Understanding the European Futures Markets on Dairy Products: a Multi-Product Perspective

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Paper submitted to the JRSS 2020

Abstract

The European Union has radically reformed its milk policy in the last decades by reducing price support levels and removing production quotas. European dairy operators are now facing volatile milk and dairy prices but can participate in new futures markets. However the liquidity on these markets remains limited so far. This paper develops original economic and statistical methods to understand this apparent puzzle. We first reveal the productive responses of European dairy processors using monthly price data over three distinct periods: under the milk quota, during the soft landing and finally without quotas. Then we find that the production flexibility of dairy processors and the milk price mechanisms are important factors hampering the liquidity of futures market on dairy products. We finally argue that both European dairy processors and milk producers can benefit from efficient futures dairy markets, by expanding their business and saving costs on milk price negotiations.

1. Introduction

When the Common Agricultural Policy (CAP) was instituted in the 1960s, the European Union (EU) was not self-sufficient for many products, notably dairy products. By defining a complex price support system, the initial milk Common Market Organization did provide high and stable prices to European dairy producers and processors. The price incentives led to a significant development of European productions and the EU quickly became self-sufficient. In order to limit public expenditures induced by the dairy surplus, milk production quotas were imposed on producers in the mid 1980s and then gradually reduced.

In 1999, a radical reform of this EU milk policy is announced with implementation delayed to 2006. In fact this reform is advanced with the 2003 CAP Mid Term Review. The reductions of the intervention prices on butter and skimmed milk powder started in 2004. Then the CAP Health Check in 2008 implement the soft landing of milk quotas, from 2009 to 2015. From 2004, direct payments are granted to dairy farmers to compensate the expected decreases of market prices. Later reforms of the CAP condition these payments on stricter environmental farm practices. Finally a milk package defines general guidelines that dairy farmers and processors have to follow when negotiating milk price and volumes.

Like other European farmers, such as grain, sugarbeet and pig farmers, European dairy operators now have to deal with volatile prices. Measured with a yearly coefficient of variation, the volatility of European market prices of butter and milk powders now reach 15%, compared to 2% before the milk reform. Even if the average prices of milk and milk products did not decrease as the intervention prices, the significant rise of the price volatility on dairy markets rapidly becomes a major political concern. This issue is obviously critical when the milk and dairy product prices are particularly low, which occurs twice in the last ten years (in 2009 and 2016). In both cases, public debates on the efficiency of the milk reform reopen. Proponents of the reform argue that, with less public intervention on the physical dairy markets, futures market will emerge and allow operators to efficiently manage their price risks. It is also argued that public intervention should help the initial development of these futures market (recent examples include the EC, 2017). Some dairy economic actors also welcome these futures market (Eucolait, 2017).

While some futures market defined on European dairy products (butter and skimmed milk powder) exist for some years now, the liquidity of these markets remain very limited, with very limited open positions and daily trade. The central question of this paper is to understand this apparent puzzle. With a rather similar price volatility, the futures markets on EU cereals are now significantly liquid. In the US and New Zealand, the futures market on dairy products are also operational, albeit much less than grain markets. So what is different so far in the EU dairy case?

This paper is organised as follows. The first section provides a synthesis of the main insights of the large economic and financial literature that analyses the success and failure of futures markets. We also report the main insights of papers analyzing the European on futures dairy markets. The second section develops a new economic simulation model assessing the relative importance of different factors behind the success of dairy futures markets. This new model features two main original contributions. First this is a multi-product model accounting for the complex substitution relationships between the different dairy products that can be obtained by processing milk. Second this model encompasses many factors, including the institutional arrangements between milk farmers and processors on milk price and volumes. In order to implement this simulation model, the third section develops original statistical analyses using available price series from the new EU milk market observatory. The cointegration results on EU spot/forward dairy prices confirm that dairy processors adapt their production portfolio to benefit from price developments and to avoid price fluctuations. The fourth section is devoted to simulations to understand the positions of dairy processors on futures markets, as well as assessing the usefulness of these markets. The simulation results reveal that the production flexibility of dairy processors and the milk price mechanisms are important factors of the liquidity of futures market. Section five concludes.

2. Literature review

The first organized futures markets date back from the 1850's. Since that time, many new futures market on agricultural and food products have been launched. But only one third of them lasts many years and the other two thirds fail rapidly. A large economic and financial literature analyses the conditions of success of these markets. This literature is always active, with recent papers analyzing new specific cases and/or developing new methods. For instance, Bekkerman and Tejeda (2017) develop an original multi-commodity analysis upon which we elaborate below. These authors find that that the viability of new futures contract for commodities that are jointly produced with other commodities is impacted by the position of economic agents on related futures contract.

We offer a synthesis of this literature, supported with illustrative references on dairy futures markets. In a general way, the factors of success of futures market already identified Brorsen and Fofana (2001) remain relevant in the recent studies. We first find factors on the physical markets.

In particular the spot price must be sufficiently volatile so that price hedging brings value to participants. Pennings and Meulenberg (1998) analyze the usefulness of futures contract on European milk production rights, because their prices can be much more volatile than the milk prices. The higher is the risk aversion of economic agents, the higher is the potential liquidity. But risk aversion is not a necessary condition (Williams, 1987). Other solutions, such as the credit market, to manage the consequences the price risks are not "ideal". In this respect, Loughrey et al. (2018) evaluate different tools, including fiscal policies, to manage price/income volatility at the dairy farm level in Ireland and find, as expected, that fiscal policies matter.

We also find factors pertaining directly on the futures markets. This includes the price convergence at settlement between spot and futures prices (this factor can be endogenous to the success of futures contract). Numerous analyses consider basis risk as a crucial factor with for instance, Bialkowski and Koeman (2017) in the US and New Zealand case, O'Connor et al. (2015) and Weber (2017) in the European case. This last author concludes that the European futures market on dairy products (butter, skimmed milk powder and whey powder) efficiently fulfill their functions. Besides, the liquidity on futures markets is higher with lower "transaction" costs. The transaction costs differ according to the contract settlement (delivery/cash), the product homogeneity (involved grading system for differentiated commodities), the trading system (such as electronic). Finally the presence of market makers/scalpers, at least in the initial phase, is often advanced.

More generally, a futures market can develop if there is no market price manipulation due to the market power by some participants. A futures market can disappear if a "similar" futures market already exist (for instance, in a close country). And, not least, the public policy on both the physical and futures markets should be predictable and does not crowd out private incentives. Newton et al. (2014) is an example showing the interaction between the complex US milk policy and participation in futures markets (for both inputs and outputs).

This predictability of public policies is very difficult to assess but can be invoked in the European dairy case. The different CAP reforms conduced over the last 25 years always contain some ambiguous measure, such as the use of the crisis reserve in case of exceptional market disturbance. While the existence of crisis reserve is clear with some allocated public funds, the definition of an exceptional market disturbance is lacking. This may have contributed to the absence of liquidity of European futures contract on dairy products.

A coherent quantification of these different factors in the case of European futures contract on dairy products is highly challenging, requiring a huge amount of data (or assumptions when data are not available such as the policy expectations by economic agents on the use of the crisis reserve). Rather, we develop below an original economic framework allowing us to quantify two factors that contribute to the low participation of European dairy processors on futures market.

3. Modelling assumptions

Commodity futures markets may exist even if commodity producers and users do not take financial contracts. But it is natural and common to analyze the existence of futures markets by first investigating the likely positions of producers/users on this market. We focus on the potential participation of European dairy processors on two futures contracts: butter and skimmed milk powder. These two futures contracts were first proposed by Euronext in 2010, then stopped and reopened by Euronext and EEX in 2015 (EC, 2017).

The European dairy processors have long been constrained on the input side by the milk availability (due to the milk quotas) and the intervention price regime. If this regime ensures minimum price for two products (butter, skimmed milk powder), this regime also defines the milk price they pay to dairy farmers. In fact, from 1984 to 1999, the production choices of dairy processors were mostly limited to the type and volume of productions (quantity of butter/ skimmed milk powder, other dairy products such as cheese, fresh dairy products, ….). With the Agenda 2000 CAP reform, the dairy processors know that the future price of dairy product may be lower due to the reduction of the intervention prices. Their production choices remain the same but less constrained. On the other hand, they can expect that the volatility of output prices will increase. The transmission of dairy product prices to the milk price also becomes an increasing concern. The “2009” milk crisis with low dairy product prices dramatically makes this concern concrete, leading policy makers to adopt the milk package in 2012.

The eventual participation of dairy processors to the futures market may depend on this complex context. Our economic model intends to capture it. We assume that the objective of the dairy processor is to maximize his expected utility of profit subject to the price (volatility) of inputs and outputs and technological relationship (the possibility to produce dairy products given an amount of milk delivered by dairy farmers). Formally, the program of the dairy processor is given by:

$$max_{Y,X,H} EU(\pi_s) = \sum_s w_s U(\pi_s)$$

Subject to

$\pi_s \leq PY_s.Y - PX_s.X + (F - tf - PY_s).H$

$T(Y,X) = 0$

With : s is the state of nature (the random price of output and input), E the expectation operator, $U(\pi_s)$ the utility function, w_s the probability of this state of nature, π_s the profit, PY_s the vector of risky output dairy prices, Y the vector of dairy product productions, PX_s the vector of risky input prices, X the vector of input uses, F the vector of futures price on dairy products, tf the vector of transaction costs supported by the dairy processor when participating in futures market, H the vector of hedging, $T(Y,X)$ the production possibility frontier (PPF).

This PPF is written in very general form but, as explained below, is highly involved to capture the complex relationships between input and outputs of the dairy processor.

First order conditions determining the optimal behavior of the dairy processor are given by:

$$\sum_s w_s.U_\pi(\pi_s).\big(PY_s - \lambda.T_Y(Y,X)\big) \leq 0 \qquad (1)$$

$$\sum_s w_s.U_\pi(\pi_s).\big(PX_s - \lambda.T_X(Y,X)\big) \leq 0 \qquad (2)$$

$$\sum_s w_s.U_\pi(\pi_s).(F - tf - PY_s) \leq 0 \qquad (3)$$

λ is the lagrangian multiplier associated with the PPF constraint. Equation (1) determines the optimal production level, equation (2) the optimal level of input use and equation (3) the optimal use of futures contract. It should be clear that the three types of equations form a square system that must be solved simultaneously. The derived demand of milk by the dairy processor depends on his risk attitude (captured by the derivative of the utility function), the price volatility (captured by the profit in the different state of nature), the technical constraints (captured by the derivative of the PPF) and the futures market parameters (again through the definition of the profit in the different state of nature). If the dairy processor can easily switch from one dairy product to another (say from the couple butter/skimmed milk powder, to cheese and whey powder), this will change his expected profit and hence the demand of futures contract. These equations are expressed in complementarity format, meaning that the dairy processor may not participate in the futures market if, for instance, transaction costs are too high.

These equations generalize the 2 commodities model developed by Bekkerman and Tejeda (2017) to n commodities, taking into account both output and input price risks. The relation between both prices can be formalized as:

$$E(PX_s) = F\big(E(PY_s)\big) \qquad (4)$$

This equation does not define a new production and financial endogenous variable. It only captures the milk price expectation by the dairy processors given output prices. The function F capture the policy regulation on milk prices.

The main difficulties when implementing this model relates to the calibration of the parameters involved in the utility function and the PPF, to which we turn now.

4. Empirical assumptions

Data availability often constrains economic analysis. This is also our case because economic data on European dairy processors are rare (Jongeneel et al., 2011). For instance, Hirsh et al. (2019) assess the so-called tactical production flexibility of these processors and not their operational flexibility because they don't have their many production decisions (only the aggregate sales of dairy products). In their analysis of the soft landing of milk quotas, Bouamra Mechemache et al. (2008) assume that the unitary costs of processing milk components (fat and protein) into dairy products. Chavas and Kim (2006) adopt the same assumption when analyzing the hedonic pricing of milk components. These authors implicitly assume that the dairy processors can perfectly adapt their plants to produce more of profitable products and less of other products, given the fat and protein delivered by milk farmers. This assumption may pertain in the very long run, less likely in the short run. Above all, this assumption already excludes the usefulness of futures market for dairy processors to manage price risks. Dairy processors can easily change their production decisions at no additional costs in order to reduce their price risks.

In order to avoid this extreme assumption preventing our analysis, we need to learn as much as possible from available data. Most accessible are the market (spot/forward) prices of dairy products and milk (from the milk market observatory). The prices obviously contain useful information allowing time series analysis using cointegration techniques (when prices are not stationary). While necessary, these price data are not sufficiently to correctly identify the behavior of economic agents, either producers or consumers. Additional market information, such as demand/production shifters, are useful to interpret price analysis (Fackler and Goodwin, 2001). Information on public stocks of butter and skimmed milk powder are available at the demand side ; at the supply side, we have the milk deliveries by farmers and their composition in terms of fat and protein. Below we use all these information.

These data are available since 2001 at the monthly frequency. Performing a statistical analysis on the whole period does not make economic sense because policy and market contexts have dramatically changed under this period. We divide this period into three subperiods. The first period extends from the campaign 2001 to the 2006 campaign when the intervention prices are reduced. It appears that the market prices during this first period were not much volatile and followed the reduction of intervention prices. Thus we can reasonably assume that dairy processors adapt to the true market signals during that period (in other words, that expected prices equal true prices), where milk quotas were basically unchanged. We use this first period to partially identify the features of their PPF, using in particular data on the public stocks.

The second period corresponds to the soft landing of quotas (2007 to 2015). Compared to the previous one, dairy processors have uncertainty on the evolution of milk deliveries by milk farmers. Will they fulfill their production quotas? This period also sees the first major price swings, with “high” prices in 2007/2008 and “low” prices in 2009/2010. It is less obvious to define correct price expectations of dairy processors for that period. This is also the case for our last period which corresponds to 2015 up to now, without quotas. Price volatilities continue to increase, with the effect of the Russian embargo in 2015/2016. The policy and market contexts of the second and third periods are thus much more different: public stocks are often null and when positive, very likely quite difficult to predict by European dairy processors. Thus we can not expect that these stock data allow us to reveal the attitude of dairy processors. On the other hand, we can contrast the results of the cointegration estimation conducted on these two periods. If results are statistically significant, this may signal that their behavior has changed.

Let’s start with the price analysis on the price reduction period, where our main objective is to identify the PPF of dairy processors. Chavas et Kim, Bouamra et al. develop a hedonic approach, assuming that the composition of dairy products (fat/protein) and milk is constant. The PPF is thus given by fixed Leontief input/output coefficient. While intuitive for some “homogenous” products such as butter and milk powder, this assumption is not evident for other dairy products (liquid milk or cheese). Accordingly we prefer to adopt a more general specification of their production technology but compatible with our limited data set. We assume that, during our first period (and in fact in early years as well), dairy processors seeks to maximize profit (without risk aversion). This involves the cost minimization (over variable inputs such as labor) under their PPF subject to fixed factors (dairy plants) and the availability of milk components (fat/protein). We assume that this cost minimization leads to a normalized quadratic multi-product cost function, which is concave with respect to input prices. This cost function is used for instance by Wieck and Heckelei (2007) to analyse milk production by European milk farmers. Keeping the notation of the previous section, this cost minimization program is given by:

$C(w, Y, X) = min_L w.L$

Subject to $T(Y, L, X) = 0$

Where w is the price of variable inputs (in the application, we have only one aggregate variable inputs), L the quantity of variable inputs, and X the vector of (quasi) fixed factors. This includes the quantities of fat and protein that dairy processors have to process. The marginal costs of production are given by:

$$C_Y(w, Y, X) = w.(E + G.Y + H.X) \tag{5}$$

Where E, G and H are parameters reflecting the PPF of dairy processors and their cost minimization behavior. Chavas et Kim, as well as Bouamra Mechemache et al. assume that the G matrix is null. One can show that our specification is similar to their specification, with the H matrix of parameters capturing the opportunity prices of milk components.

As usual, we assume that dairy processors adjust their production volumes to maximize their profit, so that prices equal marginal costs: $P = C_Y(w, Y, X)$. At the demand side, we assume during this first period two types of demands: net demand by consumers that is price dependent (with B the price response, F the constant) and the exogenous variation of public stocks decided by the EC (noted by S):

$$D = F - BP + S \tag{6}$$

At each month, there is an equilibrium between production and demand (which includes private stocks). So combining (6) and (5) (and normalizing the price of variable inputs), we obtain:

$$(I + G.B).P = E + G.F + G.S + H.X \tag{7}$$

We underline that the milk price does not enter this equation because our assumption is that dairy processors always deal with all milk delivered by milk farmers.

We are interested by the G matrix capturing the production response of dairy processors. Unfortunately the parameters of this matrix are not identified (as they are multiplied by the parameters of the B matrix, capturing the price response of consumers). We are not able to individually estimate them, only in relative terms.

In order to minimize the number of parameters, we estimate the system of equations (7) for three products: butter, skimmed milk powder and one cheese (we report below the case with Emmental). We assume that the B matrix is diagonal (that is there is no marshallian substitution between these pairs of products). We also assume that the quantity of fat (protein) has no direct impact on the marginal cost of skimmed milk powder (butter) for given quantity of all dairy products. Similar to Bouamra Mechemache et al., 2008, we use the Generalised Maximum Entropy approach to perform the estimation and the entropy ratio test to test the significance of estimated parameters. Stationarity of the residuals is checked with the ADF test.

Main econometric results are reported in the Table 1. We underline that the results are not price elasticities because we do not have quantities. We can simply observe that the price responses of the supply functions (given by the inverse of the G matrix) are larger than the price responses of final demands (directly given by the B matrix). We test and find that the parameters of the G matrix are globally statistically different from zero (on diagonal and/or off diagonal). We underline that we do not impose the convexity of the cost function with respect to the production vector (as in Wieck and Heckelei). The supply responses are nevertheless of the expected sign, with for instance ae positive own price response for butter. The impacts of the fat/protein availability are also expected, with positive effect of fat supply on butter production. Overall these estimation results suggest that the production response of dairy processors are not null, nor infinite in the short run. They adapt their production volume to the market signal but are constrained by their fixed factor in the short run. As we will see in the next section, this price response of dairy producers lead them to produce less butter and skimmed milk powder, reducing the usefulness of futures markets on these commodities.

Table 1. Econometric results of the price equilibrium conditions on 2001/2007

	Butter price	SMP price	Emmental price	Fat supply	Protein supply
Supply:					
Butter	3.32	-3.13	-1.37	1.20	-2.14
SMP	-3.13	7.95	-1.82	-2.85	3.46
Emmental	-1.37	-1.82	1.04	-0.22	-0.56
Demand:					
Butter	-0.72				
SMP		-0.60			
Emmental			-0.84		

Performing a similar structural estimation on the two other periods is not possible for two reasons. One is that public stocks are often zero and the other is that the price volatility increases. This means that the introduction of risk aversion, price expectations by dairy processors may matter, at least cannot be totally ignored from the analysis. We can still perform a reduced form price analysis where the objective is simply to check if the estimated parameters remain the same or not.

We perform standard cointegration estimation on two triplets of dairy products: butter, skimmed milk powder and milk for the first triplet, emmental, whey and milk for the second. As argued above, dairy processors are less “constrained” in their production decisions since mid 2000. From 2015, they are free to negotiate with milk farmers the quantity and price of milks. On the other hand, they have to manage greater price volatility on their products, as well as the transmission to milk prices. Results of the cointegration estimations are reported in Table 2. These coefficients have not direct economic interpretation. Most important is the fact that the cointegration parameters change with the periods. For the 2015/2019, the butter, smp and milk prices are no longer cointegrated, while they were in the previous period. One possible reason is that dairy processors have continued to modify their production decisions (for instance, modifying the type of butter or the marketing of butter with forward contracts, leading to a thiny spot market of butter). One may object that the demand of dairy products, in particular, has also changed. It is less obvious that the eventual demand change has occurred at the end of the milk quota period.

The prices of emmental, whey and milk are always cointegrated over the two periods, but with significantly different cointegration parameters. Here too, this may result more from the adaptation of dairy processors to their new policy and market context, than a shift in final demand.

Table 2. Cointegration parameters between dairy and milk prices

	Butter	SMP	Milk
Period:			
2007/2015	1	1.47	-20.6
2015/2019	-	-	-
	Emmental	Whey	Milk
Period:			
2007/2015	1	3.06	-20.48
2015/2019	1	1.22	-16.04

Overall, our statistical efforts tend to indicate that dairy processors are not "passive" economic actors, simply processing the fat and protein delivered by milk farmers. They adapt their production decisions in order to maximize profits and avoid risks. However we are not able to precisely identify all structural parameters. We are thus forced to make calibration assumption when implementing our economic simulation model. We now explicitly explain the calibration of the parameters of this model.

We first focus on the behavior of the "average" dairy processor. Data are coming by default from the milk market observatory, then from Bouamra Mechemache et al. (2008) for technical coefficients (how much cream in raw milk, butter, whole milk powder, cheese, …) and French accounting data for the structure of production costs of dairy processors. We use pre reform data for 2001 as the benchmark and assumes a representative EU dairy processors.

For the parameters of the PPF, we follow Finger et al (2019) who themselves uses guess estimates from the CAPRI model. In practical terms, the PPF is specified assuming a strong separability between inputs and outputs. At the input side, we specify a CES function with three inputs: raw milk, variable inputs and capital. The elasticity of substitution is fixed at 0.1. Raw milk is then divided in two components (fat/protein). At the output side, we consider 5 products : butter, skimmed milk powder, whole milk powder, cheese and an aggregate of other dairy products. We specify a parsimonious CET function. As in CAPRI, we start with 0.5 value for the elasticity of transformation. As regards risk aversion, we have even less econometric evidence for food processors. We assume a standard power utility function, and start with a risk aversion coefficient of 2. Assuming 2% price volatility before the CAP reforms, this means that the risk premium represent 1% of expected profit by the dairy processor.

5. Simulation results

Our initial situation correspond to the pre reform situation with “high and stable” prices of dairy products and milk prices (reported in the first column of Table 3). In this initial situation, we assume that the futures markets on butter and skimmed milk powder are absent (equivalently prohibitive transaction costs) because the price risks on dairy products (coefficient of variation of 2) are limited. Milk prices are also quite stable (CV of 1%). We now conduct several simulations to identify the likely participation of dairy processors in futures markets.

Our first simulation (reported in the second column of Table 3) implement the price decrease decided during the 2003 Mid Term Review (by 22.5% for butter, 12.5% for SMP and 17.5% for WMP). We consider that the market price decrease slightly less than the intervention price (as in the cereal case in the first years following the 1992 CAP reform). We also assume that this reform induces a decrease of milk price by 17.5%. The results of this first simulation are standard and similar to Bouamra Mechemache et al. for instance. The dairy processors reduce their production of butter and milk powders. On the other hand, they increase the production of cheese. Thanks to the reduction of the milk price, they are ready to process more milk (by 1%) if milk farmers decide to produce (despite the milk price reduction but thanks to the support given by direct payments). Following this scenario, the milk price volatility (measured by the Coefficient of Variation) marginally increases due to the reduction of average milk prices.

Our second simulation consider the same price decrease but also an increasing volatility of butter and milk powder prices (CV of 15%). In this scenario, we maintain a low volatility of milk prices. As expected, this leads the European dairy processors to further decrease their production of these commodities. They also demand less milk in order to limit their exposition to output price volatility.

Table 3. Results of the four simulations (in % with respect to the initial situation)

Simulation	Initial situation	Price reduction	Price volatility	Futures markets	Milk Package
Production (MT)					
Butter	1.8	-3.0	-4.2	-3.6	-2.0
SMP	1.2	-11.4	-14.0	-12.7	-8.6
WMP	1.0	-13.3	-14.5	-13.9	-12.2
Cheese	4.2	12.3	12.4	12.4	11.8
Oth dairy	Index	-1.4	-1.4	-1.4	-1.4
Milk demand (MT)	120	0.9	0.5	0.7	1.1
Hedging ratio (H/Y)					
Butter	0	0	0	63.3	0
SMP	0	0	0	22.0	0

Compared to the second simulation, our third simulation introduces the futures markets on butter and skimmed milk powder. We assume limited transaction costs on the futures market (10€ per contract) and unbiased futures price. Compared to the previous simulation, the introduction of these futures market favors the production of butter and milk powders. This translates to the milk farmers who benefit from higher demand from dairy processors. We observe that participation of dairy processors on the futures markets are significant. The hedging ratio is higher for butter than skimmed milk powder, simply because the butter activity is more risky (the butter price is on average higher than the SMP).

We conduct the same third simulation assuming now that dairy processors have no possibility to change their production system (results not reported in table 3). They always produce the same level of dairy products, using the same amount of milk. In this purely theoretical situation, dairy processors suffer a lot from the increasing price volatility. Accordingly they are ready to participate more on the futures markets. We find that their hedging ratios reach 74.7% for butter and 63% for SMP. For this last product, this is a huge increase compared to the previous result (from 22% to 63%). This nicely illustrate that dairy processors may have low participation on futures markets because they are less exposed on the physical markets thanks to their production possibilities.

Our final simulation introduces some features of the milk package, namely that the milk prices paid to the milk farmers is partly determined by the butter and skimmed milk prices. That is, we assume that dairy processors (nor milk farmers) know in advance the dairy product prices. But they agree that the milk price that will be paid at the end of the period will depend on the true prices perceived by dairy processors on these two products. This way, dairy processors transmit part of their output price volatility to milk farmers. Concretely, we assume that both dairy processors and milk farmers know the true distribution of butter and SMP prices (mean and covariance). They agree on an equivalent milk price when processed only into butter and SMP (using fixed input/output coefficient). We assume that 25% of the milk price is determined by this equivalent milk price, the other 75 being fix. This intends to capture the imperfect transmission between the real milk price paid to farmer and the milk equivalent price (see the Milk Market Observatory). In this simulation, the dairy processors no longer participate in futures contracts. On the other hand, they transmit their price risks to the milk farmer. Facing less risks on their profits, dairy processors are ready to process more milk (up to 1.1%). On the other hand, milk farmers now face a significant increase of their price risks (roughly the double).

As expected, this last simulation shows the crucial role of the volatility transmission on the participation to futures markets. We underline that this result depends in fact on the production decisions of dairy processors. If we again admit for theoretical purposes that the production decisions of dairy processors are fixed, then the introduction of milk packages has no impact on their participation to futures markets. The dairy processors always want to participate to the futures market (with hedging ratios of 74.7% and 63%) because this is their only way to manage their income risks.

Concluding remarks

This paper deals with the low liquidity of European futures markets on dairy products. We focus the analysis on the potential participation by dairy processors. We find that both their production decisions and the transmission of volatility to the milk prices are critical factors that likely explain their limited participation.

In a more normative way, the introduction of liquid futures markets may benefit both dairy processors and milk farmers (as nicely discussed by O'Connor et al, 2015). Concretely they can engage ex ante in milk price negotiation using futures prices. This will reduce the risk exposure of both dairy processors and milk farmers. Our simulation model allows the quantification of these benefits.

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