Agricultural trade on the example of milk from the perspective of the multi-criteria analysis

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Abstract: Traditional farming on agricultural land under the standard soil and natural-climatic conditions within the EU is based on the structure of the polygastric livestock (especially cattle), which ensures the complex carbon recycling and its return to arable soil. In the last 15 years, we have been witnessing to a sharp decline in the number of dairy cows in the Czech Republic. This fact has resulted in certain destabilising factors that have disrupted the stability of the biological system. Breeding dairy cows and its profitability is a function of the conditions for the realisation of milk production. This paper examines these aspects within a complex of factors from the use of milk production to the structure of the decision making process and it classifies and quantifies the individual problems from the perspective of the multi-criteria analysis.

Key words: role of milk in human nutrition, quality of milk production, producer's strategic decision making capacity, applied methods of multi-criteria analysis, quality of milk production, quantitative factor analysis

A number of years ago the then Minister of Agriculture Josef Lux made a historic statement of approximately the following: "After the revolution, our agricultural sector opened up to the world, but the world did not open up to us."

The validity of this statement has been fully confirmed at present, as Czech producers of agricultural and final food products face an uneven competition of s the ubsidised and, in essence, dumping import prices in practically all areas of the market with agricultural and food products within the existing complex of the international retail chains.

A deeper analysis of the given problem shows that achieving at least the minimal profitability for the individual agricultural commodities is basically an exception. The authors of this article would even venture to say that the vast majority of agricultural production is not profitable for the primary agricultural producers. However, the sharp fall in the number of the polygastric livestock in all categories will cause far-reaching structural changes in the future, which could affect the overall stability of the biological system as a whole in the objectively existing soil and natural-climatic conditions. On the other hand, the reduced amount of dairy cattle could help to reduce the impact of livestock on environment as mentioned in the study by Havlikova and Kroeze (2010).

However, the systemic aspects of this problem have much wider consequences, as the current situation is also predetermined by a series of significant, though unspecific groups of factors in the future, whose negative residual effects could affect the entire future generations.

There exists a strong link between agricultural production and landscape. More open agricultural markets will change agricultural production and thus the landscape will change as well (Hubber and Lehmann 2009).

Although agricultural production is generally claimed to be understood as a stochastic process in the production of key agricultural products, agricultural production is placed on the same level as numerous branches of industrial production and services in terms of economic indicators and factors, the level of whose automation and robotisation more closely approximates a deterministic production model. It thus seems essential for each agricultural primary producer to accept the system of marketing conditions, predetermined for agricultural production by the profits arising from the margins of determining,

i.e. key marketing chains, which create a certain competition-oriented monopoly with regard to the formation of purchase prices.

The efforts to maximise trade margins and the resulting profits thus logically force purchase prices for agricultural production to the minimum possible level. Purchase prices thus often reach a level where, in the decisive majority of cases, they only cover the producers' real costs with difficulty (Anonym 2005).

This principle establishes the conditions for the creation of differing degrees of profitability in the individual phases of product verticals in agricultural production.

From this perspective, there is a real danger that a further growth in the price gap affecting the profitability of agricultural primary production could result in systemic structural negative effects in the long-term horizon. The factors which affect the current growing trend in food prices worldwide are discussed in details by Krížová (2009).

However, the price gap could also affect not only the agricultural primary production, but also the first processing phase, i.e. in particular, dairies, abattoir operations, mills and others, as well as the second phase, i.e. the production of final products such as meat products, bakery goods, cheeses and similar products, where Czech producers are not fully competitive in relation to the subsidised imports preferred by the retail chains in relation to food products, given the prices of input factors.

Although there are several differences in commodities where, in particular, malt barley, hops and rape in plant production and eggs and broiler chicken in livestock production may show a relatively acceptable degree of profitability, other agricultural production shows a zero or negative profitability and our agricultural primary producers are gradually finding themselves in the so-called "survival" decision making mode in the sense of the survival theory. The key element for encouraging agriculture in the European Union's Common Agriculture Policy is organic farming (Cederberg and Mattsson 2000). The EU dairy sector is facing significant changes due to the EU enlargement and the WTO negotiations (Bouamra-Mechemache et al. 2008).

Production method, nutritional information, protected denomination of origin/certification and origin were directly linked with consumer concerns about the product until the financial crisis (Iop et al. 2006). At present, the given economic situation is also affected by the problems arising from changes in the structure of the population's consumer basket, where the conditions of the global financial crisis and a whole series of economic measures have forced a large percentage of the population to buy cheaper, lower quality food products in view of the fact that food costs are still one of the major key elements of the annual and everyday family budget. The previous introductory comment was basically aimed at defining the complex area of the problem and the conditions under which agricultural primary production decides on the structure and intensity of production, and how food processors decide on the structure and quality of food products. Incentive contracts between farmers and processors, shippers, and other buyers are an increasingly popular means of coordination to improve food quality (Goodhue 2011). The buyer determines the structure of the consumer basket, i.e. the purchased food products, attempting not only to qualify (classify) this essential problem area using objective criteria, but also its exact depiction in the terms of the system approach and modern quantitative methods.

The objective of this paper is to draw attention to the existing factorial disproportions and to direct the interest of the expert public towards the stabilisation and creation of conditions for the possible positive development of the commodity "Milk and Milk Products" in the coming period.

Dairy products are regulated in many countries. The specificity of these products – perishability, seasonal imbalances, and inelastic supply and demand for milk – cause market instability (Suzuki and Kaiser 2005). Inefficiencies related to the milk quota regionalism are discussed by Hennessy et al. (2009).

The dairy sector has a tradition of the regulated production and trade through identity standards, and identity standards for milk and milk products are still important as the legislative references for trade (Heggum 2011).

Sustainable dairy production requires farms that are economically viable, environmentally sound and socially acceptable (Thomassen et al. 2009).

MATERIAL AND METHODS

A specifically oriented method was chosen to meet the given objective, combining the generally known information databases, statistical data and the modern quantitative analysis tools.

Based on the formulated problem, a system structuralising the concept of factors involved in the given problem was defined, including the basic prediction, and the individual factors were solved as intersections using the software MCA KOSA.

The individual results were then generalised in the logic of the presented conclusions.

Formulation of the problem and objective

The advantage of the production of agricultural raw materials and food products lies in their non-substitutability. The problem is their structure, quantity and quality, which is a function of price. The total global production of milk, dairy and beef do not change with full liberalisation, but production shifts were observed from North America and Europe to South America and Southeast Asia (Verburg et al. 2009).

Another difference in agricultural production lies in its orientation on the produced volume, where the market, i.e. the total demand, is more or less constant, but it differs in the compositional structure of products. From this perspective, the market in agricultural and food products behaves stochastically, i.e. it shows fluctuations in the individual years and periods, especially in relation to the competitive import sources.

Basic tenet of the problem

Developments in views of the role of milk have seen an extremely dynamic development, as this is usually a function of the available sources and the economic situation.

In contrast to the tenet that milk is a food, beverage and medicine in one, articles have appeared which claim that adults should not drink milk at all as their digestive system is not adapted to this adequately. For this reason, it is imperative to divide the commodity "Milk and Milk Products" into several logical functional groups aimed at the individual age categories of the population. There has also recently been an increase in the incidence of allergies to cow's milk and the related products but the ability of milk proteins to adsorb at the oil-water interface and to stabilise emulsions is still used in the food industry in the manufacture of nutritional products, specialised medical foods, dietary formulations, liqueurs and milk desserts (Singh 2011).

This is also the basis of the economic conditions for the structure of the consumer basket for the commodity "Milk and Milk Products". This aspect is more complicated, in that there are dynamic intersections of various source groups, not just from the perspective of the actual milk sources, but also from the perspective of the whole structure of milk products, which are virtually non-substitutable in human nutrition.

The situation is somewhat different under the conditions of the Czech Republic, to that, for example, of a number of countries in the Southern Europe or West and South Asia, which lie in subtropical regions where the buffalo milk, in particular, plays an important role, and it is the basis, for example, for mozzarella cheeses (Kadlec 2004). Different types of mozzarella cheeses depend on the rennet used. (Nawaz et al. 2011).

The basic problem, however, is the biochemical structure of milk in relation to whether this is milk with a predominantly albumin or casein content, which is strongly reflected in the structure of human nutrition (Červenka et al. 2004).

In predicting the behaviour of the commodity "Milk and Milk Products" in the market, it is essential to consider 4 basic factor groups:

(a) the available amount of production
(b) the product structure
(c) the structure of dietetic and nutritional effects
(d) vector prices of the individual elements in the given commodity (Dragounová 2003).

However, these aspects must be divided according to the time frame of the individual's development needs and the consumer structure of demands on the given product within the given commodity in the concrete structure of society, while taking the dynamics of the systemic development in consumer demand and the financial capacity of the individual age groups in society into account. This principle is the basis of the complex econometric model analysing the consumption of the commodity "Milk and Milk Products" (Doubek 2010).

The chosen approach also analysed a number of economic effects and impacts that gradually affected the inclination to create new final milk products. These represent modern trends today, through all types of long-life products such as long-life yoghurts, especially those with a variety of local and imported fruit production from the subtropical and tropical regions added with the aim of maximising their marketing and profit effect, irrespective of the actual bio-dietetic quality of these products.

In this area, we see a marketing oriented retreat from the classic live cultures contained in the basic, natural types of cottage cheese and yoghurt over to the artificially stabilised products using various types of additives that reduce the natural, positive biological properties of these products, which are important for the development of the organism. This not only includes various sweeteners, antioxidants and preservatives, but also a whole series of other additives such as the colouring agents, flavouring, etc.

In view of the systemic nature of this paper, it must be objectively said that there are currently several dairy companies such as the Madeta s.a. and others, which have chosen the path of the biological live cultures.

Table 1. Trend in the average milk yield in kg (1989, 1997–2010)

Milk yield	1989	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Daily	10.91	11.96	13.25	13.76	14.36	15.31	15.67	15.77	16.41	17.13	17.15	17.94	18.51	18.82	18.91
Annual	3 982	4 366	4 837	5 022	5 255	5 589	5 718	5 756	6 006	6 254	6 370	6 548	6 776	6 870	6 904

Source: CSO, modified

The consumer basket behaviour is primarily affected by the factors including:
– family tradition and customs,
– income and disposable financial resources,
– state of health, including the prescribed diets and so on,
– lifestyle and taste preferences,
– the standard structure of the predominant type of production and food consumption evoking the need for individual types of milk products according to the actual production and orientation of the individual types of food, viz. the consumption of hard, grated cheeses (e.g. parmesan, edam, etc) according to the types of food preparation and use.

It can be shown that the dynamics in the development of costs for the consumption of milk and milk products historically evolved in a very complex way. The wiews on the effect of the consumption of milk products were not always clear. Scientific studies, however, confirm the beneficial effect of probiotics on human health. (Cobo Sanz et al. 2006). The impact of the consumption of raw cow's milk is debatable and it is still studied. Milk production represents a major component in the global food production and the implications of change could be enormous (Maiala 2000).

RESULTS AND DISCUSSION

Systemic aspects of the broad problem

The current commercial milk samples are:
Cow's milk – whole, half-skimmed, and skimmed
– with well-defined heating treatments (Morales and Jiménez-Pérez 1999) (sheep's and goat's milk similarly).

At present, we are witness to a phenomenon where a certain part of the population, which is very hard to estimate, but which we estimate at 5–6% of the population, are allergic to the cow's or other natural milk (sheep's and goat's milk) to various degrees and that this part of the population is turning to the so-called artificial milk substitutes, which are milks made by the emulsification of various types of vegetable oils, such as soya milk and other artificial milk, relying on the availability of the emulsifying technology to process vegetable oils.

On the global development level, we can also soon expect to see sunflower milk, peanut milk and others. We can still observe a lower evaluation of the organoleptic properties of artificial milk by the consumers. Soya milk received lower ratings on the sensory quality and convenience than dairy milk (Bus and Worsley 2003). Although artificial milk is considered less tasty, health problems are forcing consumers to modify their preferences.

This effect causes the so-called production marketing substitution, which also has a major affect on the price to cost ratio within the commodity "Milk and Milk Products". The structure and effects of these substitution activities, which are objectively conditional, bring about partial and more complex changes in the consumer basket, i.e. the structure of demand for milk products, the conditional effects of market realisation and the feedback on the structure of production.

Note: In this context, it must also be said that the structure of the consumer basket, especially in the current period of the so-called financial crisis, which has had a global impact, has experienced a growing need for major savings on the widest possible

Table 2. Trend in the cattle numbers in the individual categories (1989, 1998–2010)

Indicator	1996	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Dairy cows	712 166	598 234	583 301	547 493	529 138	495 962	466 173	436 806	432 578	424 017	410 349	406 321	400 516	384 115
Other cattle	38 427	48 595	58 725	67 294	82 257	100 333	124 149	136 081	141 146	139 706	154 337	162 936	160 245	168 281
Cattle total	750 593	646 829	642 026	614 787	611 395	596 295	590 322	572 887	573 724	563 723	564 686	569 257	560 761	552 396

Source: CSU, modified

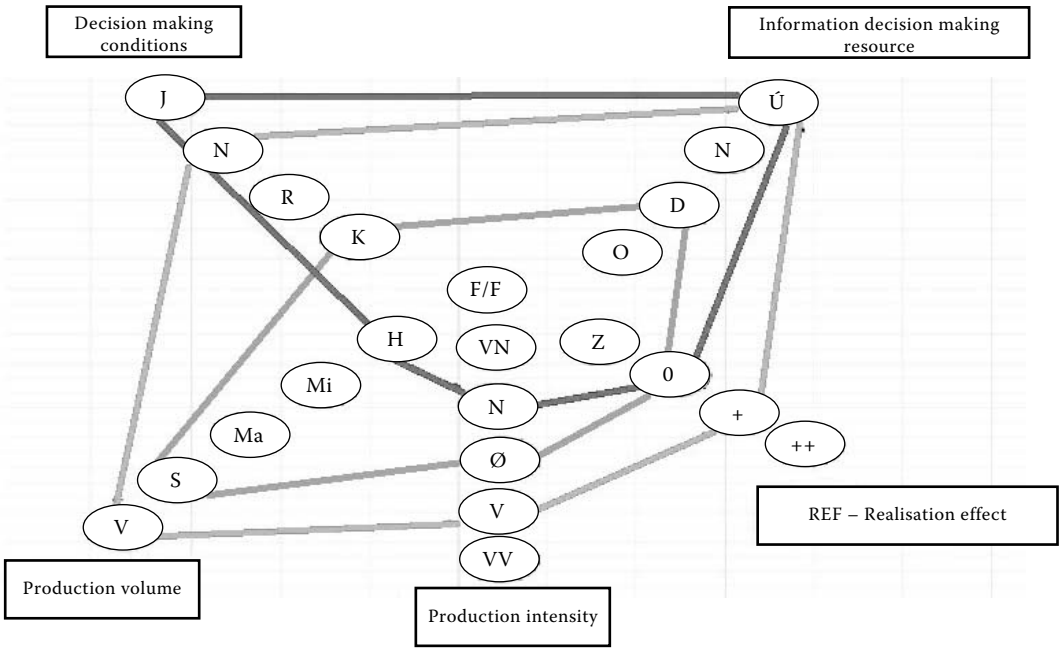


Figure 1. Classification of the farmer/producer's decision making capacity[1]

F/F = farmer in fuzzy conditions, there is a pentagon of the possible situations
Decision making conditions: J = certainty, N = uncertainty, R = risk, K = combination of conditions
Production volume: H = hobby producer, Mi = micro producer, Ma = small producer, S = medium producer, V = large producer
Production intensity: VN = very low, N = low, Ø = average, V = high, VV = very high
Realisation effect (REF): Z = negative (loss), 0 = zero, + = profit, ++ = maximum profit
Information decision making resources: Ú = complete information, N = incomplete information, D = additional information, O = individual communication

Source: own calculation

scale among the individual groups of milk and milk product consumers in relation to the structure of their disposable incomes. However, this fact cannot be separated from the major changes that have occurred in the Czech Republic in the last 20 years in the area of the primary agricultural production, i.e., in particular in the number of dairy cows and their average annual production.

Table 1 on milk production documents this development and in Figure 1, we note the decision making process classification, in Figure 2 the factor orientation of the production process. The development in numbers of cattle is shown in Table 2.

An important aspect in terms of economic effect from the perspective of the manure production appears to be loose stalls with a manure slurry system, although this also requires the existence of the related processes or the so-called separators, where, however, the final product has different biological properties to manure.

This brings us to 2 groups of problems:
(1) the production effect of milk production,
(2) breeding dairy cows as the foundation for the stability of the bio-system of the basic land fund.

One area of the problem are the investment and production costs in relation to the stability of the production system and production effect (Jablonský 2002).

MCA Model

In constructing the multi-criteria analysis model, 8 possible alternatives in decision making by primary agricultural producers were chosen. These alternatives

[1]Quantitative systemic problem solution:
The behaviour of product verticals can be divided into a final number of phases: P1 – producer or manufacturer, P2 – customer or processor , P3 – retail chain, P4 – final consumption
P1 can be divided into 5 groups: (1) H – hobby producer (3 cows), (2) Mi – micro producer (10–15 cows), (3) Small producer (up to 50 cows), (4) Medium producer (circa 100 cows), (5) Large producer (over 100 cows)

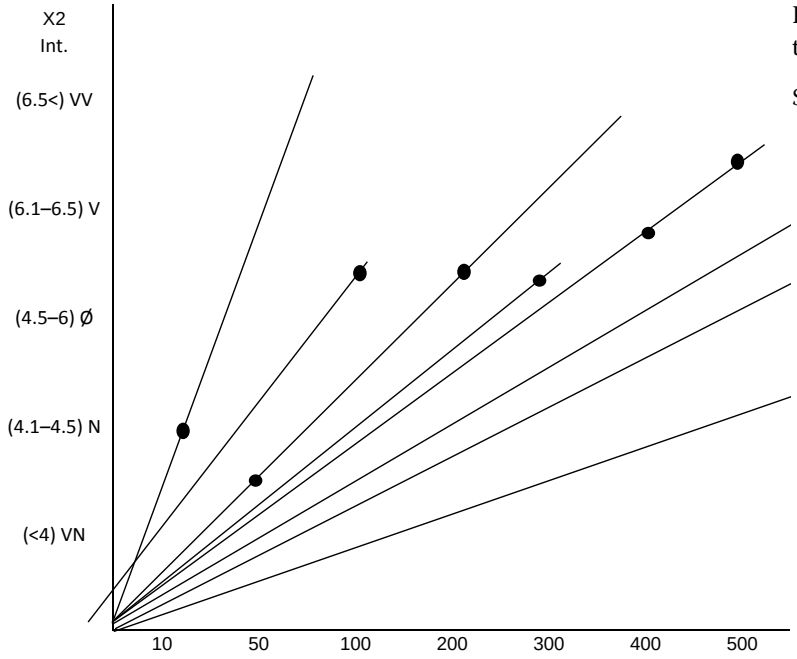


Figure 2. Factor orientation of the production process in terms of secondary outputs[2]

Source: own calculation

Table 3. Initial MCA Matrix[3]

Alternatives	K1	K2	K3	K4	K5	K6	K7	K8
1.	6.7	5.1	5	7	3	6	5	3
2.	7.3	5.2	4.9	8	4	7	5	4
3.	5.5	4.7	4.6	5	2	5	6	2
4.	6.8	5	4.7	7	2	4	5	2
5.	7.5	5.1	4.8	9	3	5	6	3
6.	5.2	4.5	4.5	6	2	4	6	2
7.	7.3	5.1	4.6	7	4	6	4	3
8.	6.9	5.3	4.6	6	5	6	3	2
Type of criteria	MAX	MAX	MAX	MIN	MIN	MAX	MAX	MAX
Weight	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125

Alternatives:

1 = Current nos. at standardised level of production
2 = Current nos. with intensified production
3 = Current nos. with extensified production
4 = Decreased nos. at average production
5 = Decreased nos. with intensified production
7 = Change in customer at current nos.
8 = Change in customer with decreased nos.

K1 = average annual output per 1dairy cow (in 000 l)
K2 = fat content
K3 = other complex parameters of milk quality
K4 = cost index
K6 = ARP – achieved realisation price
K7 = terms of payment from customers
K8 = other realisation

Source: own source based on expert consulted estimates

[2]As a part of the research project, alternative case studies of the economic efficiency of milk production at various intensities and with various numbers of dairy cows were analysed. This factor orientation of production intensity was determined based on the analysed body of data and the preliminary data for 2010 provided by the Institute of Agricultural Economics and Information (ÚZEI) (Bašek 2010).

[3]The authors of this paper are aware that the presented matrix is considerably simplified and it only represents the basic system relationships between the alternative decision making situations and evaluation criteria.

Table 4. MCA of the studied problem

Alternatives	Alternative rankings				MCA milk			
	AGREPREF method		weighted sum method		TOPSIS method		ORESTE method	
	Dn index	ranking	benefit	ranking	distance	ranking	rl values	ranking
1.	0	4	0.675272	2	0.574634	3	223	3
2.	2	1	0.729755	1	0.440368	6	184.5	1
3.	1	2	0.489221	5	0.717027	1	267.5	4
4.	–1	5	0.485915	6	0.573068	4	297.5	7
5.	1	2	0.60625	3	0.40725	8	219.5	2
6.	–1	5	0.34375	8	0.644	2	329	8
7.	–1	5	0.524547	4	0.455846	5	272.5	5
8.	–1	5	0.419475	7	0.431301	7	286.5	6

Alternatives – see Table 3

were evaluated from the perspective of 8 criteria. The following multi-criteria analysis matrix and the legend in Table 3 shows the relationship between the decision making alternatives.

Due to the limitations of this paper, 6 basic methods of multi-criteria analysis were chosen for the actual calculation, i.e. AGREPREF, weighted sum, TOPSYS, PROMETHE, ORESTE and MAPAC. Given the limited scope of this paper, we have only presented the results of 2 methods.

As a supplement to the analysis, we are including the following Tables 4–6 of mutual relationships for the weighted sum method and the full supplementary information on the calculation for the ORESTE method.

The tabular layout of results requires a deeper analysis than the given scope of the submitted paper. From this perspective, the authors would like to tate that the economic-production parameters within the individual alternatives can behave differently in various regions given various concentrations of dairy cows and various levels of production intensity.

However, the aim of this paper was to point out the possibilities of quantitative methods in relation to the complex of the product vertical milk. The relative stability of results for the individual methods used and the supplementary analysis coefficients document, for readers familiar with the given problem, the relatively high degree of reliability of the chosen alternatives and types of the chosen criteria. Based on the completed analyses, where the resulting tables were scaled down to conform to the scope of this paper, the following conclusions can be made.

CONCLUSION

If we analyse the given problem from a purely economic perspective, it can be seen that milk production

Table 5. Analysis of the MCA model for milk

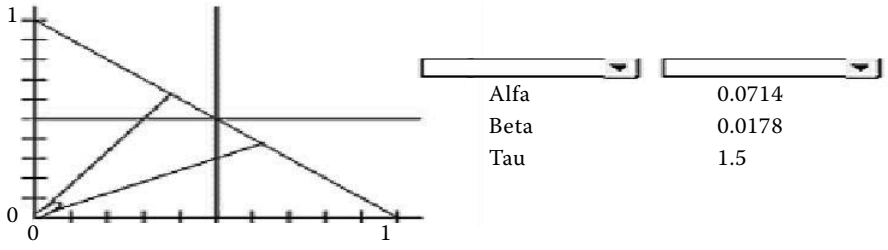
Alternatives	K1	K2	K3	K4	K5	K6	K7	K8
1.	0.652174	0.75	1	0.5	0.666667	0.666667	0.666667	0.5
2.	0.913043	0.875	0.8	0.25	0.333333	1	0.666667	1
3.	0.130435	0.25	0.2	1	1	0.333333	1	0
4.	0.695652	0.625	0.4	0.5	1	0	0.666667	0
5.	1	0.75	0.6	0	0.666667	0.333333	1	0.5
6.	0	0	0	0.75	1	0	1	0
7.	0.913043	0.75	0.2	0.5	0.333333	0.666667	0.333333	0.5
8.	0.73913	1	0.2	0.75	0	0.666667	0	0
Ideal alternative	7.5	5.3	5	5	2	7	6	4
Bazal alternative	5.2	4.5	4.5	9	5	4	3	2

Alternatives – see Table 3

Table 6. Supplementary information on calculation using the ORESTE Method

Preferential relationship matrix						
	1.	2.	3.	4.	5.	6.
1.	indifferent	worse	not comparable	better	not comparable	better
2.	better	indifferent	better	better	not comparable	better
3.	not comparable	worse	indifferent	not comparable	not comparable	better
4.	worse	worse	not comparable	indifferent	worse	better
5.	not comparable	not comparable	not comparable	better	indifferent	better
6.	worse	worse	worse	worse	worse	indifferent
7.	worse	worse	not comparable	not comparable	worse	not comparable
8.	worse	worse	not comparable	not comparable	worse	not comparable

Standardised preferential intensity matrix						
	1.	2.	3.	4.	5.	6.
1.	0	0.097098214	0.275669643	0.231026786	0.139508929	0.383928571
2.	0.183035714	0	0.443080357	0.380580357	0.204241071	0.551333929
3.	0.176339286	0.2578125	0	0.167410714	0.176339286	0.137176786
4.	0.064732143	0.128348214	0.100446429	0	0.103794643	0.170758929
5.	0.147321429	0.126116071	0.283482143	0.277901786	0	0.391741071
6.	0.147321429	0.228794643	0	0.010044643	0.147321429	0
7.	0.61383929	0.041294643	0.246651786	0.219866071	0.098214286	0.354910714
8.	0.133928571	0.100446429	0.214285714	0.231026786	0.196428571	0.322544643



Alternatives see Table 3

Source: own calculation

under the macroeconomic conditions in the Czech Republic is currently on the threshold of profitability.

However, if we look at the problem from the perspective of the macroeconomic and systemic stability of the agricultural system, we can only come to one conclusion.

The catastrophic decrease in the number of dairy cows from their original number in the period from 1992–2010 (Table 2), which is below the level of self-reproduction and renewal of soil production potential, can cause problems in the stability of the soil bio-system as an aspect in the long-term development of agriculture in the Czech Republic.

The situation can be considerably different in the individual cases as there are a certain number of business subjects practising the principles of green farming and maintaining the structure of cattle herds according to the individual key structural relationships in the individual categories of cattle.

It can thus be said that the specific marginal dimensions in the threshold factor limits for the correlation of categories of cattle under agricultural conditions in the Czech Republic have been disrupted. This is logically reflected in the customer behaviour i.e. especially that of dairies in the Czech Republic.

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