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Does price volatility matter? An assessment along EU food chains

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Abstract

Agricultural prices in European food markets have become substantially more volatile over the past decade thereby exposing agribusinesses to risk and uncertainty. How food chain actors perceive and manage the risk from price volatility remained unexplored so far. We interviewed farmers, wholesalers, processors and retailers in six European food supply chains on their price volatility perceptions and management strategies. Contrary to common belief, findings show that price volatility matters not only to farmers but to all food chain actors. Actors perceive a more than 15% deviation of prices from their expected levels as price volatility. We further show that three factors determine whether price volatility is perceived as risky: the persistence, the reason and the direction of price deviations. Price volatility management strategies in EU food chains are very diverse and well beyond futures and forward contracts. The scope for policy interventions is identified based on strategy gaps identified in the chains.

Key words: Price volatility perceptions, management strategies, European food supply chains, in-depth interviews.

JEL codes: Q11

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1. Introduction

Prices in European agricultural markets have become increasingly volatile in the past decade (Tangermann 2011). The decoupling of farm income supports through the successive reforms of the Common Agricultural Policy led to a more market oriented EU farm sector (Badarji et al., 2011). In an increasingly globalized agricultural market, factors such as import and export restrictions in major producing countries, climate hazards, and animal health scares lead to supply and demand shocks that increase volatility in agricultural commodity prices (Badarji et al., 2011). Price volatility leads to risk and uncertainty that has undesirable effects on farmers' investment decisions (Tangermann 2011), sourcing strategies of middlemen and the food processing industry (Rabobank 2011), and food consumers (Hernandez, Ibarra, and Trupkin 2013). Price volatility is therefore a concern requiring the concerted attention of all food supply chain actors.

Measures of price volatility range from a simple coefficient of variation to the volatility predictions of sophisticated time series models (See for instance Assefa et al. 2014). Despite their technical differences, these measures share a commonality in that they define price volatility as the deviation of prices from their expected or mean levels. A natural question that arises is whether every deviation of price from its expected level is perceived as price volatility by chain actors. Answering this requires understanding chain actors' perception of price volatility. Two key perception elements are important in this respect: how much price deviation is perceived as price volatility? and which factors determine whether price volatility is perceived as risky? One would naturally expect actors' responses to price volatility to depend on their perception about the riskiness of price volatility. From a policy perspective, critical volatility thresholds can signal policy makers on when to intervene in the market.

Previous research has extensively investigated farmers' perceptions and management strategies of agriculture related risks, with price risk included as one type of risk (for instance, Martin 1996, Bown et al.1999, Meuwissen et al. 2001, Hall et al. 2003, Greinier et al. 2009, Bergfjord 2009). These studies limit their investigation to a narrow set of traditional price risk management strategies consisting of hedging in derivative markets, forward contracts and diversification. A valid question is whether these are the only strategies farmers adopt to manage

the risk from price volatility. Open-ended approaches to explore the diversity in farm-level strategies are lacking in the current literature. Even more lacking are studies that explore strategies of actors downstream to the farm stage.

The report by Badarji et al. (2011) stresses that price volatility in EU food markets should be investigated at a disaggregate level due to variations in price developments across member states, agricultural commodities and various stages of food supply chains. All this implies a possible diversity in price volatility perceptions and management strategies across actors in EU food supply chains. In an era of increasingly volatile agricultural and food prices, it is important to show the absence of a "one-size-fits-all" type of strategies and lay down the strategic options that various agribusinesses could use to manage the risk from price volatility. This further helps to rethink current modelling assumptions that actors mainly use traditional instruments such as futures and options to manage the risk from price volatility. In addition, gaps in risk management strategies are better filled through policy intervention when strategies currently used in EU food chains are made known to policy makers.

The objective of this research is to explore the price volatility management strategies and perceptions of price volatility of farmers, wholesalers, processors and retailers in six EU food supply chains. These are the Bulgarian wheat, French wheat, German pork, Dutch cheese, Dutch tomatoes, and Spanish tomatoes supply chains. In the remainder of this paper, we briefly discuss previous studies related to price risk perceptions and management strategies, detail the methodological approaches used in this study, present the results, and conclude the study and draw policy implications.

2. Previous research

Previous research on risk perceptions and management strategies in the agricultural sector has mainly focused on the farm stage. Wilson and Armstrong (1987, p.545) defined risk perception as "the awareness of the factors in the social and economic environment that create risk and the degree to which one factor is more critical than the other". This definition is shared by most of the studies that investigated farmers' risk perceptions. The methodological approach these studies followed is that of listing a set of possible sources of agricultural risks and asking farmers to rate the importance of each source of risk using Likert scales (for instance, Patrick et al. 1985,

Wilson and Armstrong 1987, Martin 1996, Knutson et al. 1998, Meuwissen et al. 2001, Hall et al. 2003, Ackaoz et al. 2005, Greinier et al. 2009, Bergfjord,2009). A finding consistent across many of the studies is the high score that farmers assign to price risk (for instance, Patrick et al., 1985, Wilson and Armstrong 1987, Knutson et al. 1998, Meuwissen et al. 2001, Bergfjord 2009). The inconsistency in the terminologies the authors use to define price risk reflects, nevertheless, a lack of agreement of what price risk really is. Some of the terms used by the authors are "price changes" (Martin 1996), "declining prices" (Greinier et al. 2009), "price volatility" (Morales et al. 2008). What farmers perceive as price risk therefore remains unclear.

The above cited studies adopt a similar approach to assess farmers' risk management strategies. That is, farmers are presented a list of pre-specified risk management strategies and asked to rate the importance or the relevance of each strategy using Likert scales. A comparison of the scores assigned to the risk sources and those assigned to the risk management strategies are then compared. Surprisingly, many authors do not find a match between the score assigned to price risk and those assigned to the price risk management strategies considered (for instance, Martin 1995, Meuwissen et al. 2001, Hall et al. 2003, Bergfjord 2009). That is, while price risk ranks on the top of the list on risk sources, the importance or relevance scores assigned to the listed price risk management strategies are unexpectedly low. The main price risk management strategies these studies considered were forward contracts, futures and options, and off and on farm diversification. This raises the question on whether these strategies are indeed the strategies farmers adopt to deal with price risk. The structured nature of the questionnaires used in these studies restricts the identification of the possible set of strategies that farmers use in practise.

The only two studies that attempted to investigate the price volatility perceptions and management strategies of actors downstream to the farm stage are those of Heyder et al. (2010) and of von Davier (2010). Heyder et al. (2010), who surveyed German agribusiness firms, used actors' expectations of price volatility developments in the next five years as a measure of price volatility perceptions. Similar to farm level studies, a set of pre-defined price volatility management strategies were presented to the actors who had to evaluate the relevance of each strategy using Likert scales. The study by von Davier (2010) relied on a media content analysis to identify perceptions about causes and developments of price volatility and suggested management strategies. A limitation of both studies is that they failed to explore actual

management strategies adopted by firms. Another limitation is that actual volatility levels that chain actors perceive as volatility are not investigated.

In summary, previous research provides limited evidence on actual price risk perceptions and management practises in the chain. The excessive reliance on structured questionnaires limits the opportunity to explore actual practises. The downstream sector of the chain has remained overlooked in previous research as the focus has been mainly on the farm sector. In this research, the mentioned gaps in the literature are addressed by following an exploratory methodological approach and by including the downstream stages of the chain in the analyses.

3. Methods

3.1.Exploration through in-depth interviews

Exploration is used as a methodological approach "when a group, process, activity or situation has received little or no systematic empirical scrutiny or has been largely examined using prediction and control rather than flexibility and open-mindedness" (Stebbins 2001, p.9). Previous research has given little attention to price volatility perceptions and management strategies of actors along food supply chains. At the farm stage, the structured nature of the questionnaires distributed to farmers restricts the identification of the set of strategies farmers adopt in practise. An exploratory approach is therefore deemed appropriate to investigate chain actors' price volatility perceptions and management strategies.

Data was collected through in-depth interviews with semi-structured questions. Some structure was imposed on the questions to guide the interview process and keep the focus on the key topics that are the subjects of the investigation. The imposed structure also assured some consistency in the questions across the respondents. The questions, nevertheless, allowed some room for probing and in-depth inquiry. Probing was facilitated by including 'non-standardized' or semi-structured questions that can differ across respondents. Non-standardization in interviews is "most helpful when exploring new topics, sensitive [...] issues, and when the businesses are highly variable in their characteristics" (Healey et al. 1993, p.342). The newness of the topic of price volatility perceptions and management strategies, the sensitive nature of

disclosing price related business strategies, and the wide ranging types of companies included in this study justify the use of semi-structured interviews.

3.2.Respondent selection

To account for the diversity in EU food chains, we constructed a sample with representatives from five EU countries, four types of food products, four stages of the food supply chains, and different types of farms and companies. The respondent selection process followed a series of steps. In the first step, food chains corresponding to different classes of food products (i.e. meat, dairy, cereals and vegetables) were selected. This yielded the selection of the fresh pork, cheese, bread-wheat and fresh tomato supply chains.

Five countries from different geographical corners of the EU were selected, i.e. the Netherlands, Germany, France, Spain and Bulgaria. Indicators such as the share of area used for tomatoes in total land for fresh vegetables, share of pig production in total livestock production, share of cheese production in raw milk collected, and share of wheat in total cereal production were used to rank the countries and determine the level of importance of each product in each country. Production, area of agricultural land and consumption data from 2006 to 2013 compiled from the Eurostat was used to calculate the indicators. The following six chains resulted from the rankings: Dutch cheese, Dutch tomatoes, German pork, French wheat, Bulgarian wheat and Spanish tomatoes supply chains.

Next, experts from academics and industry were contacted for brief interviews on the structure of each of the six supply chains. The aim was to have a grasp of the mainstream types of farms (for instance, cooperative members/ and non-members) and companies (for instance, cooperatives and non-cooperatives) that characterized the respective chains. Types of farms and companies that represent a minor share of the respective markets were not included in the sample.

The experts gave the names, email addresses and phone numbers of some of the interviewees. Contacts of additional interviewees were obtained using a snow-ball approach. While farm owners are the respondents in the farm stage, general managers, sales managers, sourcing managers and financial directors were the respondents at the wholesale, processing and retail stages. Even though a minimum of 2 interviews were planned per country/chain/chain

stage, it was not possible to reach any respondents in some of the country/chain/chain stages. In particular, German pig slaughterhouses/processors and retailers were often not willing to participate, most likely because price related strategies are confidential in these companies. The sample selection process resulted in the selection of a total of 42 people for the interviews. The respondents were 15 farmers, 15 wholesalers, 9 processors and 3 retailers. Table 1 summarizes the characteristics of the participant farms and companies.

INSERT TABLE 1. ABOUT HERE

3.3.

3.4.Interview questions

The interview questions consisted of four major blocks, with two structured and two semi-structured blocks of questions. *The first block* was an introductory block where characteristics such as farm size, company size, farmer cooperative membership, and legal form (cooperative/non-cooperative) of companies were inquired using structured questions. In *the second block* of the interview, structured questions were used to evaluate whether the respondents have found various sources of business risks as challenging in the past 5-7 years. Likert scales from 1 (= extremely challenging) to 7 (= not challenging at all) were used for this purpose. The aim of this second block was to determine how challenging price volatility was relative to other business risks. The list of business risks presented relate to sourcing and selling activities of the farms and companies.

The third block of the interview consisted of semi-structured questions on actors' perceptions of price volatility. Two aspects of actors' perceptions were investigated: 1) the percentage price deviation from an expected price level which actors perceived as price volatility and 2) the factors that determine whether price volatility is perceived as risky. To investigate the first aspect of perceptions, actors were asked to give the percentage price deviations with respect to the periods prices are settled in the respective chains. *The fourth block* of the interview, also consisting of semi-structured questions, inquired about the strategies actors used, and would use, to manage the risk from price volatility.

The interviews were conducted from January till July 2014. The questions were sent one day in advance to the interviewees to allow them to prepare prior to the interviews. Each interview lasted from forty-five minutes to one hour and a half. The interviews were made in person with accompanying translators in some cases. The responses were audio-recorded and transcribed on the same day the interviews took place.

3.5.Analysis

A descriptive approach is followed to analyse the price volatility perceptions and management strategies of the chain actors (i.e. farm, wholesale, processing and retail). A comparative approach additionally highlights the differences and similarities in perceptions and strategies across chain stages. Within chain stage differences and similarities in perceptions and strategies are also highlighted whenever necessary. Both descriptive and comparative analyses are qualitative in nature.

To facilitate the analyses of the price volatility management strategies, identified strategies were classified into four categories: Survival strategies, adaptive strategies, control strategies and hedging strategies. A brief definition of each category is provided below.

Survival strategies: the focus is on minimizing losses from an adverse price movement.

Adaptive strategies: the focus is on flexibility, following the market, and securing a stable margin regardless of price movements.

Control strategies: the focus is on achieving price stability by taking control over prices.

Hedging strategies: the focus is on transferring price risk to another party.

4. Results

4.1.Price volatility perceptions

Before proceeding to describing and comparing price volatility perceptions across chain stages, we show the degree to which various business risks have been a challenge to each actor in the

past 5-7 years. The risks relate to business-to-business input sourcing and output selling activities.

A look at the 'challenging' or 'C' columns of Table 2 reveals that price volatility has been a prime challenge for a majority of the actors. The Table further emphasizes that price volatility is not the sole concern of farmers as is often believed. A finding worth noting is the comparable scores the majority of the actors assigned to high input/ low output prices and input/output price volatility. A definitive conclusion cannot be reached, however, on the degree to which price volatility is an important challenge relative to high input/low output price levels. Doing so may require a wider sample of participants. The following subsections describe and compare actors' perceptions of price volatility. Table 3 and 4 summarizes these perceptions.

INSERT TABLE 2. ABOUT HERE

INSERT TABLE 3. ABOUT HERE

INSERT TABLE 4. ABOUT HERE

4.1.1. Percentage price deviations perceived as price volatility

Deviations of prices by more than 10-15% from their expected levels are perceived as price volatility by a majority of the respondents. Actors in the Dutch and Spanish tomato chains are an exception to this as the majority perceives a more than 20% price deviation as price volatility. A similar perception is that of Dutch dairy farmers who argue that feed prices (maize in particular) are volatile if prices deviate by more than 20% from their expected values. Recurring large changes in fresh tomatoes and cattle feed prices justify the price volatility perceptions of the tomato and dairy farmers.

Actors specified percentage price deviations with respect to the periods prices are set in the respective chains. In the Dutch cheese supply chain, these periods are from a month to month basis. Although cheese prices are set for a longer time period (exceeding a month), Dutch cheese processors, wholesalers and retailers form cheese price expectations on a month to month basis

because milk prices serve as reference prices for cheese. In the tomato and pork chains, prices are mostly set on a week to week basis. In the wheat supply chains, although high frequency trading can take place at the wholesale stage, weekly price expectations seem to be the norm.

A comparison across chain stages shows some similarities and differences in the specified percentage price deviations. On average, the percentage price deviations (as reported in Table 3) are rather comparable across chain stages and chains, with 10% being the norm. A closer look at percentages specified at the level of individual respondent reveals some differences in perceptions. That is, processors and retailers seem to perceive lower percentages of price deviations as price volatility than farmers and wholesalers. For example, a more than 5% deviation in grain and flour prices was perceived as price volatility by a Bulgarian and a French wheat miller. Also, the interviewed Dutch retailer indicated that a more than 3% deviation of cheese prices from expected levels can be considered as price volatility.

4.1.2. Factors determining the riskiness of price volatility

Price volatility as defined above is not perceived as risky by all interviewed actors. The persistence of price deviation is one of the factors that determine whether price volatility is perceived as risky. A finding common to most of the interviewed farmers is that a high input price or low output price level persisting for one year/production cycle (i.e. a year for wheat and dairy farmers, and one production cycle for pig and tomato farmers) or longer is perceived to be more risky than weekly or monthly changes in prices. Even more risky is when a persisting high output price level (or low input price level) changes to a persisting low output price level (or high input price level) between years/production cycles. When such reversals in price change directions occur, it becomes challenging for farmers to reverse major investments made during good price years. Though undesirable, higher frequency price changes (within the year/production cycle) are seen as less risky because the farmers cannot easily respond to these changes anyway. Similar to farmers, retailers tend to be more concerned about the changes in yearly prices. Their argument is that higher frequency price changes can compensate each other during the year. This argument was also shared by some of the interviewed farmers.

Price changes occurring during the year were found to be more of a challenge to the wholesale and processing stages. This is particularly true for the wheat and cheese wholesalers

and processors. Fixed-price sales contracts unmatched with a fixed-price purchase contracts (and vice versa) and storage are the main causes of this challenge. For instance, it is risky when output prices drop and stay low during the period the input price is fixed at a high level through a contract (and vice versa for input prices). Sudden output price drops are also risky for goods in stock. Cooperative German pig, Spanish tomatoes and Dutch tomato wholesalers are concerned about both weekly changes and persisting changes in pig and tomato prices received by their member farmers.

The reasons why prices deviate or change from their expected levels also determine whether price volatility is perceived as risky. Price changes caused by sudden and major changes in local weather conditions and changes in global demand and supply conditions (caused for instance by conflicts in major producing countries and by border restrictions by major importing countries) are seen as worrying by actors in the cheese and wheat supply chains. Actors in the tomato supply chains mainly consider price changes caused by sudden and major changes in local weather conditions as risky ones. In the pork supply chains, the most challenging price changes are those caused by animal health related crises. Predictable seasonal price changes and price changes believed to have arisen from speculation are not considered as alarming by most of the actors.

Finally, the direction of the price deviation determines the riskiness of price volatility. The interviews revealed that actors are more concerned about downside price changes (increase in input price or decrease in output price) than price volatility in the sense of fluctuations (both upside and downside) in prices. Moreover, stability in margins was found to be more important than the stability in prices. All interviewed actors argue that a sudden and large decrease in an output price is not a concern if it is matched by a proportionate and immediate decrease in the input price (and vice versa). In practise, this rarely happens due to, among others, time lags in production, contracts (either on the buying or selling side), or price influences of retailers.

4.2.Price volatility management strategies

Below, the major types of strategies adopted are described and compared across chain stage. Table 5 summarizes the management strategies per chain stage and per strategy category. For

clarity, the number of actors across chain stage and strategy category is presented separately in Table 6.

4.2.1. Survival strategies

Survival strategies are loss minimizing strategies achieved, among others, through reductions of physical production, reduction of major investments, improvement in efficiency and diversification. These strategies, which are mainly long-term strategies, are mostly adopted by farmers. Since farmers cannot easily respond to short-term price changes, a majority of them concentrate their strategies on price changes that persist for one or more year/production cycle. Producers of storable products, as French wheat farmers in our sample attest, can be considered an exception to this as their ability to store wheat gives them the flexibility to decide when and how to sell. The interviewed Bulgarian wheat farmers, on the other hand, indicated their limited capacity to store wheat during the year. Survival strategies are also adopted among cooperative pig and tomato wholesalers. The only strategy these wholesalers can adopt to minimize their member farmers' losses in times of sudden price drops is to wait one more week before selling farmers' pigs and tomatoes to processors and retailers respectively. Keeping pigs and tomatoes for a longer period of time can result in further loss in the values of the produces.

4.2.2. Adaptive strategies

Except for cooperative pig and tomato wholesalers, most of the interviewed wholesalers and processors adopt adaptive strategies which allow them to secure a stable margin regardless of market price movements. Setting buying and selling prices on the same day, linking output prices to input prices, and avoiding open long-term fixed price forward contracts are some of the major adaptive strategies these actors adopt. The focus is on flexibility achieved through quick adaptation to market price movements. Not only is there an interest for flexible prices but also for flexible production. For instance, a Bulgarian wheat baker argues that switching from flour to bread production can be a solution in times of big drop in grain prices, and from bread to flour in case of big rises in grain prices. A specialty cheese processor argues that switching from processing milk to processing more volumes of cheese can be a solution to manage the risk from

milk price volatility. In case of a large drop in milk prices, it becomes profitable to process more cheese than processing and selling milk because of the value that cheese adds to the low priced milk.

4.2.3. Control strategies

The interest for control strategies through price-fixing contracts and vertical integration was not found as expected among most of the chain actors. This is particularly true for wholesalers and processors. Interest for contracts and vertical integration was however found among farmers (for instance Dutch dairy, German pig and French wheat farmers). Producing and trading premium products (for example, production of specialty cheese by cheese processors, production and trading of tomatoes with no pesticide residues and tomatoes of specialty varieties by tomato farmers, wholesalers and retailers) is another way of exercising control over prices. Many of the interviewed actors argue that prices of premium products are not as volatile and low as standard products. Such argument prevails in particular among actors downstream from the farm stage. For retailers, transmitting sudden increases in input prices is easier when the product is a premium product. Improved marketing of produces through promotion and better services to fill customers' needs is yet another method to add value to the product and command higher and more stable prices.

4.2.4. Hedging strategies

Though hedging through futures and option contracts is a widely accepted price volatility management strategy, its use was limited among the interviewed actors. Interest to use these instruments in the future was, nevertheless, expressed among a German pig farmer, a French wheat farmer, a Bulgarian wheat wholesaler, a pig wholesaler, a Dutch cheese wholesaler and a Dutch cheese processor. The absence of active futures markets for the respective products in the respective countries was mentioned as the main reason for the current non-use of these instruments. Except for one German pig farmer and one French wheat farmer who currently use options, no mention of interest for hedging with futures and options was made by any of the remaining interviewed farmers.

INSERT TABLE 5. ABOUT HERE

INSERT TABLE 6. ABOUT HERE

5. Discussion

This research demonstrated the diversity in price volatility management strategies adopted by actors in EU food supply chains. The results show that farmers' strategies include, but are not limited to frequently mentioned strategies in the literature, such as futures and options, forward contracts, and output diversification (for instance in Martin 1995, Meuwissen et al. 2001, Hall et al. 2003, Bergfjord 2009). A notable new development in farmers' strategies is to create added value through selection of better varieties to plant, production with less pesticide residues, product promotion, and collaboration with the retail sector to develop improved products. Some farmers are looking into the commercial side of farming as a way to manage the risk from the increasingly volatile prices of agricultural products. These farmers are moving from a supply-oriented to a demand-oriented farming by shifting their focus away from maximizing production volume towards satisfying customer demands. Better serving customers' needs requires in turn a coordination along the supply chain as argued in Chopra and Meindl (2013).

Current chain practises confirm the strategies identified in some of the investigated chains. Although not driven by the need to manage price volatility, the move towards market-oriented farming and towards further collaboration in the chain is already observed in the tomato supply chains. In the Dutch tomato chain, the replacement of the auction clock system by bilateral negotiations along the chain is one such example. Such replacement is driven, among others, by the need of some innovative growers to exploit market opportunities with new varieties that better serve customer demands (Bijman and Gijselinckx, 2012). Another driver was the need of retailers to establish long-term agreements with grower cooperatives and assure the supply of customized and differentiated products (Bijman and Gijselinckx, 2012). Closer collaboration among growers and retailers is also observed in the Spanish tomato chain (Pleite, 2004). In the French wheat supply chain, output diversification, enlargement of the size of high-value production (for example through the application or organic manure) and search for niche markets were found to be effective tools to deal with wheat price volatility (David et al., 2010).

Although the strategies identified in this study can be implemented by any of the investigated chain actors, it is not unreasonable to expect a possible link between firm characteristics and the price volatility management strategy adopted. For instance, due to the large investments required (technology, land and labour), the production of high value-added crops is a better option for medium and large sized farms than for small farms (David et al., 2010). Another strategy likely to be implemented by large-sized firms is the diversification of suppliers and buyers both at local and international levels. As the case of the Dutch tomato farmers attests, farmers who are members of a producer organization or a cooperative can better achieve a closer collaboration with the retail sector than the lone farmer.

Another link worth mentioning is the one between price volatility perceptions and the choices for price volatility management strategies. In fact, the perception of price volatility seems to drive the choice of management strategies. Concern about the persistence of price changes in the long run, as opposed to monthly or weekly price changes during the year or production cycle, can explain why most farmers adopt long-term strategies (that include diversification, achieving cost efficiency and quality product development). Wholesalers and processors, on the other hand, worry about monthly or weekly price changes from expected prices, and therefore choose flexibility to manage the risk from these price changes. It is worth mentioning that this latter finding contradicts Heyder et al. (2010) who found that control types of strategies, such as long-term contracts and vertical integration, are preferred ways to deal with risk and uncertainty.

In this study, the small sample size used hampers the statistical generalizability of the chain actors' strategic choices to a wider population. Nevertheless, the repetition of strategies across respondents at chain stage level provides some reliability in the results. For instance at the farm stage, getting rid of less productive cows and feed ingredient substitution were strategies adopted by all of the interviewed Dutch dairy farmers. Waiting one week before selling until prices recover was a strategy used by all of the interviewed German pig and Spanish tomato farmers. At the processor stage, short-term contracts were recurrently used by Dutch cheese processing companies. We point, nevertheless, to future research needs to investigate the applicability of the identified strategies to a wider population. Another avenue for future research concerns the variety in the identified strategies. For instance, future studies that are based on closed-ended

questionnaires and investigate actors' choices of price volatility management strategies could include the diverse set of strategies identified in this study in their list of alternative strategies.

6. Conclusions and outlook

This study conducted forty-two in-depth interviews in order to explore the price volatility perceptions and management strategies of farmers, wholesalers, processors and retailers in six EU food-supply chains. Results show that a more than 15% deviation in prices from their expected levels is perceived as price volatility by a majority of the respondents. Three main factors determine whether price volatility is perceived as risky by the chain actors: the persistence of the volatility and the reason and the direction of price deviations. While farmers and retailers perceive persisting price deviations as risky, short-term price changes occurring during the year or production cycle are also perceived to be risky by wholesalers and processors. Farmers' strategies were mostly survival strategies through output and cost reduction in response to adverse price movements. Wholesalers and processors focus on adaptive strategies that allow them to secure stable margins regardless of price movements. Retailers' main focus is to secure a continuous supply of quality produce for their customers rather than to reduce price volatility. Overall, the findings suggest a diversity in perceptions and strategies along EU food chains. Furthermore, it is shown that price volatility gives rise to the development of non-traditional types of strategies, and to changes in the structure of the chains and in the competitive landscapes of EU food markets.

Some of the identified price volatility management strategies can be better implemented with support from policy makers. Given the interest for cooperation in the chains, the current exemption of farmers' collusive behaviour under Articles 175 and 176 of European Commission Regulation 1234/2007 (Badarji et al. 2011) and the current support of inter-professional organizations are useful in this regard. Another area of policy support concerns futures markets. Given the interest in futures market in the Dutch dairy and Bulgarian wheat sectors, policy makers could consider investigating the needs and possibilities for the establishment of such markets. A third opportunity for policy intervention concerns the timely dissemination of improved and accessible demand, supply and price data and predictions to chain actors. This study showed that some actors relied on such information for their production and sales

decisions. Given the confidentiality of price data in the private sector, collecting and disseminating such information becomes a responsibility of the public sector.

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Table 1. Characteristics of farms and companies

	Farm[1] (n=15)						Wholesale (n=15)						Processing (n=9)			Retail (n=3)	
	BW n=2	FW n=2	GP n=2	DC n=3	DT n=3	ST n=3	BW n=3	FW n=1	GP n=2	DC n=3	DT n=2	ST[2] n=4	BW n=3	FW n=1	DC n=5	DC n=1	ST[3] n=2
Member of a cooperative?																	
Yes	1	2	0	3	2	1											
No	1	0	2	0	1	2											
Cooperative?																	
Yes							0	1	1	0	0	3	1	0	4	0	0
No							3	0	1	3	2	1	2	1	1	1	2
Number of employees																	
<= 49							0	1	2	0	0	1	0	0	0	0	1
50 - 249							0	0	0	2	2	0	2	0	3	0	0
>= 250							3	0	0	1	0	3	1	1	2	1	1
Involved in exports?																	
Yes							3	0	0	3	2	3	0	1	4	0	0
No	2	2	2	3	3	3	0	1	2	0	0	1	3	0	1	1	2

[1]Farm size per chain: BW:40 ha and 7250 ha of total cultivated land; FW:220 ha and 130 ha of total cultivated land; GP:2000 and 3300 fattening pig places; DC:120, 275 and 700 milking cows (both heifers and calves); ST: 1.5, 2.5 and 3 ha of total greenhouse area; DT:11 ha of total greenhouse area.
Note that BW: Bulgarian wheat chain, FW: French wheat chain, GP: German pork chain, DC: Dutch cheese chain, DT: Dutch tomatoes chain, ST: Spanish tomato chain. ***Farmers sell*** wheat in BW and FW, pigs in GP, milk in DC and tomatoes in DT and ST. ***Wholesalers sell*** wheat grain in BW and FW, pigs in GP, cheese in DC, and tomatoes in DT and ST. ***Processors sell*** wheat flour (n=2) and bread (n=1) in BW, wheat flour in FW, and cheese in DC. ***Retailers sell*** cheese in DC and tomatoes in ST. ***Farmers source*** pig feed in GP and cattle feed in DC. ***Wholesalers source*** wheat grain in BW and FW, pigs in GP, cheese in DC, and tomatoes in DT and ST. ***Processors source*** wheat grain (n=2) in BW and in FW, and milk in DC. ***Retailers source*** cheese in DC and tomatoes in ST.
[2]One of the wholesalers is a giant Dutch cooperative buying tomatoes from Spain. The suppliers in Spain are not a member of the Dutch cooperative.
[3]One of the retailers is a British supermarket buying tomatoes from Spain.

Table 2. Number of actors per rating of various business risks

	Farm [1] (n=15)			Wholesale[2] (n=15)			Processing[3] (n=9)			Retail[4] (n=3)		
	C	MC	NC	C	MC	NC	C	MC	NC	C	MC	NC
Input sourcing related risks[5]												
High input prices	**3**	2	0	**6**	4	5	**4**	2	3	**2**	1	0
Instability in volume of input supply	0	0	5	6	2	7	4	1	4	1	0	2
Low volume of input supply	0	0	5	4	1	10	4	0	5	1	0	2
Low quality of input supply	0	1	4	3	2	10	1	1	7	1	0	2
Inconsistent quality of input supply	0	1	4	6	1	8	2	1	6	1	0	2
Poor on-time delivery of inputs purchased	0	0	5	3	2	10	1	0	8	1	0	2
Tracing and tracking challenges	0	0	5	1	0	14	2	0	7	1	0	2
Detection of diseases in inputs	0	0	5	3	1	11	1	0	8	1	0	2
Input price volatility	**1**	0	4	**8**	2	5	**6**	0	3	**1**	1	1
Imbalance of market power with input suppliers	1	0	4	5	5	5	1	0	8	1	0	2
Output selling related risks												
Low output prices	**9**	2	4	**10**	1	3	**6**	1	1	Ni[6]	Ni	Ni
Instability in demand volume	3	1	11	5	3	6	3	1	4	Ni	Ni	Ni
Low demand volume	3	0	12	6	1	7	5	0	3	Ni	Ni	Ni
Lack of capacity to fill high demand volume	0	2	13	2	1	11	1	1	6	Ni	Ni	Ni
Lack of capacity to fill high quality specifications of customers	1	1	13	2	1	11	1	0	7	Ni	Ni	Ni
Instability in quality specifications demanded by customers	3	0	12	4	0	10	0	1	7	Ni	Ni	Ni
Output price volatility	**8**	2	5	**7**	1	6	**6**	2	0	Ni	Ni	Ni
Imbalance of market power with customers	6	1	8	6	1	7	3	0	5	Ni	Ni	Ni
Poor on-time payment for deliveries	1	0	14	5	1	8	4	1	3	Ni	Ni	Ni

[1]Highlighted in bold are the number of farmers, wholesalers, processors and retailers which found high input/low output prices and input/output price volatility as challenging. C: Challenging (=1, 2, 3 in Likert scale), MC: Moderately challenging (= 4 in Likert scale), NC: Not challenging (= 5, 6, 7 in Likert scale).
[2]One of the wholesalers was not familiar with the selling related challenges of the company as the company sold its output to the parent company.
[3,4] The selling related challenges were not inquired for companies (bakery and retailers) selling directly to final consumers.
[5]Input sourcing related challenges were not inquired in the case of wheat and tomato farmers.
[6]Not inquired.

Table 3. Price volatility

	Farm	Wholesale	Processing	Retail
Percentage deviation[1]	➢ Wheat grain:10% ➢ Pig feed:10% ➢ Pigs:10% ➢ Cattle feed: 15% ➢ Milk: 10% ➢ Tomatoes: 20%	➢ Wheat grain: 10% ➢ Pigs: 10% ➢ Cheese:10% ➢ Tomatoes: 20%	➢ Wheat grain and flour: 10% ➢ Milk and Cheese[2]: 10%	➢ Cheese: 3% ➢ Tomatoes: 20%

[1] Percentage deviations, plus or minus an expected price level, that exceed the specified percentages are perceived as price volatility by the chain actors. The percentages are averages across respondents, rounded to the nearest decimal. Percentages relate to various price settlement periods in the respective chain, namely monthly in the Dutch cheese chain, and weekly in the rest of the chains.

[2]Note that only one cheese processor perceived a more than 20% price deviation as volatility, with the rest of the processors perceiving less than 5% price deviation as volatility.

Table 4. Factors determining the riskiness of price volatility

Factors[1]	Farm	Wholesale	Processing	Retail
Persistence of deviation	➢ A year or a production cycle[2] (DC, DT, BW, GP, ST) ➢ Depending on stock level and position in forward contract[3] (FW)	➢ Depending on stock level and position in forward contract (BW, DC, FW) ➢ One week and longer[2](GP, DT, ST)	➢ Depending on stock level and position in forward contract (BW, DC)	➢ A year (DC, ST)
Reason of deviation	➢ Local and global weather shocks (DC, BW, FW) ➢ Animal health crisis (GP) ➢ Local weather shocks (ST, DT)	➢ Local and global weather shocks (DC, BW, FW) ➢ Animal health crisis (GP) ➢ Local weather shocks (ST, DT)	➢ Local and global weather shocks (DC, BW, FW) ➢ Animal health crisis (GP) ➢ Local weather shocks (ST, DT)	➢ Local and global weather shocks (DC, BW, FW) ➢ Animal health crisis (GP) ➢ Local weather shocks (ST, DT)
Direction of deviation	➢ Increase in input price and/or decrease in output price	➢ Increase in input price or decrease in output price	➢ Increase in input price or decrease in output price	➢ Increase in input price or decrease in output price

[1]Price volatility is perceived as risky if price deviations from expected levels persist for the indicated periods, if they are caused by the indicated reasons, and if they occur in the indicated directions. Note that BW: Bulgarian wheat chain, FW: French wheat chain, GP: German pork chain, DC: Dutch cheese chain, DT: Dutch tomatoes chain, ST: Spanish tomato chain.

[2] It is risky if a high input or low output price level persists for the specified or longer period.

[3] It is risky when output prices drop (input prices rise) and stay low (high) during the period input prices (output prices) are fixed through contracts at a high (low) level. It is risky when output prices drop while there are goods in stock.

Table 5. Price volatility management strategies

SC[1]	Farm	Wholesale	Processing	Retail
Survive	➢ Substitute or cut production (DC, ST, BW) ➢ Substitute expensive ingredients (DC) ➢ Increase production efficiency, reduce costs and increase productivity (DC, BW, DT) ➢ Avoid major investments (DC) ➢ Wait a bit and sell at whatever price (ST, GP, BW) ➢ Diversify production (BW, FW) ➢ Promote product by producer organization in times of sudden price drop caused by excess production (DT)	➢ Wait a bit and sell[2] (ST) ➢ Ask farmers to wait a week or two weeks more before harvesting the plant[2] (ST) ➢ Agree with competitors to throw away excess production and raise back prices (ST[2], DT) ➢ Increase production efficiency[2](ST) ➢ Diversify suppliers (ST) and buyers (DT)[2] ➢ Sell quickly at whatever price[2] (GP, DC) ➢ Sell excess production through retail promotion (ST, DT[2]) ➢ Cut purchases during overproduction as prices are too low to sell back (ST)	➢ Diversify production (DC) ➢ Cut production (BW)	➢ Diversify suppliers (ST)

[1]SC: Strategy category. Note that BW: Bulgarian wheat chain, FW: French wheat chain, GP: German pork chain, DC: Dutch cheese chain, DT: Dutch tomatoes chain, ST: Spanish tomato chain.
[2]Strategies used by cooperative wholesalers whose main objectives are to minimize losses that member farmers face in times of sudden drop in prices.

Table 5. (Continued) Price volatility management strategies

SC	Farm	Wholesale	Processing	Retail
Adapt	➢ Shorter contracts with small quantities per contract (FW) ➢ Closely follow market development, improve price predictions and concentrate production in high price weeks (ST, DT)	➢ Shorter contracts (DC) ➢ Renegotiate fixed price contracts (DC) ➢ Long-term contracts with flexible output prices (DC) ➢ Buy aggressively in case of price spikes (due to shortages) and wait when prices are too low (BW) ➢ Take risk by taking a long or short position to profit from cheese price volatility (DC) ➢ Secure supply at whatever price (ST, BW) ➢ Agree on buying and selling price on same day (BW) ➢ Sell majority of grain right after purchasing it during harvest (FW) ➢ Closely follow market development and improve price predictions (DT, BW, DC)	➢ Use milk pools to set output prices[3] (DC) ➢ Shorter sales contracts (DC) ➢ Contracts with flexible output prices (flexible with input prices; use output price bands to share price risk with retailer) (DC) ➢ Switch production among alternative products (DC, BW) ➢ Adjust production volume (BW) ➢ Cost-plus pricing for output (DC) ➢ Agree on input and output price on same day (FW, BW) ➢ Avoid storage/buy only for daily needs (BW) ➢ Transmit price changes (BW) ➢ Buy spot milk to take advantage of volatility (sudden drop in milk prices) (DC) ➢ Renegotiate fixed price contracts (DC)	➢ Secure supply at whatever price (DC) ➢ Transmit price changes (price decreases in particular) (DC, ST)

[3]A cooperative producing only cheese can pay farmers a competitive milk price calculated based on a 'weighted-average' of final dairy prices of competitors

Table 5. (Continued) Price volatility management strategies

SC	Farm	Wholesale	Processing	Retail
Control	➢ Fixed price forward contract for inputs (DC, GP) ➢ Fixed price forward contract for outputs (FW, DT[4]) ➢ Forward integration to process own milk[4] (DC) ➢ Backward integration to produce own maize (DC) ➢ Improve output quality (BW[4], DT, ST) ➢ Closer relationship with retailers for improved product development and with long-term fixed price contracts[4] (DT) ➢ Better marketing/promotion of produces by producer organization to add value to the produce (DT)	➢ Trade quality produce (ST, BW) ➢ Fixed price forward sales contract with 100% advance payment[4] (BW) ➢ Fixed price forward contract for outputs (ST) ➢ Pay farmers an average of 2 weeks' prices (GP) ➢ Merger among wholesalers to gain more market power[4] (DT) ➢ Closer relationship with retailers for better marketing/promotion of produces to add value to the produce (DT)	➢ Produce quality product (DC, BW) ➢ Do not overreact: fix milk price at moderate level (DC) ➢ Store (BW)	➢ Secure quality product (DC, ST) ➢ Fixed price purchase contract (ST)

[4]Strategies not yet implemented, but planned for the future.

Table 5. (Continued) Price volatility management strategies

SC	Farm	Wholesale	Processing	Retail
Hedge	➢ Hedge in futures market (GP[4], FW) ➢ Use average seasonal price offered by cooperatives (FW)	➢ Hedge in futures market[4] (DC, GP, BW) ➢ Use options (FW)	➢ Hedge in future market[4] (DC) ➢ Over-the-counter contracts for milk[4] (DC)	➢ None

[4]Strategies not yet implemented, but planned for the future

Table 6. Number of actors per strategy category and chain stage

Strategy[1] category	Farm (n=15)	Wholesale (n=15)	Processing (n=9)	Retail (n=3)	Total
Survival	13	7	2	0	12
Adaptive	2	10	9	3	24
Control	5	4	3	1	13
Hedging	3	3	1	0	7

[1]Note that one actor can use a combination of strategies