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Contributing research paper

# Producer price volatility in the German fruit and vegetable industry

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## Summary

**The study analyzes producer price volatility of apples, strawberries, tomatoes, and onions on the German market. For the analysis, time series (2006–2014) of weekly producer prices were used. Marketing channels under study are wholesale markets and producer organizations. Results indicate that German fruit and vegetable producers have to deal with high producer price volatility that differs between marketing channels. Selling through the wholesale market results in the lowest producer price volatility for all analyzed fruits and vegetables, except for strawberries. Therefore, producers can partially manage their price risk by deciding on a specific marketing channel. Furthermore, the results show that contrary to popular belief, there is no clear indication of an increase in producer price volatility of fruits and vegetables in the past decade. In conclusion, developing innovative instruments to manage price risk of fresh produce remains an important task for the future.**

**Keywords**

fresh produce, marketing channels, risk management, time trends in price volatility

## Significance of this study

*What is already known on this subject?*

- Producers of fruits and vegetables are exposed to high price and production risks.

*What are the new findings?*

- Price volatility differs between marketing channels. However, there is no clear indication of an increase in price volatility in the past decade.

*What is the expected impact on horticulture?*

- German fruit and vegetable producers can partially manage their price risk by deciding on a specific marketing channel.

## Introduction

Price volatility belongs to the most important sources of risk in fruit and vegetable production. Competitive pressure is continuously increasing due to globalization (Lange, 2009) and concentration trends in retail (Flenker et al., 2009). In addition, political risks, like Russia's ban on fruits and vegetables produced in the European Union, and food crises (e.g., *E. coli* outbreak in 2011) are discussed as possible reasons for increasing producer price volatility. Seasonality of many fruits and vegetables is further amplifying the issue. Also, perishability constrains the possibility to store fruits and vegetables, and leads to volatile markets (Cook, 2011). Furthermore, limited availability of price hedging instruments (Hartwich and Gandorfer, 2014; Hartwich et al., 2015) challenges price risk management. For instance, commodity futures contracts do not exist due to the perishability and limited storage capability of most fresh produce (see Manfredo and Libbin, 1998). The only horticultural products traded at commodity exchanges are orange juice, cacao, and coffee (www.theice.com). A commodity exchange is a market in which standardized (quantity, quality, and price) futures contracts are traded to hedge price risk (see OECD, 2009). Therefore, the choice of the marketing channel is one of the most important options available to fruit and vegetable producers to manage price risk.

Relevant marketing channels in the German fruit and vegetable industry are producer organizations, wholesale markets, direct marketing (e.g., farmers markets), and supply contracts with retailers and the food industry. The share of each marketing channel varies between fruits and vegetables. For instance, more than 50% of the apples and tomatoes produced in Germany are sold through producer organizations. On the contrary, direct marketing is the most important marketing channel for strawberries and onions (Table 1).

According to the Bavarian State Ministry for Food, Agriculture, and Forestry (2014), producer organizations should play an important role in risk mitigation by pooling production, and therefore, generating more stable producer prices through increased market power. In order to support fruit and vegetable farmers, the Common Agricultural Policy of the European Union provides subsidies for producer organizations if they fulfill specific criteria.

Although trends in price volatility have been researched extensively for agricultural commodities in recent years (Gilbert and Morgan, 2010), a lack of knowledge exists in the fruit and vegetable sector. For fruit and vegetable producers, the knowledge what price risk is associated with each specific marketing channel is paramount for related business decisions. This information is essential to develop appropriate price risk management strategies, particularly when instruments to manage price risk are limited. Therefore, the study investigates whether there are differences in producer price volatility among marketing channels in the German fruit and vegetable industry. Furthermore, the study seeks to provide insights in time trends of producer price volatility, because according to popular belief, producer price volatility has increased after recent food crises.

**Table 1.** Share of marketing channels in Germany (2012), in %.

| | Apple | Strawberry | Tomato | Onion |
|---|---|---|---|---|
| Industry | 12 | 1 | 0 | 9 |
| Recognized producer organizations | 54 | 17 | 56 | 22 |
| Wholesale and retail | 22 | 34 | 30 | 12 |
| Direct marketing | 12 | 48 | 14 | 57 |

Based on data provided by the Agricultural Market Information Company, 2015.

## Literature review

Volatility of agricultural commodity prices is a well-researched topic that attracts growing attention in the recent scientific literature. Price volatility is one of the most important sources of risk for fruit and vegetable producers (see Hartwich et al., 2015) due to its negative effect on farm income stability. High price volatility leads also to "extremely serious risks and potential high costs for society" (Prakash 2011, p. 21). As a result, price volatility is a major concern for policy-makers and actors in the supply chain (Huchet-Bourdon, 2011). A study by Felis and Garrido (2015) emphasizes these concerns. They analyze the impact of price volatility on the market power of actors (retailer, wholesaler) in the fresh produce supply chain, and find that market power is sensitive to price volatility. Increasing price volatility caused by external shocks rises the variability of their price margins.

Gilbert and Morgan (2010) identify increases in the variance of demand and supply shocks as sources that possibly increase price volatility. Examples of recent demand shocks in the fruit and vegetable sector are Russia's import ban on European fresh produce (European Commission, 2014), and food crises, like *E. coli*. For instance, Bitsch et al. (2014) describe significant decreases in the percentage of German households buying cucumbers when the *E. coli* outbreak started in 2011. Supply shocks in the fruit and vegetable sector are mainly associated with severe weather events (e.g., frost or hail) or diseases. For a more detailed empirical analysis of variables (e.g., stocks levels, yields, exchange rate, and oil price volatility) that may affect volatility, see Balcombe (2011) and Brümmer et al. (2016).

Three research questions are of particular interest when analyzing producer price volatility: 1) Is price volatility of agricultural crops increasing over time? 2) Is there a difference in price volatility between different crops? 3) Do marketing channels differ in terms of price volatility? The vast majority of available studies (e.g., Sumner, 2009; Artavia et al., 2011; Gilbert and Morgan, 2010; Wang et al., 2010; Huchet-Bourdon, 2011) is focusing on questions 1) and 2). The main emphasis of these studies lies on cereals, meat, and dairy. Only few studies consider specialty crops, including fruits and vegetables (e.g., Gilbert and Morgan, 2010; Wang et al., 2010). According to the authors' knowledge, no recent studies compare different marketing channels for specialty crops in terms of price volatility.

Regarding the question whether price volatility of agricultural products has been increasing over time, the reviewed studies show comparable results. Gilbert and Morgan (2010, p. 3033) conclude in their review that volatility has been increasing in the last years but "the recent episode does not appear exceptional" compared to the past. Also, Huchet-Bourdon (2011) argues that volatility of agricultural product prices showed no increasing trend in the long run. Artavia et al. (2011) conclude that price volatility in Germany increased substantially for wheat, barley, and milk in the period between 1993 and 2008. Price volatility of canola and beef was only slightly increasing, and volatility of pork prices was decreasing in the same period. The authors argue that the increasing trend in price volatility in the case of wheat, barley, and milk was associated with market deregulation in the analyzed period.

Wang et al. (2010) are among the few authors that analyze price risk of fruits. They distinguish between three groups of crops regarding their market risk by applying the value at risk concept to Chinese wholesale market prices (2000–2009). Strawberries and watermelons show high market risk, grapes and oranges medium market risk, and apples, bananas, and pears low market risk. Gilbert and Morgan (2010, p. 3025) show that price volatility of fresh fruits, namely bananas and oranges, is much higher compared to other agricultural products, like grains. While price volatility of analyzed grains is between 19.2% and 23.3% (1990–2009, prices in real US dollars), the price volatility of bananas and oranges is 65.5% and 45.1%, respectively.

To summarize, there is broad consensus in literature that price volatility of agricultural commodities was high in recent years, but not exceptional taking a long-term view. Available studies show that price volatility of fresh produce is higher compared for agricultural commodities, but there is only few information available in terms of time trends and differences in price volatility of marketing channels.

## Data and methods

In terms of consumption and production, tomatoes, onions, apples and strawberries belong to the most important fruits and vegetables in Germany. For the analysis, we use marketing channel specific time series (2006–2014) of weekly nominal producer prices for tomatoes, onions, apples and strawberries, provided by the Agricultural Market Information Company (AMI). Nominal prices were deflated using the food and non-alcoholic beverages consumer price index (Destatis, 2015), with the base 2010. Only data that were consistently available over the years for the marketing channels were considered in the analysis. For apples and onions, prices form calendar week 1 to 52 were used, for strawberries from calendar week 27 to 38, and for tomatoes from calendar week 12 to 52.

Price volatility is defined as "a directionless measure of the extent of the variability of a price" (Gilbert and Morgan, 2010, p. 3023). Thus, price volatility can be analyzed by various measures, including the coefficient of variation, the corrected coefficient of variation or the standard deviation of the logarithm of prices in differences (Huchet-Bourdon, 2011). As Gilbert and Morgan (2010) pointed out the analysis of price volatility should be based on detrended price data to avoid trends bias volatility measures. To avoid detrending that requires an assumption about a specific trend model, price volatility is often described by the standard deviation of price returns (Gilbert and Morgan, 2010). Price returns can be described in this context as the relative change of

prices (ratio of the price at time *t* and the price at time *t*-1). Thus, based on Artavia et al. (2011), historical producer price volatility (1) is calculated in this study as the standard deviation of returns $R_t$.

$$\sigma = \sqrt{\frac{1}{n-1} * \sum_{t=1}^{n} (R_t - \overline{R_t})^2} \quad (1)$$

Where $R_t$ is the log return:

$$R_t = logY_t - logY_{t-1} = log(\frac{Y_t}{Y_{t-1}}) \quad (2)$$

$Y_t$ is the price at time t.

Stationarity of time series is important in order to provide unbiased comparison between market channels. To check whether time series are stationary, the augmented Dickey-Fuller (ADF) test (the null-hypothesis assumes non-stationarity) is employed (Said and Fuller, 1984).

To assess whether historical producer price volatility is increasing over time, the time series are split into two sub-periods. Data of 2006 is excluded from this analysis to be able to compare two sub-periods of equal length. Sub-period 1 lasts from 2007 to 2010 (before the *E. coli* outbreak) and sub-period 2 from 2011 to 2014 (after the *E. coli* outbreak). The time series are split into the time periods before and after the *E. coli* outbreak to analyze the impact of food crises on producer price volatility. Finally, the Levene's test is used to test for differences in historical producer price volatility between sub-period 1 and 2, and between the market channels under study. Gastwirth et al. (2009) describe the Levene's test as a powerful and a popular approach to check the homogeneity of variances. The authors provide examples where the test was successfully used in economic studies, including a study that analyzes time trends of oil price volatility. Also, Artavia et al. (2011) use the Levene's test to analyze agricultural price volatility.

## Results and discussion

Descriptive statistics of weekly producer prices show that selling through wholesale markets results in generally higher prices compared to selling through producer organizations (Table 2). However, it has to be considered that mean prices are not directly comparable since selling through wholesale markets is associated with additional cost (e.g., packing).

The analysis shows that selling through the wholesale market results in the lowest producer price volatility for the analyzed fruits and vegetables, except for strawberries (see Table 3). In the case of strawberries, selling through producer organizations is associated with a marginal (not statistically significant) lower producer price volatility. This suggests that strawberries are the only case analyzed where producer organizations are successful in providing comparable price stability to the alternative marketing channel. A possible explanation for this result is that many producer

**Table 2.** Descriptive statistics of weekly producer prices (€ 100 kg$^{-1}$) for the period 2006–2014 (calculated based on data provided by AMI).

| | Apple | | Strawberry | | Tomato | | Onion | |
|---|---|---|---|---|---|---|---|---|
| | WM[1] | PO[2] | WM[1] | PO[2] | WM[1] | PO[2] | WM[1] | PO[2] |
| Mean | 74 | 43 | 307 | 194 | 186 | 125 | 39 | 19 |
| Minimum | 49 | 23 | 148 | 78 | 93 | 57 | 24 | 1 |
| Maximum | 106 | 103 | 484 | 304 | 442 | 396 | 85 | 47 |
| Standard deviation | 14.5 | 12.6 | 60.3 | 40.6 | 61.7 | 57.1 | 10.9 | 12.9 |

[1] WM: wholesale markets.
[2] PO: mainly recognized producer organizations.

**Table 3.** Weekly historical producer price volatility (calculated based on data provided by AMI).

| | Apple | | Strawberry | | Tomato | | Onion | |
|---|---|---|---|---|---|---|---|---|
| *Period (2006–2014)* | WM[1] | PO[2] | WM[1] | PO[2] | WM[1] | PO[2] | WM[1] | PO[2] |
| Volatility %[3] | 4a | 10b | 18a | 17a | 12a | 16b | 9a | 18b |
| ADF-Test[4] (Base: prices) | non-stat. | non-stat. | stat. | non-stat. | stat. | stat. | stat. | stat. |
| ADF-Test[5] (Base: $R_t$) | stat. | stat. | stat. | stat. | stat. | stat. | stat. | stat. |
| *Period 1 (2007–2010)* | | | | | | | | |
| Mean € 100 kg$^{-1}$ | 67 | 39 | 306 | 195 | 177 | 122 | 38 | 18 |
| Volatility % | 3 | 6 | 19 | 15 | 12 | 16 | 9 | 14 |
| ADF-Test[4] (Base: prices) | non-stat. | non-stat. | stat. | stat. | stat. | stat. | non-stat. | non-stat. |
| *Period 2 (2011–2014)* | | | | | | | | |
| Mean € 100 kg$^{-1}$ | 85 | 50 | 307 | 198 | 201 | 135 | 43 | 20 |
| Volatility %[6] | 4 | **14** | 16 | 17 | 11 | 16 | 8 | 23 |
| ADF-Test[4] (Base: prices) | non-stat. | non-stat. | non-stat. | non-stat. | stat. | stat. | stat. | non-stat. |

[1] Wholesale markets.
[2] Mainly recognized producer organizations.
[3] Different letters (a, b) indicate significant differences (Levene's test, 95% significance level) between marketing channels.
[4] Augmented Dickey-Fuller Test to test for stationarity of weekly producer prices ($H_0$: non-stationary, 95% level of significance).
[5] Augmented Dickey-Fuller Test to test for stationarity of $R_t$ ($H_0$: non-stationary, 95% level of significance).
[6] Bold numbers indicate significant differences (Levene's test, 95% significance level) between sub-periods.

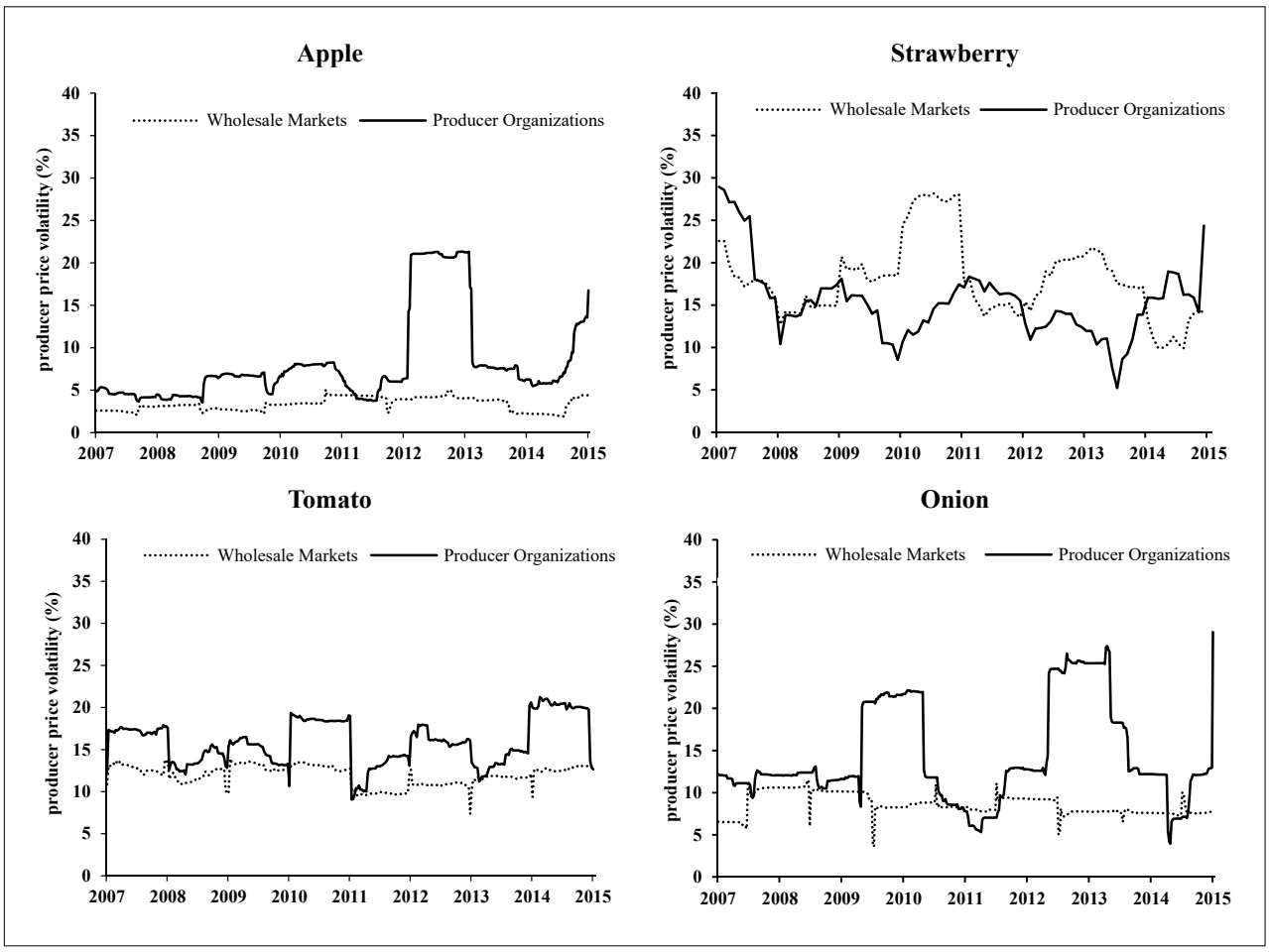


**Figure 1.** Historical producer price volatility based on a 52-week moving window for apples and onions, a 41-week moving window for tomatoes, and a 12-week moving window for strawberries.

organizations face management and governance problems. Because of these limitations, producer organizations are currently not able to use their important position in the value chain for fruits and vegetables effectively enough to provide more stable prices to their members (Gandorfer et al., 2015).

It is further notable that the producer price volatility of strawberries is comparable high. The likely reason is the weather dependency and the short marketing period for strawberries compared to other products, along with their high perishability, and consequently, low storage ability (see Wang et al., 2010). These factors can lead to relatively high producer prices at the beginning, and at the end of the production season in Germany. Together with comparably low prices during production peaks, this results in high producer price volatility. In contrast, producer price volatility of apples is low due to good storage ability, and year-round marketing. Wang et al. (2010), focusing on the Chinese market, found similar results, and identified strawberries as riskier compared to apples in terms price risk. To summarize, the statistical analysis of producer price volatility between crops sold through wholesale markets shows that apple has the lowest producer volatility followed by onion, tomato, and strawberry, respectively. All of the differences in producer price volatility displayed in Table 3 are statistically significant (Levene's test, 95% significance level) with the exception of that between onion and tomato. Apple also shows the lowest producer price volatility when sold through producer organizations. In this case, however, tomato, strawberry, and onion follow (in order of increasing price volatility). Again, all of the differences in producer price volatility displayed in Table 3 are statistically significant (Levene's test, 95% significance level).

Contrary to expectations, a statistically significant increase in producer price volatility from sub-period 1 to sub-period 2 can be observed in only one out of the eight cases analyzed. The increase can be observed in the case of apples sold through producer organizations. The high apple producer price volatility in sub-period 2 is probably associated with supply shocks caused from weather effects. While apple yields in Germany were low in 2010 due to low temperatures and high rainfall during spring (DBV, 2011a), apple yields in 2011 increased. However, they were still below average due to frost and hail events (DBV, 2011b).

In 2012, apple yields were comparable to those of 2011 (DBV, 2013). Apple yields in 2013 were again exceptionally low (17% less than in 2012) due to low temperatures and rainy weather during the flowering stage (DBV, 2013). To summarize, yield variability was much higher in sub-period 2 compared to sub-period 1. It remains unclear why these developments had seemingly only an impact on producer price volatility in the case of selling through producer organizations, and not on selling through wholesale markets. Also, producer price volatility of onions increased from sub-period 1 to sub-period 2 in the case of selling through producer organizations. However, this trend is insignificant. In all other cases, minor decreases and increases of producer

price volatilities from sub-period 1 to sub-period 2 are not statistically significant. Gilbert and Morgan (2010, p. 3033) conclude that "There is a general tendency for commentators to assert that food price volatility has increased over time – however, the reverse appears to be true." Although the results of this study do not support the conclusion that the reverse appears to be true, there is little empirical evidence for increasing producer price volatility, at least for the analyzed period and crops, respectively. To provide more detailed insights into the development of producer price volatility over time, producer price volatility is illustrated in Figure 1.

The charts graphically underpin the presented results in Table 3. Producer price volatility is clearly higher when selling through producer organizations compared to selling through wholesale markets in the case of apples, tomatoes, and onions. Only in the case of strawberries, the two lines are crossing several times within the analyzed period, resulting in longer periods where selling through wholesale market shows lower producer price volatility compared to producer organizations. As a result, diversification in terms of selling through both marketing channels reduces price risk in the case of strawberries. The increase of producer price volatility over time is also visible for apples sold through producer organizations (see Table 3).

## Conclusions

German fruit and vegetable producers have to deal with high producer price volatility that differs among crops and marketing channels. Therefore, producers can manage their price risk with the decision for a specific marketing channel. Selling through wholesale markets is mostly preferable with respect to producer price volatility. However, it has to be considered that market access through wholesale markets is limited, and therefore, not an option for all producers. Despite the relatively strong position of producer organizations in German fruit and vegetable value chains, they are not successful in terms of generating the most stable producer prices. Therefore, future research could focus on strategies that can help producer organizations to benefit more from their position in the value chain in order to be able to provide more stable prices to their members. In this context, it would be important to analyze strawberries in more detail in order to identify factors that lead to comparable producer price volatilities when selling through wholesale markets and producer organizations.

As stated above, producer organizations play an important role in German fruit and vegetable value chains because they perform various tasks (e.g., risk management, marketing activities, and extension) and, thus, strengthen the position of producers within the value chain. The analysis of risk management instruments provided by producer organizations shows a focus on instruments reducing yield risk (e.g., investment subsidies for anti-hail nets). Thus, specific policy measures should be implemented to encourage producer organizations to focus more on instruments for price risk management. Generally, developing appropriate and innovative price risk management instruments and strategies for fresh produce remains an important task for the future.

Furthermore, our results show that, contrary to popular belief, there is no clear indication that producer price volatility of fruits and vegetables has been increasing in recent years. Observed increases in producer price volatility of apples can be attributed to short-term supply shocks caused by weather events. However, producers of fruits and vegetables have always been exposed to high production risks, and resulting price risk. Nevertheless, it remains a challenge to manage the price risk of perishable fruits and vegetables.

Finally, it can be concluded that distinguishing between horticultural and agricultural crops is essential in the discussion of producer price volatility. Fruit and vegetable producers were consistently exposed to liberalized markets, and therefore, used to higher price risk. For producers of agricultural commodities (e.g., cereals) the recent and ongoing market liberalization together with other reinforcing effects (e.g., bioenergy policy, inventory levels) on price volatility have created a new situation, and thus, raised various stakeholders' attention.

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