# LINKING MARKETING CHOICES WITH FARMING PRACTICES OF GRAIN PRODUCERS: A FARM LEVEL MODELING APPROACH APPLIED TO THE SOUTH-WEST OF FRANCE

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Abstract:

With the increasing commodity prices volatility over the last years and the successive agricultural policy reforms, European grain producers face greater uncertainty. To better understand consequences of a price risk increase on production decisions, marketing decisions and farm revenue as well as linkage between production and marketing decisions, we develop a multiperiodic risk farm model. Production decisions concern selections of crop mix and farming practices (conventional or integrated farming) while marketing decisions focus on four types of pricing arrangements. The model is applied to a representative farmer of a region located in the Southwest of France. The results exposed in this paper shows that with a price risk increase, production adjustments of a risk averse farmer are oriented toward less risky (environmentally friendly) farming practices unless marketing contracts allow to mitigate price risk.

Key words: multiperiod farm model; marketing contracts; risk; Common Agricultural Policy.

## 1. Introduction

The Common Agricultural Policy (CAP) has been subject to successive reforms over the last twenty years. These reforms have led to a step-wise reduction of grain price support. While the price support system was initially offset by an increase in direct (coupled) payments, independent of the production level, these payments are now gradually substituted for Single Farm Payments (SFP), independent of the level of production as well as crop mix. One of the underlying objectives behind these changes is to give an incentive to European grain producers to take more market-based oriented decisions, so as to allow a better economic efficiency of the overall European Union (EU) agricultural subsidies. Together with rising world prices for commodities (Voituriez, 2009), these reforms have led to expose farmers to volatile commodity prices. As such, farmers experience a greater difficulty in forming price expectations.

To cope with this greater ex ante price uncertainty, farmers can adopt risk-sharing instruments specific to this source of risk which are (revenue) insurances and marketing strategies (Harmignie et al., 2004). Among these tools, revenue insurance instruments are currently not available to EU farmers. This can be explained by the fact that the risk linked to market price changes is a systemic risk which is hardly insurable without large government subsidizing of the premium. Until now, there is no EU program subsidizing such revenue insurance for farmers. In this setting, marketing strategies selected by farmers become critical to deal with an increasing price risk[1]. Nevertheless, farmers can also use on-farm price risk management strategies composed of production adjustments. Moreover, given the fact that the riskiness of the farm enterprise is affected by marketing strategy itself, one would expect that marketing contracts used by a farmer have an incidence on the production side of his farm. Thus, one would expect relationship between marketing strategies and production adjustments.

The purpose of the paper is to examine marketing strategies and production adjustments of farmers in response to an increasing of the agricultural prices volatility as well as the relationship between marketing strategies and production adjustments. We built a multiperiodic risk farm model using non-linear programming method to simultaneously analyze marketing and technical decisions with respect to the whole farm constraints. The model includes factors likely to influence these decisions such as the level of yield and price

[1] It is worth noting that pricing arrangements and other types of coordination throughout the agri-food sector, particularly between cooperatives and farmers, are deeply changing. In France, we observe cooperatives updating and seeking to improve grain marketing alternatives proposed to their members in order to be closer to the diversity of the new farmer marketing demands.

risk, degree of risk aversion, liquidity and credit constraints, CAP instruments and farmer's expectations in terms of correlation between crop yields and prices.

The following section of the paper is dedicated to a brief literature review on farmer's marketing decisions (section 2). Next, we present the general structure, activities, contracts and constraints of the multiperiodic mathematical programming model (section 3). We then describe the data used for the applied analysis and explain the procedure selected to introduce risk in the model is explained (section 4). Finally, we present results from the simulation. The paper ends with a discussion on results and futures simulations since it is a work in progress.

## 2. Literature review

While alternative marketing strategies are potentially large, they can be grouped in three groups (Tomek and Peterson, 2001): spot market strategies (harvest-time sales or post-harvest marketing of grain for diversification of selling time); forward (marketing) contracts; standardized contracts such as futures and options on derivatives markets. The two last categories of marketing strategies, which are pre-harvest marketing strategies, are considered as hedging strategies.

Theoretical models have been devoted to explain the relevance of hedging for risk averse farmers. These hedging models can be distinguished according to the modeling approaches and assumptions (Coad, 2001). Some models are based on the risk minimization criterion (e.g., Johnson, 1960; Lence and Hayes, 1994) while others are based on profit maximization (Brorsen, 1995), mean-variance criterion (McKinnon, 1967; Lapan and Moschini, 1994) or expected utility maximization (e.g., Stein, 1961; Bond and Thompson, 1985; Park and Antonovitz, 1990). Although these models differ in assumptions (e.g., correlation between price and production, farmer's risk attitude, source(s) of agricultural risk, basis risk, level of transaction costs) they show that risk-averse farmers can benefit of large potential risk reduction from hedging (Tomek and Peterson, 2001). Nevertheless, surveys on use by farmers of cash forward contracting, futures or options show that few farmers actually use such price risk management tools (e.g., Goodwin and Schroeder, 1994; Musser et al., 1996; Blank et al. 1997; Collins, 1997; Patrick et al., 1998; Jordaan and Grové, 2007). These evidences appear to contradict literature on optimal hedging (Collins, 1997; Carter, 1999). Yet, there have been several studies intending to propose reasons explaining the gap between the predicted optimal hedging ratios by the majority of analytical models and the actual hedging ratios used by the producers. The potential factors identified are biased price expectations (Lapan et al., 1991), optimistic attitudes (Tuthill and Frechette, 2004), basis risk (Lapan and Moschini, 1994), production risk which involves the additional risk when contracting impose for farmer to purchase grains to fulfill delivery obligations (Lapan and Moschini, 1994), transaction costs (Kahl, 1983), business size (Makus et al., 1990), lack of knowledge on how futures markets work (Hardaker et al., 2004), socio-demographics factors such as education, wealth and business size (e.g., Velandia et al., 2009), debt-to-asset ratio (Katchova and Miranda, 2004), income support programs (Coble et al., 2004; Woolverton and Sykuta, 2009) and, finally, expected gain to the producer from hedging (Pannell et al., 2008).

If we better understand why hedging strategies are not used as predicted and if theoretical models explain the impact of hedging on production level (Holthausen, 1979; Feder et al., 1980), to the author's knowledge, there are less applied studies on the impact of marketing strategies on production choices.

Furthermore, here, we characterize marketing contracts by a specific expected price, a price risk content but also by one (or several) period(s) of payment. Thus, the adoption of a specific marketing strategy is not only influenced by riskiness, risk aversion and potential price enhancement but also by the cash flow constraint.

## 3. The farm model

The non-sequential mathematical programming model of a representative farmer is depicted over a planning horizon of two years N={1,..,n} where n=2, subdivided in p monthly periods indexed by P= {1,…,p} where p=12. The decisions are taken in first period for the whole horizon.

### *3.1 Crop production management*

Crop activities C={1,…,c} introduced in the model can be grown on different types of land indexed by Z={1,…,z} distinguished according to soil structure characteristics and possibility of irrigation (equipment available). Furthermore, each crop can be grown applying different farming practices (T={1,…,t}). Crop activities are also depicted by specific premiums per cereal area (Arable Area Payments). Then, the resulting two-year crop mix consists in allocating, across each zone, a crop and a crop-specific farming practice. There is one structural constraint and one agronomic constraint:

Land resource: we consider a fixed representative farm size with a limited endowment of land for each land type.

Crop rotation constraint: cropping successions are taken into account with bounded share of crop acreage.

*3.2 Marketing strategies*

Once the farmer allocate the land across crop activities, stochastic output quantities harvested need to be sold through one or more of the sale agreements. The model takes three dimension of a marketing arrangement into consideration: an average price, a risk content and date(s) of payment. Contractual choices are then influenced by price enhancement, risk and cash flow considerations. The pre-harvest contract such as forward contract binds the farmer to deliver a specified quantity of grain at a future date. Because the cooperative could sue for damages if the farmer, for whatever reason, fails to deliver the contracted tons, there is a delivery risk. We decided to model contractual choices so that they occur after the harvest yield state of the nature. These yield-contingent contractual choices imply that delivery risk is not taken into account. Interviews with cooperative employees responsible for marketing contract affirmed that the delivery fail is very rare because farmer are used to hedge as a maximum on half of their production. Then, it is possible to add such a constraint. We will discuss here about the most four marketing opportunities (K) proposed across the studied area and which have been introduced in the model.

The first contract, the cooperative's traditional one, denoted K1, requires that the producer delivers grain at harvest, where he is paid an average sale price per quarter. This pricing arrangement allows the farmer to bear only the inter-annual price risk since the intra-annual price volatility is smoothed thanks to the regular sales realized by the cooperative all along the sales campaign (time diversification). Payments are quarterly.

The cash at harvest is the K2 contract. This cash sale strategy assumes that the manager sells the crop at harvest for the prevailing spot price. The farmer bears the entire responsibility for the intra-annual price risk. Payment occurs one month after the delivery/harvest.

The third contractual arrangement (K3) is forward contract. A fixed price contract for deferred delivery allows hedging of the products since the farmer does not faces price risk. The use of forward strategies has an implicit opportunity cost due to the fact that the farmer as to forego any favorable price changes before delivery (Sykuta and Parcell, 2003). He also bears a hedging cost asked by the cooperative[2]. The model allows these hedging costs to vary in order to study the impact of such costs on hedging decision. Payments are made one month after the contract commitment. That means that forward arrangement has a positive effect for a risk averse farmer but also for a famer with a binding financial constraint. The model does not account for derivatives but the aim is to focus on marketing arrangements proposed by cooperatives of the study area and not to detail different financial products. In addition, a farm survey lead in 2009 among 170 crop producers of the study area has shown that very few farmers actually use futures markets. This observation is consistent with much of the survey published. The attractiveness of forward contracting over futures markets suggests that many farmers believe that forward contracting has a more favorable benefit-to-cost ratio (Tomek and Peterson, 2000).

In the model, farmer can decide to lock-in a crop price at two different periods: either three months before the harvest (K3A) or one month before harvest (K3B). These two possibilities of hedging periods are the most common among the 170 farmers surveyed having stated that they have already used forward contracts.

The fourth pricing arrangement is post-harvest marketing strategy. This corresponds to grain storage. Even if farmers can invest in grain silos to store the harvested quantities, we only consider the more flexible strategy which is to store quantities in the grain collector' silos. Storage costs were assumed at commercial rates. To reduce the model size, we also limited the sales at two periods. The first period is 4 month after harvest (K4A) and the second is 7 month after harvest (K4B). We also used answers from the farm surveys to decide the timing between harvest and post-harvest sales. Table 1 display the method used to compute the average crop price for each contract and its standard deviation.

To model contractual alternatives in the multiperiodic model, we introduce annual and periodic constraints. First, the total grain harvested must be sold over the year through one contract type at least (eq. 1).

$$\sum_{K} "Sales_{C,N,P,K,F} = \sum_{T,Z} X_{C,T,Z} * YIELD_{C,T,Z,N,P-1,F} \qquad \text{(eq. 1)}$$

*$Sales_{C,N,P,K,F}$: quantity of crop C sold in year N at the period P under contract K and at the state of nature of crop yield F (F is the set for states of nature of crop yields) (contractual choices)*

*$X_{C,T,Z}$: area allocated to the different crop activities (productive choices)*

*$YIELD_{C,T,Z,N,P,F}$: stochastic crop yield*

[2] Such costs could also partly reflect payment of a risk premium to speculators or forward buyers as reward for their acceptance of greater risk.

In addition, for each contract, the product value per contract K is computed (eq. 2). Because dates of payments are different among contract, the set of equations is indexed on each period P. The product value depends also on the state of nature E={1,…,e} for the prices. The total product value per period is given by the sum over the partial product value of each contract (eq. 3). Further

$$Val_{K,C,N,P,E,F} = Sales_{C,N,P,K,F} * Price_{C,N,P-1,K,E} \quad \text{(eq. 2)}$$

$$TotVal_{C,N,P,E,F} = \sum_K Val_{K,C,N,P,E,F} \quad \text{(eq. 3)}$$

*$Val_{K,C,N,P,E,F}$: value of the sales for each contract K*
*TotValC,N,P,E,F: total value of the sales*
*$Price_{C,N,P,K,E}$: stochastic crop prices*

Another set of dynamic equations ensures that the stock of grain available at the end of a period is transferred at the beginning of the following period (eq. 4). Crop products stored constitute the maximal quantities available to the farmer which can be sold under K4A and K4B contracts (eq. 5).

$$Stock_{C,N,P,F} = Stock_{C,N,P-1,F} + \sum_{Z,T} X_{C,T,Z} * YIELD_{C,T,Z,N,P-1,F} - \sum_K Sales_{C,N,P-1,K,F} \quad \text{(eq. 4)}$$

$$Sales_{C,N,P,'K4A',F} + Sales_{C,N,P,'K4B',F} \leq Stock_{C,N,P,F} \quad \text{(eq. 5)}$$

*$Stock_{C,N,P,F}$:quantity of crop product stored*

The last important set of equations relates to the liquidity constraint allowing the introduction of a short-term financing (eq. 6), with a credit constraint (eq. 7). Short-term financing allows for supplementing cash flow each year for operating expenses and requires principal and interest repayments at the end of each year (eq. 8).

$$Cash_{N,P,E,F} = Cash_{N,P-1,E,F} - \sum_{C,T,Z} X(C,T,Z) * VC_{C,N,T,P-1} - \sum_C Stock_{C,N,P-1,F} * st\_cost_{C,P-1} + Borrow_{N,P-1} + \sum_{C,T,Z} X_{C,T,Z} * AAP_{C,P-1} + SFP_{P-1} + Sales_{C,N,P-1,K,F} * Price_{C,N,P-1,K,E} \quad \text{(eq. 6)}$$

$$\sum_P Borrow_{N,P} \leq \max\ \_borrow_N \quad \text{(eq. 7)}$$

$$Repayment_N = \left(\sum_P Borrow_{N,P}\right) * (1 + i) \quad \text{(eq. 8)}$$

*$Cash_{N,P,E,F}$: cash flow level*
*$Borrow_{N,P}$: short-term borrowing*
*$Repayments_{N}$: total repayments*
*$VC_{C,N,T,P}$: Variable Cost*
*$St\_cost_{C,P}$: storage cost*
*$AAP_{C,P-1}$: Arable Area Payments*
*SFP: Single Farm Payment*
*Max_borrow: borrowing capacity*
*i: interest rate*

Economic theory suggests that hedging play a role to reduce the market risk but also to increase the farmer's capacity to borrow (Harris and Baker, 1981). Nevertheless, due to the fact that no data was available to test this hypothesis, the borrowing capacity has not been considered as an endogenous variable.

### *3.3 The farmer's decision problem*

Endogenous dynamic decision variables are related to production, marketing and short-term financing. The productive decision problem of the farmer consists to select, across each land type, a combination of crop, using one or several farming practices under biological and agronomic constraints (crop rotation constraints), structural and economic constraints (land constraints and liquidity constraints). Short-term financing decision is the second type of decision and depends on liquidity and credit constraints. The third important decision of the farmer is to select, conditionally to states of nature of yield, a set of marketing contracts to sell the harvested products.

The producer makes choices so as to maximize a discounted expected utility of the stochastic net profit. Here, the net profit can be defined as the difference between the stochastic total income and the determinist total costs. The total income is composed of the total value of outputs plus first pillar direct supports from the CAP (arable area payments (AAP) and single farm payment (SFP)). Here, we assume that all the hectares are eligible to SFP so that the number of payment entitlements equals the sum of land types. Costs are divided between variable costs, a fixed cost per year, storage costs and credit costs. Variable costs encompass grain and chemical inputs purchases as well as labour and mechanization costs for the different farming operations (tillage, sowing, fertilization, …, harvest).

The discounted expected utility function allows taking into consideration risk and time preferences (eq. 10). The first is related to the intra-temporal variability of the outcomes while the second is related to the fact that to have in one's possession a certain amount of money now brought more utility than holding the same certain amount later on. The power functional form of the utility has been selected for the suitable risk preference structure that it implies. This form represents a farmer who exhibits a Decreasing Absolute Risk Aversion (DARA) and Constant Relative Risk Aversion (CRRA). DARA assumption is supported by empirical evidence (Chavas and Holt, 1990) but there is no evidence on the sign of the variation of the coefficient of the relative risk aversion when wealth increases. Then, CRRA assumption seems an acceptable compromise (Havlik et al. 2005).

$$W = \sum_N \left[ \left( \frac{1}{1+\delta} \right)^{N-1} \sum_{E,F} \left( \frac{1}{1-r} \right) Y^{1-r} * \pi_{E,F} \right] \qquad \text{(eq. 10)}$$

*W: discounted expected utility function (objective function)*
*Y: stochastic net profit*
*1/(1+δ): discount factor*
*r: coefficient of relative risk aversion*
$\pi_{E,F}$: *joint probability of allowed combination of states of nature E and F*

Risk programming for assessing alternative farm management strategies requires reasonable representation of risk aversion, but also robust inclusion of activities' riskiness. The procedure used to introduce risky events is presented with data in the following section.

## 4. Empirical analysis and data

### *4.1 Area study and farm types*

The different marketing alternatives are assessed on typical cash crop farms of the Midi-Pyrénées region in the southwest of France. This region accounts for 26 per cent and 27 per cent for respectively French production of durum wheat and sunflower (AGRESTE, 2007). No futures markets for these crops are available to farmers. In that context, forward contracts issued by cooperatives are the only tools available to hedge a part of their production.

A typology of large arable farms based on Data from Farm Accountancy Data Network (FADN) was used. The typology distinguishes farms on land resource quantities and qualities and share of irrigated area density. Among the three cash crops farm types, we select the one with the intermediate characteristics in term of land size and irrigation density. The land size of the simulated representative farm is 100 ha with three land types. 24 ha are on irrigated land located in an alluvial corridor, 70 ha are on clay-muddy soil and 6 ha on sandy-clay soil.

*4.2 data and procedure to simulate multivariate normal probability distribution*

Data for input-output coefficients:

The six main crops of the studied area are proposed in the farm model: soft wheat, durum wheat, dry corn, irrigated corn, sunflower and rapeseed. Irrigated lands can only be allocated with irrigated corn. Dry corn can be cultivated only on clay-muddy soils. The other crops can be grown on any of the two dry land types. We introduce two farming practice, an intensive practice and an integrated practice.

Variables costs, average crop yields and standard deviation of the crop yields differ across land types and farming practices. Integrated farming practices are characterized by lower overall variable costs (lower chemical input costs are not fully compensated by larger mechanization and labour costs during the different farming operations), same or lower yields and higher yield's variability than the intensive technique (Table 2 in appendix). Cost and return data for crop activities were obtained from regional references of year 2007 provided by the regional extension service (Chambre Régionale d'Agriculture).

It is important to notice that we include labour costs in the variables costs but we did not introduce a set of labour constraints in the model. Even if it has been shown in a previous study that labour management can retrain the adoption of new farm practice in the studied area (Ben Elghali et al., 2009), this oversight leads to intentionally overestimate the attractiveness of integrated technique which is justified by the fact that one of the objective of the present study is to assess the specific effect of detailed marketing opportunities on the farming practices adoption.

Data for risk assessment:

In order to introduce risk into the model, we used time-series observations of regional average yields (1975-2008) and national monthly product prices (1993-2008[3]). To ensure that historical intra- and inter-temporal stochastic correlations between all random variables (crop yields and contract-specific product prices) are maintained in the model, we used a procedure inspired by Richardson et al. (2000) for correlating random variables in a computer simulation using information from the covariance matrix[4].

[3] derived respectively from the regional agricultural statistics service (AGRESTE) and from the public agricultural service responsible for price registration (FranceAgriMer).

[4] The difference with procedure of Richardson et al. (2000) holds on the fact that we assumed multivariate normal probability distribution instead of a multivariate empirical probability distribution.

We used the 1993-2008 time-series to compute an average price and standard deviation for each contract. However, it was decided to deliberately leave out observations related to the commodity price peak from 2007 to 2008. By ignoring these observations, we preferred to keep away from important standard deviation values and to simulate increasing volatility with sensitivity analysis.

We estimate parameters and simulate the multivariate normal distribution from de-trended yield and price series to correct respectively from technical progress and inflation. Monte-Carlo sampling[5] was used to generate 20 states of nature[6] for the 26 random variables (K3 hedging contracts was not include in the procedure since there is only one state of nature). The states of nature are assumed to have the same probability of occurrence. The whole simulated set is not presented here but we display the average and standard deviation of the 6 crop yields (table 2) and the same information for the crop price in the simulated first year (table 3). Average yields of the second simulated year are slightly different from the first year due to the trend (not shown in the table).

As seen previously, we distinguish state of nature of yield (F={1,…,20}) from state of nature for price (E={1,…,20}). It allows determining yield-contingent contractual choice, but also to possibly account for two types of farmer's price expectation. First, farmer aware of historical (negative) correlation between yield and price (the state of nature $E_i$ can only appears with the state of nature $F_i$) and farmer that do not perceive any correlation (the state of nature $E_i$ can appear with any states of nature $F_j$ $\forall j \in [1, \dots, 20]$). With the first type expectation, it becomes possible to investigate the actual role of natural hedging on farmer's decisions and revenue.

## 5. Results and discussion

### *5.1 case 1: results with a unique marketing contract opportunity*

In the first set of simulation, we introduce only the cash at harvest contract (K2). The presence of this unique contract corresponds to a situation where the farmer cannot manage price risk thanks to a specific marketing strategy. For different level of risk aversion, we display the expected discounted profit, the total areas dedicated respectively to the

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[5] To perform simulation, we used PopTools, a free add-ins for PC versions of Microsoft Excel. The Latin Hypercube sampling is not available so that we have to use instead a Monte-Carlo sampling.

[6] We first simulate 50 states of nature. However, when we insert the data into the model, the time to run the model was about 1 hour. We decide to reduce the number of states of nature introduced in the programming model to 20 after having checked that solutions were similar to ones with 50 states of nature.

conventional and the integrated farming practices, the simulated conversion rate (SCR) and the optimal cropping plan (table 4). The SCR is the ratio of land cultivated using integrated farming practices over total cultivated land. We also simulate commodity prices risk increase. In that purpose, we multiplied the standard deviation of each contract-specific crop price by an expansion factor (E). If E equals 1, it corresponds to the baseline scenario with a low empirical standard deviation. A value of 2 or 3 corresponds respectively to a standard deviation multiplied by 2 or 3. Here, for each simulation, the expansion factor of each contract specific crop price is identical. Furthermore, the level of risk aversion is based on the value of the coefficient of relative risk aversion (r) which is used in the objective function. The higher the coefficient is, the higher the level of risk aversion. With a coefficient equals to zero, the farmer is risk neutral. A value between 0 and 1 corresponds to a farmer hardly risk averse. A value of 1.5 correspond to a normal risk averse farmer and a value of 2.5 correspond to a farmer highly risk averse (Hardaker et al., 2004).

We observe that it is optimal to a risk neutral or hardly risk averse farmer ($r < 1$) to cultivate the total area using the integrated technique. When r increases, the percentage of conventional technique adopted increases. The switch from integrated to conventional technique is first made on the durum wheat. We also observe that risk aversion modifies crop mix and not only the SCR. With an increasing risk aversion, a preference for crop diversification appears. Thus sunflower and dry corn appears in the crop mix to partially replace rapeseed, and the durum wheat is partially replaced by soft wheat much less risky.

Impacts of price risk increases (E=2; E=3) on SCR are significant for a coefficient of risk aversion greater than 1.5. Nevertheless, for a less risk averse farmer, even if price risk does not change the SCR, the crop mix is modified. This result shows that hardly risk averse farmers can manage partially price risk with production adjustments without any change on farming practices.

### *5.2 case 2: all the marketing contracts are available*

In this set of simulation, all the marketing contracts are available to the farmer. Thus, the farmer can define here a marketing strategy in order to cope with price risk. To assess the impact of an increasing commodity prices volatility on production adjustments when all the price alternatives are proposed to the farmer, we also used an expansion factor that multiplies standard deviation by 2 and 3. The farmer faces choices on both productive and marketing sides. We show the results for a farmer with a coefficient of relative risk aversion equals to

1.5 (table 5). From the previous results (where only contracts K2 are available to the farmer) we have noticed that the farmer has a SCR equals to 92.7 % under the baseline scenario (E=1) but decrease sharply with the increasing price risk. Here, under the baseline scenario, the SCR equals 82.5 which is close to the previous result. We also observe that the crop plan selected is really close to a farmer hardly risk averse when only K2 is available. This result is explained by the fact that the farmer sells a part of the harvested quantities under one of the two forward contracts K3A or K3B (43% of the durum wheat, 14% of the corn and 57% of the sunflower). The choice to hedge a part of the grain strategy allows him to take more risk on the productive side of his farm and then to behave as a less risk averse farmer. We also observe a decrease of the crop diversification.

The simulation of an increase of the price volatility (E=2 and E=3) gives a SCR equals 100% (E=2) and 39% (E=3). With only K2 available, we have seen that the SCR drops to zero. This result indicates that the risk averse farmer get a larger capacity to cultivate under integrating farming practices when all contracts are available. It also shows how much farming management and pricing arrangements offer to farmers are actually linked for risk averse farmers.

If we look at the marketing decisions selected by the farmer when price risk increase (table 5), we first note that K1 contract, which corresponds to an average price, is selected only when price volatility increase. Moreover, the proportion of the production hedged also increase.

## 6. Conclusion

Farmers become exposed to greater volatile world commodity prices compared to earlier years that lead to an increasing overall risk in the farm business. The model described in this paper has the objective to study and to assess farmer’s reactions to price risk increases on both marketing and production choices. To adequately investigate this objective, we introduce in the model the main pricing arrangements available to a representative crop farmer of the Midi-Pyrénées area. Marketing alternatives are characterized by an average price, a standard deviation and date(s) of payment. Thus, contract selected by the farmer are potentially based on risk aversion and risk content consideration but also on cash constraints consideration. Furthermore, the model also distinguishes states of nature of yield and states of nature of price, which contribute to a better appraisal of the effects of each sources of risk on decisions and farm outcomes. Sensitivity analysis performed show that contracts can help farmers to cope with price risk and that it act upon production adjustments. Thus, performance of different selling strategies should not be evaluated apart from production decisions.

Nevertheless, we do not make use of the full model’s capacity to study links between marketing and production decisions. First, the effects of liquidity constraint, CAP instrument changes and farmer expectations in terms of correlation between crop yield and price need to be investigated. Second, as mentioned in the brief literature review, a few farmers use forward contracts. Further analysis could help to better understand key factors explaining the low level of adoption and incidences on production choices.

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Table 1: method used to compute contract-specific crop prices and standard deviation

| contract | |
|---|---|
| K1 | Average of the monthly crop price prevailing during the campaign |
| K2 | Average price prevailing the month of the harvest |
| K3A and K3B | Average price prevailing the hedging month – transaction cost |
| K4A and K4B | Average price prevailing during the sales' month |

Table 2: variable costs, average yield and yield risk per crop activity

| | Soft wheat | | Durum wheat | | Irrigated corn | | Dry corn | | sunflower | | rapeseed | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Conv | int | Conv | int | Conv | int | Conv | int | Conv | int | Conv | int |
| Variable costs (€) | 440 | 349 | 522 | 391 | 817 | 776 | 606 | 565 | 337 | 318 | 535 | 458 |
| Average yield (LT1) | 6.2 | 5.6 | 4.9 | 4.4 | | | 6 | 6 | 2.4 | 2.4 | 3.2 | 3.2 |
| Average yield (LT2) | 5.7 | 5.1 | 4.4 | 3.9 | 10.5 | 10.5 | | | 2.2 | 2.2 | 3.2 | 3.2 |
| CV on LT1 | 9.6 | 19 | 14.7 | 27.2 | | | 16.6 | 24.6 | 18.7 | 20.4 | 11.5 | 28.1 |
| CV on LT2 | 10.5 | 21 | 16.3 | 30.3 | 5.9 | 10.4 | | | 20.4 | 31.8 | 11.5 | 28.1 |

Conv= conventional technique; Int=integrated technique; yield are given in tons/ha ; CV= coefficient of variation of the crop yield ; LT1= land type 1 (clay muddy soil) ; LT2=land type 2 (sandy-clay muddy soil and irrigated land when equipped of irrigation)

Table 3: contract-specific average crop prices and coefficient of variation

| | K1 | K2 | K3A | K3B | K4A | K4B |
|---|---|---|---|---|---|---|
| *Price:* | | | | | | |
| Soft wheat | 130 | 122 | 132 | 127 | 135 | 131 |
| Durum wheat | 178 | 175 | 177 | 174 | 185 | 177 |
| Corn | 139 | 132 | 150 | 135 | 140 | 139 |
| Sunflower | 265 | 251 | 267 | 256 | 272 | 270 |
| rapeseed | 255 | 240 | 268 | 253 | 263 | 255 |
| *CV:* | | | | | | |
| Soft wheat | 9.4 | 8.6 | 0 | 0 | 11.2 | 10.7 |
| Durum wheat | 9.5 | 9.9 | 0 | 0 | 10.5 | 10.7 |
| Corn | 7.2 | 9.4 | 0 | 0 | 10.5 | 10.7 |
| Sunflower | 10.8 | 8.2 | 0 | 0 | 15.2 | 16.6 |
| rapeseed | 10.5 | 9 | 0 | 0 | 10.9 | 14.3 |

CV = coefficient of variation of the contract-specific crop price

Table 4: model outputs when only one contract (K2) is available to the farmer

| coefficient of relative risk aversion | 0 | | | 0.9 | | | 1.1 | | | 1.5 | | | 2.5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Expansion factor | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| Expected profit (€) | 149684 | 145350 | 142308 | 149684 | 145345 | 142251 | 149684 | 145343 | 142245 | 36068 | 30032 | 24162 | 8646 | 8513 | 8313 |
| conventional (ha) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7.3 | 91.1 | 100 | 82 | 92.6 | 100 |
| integrated (ha) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 92.7 | 8.9 | 0 | 18 | 7.4 | 0 |
| total area (ha) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| simulated conversion rate (SCR) (%) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 92.7 | 8.9 | 0 | 18 | 7.4 | 0 |
| optimal cropping plan (ha): | | | | | | | | | | | | | | | |
| *conventional:* | | | | | | | | | | | | | | | |
| Durum wheat | | | | | | | | | | 7.3 | 45.6 | 52.4 | 3.9 | 26.9 | 49.2 |
| Soft wheat | | | | | | | | | | | | | 38.1 | 18.7 | |
| Irrigated corn | | | | | | | | | | | 15.1 | 24 | 24 | 24 | 24 |
| Dry corn | | | | | | | | | | | 28 | 14 | 7.2 | 11 | 15 |
| Sunflower | | | | | | | | | | | 2.4 | 9.6 | 9.3 | | 10.5 |
| rapeseed | | | | | | | | | | | | | | 12 | 1.3 |
| *integrated:* | | | | | | | | | | | | | | | |
| Durum wheat | 57 | 57 | 57 | 57 | 57 | 57 | 57 | 57 | 57 | 39.1 | | | | | |
| Soft wheat | | | | | | | | | | | | | 3.6 | | |
| Irrigated corn | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 8.9 | | | | |
| Dry corn | | | | | | | | | | 28 | | | | | |
| Sunflower | | | 9 | | 1.4 | 9.1 | | 1.8 | 9.2 | | | | | 7.4 | |
| rapeseed | 19 | 19 | 10 | 19 | 17.6 | 9.9 | 19 | 17.2 | 9.8 | 1.6 | | | 13.9 | | |

Table 5: model outputs when all contracts are available

| expansion factor (E) | 1 (baseline) | 2 | 3 |
|---|---|---|---|
| expected profit (€) | 136717 | 144655 | 112473 |
| conventional (ha) | 17.5 | 0 | 61 |
| integrated (ha) | 82.5 | 100 | 39 |
| simulated conversion rate (SCR) (%) | 82.5 | 100 | 39 |
| **optimal cropping plan (ha):** | | | |
| *conventional:* | | | |
| soft wheat | | | 30.6 |
| sunflower | 17.5 | | |
| rapeseed | | | 30.4 |
| *integrated:* | | | |
| durum wheat | 57 | 57 | 15 |
| irrigated corn | 24 | 24 | 24 |
| sunflower | 1.5 | 19 | |

| **optimal contractual choices (%):** | | | | | | |
|---|---|---|---|---|---|---|
| | Year 1 | year 2 | year 1 | year 2 | year 1 | year 2 |
| durum wheat | | | | | | |
| K1 | | 0.14 | 0.29 | 0.14 | 0.14 | |
| K2 | | 0.14 | | 0.14 | | |
| K3A | 0.43 | 0.57 | 0.14 | 0.71 | 0.57 | 0.29 |
| K3B | | | | | | 0.71 |
| K4A | 0.57 | | | | | |
| K4B | | | 0.57 | | 0.29 | |
| soft wheat : | | | | | | |
| K1 | | | | | 0.14 | 0.14 |
| K2 | | | | | | 0.14 |
| K3A | | | | | 0.29 | 0.57 |
| K3B | | | | | 0.71 | |
| K4A | | | | | | 0.14 |
| corn: | | | | | | |
| K1 | 0.14 | | 0.14 | 0.14 | 0.29 | |
| K2 | 0.29 | 1.00 | 0.43 | 0.86 | 0.14 | 0.71 |
| K3A | | | | | | |
| K3B | 0.14 | | 0.29 | | 0.43 | 0.29 |
| K4A | 0.43 | | | | | |
| K4B | | | 0.14 | | 0.14 | |
| sunflower: | | | | | | |
| K1 | | | | | | |
| K2 | 0.14 | 0.14 | 0.14 | | | |
| K3A | 0.57 | 0.86 | 0.71 | 1.00 | | |
| K3B | | | 0.14 | | | |
| K4B | 0.29 | | | | | |
| rapeseed: | | | | | | |
| K1 | | | | | 0.29 | 0.14 |
| K2 | | | | | 0.14 | |
| K3A | | | | | 0.43 | 0.14 |
| K3B | | | | | | 0.71 |
| K4B | | | | | 0.14 | |