- **3rd AIEAA Conference, Porto Conte-Alghero (SS), 25-27 June 2014**

- **Feeding the Planet and Greening Agriculture:**
- **Challenges and opportunities for the bio-economy**

Session 2D CAP first pillar

- 1 - Sanguatti A., K. Erickson, L. Gutierrez, «Spatial panel model for the analysis of land prices»;
- 2 – Guastalla G., D. Moro, P. Sckokai, M. Veneziani, «The capitalization of fixed per Ha payments into land rental prices: a spatial econometric analysis of regions in EU»;
- 3 – Puddu M., F. Bartolini, M. Raggi, D. Viaggi, «Effects of 2013 CAP reform on land market: regionalization farm payments and changes in farm intended behavior»;
- 4 – Rosa F., «Climat, market and risk: a case study of farm planning in Northern Italy

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Feeding the Planet and Greening Agriculture: Challenges and opportunities for the bio-economy

Climat, market and risk: a case study of farm planning in Northern Italy

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- Summary
- Statement: farmers are taking decisions in a risky contest
- Objective: provide to the farmers some quantitative instruments

  to improve the outcomes of their decisions
- Hypothesis: how to manage the farm planning under risk aversion
- Sources of risk: climate and market affecting yield and price fluctuations
- Farm planning decisions and risk aversion
- Theory: Stochastic efficiency approach
- Inferential instrument: Sumex Utility function: description and properties
- Methodology MOTAD: MAD and formulation of the problem
- Data: hystorical series of yield and prices
- Results: utility efficient frontier and whole farm planning
- Conclusion, comments and future

1 Statement: on a daily basis, farmers are confronted with an ever-changing landscape of possible price, yield, and other outcomes that endanger their financial returns and their overall welfare. The farm management is focused on performing actions to limit the negative consequences (lower payoff) of risky prospects.

State Θ	**P(**Θi)	action and payoff ($)	
		A	B
Θ1	0,5	200	1000
Θ2	0,5	0	-800
Expected	money value	100	100

risky prospect A = U_A	200*0,5 + 0*0,5 = 100
risky prospect B = U_B	1000*0,5 -800*0,5 = 100

Action A and B generate risky prospects resulting from the sum of payoff of different state of nature with a probability distribution;

2: Objective: Elaborate a decision framework to afford the risk in farm management to minimize the losses.

3 – Hypotheses

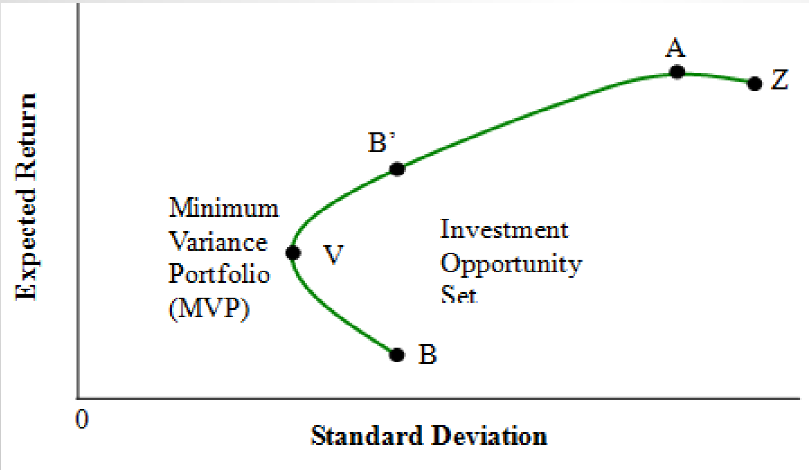
- Hypothesis 1-Farmers can evaluate the risky prospects genered by states of nature with associated probability distribution;
- Hypothesis 2 – farmers usually exhibit a risk aversion behavior (survival first)and tend to overweight the negative outcomes;
- Hypothesis 3 – Risk aversion can be used for farm planning modelling using «ad hoc» utility function for an optimal portfolio choice

4 - Markowitz portfolio analysis: the production frontier

Modelling risk: first generate a frontier with the set of possible combinations of risky prospects generated by crop A and crop B from the two extreme of pure crop A and pure crop B to all possible intermediate combinations of A and B.

The curve passing through A and B shows the risk-return combinations of all the portfolios that can be formed by combining crop A and B. Farm entrepreneurs desire portfolios that lie to the northwest in figure with higher expected returns (toward the north of the figure) combined with lower volatility (lower to the west).

Markowitz efficient portfolio: combination of crops A and B producing risk



Investment opportunity set for crop A and B

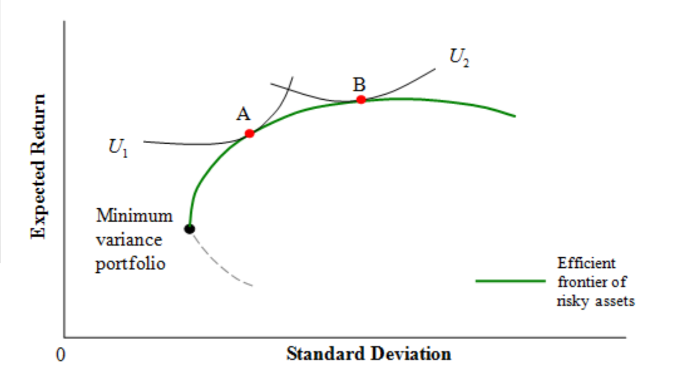
4.1 – Production frontier,risk aversion and portfolio selection

The choice of the optimal portfolio depends on the risk aversion: the level of risk aversion can be defined by the position of investor's indifference curves, U1, U2…where Ui is one of the family of risk/return pairs defining the trade-off between the expected return and risk. It establishes the increment in return that the entrepreneur desires in order to make an increment in risk affordable.

The optimal portfolio along the efficient frontier is not unique and depends upon the risk/return tradeoff utility function of each investor defined by the slopes of the curves Ui.

The farmer is indifferent to any combination along a given indifference curve: in figure, two sets of convex indifference curves U1 and U2 are shown along with the efficient production frontier: the curve U1 has a higher slope respect U2, indicating a greater level of risk aversion; the curve U2 is appropriate for a less risk-averse farmer, willing to accept relatively higher risk to obtain higher levels of return. The optimal portfolio would be the one that provides the highest utility a point in the northwest direction (higher return and lower risk). This optimal point will be at the tangent of a utility curve and the efficient frontier.

Indifference curve to risk and efficient set

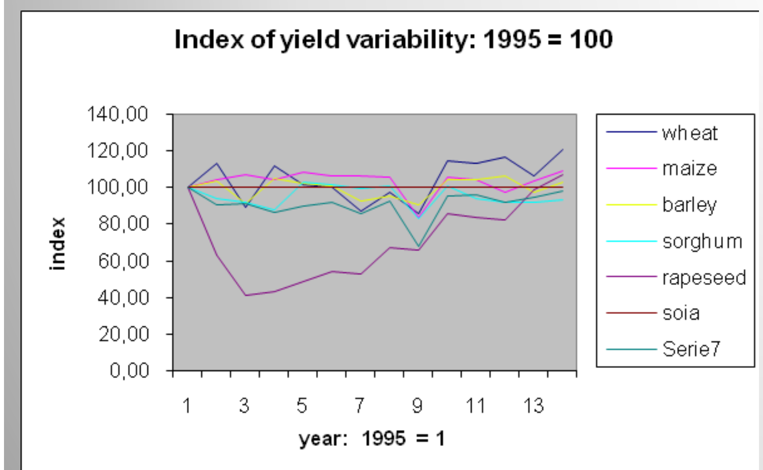


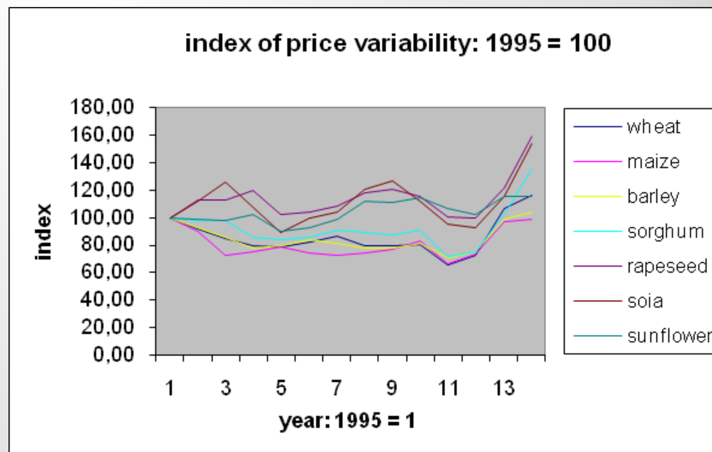
5 – Sources of risk: mean variance – covariance model

- e_i = expected value of prospect i (yield-mean)
- e_j = expected value of prospect j (price-mean)
- σ_{ii} = s.d. prospect i (yield)
- σ_{jj} = s.d. prospect j (price)
- σ_{ij} = covariance prospect i-j (price)
- say qi = investment in prospect i
- E = Σ i=1..n qi ei
- V = Σ i=1..n Σ j=1..n σ_{ij} qiqj
-
- (see slide 6)

5.1 Average yield and price fluctuation in Italy: period 95-08

	Yield		Price		Covariance	Cov ratio
Crop	Mean	s.d	Mean	s.d	Yield - price	price/yield
Wheat	3,34	0,37	14,62	2,43	0,14	8,43
Maize	9,27	0,59	10,34	1,97	0,34	8,48
Barley	3,63	0,20	12,88	1,84	-0,01	33,59
Sorghum	5,95	0,37	10,36	1,71	-0,03	7,05
Rapeseed	1,48	0,46	26,55	10,22	3,31	3,49
Soybean	3,46	0,35	22,49	6,76	-0,71	50,66
Sunflow er	2,11	0,18	24,00	6,95	0,34	199,52





A-D-H p 176, 191

6 - Stochastic efficient analysis (SEA)in whole farm planning (WFP)

SEA analysis is used to derive the efficient set of possible solutions selected from a set of risky plans, consistent with the utility maximization.

Best known application of SEA for WFP are: the quadratic risk programming and the linear MOTAD approximation to generate efficient set of farm plan with the mean-variance moments. This usually requires the assumption of normality distribution of incomes which is not the norm and/or quadratic utility function (for decision maker not indifferent to skewed and asymmetric distribution of risky prospects).

The Lambert and Mc Carl (1985) elaborated a math programming solution to find the optimal farm plan (expected utility maximization solutions) consistent with the subjective risk preferences by using a specific class of utility functions.

For our purposes it is selected the sumex utility function having some desirable properties: separability, concavity (monotonically increasing with positive marginal utility), doesn’t require the assumption of normality distribution of events generating risk (returns).
It requires the specification of bounded upper and lower limits of increasing absolute risk aversion.

7 - Description of the Sumex utility function

$\text{Max } E(U) = \Sigma_{k=1..s}\, p_k\, (G(z_k) + \lambda H(z_k))$ (Lambert & McCarl, 1985)

λ is a non negative parameter of risk aversion varying parametrically between the lower limit $\lambda = 0 \longrightarrow r_a = a$ and upper limit $\lambda \longrightarrow \infty$ then $r_a = b$

p_k is the probability of state k;
G and H are two components of the U varying in function of z_k;
z_k is an economic variables here represented by the gross margin of state k given by $c'_k * x$; c' is the gross margin vector per unit of activity j and state k;
x_j is the dimension of activity j.
r_a risk aversion: the meaning is explained in the following slide.
The returns are obtained from recent year's observations being the sample of states, each one associated to a given probability.
Solutions are obtained using a parametric linear programming with linear approximation of G and H.

The parametric linear programming MOTAD approximation allows to find the corner solutions required to build the efficient frontier.

For any change of basis caused by λ corresponding to a given level of risk aversion, a utility maximization solution is identified.

7.1 - Properties of the Sumex utility function

$U(z) = -\exp(-az) - \lambda \exp(-bz)$

$U'(z) = -(-a)\exp(-az) + \lambda b \exp(-bz) > 0$ (first derivative, positive)

$U''(z) = -(a^2)\exp(-az) + \lambda b^2 \exp(-bz) < 0$ (second derivative, negative)

the absolute risk aversion coefficient is given in theory by the ratio ra = - U"/U':

$|-r_a| = (a^2 \exp(-az) + \lambda\, b^2 \exp(-bz)) / (a \exp(-az) + \lambda\, b \exp(-bz))$

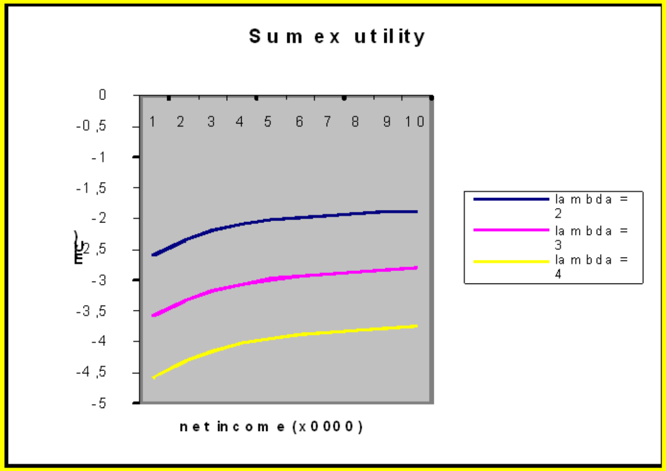
The range of r_a is derived from the relative risk aversion r_r: $r_a = r_r / w$ (Arrow)
Assuming a permanent annual GM as a measure of the wealth, the wealth w is obtained by the capitalization of the net GM (GMN) (land rent):
$GMN = GM - (VC + C_k + C_L + C_{gen})$.
The ratio used to capitalize GMN is r_r wich incorporate the risk: $r_r = r - \alpha + \phi\rho\sigma$;
r is the ratio without risk, α is the anticipated growth of crop price,
ϕ is the price equivalent to perception of market risk, ρ is the correlation between the crop's profit and a selected portfolio of representative financial assets, σ is the standard deviation of the crop price. (Dixit and Pindick).
The ratio is assumed to vary between the range values 1 and 3.
In this range will be found the corner solutions consistent with the risk aversion.
The lower and upper limits of U(Z) obtained by ra computed above are: a = 1*10^(-4) and b = 1*10^(-6). With the above specified conditions, the Sumex Utility function is:

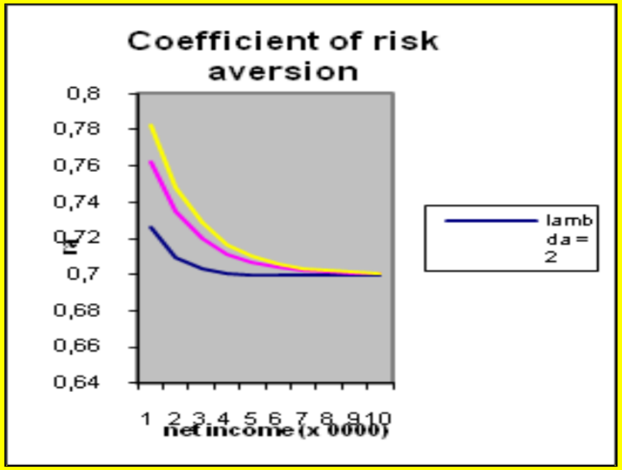
$U(z) = -\exp(-0{,}0001z) + \lambda(-\exp(-0{,}000001z)$

Numeric and graphic development of the Sumex utility function

z	Sumex Utility ÷ = 2	÷ = 3	÷ = 4
10000	-2,59237916	-3,58539921	-4,57841927
20000	-2,3398247	-3,32591352	-4,31200234
30000	-2,18133071	-3,16053669	-4,13974266
40000	-2,07990669	-3,05227785	-4,02464901
50000	-2,01312355	-2,97870762	-3,94429168
60000	-1,96738145	-2,92622578	-3,88507011
70000	-1,93443397	-2,88658562	-3,83873727
80000	-1,90928076	-2,85478644	-3,80029212
90000	-1,88888965	-2,82779574	-3,76670184
100000	-1,87142185	-2,80377443	-3,73612701

z	ra - risk aversion coefficient ÷ = 2	÷ = 3	÷ = 4
10000	0,72626353	0,76273501	0,78276361
20000	0,7096561	0,73483916	0,74821667
30000	0,70309591	0,71973843	0,72838475
40000	0,70068348	0,7113658	0,71683633
50000	0,69989402	0,70662298	0,71003769
60000	0,69970222	0,70389086	0,70600439
70000	0,69970987	0,70229797	0,70359929
80000	0,69976987	0,7013617	0,70216036
90000	0,69983218	0,7008085	0,70129768
100000	0,69988279	0,70048056	0,70077983





8 - MOTAD: computation of MAD from the sample

In our experiment the sample mean activity GM includes 14 years observation (period 1995-2008) that are the states of nature assumed with the same probability; Σpr, r = 1..14 = 1 or p1 = p2 = … p14 = 1/14; then the unbiased estimator of the mean absolute deviation (MAD) of the expected gross farm income is:

$$M = s^{-1} \sum_{r=1}^{s} \left| \sum_{j=1}^{n} c_{rj} - c^{*}_{j} x_{j} \right|$$

s, the sample size is equal to 14, c_{rj} is is the gross farm income per unit of activity jth in year rth (for r = 1..14), c^{*}_{j} is the sample mean value of the gross margin income per unit of activity jth, Xj is the size of activity j.

The measure of risk is computed by using the LP to minimize the MAD for a given level of expected gross margin E(z) (Hazell). The utility efficient programming will find solutions using a parametric linear programming routine with linear approximation of the concave Utility. (Duloy & Norton).

The objective function is:
Max E(U) = $S_{k=1..s}$ p_k (-exp (- 0,0001z_k) + λ (- exp (-0,000001z_k)
with λ varied parametrically from 0 to its maximum relevant value 0 <= λ <=λ_{max}. to find solutions coherent with risk aversion.

MOTAD: formulation of the whole farm planning model

Max (U) = -exp (- 0,0001zk) + λ(- exp (-0,000001zk))

z_k is the expected gross margin ($c_{rj} – c^*_j$) to be maximized
with a parametric constraint on the sum of negative deviations

$$\sum_{j=1}^{n} a_{hj} x_j \le b_h \quad for \quad h = 1..m$$

$$\sum_{j=1}^{n} (c_{rj} - c^*_j) x_j + y_r \ge 0 \; for \quad r = 1..s$$

$$\sum_{r=1}^{s} y_r \le \lambda \quad for \quad \lambda = 0 \rightarrow .\lambda \max$$

For the linearity condition, the all a_{hj}, b_h and c^*_j are known and constant
First Constraint is the restrictions in use of resources: land, labour and working capital;

Second Constraint is specific to the MOTAD and refer to the r = 1..n deviations from the sample mean c*j, of each of the activity j (1..7) in specific year r (1..14). The sample includes the all states of nature that are assumed with same probability. The non negative variables Y allow to satisfy the constraint that the deviations of gross margin for a single state r must be non negative.

Third constraint takes account of the sum of total negative deviations throughout the all 14 states and allow to compute the lambda critical values at each change of basis.
The all x and y are nonnegative variables and λ is a value varied parametrically from 0 to its maximum relevant value.

9 - Data: Gross margins per Ha of crop products for 14 year observations

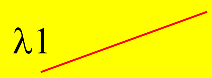
Year	Wheat	Maize	Barley	Sorghum	Rapeseed	Soybean	Sunflower
1995	577,87	1698,23	649,35	699,35	320,41	693,14	441,52
1996	603,05	1586,58	621,38	644,59	228,16	766,48	396,66
1997	439,59	1323,76	507,29	629,58	147,76	884,80	395,85
1998	513,98	1326,04	530,84	525,51	164,34	694,05	390,08
1999	460,67	1451,08	529,86	602,06	159,03	580,00	359,99
2000	475,69	1340,38	548,03	611,32	181,51	657,77	374,04
2001	437,00	1312,91	492,05	633,22	183,88	723,57	373,19
2002	450,00	1341,13	482,30	632,53	254,18	831,05	457,72
2003	396,94	1094,52	459,80	508,31	254,79	599,99	333,75
2004	534,69	1489,25	554,63	641,23	317,20	712,04	481,71
2005	431,49	1185,70	482,00	468,10	270,14	639,05	451,14
2006	491,16	1207,15	522,18	481,64	262,80	528,37	415,78
2007	600,00	1713,41	629,53	658,21	384,54	667,46	482,00
2008	650,00	1833,22	695,83	884,44	544,81	910,73	501,17
Mean state r	504,44	1421,67	550,36	615,72	262,40	706,32	418,18
dev st	111,73	217,68	279,52	104,85	106,90	111,21	51,47
CV	0,22	0,15	0,51	0,17	0,41	0,16	0,12

$(C_{rj} – C^*_j)$

10 – Tracking the efficient frontier U - M

The problem consists in maximizing the E(U) by finding corner values close together in the region of the GM values for each state found in this solution. Proceeding in this way it is possible to refine the length of the segment G and H to improve the approximation.

Starting with the initial solution with $\lambda = 0$ and zero activities included in the plan, the lambda is increased parametrically and the value of the OF changes linearly until one of the constraint is met or one of the variables is driven to zero.

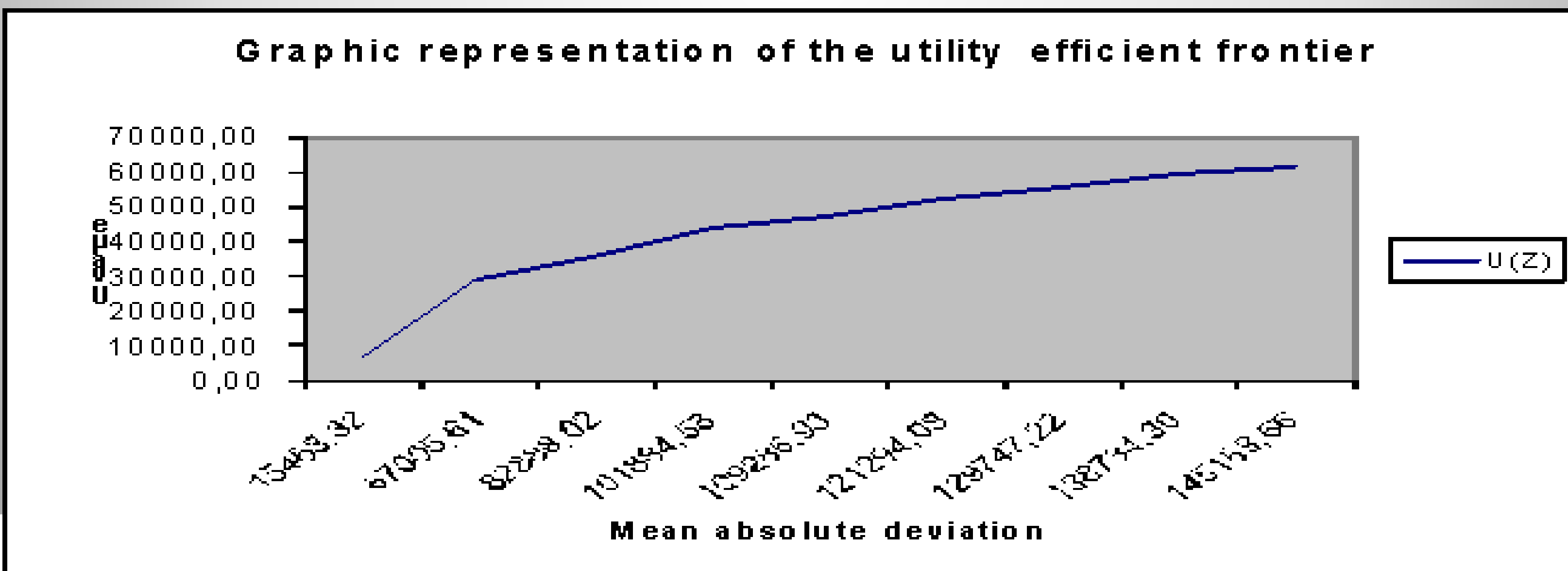


At this point a change of basis occurs and lambda can be further increased with the activity level varying now in a different way from the previous combination of activities and we continue to find an exaustive efficient set.

In the second step are ascertained the utility maximizing member of this set. In the following table are reported 11 solutions obtained with the values of the objective function U (z), the variability M corresponding to a given level of risk aversion with lambda values determined at the corner, and values (number of Hectares) of the variables included in the basis solution

11 - Corner solutions and the efficient frontier U - M

lambda	M	U(Z)	Wheat	Maize	Barley	Sorghum	Rapeseed	Soybean	Sunflower
153071,00	15463,32	6684,01	100,00	200,00	0,00	0,00	0,00	20,00	0,00
294580,00	51542,30	22216,71	0,00	425,00	0,00	0,00	0,00	0,00	0,00
152941,00	15882,41	6793,23	100,00	200,00	0,00	0,00	10,00	20,00	0,00
170406,00	18996,56	8124,36	100,00	200,00	100,00	0,00	0,00	0,00	0,00
173833,00	22152,40	9418,39	100,00	200,00	100,00	0,00	10,00	50,00	35,00
93629,00	7402,35	3130,56	100,00	100,00	0,00	0,00	10,00	100,00	0,00
86257,00	12007,16	4969,15	0,00	300,00	10,00	0,00	50,00	0,00	0,00
141700,00	8453,12	3437,23	0,00	200,00	10,00	0,00	50,00	0,00	0,00
97876,00	8987,09	3622,47	100,00	100,00	10,00	0,00	50,00	100,00	0,00
90090,00	6429,36	2573,47	100,00	100,00	10,00	0,00	50,00	0,00	0,00
148457,00	18426,04	7290,03	100,00	150,00	40,00	50,00	50,00	50,00	50,00



12 - Discussion of results

The 2.nd line reports the solution of the most specialized plan represented by activity mais, covering the 425 of 500 Ha (85% of the available land); the utility has the highest absolute value with the highest absolute risk aversion and the ratio M/U is 2,32 (slope of the Utility frontier as a measure of the risk aversion).

At the opposite in the last line there is the most diversified plan including all possible activities in the base solution, covering 480 Ha (96% of the total surface). The diversification has produced a utility value much lower than the previous one equal to 7290 with risk aversion equal to 18426 and ratio equal to 2,53, higher than the specialized solution.

A similar diversification is the solution of the row 6 where only sorghum is excluded and the land dedicated to activities is 495 Ha, the utility value is better at 9418 with M = 22152 and ratio M/U = 2,35 that is closer to the specialized solution. The difference between the solutions of row 6 and 11 justifying the difference in U and M are: + 50 Ha of Mais, +60 Ha of Barley, - 50 Ha Sorghum, -40 Ha Rapeseed and –50 Ha of Sunflower, Wheat and soybean remained unchanged.

13 - Conclusions and suggestions

The above results suggests that with the growing expected value the farmers tend to specialize their farm plan to Mais that implies a reasonable level of risk while it is not so evident that the diversification represents a viable strategy to trade off the risk with expected higher return. Another consideration regards the level of risk growingly driven by volatility in the energy market more than climate change. The price changes, more than the market fundamentals (demand, supply, stock) are driven by speculation in future markets.

An alternative to the historical crop yield data, the crop modelling approach can be used for crop yield estimation, taking into account also uncertainty deriving from weather conditions, soil characteristics and cropping practices. This will be performed using CSS (Cropping System Simulation - Danuso *et al*., 2010), a crop simulation model developed at the University of Udine implemented with the non procedural modelling language SEMoLa (Simple Easy to use Modelling Language; Danuso, 2003).

CSS is designed to simulate the dynamics of crops growth. The model can be generalized, this means that the same structure is used for the simulation of different crops (wheat, corn, soybeans, etc.), in relation to the specific parameters used. CSS is formed by a set of interconnected modules that simulate the dynamics of the cropping system and their interactions with the environment.