope, that may influence the robustness and generalizability of the results. To address these limitations and further enhance the understanding of agricultural markets, future research could explore alternative methodologies, expand the scope of analysis, and incorporate qualitative approaches. By doing so, policymakers and industry stakeholders can make more informed decisions to foster a fair, efficient, and sustainable apple sector in Slovakia and beyond.

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