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Risk and Subsidies in Czech Agriculture - an ex-ante Analysis of Farmers´ Decision-making[1]

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Abstract

This paper deals with the ex-ante analysis of the effects of farm subsidies on farm behaviour. Beside that the risk factor is implemented in the farm model to reflect and quantify potential (negative) impact on farm results. A farm-level optimization model is used to assess the effects of different kind of policies and risk on production structure, income indicators and land use management. It appeared that a reasonable level of risk (via income variation) have impact, but not significant. If liberalisation would have happened (zero direct and disadvantageous payments) production would homogenised, 30% of land would remained abandoned, production and income would clearly decline. Other scenario points out that environmental objectives (here through more extensively managed land) could not be necessarily more costly, but in such a case without accompanying livestock. To increase profitable livestock production requires to provide grassland and animal payments above the current level (obviously in addition to stimulating production economizing) whereas both payments should be conditional to each other.

Key words

Agrarian policy, risk assessment, farm model, direct payments.

Anotace

Příspěvek je zaměřený na ex-ante analýzu možných vlivů zemědělských podpor na chování (rozhodování) zemědělců. Navíc je model obohacen o vliv faktoru rizika při rozhodování a tudíž možnost vyhodnotit případné (negativní) dopady do hospodaření podniku. K analýze je použit optimalizační model na úrovni farmy, který umožňuje vyčíslit dopady různých typů zemědělských politik-scénářů (včetně analýzy rizika) do oblasti výrobní struktury, příjmových ukazatelů a užití půdy. Bylo zjištěno, že při uvažování rizika by bylo částečně hospodaření podniku ovlivněno. Liberální scénář (znamená nulové přímé platby a platby na LFA) by vedl k nižší diverzitě pěstovaných plodin, 30 % půdy by zůstalo neobhospodařovaných a produkce i příjmy by se snížily. Zlepšení péče o půdu prostřednictvím většího podílu extensivně obhospodařovaných ploch nemusí znamenat nutně vyšší náklady; v tomto případě ovšem bez adekvátního zvýšení chovaných zvířat. Ke zvýšení rozsahu chovaných zvířat (přežvýkavců) by bylo zapotřebí u vybrané typové struktury podniku (vedle zvýšení účinnosti vstupů) navýšit podporu travních porostů a platbu na zvíře (top-up) nad současnou úroveň, přičemž obě platby by měly být vzájemně provázané.

Klíčová slova

Zemědělská politika, hodnocení rizika, faremní model, přímé platby.

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Introduction

Decision about land allocation among farm activities is an important aspect in farming businesses with several economic (farm revenues, cash-flow), socio-managerial (input, capital and labour allocation) and environmental (landscape mosaic, soil erosion threat, diversity, etc.) implications. At the same time, nature, climate, developments in markets, technology and societal concerns generate many types of risks. In this paper we look at two phenomena determining decisions: provision of (income) subsidies and the role of risk. Both are highly relevant not only for individual producers but for policy makers as well with regards to: i) allocation of national direct payments to certain targets, ii) directing policies after 2013 – first draft of policy is just communicated, iii) expectation on the increasing fluctuation of farm incomes (changing condition on climate and markets). We implemented the effects resulting from subsidies (area payments plus agroenvironmental payments) into simulation to see the shifts between intensive and extensive land managements. The analysis focuses on a farmers´ possibility to adjust production structure according to economic results. A particular attention is given to incentives that stimulate cattle breeding which is thought be a sector potentially threatened if special support is not provided. An optimization mathematical model FARMA 4 (Foltýn, et. al. 2007) is used. The concepts of risk finds its theoretical justification in the expected utility maximisation decision model (Robinson and Barry, 1987), where the risk of the crop production is usually defined in terms of the levels of income variability associated with different states of nature (lower expected income). This variability results from price (market risk) and yield (production risk) fluctuations.

Farmers´ decision is not static but rather it is inter-linked: economists often assume that risk consideration has been related to the existence of safety net: obviously such safety net may not be provided only by governmental payments but also off-farm revenues (or other types of income). Yet, not only the existence of certain support is crucial for decision but also the type or criteria the payment is distributed or whether it is tied to production or not. In this sense Bhaskar and Beghin (2010) state that in the presence of uncertainty, decoupled payments reduce the coefficient of risk aversion (they call it as wealth effect) and income variability (as insurance effect). OECD (2008) view decoupled payments rather as providing compensation and adjustment assistance, rather than as a fundamental policy of income support to farmers. In fact, that has impact on the way how payments are spent: more progressive farmers declared they tend to invest them what basically confirms the existence of production linkage.

The aim of this contribution is: i) to ex-ante estimate production and income effect of direct payments reduction (full liberalization as an extreme scenario); ii) how risk-averse behaviour might influence farmers results and iii) to simulate (calculate) a sort of compensation payment when shift in production intensity is followed on a selected typical Czech farm.

Risk behaviour in the literature

Omitting risk and uncertainty in decision has been criticised in the neoclassical theory of the firm since the 1960s. Over the last decades, better insight has been developed about risk assessment, risk preferences and value of information. Harwood et al. (1999) offer specific definition of risk. They define risk as uncertainty that "matters" and may involve the probability of losing money, possible harm to human health, repercussions that affect resources (irrigation, credit), and other types of events that affect a person's welfare. Uncertainty (a situation in which a person does not know for sure what will happen) is necessary for risk to occur, but uncertainty need not lead to a risky situation. In this paper we concentrate on pure risk which is considered as downside risk[2] only, although the business risk usually incorporates both downside and upside risk[3].

The literature on farmers' risk exposure usually covers either price risk or yield risk. A closer look at price risk provided e.g. OECD (1993), Ray et al. (1998), Harwood et al. (1999) and Goodwin, Roberts, Coble (2000). They focused on the variability and estimation of the probability distribution of agricultural output prices. Studies differ in the length of the measured period, locality,

[2] *Downside risk means the likelihood of only negative deviation of the critical variable (i. e. negative consequences if risk occurs).*

[3] *Upside risk refers to the positive features of risk (e. g. the probability of plan excess).*

type of price (future price, spot price, export price), method of adjustment of the time series (deflating, detrending, using nominal prices) and time scale (usually average annual price or average monthly price). Most of authors have used the coefficient of variation as the tool for the assessment of price volatility. The regional aspect is very important for the interpretation of results because market interventions and market price support vary widely across the world.

Yield risk is the second essential part of the income risk of agricultural enterprises. Many authors have tried to estimate the probability distribution of natural yields of various crops but there is no clear evidence of the kind of skewness (Day, 1965 vs. Ramirez, 1997 or Harwood et. al, 1999). For the purpose of this paper it is necessary to point out the influence of spatial aggregation of yield data on the distortion of yield variance. Regional average data reflects the regional randomness or risk factors which are common to all farmers in the region. On the other hand, individual variability of natural yield can be caused by management failures or local weather conditions. Hence using spatially aggregated data is not suitable for the estimation of individual farmers risk exposure (Harwood et al, 1999, Popp, Rudstrom, Manning, 2005). Furthermore, the results of these empirical studies revealed a different nature of yield and price risks in agriculture. The natural yields are low spatially correlated and the rate of yield risk depends on the climate and weather features, soil properties, technology of production and other predominantly natural variables. Estimates of yield probability distribution require the most individualized data.

In connection with natural risks, some research teams have been dealing with specific underlying risks faced by farmers, such as epidemic diseases or climate change (e.g. publications of LEI Wageningen).

The correlation between price and yield volatility has been considered in risk analysis as well. From the results of empirical studies (e.g. Weisensel, Shoney, 1989, Coble, Heifner, Zuniga, 2000) implicitly follows the assumption that open economies (markets) show lower correlation between output prices and natural yields than more isolated economies. Correlation coefficients also depend on the crop, growing conditions, access to storage capacities and the level of contracting.

The agrarian policy is another significant factor determining the level of farm income and farmers' behaviour. Since discussions on the topic of suitable risk management schemes have taken place at a global level, some studies of risk management tools in agriculture have been published. The OECD publications (2000, 2009) may be considered as significant and relatively comprehensive studies of income risk management in agriculture. The overview of the European agricultural risk management schemes was introduced in the common research project EC-JRC Ispra Italy with data contributed from European countries (Bielza et al., 2006). This study constituted the basis for analyzing strategies to integrate risk management tools within the Common Agricultural Policy (CAP). The strategic objective of the parallel research projects was to analyze the potential of different risk management tools for stabilizing farm household incomes in the EU (Meuwissen et al., 2008).

Some papers also examined the relationship between the farmers' operating risk and current subsidies. Based on the simulation at the commodity level the results revealed that partially or fully decoupled payments extend the farmers' decision-making possibilities. The current subsidies (in Czech agriculture) are a suitable complement to other commonly used risk management tools primarily designed to reduce the farmers' income volatility and farm income volatility (Špička et al., 2009).

Data and methods

Prices (and variations) were collected from Czech Statistical Office and calculated for a period between 1991 – 2009[4]. Cost structure of characteristic farm types was taken from an annual survey carried out by IAEI (Poláčková, et. al., 2009). It provides a standard costs assignment for each commodity included in a survey in a regional classification (maize, sugar-beet, potatoes, potatoes-

[4] *For some commodities the period had to be shortened due to incomplete time series. If monthly data were used spot (current) prices for some commodities had to be avoided due to extreme drops recorded.*

oats, mountainous). Data on yields (and monthly variations) were calculated for time period 2007-2010.

We use a mathematical static farm optimization model (FARMA 4, Foltýn et. al., 2007) which simulate behaviour of selected farm types. An optimization function is

$$\max \pi = TR + TS - TC ,$$

where π is a farm profit[5], TR is total revenue (from crop and livestock activities), TS is total subsidies. Production (and revenues) are endogenously determined based on the area and number of animals calculated, respectively. Unit payments are exogenously given either as area payments or commodity payments (if applicable). TC is total costs including labour and fixed costs. Costs are linear[6] and thus do not assume scale efficiencies. Beside factor (and nutrients) restrictions there are also "agro-environmental" options which allow simulating more "environmental" sensitive behaviour and related economic effects. This is e.g. positive balance of organic fertilizers, elimination of erosion threats, balance of nutrients. Model simulates both crop and livestock activities whereas there are possible two management strategies for crops: intensive and extensive. Extensive management is usually given a subsidy as stimulus. It enables to assess the trade-offs between more profitable intensive scenario against more environmental sensitive extensive one.

Risk is taken into account through subtraction of the variation in yield[7] (income-variance criterion) as follows:

$$Y_{ex} = Y_{av} - \phi\lambda ,$$

where Yup is expected yield, Yav is the average yield, ϕ is an exogenously determined risk-averse coefficient indicating to what extent the farmer avoids risk (parameter close to zero indicates risk neutrality and the value close to one implies risk-averse behaviour) and λ is the variance of yield, respectively. Yields are endogenous parameters depending on the management. Yield variation is not provided for livestock commodities and for some crops (this assumption substitutes agronomic limits in the crop rotation). Extensively cultivated crops are supposed to exhibit large yield variation and that is reflected in the model as well. Precise data for yield and variations are given in the appendix (Table A1).

For the analysis a typical farm representing "average conditions" of the Czech Republic (half of territory designed as LFA) was selected. The farm represents corresponding production and cost structure for such territory (although the size is rather normative).

The following assumptions have been applied between crop and animal production: i) the farm is assumed to be self-sufficient in forage and straw via required energy intake, ii) animals receive the required amount of feed and roughage, which satisfies the ingredient and nutrient restrictions, iii) animal transactions (buying and selling) are made at the start of the planning period and these transactions are restricted, iv) animals are categorised into calves, heifers (dairy and suckler), suckler cows, dairy cows, fattening beef, v) all crops produced are sold or used as animal feed or seeds. No storage costs are assumed.

As previously outlined an objective is to see the possible effects of introducing certain types of policies (coupled or decoupled payments) on production structure, crop management, livestock density and economic results. We applied 6 scenarios, in more details are presented in the table below. The first one serves as a "Baseline" scenario (without risk consideration), the remaining ones simulates either more liberalised conditions or provision of environmental or livestock payments: the "Current policy" scenario explores the effects of risk implementation and other parameters are the same as in "Baseline", the next scenario ("Liberalized") is used to look at on the extreme effects resulting from complete subsidy cut. The

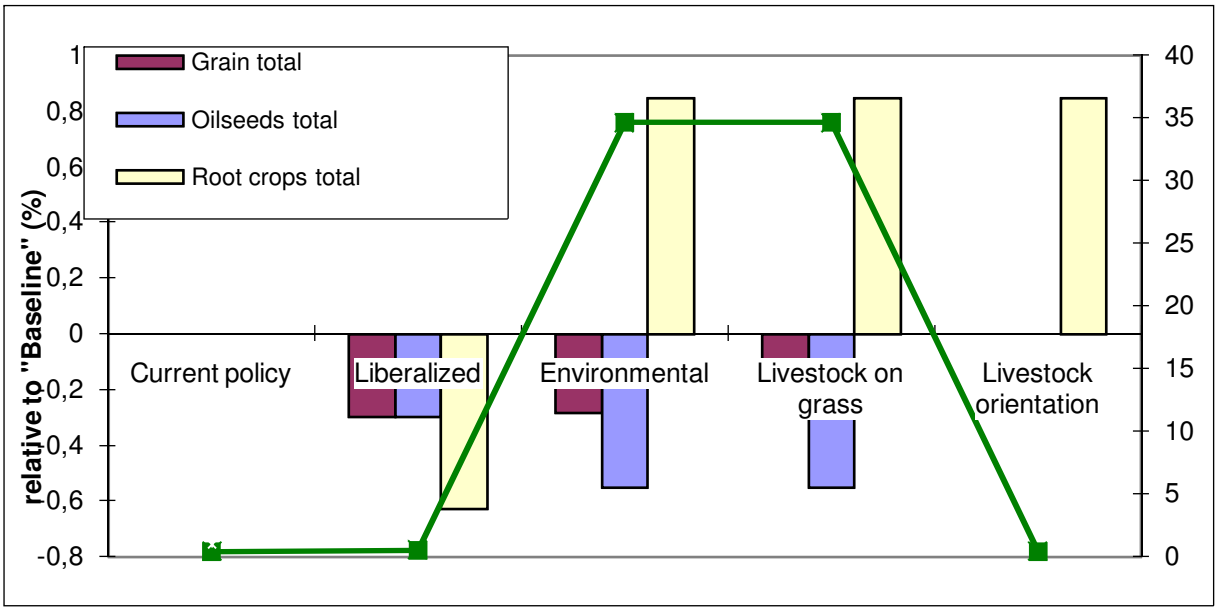
[5] Alternatively it can be altered to value added (external factors are not deducted from revenues) or gross margin objective function.

[6] In the version applied here. By using positive mathematical programming algorithm (e.g. Howit, 2005) it allows cost function to be non-linear and thus reducing the need for further production constraints.

[7] Model enable also to implement price variation. For this simulation this option was off.

Scenario	Description	Risk
"Baseline"	Policy as for 2009: no difference in subsidies between intensive and extensive management, area payment 188 €/ha (SAPS+top-up 2009), no payment for livestock; Agro-envi programmes do not apply; production limits max 200% of initial level.	No
"Current policy"	Policy and production limits applied as in "Baseline", risk implemented.	Yes
"Liberalized"	No subsidies for any crop and management; Agro-envi programmes do not apply as well, production limits as in "Baseline".	Yes
"Environmental"	Intensive management is not supported, crops with extensive management receive 282 €/ha, extensive grassland 564 €/ha, in fact zero crop limits, livestock maximum 200% of initial level.	Yes
"Livestock on grass"	="Environemtnal" scenario, beside that livestock subsidy 392 €/LU (coupled payment).	Yes
"Livestock oriented"	="Livestock on grass", extensive grass management do not receive subsidy.	Yes

Table 1. Description of scenarios applied in the model FARMA 4.



Graph A1. Land use in scenario break down (in % relation to "Baseline").

"Environmental" assumes support provision for extensive management and do not limit maximum of individual crop area. In addition to this "Livestock on grass" provides additional payment for each livestock unit (LU) and its aim is to envisage potential to increase livestock ruminants on grassland. The last scenario "Livestock oriented" relates to the previous one but does not provide support for grassland to see potential livestock restructuralization.

Model results

The following section describes the outcomes of the model for selected scenarios. All scenarios are expressed relative to "Baseline" scenario until otherwise stated. Three areas are of high interest: land use changes, animal structures (animal density), economic results.

Land use

Czech agriculture applies Common Agricultural Policy (CAP) since 2004. Pillar one consists, beside market interventions, of direct payments paid as single area payments (SAPS), national financed direct payments for area and for certain crops and animals (top-ups), payment for sugar-beet growers, and payments for dairy cows. In the model we therefore implemented SAPS and top-ups crop area payments. In respective scenario top-up payment for livestock unit is applicable as well. Pillar two

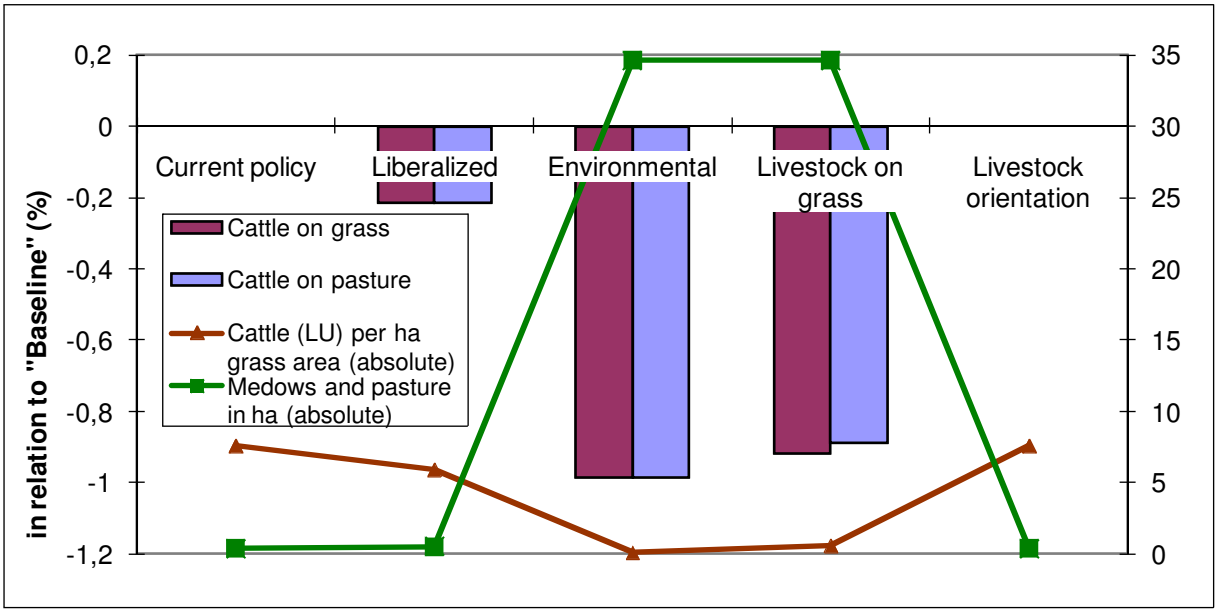
consists of structural assistance payments (not applicable here), agro-environmental payments (payment to compensate either income loss or higher costs due to specific management application, usually on grassland) and payments for less favourite areas. We implemented agri-environmental subsidies via area payments for extensive management and for grassland management.

Total utilised agricultural area was used completely in all scenarios except the "Liberalised" one. Here, some 30% of UAA remained abandoned (a few individual crop area limits were fulfilled). Land abandonment used to be often placed as a threat by professional groups which, as simulation shows, is not be so dramatic under current policies.

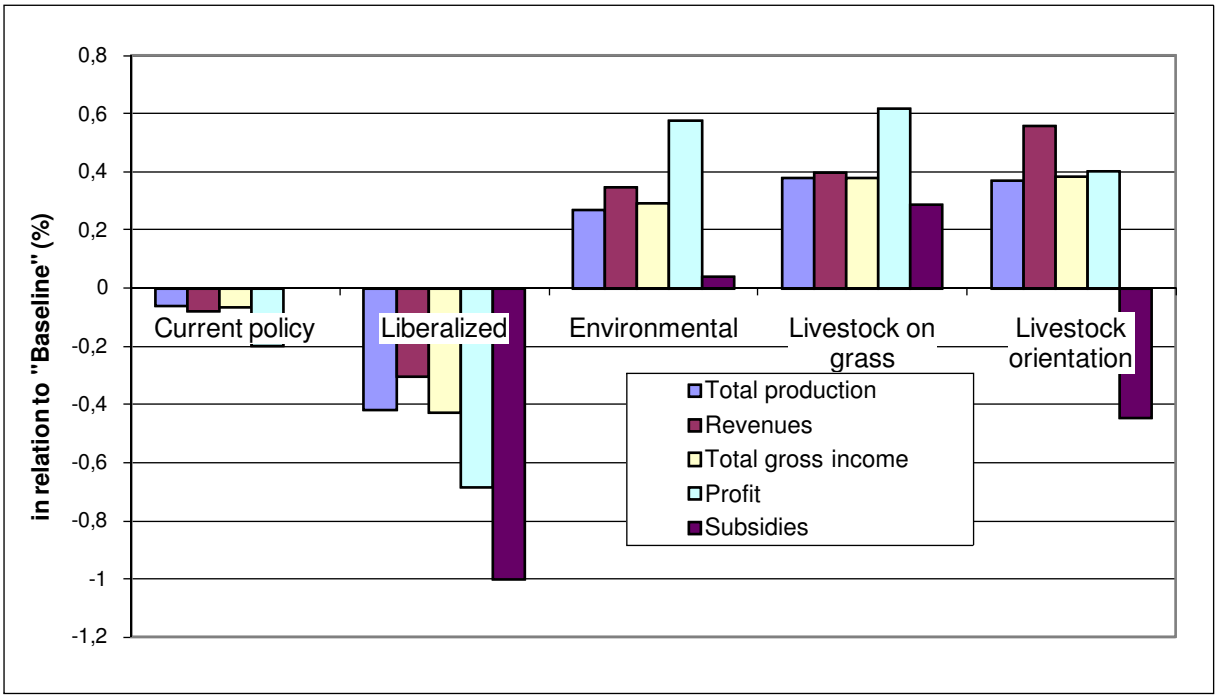
Implementation of risk into model does not change production structure significantly (only small changes are observed inside intensive or extensive commodity groups; variation in livestock was not considered), see graph A1 in the Appendix. Notably, extensively cultivated wheat got more attention if risk was implemented (though yield variation in extensive scenario was higher than in intensive). Yet the opposite is true for barley – its profitability in extensive management was outweighed by winter wheat which has lower variation than barley. "Liberalized" scenario leads to reduction of most cash crops (particularly roots), grassland remains unchanged at the end (intensive grass disappeared in favour of extensive management on pasture). Hence extensive crop production did not expanded on the expense of intensive crops (partially due to larger variation for extensive crops than for intensive management). The next two scenarios ("Enviromental" and "Livestock on grass", recalling that extensive crops and grassland get more supports compared to the previous ones) exhibit decrease in some cash crops, except potatoes, but increase of maize and particularly grassland (solely extensively managed grass due to higher supports; it contributed also to sharp drop in cattle density on grass). However, in the "Environmental" scenario livestock remained unchanged in absolute figures (graph A2 in the Appendix). Scenario ("Livestock orientation") due to zero grassland support (only ruminants are supported) indirectly allowed cash crops (grains and oilseeds) to be allocated on land (and even root crops raised up). In this scenario livestock surprisingly did not get maximum possible level (grassland area was reduced due to diminished subsidy) although largely supported (392 € per LU). It follows that even payment which is 3 times higher than the real current level still does not make a sufficient incentive for increasing beef cattle stock. In this scenario ("Livestock orientation"), cattle density on grass remained on the "Baseline" level due to drop in total grass and relative increase of cattle stock. The largest expansion of livestock was recorded in "Livestock on grass" scenario where both – LU and extensive grassland management – is largely supported. Results regarding livestock clearly suggest that only strong impetus (animal and area support) is capable to increase animal breeding. Under simulated conditions suckler cows - eligible to be supported - are getting the attention when receiving as much as around 390 € per LU plus support for grassland 3 times higher than area payment in 2009. Notably milk production did not increase across any scenario even despite setting the prices on pre-recession level. Non-ruminants (this category were not directly supported in the model) still remained on the minimum level allowed by the model.

Economic results

The interpretation of economic results needs to be done in relation to the assumptions and often to strict rules existing in the model. However, many production specificities (eg. costs of structural adjustment) will still remain outside the model consideration. As expected the most visible drop of production and income indicators took place in "Liberalized" scenario followed by "Current policy". Contrary to other scenarios, profit declined in these two scenarios by more than 60% and 20%, respectively. This is also due to the fact that scenario without subsidies do not exploited even all land available. Moreover if production limits on certain crops would not be restricted the abandoned land could be possibly even larger. Hence, intensive management dominates in subsidy-zero scenario (but still total production would drop by more than 40% in "Liberalized" scenario). Production do not decline as fast as profit. It needs to have in mind that if risky expectation yields would not have finally realized production would not differ as much. Looking at "Current policy" scenario it confirms that area-based payment is partially capable of stimulating extensively cultivated cash crops (even with higher yield variation). This



Graph A2. Cattle density according to scenarios break down (in % relation to "Baseline")



Graph A3. Farm economic results according to scenarios break down (in % relation to "Baseline").

scenario could be also a proxy simulation for extreme weather conditions when yields drop down. It shows that though production would diminished by 6% profit would be down by some 20%. "Environmental" and "Livestock on grass" scenarios lead to profit increase; it is caused by increasing supports for both intensive and extensive land management and setting the crop production limits less strict (resulting in reallocation of land even into more profitable crops). Although production and profit do not differ significantly, the "Livestock on grass" is "more costly" for taxpayers: increase in subsidies (+ 29%), in the "Environmental" scenario (+ 4%), both in comparison with the "Baseline". Such trend is also visible as for "Livestock orientation" where production neither gross income do not decline but total subsidies dropped by more than 40% in

relation to base situation. Nevertheless, difference between these two last scenarios is caused by various revenue sources: "Livestock orientation" generates more revenues from cash crops than in the "Livestock on grass" scenario. Hence from policy perspective this is relatively cheapest option but does not contribute to animal production change (both categories - ruminant and non-ruminant). From environmental perspective there is a clear lost of extensively farmed grass in favour of arable land (cash crops and fodder on arable land) in "Livestock orientation" scenario. Unit subsidies (per ha UAA) are approximately 239 Euro in the scenario with the largest share of grassland ("Livestock on grass") but without any effect on cattle density.

Conclusions

The paper tries to contribute to the discussion about direction of Czech agriculture while the political relevance for these projections is twofold: to anticipate the effects of changes after 2013 (though specific policy is not considered in this period) and to support decision about direction of national policies (including the application of an article 68 of Council Direction 1782/2003) in 2011- 2013. Model implemented market parameters (prices) according to OECD projections (but without incorporating significant drops related to global recession to avoid extreme model solutions). Typical farm represented average agro-ecological production conditions. Based on that, the following observations can be drawn:

- Only highly profitable crop commodities would be produced (eg. rape seed) if direct payments completely vanish. Livestock production is mostly not profitable even under current conditions. Therefore liberalized conditions (abolished direct and compensatory payments) would likely lead to land abandonment, livestock breeding would cease. That would obviously cause several negative effects, for example on the soil fertility deterioration due to organic matter lost.
- If environmental compensatory payments are introduced in less favourite areas their total profitability is ensured even under risk consideration (meaning smooth reduction in yield variation) that guarantees their production.
- Under current conditions in livestock sector, certain beef breeding can be guaranteed either by administrative rules that require minimum livestock density or by introducing coupled animal payment which however has to be higher than currently applied (50 €/LU).
- If yield variation in intensive areas (land management) is considered it may easily reduce revenue to the level currently achieved by extensive management. In such a case that would impose certain income threat on those farms operating in intensive areas as compensatory payments are unlikely to be introduced here.

The concept of risk was defined in this paper in terms of income variability and to some extent "normalised" for a decision-making; it is clear that perception of risk is very specific. However the risk-attitude (here only as a prevention against price and yield deviations) also mirrors the institutional conditions surrounding farmers (access to external financing, market transparency, access to information, etc.). In this sense one may assume the more developed and flexile environment the more likely farmers will be willing to accept higher risk.

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Normative Economics or Improvement of Economic Life at Regional Level in the Czech Republic.

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Abstract

In the context of improvement of economic life, normative economics has to cope, if it is not only a theoretical construct, with various facts which are brought by the economic reality. Becoming aware of the mutual causality of economic phenomena and processes, the consideration of these facts should first define factually a particular area of interest and then identify formally a direction of its improvement. To reduce regional disparities, the key points are both the selection of disparities identification criterions and the specification of values of these criterions.

The paper deals with the area which is nowadays relatively common – regional disparities. The improvement in this sense focuses on the decreasing of differences between particular regions regarding the defined values, respectively levels of partial criterions which serve as a base for identification of regional differences. Data envelopment analysis (DEA) and cluster analysis are used to evaluation of the regions.

Key words

Normative economics, region, regional disparities, Data Envelopment Analysis, Cluster Analysis.

Anotace

Normativní ekonomie se v kontextu zdokonalování ekonomického života společnosti, pokud nemá jít výlučně o teoretický konstrukt, musí vypořádat s nejrůznějšími skutečnostmi, které ekonomická realita přináší. Zohlednění těchto skutečností by mělo, s vědomím vzájemné kauzality ekonomických jevů a procesů, jednak věcně vymezit konkrétní oblast zájmu a posléze formálně identifikovat směr onoho zdokonalení.

Uvedené pojednání se zaměřuje na oblast, která je v současnosti poměrně frekventovaná a to oblast regionálních disparit. Zdokonalení v tomto smyslu se zaměřuje na snížení rozdílů mezi jednotlivými regiony v návaznosti na definované hodnoty, resp. úrovně dílčích kritérií, na základě kterých jsou regionální rozdíly identifikovány. K hodnocení regionů byly použity metody DEA (Analýza obalu dat) a shluková analýza.

Klíčová slova

Normativní ekonomie, region, regionální disparity, analýza obalu dat, shluková analýza.

Introduction

The investigation was oriented on the chosen variables (particular criteria), which were not solitary considering the interest of the theoretic and strictly pragmatically oriented platform. Most contributions and papers pay attention more or less to the mutual relationships between these variables, not to their multilateral relationships. The paper declares an attempt to create a more complex approach in the investigation of particular variables and to seek for connections between them. The main focus is the investigation of connections between unemployment, incapacity to work, and criminality on one hand, and economically active population on the other.

The most important processes of social spatial differentiation leading to the regional disparities emergence can be split into several categories: social-economic and demographic processes, economic processes and the third category consisting of processes which are too specific to be

included into two main categories – other processes.

Regional disparities are closely connected with the quality of life in particular regions. The essential factors, we consider as the most influencing the quality of life, are above all availability of work, education, and public and private services. The differentiation in possibilities of approach to work, education, health care, and other services make regional differences in the quality of life of the Czech Republic. In certain cases, the regional differences can become an obstacle of cohesion and balanced development of society (Blažek 1996, Hampl 2005).

The Czech Republic has been gone through many social and economic changes after 1989. These changes gradually transform the structure and stratification of the Czech society (Večerník 1995). The increasing social differentiation successively projects to changes of spatial organisation of the Czech society. It can be illustrated, for example, by the increase of the imbalance in the regional development during the transformation period (Hampl, 1996, 2005). Social and economic disparities reflect the quality of life and different development rate of individual regions and municipalities. Different natural and socio-economic conditions make some regions advantageous and some make disadvantageous for function localisation as well. Many of these inequalities are confirmed in the Czech settlement system and could not be influenced significantly. It is mainly evident in the municipalities and regions in peripheral or otherwise disadvantageously localised positions (Jančák, 2001). Conversely, some manifestations of social differentiation are new and connected with economic and social processes after 1989 (Mareš, Rabušic 1994, Sirovátka 1997, Večerník 2004). These processes has been resulted in the increasing social spatial differentiation not only among peripheral and metropolitan regions but also social polarisation inside micro-regions or seats with similar economic or social characteristics and the position in the settlement hierarchy (Ouředníček 2003).

The increasing polarisation between important regional centres on one hand and relatively rural spaces on the other hand is characteristic feature of the changing spatial differentiation (Hampl 2005). One of important results of economic transformation is a noticeable shift in the spatial distribution of work opportunities. The number of work opportunities decreased in peripheral areas during last 15 years. New jobs are mainly concentrated in larger regional centres. Similarly, the spatial differentiation of services increases as a result of the market principles application. Retail business and basic services disappear in geographically disadvantaged localities, the level of transport accessibility decreases. All these factors lead to a lessening of the quality of life in smaller municipalities with peripheral location. Younger and more educated people cannot find a fulfilment here and leave to larger seats. An intensive outflow of inhabitants from disadvantaged seats worsens their social, demographic and economic situation and leads to "catching" of remaining, often old or less educated inhabitants. Thus, social capital, participation on public life and social solidarity of these villages and regions decreases.

Similar "catching" of mainly older or poorer population is known from inner parts of the largest cites as well. The processes of commercialisation and gentrification contribute to it (Sýkora 1996, 1999). An influx of young, free and richer people into central parts of towns is in a sharp contrast to ageing inhabitants of controlled tenement houses. The influx of the new people with different life requests and style causes a gradually change of goods and services supply, rental level and character of entire gentrified areas. Thus, the relatively less mobile older population is caught in the trap of city centres and is forced to use much more expensive goods and services or to commute for them to farther localities. This fact supports the decreasing quality of life of some population groups and thus social cohesiveness of localities.

Increasing differences among social-economic status of inhabitants can be seen in surrounding of the large Czech cities as a result of the residential suburbanisation process (Ouředníček 2001, 2003). This process represents the strongest migration flow at present (Čermák 2001). Although the influx of younger and richer people in suburbia can be perceived as a fortifying of the social structure of villages, serious problems occur between denizens and new residents which stem from different economic situation, life style and in some cases also from different views on a further development of

the village. Suburbanisation is sometimes felt as a threat for social cohesiveness of the whole society (Putnam 2000).

One of the main components of the regional potential is social capital. The importance of social capital for local and regional development has been widely acknowledged during last decades. Localities, regions, nations and communities are more likely to achieve higher levels of development and to mitigate negative external influences if they have higher level of embedded social capital. Social capital is one of several factors influencing regional development. However, its role is growing due to increasing importance of mutual interactions in society and the impact of international division of labour on lives of people and communities (Castells, 1996). Territoriality of social networks and to horizontal and vertical relations between social networks at various scales, reflecting the distinction between bonding, bridging and linking types of social capital was discussed for example by Matoušek and Sýkora (2008).

Human resources can be assessed among others for example using age, social and educational structure of the regional population. A significant problem, which is faced by regions of develop countries, is the demographic aging, which started to be very intensively discussed in 1960s.The demographic aging means that the absolute as well as the relative number of the given population. In other words, there is a change of the pre-reproductive and post-reproductive section of the population. This aging is heavily influenced mainly by the improving mortality conditions causing a decreasing mortality rate in higher age, as people live longer. This phenomenon is accompanied in modern societies by other phenomena which is the decrease of fertility. The result is that the natural renewal of the population is not reached. This behaviour is rooted in history (Dimitrová 2010).

The process of demographic ageing becomes also of a big importance in the Czech Republic as a result of radical social changes after 1989. One of the components of transforming changes is also an acceptance of the west-European model of demographic behaviour – the decreasing fertility, increasing mortality conditions. The demographic ageing has many serious economic and social consequences which can provoke problems of various intensity in regions (for example in relation to the income level, unemployment rate etc.).

The age of a population can be expressed by various demographic indices: index of ageing (the ratio of inhabitants above 65 years to the inhabitants under 15), average age, median age, life expectancy. Economic relations to demographic ageing are usually assessed by for example index of economic burden (it compares number of persons in economically inactive age to the number of persons in economically active one).

In the Czech Republic as well as in the most post-socialist countries, the second demographic transition has been in progress at the beginning of nineties. The centre of demographic transition is not only in the preservation of a low level of mortality and its shift to higher age but also in the decreasing level of natality.

The distinct population ageing is obvious in the European Union in the last decades. It is caused by the permanently increasing life of expectancy on one hand and by very low crude rate of natality on the other hand. It is supposed that this trend will continue (MPSV 2006). A population with the ratio of old people above 65 years of 8% or more is marked as an ageing population. This limit exceeded in most European countries at the end of last century. The process of ageing proceeds quicker in more developed countries (Jarošová 2006).

Various methods are used for the analysis of regional disparities, among them also DEA (Data Envelopment Analysis) models. DEA models come out from the Farrel model for the unit´s effectiveness assessment with one input and one output (Farrel, 1957) which was extended by Charnes, Cooper a Rhodes (CCR) (1978) and Banker, Charnes a Cooper (BCC) (1984). We suppose a constant return to scale. BCC models suppose variable returns to scale. Many authors still try to improve basic models to better meet real conditions. We used an extended CCR model which caters a possibility to influence inputs. This model calls Non-discretionary and was designed by Banker and Morey in 1986.

DEA models were applied in many areas. For example Herman applied DEA models in the health service in 1984, Bessent at al. for the schools

assessment in 1982, Gaspar at al. in agriculture, 2009, etc.

Martic and Savic (2001) assessed performance of regions in Serbia where discriminant analysis was also used. They used Andersen-Petersens model for the comparison of effective units. Xiong, Liu and Tang (2008) showed the problematic of criteria selection for DEA assessment in the area of regional development and the results comparison with statistical comparative analysis. Li and Cheng (2010) analysed a social-economic development in the Sichuan province. Relationships among DEA and some of traditional economic theories for an assessment of sustainable regional development are also discussed by Ma and Liu (2008).

The following text focuses on an investigation and seeking of relations among the rate of unemployment, incapacity for work and criminality on one hand and economically active population on the other hand which enables to analyze characteristics influencing qualitatively and quantitatively not only economic growth but also economic development.

Approaches to incapacity of work, as a phenomenon with both individual and social dimension, can be monitored from several points of view. Muskin and Collings (1959) has concerned with a mutual link between the price of health and illnesses costs in the middle of last century.

The investigation at national level (Doherty, 1979, Bonato, 2004, Khan, 2004, Cai, 2005) focuses on the relationship between public expenditures in the context of the system of health insurance and invalidity. Also from the viewpoint of corporate interests and goals (profit maximization), the incapacity of work is evaluated by the optic of workers deciding to labour-leisure and by the optic of producers influenced by insurance provisions and labour market institutions, all in the context of costs, respectively opportunity costs of an absence in work caused by a disease (Bonato, 2004) which represents a partial link with the problematic of criminality and its consequences in health, not only by the population in productive age. There has demonstrated an interest in an investigation of social harms connected with crimes in succession to their punishment and a reduction of their results in history (Becker, 1968, Hagan, 1993).

Concerning a mutual relationship between criminality and unemployment, contributions concentrate on an analysis of relations among unemployment and various kinds of crimes, respectively suicides (Chiricos, 1987, Yang, 1994, Raphael, 2001).

Material and Methods

The cornerstone of the choice of the chosen variables was primarily their verbal, partially intuitive formulated causality, but without relevant economically and mathematically tors formulated, exactly expressed range and extent, or with its expression based only on a partial relationship between two variables.

Districts of the Czech Republic (76 NUTS-4, resp. LAU-1, where the capital of Prague, due to its specificity, was not assessed.) were taken as the basic units chosen for the assessment As indicators were taken: unemployment rate (number of unemployed in %), criminality (number of crimes per 10 thousand inhabitants), average length of incapacity to work (number of calendar days of incapacity to work per one registered event), index of aging (ratio of inhabitants aged more than 65 to the number of people under 15), and proportion of economically active inhabitants (proportion of inhabitants aged from 15 to 64 to the whole population). The last indicator (the proportion of economically active inhabitants) was considered as an output, as from the sustainable regional development's point of view, higher values of this indicator are desirable. The other indicators are considered to be inputs – their lower values are desirable. The analysed data are from the year 2008.

The aim of Data envelopment analysis (DEA) method is to divide evaluated subjects (Decision Making Units - DMUs) according to expended inputs and produced outputs into two groups – efficient and inefficient. DEA compares units with the best units on the base of linear programming theory. In this paper DMUs are districts in the Czech Republic.

Basic DEA models (CCR and BCC) are either input or output oriented. Output oriented model aims to maximize outputs without requiring more of any of input values. Input oriented model try to minimize

inputs while least the given output levels. In case inefficient unit optimal level input or output can be determined.

The CCR model has assumed that all inputs and outputs can be varied. In this paper one of chosen input is non-discretionary therefore the basic CCR model is not suitable for this application. For this reason we will use non-discretionary variable models proposed by Banker and Morey (1986). This variable need to be considered for efficiency evaluation but changes of this variable is not suggested.

Suppose p DMUs and m inputs (x_i , i=1, 2, …, m), n outputs (y_j , j=1, 2, …, n) for each of these p units. We have to solve p optimizations (one for each of p units) to obtain weight (v) for each of m input and weight (u) for each of n outputs for k-th DMU (k=1,2,...,p).

Mathematical model for unit H (one of p units) is following linear programming problem (primal):

Maximize

$$\sum_{j=1}^{n} y_{jH} u_{jH} - \sum_{i \in ND} v_{iH} x_{iH} \qquad \textbf{(1)}$$

subject to

$$\begin{aligned}
&\sum_{j=1}^{n} y_{jk} u_{jH} \le \sum_{i \in ND} x_{ik} v_{iH} + \sum_{i \in D} x_{ik} v_{iH}, k = 1,2,..., p,\\
&\sum_{i \in D} x_{iH} v_{iH} = 1,\\
&u_{jH} \ge \varepsilon,\\
&v_{iH} \ge \varepsilon (i \in D),\\
&v_{iH} \ge 0 (i \in ND).
\end{aligned} \qquad \textbf{(2)}$$

where $(i \in D)$ marks inputs, which are discretionary and $(i \in ND)$ denotes inputs non-discretionary.

Weights in this model are determined so that objective function (1) is maximal (it is dependent on model orientation). If objective function is equal to one, the unit is efficient. A non-efficient unit's coefficient is less or more than one (output or input oriented model).

The dual problem of LP (primal) model is expressed as follows:

Minimize

$$\theta_H - \varepsilon(\sum_{i \in D} s_i^- + \sum_{j=1}^{n} s_j^+) \qquad \textbf{(3)}$$

subject to

$$\begin{aligned}
&x_{iH} \theta_H = \sum_{k=1}^{p} x_{ik} \lambda_{kH} + s_i^- 0, i \in D,\\
&x_{iH} = \sum_{k=1}^{p} x_{ik} \lambda_{kH} + s_i^- 0, i \in ND,\\
&y_{jH} = \sum_{k=1}^{p} y_{jk} \lambda_{kH} - s_j^+, j = 1,2,...,n,\\
&\lambda_{kH} \ge 0, k = 1,2,..., p,\\
&s_i^- \ge 0, i \in D,\\
&s_i^- \ge 0, i \in ND,\\
&s_j^+ \ge 0, j = 1,2,..., n.
\end{aligned} \qquad \textbf{(4)}$$

where λ_{kH} expresses a coefficient of a combination of peer units for unit H, $s_i^- \in R^m$ input excesses and $s_j^+ \in R^n$ output shortfalls.

The value of the objective function of dual model is equal to the value objective function of the primal model (1), (2). We can interpret this value as a necessary reduction of inputs in order to become efficient. DEA models give for non-efficient units a set of recommendations in order to improve their efficiency, with increasing outputs or decreasing outputs.

The λ_{kH} coefficients determine a linear combination of inputs and peer units creating a virtual efficient unit for unit H (see (5)).

$$\begin{aligned}
&x'_{iH} = \sum_{k=1}^{p} x_{ik} \lambda_{kH}, i = 1,2,..., m,\\
&y'_{jH} = \sum_{k=1}^{p} y_{jk} \lambda_{kH}, j = 1,2,..., n.
\end{aligned} \qquad \textbf{(5)}$$

where x´iH is the optimal size of the i-th input for H-th unit and y´jH is the optimal size of the j-th output for the H-th unit.

Based on coefficients λ and sizes of the recommended changes for ineffective units, it is possible to calculate percentage proportion of the corresponding peer unit for each ineffective unit.

The chosen inputs and outputs should not be correlated too much. Table 1 shows partial correlations between each couple of indicators.

The ratio of economically active population (as a demanded input) is statistically important correlated with all the input variables at the significance level $\alpha = 0.05$, except of incapacity to work. It is thus theoretically possible to recommend such a configuration of inputs and their weights which should lead to a maximization of input variable and reaching maximal effectiveness of particular administrative units (district) with a mutual combination.

In the next step of the analysis, a typology of ineffective districts was created according to the original values of the input variables (index of aging, rate of incapacity to work, criminality and unemployment rate). This typology should help to compare particular clusters with the results of the DEA analysis and help to make recommendations of the future development of particular groups. Cluster analysis (Aldenderfer and Blashfield 2006, Everitt and Dunn, 2001, Romesburg, 2004) was used to obtain rough typology of Czech districts in 2008. Various algorithms and metrics were tested and their results compared to find the best solution. Hierarchical clustering served as the first step of the classification. The aim of this step was to find a proper count of clusters. Ward´s method gave the best results. This method is distinct from all other methods or linkage rules because it uses an analysis of variance approach to evaluate the distances between clusters.

In short, this method attempts to minimize the Sum of Squares (SS) of any two (hypothetical) clusters that can be formed at each step (Ward 1963). Notation that we can use is as follows: Let Xijk denote the value for variable k in observation j belonging to cluster i.

Furthermore, for this particular method we have to define this as follows:

Error Sum of Squares:

$$ESS = \sum_i \sum_j \sum_k \left| X_{ijk} - \bar{x}_{i \bullet k} \right|^2, \qquad \textbf{(6)}$$

Here we are summing over all variables, and all of the units within each cluster. Here, we are comparing the individual observations for each variable against the cluster means for that variable. Note that when the Error Sum of Squares is small, then this suggests that our data are close to their cluster means, implying that we have a cluster of like units.

Total Sum of Squares:

$$TSS = \sum_i \sum_j \sum_k \left| X_{ijk} - \bar{x}_{\bullet \bullet k} \right|^2, \qquad \textbf{(7)}$$

The total sum of squares is defined in the same as always. Here we are comparing the individual observations for each variable against the grand mean for that variable.

	Index of ageing	Incapacity to work	Criminality	Unemployment rate	Economically active
Index of ageing	.	-0.052265	-0.270278*	-0.316957*	-0.609859*
Incapacity to work		1	-0.237311*	0.089349	0.083163
Criminality			1	0.117066	0.372976*
Unemployment rate				1	0.513089*
Economically active					1

Correlations marked * are significant at the level of α = 0,05..

Table 1: Correlation matrix of analysed variables.

R-Square:

$$r^2 = \frac{TSS - ESS}{TSS}, \qquad \textbf{(8)}$$

This r2 value is interpreted as the proportion of variation explained by a particular clustering of the observations. In general, this method is regarded as very efficient, however, it tends to create clusters of small size (Morey et al., 1983).

The clusters were identified by the k-means method. Computationally, this method seems as analysis of variance (ANOVA) "in reverse." The program will start with k random clusters, and then move objects between those clusters with the goal to 1) minimize variability within clusters and 2) maximize variability between clusters). This is analogous to "ANOVA in reverse" in the sense that the significance test in ANOVA evaluates the between group variability against the within-group variability when computing the significance test for the hypothesis that the means in the groups are different from each other. In k-means clustering, the program tries to move objects (e.g., cases) in and out of groups (clusters) to get the most significant ANOVA results. In the Cluster Analysis module of STATISTICA, the k-means algorithm uses the unscaled squared Euclidean distances for the distance measure; the distance D(i,k) of an observation i from cluster k, for M continuous variables Xj is computed as:

$$D(i,k) = \sqrt{\frac{1}{M}\sum_{j=1}^{M}\left(X_{ij} - \overline{X}_j^{(k)}\right)^2}, \qquad \textbf{(9)}$$

where $\overline{X}_j^{(k)}$ is the mean for variable j and cluster k. The computations were realized with the programs Statistica 9 and the results visualized in ArcGIS 9.3.1.

Results and discussion

According to the chosen indicators, 13 districts seem to be effective: Benešov, Český Krumlov, Hodonín, Hradec Králové, Jeseník, Mělník, Plzeň – jih, Plzeň – sever, Praha – západ, Prachatice, Rychnov nad Kněžnou, Vyškov a Žďár nad Sázavou. Other districts have the score smaller than 100% which is shown in Figure 1.

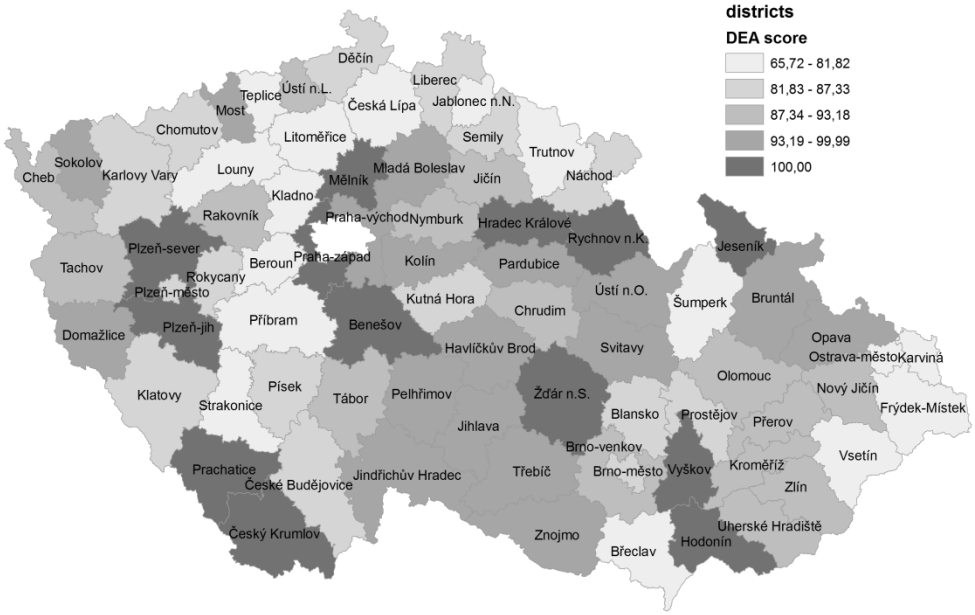

Figure 1: DEA score of Czech districts.

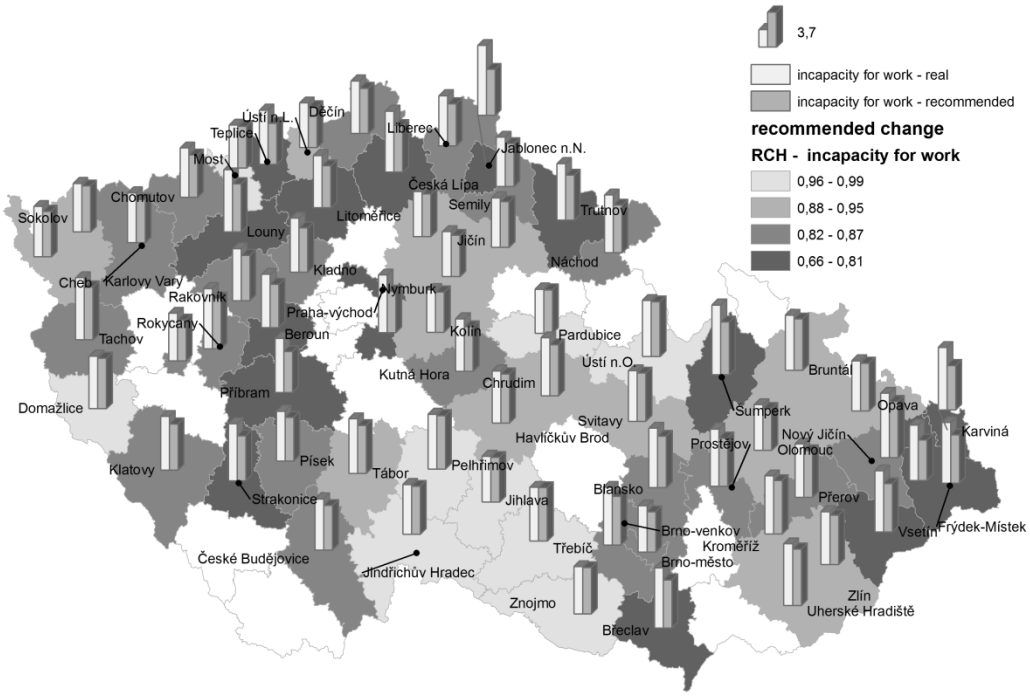

Figure2: Recommended changes for inefficient districts (incapacity for work).

As the reached effectiveness is less than 100%, the DEA models recommend to change the size, i. e. to reduce inputs (rate of unemployment, criminality, length of incapacity to work) to approximate peer districts. Recommended changes come out from the inputs´ level at the effective units (which are either real or are created by as a combination of real units, not from a theoretically constructed ideal) and hence these changes could be feasible. Figures 2-4 display the recommended changes of individual variables.

The effective districts do not differ from the ineffective ones significantly from the viewpoint of the length of incapacity to work. According to the model, the highest decreasing is recommended at the districts with the highest rate of unemployment accompanied by high criminality and social problems: north Bohemia, Ostrava and Příbram. Only small decreasing is recommended to some districts in Vysočina region, south Bohemia and south Moravia.

The criminality should be (according to the model) decreased to almost one half in most problematic regions which have undergone through industry restructuring or a mining slump after 1989 (north Bohemia, Ostrava, Příbram).

It is worth noticing that most of ineffective districts, respectively "problematic" regions show convenient values of index of ageing which evokes an idea about a necessity of purposeful measures to young population to eliminate its danger by unemployment, criminality, respectively unfavourable health.

Using the k-means method of cluster analysis, we have found that the differentiation of ineffective districts in their economic and social development is statistically significantly determined (at the level of statistical significance of $p<0.05$) by almost all of the input variables, instead of incapacity for work. The allocation of the districts into 3 clusters denotes Figure 5. Particular variables were transformed (divided by compensatory factor) to remove too large influence of measure unit of some variables on the analysis result (Hebák a kol., 2005).

The comparison of the groups of effective and ineffective districts can be seen in Table 2.

Regardless the effective districts cannot be assessed as the districts with more convenient age structure, with higher proportion of young people which is perspective for further development, the lower level of criminality and unemployment is also typical for them. Thus, it would be possible to characterize

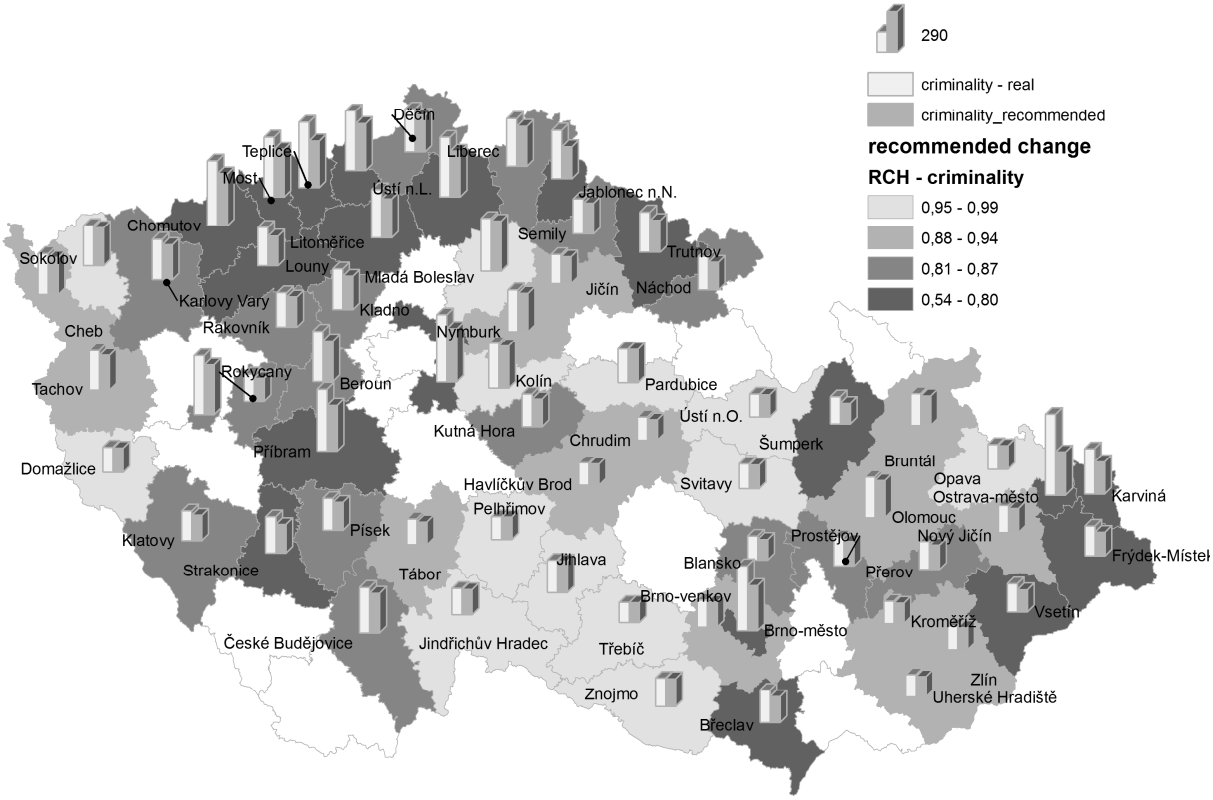

Figure3: Recommended changes for inefficient districts (criminality).

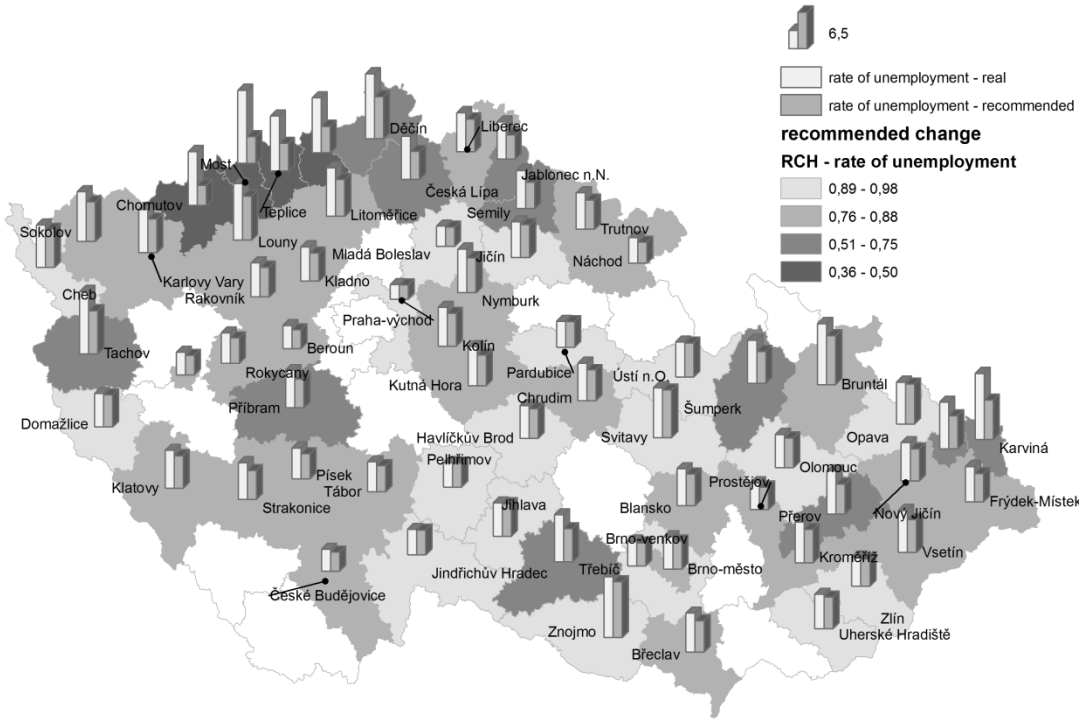

Figure4: Recommended changes for inefficient districts (unemployment).

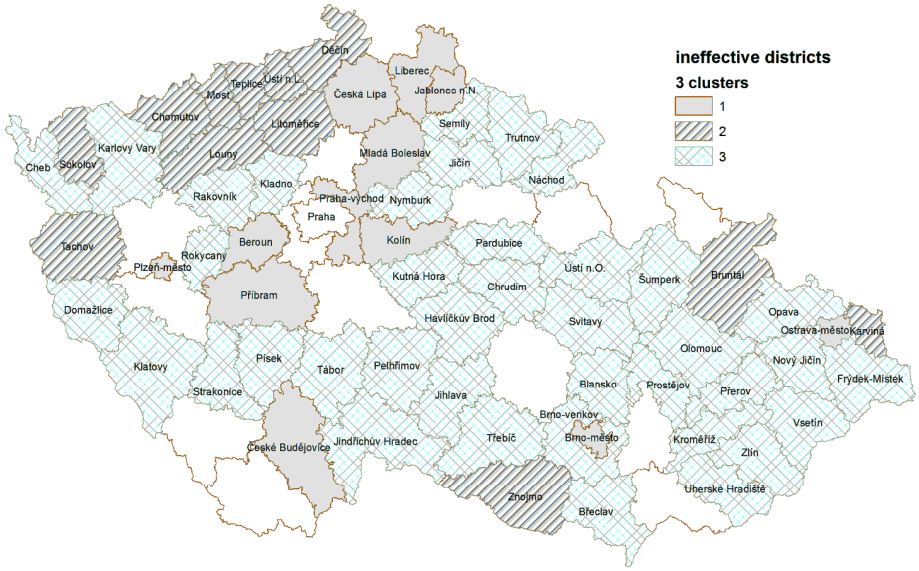

Figure 5: typology of ineffective districts.

Variable	Ineffecitve districts – cluster no.			effective districts
	1	2	3	
Index of ageing	102.5	88.6	106.3	97.7
Incapacity for work	5.54	5.54	5.71	5.4
Crime rate	412.2	340.4	215.8	210.6
Rate of unemployment	5.57	10.4	6.3	5.8

Table 2: comparison of the effective and ineffective groups of districts (means).

these districts as the districts with relatively good work opportunities. This group of districts shows lower values of incapacity for work, it doesn´t differ statistically from the group of ineffective districts ($p = 0.395$).

Ineffective districts can be on the base of realized cluster analysis divided into three groups:

Cluster 1 consists of, according to the value of reached score, problematic districts with less suitable age structure, high criminality but paradoxically the lowest rate of unemployment in comparison to other clusters. This group includes districts with important regional centres where a reduction of industrial production in nineties was more – less successfully compensated by new jobs. Mainly industrial districts with traditional production, undergoing the restructuring after 1989, belong to this cluster. The average score of the cluster is 83.6 with the standard deviation of 9.1.

Cluster 2 can be marked as a group of "most problematic" Czech districts with the high criminality, connected with the high rate of unemployment. Typical industrial districts undergoing the industry restructuring or mining slump after the velvet revolution (north Bohemia) belong to this group. A relatively favourable age structure can be perceived as a positive factor for further development.

Cluster 3 represents a numerously largest group. It includes districts with lower rate of unemployment, low criminality but undergoing process of demographic ageing in comparison to other clusters which leads to less convenient age structure with higher counts of older people. This fact could be connected with the highest value of incapacity of work. Mainly regions of Moravia, Vysočina and cross-border region of South and West Bohemia with traditional population belong to this group.

Variable	Příbram district	
	Original value	Recommended value
Efficiency score	75.42	100
Index of ageing	104	104
Incapacity to work	5.7	4.3
Crime rate	447	331
Unemployment rate	6.7	5

Table 3: Recommendations for cluster 1 representatives – Příbram district.

Variable	Děčín district	
	Original value	Recommended value
Efficiency score	85.7	100
Index of ageing	86.4	86.4
Incapacity to work	5.5	4.72
Crime rate	309	265
Unemployment rate	11.4	7.4

Table 4: Recommendations for cluster 2 representatives – Děčín district.

Variable	Tábor district	
	Original value	Recommended value
Efficiency score	87.8	100
Index of ageing	114.7	114.7
Incapacity to work	5.8	5.1
Crime rate	188	165
Unemployment rate	5.3	4.7

Table 5: Recommendations for cluster 3 representatives – Tábor district.

One representative (district) was selected from each cluster and the inputs' changes recommended by DEA model by the given output to reach 100% effectiveness are shown in tables 3-5.

Conclusion

Some findings offer a relatively new view at a possible regional (districts) structuring. One of the advantages of the DEA models is that, except an assessment of effectiveness, they give recommendations to ineffective units which lead to improvement of the effectiveness of these units. The recommendations are based on comparisons with other real units. Only some of the units are very close to the effectiveness limit and the other can approach the limits using suitable adjustment changes of inputs, respectively outputs. Naturally, it is not always possible to follow all the recommendations but it is minimally possible to consider on what the particular unit should concern.

Any proposed solution of a given state is not applicable without considering other facts which were not included in the examination. In spite of it, this analysis can be assumed to be inspiring for a direction of the regional, respectively economic policy. It indicates on the base of mathematic-statistical instruments, that it is possible to reduce existing differences among Czech districts. According to conditions of particular districts, it is

not probably realistic to try to reach the same, "ideal" values of examined variable: the rate of unemployment, frequency of cries, average length of incapacity for work and also index of ageing. However, the comparison to existing and in examined connections "potentially achievable" values of the above mentioned indicators offer to authors of economic policy information for formulation of steps enabling a realisation of adequate growth goals and regional development in the Czech Republic.

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Sectoral Production Function of Chicken Broiler Fattening

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Abstract

The function was formed on the basis of sectional data from seven Czech businesses using data from seven to eight annual observations. The Least Square Dummy Variable Model was used to estimate the power function. The information presented in the article is the product of working on the Institutional Research Plan MSM 6046070906, "The Economics of Czech agriculture resources and their efficient use within a multifunctional agri-food systems framework".

Key words

Production Function, Broiler Chicken, Model.

Anotace

Funkce byla vytvořena na základě panelových dat z celkem sedmi českých podniků při sedmi až osmi ročních pozorováních. Tvar analytické funkce je mocninný a byla použita metoda nejmenších čtverců fixních efektů. Poznatky prezentované v článku jsou výsledkem řešení výzkumného záměru MŠM 6046070906 „Ekonomika zdrojů českého zemědělství a jejich efektivní využívání v rámci multifunkčních zemědělskopotravinářských systémů“.

Klíčová slova

Produkční funkce, kuřecí brojler, model.

Introduction

The rearing of broiler chickens counts itself among the most important agri-food sectors in the Czech Republic and of all three main types of meat (pork, beef, poultry) it is this sector which is the only one to have displayed a trend of increasing consumption and related indicators over the last 20 years. In 1990, poultry had a mere 14 % share of total meat consumption in the CR and by 2007 it had already reached a full 30 % share. The highest poultry consumption per person was reached in 2005 (26.1 kg), with stagnation or slight decline recorded since this period [2]. This fact can mainly be ascribed to avian flu and the related global hysteria over the problem. In the same year, the lowest historical beef consumption was reached (9.9 kg). This is because there was a substitution effect between beef and poultry in consumption patterns – in 1990 beef had a 29 % share of total meat consumption, which had reached a mere 13 % by 2007. Nevertheless, the above described situation does not fully correspond to the level of national production, or specifically to levels of Czech poultry. In 1993 (earlier data is not available) there were 28.2 millions poultry in the CR while in 20078 there were 27.3 millions heads of poultry. These details make it clear that increased consumption has been covered by imports and thus that Czech produces are losing their position in relative terms.

Aim

The aim of this article is to estimate the industry's production function in the broiler chicken rearing sector and to apply it to the average business; this will focus particularly on:

- the production efficiency of separate production factors (feed mixes),
- deriving the average and marginal product functions,
- simulation calculations.

[8] *Until 2002 the state was monitored to 1.3., from 2003 to 1.4.*

Methods

The data base used for estimating the parameters was obtained from our own research from selected Czech businesses in the poultry rearing sector. The underlying data is in the form of panel data and was subject to critical analysis; extreme observations were eliminated in order to reduce distortions to the results to a minimum. The selected set of panel data examined contains a total of 112 observations which were obtained from seven businesses in the years 2006 and 2007. The average period between two removals from feedlot was 45 days including sanitation. Most of the businesses house their fowls in large sheds using various kinds of litter.

In terms of size (number of animals kept) the businesses cannot be considered a homogenous group, as the number of heads kept varies from 20 613 heads to 131 706 heads in one cycle. The average number of animals kept for all businesses and cycles comes to 59 520. The average starting weight of one animal is 0.04 kg for almost all cycles, with the exception of a number of cycles in two businesses in 2007, where the weight was given as 0.05 kg/animal. The underlying data also suggests that average slaughter weight is somewhere between 1.8 – 2.05 kg/head, with an average for the whole selected set of 1.9 kg/head.

In terms of number of animals kept, individual cycles (businesses) in the selected set can be divided into three groups - small (19 740 – 61 911 heads), medium (61 912 – 104 083 heads) and large (104 084 - 146 255 heads).

The duration of feeding in each business did not fall below 33 days and is not higher than 42 days, while the same duration of feeding did not lead to the same slaughter weight for all businesses, which also varies according to individual cycle. Equally, the duration of sanitation for each cycle displays a marked variability with values within the range of 7 – 30 days. However, it should be noted that a sanitation duration of greater than 20 days is really an exception (occurred for seven cycles), displaying an average of around 15 sanitation days.

The consumption of feed mixtures is divided among three kinds of feed mixture during the whole feeding period, these being BR1, BR2 and BR3. The use of each mixture as a percentage of total feed within the cycle also differs to some extent between separate businesses and cycles.

The feed mixture with the lowest represented percentage, BR1, is at around a level of 7.8 %, maximum 12.6 %. BR2 is represented in the feed at between 50.5 – 64.3 % and for BR3 its consumption interval as a percentage share of total feed mixture consumption is 29.1 – 37.2 %. The general production model was further broken down into the following form9:

$$YP_{nt} = \gamma_0 \times BR_{1nt}^{\gamma_1} \times BR_{2nt}^{\gamma_2} \times BR_{3nt}^{\gamma_3} \times e^{I_{nt}} \times e^{u_t}$$

where: BR1 – feed mixture BR1 consumption (kg/cycle),

BR2 – feed mixture BR2 consumption (kg/cycle),

BR3 – feed mixture BR3 consumption (kg/cycle),

YP – weight gain in kg/animal/cycle,

γ0, γ 1,…, γm – "m-th" structural parameter,

Int – dummy variable for "n-th" business,

e – Euler number

unt – stochastic variable for n-th business at time t.

The above detailed model is based on these basic suppositions:

- businesses focused on feeding broilers use their technological know-how and are thus stable producers of chicken meat, meaning that they had produced chicken meat for a sufficient length of time before the period the underlying data was obtained, making them established in their sector;
- the feed used is always made up of three kinds of feed mixture, these being BR1, BR2, BR3 and these mixtures are identical for all cycles in terms of nutritional content and conversion
- feeding lengths for separate mixtures BR1, BR2 and BR3 vary because the ingredients of these feeds substantially differ;

[9] *The reasons – see e.g. Tung and Rasmussen, 2005*

- feed mixture BR2 makes up the highest share of consumption within one cycle;
- consumption of feed mixture BR3 lasts for at least 5 days before animals are sent for slaughter, as this requirement arises from zoo-veterinary regulations (anticoccidial);
- all seven businesses monitored apply the same or similar rearing technology, this being floor or deep litter husbandry.

After undertaking a partial analysis and on accepting the above detailed suppositions the following hypotheses were stipulated:

H1: Consumption of BR1 feed mixture positively affects the weight gain of broilers fed on it.

H2: Consumption of BR2 feed mixture positively affects the weight gain of broilers fed on it.

H3: Consumption of BR3 feed mixture positively affects the weight gain of broilers fed on it.

H4: All elasticity values (production efficiencies for each feed mixture) are within the range (0;1), which characterises the rational stage.

Results and discussion

The specified model was first estimated using an ordinary least squares method (OLSM); however this estimation did not have the required agreement between theoretical and empirical values of endogenous variables and therefore it was decided to do the estimation using a fixed effects least squares model (LSDVM). The resulting estimates now had the required properties and are presented in the results[10]. Because the estimated function was a power function, it was necessary to linearise it (see method, eg Hušek, 2003).

Model analytical form:

$$\ln(YP) = -0.117*\ln(BR1) + 0.192*\ln(BR2) + 0.073*\ln(BR3) - 1.426 + 0.268*\ln(I1) +$$

(SE)[11] (0.058) (0.027) (0.014) (0.386) (0.054)

$$0.073*\ln(I2) + 0.323*\ln(I3) + 0.159*\ln(I4) + 0.272*\ln(I5) + 0.546*\ln(I6)$$

(0.023) (0.05) (0.021) (0.083) (0.106)

The interpretation of the results of the estimated production function will be focused on a number of points. Firstly, the estimate as a whole and its full range of elemental descriptive characters will be assessed. Subsequently, an analysis and interpretation of the estimated parameters will be undertaken from a statistical and practical viewpoint. Finally, a test of the estimate will be carried out.

The R^2 value = 0.54 % (explanatory capability of the model) can be considered rather poor. However, account should be taken of the fact that apart from the dummy variables, the model includes only three variables, representing the consumption of the three types of feed mixtures, and the resultant production is doubtlessly influenced by other variables unavailable to us. The estimate was also calculated using an unbalanced set of panel data. Of the seven businesses used, the smallest number of observations was 12 for two businesses, with the largest being 15 observations for one business. The average business provided 13 observations. The estimate was created on the basis of a total of 94 observations. In this way, using the above detailed LSDVM a total of 10 parameters were estimated, three of which characterise the relationship between the consumption of specific feed mixtures and the remaining 7 quantifying the relationship between the dummy variables and the endogenous variable (production). The dummy variables are symbolised 'I1...I7'. The effect of time, specifically any seasonality, was insignificant; livestock farming and especially livestock farming in enclosed spaces is not subject to these influences.

Although at first glance a power function estimate may appear more complicated than the estimate of a linear function, because all empirical values must be transformed into their logarithmic forms, the resultant parameters can be interpreted as elasticity. The validity of the above detailed hypotheses was tested with the following results. The first hypothesis was rejected due to negative signs, the second and third hypotheses could not be rejected on the basis of the production surface created. The final hypothesis was then rejected for a similar reason to the first. The second variable, consumption of the BR2 feed mixture, has the

[10] The OxMetrics5 software was used for our estimate (PCGive12)

[11] SE means standard error for the structural parameter estimate

greatest effect on production. The efficiency of variable production factors can thus be interpreted in the following way:

i. Increasing consumption of feed mixture BR1 (in kg/cycle) by 1 % results in a reduction in weight gain (in kg/head/cycle) of 0.117 %. This at first sight illogical relation has its origin in higher death rates of chickens during the first phase of feeding. BR1 feed mixture makes up only 7.8 % to 12.6 % of total consumption in the selected set monitored. The p-value of this parameter is 0.045, meaning the parameter is significant at significance level of 0.05.

ii. Increasing the amount of feed mixture BR2 (in kg/cycle) by 1 % results in an increase in weight gain (in kg/head/cycle) of 0.192 %, which can be considered as the conversion of feed mixture BR2. If the price of feed mixture BR2 is calculated at 6 CZK/kg, then the cost for a weight gain of one gram of chicken is 3.1 hellers and the production effect is 2.3 hellers for a realisation price for farmers of 22.82 CZK/kg, which is the average value valid for 2008. This would then imply that the marginal product point is slightly below the point of marginal costs (price of BR2 production factor) and the chickens are unnecessarily overfed without it bringing the sought economic effect. The p-value was generated as 0.000, meaning the parameter is statistically significant even for the strictest criteria.

iii. Increasing the consumption of feed mixture BR3 (in kg/cycle) by 1 % results in an increase in weight gain (in kg/animal/cycle) of 0.073 %. Because feed mixture BR3 is only slightly cheaper than BR2, the distance between the price of BR3 and the point of marginal income will be even worse. The p-value was generated as 0.000, meaning the parameter is statistically significant even for the strictest criteria.

The partial production functions for each business are displayed in Table 1.

The next part will be focused on the average business, or more specifically the business whose constant lies on the median. This is the second business with company specification parameter 0.314, as the estimated parameter could be called. For this business, the behaviour of the BR2 average production factor is:

$APP2BR2 = 0.105 \times BR2^{-0.808} \times BR3^{0.073}$,

BR2 marginal production factor:

$MPP2BR2 = 0.020 \times BR2^{-0.808} \times BR3^{0.073}$,

BR3 average production factor:

$APP2BR3 = 0.105 \times BR2^{0.192} \times BR3^{-0.927}$,

Identification	Function
Business P1 function	$YP_{P1} = 0.240 \times BR1^{-0.117} \times BR2^{0.192} \times BR3^{0.073}$
Business P2 function	$YP_{P2} = 0.314 \times BR1^{-0.117} \times BR2^{0.192} \times BR3^{0.073}$
Business P3 function	$YP_{P3} = 0.258 \times BR1^{-0.117} \times BR2^{0.192} \times BR3^{0.073}$
Business P4 function	$YP_{P4} = 0.331 \times BR1^{-0.117} \times BR2^{0.192} \times BR3^{0.073}$
Business P5 function	$YP_{P5} = 0.281 \times BR1^{-0.117} \times BR2^{0.192} \times BR3^{0.073}$
Business P6 function	$YP_{P6} = 0.315 \times BR1^{-0.117} \times BR2^{0.192} \times BR3^{0.073}$
Business P7 function	$YP_{P7} = 0.414 \times BR1^{-0.117} \times BR2^{0.192} \times BR3^{0.073}$

Source: Own investigation and calculations

Table 1: Production function for each business.

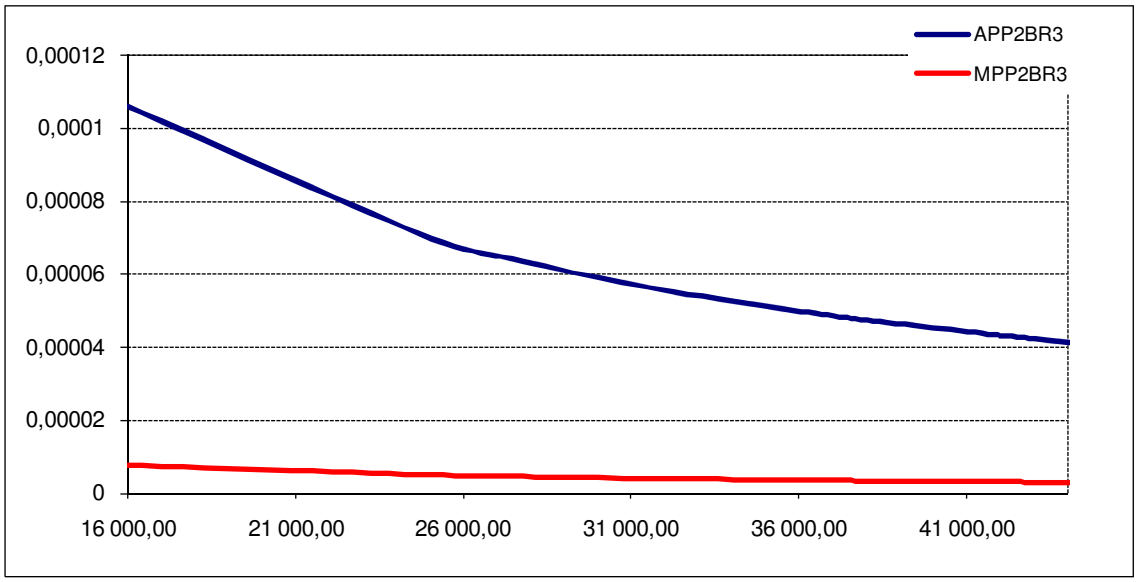
And finally the BR3 marginal production factor:

$MPP2BR3 = 0.008 \times BR2^{0.192} \times BR3^{-0.927}$.

Graph 1 summarises the behaviour of feed mixture BR3's marginal and average production for the average business.

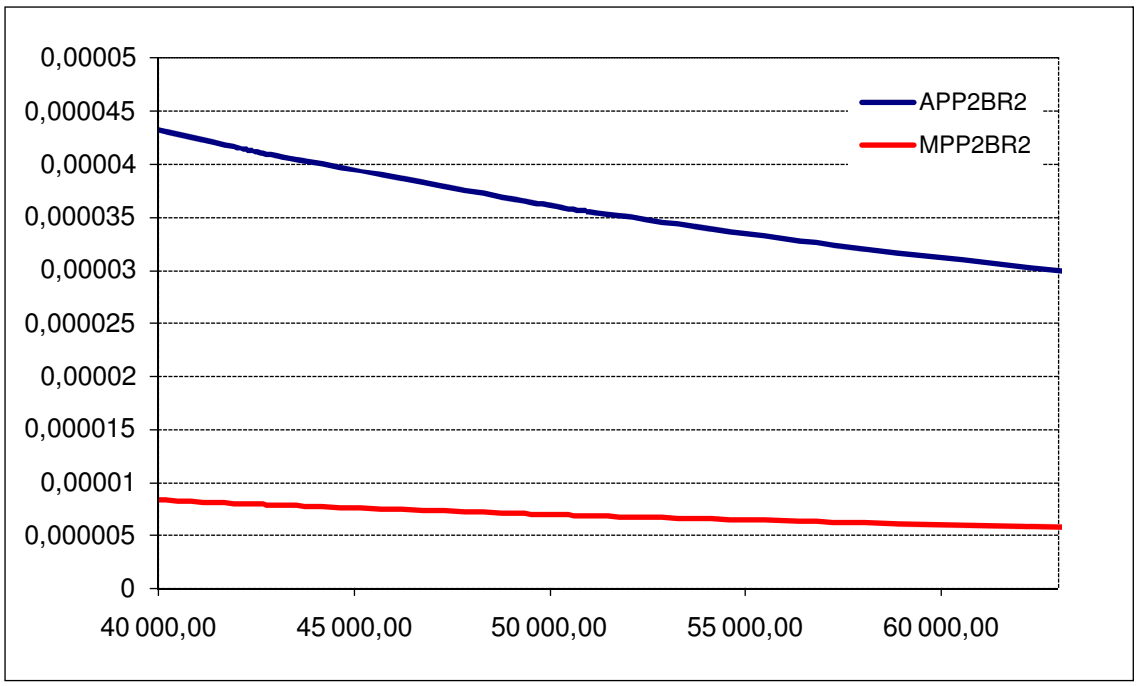
The average production for feed mixture BR3 falls over the whole range of use of the detailed production factor considered. This fact suggests a falling conversion for this feed mixture, which clearly corresponds to the observed facts.

The marginal production function behaviour is similar (Graph 2), which according to the laws of economics should also fall. In practice, this means that a constant consumption of feed mixture BR2 and increasing consumption of mixture BR3 leads to falling chicken meat production growth.



Source: Own investigation and calculations

Graph 1: BR3 marginal and average production factor for business ϕ AVE.



Source: Own investigation and calculations

Graph 2: BR2 marginal and average production factor for business ϕ AVE.

Where the amount of BR3 feed mixture is fixed to an average with BR2 feed mixture varied, the behaviour of the marginal and average production functions are very similar to the previous case, except that both functions do not drop so steeply.

Conclusion

The efficiency of feed mixture BR2 is more or less in agreement with the zootechnical and economic reality. The efficiency of feed mixture BR2 is the highest of all feed mixtures because it is used for the longest, 'supportive' part of feeding and is also within the range (1;0), which just demonstrates that optional production occurs in the rational part of the range. Were it to be greater than one, the factor's production efficiency would be unnecessarily strong, i.e. production would stop while there was still a very large marginal growth of production. The same kind of dependence is displayed by feed mixture BR3's production efficiency, except that the factor efficiency here is significantly lower. This is because this feed mixture is not as efficient as feed mixture BR2 in economic terms, although it must nevertheless be included for zoo-veterinary reasons. It is probably most difficult to explain the negative impact of feed mixture BR1. To a certain extent, this will probably be caused by two antagonistic and related factors: as feed mixture BR1 is only fed for a short period, this results in higher mortality and thus to a negative impact on production; if it is fed for a sufficiently long period then there is less time to feed mixture BR2 in particular, which has the highest (conversion) efficiency. The decision when exactly to transfer from BR1 to BR2 is determined by many other factors and in addition this moment needs to be determined with relatively high precision. Another big problem is the fact that chickens are to some extent heterogenous in their growth and weight over the whole cycle, but in terms of transaction costs, it is not possible to choose an individual approach, even to the most minimal extent. The statistical significance of the effect of BR1 is lowest for all variables monitored, but nevertheless its significance level comes to 0.045. The other parameters are statistically significant even under the strictest of conditions.

Because of the method used, the model also contains dummy variables I1 to I6 and a constant, a total of 7 dummy variables; this number thus represents the number of businesses in the selected set. Their structural parameter values can thus be interpreted as a quantification of each business's specific characteristics. The quantified specific characteristics of the first business is mathematically the anti-logarithm of the constant, the quantified special characteristics of the second business is then the anti-logarithm of the difference between the constant and the I1 dummy variable parameter, the quantified specific characteristics of the third business is then the anti-logarithm of the difference between the constant and the I2 dummy variable parameter, and so on. It seems then that one of the model suppositions can be said to be fulfilled, that being that there are no significant differences between businesses.

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Specifics in the chosen production chain?

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Abstract

It is possible to consider the production chain as a highly complicated system, within the framework of which different links and mutual relations function. Therefore it is necessary to analyze the complexity of the production chain functioning for the purpose of enhanced knowledge on the existence and the regularities functioning among different production elements. The contribution deals with an analysis of the price transmission in the production chain of cereals, within which only certain partial parts have been earmarked. Co-integration analysis, VECM and impulse-response analysis have been used for the price transmission analysis. Information mentioned in the paper resulted from the solution of a research intention VZ MSM 6046070906 „The Economics of resources of Czech agriculture and their efficient use in framework of multifunctional agri-food systems“.

Key words

Price transmission, wheat, industrial producers' price, agricultural producers' price, fodder mixtures, poultry meat, pork.

Anotace

Výrobkovou vertikálu lze považovat za velmi složitý systém, v rámci něhož fungují rozličné vazby a vzájemné vztahy. Složitost fungování výrobkové vertikály je proto třeba analyzovat za účelem zvýšení poznání o existenci a zákonitostech, které fungují mezi různými výrobními články. Příspěvek se zabývá analýzou cenové transmise ve výrobkové vertikále obilovin, v rámci které jsou vyčleněny pouze některé dílčí části. Pro analýzu cenové transmise jsou využity kointegrační analýza, VECM a impulse-response analýza. Příspěvek vznikl v rámci řešení Výzkumného záměru MSM 6046070906 „Ekonomika zdrojů českého zemědělství a jejich efektivní využívání v rámci multifunkčních zemědělskopotravinářských systémů".

Klíčová slova

Cenová transmise, pšenice, cena průmyslových výrobců, cena zemědělských výrobců, krmné směsi, drůbeží maso, vepřové maso.

Introduction

The agricultural commodities market belongs to highly organized markets (Mankiw, 2000). Havránek (1992) draws the attention to the fact that the market structure of the sector is always more complicated, it is a combination of more types, with a transitory form among the particular types, and thus it can be described with model categories with difficulties. Therefore for a deeper analysis, it is always necessary to consider, whether the market of the given sector is more perfectly competitive, as the case may be less imperfectly competitive, where the market solution will approximate the perfect competitive solution. Upon considerable simplification it is then possible to determine the competition type according to the fact whether the entity is the so-called price taker (accepting the price) or price maker (creating the price).

Various price levels may be identified in the production chain of the commodity of wheat – agricultural producers' price, industrial producers' price, consumer prices, import price, export price, etc. Within the analysis of the price transmission, the mutual relations between the price of wheat agricultural producers, the price of poultry meat and pork agricultural producers and the price of industrial producers of fodder mixtures for broilers and pigs are explored.

The results of this research follow up with the achieved results concerning the price transmission analysis that has been carried out according to the hypothesis: price of the industrial producers of fodder mixtures (PIPFM) for particular animal categories (pigs, poultry – broilers) is significantly determined by the price of the wheat agricultural producers - PWAP (Gallová, 2009). It results from these results and from the analysis of the relations between PWAP and PIP of all fodder mixtures that the fodder mixtures for fattening of pigs accept the wheat price change and transfer it into the fodder mixture price. It means that the producers of the fodder mixtures for pigs react in case of increase of PAP of wheat by increase of the fodder mixture price for pigs and to the contrary, however with a different intensity. To the contrary, the statistically significant relation between PWAP and PIPFM for broilers and PIPFM for pigs has not been proven. It means the producers of these fodder mixtures do not consider the wheat price increase or decline as a significant factor leading to increase of decline in the fodder mixtures prices. These prices tend to converge to equilibrium state.

Representation of wheat in the fodder mixtures for the particular animal categories is considerably differentiated. The highest wheat utilization, as regards the natural extent, is obvious in poultry breeding, followed by pig breeding. This is given in particular by the number of animals, fodder mixture consumption in a feeding ration and at the same time by high wheat share in the fodder mixtures for poultry, namely both in fattening of broilers and in fattening of turkey and in breeding of laying hens.

Objective and methodology

Frey and Manera (2005) were dealing with the analysis of asymmetric price transmission and they mention that a number of econometric tools exist that may be used for exploration of mutual relations between the prices of inputs and outputs. Among these tools, they mention e.g. ADL models (Autoregressive Distributed Lag), PAM models (Partial Adjustment Model), ECM (Error/Equilibrium Correction Model), RSM (Regime Switching Model), etc.

The objective of the contribution is to analyze by means of the econometric modeling tools, VAR models (Vector autoregressive model), as the case may be VECM (Vector Error Correction Model) the price transmission in the production chain of cereals, and using the impulse-response analysis the exploration of the long-term dynamics of the chosen system. With regard to the complexity of the whole production chain of the cereals, the analysis has been carried out in the part of the production chain focusing on fattening of farm animals. For this reason, as the basic variables entering into two price transmission models being analyzed the following have been defined: prices of industrial producers of fodder mixtures in CZK/t (differentiated according to the farm animals categories to fodder mixtures for broilers in model 1 – PIPFMB - prices of industrial producers of fodder mixtures for broilers), for pigs in fattening above 65 kg in model 2 – PIPFMPF/price of industrial producers of fodder mixtures for pigs in fattening above 65 kg) and the price of agricultural producers of meat in CZK/t (differentiated according to the animal categories to the price of agricultural producers of a table chicken in model 1 – PAPCM /price of agricultural producers of chicken meat/ , slaughter pig in model 2 – PAPSP /price of agricultural producers of slaughter pig/). The source data with monthly periodicity have been drawn from the database of the Czech Statistical Office for the period of 1995 – 2007.

VECM may be written down as follows:

$$\Delta X_t = \eta + \Pi X_{t-1} + \sum_{s=1}^{p} C_s \Delta X_{t-s} + u_t \qquad (1)$$

where Cs = 0 for s > p, Xt is k x 1 vector of variables integrated of order 1, i.e. I(1), u1, …,ut are iid (0,Σ) and Π is matrix of long-run relation. If the variables are not co-integrated, then VECM reduces to VAR model that may be written e.g. as follows:

$$\Delta X_t = \eta + \sum_{s=1}^{p} C_s \Delta X_{t-s} + u_t \qquad (2)$$

The procedure is modified similarly also in case of inclusion of a long-term relation. If the matrix Π has a full rank, then there is no difference between the VAR model and the Vector Error Correction model (VECM), i.e. the time series are stationary. The model VAR(p) may be written down in the form (3) (see e.g. Bierens (2007), Banerjee et al.

(2003) and others), while it is assumed that CS = 0

$$X_t = \eta + \sum_{s=1}^{p} C_s X_{t-s} + U_t$$

for s > p: (3)

A necessary condition for a strict stationary of the VAR(p) model is that the error process Ut is strictly stationary and lag polynominal (4).

C(L) = Ik – C1L - … - CpLp (4)

This process is stationary, if the roots of the equation Ik – C1L - … - CpLp = 0 lie outside the unit circle. Then it is possible to write (on condition that E(Xt)=η=0, i.e. we consider for illustration a simpler model structure form):

$$X_t = [C(L)]^{-1} U_t = \sum_{s=0}^{\infty} \psi_s U_{t-s} \quad (5)$$

where $\sum_{s=0}^{\infty} \psi_{ij,s}^2 < \infty$ for i = 1, 2, …, k and j = 1, 2, …, k.

In connection with the contribution's objectives the following hypotheses have been defined:

H1: The price of agricultural producers of different types of meat (pork, chicken) is determined by the fodder mixtures prices significantly.

H2: The analyzed prices in the chosen wheat production chain are co-integrated, i.e. they converge to equilibrium state in long period of time.

H3: Time lag exists within particular elements of the wheat production chain corresponding to the production cycle length of the particular use directions (fattening of pigs and poultry).

The first step in the price transmission analysis was testing of seasonability of the source data of the monthly time series using seasonal indexes. If the seasonability had been proven in the time series on the basis of the performed seasonal character test, then it was necessary to proceed to the data adjustment fort the seasonal character by means of adding a seasonal variable (SIN2Π), an dummy variable (DUM). The dummy variable (DUM) has been constructed as a null-one vector. In this vector, ones are attributed to the periods (months) in which significant fluctuations occurred in the time series of the analyzed data, i.e. they eliminate short-term extreme price values. The seasonal variable and the variable describing the production cycle length have been defined using the harmonic function in the following form: $f: \quad y = A\sin(\omega t + \varphi_0)$ (6) , where A, ω, φ0 are real constants, t is time. The constant A, i.e. the amplitude of the function, is estimated as a parameter of the variable $(\sin(\omega t + \varphi_0))^2$ of the defined econometric model. $(\omega t + \varphi_0)$ phase (φ0 initial phase), as the case may be the period of the function has been determined according to the expectation of the nature of the seasonal character in the agricultural sector. It means the seasonal variable is expressed according to relation (7).

$$\left(\sin\left(\frac{\pi}{12}t - \frac{\pi}{12}\right)\right)^2 \quad (7).$$

After the adjustment of the data for the seasonability it is possible to proceed to unit root test – the stationarity test. The stationarity of the time series has been analyzed using ADF (Augmented Dickey-Fuller) test for maximum lag equal to12 (p = 12). The null hypothesis H0 assumes the data is not stationary and thus integrated of order 1, it means I(1). This hypothesis is not rejected if the calculated value of the testing criterion is higher than the tabular value of the testing criterion of ADF test (testing has been performed at the significance level 0.05). If it be to the contrary, then it is valid that the time series are stationary – integrated of order 0, i.e. I(0).

If the data is not stationary, it is possible to proceed to VECM construction, namely by means of testing of a long-term relation among the variables. If there is a long-term relation among the variables, then a co-integration vector (r) exists, characterizing this relation. If the existence of the long-term relation among the variables is confirmed (of the co-integration vector) by means of eigenvector, then the calculated value of the testing criterion must be higher than the critical value (again tested at the significance level 0.05). Thus the null hypothesis H0 is refused: r = 0 in favor of the alternative hypothesis: HA: r = 1 (where r = number of co-integration vectors). Co-integration can be

understood as the statistical proof of the long-term relation existence among the variables (Thomas, 1993 in Zhou, Buongiorno, 2005), where the co-integrated variables are not stationary, but their linear combinations are stationary.

Using the Microfit 4.0 software an estimation of the model parameters has been carried out on the basis of the method of the least co-integrated squares with subsequent diagnostic tests (Pesaran a kol., 2003): functional form test, normality test, heteroscedasticity test, test of serial autocorrelation of residuals. The diagnostic tests come out from the assumptions the classical linear regression model shall fulfill: assumption of homoscedasticity (i.e. assumption of final and constant dispersion of random components), uncorrelated residuals, assumption of orthogonality (the random component and the regression coefficients are uncorrelated), zero mean value of the random component and the assumption of the normal distribution.

For each of these diagnostic tests, two testing statistics have been calculated – Lagrange multiplicator (LM statistics) coming out from $\chi 2$ distribution and F-statistics, as the case may be modified LM (LM F) coming out from F-distribution. Impulse-response analysis has been used for exploration of the long-term system dynamics. Using these methods offers detailed information on the price transmission nature and the influence of innovations (shocks) on the price development. Graphic display of the impulse-response analysis assumes then a shock (measured in the chart on the axis y) at the amount of the standard deviation, it means that the unit shock caused by the given variable corresponds to the size of the standard deviation of this variable.

Results and discussion

By means of two-equation model 1, as the case may be model 2, the relations have been analyzed between PIP of fodder mixtures for broilers, as the case may be for pigs, and PAP of poultry meat – chicken I, as the case may be slaughter pig. Construction of both models comes out from the following hypothesis: if PIP of the fodder mixture for the given farm animal category grows, then on condition of functioning price transmission increase of PAP of meat of the given animal category occurs, since the fodder mixtures represent significant cost item in the fattening and increase in the production costs should transpose in the price of the product being offered (the price of the fattened broiler, as the case may be the price of the slaughter pig).

However, increase in PIP of the fodder mixture may be also related to a number of shocks, which may occur both in plant production and in animal production (e.g. influence of weather, lack or excess of precipitation, poor harvest, consumers' interest in the given meat type, etc.). Let's suppose that the increase of PIP of the fodder mixture, e.g. for broilers occurs in consequence of increase in the price of the fodder mixture components. If we suppose the fodder mixtures producers adhere to the fodder mixture composition, i.e. they do not, within the endeavor to maintain the fodder mixture quality, (i.e. its nutrient parameters, digestibility and assumed body mass gain of the animals in fattening) replace the more expensive components with the cheaper ones. The problem of the fodder mixtures components substitution can be exactly worse digestibility of the fodder mixtures, which has its negative impacts on efficiency of animals and their body mass gain. Limited substitution of the fodder mixture components is also related as a rule with the fodder mixture production according to the client's conditions, i.e. with "made-to-measure" fodder mixture production for a specific company and with the specific efficiency rate.

It means that if supply shock occurs in the agricultural producers' market (e.g. due the influence of increase in the price of fodder – fodder mixture), then under otherwise same conditions, shifting of the supply curve occurs. The newly arisen break-even point of the supply and demand curves is, compared to the original equilibrium state, characterized with a higher price and lower quantity.

Increase in the fodder mixture price as of the production factor may lead with certain economic entities operating in the fattening area to short-term or long-term unprofitability in consequence of the fact that the price of the product being produced (chicken meat) does not achieve the minimum price limit (i.e. that PAPCM is below the level of the minimum average costs during long period of time, as the case may be below the level of the minimum of average variable costs in short period of time)

and is subsequently transposed in the negative profitability of the fattening.

Negative income from operations or fall in the profitability of the fattening will result in lower interest of the meat producers in this part of the business plan, which will show up with certain lag in drop in poultry meat production. With regard to the market environment dynamic character, rational behavior of the economic entities and the market reaction (i.e. of offering entities and those making enquiries), it is obvious that the supply shock will not remain without a response. Thus, e.g. due to the drop in the domestics poultry meat production, growing foreign trade share in the form of import may occur on condition that the imported meat price is lower than the price in the domestic market. The similar situation may occur then also within model 2.

The source data of model 1 was, with regard to the methodic procedures, first tested for the presence of the seasonability using seasonal indexes. This test has proven that the time series contain a seasonal component. In respect of this fact, artificial variables DUM1 have been added into the model (null-one vector to PAPCM – values one in the period 7/1996 – 2/1999 and 2/2001 – 2/2002) and DUM2 (null-one vector to PIPFMB /price of industrial producers of fodder mixtures for broilers/ – values 1 in the period 2/2001 – 2/2002).

The similar situation has occurred also in case of model 2, where the monthly price series of the source data (PAPSP and PIPFMPF) have confirmed presence of the seasonability based on the results of the seasonal indexes. In respect of this fact, three variables have been added into the model 2 (DUM1, DUM2, SIN2Π). The artificial variable DUM1 has been constructed to the variable PAPSP in the form of a null-one vector, where it acquired the value 1 as a rule in the last three months of the first three years, subsequently then in the summer period of 1998 and in autumn 2000, 2001 and 2004. The variable DUM2 is related to the variable PIPFMPF. Vector of the values DUM2 acquired the value 1 from September 1996 as long as till July of the following year, than at the turn of 2000 and 2002 and in the end of 2003. The endeavor of both DUM variables was to eliminate high price variances (high decline or increase in prices from the average level).

The unit root test – ADF test for testing of stationarity of both models has shown that the data appear at the chosen lag of (lag for 12 periods have been tested) as non-stationary, integrated if order I(1). The order of the model has been determined according to the AIC testing criterion, where on the basis of its results the lag of 9 periods has been chosen for model 1 (VECM(9) estimation has been performed) and 6 periods for model 2 (estimation VECM (6)).

It results from the co-integration test results of both models that at the significance level of 5%, the calculated value of the testing criterion is higher than the critical value, and thus the long-term relation exists among the variables. At the significance level of 5% we refuse the null hypothesis in favor of the alternative hypothesis (HA: number of co-integration vectors r = 1). It means that the variables are co-integrated with one co-integration vector and the long-term relation exists among them.

The parameters VECM(9) and VECM(6) (with an unlimited constant and trend in the co-integration vector) have been estimated with the method of the least (co-integrated) squares. The statistical characteristics of the price transmission models show that the parameters estimations seem to be unbiased and consistent. (Table 1, Table 2).

Different rate of dependence tightness in particular equations of model 1 results from the values of the determination coefficients (R2). It is possible to state that the changes of the dependent variable in the 1st equation (PAPCM) are explained of 56.23% by the changes of the independent variables. In the 2nd equation, the change of the dependent variable (PIPFMB) is explained by the chosen regression of 39.60%. Both two values of the determination coefficients may be considered, with regard to the character of the analyzed relations, as satisfactory and it is possible to proceed to further analysis VECM(9). The results of the diagnostic statistical tests mentioned in Table 1, Table 2 show further characteristics of model 1 and of the estimated parameters. In both equations of the model no serial autocorrelation of residuals has been proven since the results of the test refuse the hypothesis on autocorrelation of residuals. The test of the functional form of both equations being followed shows correctness of the analytical form of the

ECM for variable CZVMK estimated by OLS based on cointegrating VAR(9)

Dependent variable is dCZVMK
135 observations used for estimation from 1995M10 to 2006M12

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
Intercept	2835.0	637.7482	4.4453[.000]
dCZVMK1	.30475	.085808	3.5515[.001]
dCPVKSB1	-.24283	.26529	-.91534[.362]
dCZVMK2	.25461	.087799	2.8999[.004]
dCPVKSB2	-.11823	.26472	-.44663[.656]
dCZVMK3	-.098007	.087012	-1.1264[.262]
dCPVKSB3	.058394	.26370	.22144[.825]
dCZVMK4	.11337	.087885	1.2900[.200]
dCPVKSB4	.22353	.26375	.84753[.398]
dCZVMK5	.14443	.088062	1.6401[.104]
dCPVKSB5	.16216	.26396	.61433[.540]
dCZVMK6	-.20141	.087063	-2.3133[.022]
dCPVKSB6	.11686	.26363	.44328[.658]
dCZVMK7	.37555	.088473	4.2448[.000]
dCPVKSB7	-.31125	.26301	-1.1834[.239]
dCZVMK8	-.030729	.092945	-.33062[.742]
dCPVKSB8	.45907	.25662	1.7889[.076]
ecm1(-1)	-.13515	.030793	-4.3889[.000]
DUM1	206.7250	110.2908	1.8744[.063]
DUM2	-23.0800	101.5773	-.22722[.821]

R-Squared	.56230	R-Bar-Squared	.48998
S.E. of Regression	301.4228	F-stat. F(19, 115)	7.7755[.000]
Mean of Dependent Variable	-15.7407	S.D. of Dependent Variable	422.0685
Residual Sum of Squares	1.04E+07	Equation Log-likelihood	-951.3830
Akaike Info. Criterion	-971.3830	Schwarz Bayesian Criterion	-1000.4
DW-statistic	1.9192	System Log-likelihood	-1758.5

* Test Statistics *	LM Version	F Version
* A:Serial Correlation	*CHSQ(12)= 17.3919[.135]	*F(12, 103)= 1.2693[.248]
* B:Functional Form	*CHSQ(1)= .53617[.464]	*F(1, 114)= .45457[.502]
* C:Normality	*CHSQ(2)= 4.7111[.095]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1)= 12.1226[.000]	*F(1, 133)= 13.1212[.000]

Source: own calculations

Table 1: VECM(9) – 1st equation of model 1.

ECM for variable CPVKSB estimated by OLS based on cointegrating VAR(9)

Dependent variable is dCPVKSB,
135 observations used for estimation from 1995M10 to 2006M12

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
Intercept	847.5960	219.2020	3.8667[.000]
dCZVMK1	.029725	.029493	1.0079[.316]
dCPVKSB1	.12685	.091185	1.3911[.167]
dCZVMK2	.011651	.030178	.38607[.700]
dCPVKSB2	.035156	.090987	.38638[.700]
dCZVMK3	.038140	.029907	1.2753[.205]
dCPVKSB3	.0059054	.090636	.065155[.948]
dCZVMK4	.0015511	.030207	.051348[.959]
dCPVKSB4	-.030172	.090654	-.33283[.740]
dCZVMK5	.031649	.030268	1.0456[.298]
dCPVKSB5	-.034910	.090727	-.38478[.701]
dCZVMK6	.026369	.029925	.88120[.380]
dCPVKSB6	.080102	.090611	.88402[.379]
dCZVMK7	.029669	.030409	.97564[.331]
dCPVKSB7	.043371	.090398	.47977[.632]
dCZVMK8	.046400	.031946	1.4524[.149]

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dCPVKSB8                  -.18634            .088203           -2.1126[.037]
ecm1(-1)                 -.040524            .010584           -3.8288[.000]
DUM1                      92.8651            37.9083            2.4497[.016]
DUM2                      -3.5948            34.9134           -.10296[.918]
*******************************************************************************
R-Squared                    .39596   R-Bar-Squared                    .29616
S.E. of Regression         103.6028   F-stat.    F( 19, 115)    3.9676[.000]
Mean of Dependent Variable   3.7990   S.D. of Dependent Variable    123.4911
Residual Sum of Squares    1234357   Equation Log-likelihood      -807.2098
Akaike Info. Criterion    -827.2098   Schwarz Bayesian Criterion   -856.2625
DW-statistic                 1.8944   System Log-likelihood         -1758.5
*******************************************************************************
     *    Test Statistics  *        LM Version        *         F Version
*******************************************************************************
* A:Serial Correlation*CHSQ(  12)=  17.5683[.129]*F(  12, 103)=   1.2841[.239]
* B:Functional Form   *CHSQ(   1)=  .031449[.859]*F(   1, 114)=  .026563[.871]
   * C:Normality         *CHSQ(   2)=  49.4746[.000]*       Not applicable
* D:Heteroscedasticity*CHSQ(   1)=   1.5252[.217]*F(   1, 133)=   1.5198[.220]
*******************************************************************************
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Source: own calculations

Table 2: VECM(9) – 2nd equation of model 1.

model. Assumption of normality has been fulfilled only in the first equation where the hypothesis on the normal distribution of the residuals has not been rejected. It also results from the performed tests that there is significant heteroscedasticity in the 1st equation of the model; it means that the assumption of final and constant dispersion of random components (residuals) is not fulfilled. The second equation already rejected the null hypothesis in favor of the alternative hypothesis, it means that in the second equation the above-mentioned assumption of homoscedasticity of the random component is fulfilled.

Estimations of the parameters VECM(6) and results of the diagnostic tests are given in Table 3 and Table 4. The values of the determination coefficients (R2) show medium high rate of dependence tightness in particular equations of the model. Changes of the dependent variable in the 1st equation (PAPSP) are of 46.6% by the changes of the independent variables. In the 2nd equation, the change of the dependent variable (PIPFMPF) may be explained by the chosen regression of 57.7%. It results from the results of these tests in both equations that the hypothesis on serial autocorrelation of residuals and heteroscedasticity has been refused in the model. It means the results do not confirm the dependence of random components and confirm the assumption of final and constant dispersion of random components. Choice of the correct analytical form of the model results from the functional form test. Assumption of normality was fulfilled only in the second equation where the hypothesis on the normal distribution of the residuals has not been refused.

The results of the co-integration analysis of model 1 (VECM(9)) are based on testing of structural hypotheses where the co-integration vector has been normalized according to the variable PAPCM (thus A1 = 1). The normalized co-integration vector (PAPCM; PIPFMB; Trend) (1.0000; -0.55036; 34.6485) shows long-term equilibrium relation among the variables, of which it results that PIPFMB influences PAPCM positively and from the point of view of the sign it complies with the above-defined hypothesis (increase in the fodder mixture price will lead to increase in the cost for chicken fattening and thus to fall of the producers' interest in production of this meat type; this fact may result in drop in production, i.e. in lower meat supply being expressed in the growth of PAPCM; similarly, the growth in the chicken meat price will lead to increase in the producers' interest in production of the chicken meat, thus to increased supply, which will express itself as growth in the inquiry for the production factor – the fodder mixture price). It means the unit price in PIPFMB (PIPFMB growth by 1 CZK/t) will lead to PAPCM growth (by 0.55 CZK/t). To the contrary, the influence of the trend on PAPCM is negative; interannually the decline of PAPCM by 34.65 CZK/t occurs. The magnitude of this interannual change is in accordance with the direction of the linear trend function describing dependence of PAPCM on time (y = 25533 – 34.603x, where x is the time vector) since PAPCM

```
    ECM for variable CPVKSV estimated by OLS based on cointegrating VAR(6)
*******************************************************************************
                        Dependent variable is dCPVKSV
          138 observations used for estimation from 1995M7  to 2006M12
*******************************************************************************
Regressor              Coefficient       Standard Error         T-Ratio[Prob]
Intercept                300.3203            65.8039            4.5639[.000]
dCPVKSV1                  .27592            .085677            3.2205[.002]
dCZVMV1                -.0010330           .0035200           -.29347[.770]
dCPVKSV2                  .17195            .089222            1.9272[.056]
dCZVMV2                -.0057017           .0038102           -1.4964[.137]
dCPVKSV3                  .14323            .092198            1.5536[.123]
dCZVMV3                .0025004           .0041101            .60834[.544]
dCPVKSV4                  .14433            .092497            1.5604[.121]
dCZVMV4                -.0024508           .0036641           -.66886[.505]
dCPVKSV5                .073698            .090684            .81269[.418]
dCZVMV5                -.0021409           .0032910           -.65053[.517]
ecm1(-1)               -.079052            .020006           -3.9515[.000]
DUM1                    -6.5171            22.5097           -.28952[.773]
DUM2                    47.2775            24.2417            1.9503[.053]
SIN2PI                  -51.3878            25.4043           -2.0228[.045]
*******************************************************************************
R-Squared                    .46636   R-Bar-Squared                    .40562
S.E. of Regression         79.6077   F-stat.    F( 14, 123)    7.6779[.000]
Mean of Dependent Variable  3.2728   S.D. of Dependent Variable    103.2575
Residual Sum of Squares   779498.4   Equation Log-likelihood      -791.9150
Akaike Info. Criterion   -806.9150   Schwarz Bayesian Criterion   -828.8694
DW-statistic               1.9960   System Log-likelihood         -2023.8
*******************************************************************************
     *    Test Statistics  *        LM Version        *         F Version
*******************************************************************************
* A:Serial Correlation*CHSQ(  12)=  12.0271[.444]*F(  12, 111)=   .88313[.566]
* B:Functional Form   *CHSQ(   1)=  .011974[.913]*F(   1, 122)=  .010587[.918]
    * C:Normality         *CHSQ(   2)= 285.9287[.000]*       Not applicable
* D:Heteroscedasticity*CHSQ(   1)=   1.0190[.313]*F(   1, 136)=   1.0117[.316]
*******************************************************************************
```

Source: own calculations

Table 3: VECM(6) – 1st equation of model 2.

```
    ECM for variable CZVMV estimated by OLS based on cointegrating VAR(6)
*******************************************************************************
                        Dependent variable is dCZVMV
          138 observations used for estimation from 1995M7  to 2006M12
*******************************************************************************
Regressor              Coefficient       Standard Error         T-Ratio[Prob]
Intercept               -3477.2             1612.8           -2.1560[.033]
dCPVKSV1                -.68988             2.0999           -.32854[.743]
dCZVMV1                  .50575            .086272            5.8623[.000]
dCPVKSV2                 4.2619             2.1868            1.9490[.054]
dCZVMV2                 -.53521            .093385           -5.7312[.000]
dCPVKSV3                -2.9148             2.2597           -1.2899[.200]
dCZVMV3                  .20430             .10074            2.0280[.045]
dCPVKSV4                -2.4667             2.2670           -1.0881[.279]
dCZVMV4                 -.28250            .089804           -3.1457[.002]
dCPVKSV5                 5.7375             2.2226            2.5814[.011]
dCZVMV5                  .14641            .080659            1.8152[.072]
ecm1(-1)                 .68436             .49032            1.3957[.165]
DUM1                     1747.4           551.6975            3.1674[.002]
DUM2                    -1536.6           594.1473           -2.5863[.011]
SIN2PI                   2742.8           622.6413            4.4051[.000]
*******************************************************************************
R-Squared                    .57726   R-Bar-Squared                    .52914
S.E. of Regression          1951.1   F-stat.    F( 14, 123)   11.9969[.000]
Mean of Dependent Variable  11.3478   S.D. of Dependent Variable      2843.4
Residual Sum of Squares   4.68E+08   Equation Log-likelihood        -1233.4
```

```
Akaike Info. Criterion       -1248.4   Schwarz Bayesian Criterion     -1270.3
DW-statistic                  1.9667   System Log-likelihood          -2023.8
**************************************************************************
     *    Test Statistics  *        LM Version        *         F Version
**************************************************************************
* A:Serial Correlation*CHSQ(  12)=  17.7697[.123]*F(  12, 111)=   1.3671[.192]
* B:Functional Form   *CHSQ(   1)=   .31893[.572]*F(   1, 122)=   .28260[.596]
   * C:Normality         *CHSQ(   2)=   1.9076[.385]*       Not applicable
* D:Heteroscedasticity*CHSQ(   1)=   .10319[.748]*F(   1, 136)=   .10177[.750]
**************************************************************************
```

Source: own calculations

Table 4: VECM(6) – 2nd equation of model 2.

shows long-term downward tendency. The parameter α signifies that in case of a shock, the 1st equation returns faster to the equilibrium state, i.e. PAPCM. Existence of the long-term relation between PAPCM and PIPFMB is obvious from the resulting co-integration vector. The long-term influence among the prices is, with regard to the statistical significance of the co-integration vector bidirectional, which is in accordance with the defined hypothesis, on the basis of which, according to the assumption of the functioning price transmission, PAPCM influences PIPFMB and to the contrary. In case of the influence of PIPFMB on PAPCM it is possible to search for the links where the fodder mixtures create the main and in fact also "the only one" type of the fodder that may be used for fattening of chicken and they are thus the main component of the costs of fattening. The fodder mixtures are understood here as the only fodder in wider meaning, i.e. as structure of various types of fodder mixtures with regard to the fattening stages and age of the animals. It means it is not possible to combine the feeding ration of other types of fodder, such as e.g. in case of bovine animals; i.e. it is not possible to combine nutrition e.g. of bulk feed and concentrates (fodder mixtures). Nutrition of the poultry comes out from the fact that according to the category and age of the poultry, feeding only with the relevant fodder mixture intended for the given animal category is possible. With regard to rational behavior of the entities operating in the agricultural market and in the suppliers' market (the suppliers' market = the market where the fodder mixture producers operate) and with regard to the fodder not being substitutable, it is therefore obvious that this price, based on model 1 results, from the long-term point of view has been co-creating the development of the costs of fattening, by means of which it also influences determining of the minimum price level, i.e. the minimum price of 1 kg of the table chicken. However, the practical problem remains that the immediate PAPCM in the time of expedition of the particular cyclic fattening does not have to cover this minimum level in full and impacts the resulting fattening profitability (of the cyclic fattening taken out of store).

The long term relation between PAPCM and PIPFMB may be interpreted as follows. If in consequence of a shock e.g. decline of PAPCM occurs, this change is accompanied with reduced producers' interest in poultry meat production. In respect of this fact, necessarily fall in the interest of the primary agricultural producers in the fodder mixtures for fattening of broilers occurs. Surplus of the fodder mixtures in consequence of lower sales induces pressure on price reduction of the fodder mixtures. The price reduction of the fodder mixtures on the part of the fodder mixture producer may occur in different ways. E.g. if the FM producer has no possibility to influence the input raw materials prices, then it has a possibility, in accordance with the quality parameters, requirements for the nutrition and limitations in accordance with the valid regulations, to modify the fodder mixture composition so that the more expensive raw materials might be replaced with cheaper ones. It means the producer will consider minimization of the production cost detrimental to other parameters – e.g. the qualitative ones, showing up in aggravated conversion of the fodder with regard to digestibility of components, etc. The price reduction of the fodder mixtures will subsequently lead to reduction of the production costs of poultry meat (under the assumption that the costs of the fodder influence significantly the structure of the total costs of fattening), due to which the change of the profit margin in poultry meat production may occur. The change of the profit margin influences then the agricultural producers' decision-making. If at the same time

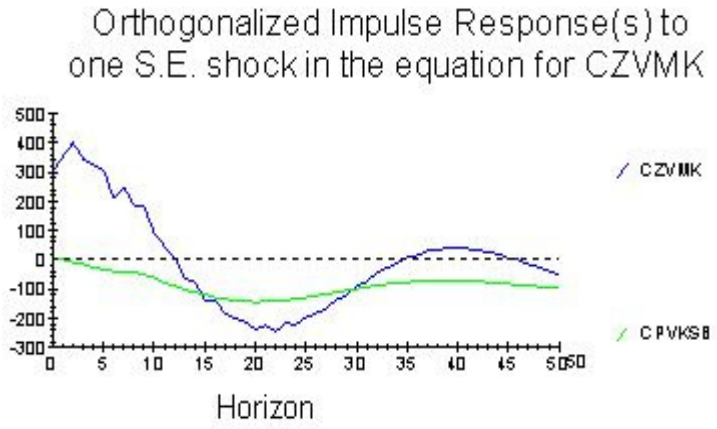
with regard to the lower PAPCM growth in demand for the poultry meat occurs, then rational behavior of all entities will occur, which is analogy to the above-defined process. However, it is necessary to point out at the same time that besides the mutual influence of the prices also other factors impact, which determine the price development. As the other determinants e.g. foreign trade, in particular import from abroad, health conditions (e.g. bird flu), size and utilization degree of the production capacities in the Czech Republic, length of the production cycle and others may be considered. However, the influence of these components and its quantification is not a subject-matter of this analysis.

The results of the co-integration analysis of model 2 (VECM(6)) are based on testing of structural hypotheses. The co-integration vector has been normalized according to the variable PAPSP (thus A1 = 1). The normalized co-integration vector (PAPSP; PIPFMPF; Trend) shows the long-term equilibrium relation among the variables, which may be quantified as follows: (1.0000; -37.8241; -63.3377). The co-integration vector values confirm positive influence of PIPFMPF on PAPSP, and on the basis of the calculations, it is possible to state that the unit change in PIPFMPF (PIPFMPF growth by 1 CZK/t) will lead to PAPSP growth (by 37.82 CZK/t). From the point of view of the sign (positive influence of PIPFMPF on PAPSP), it complies with the defined hypothesis (increase in the pork price will lead to increased producers' interest in production of this meat type, thus to the growth in supply, which will show up in increased demand for the production factor – and thus also in the fodder mixture price). The influence of the trend on PAPSP is also positive; interannually it leads to the increase of PAPSP by 63.34 CZK/t.

The long-term relation between PAPSP and PIPFMPF is obvious from the resulting co-integration vector. The co-integration vector (ecm1) is statistically significant only in the 1st equation of the model, thus in case of the dependence of PIPFMPF on the other endogenous and exogenous variables of model 2. It means that the statistically provable influence of PAPSP on PIPFMPF exists, however the influence of PIPFMPF on PAPCM is not significant according to the results. Magnitude of the parameter α signifies that in case of a shock, the 2nd equation returns faster to the equilibrium state, i.e. PAPSP. The existence of the long-term relation between PAPSP and PIPFMPF may mean that if, e.g. due to an influence of a shock, the decline of PAPSP occurs, then this change is accompanied with reduced producers' interest in pork production. In respect of this fact, necessarily fall in the interests of the primary agricultural producers in the fodder mixtures for fattening of pigs occurs. Surplus of the fodder mixtures in consequence of lower sales induces pressure on price reduction of the fodder mixtures. The price reduction of the fodder mixtures (under the similar conditions defined in model 1) will subsequently lead to reduction of the production costs of pork, due to which change of the profit margin in fattening may occur. The change of the profit margin influences then the agricultural producers' decision-making. If at the same time with regard to the lower PAPSP growth in demand for the pork occurs, then rational behavior of all entities will occur, which is analogy to the above-defined process. However, it is necessary to point out at the same time that besides the mutual influence of the prices also other factors impact, which determine the price development. In particular foreign trade (either with meat or piglets) can be considered as another determinant since PAPSP is related to the price in the EU. Other determinants, which may play their role here, are e.g. health conditions, size and utilization degree of the production capacities in the Czech Republic, length of the production cycle, concentration of the production, meat producers' negotiation position in the production chain and others. However, the influence of these components and its quantification is not a subject-matter of this analysis.

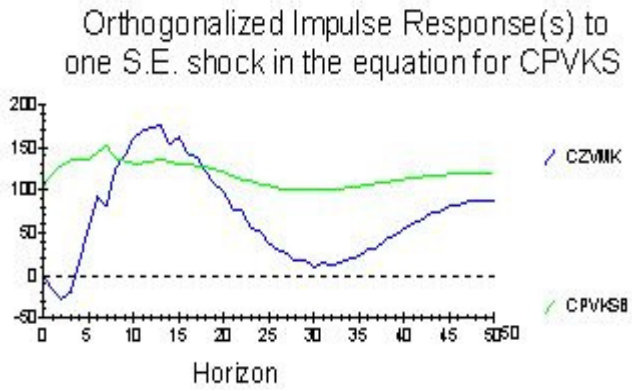
From long-term point of view and **the results of impulse-response analysis** of model 1 (chart 1 and 2) it is possible to state that the prices tend towards an equilibrium, while the length of return to the equilibrium is similar for particular innovations (90 months). Higher reaction intensity is obvious for PAPCM compared PIPFMB, namely in case of both innovations (both in PAPCM and in PIPFMB). The system dynamics and character of the price transmission may be influenced by many factors. One of the factors may be the length of the production cycle of the fodder mixture components, which corresponds to certain extent to the lag of the analyzed model (i.e. 9 months). As the beginning of the production cycle of the cereals, the months of September/October may be considered with the highest probability, i.e. the time sowing. With regard to the fact that in particular cereals represent a significant share in the fodder mixtures structure, influence of this production cycle, together with its characteristics, may be considered as significant. However, in practice it is also possible to consider the market cycle as the length of the production cycle of cereals, i.e. the cycle e.g. from harvest to harvest in the length of 12 months. With regard to the fact that the corn of wheat is not convenient to be fed directly after the harvest but to the contrary, it is convenient to let it "stand", exactly this market cycle may appear as insignificant and the difference

between the production and the market cycles may be related to inventory creation. The production cycle length itself of the fattening of chicken broilers (2 months) does not obviously play the decisive role in the system dynamics. One of the reasons may be existence of long-term contractual relations and long-term contracts between hatchers of chicken broilers and fattening of broilers. These contracts reduce then the business plan short-term variability. At the same time, with regard to the fact that the fattening production cycle turns over 6 – 8times per year, the achieved results point out that contingent shocks affecting one of the production cycles do not influence decision-making of the economic entities (agricultural meat producers) to significant extent during very short time period. This would then mean that, within the adaptive behavior, the chicken meat producers would expect that this short-term fluctuation will "go off" till the market realization of the next cyclic fattening. However, if the above-mentioned shock in sale of broilers from the following cycle remained, then it would be possible to expect subsequent "adapting" reactions of the agricultural producers and the fodder mixture producers.



Source: own calculations

Chart :1 I-R analysis of reaction to innovations of PAPCM.

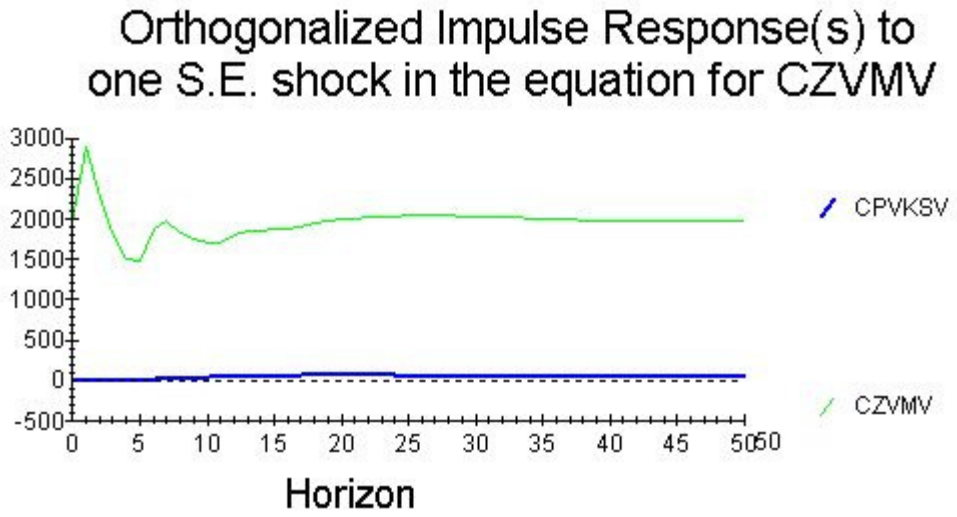


Source: own calculations

Chart 2: I-R analysis of reaction to innovations of PIPFMB.

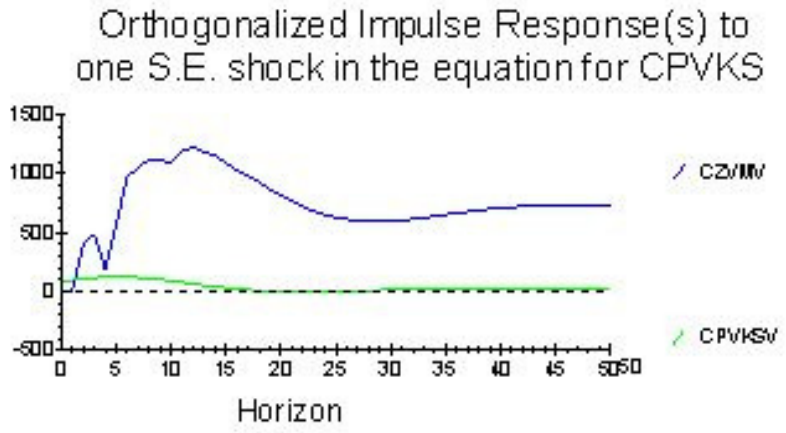
It results from the long-term point of view and the results of the impulse-response analysis of model 2 (charts 3 and 4) that the prices tend towards an equilibrium, while the length of return to the equilibrium state is similar for particular innovations (33 months). Both the price of the industrial producers of fodder mixtures for pigs and the price of the agricultural producers of pork show from long-term point of view the highest variability compared to the poultry sector. It results from the analysis of the characteristics and results of VECM(6) and the price transmission that the lag of the model corresponds to the length of the whole production cycle (i.e. from birth to slaughter). Since the average length of fattening from birth to slaughter weight (108 - 112kg) is 175 days on average. The long-term relation between the analyzed prices results from the price transmission nature, however, its statistical significance has been proven only in single-direction. This points out at the fact that while PAPSP influences statistically significantly PIPFMPF, the fodder mixture price does not influence the price of the slaughter pigs statistically significantly any more. This fact may signify to certain extent that the element on the lower production chain degree (agricultural primary

production – fattening) has smaller and slower "adapting" processes in case of innovation (market shock). This may be also a consequence of the fact that PAPSP corresponds to the price in the EU, i.e. the import price, since in the sector of pork breeding the import within the EU is relatively significant. In case PAPSP is low, growth in the export of piglets occurs. At the same time the results signify that in spite of the fact the farmers note the change in the fodder mixture price, they transfer this change in the production costs (of the fodder mixture price) into the final product price change much more slowly and, as a rule, with very low intensity. Thus it is possible to conclude about the control mechanism "from the top", i.e. to the vertical controlled from the top – by the higher element of the production chain. With regard to the relatively longer production cycle, e.g. compared to the poultry fattening, the suppliers' market (i.e. the fodder mixture producers for pigs) in the fattening category above 65 kg has enough time for adaptation processes, namely for several reasons. One of them may be the fact that on the basis of the number of animals and fattening in A2 category (30 – 65kg), it is possible to estimate the need of the fodder mixtures for the follow-up category A3. If we assume that the meat price influences the size of fattening (the farmers' interest in fattening and thus also the numbers of animals in fattening), then the demand for the production factor related to fattening – the fodder mixture – co-creates the price of fodder mixtures.



Source: own calculations

Chart 3: I-R analysis of reaction to innovations of PAPSP.



Source: own calculations

Chart 4: I-R analysis of reaction to innovations of PIPFMPF.

Conclusion

Analysis of the dynamics of the chosen production chain points out at the fact that there are long-term relations among the chosen prices in the production chain, however the character of these relations is different to certain extent depending on the animal production sector where the feeding wheat is consumed and in relation to the length of the production cycle of the fattening itself. It is not possible to claim that use of wheat in fattening of monogastric animals shows identical regularities. To the contrary, a number of differences have been identified that are related either only to pig breeding or only to poultry breeding. In all elements of the analyzed production chain, different intensity in the transmission of the price change into the price of the coherent products has been proven, and to the contrary, thus the different influence of the market force of the coherent elements in the production chain.

The results of the co-integration analysis, VECM, Impulse-Response analysis point out at certain regularities of the relations between the industrial producers' prices of the fodder mixtures and the prices of the agricultural meat producers and they signify possibilities of effective allocation of wheat in the production chain.

The link between the production cycle length and the order of the model leads in the analysis of the relations between PIPFMB and PAPCM (model 1) to rejection of hypothesis H3, which claims that the time lag exists within the particular elements of the wheat production chain corresponding to the production cycle length. According to AIC criterion, the length of the lag has been determined as 9 cycles in poultry breeding. However, if we take into account the production cycle length of fattening of broilers (2 months), then it is obvious that this production cycle does not play the decisive role in the system dynamics, and in the same way the production cycle in breeding of pigs being fattened may not be described as 2 month cycle. To the contrary, it is not possible to refuse hypothesis H3 in model 2, since the order of the model corresponds to the production cycle length, i.e. 6 months.

By means of the results of model 1, it is further possible to evaluate the mutual relations between the price of the fodder mixtures for broilers and the poultry meet price. The results of the co-integration analysis and VECM(9) signify functionality of the price transmission in both directions, i.e. PAP of poultry meat influences PIP of fodder mixtures for broilers and to the contrary, PIP of fodder mixtures for broilers influences PAP of poultry meat. Impulse-Response analysis points out at the fact that in case of a shock in some of the analyzed variables, going off of this reaction occurs in certain time horizon and the prices tend to converge to equilibrium. These facts lead to the situation where it is not possible to reject hypothesis H1 or hypothesis H2 in the poultry breeding sector. Functionality of this price transmission is obviously related also to the production concentration and the vertical integration extent among the poultry meat producers and the producers of the fodder mixtures. Peak and little differentiated technology among the companies may thus in case of the price transmission malfunction react, due to the short production cycle, much earlier by reducing of the production. With regard to the vertical interconnection among the producers of the fodder mixtures and the poultry fattening, then in case of increase in PIPFM, short-term meat production reduction occurs. With regard to the loss (as the case may be decline in the profit), which due to this situation arises to the producers of the fodder mixtures, the meat producers may induce pressure on faster reaction of PIPFMB towards the targeted price level.

The results of model 2 show whether and, as the case may be in which manner the pork producers react to the fodder mixture price change. It results from the price transmission nature and the relations between PAPSP and PIPFMPF that PIPFMPF does not influence statistically significantly the price the farmer will get when selling slaughter pigs and leads at the same time to rejection of hypothesis H1 in the pig breeding sector. Further to hypothesis H2, it can be stated it is not possible to refuse this hypothesis since the prices are co-integrated with one co-integration vector and in case of an innovation (shock) its going-off occurs and the reaction exhausts. In fattening of pigs it is not possible to speak about such unified technology (from the point of view of body the mass gain and efficiency) and concentrated production. Also the production cycle length in this sector does not enable such fast and short-term production reduction and the meat producers do not have strong negotiation position in the relation to the meat industry.

The impacts of the price transmission results of the above-mentioned models on the allocation effectiveness of wheat and, as the case may be profitability of fattening or economics of agricultural companies may be analyzed further in details, and these facts shall be therefore subject-matter of further research.

The production chain shows the features of a demand controlled system. The demand controlled system both from the meat processors and from the fodder mixture producers is obvious in the poultry breeding, to the contrary, in pig breeding the influence of the fodder mixture processors is

evident, the influence of the meat processors is not significant in this production chain element. In addition to that, in the production chain of the poultry breeding, obviously the concentration of production and holding-type interconnection among the meat producers and the fodder mixture producers shows up significantly, which supports functionality of this transmission in poultry breeding. Knowledge about the regularities of the prices and their mutual links seems as fundamental with regard to the existence of the economic limitations that may influence allocation of wheat in the production chain.

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Vision Statements and Road-Map Methodology for Knowledge Management Adoption

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Abstract

The present paper describes the strategy of introducing future knowledge management system at farms. The FUTUREFARM and PREZEM projects strive to apply new knowledge management methods in arable farming where they guarantee an easy adaptation of the farming sector to the everchanging conditions in short, middle and long-term perspective. The knowledge management methods have to be put into practice on strategic, tactic and operational planning levels. Based on the project analysis and workshops with farmers, the paper brings an outline of the main goals and obstacles for new knowledge management methods adoption and furthermore defines the target groups and relevant methods of dealing with them.

Key words

Knowledge management, adaptation, arable farming.

Anotace

Příspěvek popisuje strategii pro zavádění budoucích systém znalostního managementu v zemědělských podnicích. Projekty FUTUREFARM a PREZEM si kladou za cíl zavést nové metody znalostního managementu do rostlinné výroby, který zajistí adaptaci zemědělství na měnící se podmínky ve světě a to jak v krátkodobém, tak i střednědobém a dlouhodobém časovém horizontu. Metody znalostního managementu musí být uplatněny na, strategické, taktické a operativní plánování na úrovni zemědělského podniku. Na základě analýz a workshopy s farmáři článek definuje hlavní cíle a překážky pro přijetí nových metod znalostního managementu, a definuje cílové skupiny a relevantní způsoby, adopce znalostního managementu.

Klíčová slova

Znalostní management, adaptace, rostlinná výroba.

Introduction

The objective of knowledge management is to help farmers in their efforts to be competitive as for product requirements, quality and quantity supplied. Furthermore, it helps them not only respond to market changes, subsidies system changes and environment protection requirements, but also react for example on increased input costs or climate changes. It is also important to produce with a perspective of long-term farm sustainability, to protect soil as the main means of farming production. Future farm knowledge management systems have to support not only the direct profitability or environment protection, but also

activities of individuals and groups allowing effective cooperation between and among agri-food industry, consumers and wider communities, especially in the rural domain. Having the above considerations in mind, the proposed vision lays foundations for meeting ambitious but achievable operational objectives; objectives that will definitely contribute to successful fulfillment of the identified needs in the long run.

Knowledge management represents an ongoing relationship between and among people, processes and technology systems involved in designing, capturing and implementing the intellectual infrastructure of an organization. Moreover, it encompasses essential changes in management attitudes, organizational behavior and policies. Knowledge management should create both values for the customer and profit for the firm. It is clear from the definition that knowledge management is one step ahead of the simple information systems concept as it entails other two significant factors: people and processes. The relationship of the latter should be ongoing, constant and variable; which is the principle of the concept of adaptive knowledge management. Economies grow, develop, and change incessantly.

Social organization of farmers' decision-making

The Future Farm study on social organization of farmers' decision-making analyzed the farming structure in different European countries and the way precision farming adoption progresses in these countries. In many European regions the precision farming was considered a current issue, but not the one enjoying an increasing interest. It was stated that political will and support to these technologies is not really demonstrated yet and therefore their potential is not exploited fully.

In Germany, the Czech Republic and Denmark several site specific technologies have been already put into practice. However, in other countries, such as Greece for instance, small farm size and financial constraints together with a generally lower level of agricultural education hamper the adoption of precision farming.

It was also recognized that agricultural technology firms and private consultants are considered as the main driving force for precision farming adoption. Interviewees pictured that a typical Precision Farming farm is usually larger in size and run by relatively young and highly skilled managers. The role of consultants is important as for site specific crop management where they could be regarded as intermediators or partners, facing though high expectations and pressure. European farmers still prefer to communicate directly over phone instead of using emails, but web pages play an increasingly important role. Farm data is considered commercially sensitive and farmers keep on preferring personal and face-to-face contact with their consultants.

While the communication between farmers and authorities is expected to shift towards online electronic methods within the next ten years in Germany and Denmark, this process has already been partly set up in the Czech Republic and is supposed to be rather slower in Greece.

Joint investment in PF equipment was reported by a few experts and only in case of smaller farms. In general, farmers and contractors prefer to own their machinery. It was considered quite common that farmers operate as contractors themselves to run their machines up to full capacity. Contractors usually use modern technology and they are able to employ specialized and skilled staff thanks to the scale effects. There is a tendency towards offering field services and consultancy at the same time. Site specific tools can be used to document the contractors' performance on the field. Farmers remain land owners and decision makers regarding crops. The Precision Farming industry will have to face increasing contractor requirements concerning compatibility and software solutions for data management.

Non-compatibility of solutions constitutes a significant problem as it has forced customers to purchase solely products of one single provider. Compatibility problems have delayed the adoption of site specific crop management and can still be considered as the most important barrier to investment. We therefore assume that as soon as the Precision Farming technology works trouble-free and economic benefits can be clearly demonstrated according to the kind of client (cooperative, farm, contractor etc.) the technology will develop and spread similarly to mobile phones and become a common standard.

Farmers do not search for hyper-mechanization. Their premise is to register and administer the useful and to report the inevitable. Precision Farming is adopted when economic reasons such as high input prices or environmental regulations are favourable and/or certain barriers are removed. Introduction of site specific technology also happens by evolutionary replacement of old machinery while new machinery is increasingly equipped with site specific on-board technologies. Integrative and easy to handle solutions are needed. Critical discussion on possible ecological benefits of the PF and its practicability should be deepened and intensified.

SMEs environment and culture

As for the number of employees, farms usually belong to small or medium size businesses within the framework of which the knowledge management and internal processes are obviously different from the large ones. Employers need to integrate many heterogeneous skills, such as for example gathering up-to-date information on market tendencies, innovations and new competitor product developments from close contacts with customers. On one hand, SMEs environment can facilitate knowledge management but there are also factors that impede its successful implementation. SMEs managers have a limited amount of time to deal with knowledge management and they are restricted to day-to-day activities that are vital for the survival of their businesses. Systems and procedures are not formalized, restraining the adoption and insertion of a formalized knowledge management system. Moreover, staff is inadequately qualified for the operation of information systems and needs further training, which is a time-consuming and costly option. On the other hand, knowledge management can improve decision-making, learning, innovation, efficiency, competency and value creation. That is why farming should reconsider long-term advantages of adopting such a system and invest more time and funds in this direction. In addition, the tacitness of farmers' know-how is another characteristics to be treated carefully. Tacit is the knowledge that cannot be verbalized and stems from personal experience, insight, beliefs and values. It remains in people's mind and should be externalized in order to add value. Explicit knowledge on the other hand can be articulated and is usually stored in databases.

Mission of service organizations

The study provided by Ganicky on the crucial question of precision farming adoption, i.e. on when the precision farming is or could be profitable. It is however difficult to answer this question by any published profitability review as there are

- incompatible approaches to economic analyses

- costs often overlooked

- benefits with ill-defined values

Economic analyses may focus on short and/or long term. Short-term evaluations require that immediate improvements from Precision Farming provide sufficient revenue to cover all costs of its adoption. Long-term evaluations allow returns to occur at various magnitudes over a given period. For instance, a long-term evaluation may reveal that the initial few years of Precision Farming adoption generate little or no additional revenue, but in later years, the sequential accumulation of knowledge and improvement in management can lead to significant returns. Both types of the above analyses are needed to address various financial requirements and objectives of farmers. There are still many difficulties in providing a complete accounting of costs and benefits, so economic analyses can vary considerably in their completeness and conclusions.

Is the PF more profitable than traditional farming? That is a key question. There exist a lot of studies dealing with Precision Farming economy. None of these studies attempted or considered the environmental costs and benefits of precise placement and reduced use of agricultural chemicals. Pollution from farm chemicals to the environment does not yet have a significant cost directly charged to the farmer.

In order to illustrate the costs and investments of transition from traditional to Precision Farming, let's analyze the effectiveness and indispensability of these investments. Economically effective management of within-field variability means - in other words - that a well-trained farm manager makes correct decisions based on complex information and that these decisions are precisely

implemented. As far as the investments are concerned, financial requirements are as follows:

1. The role of management in Precision Farming is crucial and therefore investment into education and training of farm management cannot be avoided. This investment into human capital belongs to fixed costs.

2. High quality information is the basis of effective management. Therefore initial investments into boundary mapping, soil sampling, management zones identification, GIS mapping etc. are also inevitable. These investments should be viewed as durable and their costs should be amortized as a fixed cost over a number of years.

3. Implementing farm management decisions in fact means to cultivate fields. All costs of this type are considered to be variable and are inevitable.

4. To operate fields, appropriate Variable Rate Technologies (VRT) and other technologies such as e.g. a GPS-receiver, yield monitor, computer, GIS and other software, VRT application equipment etc. are required. All this equipment makes part of a durable capital investment. Furthermore, there are other fixed costs such as depreciation, interest on investment, insurance costs associated with durable capital (that means the above-mentioned equipment). These investments are however evitable.

The investments and fixed costs associated with purchasing VRT application farm equipment usually constitute a substantial part of all investments made and costs encountered by a farmer when adopting Precision Farming.

However, when do all these investments become effective? Farm equipment such as a yield monitor, VRT application equipment such as a VRT fertilizer spreader, VRT herbicides/pesticides sprayer etc. can operate specified field area size per season – let us call it the Duty Cycle (DC). As soon as the field area size is smaller than the DC, a farmer can never capitalize on the VRT equipment purchased. Thus, part of the investment and part of the fixed costs such as depreciation, interest on investment and insurance costs are a mere waste of money. In other cases, financial requirements of adopting VRT may cause financial difficulties to a farmer.

In any case, effective use of PF management may require development of the knowledge base, experience and accumulating information about fields and their productivity over several years.

In all above-mentioned cases, a farmer may decide to hire the VRT equipment, yield monitor and other technology (e.g. a GPS) together with the consulting services of specialized firms. As a rule, these firms are better equipped with modern VRT machines while having at the same time highly qualified specialists and offering full service (for example GPS field boundary mapping, soil sampling and management, zone establishing, fertilizer recommendation, fertilizer prescription and VRT application). Such operating leases are offered on a variable cost basis – i.e. priced per hectare or per day of operation. For smaller farms, and in any case for a novice to PF management, this way of operating fields is both an optimal and least expensive option.

Outsourcing is a model that can bring farmers fixed cost reduction and PF profitability at the same time. Farmers purchase services from a service organization and as a result, fixed costs are turned into variable costs. Technology on the part of a service organization is used for a longer period and more effectively and thus the cost of the process is reduced. And this is in a nutshell the principle on which the Future Farm business model is based.

Overview of strategies for implementing and adopting adaptive knowledge management

Adaptation means that farms should be in the position to get changed and respond effectively to new situations faced. Innovation is the key to that direction and can provide a sustainable advantage. Close relationships maintained between customers and SMEs give insights to market tendencies, new product developments, competitors' way of doing things so new ideas and propositions are coming to the organization that can change the structure, orientation and strategy. Innovation derives from the combination of previous and new incoming knowledge. In order to achieve it, farms can capture and store previous knowledge through keeping records, archiving short reports concerning work processes and procedures written by the employees and though creating small databases. The reports

can take the form of case studies on project problems, trouble shooting, the lessons learned and the best practices. So, farm employees can help in knowledge storage by developing guidelines, best practices, expertise notes, work flow charts etc. that will be easily accessible as accumulated wisdom in future projects (Hasgall and Shoham 2008). As a result, strong organizational memory will be created, having the infrastructure to acquire and record previous experience, exploit it and integrate it with new knowledge, the stage where innovation process has been successful. However, a vast majority of information is irrelevant to organizational needs - that is why farms should establish a feedback system in order to measure the relativity, relevance and importance of information. The greater the information diversity is, the higher the chance to extract new knowledge. Organizations accomplish it through creative thinking, past experience reflection and combination of knowledge from different fields. The capture of expertise, knowledge assets reuse and assets tagging are the prime mover of the innovation process and allow the firm to respond to change (Sherif and Xing 2006, Taminiau at al. 2009).

Information availability and accessibility are another concern to be taken into account by the farms. The introduction of intranet and information technologies enables successful knowledge sharing implementation. Links to discussion forums and interest groups facilitate the exchange of ideas between and among people living in different regions and countries. People sharing their interests can join chat rooms, whiteboards, instant messaging services, shared calendars etc. to discuss, give and take responses on their topic of interest. This method simplifies the solution discovery process, shortens the time spent and broadens employees' perspective as different opinions are heard and new explicit knowledge is created by combining previous and new knowledge.

Adaptive systems require a decentralized power system where employees will be given the prerogative to act quite independently and not under a constant restriction of the power units within the firm. Namely, employees are free to express their ideas, follow the paths of their own imagination and constructive thinking, take initiatives and explore new ideas. In such a system the hierarchy of power does not restrict or interfere with the development of personal interests. Therefore, such a system should empower employees' abilities and their access to resources and ensure the parallel achievement of organizational goals, needs, abilities and use of available technology within the firm. Furthermore, knowledge sphere can be renewed and updated constantly in order to create value for the firm. Computerized information systems might offer a critical tool for updated information sources such as documents, experts and sources from out of the organization (Wong and Aspinwall 2005, Ang and Massingham 2007).

Training opens the way for constant updating, capture and sharing of skills. Usually, businesses do not take advantage of the knowledge accumulated in older people. On the contrary, older people do not get good treatment from employers who are seeking to replace them with new young employees who are eager to learn, work hard and maybe are better trained according to market trends, new technologies and organizational needs.

As a result, adaptive knowledge management systems require flexible practices that can be adjusted to each case and circumstance according to the availability of resources given to the farms. Innovation is not completely independent and can be influenced when designing and controlling the right environment within the firm. Implementing a communication-friendly culture and ideas sharing atmosphere will ultimately lead to desired outcomes and performance.

Prague workshop discussion

A validation workshop called "Strategies of Knowledge Management Adoption" was held within the framework of the Information Systems in Agriculture and Forestry 2010 conference in Prague.

It was concluded that knowledge management in agriculture production is adopted on many different levels as for using IT and professional services supported by universities or service organizations (either through government or private sector). Precision Farming plays an important role in this adoption process. Farmers involved in precision farming technologies are more flexible to work with computers or use high level technology in crop production, animal production or farm management.

Every farmer is seeking to increase productivity, yield in crop production and to maintain a good quality of production. However, the conditions on the field are not homogeneous! Precision farming system monitors the farm condition using the GPS system for crop production. Then, according to the data analysis a variable rate application for a specific place in time is prepared. Farmers monitor the conditions by data collection and analysis, then prepare fertilizer at variable rate and apply it in accordance with soil conditions, nutrient content in the soil and crop needs.

The description of Knowledge Management – step by step adoption of precision farming tools at a farm:

- Farmers who expect to profit from all the above-mentioned objects have to make up their mind on which one is the most feasible for their farms.

- Farmers do not have to make a substantial investment in the first year and then depreciate part by part every year their investment and wait for results.

- Precision farming tools can be adopted during a period of three to five years, but first results have to be seen even in the first year of its adoption.

Nowadays, many precision farming tools and IT systems exist. A farm central database must be established in order to archive different pieces of information that are processed and used in the decision-making process. Practically, farmers use computers not only for calculation or managing some work processes, but as well to seek important information on the Internet - web services.

The most important discussion notes are as follows:

- many farmers are skeptic to farm KM via information technology

- farmer's point of view: make investments into machinery rather than into KM

- first goal of farmers – farm stability using common tools rather than new technologies

- generation change, survival game

- profit rate, Which rate of profit growth is interesting?

- crop rotation - crop focus on market needs

- different regions, finding right segments for farm development

- different production, different KM (food, energy and bio-fuel, sport- culture), definition and focus

- efficiency of bio-mass energy, newly developed tools and technologies with higher profitability

- living style of farm owners and family farms

- different nature of farmers in the US and in Europe, significant difference in profit approach and creation

- taxes on fertilizers and chemicals in different locations, government stimulation and incentives to use KM at farms

- service people expect pressure from state administration, goods import and exports terms and condition, restrictions etc.

- computer user design, simple use of IT, touch screens, wireless data transport, web support communication.

An open and receptive culture where farmers will be willing to share ideas, experience and new knowledge in an open dialogue and to socialize at the same time must be inspired, motivated and taken care of by managers and leaders. The change of culture must be attached to incentives that will be offered to those adopting and implementing knowledge sharing. This can take the form of a salary increase or providing some other facilities the employees may require. Moreover, a culture which accepts the possibility of making a mistake instead of the safe and ordinary way of doing things must be enforced as it leads to innovation through experimentation.

Individual farmers could come up with knowledge through observation of their own farms where employees can be also asked to write small reports about their project in order to keep records of the progress made and creating a small and cost-effective database in this way. Information availability and accessibility through networking, journals and conference proceedings, databases etc. is a must. On the farm level, training that would include visits to competitors to see their procedures,

job rotation, induction or tutorial (experienced employees induce apprentices or trainees) has to be supported. Managers have to participate in discussion forums and interest groups. It is necessary to organize experience swapping sessions, conferences, exhibitions, seminars with external speakers and to distribute the results of them and also, to organize informal meetings or lunchtimes. It is as well important to involve advisors, innovation centers and have close relationships with universities. The role of journals, informal interviews, conference proceedings etc. is undoubtedly vital in knowledge capture and sharing.

Based on both previous experience and workshop discussion, it is obvious that knowledge management adoption will not be the same on a global or European scale and it goes without saying that not all farms will adopt the KM methods immediately. There are differences among the individual countries, but also inside the countries as such.

Criteria to be considered for the adoption strategy:

- economic criteria – given by the structure of the farming sector (scale, products)

- social and demographic criteria (age and education of farmers)

- cultural criteria – different farming tradition in individual countries

All these aspects have to be included into the Future Farm roadmap. According to the FMIS target market, there exist two ways of solution implementation, each of them having different strategy:

- deliver software as a final product

- offer knowledge management services (Software as a Service – SaaS), not the product itself

Experience acquired in different countries shows that both ways are viable while considering and adopting different strategies.

Roadmap for Future Farming adoption

The roadmap for adoption is about identifying key stakeholders of the project, assessing their interests and power, and planning appropriate forms of engagement with these groups. The analysis aims at defining relationship with different stakeholders and communication strategy for the single groups. This strategy is defined firstly for adopting the ICT platform for knowledge management and secondly as an adoption of KM services.

Platform adoption strategy

Stakeholder	The aim of the relationship	Plans to Communicate
Farmer association, consultants and service organisation	The three groups are the most important partners for platform adoption as the whole. They can attract individual farmers to use the service they provide. These groups constitute potential platform customers.	Direct communication and demonstration is necessary. Exhibition and other similar events are important for establishing and building personal relationships. This has to be combined with standard communication using the existing channels such as the Internet (eventually social networks), newspapers, magazines, TV, radio. The uttermost priority is to establish personal contacts and provide personal demonstration.
Agriculture technology producers Food business	The food business, but also technologies providers and software developers could be potentially good partners. The biggest problem is that all three groups have provided substantial investments into the development of their own platform. It means they will consider	It is necessary to analyze in detail the systems they currently use and to offer complementary components to their services at the beginning. Direct communication and demonstration is necessary taking the form of exhibition and

Agriculture software producers	the future farm solution as a competitive product/system. The only chance is to explain them advantages arising from joining the future farm solution.	conferences.
Big industrially managed farms, smaller young farmers, universities	These three groups will be highly interested in the system, but their potential for direct platform deployment is quite limited. (However, there is an expectation, for example from WIMEX that started the AgroSat company.)	The communication has to be provided through standard communication tools and using the existing communication channels such as the Internet (eventually social networks), newspapers, magazines, TV, radio.
Small older farmers	The potential of this group as for deploying the platform is almost none.	No specific action required

Table 1.

Adoption of knowledge services strategy

Stakeholder	The aim of the relationship	Plans to Communicate
Young small farmers Large industrial farms Farmers association Consultants Service organizations	These are the most important groups for FF services adoption. These services have to be offered in the form Software as a Service. It means they will use future farm platform provided by FF team members.	Direct communication and demonstration is necessary. Exhibition and other similar events are important for establishing and building personal relationships. This has to be combined with standard communication using the existing channels such as the Internet (eventually social networks), newspapers, magazines, TV, radio. The uttermost priority is to establish personal contacts and provide personal demonstration.
Food business	Key player on the market that can profit from the Future Farm system. Previous investment into their own platform and low willingness to use external systems are a real problem.	It is necessary to analyze in detail the systems they currently use and to offer complementary components to their services at the beginning. Direct communication and demonstration is necessary taking the form of exhibition and conferences.
Service organizations	Service organizations could be system providers that will introduce the system in regions. The strategy based on selling services can introduce the system without any big investments.	Direct communication and demonstration is necessary. The communication has to be provided mainly through service organizations.
Universities	Universities could use the FF system for educational and research purposes, but they can also offer their consultancy through it. The strategy	Direct communication and demonstration is necessary mainly using the Internet and social networks.

	based on selling services can introduce the system without any big investments.	
Small older farmers	Low potential market, difficult to attract this user group to FF services.	Exhibition

Table 2.

Implementation Strategy

As we have already mentioned earlier, the system is focused on offering services – a strategy with a high market success potential.

Firstly, offering services to final users – farmers - through partner service organizations.

Secondly, finding new partners - potential service providers. The strategy is mainly to offer services under the form of Software as a Service (see above). The profit is normally generated from the services on the basis of costs per hectare payment.

An alternative strategy will be to search for a bigger potential seller of the system (machinery producers, software developers). Chances to succeed on this market are lower, but on the other hand, there exist a potential for different kinds of disclosure or non-disclosure agreements.

Conclusion

Basic strategy of increasing fast the precision farming position and knowledge based system is to offer mostly the services that can attract more local providers, because the initial investment will not be necessary. On the other, this strategy also enables entering new markets quite cost free, without any investment.

At first, the services have to be offered in regions by single project partners as it is obviously difficult to attract the global market immediately.

The market position can be rapidly built and improved by and through

- strategic partnership with food business

- strategic partnership with machinery producers

- strategic partnership with software producers

Main potential threats arising from team cooperation:

- - clash of interests in the team
- - insufficient economic power to grow
- - competitors can copy our solution

Successful implementation of the afore-mentioned strategy requires the following:

- team cooperation on future implementation strategy
- clearly defined spheres of interest
- establishing member management board
- regular checks upon the indicative numbers, comparison with reality and implementing relevant changes in time
- looking for strategic partners

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Selected approaches of variables weighting in frame of composite indicator analysis

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Abstract

Composite indicators are useful as tool for complex evaluation and aggregation of different variables of regional development. Variables which are aggregated in a composite indicator have first to be weighted. All variables may be given equal weights or they mea be given differing weights which reflect the significance, reliability or other characteristics of the underlying data. The weights given to different variables heavily influence the outcomes of the composite indicator. Aim of this paper is an evaluation of selected methods for weighting of particular variables in frame of composite indicator construction. Evaluation is verified on group of regional economic variables based on Strategy of regional development.

Key words

Composite indicator, region, principal component analysis, expert.

Anotace

Souhrnné indikátory jsou užitečné pro souhrnné a komplexní hodnocení různých ukazatelů regionálního rozvoje. Proměnné, které jsou zahrnuty do souhrnného indikátorů, mohou být ohodnoceny stejnými nebo různými vahami. Váhy pak můžou odrážet významnost, věrohodnost nebo různá specifika podkladových údajů. Přidělené váhy pak mohou výrazně ovlivňovat výsledek hodnocení. Cílem příspěvku je zhodnotit vybrané metody vážení a ověřit, zda některá z testovaných metod je vhodná pro komplexní zhodnocení ekonomik regionů. Analýza je založena na proměnných a datech pocházejících ze Strategie regionálního rozvoje.

Klíčová slova

Souhrnný indikátor, region, analýza hlavních komponent, expert.

Introduction and aim

The structural policy of European Union focuses on regions with declining industries, distant and rural regions. Its target is to reduce their backwardness and provide balanced and sustainable development through development programs and projects. For the identification of less developed or backward regions there are different standards exploited, these are often based on a one-dimensional point of view (e.g. level of 75 % GDP) [3]. As illustrated, GDP is an important indicator; nevertheless it is not the only important indicator for the evaluation of development and the level of regions [8], [11]. The multidimensional point of view on the regional development appears to be more appropriate. The use of multi-criteria framework is a very efficient tool to implement a multi/inter-disciplinary approach [10]. It is asserted through so called composite indicator. Composite indicators – which are synthetic indices of individual indicators – are being developed in a variety of economic performance and policy areas. The proliferation of composite indicators in various policy domains raises questions regarding their accuracy and reliability. Given the seemingly ad hoc nature of their computation, the sensitivity of the results to different weighting and aggregation techniques, and continuing problems of missing data, composite indicators can result in distorted findings on regional performance and incorrect policy prescriptions.

Variables which are aggregated in a composite indicator have first to be weighted. All variables may be given equal weights or they mea be given

differing weights which reflect the significance, reliability or other characteristics of the underlying data. The weights given to different variables heavily influence the outcomes of the composite indicator.

Aim of this paper is an evaluation of selected methods for weighting of particular variables in frame of composite indicator construction. Evaluation is verified on group of regional economic variables. For its achievement there has been set a few partial aims:

A) Selection of weighting's method

B) The valuation of region's position with the regard for results of weighting

Material and methods

The model of the aggregate indicators and the ways of weighting has been applied on chosen indicators of the theme of SRD Economics of regions. The indicators have been chosen on the basis of expert decision, 7 experts participated (4 from the sphere of research, 2 from the sphere of the regional development of regional authorities and 1 from the Ministry for regional development) and on the basis of the statistic methods of the cluster and the correlation analyses. The selection itself is not the content of this article.

These indicators have been chosen:

GDP per capita, share of employed in construction, unemployment rate, average wage, registered job applicants, share of traders and research and development expenditure. The resources of indicators for the years 2007 have been the regional yearbooks of The Czech Statistical office.

The verification of chosen method has been applied on group of 13 regions NUTS3 in the Czech Republic excluding the capital city Prague. The city Prague is featured by specific position compared to other 13 districts, it only consists of city and for period of time before the year 2007 it was restricted from the structural funds. The work is focused on the modeling of multidimensional statistic methods whose analytical apparatus enables complex analyses mutual incidence relevant indicators.

Also has been selected method of construction of composite indicator. Based on [6] it is Ratio-Median method (RMCI), this indicator was defined

$$RM^{CI} = \frac{\sum_{j=1}^{m} y_{ij} \cdot w_j}{\sum_{j=1}^{m} w_j}, \qquad (1)$$

where

$$y_{ij} = \frac{x_{ij}}{\tilde{x}_{.j}} \qquad (2)$$

Note: index i represents region; i = 1, …., 13 and index j variable; j = 1, …, m; where m is number of variables; xij is original variable; $\tilde{x}_{.j}$ is median of the variable; wj is weight of the variable.

Selected approaches for weights wj determination

As is written above, each variable can be given equal or different weight. Different authors such as Freundenberg [4], Saisana [12] or Svatošová [13] have outlined a range of ways of the weights´ determination for the tracked indicators. Also Grupp and Schubert [5] stress to use weights included in composite indicator, but authors mention that composite indicator should be sensitive to weight changes. The multivariate analysis of principal components seems to be appropriate for the exact appraisal of weights on the basis of primary indicators. Weights can be determined also subjectively on the basis of external decision; this approach has been chosen in the field of environment in the work [7].

PCA – principal component analysis seems to be suitable for the identification of factors and analyses of disparity. The method has been thoroughly theoretically illustrated in [1] and [9].

The method is based on covariance matrix or correlation matrix of input variables from whose the set of eigenvectors of this matrix is obtained, that all is done to represent the variance of primary data as well as possible. The target is to find hidden quantities represented as principal components describing the variability and the dependence of variables. In other words, the method has been trying to express the primary variables with the help

of fewer independent fictive variables which can not be directly measured, but might have certain factual interpretation.

The result of analysis of principal components is consecutive components depleting the maximum of remaining variance of set of variables which are mutually independent. The correlation coefficients of primary variables with gained components are usually the base for the interpretation of the principal components. These correlation coefficients are usually described as component weights. With regard to use of the principal components analysis in the evaluation of regional development, it is possible to refer to work [13] in the field of disparities analysis among regions or [12] in the case of construction of variable's weights.

For the selection of suitable method of weighting is one important requirement thought: weights enable differentiate observed variables

Selected approaches are defined:

PCA^{SUM}

$$w_j = \sum_{s=1}^{r} \left| r_{js} \right| \cdot \mathrm{var}_s \qquad (3)$$

PCA^{SELECT}

$$w_j = \left| r_{js} \right| \cdot \mathrm{var}_s \qquad (4)$$

EXP

$$w_j = \frac{pr_j}{k} \qquad (5)$$

Note: wj is weight of the variable, $\left| \mathrm{rjs} \right|$ is absolute value of the correlation coefficient, index j represents variable and index s selected component, vars is share of variance explained by selected component; j = 1, …, m; where m is number of variables; s = 1, … , r; where r is number of selected components; prj is number of assigned preferences, k is number of experts, it express maximal number of preference that could be assigned (in our case 7).

Method PCA^{SUM}

By the share of explained variability of single chosen components (we do not work with all of them, only with those which represent adequately large proportion of primary variability, usually 70 – 90 %) and correlation coefficients of indicators with those components have been determined the weights for each indicator. The weights may take values from 0 to 1 and are expressed in an absolute amount (all of them are stated with the positive sign).

Method PCA^{SELECT}

The second method is also based on the analysis of the main components. The correlation coefficient which is for certain indicator under the chosen components highest is crucial for determination of the weight of each indicator. The proportion of variance, which is explained by the certain component, is also included in the calculation (we do not work with all the components as it was in the case of the method PCA sum, but only with those which represent the sufficient proportion of the total variability, so it is based on the reduced model). The weight can take values in the interval from 0 to 1.

Method EXP

There are weights assigned by subjective opinion of chosen experts of regional development to each indicator in each thematic area. Each thematic area was evaluated by 7 experts, the indicator can theoretically obtain maximum of 7 points and the minimum was 0. The weight can range from 0 to 1, including 0 and 1.

Results and discussion

A) Selection of weighting's method

The composite indicator is possible to calculate in its weighted and non-weighted form. If we knowingly and purposely do not weight the indicators, we automatically allocate the weight 1 to all indicators. Although it is possible to weight them and to allocate higher preferences to chosen indicators which are considered to be more important. The weight can be calculated either accurately or subjectively. We are going to answer the question if and how it is suitable to weight the indicators in our thematic sphere in the following evaluation where there are chosen methods of weighting compared. The weights make sense if

they difference the indicators. If the weights are balanced, it loses sense to include them in the composite indicator. There are three different methods of calculation of weights: According to the PCA^{SUM} method calculated by the formula (3) and also according to PCA^{SELECT} method (4) and EXP method (5). In the thematic sphere Economics of regions where there have been more indicators available to which experts allocated preferences, there was lower variability of weights allocated by experts. In the mentioned sphere there was the variability zero, the experts identically allocated to all important factors-indicators 5 preferences out of 7. However the height of the weight on the basis of expert method is largely influenced by the small number of experts. It makes it impossible the weight to take the values in the interval from 0 to 1 and realistically can take the value of 8 possible heights in the case of our 7 experts. From this point of view the method didn't present to be suitable.

The highest variability of weights in most of the spheres can be traced when using the PCA^{SELECT} method which enables to emphasize differences in the evaluation for the importance of chosen indicators. The steadiest height of weights in most of the spheres is perceptible when using the results of PCA^{SUM} method.

In the thematic sphere Economics of regions there has been lower fluctuation of weights registered in the case of PCA sum method. Weights were ranking within the interval 0,43 to 0,46 excepting the indicator of the share of employed in construction (0,20) and the share of traders (0,26). In the case of PCA select method, there also occurred higher preference of indicators which are generally used for basic description of regions (GDP - 0,40, unemployment - 0,38, number of applicants - 0,36). There has higher differentiation of weights appeared. The variables with the highest weights were the share of employed in construction (0,15) and the share of traders (0,16). It is perceptible that the indicators with markedly lower preferences were separated from the group of indicators with higher weights both when using PCA sum method and PCA select method. Nevertheless, PCA select method enabled to difference the weights and that is why this method is considered to be the more suitable.

B) The valuation of region's position with the regard for results of weighting

This part of paper is engaged in utilization of weight in composite indicator calculation. Enable weight differences among variables? Influence including weights ranking of regions? Evaluation was based also on the same group of economic indicators. In the table 2 are results of composite indicators computed in weighted or non-weighted form. Non-weighted form represents approach, where weights are equal to 1. Weights in weighted form are computed using method PCA^{SELECT}.

Differences in ranking of regions are not large, but some dissimilarity is evident. Minimum of differences is visible on the fringe of ladder, e.g. first and second place and twelfth and thirteenth. On the contrary, the most number of changes was using weights caused roughly in the middle of ladder. According these results can we say, that weights have important role in regions ranking. Including or excluding of regions in or from the group of financial supported regions is very sensitive question. The best ranked regions as a rule are not supported, the worse ranked are supported. But where is the limit? The limit for supported and the rest is anywhere in the middle of the ladder.

Conclusion

There has been a methodical instrument for the evaluation of regional development suggested in this work. It has been verified on selected indicators of the economic regions sphere. The suitable method for the evaluation of position of the regions has been chosen, the method has been modified by author to suit even better the primary requirements. Also there has been possible of engaging the weights to composite indicator considered. The choice of weights can be influenced by special interest groups, it is why is possible to recommend rather exact and objective methods for their assessment. The important base for the determination of the composite indicator is the quantity of data, which is important to gather for all primary indicators. The missing indicators lower the quality of analysis. The method PCA select has been chosen for the calculation, it has enabled to differentiate the indicators the best.

Variable	PCA^{SUM}	PCA^{SELECT}	EXP
GDP per capita	0,43	0,4	0,71
Share of employed in construction	0,2	0,15	0,71
Unemployment rate	0,45	0,38	0,71
Average wage	0,44	0,29	0,71
Registered job applicants	0,45	0,36	0,71
Share of traders	0,26	0,16	0,71
Research and development expenditure	0,46	0,31	0,71
Variation coefficient of weights in %	28,08	34,69	0

Table 1. Results of weights according to used methods.

Region	Value of CI		Ranking of regions based on	
	$RM^{CI}n$	$RM^{CI}w$	$RM^{CI}n$	$RM^{CI}w$
Středočeský	1,60	1,72	1	1
Jihočeský	1,20	1,23	3	3
Plzeňský	1,35	1,45	2	2
Karlovarský	0,83	0,79	13	12
Ústecký	0,83	0,79	12	13
Liberecký	1,02	1,03	7	8
Královéhradecký	1,00	1,04	9	7
Pardubický	1,18	1,22	4	4
Vysočina	1,05	1,07	6	5
Jihomoravský	1,01	1,00	8	9
Olomoucký	0,91	0,88	10	10
Zlínský	1,06	1,07	5	6
Moravskoslezský	0,87	0,84	11	11

Note: RMCIn = composite indicator with weights = 1; RMCIw = composite indicators with weights PCASELECT.
Table 2. Values of composite indicators according to used methods

With the equal weighting approach, there is the risk that certain performance aspects will be double weighted. This is because two or more indicators may be measuring the same behavior. With the different weighting approach, greater weight should be given to components which are considered to be more significant in the context of the particular composite indicator. The relative economic impact of variables could be determined by economic theory or through empirical analysis, particularly by methods based on correlations among the sub-indicators. To be useful for policy, weights need to reflect the relative importance of individual indicators in determining performance outcomes.

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The Optimization of Pastry Delivery for NOPEK Bakery in Vysoké Mýto

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Abstract

While transporting some material a circular way of the transportation is usually applied. Usually due to some capacity or time constraints or other reasons it is necessary to use more routes (i.e. more vehicles, or one vehicle must go out from its home place more times). This case is called the vehicle routing problem and there exist many types of this task because of the variety of reasons causing the necessity of use more than one route.

Practically all the vehicle routing problems belong among the so-called NP-complete or NP-hard problems. This means that there exists no effective method which would succeed in finding a precise theoretical optimum for them. In such tasks, we can employ different approximation methods which provide us with solutions similar to a theoretical optimum and acceptable as an economic optimum.

In practice, however, companies seldom pay enough attention to dealing with such problems, especially if transportation is not their principal work load and if it concerns a transportation task of a medium size.

This article presents a case study of NOPEK Bakery in Vysoké Mýto. It demonstrates the effectiveness of the approximation method during the planning of the bakery products delivery to its customers. By the optimization of one of the so-called "fast deliveries", we succeeded in the reduction of the number of vehicles needed for the delivery – about 18% – which turned out necessary. Similar savings of all "fast deliveries" in the company may lead to the reduction of tenure price (tenure fixture) by 17 mil. CZK. At the same time the profit will increase by 0.6 mil. CZK and profitability will go up by 2.5%. We also managed to ensure a balanced use of the vehicles. This made it possible for the bakery to deliver the goods to its customers in deadlines that they found more convenient.

Key words

Bakery products delivery, vehicle routing problem, heuristics (approximation method).

Anotace

Při rozvozu či svozu určitého materiálu je obvykle výhodné využívat okružní způsob. Většinou je třeba z důvodu kapacitních nebo časových omezení použít k rozvozu více tras (tj. více vozidel nebo jedno vozidlo musí jet vícekrát). Takováto úloha se nazývá trasovací problém. Vzhledem k tomu, že důvody omezení vedoucí k nutnosti použití více tras mohou být různé, trasovacích problémů existuje mnoho typů.

Téměř všechny trasovací problémy patří mezi tzv. NP-úplné nebo NP-těžké problémy. To znamená, že neexistuje žádná efektivní metoda, která by dokázala najít jejich přesné teoretické optimum. Pro takové úlohy lze ale používat různé aproximační metody, které dávají řešení blízká teoretickému optimu přijatelná jako ekonomická optima.

V praxi ovšem firmy často nevěnují řešení těchto problémů příliš pozornost, zvláště pokud doprava není jejich hlavní pracovní činností a pokud se jedná o dopravní úlohy střední velikosti.

Tento příspěvek ukazuje na případové studii pekárny NOPEK z Vysokého Mýta, jak může aplikace aproximačních metod pomoci při plánování rozvozu pečiva zákazníkům. Při optimalizaci jednoho z tzv.

„rychlých rozvozů“ se tak podařilo snížit počet vozidel, která byla zapotřebí, o 18%. Podobná úspora u všech „rychlých rozvozů“ ve firmě může znamenat pokles ceny majetku (vázanosti kapitálu v tomto majetku) o 17 mil. Kč. Zároveň dojde ke zvýšení zisku o 0,6 mil. Kč a ke zvýšení rentability až o 2,5%. Navíc jsou vozidla rovnoměrněji využita, čímž odběratelům může být dodáno zboží v termínech, které jim lépe vyhovují.

Klíčová slova

Rozvoz pečiva, trasovací problém, aproximační metoda.

Introduction

Rozvoz pečiva, trasovací problém, aproximační metoda.

The problem of the delivery optimization of a specific material can in reality be encountered with very often. The delivery is usually realized by a circular or round trip which, in comparison with the realization of each route from the supplier to the consumer, saves expanses for individual gateways from the same supplier and/or trips to one consumer. There exist many tasks of this kind and in general they are referred to as vehicle routing problems (VRP). Most of them belong among the so-called NP-complete or NP-hard problems. This type of tasks is distinguished by a non-existent effective algorithm which would be able to find their precise theoretical optimum. All known approaches capable of this task need the number of operations increasing exponentially with the growth of data (the number of places, suppliers or consumers), which is basically the same amount as when solving the task using “brute force”, that is by calculating the values of an objective function for all possible task solutions and selecting the one whose value was found as optimal. Contemporary computer technology enables such task solutions on most effective devices within the scope of 20 places maximum; and in respect to the mentioned exponential dependency, we can assume that this number will even in the future grow only very slowly in spite of rapid computer technology development. Therefore, for these types of tasks there are created the so-called heuristics (approximation methods) offering on the one hand only approximate solutions, on the other hand, however, they are so high-quality that we can regard them as economic optimums.

The most “classical” of these tasks is the traveling salesman problem (TSP). In this case the transportation among all serviced places is to be realized by one circle. It is possibly the most solved type of “round” tasks, whose solution is at the same time a part of the solution of some VRP types. It is also one of the most solved tasks belonging among the NP-complete problems and there exist many types of heuristics for this type of task. However, very often we deal with more complicated situations. Reasons, why one round trip is not enough can vary, e.g. small vehicle capacity, distribution is necessary in due time during which it is impossible to reach all places. Above all, individual suppliers or consumers may have other special demands. In this case it is necessary to create more circles, i.e. more than one vehicle must depart from a central standpoint or, one vehicle must make more round trips and other places or standpoints (suppliers, consumers) must be reasonably divided into groups that will each be serviced during one round trip. There are many VRP types; however, a practical occurrence of individual types is less common than in case of TSP and that is why their choice of heuristics is not as wide as for TSP. The conditions of individual VRP cases are very often so specific that they do not even respond to any of the studied types. Therefore, we usually obtain VRP heuristics by the modification of TSP heuristics.

There exists no generally used software for TSP and VRPs practical solution; the first programs have started to appear on the Internet only recently. In fact, users have no chance to find out which particular method (heuristics) they use. Companies usually solve these tasks “manually” without the use of any specific method even in such cases when in other circumstances, as for instance collecting data for this type of task, they make use of the latest computer technology.

This is also the case of NOPEK Bakery, the focus of our article. The firm quarters are situated in Vysoké Mýto. The main program is the manufacture of bakery, patisserie and gingerbread products using traditional and industrial means of manufacture. Other activities involve trade, including wholesale activities and the maintenance

of technical equipment for bakeries and patisseries. NOPEK Bakery has several plants in Hořice, Hrušová, Lanškroun, Svitavy, Vysoké Mýto, Moravská Třebová and Česká Třebová. The company also has its own stores: two are found in Vysoké Mýto and Moravská Třebová, and one is found in Jevíčko, Osík by Litomyšl, Velké Opatovice and Hrušová. Besides this the company runs a non-smoking coffee shop in Vysoké Mýto and a patisserie in Svitavy. The company central storehouse is located in Hrušová. This and other information concerning the company can be found at [20].

Based on annual reports, NOPEK bakery reached 158,5 million CZK in sales and 246,0 million CZK in outputs during 2007 and 177,7 million CZK in sales and 271,7 million CZK in outputs during 2008. The turnover volume was 404,5 million CZK in 2007 and 449,4 million CZK in 2008. In 2008 the company had 356,2 million CZK tenure out of which 241,6 million CZK amounted to buildings and machinery. On the whole, the share of the buildings and machinery on the tenure was 67.84%. The earnings for the fiscal year 2007 came to 21,3 CZK million and for the fiscal year 2008 to 14,7 million CZK, i.e. the tenure profitability was 6.94% in 2007 and 4.11% in 2008. The figures presented refer to the two years 2007 and 2008 because the data used in this article represent 2008.

For dough transportation the company uses Iveco brand trucks with the capacity of 600 crates and Avia trucks with the capacity of 400 crates. The bakery has contracts with both, retailers as well as supermarkets. It is not the vehicle capacity that determines the number of gateways as strict demands on behalf of supermarkets and bigger chains. All in all, we can distinguish three types of delivery: "fast delivery", "long delivery" and "special orders". The situation is illustrated in Figure 1.

"Long delivery" usually takes a longer distance to other regions of the Czech Republic. Suppliers are most likely large businesses, department stores, supermarkets, camps, school events etc., which require a greater amount of goods, making simpler routes usually with four suppliers at the most. These routes can be easily optimized by drivers themselves.

Not even special orders give much space for optimization. They are usually placed by the largest companies and big chains whose typical representatives are supermarkets. These wholesalers demand strict meeting deadlines of their orders, and if the deadlines are not met, they may decide to change the supplier. The NOPEK Company may thus lose its clients. Usually the company sends trucks specifically for them. The trucks are usually filled only with approximately 25-30% of goods, primarily from the nearest storehouse or from the central storehouse if the nearest one has no goods available.

"Fast delivery" is defined by the company management as an area which has its own distribution plan. Furthermore, such an area is supplied from one storehouse (while more "fast deliveries" can be performed from this particular storehouse). It contains several tens of places (towns, villages) with usually more than one retailer. They usually show certain stability in their demands, that is they order the same amount of goods basically every day (this of course accounts also for weekend orders of consumers performing also at weekends). The goods must be delivered before their opening hours but, since it is usually easiest for them to take goods from local bakeries, they are always willing to make compromises when it comes to a delivery deadline. In respect to the number of consumers and a limited vehicle capacity it is necessary to use several vehicles for each area. This all opens a large space for optimization regarding not only delivery distribution among individual vehicles, but particular routes for each vehicle.

The aim of this article is to apply different heuristics on one of these "fast deliveries", compare obtained results with real bakery delivery and demonstrate the effectiveness of these methods. Some of the results (as well as the data mentioned in Introduction and other information concerning NOPEK Company) have been adopted from [10] and subsequently have been completed by our own calculations.

Case studies on delivery planning have recently been published quite frequently. In some cases commercial software is used for solution as in, for example, studies from the central Finland which concern a route proposal for seniors home care [1]

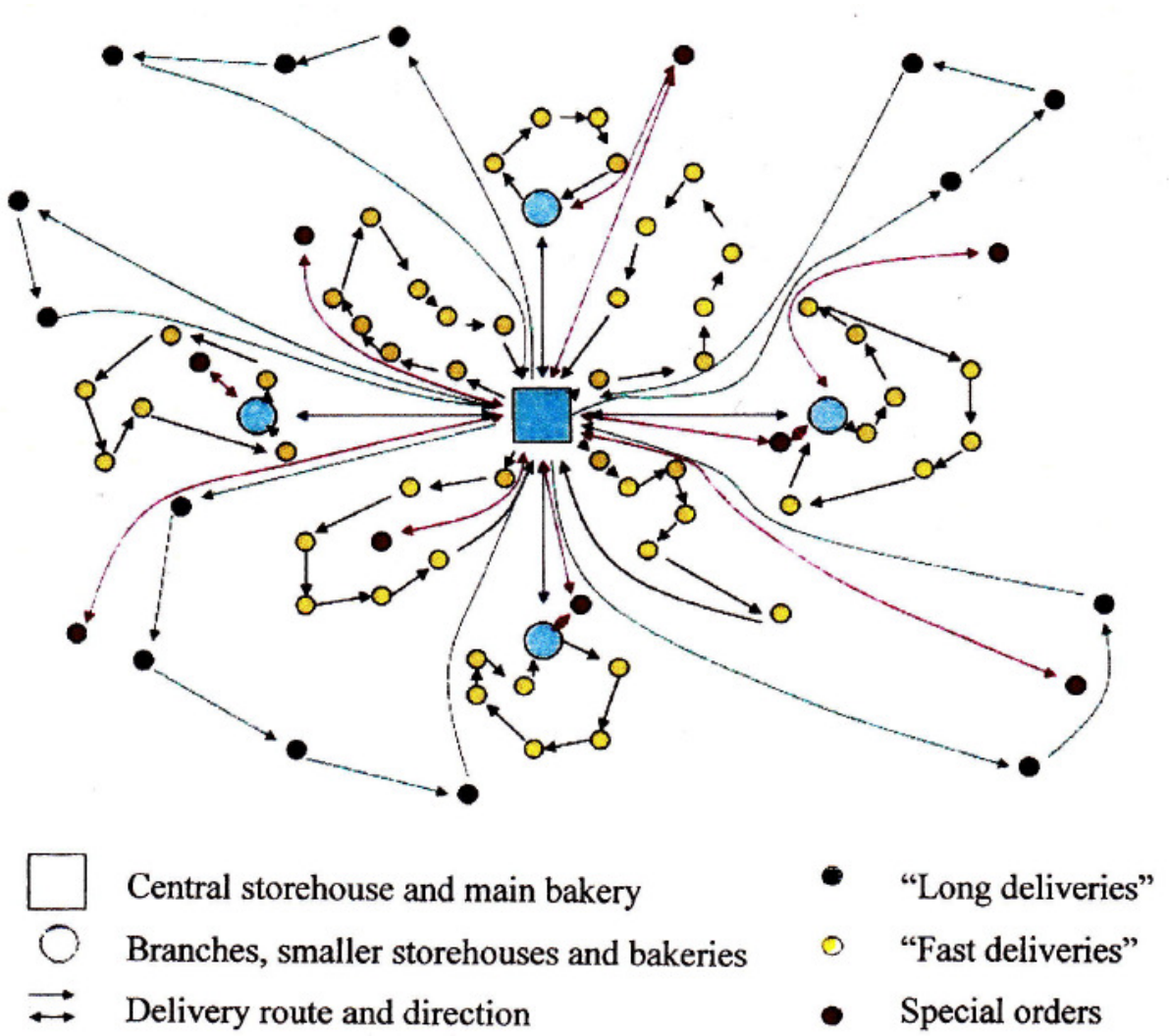

Figure 1.

and especially for food delivery to their homes [2] where significant savings were reached in comparison with the former delivery organization, or in fuel oil distribution for Petramina company from its depot to gas stations in one Jakarta district [13] where the new proposal also brought some savings. In other cases heuristics are used for a solution, as for instance in the optimization of the municipal refuse collecting system where costs were reduced significantly [11], or in planning lumber haulage [16] where one of the visited heuristics which even proved as relatively successful and suitable for this purpose was also the savings method, i.e. one of the methods used in this article. [14] and [15] compares the heuristics application with exact computation using integer programming (which in its time-difficulty corresponds to using "brute force") with the case of the transportation of the University of The Thai Chamber of Commerce employees by university buses to work. While the exact computation brought the result in sensible computational time only in some cases and in others it failed, using the heuristics results were obtained within a small amount of computational time and were good in comparison with the exact computation, provided it was successful.

Material and Methods

The article deals with one "fast delivery" from the central storehouse in Hrušová. Its consumers, all situated in the area with a dense road net in the distance of 50 km from the storehouse, can be divided into three groups based on the time of their need of goods delivery. We will further refer to these groups as time zones. Time zone 1 includes small village shops, local bakery branch stores, large businesses and cooperative farms. They demand the delivery till 5:00 or 5:30 a.m. at the latest and they will certainly not take goods before 1:00 a.m. Time zone 2 includes shops which normally open around 8:00, that is discount stores

and supermarket in Vysoké Mýto. Their time deadlines are less flexible, especially their uttermost limit 8:00 a.m. cannot be crossed. Time zone 3 also includes big large businesses, cooperatives and cafeterias preparing mid-day meals. There the goods may be delivered by 11:00 a.m. In respect to vehicle capacity and consumer demands, each vehicle will make the delivery only within one time zone and for the supply of each time zone several vehicles will be needed. The delivery for each of these time zones will be solved as an individual task.

From the above mentioned facts we can assume that the main limitation of delivery planning is a time interval during which it is necessary to carry out the delivery. Just as well, we can use time as an optimization criterion (objective function). The task for an individual time zone is to a great extent similar to the time limited vehicle routing problem (TLVRP) described in [9], where it concerns, strictly speaking, the optimization of delivery from the central standpoint to a certain amount of other standpoints (or in the opposite direction), which should be performed to a certain time limit. However, our delivery transportation plan in question is rather different in several points from the task just mentioned. To the time needed for the vehicle delivery we need to add time which is needed in every standpoint for unloading goods, and if there is more than one business in a standpoint we also need to add time necessary for transfer from one business to another. Contrastingly, from the viewpoint of consumers, the time of vehicle departure from the storehouse and the time of its arrival back are unimportant. Therefore, only the period from the arrival of the vehicle to the first consumer till its departure from the last consumer will be included to the time limit that should not be crossed. We will refer to this time consumed by individual vehicles as neat delivery time (NDT). Nonetheless, we will also observe gross delivery time (GDT), that is time which the vehicle spends on its way from its departure till its arrival in the storehouse. It is also important to pay attention to the vehicle capacity so that it is not exceeded.

However, for a quantitative task definition it is necessary to define its cost matrix. Costs will be the time required for the transfer between two standpoints available in the information system [19]. In case there is more than one business serviced in one place, there will be extra 5 minutes added the each transfer between two consecutive consumers. Generally, we may express this added time by the formula $(n–1)\cdot 5$, where n is the number of consumers in a standpoint. Furthermore, we need to add the time necessary for unloading goods. This will present 5 minutes for each 36 crates. These additional times were calculated on the basis of drivers' practical experience and we shall call them manipulation times. The cost matrix, manipulation times and the number of crates ordered by individual consumers in each standpoint for the time zones 1, 2 and 3, are shown in Table 1, 2 and 3 respectively.

The first heuristics, used during solving the problem, was the nearest neighbor method (NNM). Actually, it is the simplest known method based on the fact that from each standpoint we continue to the nearest so far unvisited standpoint (following a route with the most convenient cost). However, its obvious deficit is the fact that sectors included in the circle as last ones have inconvenient costs, which reduces the overall solution value. Rosenkrantz, Stearns and Lewis [12] tested the functioning of this method for TSP, and their findings confirmed its expected very low quality. Three different modifications were tested in [10] for our problem. The first one (further referred to as version 1) began with the construction of each circle in the central storehouse and continued to the nearest standpoint till the time limit for the NDT or vehicle capacity was exceeded. Afterwards, the vehicle returned to the central storehouse. In fact, this approach shows analogy with the method mentioned for TLVRP in [9]. However, solutions obtained by this approach displayed inconvenient ordering of the most remote standpoints from the central storehouse. Version 2 attempts to eliminate this deficit. The first visited standpoint during each route is the most remote one from the central storehouse out of standpoints so far not included in previously constructed routes, and from there we again move to the nearest one. In case of version 3 it is rather questionable whether the NNM modification is still concerned. The circles are constructed parallel (all at once) so that first the costs are ordered from the most convenient one to the least convenient. Then they are processed in this order so that each particular segment is added to the solution under condition that in case of each route it

	Vysoké Mýto	Sedliště	Roveň	Rosice	Přestavlky	Pardubice	Osík	Němčice	Moravany	Litomyšl	Kostěnice	Chrudim	Chrást	Hrochův Týnec	Honbice	Holice	**Hrušová**	manipulation time	number of crates
Vysoké Mýto	-	13	21	28	27	40	20	21	25	19	32	37	34	23	29	20	**5**	95	302
Sedliště	13	-	37	41	40	53	10	11	38	6	45	50	47	36	42	33	**8**	10	55
Roveň	21	37	-	26	22	25	41	42	9	37	12	31	30	17	24	11	**26**	20	39
Rosice	28	41	26	-	9	40	49	50	19	44	18	22	6	9	11	34	**33**	10	14
Přestavlky	27	40	22	9	-	27	48	49	14	44	14	18	10	4	8	30	**32**	10	15
Pardubice	40	53	25	40	27	-	60	61	25	56	18	17	36	22	28	23	**45**	35	87
Osík	20	10	41	49	48	60	-	11	46	6	53	57	50	44	50	41	**16**	15	59
Němčice	21	11	42	50	49	61	11	-	47	6	54	58	56	45	51	44	**20**	5	58
Moravany	25	38	9	19	14	25	46	47	-	41	8	23	22	1	20	17	**30**	10	15
Litomyšl	19	6	37	44	44	56	6	6	41	-	49	53	50	39	46	39	**11**	105	287
Kostěnice	32	45	12	18	14	18	53	54	8	49	-	22	22	9	16	19	**37**	15	20
Chrudim	37	50	31	22	18	17	57	58	23	53	22	-	21	13	14	38	**42**	90	240
Chrást	34	47	30	6	10	36	50	56	22	50	22	21	-	13	11	39	**39**	15	18
Hrochův Týnec	23	36	17	9	4	22	44	45	1	39	9	13	13	-	6	26	**28**	25	27
Honbice	29	42	24	11	8	28	50	51	20	46	16	14	11	6	-	32	**34**	5	6
Holice	20	33	11	34	30	23	41	44	17	39	19	38	39	26	32	-	**25**	10	35
Hrušová	**5**	**8**	**26**	**33**	**32**	**45**	**16**	**20**	**30**	**11**	**37**	**42**	**39**	**28**	**34**	**25**	**-**	**-**	**-**

Table 1.

	Vysoké Mýto	Újezdec	Roveň	Nová Sídla	Moravany	Makov	Kostěnice	Javorník	Chacholice	Hrušová	Holice	H. Újezd	Džbánov	D. Újezd	Cerekvice	Bučina	Chotovice	Nové Hrady	Proseč	Příluka	Suchá Lhota	Leština	**Hrušová**	manipulation time	number of crates
Vysoké Mýto	-	13	21	12	25	18	32	14	36	5	20	30	5	25	6	9	20	22	33	17	13	15	**5**	75	226
Újezdec	13	-	33	7	37	5	45	13	39	7	32	20	12	14	5	8	8	12	24	10	12	15	**7**	15	48
Roveň	21	33	-	33	9	38	12	35	34	26	11	51	26	46	27	30	41	42	54	38	34	36	**26**	10	26
Nová Sídla	12	7	33	-	37	9	44	13	43	7	33	19	13	14	5	8	12	16	28	16	12	20	**7**	5	4
Moravany	25	37	9	37	-	43	8	40	26	30	17	56	32	51	31	34	46	44	55	42	39	38	**30**	10	10
Makov	18	5	38	9	43	-	50	17	33	13	38	14	22	11	11	12	2	6	18	9	7	12	**13**	10	36
Kostěnice	32	45	12	44	8	50	-	47	26	37	19	63	38	58	39	41	50	46	55	50	46	43	**37**	5	8
Javorník	14	13	35	13	40	17	47	-	32	10	35	32	6	21	9	5	20	10	21	13	9	6	**10**	5	4
Chacholice	36	39	34	43	26	33	26	32	-	41	43	49	37	45	41	37	30	36	35	31	32	24	**41**	5	7
Hrušová	5	7	26	7	30	13	37	10	41	-	25	26	5	21	1	4	15	17	28	12	8	16	0	35	128
Holice	20	32	11	33	17	38	19	35	43	25	-	51	28	46	26	29	41	43	53	37	34	36	**25**	45	140
H. Újezd	30	20	51	19	56	14	63	32	49	26	51	-	31	5	25	27	17	21	18	24	22	27	**26**	15	62
Džbánov	5	12	26	13	32	22	38	6	37	5	28	31	-	26	6	12	20	16	26	20	16	13	**5**	5	3
D. Újezd	25	14	46	14	51	11	58	21	45	21	46	5	26	-	20	22	14	18	22	20	19	23	**21**	30	45
Cerekvice	6	5	27	5	31	11	39	9	41	1	26	25	6	20	-	4	14	16	28	12	8	16	**1**	20	80
Bučina	9	8	30	8	34	12	41	5	37	4	29	27	12	22	4	-	15	12	24	8	4	12	**4**	5	8
Chotovice	20	8	41	12	46	2	50	20	30	15	41	17	20	14	14	15	-	4	15	6	10	9	**15**	10	22
Nové Hrady	22	12	42	16	44	6	46	10	36	17	43	21	16	18	16	12	4	-	11	4	8	6	**17**	20	45
Proseč	33	24	54	28	55	18	55	21	35	28	53	18	26	22	28	24	15	11	-	16	19	18	**28**	35	105
Příluka	17	10	38	16	42	9	50	13	31	12	37	24	20	20	12	8	6	4	16	-	3	9	**12**	10	9
Suchá Lhota	13	12	34	12	39	7	46	9	32	8	34	22	16	19	8	4	10	8	19	3	-	9	**8**	5	5
Leština	15	15	36	20	38	12	43	6	24	16	36	27	13	23	16	12	9	6	18	9	9	-	**16**	5	8
Hrušová	**5**	**7**	**26**	**7**	**30**	**13**	**37**	**10**	**41**	0	**25**	**26**	**5**	**21**	**1**	**4**	**15**	**17**	**28**	**12**	**8**	**16**	**-**	**-**	**-**

Table 2.

	Vysoké Mýto	Tržek	Sedliště	Řestoky	Rosice	Přestavlky	Pardubice	Němčice	Nabočany	Litomyšl	Chrudim	Chrást	Chacholice	Hrochův Týnec	Honbice	Holice	Dašice	D. Újezd	Nové Hrady	Proseč	**Hrušová**	manipulation time	number of crates
Vysoké Mýto	-	11	13	31	28	27	40	21	27	19	37	34	36	23	29	20	30	25	22	33	**5**	75	226
Tržek	11	-	3	43	39	39	51	12	39	7	48	43	44	34	41	31	42	15	17	28	**6**	5	9
Sedliště	13	3	-	44	41	40	53	11	40	6	50	47	51	36	42	33	46	18	21	37	**8**	10	54,5
Řestoky	31	43	44	-	6	3	31	53	7	48	18	6	10	8	5	34	20	50	32	39	**36**	20	70
Rosice	28	39	41	6	-	9	40	50	11	44	22	6	10	9	11	34	22	47	30	40	**33**	5	8,8
Přestavlky	27	39	40	3	9	-	27	49	7	44	18	10	13	4	8	30	18	53	36	43	**32**	5	3,6
Pardubice	40	51	53	31	40	27	-	61	27	56	17	36	40	22	28	23	15	65	61	69	**45**	80	203
Němčice	21	12	11	53	50	49	61	-	49	6	58	56	57	45	51	44	52	16	28	38	**20**	5	28
Nabočany	27	39	40	7	11	7	27	49	-	44	12	13	17	4	2	30	18	53	39	46	**32**	5	6
Litomyšl	19	7	6	48	44	44	56	6	44	-	53	50	50	39	46	39	47	11	23	32	**11**	75	191
Chrudim	37	48	50	18	22	18	17	58	12	53	-	21	25	13	14	38	22	62	51	55	**42**	60	160
Chrást	34	43	47	6	6	10	36	56	13	50	21	-	4	13	11	39	26	44	27	34	**39**	10	12
Chacholice	36	44	51	10	10	13	40	57	17	50	25	4	-	17	15	43	30	45	36	35	**41**	5	7
Hrochův Týnec	23	34	36	8	9	4	22	45	4	39	13	13	17	-	6	26	13	49	37	46	**28**	10	11,4
Honbice	29	41	42	5	11	8	28	51	2	46	14	11	15	6	-	32	23	54	37	44	**34**	5	6
Holice	20	31	33	34	34	30	23	44	30	39	38	39	43	26	32	-	16	46	43	53	**25**	55	175
Dašice	30	42	46	20	22	18	15	52	18	47	22	26	30	13	23	16	-	56	50	60	**35**	10	17
D. Újezd	25	15	18	50	47	53	65	16	53	11	62	44	45	49	54	46	56	-	18	22	**21**	15	30
Nové Hrady	22	17	21	32	30	36	61	28	39	23	51	27	36	37	37	43	50	18	-	11	**17**	10	30
Proseč	33	28	37	39	40	43	69	38	46	32	55	34	35	46	44	53	60	22	11	-	**28**	15	45
Hrušová	**5**	**6**	**8**	**36**	**33**	**32**	**45**	**20**	**32**	**11**	**42**	**39**	**41**	**28**	**34**	**25**	**35**	**21**	**17**	**28**	**-**	**-**	**-**

Table 3.

does not violate the constraints given by NDT and vehicle capacity. Initially, the solution has contained individual pairs of standpoints which gradually connect into more complex routes. This approach is in analogy with the Borůvka [3] and Kruskal [6] algorithm for a minimum spanning tree in a graph.

As the next method we applied the savings method (SM) by Clarke and Wright [4]. It is based on the use of savings rather than costs, which are calculated as differences between the length of the route across another previously selected standpoint (the same for the calculation of all savings) and the length of a direct route (cost) between two given standpoints. For the VRP applications we use a central standpoint from where all vehicles depart. [10] uses three versions of savings method which function just the same as the above mentioned NNM modifications, making a difference only in the fact that they use savings matrix in place of costs. Version 3 is at the same time analogical to a parallel SM modification for TLVRP from [7]. Unlike [10], we further even tested version 4 which constructed routes for individual vehicles in sequence (one after another) but its starting point was a segment with the lowest savings out of so far non-included ones (it constructed routes "from the middle"). In fact, it concerns the approach analogical to the SM application for TLVRP from [9].

The last method modified in [10] for the tested problem of bakery products delivery was a loss method [17], [18]. Generally, e.g. in the TSP, the quality of the solution obtained by this method is to a great extent positively influenced by the fact that following each step (inserting a certain segment into the solution), we leave out costs of those segments which cannot become parts of the solution and, based on this, we recalculate the losses. However, solving VRPs, we can find all these segments only with difficulty, and also [10] does not do it sufficiently enough. No wonder that method did not present the best solution for either of the time zones. On each occasion of our testing some tested methods proved to be more successful. Therefore we do not mention our obtained findings in this article.

Moreover, we also tested one approach not mentioned in [10] at all. We attempted to apply Habr frequencies [5] to the optimal delivery calculation. As well as savings, Habr frequencies are determined fore each cost (a direct route between two standpoints) but unlike savings, they have the advantage in the fact that when evaluating them all other costs are taken into account, even those which do not concern the route in question (in cost matrix they are not found in the same line or column). The applied approach was analogical to the method for TLVRP from [8] including the formula taking into account a specific role of a central standpoint from where vehicles depart. It is at the same time similar to NNM and SM versions 3 described above.

Results and Discussion

Table 4 presents all variants of the delivery plans obtained by the individual methods, including the approach formerly used by the bakery. For each time zone, the obtained best solutions are emphasized. Sometimes it is difficult to decide which solution is really the most appropriate, e.g. whether to give a priority to a "mathematically" optimal solution (with the shortest sum of the NDT or/and GDT of all vehicles but with the NDT of individual vehicles at a different length) or a solution where the total is higher; however, there is not a great difference in NDT between the routes of the individual vehicles. In this case more variants have been marked as the good ones.

The contribution of the methods mainly lies in the reduction of the number of employed vehicles. Whereas the firm needed four vehicles for the time zones 1 and 3 and three vehicles more for the time zone 2, that is 11 vehicles in total, almost all solutions obtained by individual methods needed only three vehicles for each time zone (except only one method in one time zone), that is 9 in total. This of course means 18% of savings, with regard to the number of vehicles. Moreover, the methods are capable of finding solution with a better balance of NDT and GDT of the individual vehicles and with the GDT being 10% shorter. On the contrary, we were practically not able to improve the NDT. However, this is the fact that we expected due to a short distance among particular customers.

Further, it is worth noticing that for every time zone (i.e. for every partial task) each method offered a different solution. By applying more methods, the user may obtain more delivery plans and select

		Time zone 1					**Time zone 2**				**Time zone 3**				
		vehicle1	vehicle2	vehicle3	vehicle4	**in total**	vehicle1	vehicle2	vehicle3	**in total**	vehicle1	vehicle2	vehicle3	vehicle4	**in total**
Former plan	NDT	1,75	2,78	4,32	3,25	**12,10**	3,60	4,38	3,67	**11,65**	4,02	3,93	4,43	2,35	**14,73**
	GDT	1,58	2,57	2,90	2,00	**9,05**	3,43	3,62	2,25	**9,30**	3,85	3,03	3,02	1,60	**11,50**
NNM v.1	NDT	3,73	4,28	4,22	-	**12,23**	3,14	3,61	3,25	**10,00**	5,13	4,10	4,48	-	**13,71**
	GDT	3,47	3,63	3,23	-	**10,33**	3,21	3,24	2,15	**8,60**	4,15	2,93	3,50	-	**10,58**
NNM v.2	NDT	4,75	4,44	4,07	-	**13,26**	4,67	3,17	3,45	**11,29**	5,10	4,48	3,95	-	**13,53**
	GDT	3,28	3,61	3,72	-	**10,61**	3,63	2,47	3,28	**9,38**	4,27	3,50	3,47	-	**11,24**
NNM v.3	NDT	4,22	4,06	3,95	-	**12,23**	3,65	3,37	4,58	**11,60**	4,22	4,05	5,47	-	**13,74**
	GDT	3,15	3,64	3,12	-	**9,91**	3,30	3,02	3,73	**10,05**	2,87	3,78	4,25	-	**10,90**
SM v.1	NDT	3,87	5,32	5,28	-	**14,47**	4,08	3,73	2,73	**10,54**	4,50	4,47	4,20	-	**13,17**
	GDT	3,03	3,98	4,37	-	**11,38**	3,52	3,53	2,62	**9,67**	3,72	3,90	3,37	-	**10,99**
SM v.2	NDT	4,92	4,23	3,63	-	**12,78**	4,08	3,87	2,95	**10,90**	4,95	4,28	4,57	-	**13,80**
	GDT	3,70	3,72	3,28	-	**10,70**	3,73	3,52	2,10	**9,35**	3,52	3,60	4,02	-	**11,14**
SM v.3	NDT	4,60	4,07	3,95	-	**12,62**	3,98	3,47	2,88	**10,33**	4,47	4,65	4,37	-	**13,49**
	GDT	3,53	3,43	3,68	-	**10,64**	3,57	3,00	2,60	**9,17**	3,42	3,88	3,82	-	**11,12**
SM v.4	NDT	5,08	4,63	3,10	-	**12,81**	4,20	3,52	2,72	**10,44**	3,92	5,37	4,62	-	**13,91**
	GDT	3,82	4,02	2,70	-	**10,54**	3,32	3,32	2,60	**9,24**	2,67	4,48	4,43	-	**11,58**
Habr freq.	NDT	4,67	4,95	4,43	-	**14,05**	4,63	3,97	3,57	**12,17**	solution with four vehicles				
	GDT	4,35	3,97	3,47	-	**11,79**	3,77	3,65	3,55	**10,97**					

Table 4.

among them the one which s/he finds the most favorable. What is more, every time (in each time zone) a different method succeeded, including NNM or sequential versions of methods from which we could theoretically expect worse results. Therefore, it is worth testing more different methods during calculations.

Are we to express the benefit in monetary units, we can perceive the situation in several ways. The easiest way is to express costs per 1 km ride, find out how many kilometres the company drove according to the original delivery plan and compare it with a number of kilometres driven according to the new plan using the methods. To determine the costs we used the sum which is charged by services providing car transport. In companies using Avia vehicles, e.g. REFIT95 spol. s.r.o. (REFIT95 Ltd.), we can get the transport starting at 15 CZK per km and owing to the fact that this sum differs from Iveco vehicles only minimally, e.g. they are only about 2 CZK per km more expensive as it is the case of Tavočer s.r.o. (Tavocer Ltd.), we will further consider this sum. We have described the situation by the time of the ride and in order to transfer time to distance we need to know an average speed of vehicles during delivery. Let us suppose it is 50 km per hour. Having added all three time zones, the overall HDR is about two hours and a quarter shorter for the new solution and thus it saves approximately 200 CZK per every work day. Annually the savings will amount to 60,000 CZK. This concerns only a single "fast delivery", assuming there are 10 altogether. If we manage such savings during each "fast delivery", the annual costs savings as well as the increase in profit will amount to 0,6 mil. CZK, which means the increase in profitability between 1.6 and 2%.

The second type of benefit numeration is the comparison of the situation in the company before installing the optimization with the situation when the number of vehicles owned by the company was lower by the number of the vehicles saved by the company after applying the proposed optimization of a delivery plan. If the number of vehicles in each of the ten "fast vehicles" is reduced by two as in the case presented in this article, altogether 20 vehicles will be saved. In regard to the fact that one Avia vehicle costs about 850,000 CZK, the tenure of the company would be by 17 million CZK less. Further it is necessary to consider the profit increase by 0,6 mil CZK reached by saving the costs shortening the overall length of delivery routes (enumerated above in the first type of benefit formulation). The increase in profitability amounts to between 2 and 2.5% in this case.

Another optimization benefit which, however, is not possible to quantify, represents costs savings on the basis of better organization of a delivery process. It mainly presents the possibility to deliver bakery products to consumers in times which suit them better and thus improves mutual supplier-consumer partnership.

If we assess the effectiveness of a method application, we must also consider "time availability" or "stability" of the model. Vendors and businesses, supplied with goods from the bakery, reflect changes in demand of their customers and, correspondingly, they render their demands for the bakery. The majority of permanent consumers included in "fast delivery" modifies their demands every month and confirms their order for every following month. Real particular demands may differ a little from the negotiated ones during week days; however, this does not prevent anybody from the realization of stable delivery plans. Applying the methods, the calculation can be therefore made only monthly. Nevertheless, this need not be necessary, at least not for some time zones, because changes in demand may be so insignificant that using the present routes, time or capacity limitations will not be violated. In such case it is still possible to use existing routes of delivery and there is no need for the calculation of new ones. There will only be minor modifications in the times of delivery to individual customers.

Besides these regular customers, "fast deliveries" will also gradually include other customers who place orders irregularly and by a single application. Fortunately, they are only few. They are typical especially for the time zone 2. In our monitored month, which was appointed for the time of delivery and which is the concern of our article, there were only 65 such demands, i.e. three daily on average. Altogether they were from 15 standpoints and in every one of them it concerned one or two clients at the most. The size of these orders did not exceed three crates at any rate, and from the point of view of the capacity constraints, the size was therefore redundant. There was always enough

room in the vehicle for these extra crates and thus the questions of capacity did not need to be raised when preparing the delivery plan. From the time point of view, each such demand meant a detour of ten minutes in average and five minutes manipulation time for the unloading of goods (in case two irregular customers in one standpoint placed orders on the same day, it provided for another 5 minutes of manipulation time needed for the transfer from one customer to another during one delivery). Every short-term demand provided for the extension of the time of delivery about 15 to 20 minutes, 25 minutes at the most, which is tolerable – as regards time reserve of most routes of individual vehicles – and considering the NDT constraint. When planning the delivery, these irregular orders did not require any other special calculations and what is more, they were in favor of the use of routes obtained from the application of the methods introduced in this article.

The most convenient one of the proposed solutions introduced in [10] and in our article was actually acceptable even for the NOPEK Company. The bakery accepted and applied it with success into its business practice.

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New approaches to presenting information in the agrarian sector and country areas – Technological solution of the agris web portal

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Abstract

The present paper brings an overview of both technological and functional upgrade of the agrarian web portal AGRIS (http://www.agris.cz). Agris 4.0 version has been developed, tested and launched in the course of 2010. Agris 4.0 is built and runs on Microsoft technologies within the framework of MS IIS web server. Model-View-Controller (MVC) architectural pattern, an inherent part of the technology .NET framework 3.5, has been used.

Key words

WWW portal, web browser, AGRIS, agrarian portal, ASP.NET, MVC.

Anotace

Příspěvek prezentuje výsledky řešení technologické a funkční inovace agrárního WWW portálu AGRIS (http://www.agris.cz) – označena jako verze Agris 4.0, kterých bylo dosaženo v průběhu roku 2010 a které jsou postupně ověřovány a následně uváděny do reálného provozu. Agris 4.0 je postaven a provozován na technologiích Microsoft v prostředí WWW serveru MS IIS. Pro rozvoj portálu bylo použito architektury návrhového vzoru Model-View-Controller (MVC), který je součástí technologie .NET framework 3.5.

Klíčová slova

www portál, webový prohlížeč, AGRIS, agrární portál, ASP.NET, MVC.

Introduction

Nowadays information and knowledge society (economy) features a growing number of information resources from all spheres of human activity; these resources take various forms and have a different quality, relevance and availability. Not only is the number of these resources undergoing a dynamic change but as well their form and structure is. While talking about departmental information resources, the AGRIS portal **(http://www.agris.cz)** holds a very prominent position in the long term.

The agrarian web portal AGRIS is a unique on-line information resource not only for the agrarian sector (agriculture, food industry, forestry, water management) but as well for most regions and for the countryside in general. The target users are primarily company executives, state administration, local authorities, students, food consumers and rural areas inhabitants. The agrarian web portal AGRIS presents and provides access to the existing information resources, generates its own pieces of information and publishes information from the subjects that do not have but limited conditions for their own quality electronic presentation. Enhanced availability and applicability of the information presented constitute an important added value of the portal. Moreover, the academic environment offers maximum potential, guarantee of expertise and considerable independence.

The AGRIS portal has been providing its services since 1999. It was created and developed by the Department of Information Technologies FEM CULS in cooperation with the Information and Consulting Centre FEM and the Ministry of Agriculture of the Czech Republic. In 2000 it was awarded a prestigious Zlatý klas (Golden Spike) award at the international agricultural exhibition and fair Země Živitelka (Bread Basket) in České

Budějovice. Last substantial modification of the whole portal was carried out in mid-2003, i.e. more than six years ago. Further information on the general concept and solution of the fore-mentioned AGRIS portal version 3.0 can be found e.g. in [13], [14], eventually in [15].

The technological and functional upgrade was conditional for keeping qualitative and functional standards of the portal. The upgrade was realized in line with the most modern technologies, latest information resources development, current trends and requirements of the portal users.

The paper presents the upgrade outcomes that have been reached, step by step tested and subsequently launched in the course of 2010.

Objectives and methods

Based on the analyses effected, the present solution is aimed at a complex upgrade (technological, functional, content) of the agrarian portal AGRIS in order to comply with nowadays requirements of the users (professionals and general public) and of the latest technologies. Recently, the data are displayed not only by means of PC or portable computer browsers but more and more by means of a wide spectrum of mobile devices, single-purpose devices, software readers for disabled users or full text search engines robots. The portal though has to reflect the quality, relevance and structure of the existing and new information resources and support various technical means. Above all, it has to provide users with authenticated data/information at the shortest possible time and in the quality and format required.

As far as the methodology is concerned, it primarily lies in the analyses of the current AGRIS portal solution, i.e. technological, content and structural analysis. Consequently, user behaviour analysis, availability and quality of information resources analysis, user and technological requirements analysis were carried out and examined. As a result, optimal structure of the individual portal components was designed, meeting user requirements, habits and behaviour. At the same time, it was necessary to design a complex innovation of the most risky portal components in compliance with the newly proposed structure and technology requirements. Subsequently, the above-mentioned components were redesigned, including the implementation of an analytical tool for an easy and sophisticated user behaviour output. An important step of the new version implementation was its testing on the development platform.

Technical solution

The foremost objective of the innovation was to upgrade the technological solution of the portal. The AGRIS internet portal has so far run on the Microsoft platform, using the MS SQL 2005 [5] database server and Internet Information Services version 6.0 web server to be precise. While creating and developing the portal in the late 90's, the PHP [7] scripting language technology was adopted. Within the next ten years, the potential of the above technology was fully exploited. However, from today's perspective the technology has become quite outdated and therefore unsatisfactory. It was therefore indispensable to search for a new solution that would mainly upgrade the throughput of the portal and the security of the whole system.

In order to implement the changes, the following criteria have been suggested (upon analysis):

- retaining the Microsoft platform (implementation of up-to-date SW versions - IIS 7 [6] web server and MS SQL 2008 [8] database server);
- maintaining current system functionality, independent of design;
- enhancing the overall throughput, stability and availability;
- dividing data, application and presentation layers of the system
- enhancing data throughput of the applications by innovating the relational data model;
- extending the range of services provided (RSS, web services etc.)

To comply with the fore-mentioned criteria, the complex solution of Microsoft .NET technology turned out to be advantageous - from the design stage of the relational data model to the results presentation in the presentation layer. For this kind of large scale applications, it is vital to use a multilayer client-server architecture, involving database separation, transfer of the application logic onto the application server and presentation of the processed data in the presentation layer of the users (a three-layer client-server architecture using www

client). Layers separation enhances system stability, information accessibility and at the same time facilitates further extension of the services provided.

Model-View-Controller **architectural pattern** (hereinafter referred to as MVC) turned out to be a suitable solution for further portal development. MVC architecture separates three basic parts of the application: MODEL (data model), VIEW (user interface) and CONTROLLER (control application logic). The above three components are largely autonomous and therefore changing one of them does not basically influence the others. In order to implement the above changes, it was advantageous to apply a relatively young technology ASP.NET MVC [3]. This technology is a part of .NET Web application framework 3.5 [9] and should gradually replace – within more robust applications – the original one and two-layer architectures. The MVC pattern is depicted in fig. 1.

The Model component provides data access and manipulates the data of the application. This layer encapsulates the real database model and provides others only with the access to data reading and data logging methods. In case of the AGRIS portal, this component constitutes a relational data model, over which this layer operates and, by means of SQL [10] or LINQ [11] language, it supplies data for the other two layers of the application (View, Controller).

The View is situated on the opposite side of the paradigm. It obtains data from the Model and presents them. In case of the AGRIS portal, this layer displays the data (e.g. HTML site or RSS channel). The View is though aimed at presenting the current XHTML [12] webpage of the AGRIS portal.

The Controller component is situated between the Model and the View. It provides communication with the user, reacts on the actions by calling out a certain method of the Model component e.g. after clicking on the "Weather forecast" it provides redirecting to a website with the present-day forecast. The Controller as well deals with active operations, e.g. after inserting the user name and password, it provides user authentication and ensures the action logging.

Another advantage of the ASP.NET MVC application is its relatively easy, comfortable and safe extension to further services. As the layers are strictly separated, it is usually enough to extend the Model by a new functional element and use it simultaneously for the Controller and the View (represented by a generated XHTML page, web service or RSS channel).

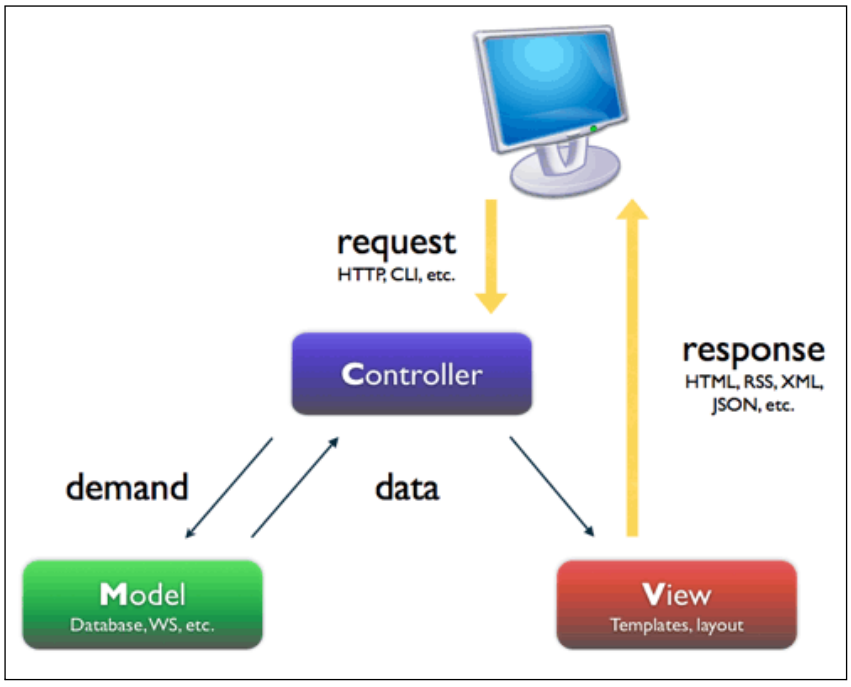


Figure 1: Graphical representation of the MVC architectural pattern [2].

Results and discussion

The presented fundamental software upgrade - AGRIS version 4.0 - has been developed by the Department of Information Technologies FEM CULS (DIT) within the framework of the Research Program of the Ministry of Education, Youth and Sports number 6046070906 as one of the "Information Technologies for Regional Development" sub-period outputs. It was developed prosecuting the first stage of the "Technological and Functional Upgrade of the Agrarian Portal AGRIS" grant that was awarded by the University Internal Grant Agency (in Czech abbreviated CIGA).

AGRIS 4.0 was developed and tested in the course of 2010. The portal is built and runs on well-proven Microsoft technologies within the framework of MS IIS web server. Model-View-Controller (MVC) architectural pattern has been employed. The MVC architecture separates three basic parts of the application: MODEL (data model), VIEW (user interface) and CONTROLLER (control application logic).The NET framework 3.5, or the MVC architectural pattern to be precise, facilitated the upgrade required leading primarily to the enhancement of the overall throughput, stability, system safety and information availability.

Based on the analyses made, the portal functionality has been retained, independently of the basic design. Together with the technological upgrade, the range of portal services has been extended by RSS, web services, map portal etc.

The AGRIS agrarian portal is often employed as a technological platform while realizing educational and research projects. A complex upgrade of the AGRIS portal is sure to promote and reinforce the position of both the Czech University of Life Sciences and the portal itself in terms of potential partnership while submitting and solving follow-up projects, new projects and subprojects at a national and international level. Let us mention for example the topical VOA3R project (Virtual Open Access Agriculture & Aquaculture Repository: Sharing Scientific and Scholarly Research related to Agriculture, Food, and Environment).

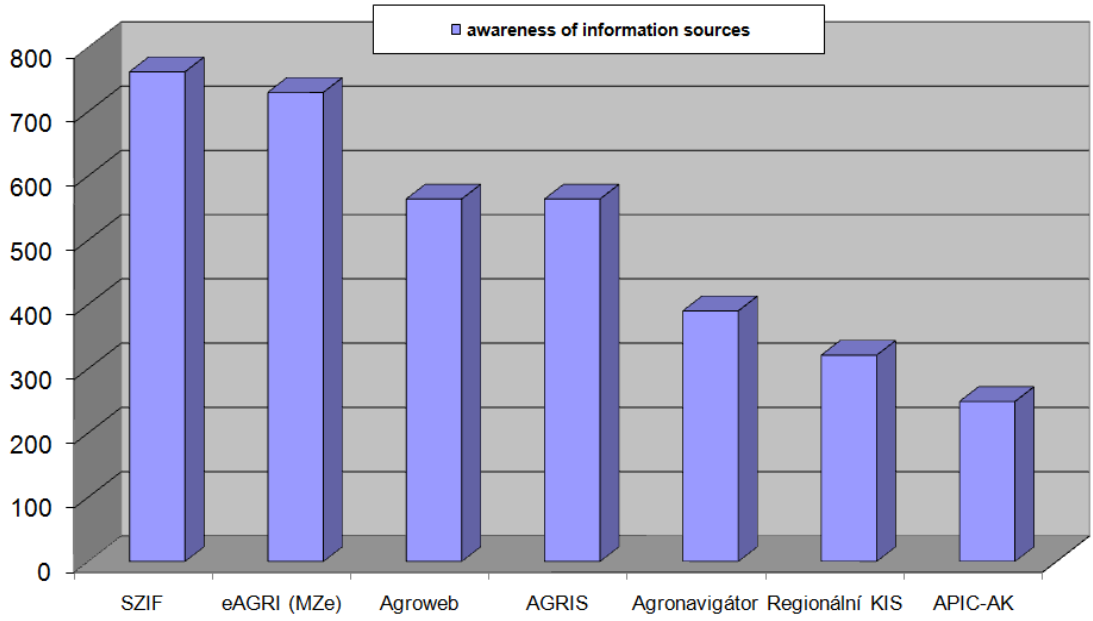
Conclusions

Agris 4.0 is the fourth version of the portal that is now fully verified, field-tested and that shows 30,000 accesses per month. It means that AGRIS is the most visited independent non-commercial departmental information portal in the long term. Enhanced availability and applicability of the information presented constitute an important added value of the portal. The software is fully exploited by the Information and Consulting Centre FEM CULS in Prague that at the same time runs the portal.

Current position of the portal is obvious for instance from the results of a complex survey dealing with ICT development in Czech agricultural enterprises that was carried out by the Department of Information Technologies FEM CULS in cooperation with the Information and Consulting Centre FEM CULS in mid-2010. According to the above survey, the AGRIS portal is perceived very positively by agriculture professionals as one of departmental information sources. Leaving apart state departmental institutions (State Agricultural Intervention Fund and eAgri), the AGRIS portal competes with a professional commercial Agroweb system and is well ahead of all other systems, such as Agronavigator (Institute of Agricultural Economics and Information – ÚZEI in Czech) and two portals of the Agrarian Chamber of the Czech Republic (see fig. 2).

Based on the upgrade realized and further upgrade scheduled for 2011, the AGRIS portal will keep on serving as a unique on-line information resource for the agrarian sector, countryside development and spare-time activity. The portal information will be available anytime, on almost any end-user device, and even with a minimum connectivity. As a result, it will hold its prominent position among quality information resources in the agrarian sector and country areas.

Further AGRIS portal development is scheduled for 2011, primarily within the framework of the FEM Research Program and second stage of the University Internal Grant Agency grant. It will be focused on the innovations that will stem from practical functioning of the upgraded version. The final portal solution will be presented at a



Graph 1: Awareness of departmental www portals – survey 2010 (source: DIT, ICC FEM CULS).

Figure 2: The AGRIS Portal – Main Page (December 2010).

prestigious European conference EFITA 2011[12] (European Federation for Information Technology in Agriculture, Food and the Environment) and other scientific conferences too.

[12] *www.efita2011.cz*

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