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Some possibilities for risk analysis in the decision support of crop production

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Abstract: This article has been made according to my dissertation in which I present some opportunity of risk analysis and risk management in the decision support of crop production.

Plant production is one of the most hazardous agricultural enterprises. Among risk sources seasonal fluctuation of average yields plays an important role in the assessment of enterprises. Therefore, I analyzed the production risk of the produced crops in Hungary compared to the European Union's, after that I took into consideration the production site's circumstances as well.

Decision-makers must possess such means, by which they can measure, oversee and manage the effects and consequences of risk. In crop production linear programming models can be used to determine the optimal crop structure, by which income-sensitivity can be taken into account, but it does not reflect the behavior to risk. This deficiency can be avoided by using risk programming models. By the complementary usage of linear programming and risk programming models the optimizing and adaptive planning can be executed.

It often causes a problem for the producers to decide when and how much to sell to realize a maximum turnover. The decision is mostly influenced by the selling prices, but also important factors are the financial status of the business, the amount of credit and its conditions, the stock-piling opportunities and costs, and the short-term investment opportunities as well. For the resolution of the problem I set up a dynamic, simultaneous financial model by which the system-conceptual analysis of the above mentioned factors and a sound decision-making can be executed.

Key words: risk, crop production, decision support

Inroduction

Crop production usually consists of more enterprises among which there are differences in their products' market perception, production technology, resource-demand, time-scattering, in their time and need for field, agronomical interactions, the level of expenditures and profitability.

The future status of external and internal factors, that affect the result of economic decisions, is not known by the farmer (*Bácskai* et al., 1976; *Hardaker* et al., 1997; *Drimba,* 1998a), and based on the contradiction that the decision concerning the business' future must be made at the time when reliable information are available about the previous period (*Buzás,* 2000).

Risk presents in all areas of the economy and nobody can avoid it. In plant production beside economic risk the risk of weather's changeableness bears an increased significance. In extreme cases, catastrophe can evolve, however fluctuations from climatic conditions can induce positive and negative changes in the growth and development of crops and in their yields (*Harnos,* 1996). These thoughts can suggest – and external observers often think so – that beside such level of uncertainty in the agriculture good weather, fertile ground, various assists and luck are needed for the good result. However, players in economic or business spheres must possess such means by which they can measure, oversee and manage the effects and consequences of risk (*Madai – Nábrádi,* 2005). One condition of this is that for the decision-makers the information needed for decision should be available up-to-date, in appropriate quality and quantity and after their evaluation, process it allows setting up and analyzing various decision alternatives, variants. By this, the support of the most appropriate decision-making that matches to the style of decision-maker can be possible. This is the task of decision support.

In the presence of needed information we can measure risk by using statistical means. Knowing the feature and level of risk, we can reject a possible alternative or if we decide so, by applying proper risk management tools we can even realize it. The thought about the risk's economic importance was born almost 90 years ago. Since then, almost in all areas of economic spheres also in agriculture significant results and applications have been evolved. The development of informatics and the internet gave a much bigger stamina to research; the practical utilization's availability is simpler and cheaper.

1. Objectives of the research

In this paper my **general objective** was to ensure efficient means for the crop production's decision support by applying present risk management methods, models and their development or by the adaptation of models which are used on other economic fields successfully taken into consideration their features of crop production.

Database, activities and outputs to be used during the research are summarized in *Figure 1*.

My concrete objective can be separated into three main groups:

Presentation of the production risk for some field crops in the level of the European Union and the Észak-Alföld Region

Among risk sources in the crop sector production risk has an extended role (*Balogh,* 2008). In the course of production risk's analysis I point out that without reference to the decision-makers behavior to risk, risk is presented in production. Both experts and researchers need quantified knowledge about the risk of various enterprises, because crop production that is developed, competitive and where the characteristics of production site are considered requires these research findings as well.

The countries of the European Union have diverse climatic, natural and economic characteristics (*Bocz,* 1996). These can be seen on the level and risk of agricultural production. By the greenhouse effect the production risk is rising and we can count with higher yield fluctuations. The European Committee gives high priority to the risks of agriculture. For the more efficient utilization of our negotiation power we must know – amongst other things – the main crops' calculated production risk in Hungary and in the other EU members, which demonstration and analysis is one of my objectives.

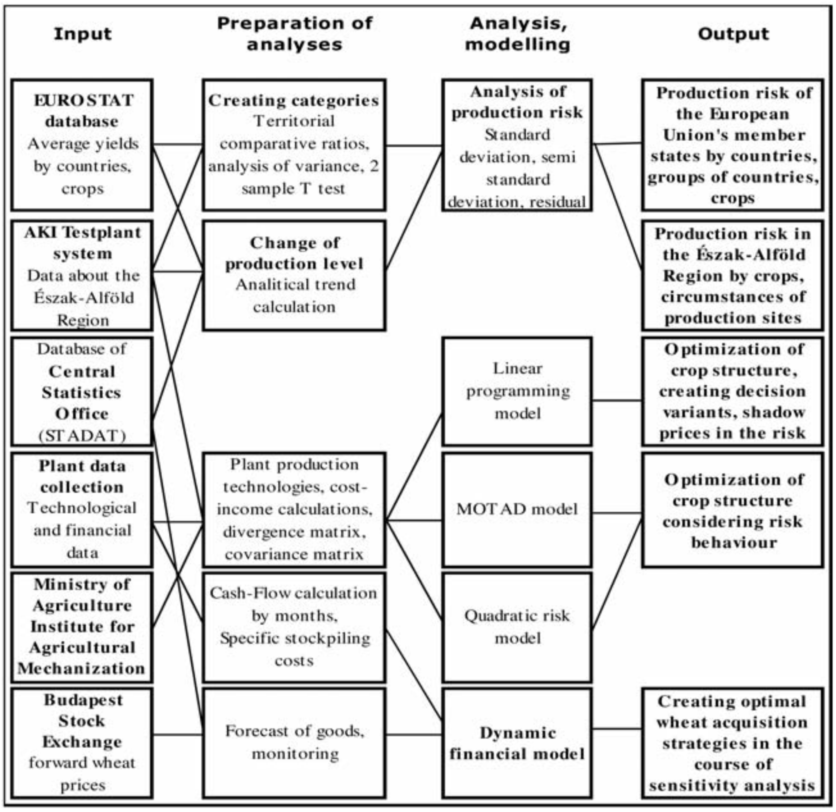

Figure 1. Objectives, inputs and activities of the research
Source: own assemblage

Considering Hungary's arable crop production, the Észak-Alföld Region ha a significant role in it, because it occupies 21,5% of 4,5 million hectares, by which it is on the second place after the Dél-Alföld. If we see the fields' characteristics the state is more unfavorable. Within the region the difference among the quality of fields is significant. In the county of Szabolcs-Szatmár-Bereg the values of golden crown are the lowest, in the county of Hajdú-Bihar and Jász-Nagykun-Szolnok there are very good production sites. My aim is to present the main enterprises' production risk by field characteristics in the Észak-Alföld Region.

Considering risk during the creation of crop structure

In the crop sector conventional planning is the most common even nowadays, which means adequate planning, however determines increasing lag in the economic competition. In this agriculture with new challenges – environmental and nature conservation aspects, biomass energy, sustainable development, etc. – only those can take part in the competition who adapt to the environment. However, its condition is the execution of adaptive and optimizing planning together. One of my objectives is to present the importance of usage of linear programming and risk programming models by case studies and its advantages in the decision support of crop production. According to my plans during the application of risk programming models I am going to analyze the behavior to risk with and without assist.

Reducing marketing risk by using optimal wheat marketing strategies

The crop sector's special characteristic is that end-products appear at a biologically determined period, but their utilization is year-round. Selling prices are always the lowest at the harvesting period, after that they show a more or less identifiable seasonal fluctuation. This situation is further complicated by the fact that among the different crop years, we can notice great divergences in prices (*Bács,* 2003; *Bács – Fenyves,* 2005). Given the above, both on the side of producers and the biggest wheat-user enterprises – mill industry, animal husbandry – economic risk increases notably.

In my research I wanted to find the answer for the question that when and how much wheat have to be sold by the producer to choose financially the most favorable decision variant in the given financial-economic state. The problem is going to be solved by a **dynamic, simultaneous linear programming model** in which I am going to take into consideration the cash-flow balances by months, borrowing, alternative capital investment opportunities and stock-piling costs as well.

2. Materials and methods

To reach the objectives which were mentioned in the introduction part widespread data collection was needed. For the calculation of the European Union countries' production risk I used EUROSTAT data among 1990–2006. For the production risk analysis that was made in the Észak-Alföld Region the Agricultural Economics Research Institute made available the data of its Testplant system among 2001–2005.

The enterprise technologies' basic data that are needed for the linear and risk programming models are from own data collection, I have been collecting information concerning crop enterprises from 15 agricultural undertakings since 2003. In the course of calculation of machine operational beside own data collection I used the comprehensive database of Ministry of Agriculture Institute for Agricultural Mechanization (*Gockler,* 2007a, b).

For the wheat's price analysis I used the historical database of Budapest Stock Exchange among 1999–2006 and monthly buying-in data of Central Statistics Office among 2001–2007.

I typified the production risk by dispersions – standard deviation, relative deviation, semi deviation – and in the case of trend effect I calculated residual deviation, residual semi deviation.

I checked the golden crown classifiability of field characteristics by statistical hypothesis testing, 2 sampled T test and variance analysis.

I did the optimization of crop structure by using linear programming, I applied the MOTAD model and the quadratic portfolio optimizing model among the risk programming models that take into consideration the decision-makers' risk behavior.

In determining the optimal wheat selling strategy I compared the different statistical forecasting models' applicability and its accuracy by using follower mark in the course of wheat prices' forecast. For the creation of strategies Drimba-Ertsey's (1999) financial planning model was the base and I made a new, dynamic simultaneous model which was needed to solve the problem.

For the statistical calculations I applied the SPSS 13.0 and XLSTAT 5.5 programs. The database operations that were needed for the creation of technologies were done by Microsoft Access 2003, the set-up, solving and formal post-work were made by Microsoft Excel 2003.

3. Results and discussion

In the first part of my paper I analyzed some field crop enterprise's production cost on the level of European Union and the Észak-Alföld Region. In the next part I examined that what kind of possibilities we have to consider risk in the course of crop structure's planning and that how the different risk behavioral decision-makers react with and without assist. At last, I took up that when and how much to sell from the already produced goods to realize the highest income.

3.1. Analysis of production risk for some field crops in the level of the European Union and the Észak-Alföld Region

The members of the European Union that can be separated into groups according to the production risk possess various climatic and economic characteristics. For the more developed west-European countries – where the climate is characteristically constant oceanic and wet continental – high yields and lower is typical. *New member states* lag behind not only in the level of production from the above-mentioned group, but *both in absolute and relative sense they produce with higher risk (Table 1.).* This can be explained with the more extreme climatic conditions and with the catching-up social, economic environment. While in the developed countries average yields have been rising in the latest 16 years, in the new member states, which joined in 2004, stagnation or decreasing tendency can be demonstrated.

Table 1. Relative deviations of average yields in the analyzed countries

Country	Barley	Potato	Wheat	Sugar beet	Corn	Turnsole	Rape
United Kingdom	4,5%	5,5%	4,1%	7,3%			9,5%
France	6,9%	6,2%	6,2%	5,6%	8,3%	5,6%	10,1%
Germany	7,8%	10,0%	6,3%	5,2%	7,7%		11,2%
Denmark	10,2%	6,2%	4,9%	6,8%			12,5%
Austria	8,5%	8,7%	8,2%	7,4%	8,7%	9,3%	17,1%
Czech Republic	15,0%	10,9%	10,6%	5,0%	19,2%	9,3%	17,2%
Slovakia	18,7%	16,8%	12,6%	10,6%	21,2%	15,0%	21,5%
Hungary	18,3%	15,1%	18,7%	16,1%	25,3%	17,5%	21,7%
Italy	5,2%	5,6%	10,0%	11,3%	9,0%	7,7%	
Greece	15,1%	11,9%	12,6%	5,9%	5,0%	13,0%	
Romania	17,9%	11,0%	21,0%	18,6%	23,8%	15,0%	
Spain	25,7%	34,2%	20,1%	6,2%	7,1%	21,9%	
Portugal	32,4%	8,8%	31,6%		12,0%	24,6%	
Netherlands	6,7%	5,1%	5,6%	9,4%	15,4%		
Poland	11,8%	13,5%	9,5%	8,8%	13,3%		
Minimum	4,5%	5,1%	4,1%	5,0%	5,0%	5,6%	9,5%
Maximum	32,4%	34,2%	31,6%	18,6%	25,3%	24,6%	21,7%

Source: Own calculation by using Eurostat data

From the point of risk Mediterranean countries constitute a separate group where in case of less intensively produced crops – for example cereals – production risk is extremely high, however in case of intensive, irrigated cultures higher yield can be reached with less risk. *Within the European Union Hungary is one of the most hazardous countries.* The values of *standard deviation* and *semi deviation* for *wheat* and sugar beet production are the highest. Rape is the only crop, which takes place in the middle.

Considering the agro potential Észak-Alföld Region is one of the weakest and the most heterogeneous area in Hungary. I examined the average golden crown value per one hectare, as a potential field characteristic impounding factor, for arable crops' average yields by using statistical hypothesis testing. In the Észak-Alföld Region the average golden crown value is 19,62, the standard deviation is 6,31. I took this into consideration, I separated 3–3 categories below and above the average by steps of half of the deviation, after that I examined by variance analysis if in the different categories' average yields significant difference could be observed. The results of the analysis are shown in Table 1. In the case of corn, wheat and turnsole we can see that among the average yields at fields with below-the-average golden crown value and with higher golden crown value the deviance is significant, but for above-the-average fields it is not so. Therefore it can be concluded that in case of some crops it was reasonable to separate the types of fields by this *grouping of golden crowns*, however there is no meaning to *grouping with more varied shades* from the point of the analysis.

Table 2. Significant divergences among average yields by categories of golden crown

Categories (golden crown/ha)	<13,31	13,31 - 16,46	16,47 - 19,62	19,63 - 22,78	22,79 - 25,93	25,93<
<13,31	-	KÁN	BKN	BKÁN	BKN	BKÁN
13,31 - 16,46	KÁN	-	BKÁN	BKNC	BKN	BKC
16,47 - 19,62	BKN	BKÁN	-			Á
19,63 - 22,78	BKÁN	BKNC		-		
22,79 - 25,93	BKN	BKN			-	
25,93<	BKÁN	BKC	Á			-

Source: own calculation

According to the values of relative residual deviation it can be demonstrated that *in the Észak-Alföld Region the riskiest is the production of winter colza and winter barley* and corn production's risk is also high on fields which quality is lower than the average. Irrespectively of field characteristic *turnsole* can be grown with *low risk (Figure 2.)*.

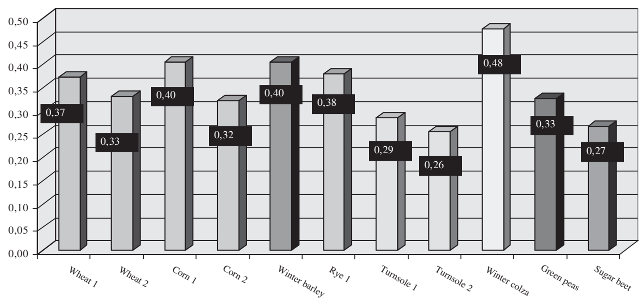

Figure 2. Production risk in the Észak-Alföld Region
Source: own calculation

In the case of wheat, corn and turnsole I had the chance to compare below average and above average fields' production risk. It can be demonstrated for corn and turnsole that in worse years in those undertakings that possess above average fields the production risk is lower, while in better years the values of relative deviation are almost the same. In case of wheat the state is in reverse: the better production site's level-off effect to yield fluctuations is predominated in favorable years *(Figure 3.)*.

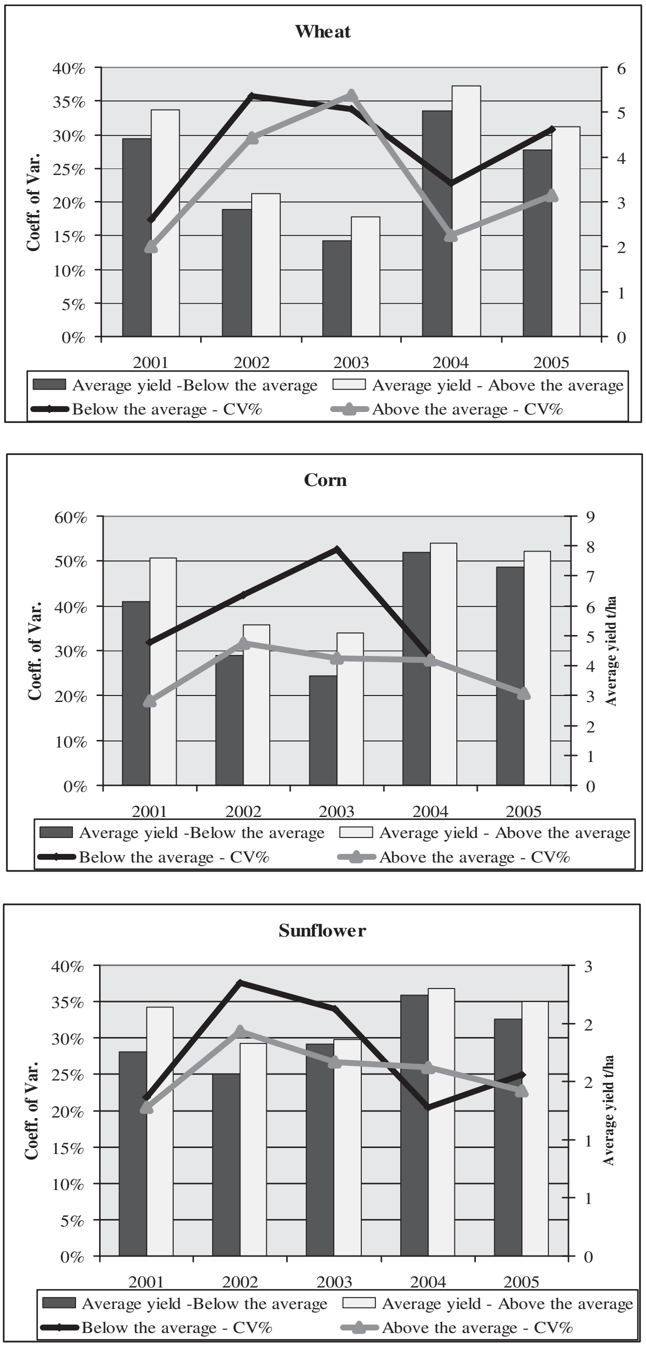

Figure 3. Wheat's, corn's and turnsole's average yields and production risk within 2001–2005
Source: own calculation

3.2. Optimizing crop structure by considering risk

Linear programming model makes for income maximalization and because of its deterministic character it is less suitable for considering risk. In the course of sensitivity analyses the proper interpretation of shadow prices can help us in the risk analysis as well. In my paper I am going to do the crop structure analysis of an undertaking of 2000 hectares. In pursuance of the analysis of activities' shadow prices, we get a precise view of the enterprises' sensitivity to income changes (*Ragsdale, 2007*). By the allowable increase and decrease an income interval can be determined within which, if its value is changed, the optimal crop structure remains unchanged. In practice it means that our production structure only have to be reasonably changed, i.e. rerun the model with new parameters, if the alteration exceeds the mower and upper limits. In other cases the **production structure shall not be changed, because we still realize the highest income with the available resources**. From the point of risk, the lower limit is more important for us, because it can acquit the undertaking of drastic income decrease *(Figure 4.)*.

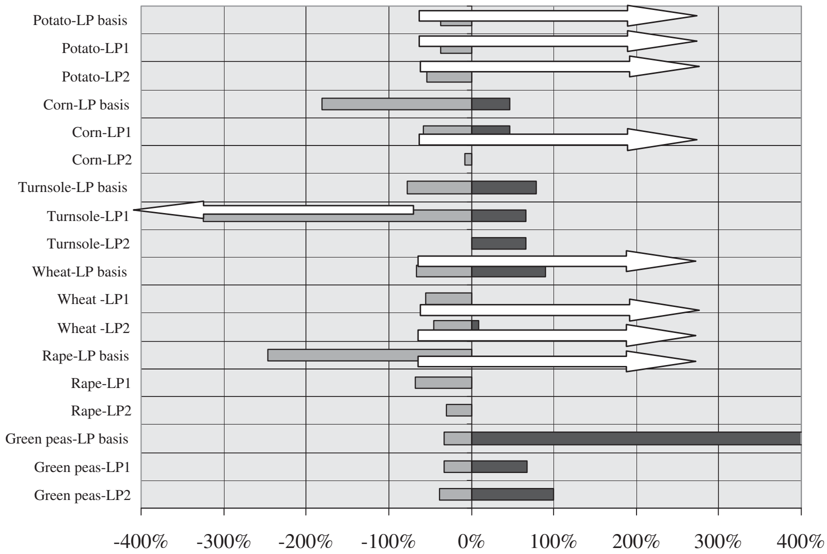

Figure 4. Sensitivity of the competed enterprises to profit contribution in various model variants *
* the arrows mean that in case of unrestricted growth or decrease of profit contribution the production structure does not change
Source: own calculation

We cannot ignore the fact that the highest risk is born by plan variants created by linear programming. Decision-makers do not always choose the plans with the highest income; their decision is affected by their behaviors to risk (*Anderson* et al., 1977, *Anderson – Dillon,* 1992). The choice is created by using risk programming models.

In these models risk is typified by income fluctuation. In the MOTAD model we quantify by negative deviations from the average value and in the quadratic model by variance. In both cases – using the expected income as parameter – model serials and efficient curves are created and the most conforming plan to the individual's utility can be chosen by the relative change average.

In the case study I analyzed how efficient limit plans with and without assist set. It can be concluded that there are significant deviances in the production structure and risk if we use the MOTAD model, while in case of portfolio model we cannot see such a pronounced difference (*Hazell,* 1971, *Hazell – Norton,* 1986). The result of the MOTAD model without assist show that in higher income zones risk values are higher than with assist, after that a level-off can be observed in the case of 5th and 6th variant, than deviances are rising again *(Table 2.)*.

The result can be examined by E-M efficient curves from other point of view *(Figure 5.)*. On the stage where the curve's slope is smaller, one percent of income-sacrifice means more risk reduction. Rational decision-makers will choose from those plans that are on the stage with smaller slope accordingly to their risk behavior.

On the critical limit there is the plan where the slope of the E-M efficient curve increases suddenly. After this, the risk reduction for an income sacrifice unit is going to be so low that even risk refusal undertakers will not choose this. Figure 5. well illustrates that without assist we reach sooner the plan, where the curve's slope is rising suddenly compared to the values with assist. This suggests that those decision-makers who are against risk may often choose plans with low expected value in the presence of assist, which worsens the competitiveness in a long-term.

Table 3. Risk after reducing profit contribution

Variants	Profit contri-bution	ΔFH/FH	With assist			Without assist		
			Risk value	ΔM/M	ΔM/M: ΔFH/FH	Risk value	ΔM/M	ΔM/M: ΔFH/FH
Variant 1.	297530	0,0%	166162	0,0%		181061	0,0%	
Variant 2.	295000	0,9%	158847	4,4%	5,178	172208	4,9%	5,751
Variant 3.	290000	2,5%	154131	7,2%	2,861	162202	10,4%	4,116
Variant 4.	285000	4,2%	149991	9,7%	2,311	154086	14,9%	3,538
Variant 5.	280000	5,9%	145907	12,2%	2,069	146871	18,9%	3,205
Variant 6.	275000	7,6%	141821	14,6%	1,935	143288	20,9%	2,755
Variant 7.	270000	9,3%	137731	17,1%	1,849	141246	22,0%	2,377
Variant 8.	265000	10,9%	133646	19,6%	1,790	139920	22,7%	2,078
Variant 9.	260000	12,6%	131598	20,8%	1,649	138594	23,5%	1,859

Δ FH/FH: Decrease of profit contribution compared to Variant 1.
Δ M/M: Decrease of risk compared to Variant 1.
Δ M/M: Δ FH/FH: Risk reduction by income-sacrifice units

Source: own calculation

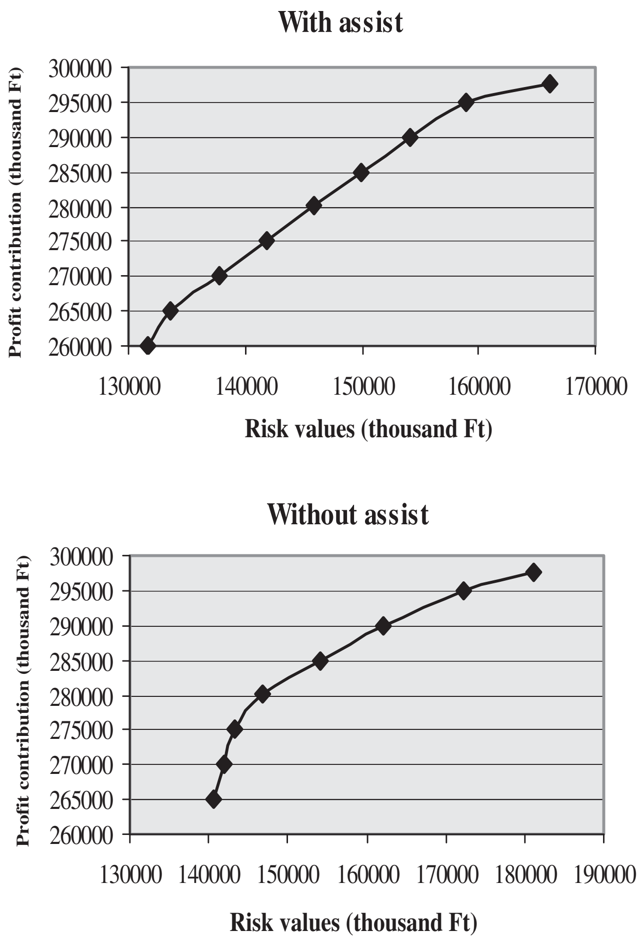

Figure 5. E-M efficient curves in the presence of assist and without assist
Source: own calculation

One condition of adaptive planning is the application of developed planning methods. Linear programming and risk programming models make possible more efficient decision-making. The implementation depends on the consistent operation of education, research and consultancy, in which the information technology instruments play an important role. In the expert systems thereby caused, risk management tools can play an important role.

3.3. Reducing marketing risk by using optimal wheat marketing strategies

The crop sector's special characteristic is that end-products appear at a biologically determined period, but their utilization is year-round. Selling prices are always the lowest at the harvesting period, after that they show a more or less identifiable seasonal fluctuation. This situation is further complicated by the fact that among the different crop years, we can notice great divergences in prices. Given the above, both on the side of producers and on the side of the biggest wheat-user enterprises, economic risk increases notably (*Nagy – Gál,* 2007).

For reducing costs forwards and futures and good-exchange options can be used, but in the countries of the European Union these techniques are not widespread (*Pálinkás – Székely,* 2008). Either by futures, or contracts, or by free market 'sit-outs', or by other methods is happening the sale, *not only the available selling price*, however this is beyond doubt the most important factor, *affects the marketing strategy to be chosen*. In the decision the financial state of the business, the available credit and its conditions, gains from alternative investment and stock-piling costs as well. My objective was to set up such a model by which we can examine these factors relatedly, at one time.

The creation of strategies is happened in three closely related steps. The first step is the forecast of prices, the second one is the setting up of the model, giving its parameters, solving and at last different decision variants are created by sensitivity analysis and after the comparative analysis is done, the decision can be made.

The first step, the reliable price forecast is a very important part of the exercise. There are a lot of available statistical methods and the most reliable must be chosen. For the comparison of methods and their continuous monitoring I used an easily applicable follower mark which was working at the forecast of needs (*Koltai,* 2006). The gist of the follower mark's use is that the error of the estimation shall be within a set-up interval, which can be narrower or wider according to the feature of the problem. If the value takes place out of the interval, the forecasting method must be re-examined, because it van happen that for the next period another method gives more reliable results. The advantage of the follower mark, beside its simplicity, is that in contrast to

Description	Alternative investments	1st period						…	1st period						R	Capacity vector
		Credit	Wheat marketing	Income of investments	Closing stock	Average stock	Transfer		Credit	Wheat marketing	Income of investments	Closing stock	Average stock	Transfer		
Money balance 1st period		-1					1	…							=	CF 1st period
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮		
Money balance 1st period							-1	…	-1					1	=	CF 1st period
Credit constraint		1						…	1						<=	H_{max}
Constraint for alternative investment	1							…							<=	A_{max}
Wheat commodity balance			1					…		1					=	V
jnth investment inth period	-1/h			1				…							=	0
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮		
Commodity balances jnth investment inth period	-1/h							…			1				=	0
Closing stock 1st period			-1		-1			…							=	-V
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮		
Closing stock 1st period					1			…		-1		-1			=	0
Average stock 1st period			1/2		1	-1		…							=	0
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮		
Average stock 1st period										1/2		1	-1		=	0
Objective function					0		0	…				0		0		MAX!

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Figure 6. The financial model's schematic structure
Source: own figure

other techniques it requires constant freshening. I compared three techniques for the forecast of wheat prices: seasonal decomposition, moving average and Winter's smoothing method, among which the third one proved to be the most reliable.

After the price forecast I set up such a *dynamic simultaneous financial model (Figure 6.)* to solve the problem that beyond the application of classical risk management methods manages stock-piling, equity-binding costs and it allows gaining maximal corporate income.

Table 3. The set variants in the course of sensitivity analysis

Variant	Credit (thosand Ft)	Credit's interest rate	Constraint for investment (thousand Ft)
A1	0	12,0%	0
A2	20000	12,0%	0
A2_1	20000	7,50%	0
A3	20000	12,0%	50000
A3_1	20000	7,50%	50000

Source: own calculation

Table 4. The sensitivity analysis' summary data

Variant	Wheat marketing tons		Credit thousand Ft	Short-time investment thousand Ft	Objective function thosand Ft	Change of objective function (A1=100%)
	July	October				
A1	1 801,1	2 417,4	-	-	102783	100,0%
A2	1 801,1	2 417,4	-	-	102783	100,0%
A2_1	975,2	3 243,3	20 000	-	102912	100,1%
A3	3 865,6	352,9	-	50 000	106521	103,6%
A3_1	3 039,8	1 187,7	20 000	-	106650	103,8%
A4	4 218,5	-	20 000	100 000	109958	107,0%

Source: own calculation

Table 5. The prices' extremes in the course of basic variants

Period	Objective function	A1		A2		A3		A4	
		Lower price bound	Upper price bound	Lower price bound	Upper price bound	Lower price bound	Upper price bound	Lower price bound	Upper price bound
July 2006	23,50	23,40	25,32	23,40	25,32	23,40	25,32	23,40	
August 2006	24,46		24,56		24,56		24,56	24,38	24,56
September 2006	26,63		27,32		27,32		27,32		27,40
October 2006	28,58	28,00	28,76	28,00	28,76	28,00	28,76		28,66
01 November 2006	29,61		30,20		30,20		30,20		30,28
01 December 2006	31,58		32,17		32,17		32,17		32,25
January 2007	32,47		32,91		32,91		32,91		32,95
February 2007	34,01	33,13	37,20	33,13	37,20	33,13	37,20	33,05	37,28
March 2007	34,87		37,06		37,06		37,06		37,06
April 2007	35,58		40,47		40,47		40,47		40,47
May 2007	35,80		44,24		44,24		44,24		44,24

Source: own calculation

At the calculation of periodical money balances the paid out amount for the alternative investments is on the side of expenditures in the model, the planned Cash-Flow is on the side of liabilities; the borrowed money, the earnings of the wheat and the incomings from alternative investments mean turnovers. I store the closing balance by periods in a so-called transfer variable, which means of course that it is the opening balance for the next period. Credit constraint and the maximum amount that can be put into alternative investments can be fixed in the model. In the wheat's commodity balance I set the quantity of wheat to be marketed and we can set here if we allow stocks to be continued to the next period or not, by correctly using the relations. Constraints for alternative investments are model-technical. Besides, I modeled dynamically the change of wheat stock and I determined the average stock for all periods to calculate stock-piling costs.

After having solved the model, considering shadow prices I created more variants *(Table 3.)*. A1 variant reflects the parameters given by the managers of the undertakings which mean that I did not calculate with credit or short-term investments.

In Table 4 I summarized the results. It shows that, among the modeled variants by sensitivity analysis, A4 ensures with 7 percent higher income for the undertaking and in this case the whole quantity is sold in the buying-in period.

Another advantage of the system-conceptual analysis is that price flexibility analysis becomes possible to execute. Lower and upper price limits in Table 5 mean that the result is going to alter if the objective function is risen above or reduced below. Blanks in the table mean that if the prices are moved up or down the result is unchanged in case of infinitely great alterations. In the case of A1, A2 and A3 variants' marginal prices are the same which means the three model's price flexibility is the same. In the course of A4 variant the upper marginal price is higher from September compared to other variants that refers to the advantage of short-term investments.

In conclusion, the **dynamic, simultaneous linear programming model** that was made for the risk management of wheat marketing can be applied successfully to choose the optimal sale strategy. I used the follower mark for easing the model's implementation, controlling the accuracy of forecasts and for using the proper forecasting technique. The model can be used successfully for any arable crop to choose the optimal marketing strategy.

References

Anderson J.R. – Dillon J.L. (1992): Risk Analysis in Dryland Farming Systems. Food and Agriculture Organization of the United Nations, Rome

Anderson J.R. – Dillon J.L. – Hardaker J.B. (1977): Agricultural Decision Analysis. The Iowa State University Press, Ames, Iowa

Bács Z. (2003): Az étkezési búza tőzsdei áralakulásának elemzése, Agrárgazdaság, vidékfejlesztés és agrárinformatika az évezred küszöbén, DE-ATC kiadvány, Debrecen

Bács Z. – Fenyves V. (2005): Vállalkozások pénzügyei és elszámolása Szaktudás Kiadó Ház Budapest

Bácskai T. – Huszti E. – Meszéna GY. – Miko GY. – Szép J. (1976): A gazdasági kockázat mérésének eszközei. Közgazdasági és Jogi Könyvkiadó, Budapest

Balogh P. (2008): Kockázati tényezők feltárása A Sertés XIII. évfolyam 1. szám 2008/1. NEDVET Bt. 22–24. p.